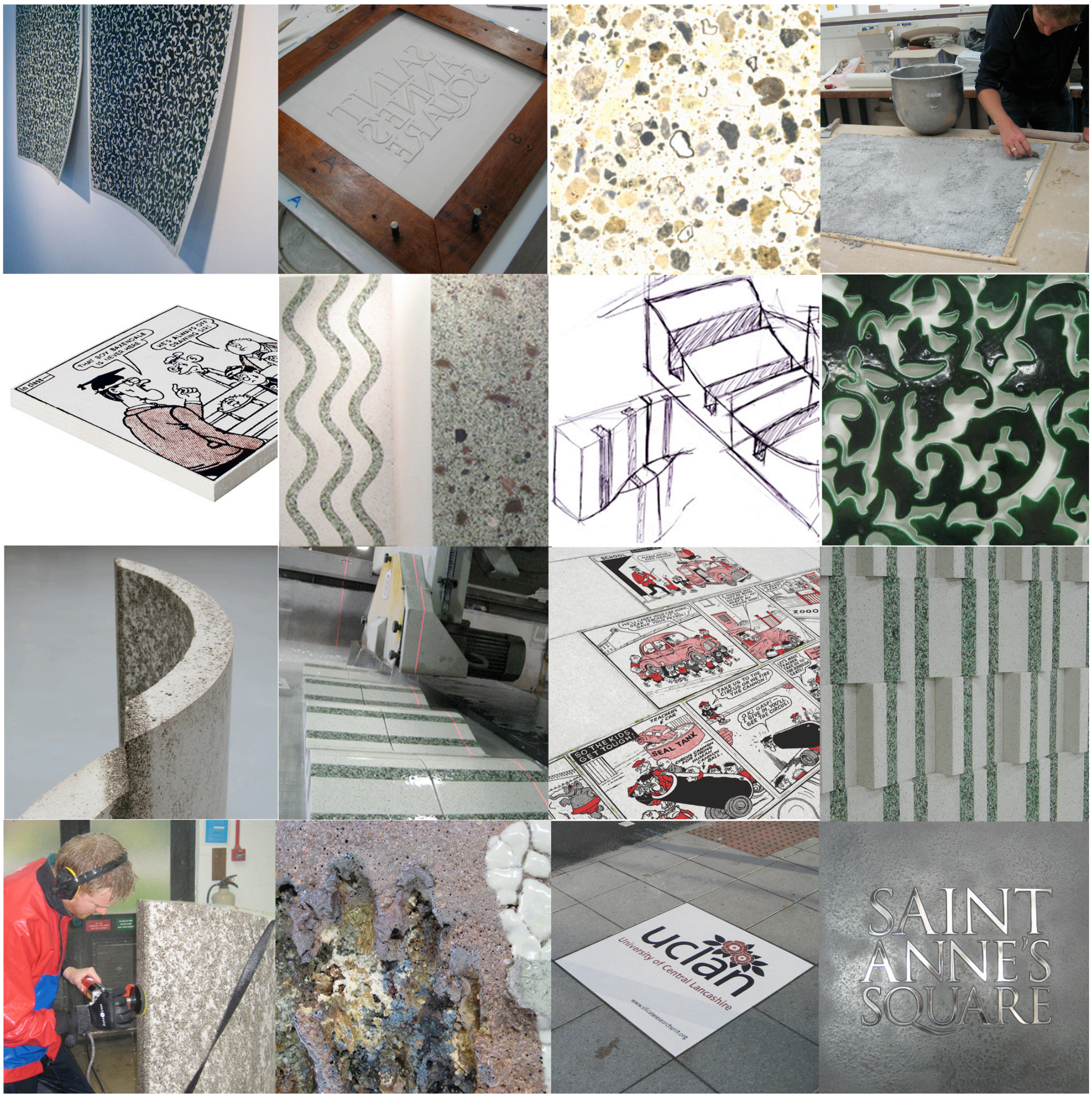
An Investigation into the Potential Creative Applications of Refractory Concrete

Submitted By: Mr Aladair Bremner

Submitted in part fulfilment for the award of Doctor of Philosophy

The University of Central Lancashire



Department of Design, University of Central Lancashire, April 2008

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Abstract

Refractory concretes (RC) are industrial materials used most commonly in high temperature applications, primarily in the steel and glass industries. In most cases they are a mix of refractory aggregate’s chosen for specific hot engineering applications combined with a cement binder. RCs are known to ceramicists largely only for their insulating properties for which they are used in the manufacture of kilns as hot face lining. However, currently very little information is available regarding the structural and aesthetic possibilities that RC can offer to the artist and designer. It is the researcher’s view that refractory concrete displays novel handling properties that include: increased green and fired toughness and strength, thermal shock resistance, ceramic glaze compatibility, thixotropic effects and rapid setting. These properties offer the opportunity to achieve the creation of objects that do not conform to some of the traditional limitations of conventional clay. This research asks whether new products and visual qualities might be achieved by the adoption of these materials in a sphere different from their intended industrial application.

The thesis demonstrates these properties through a series of practice based projects each designed to capatilise on the unique and novel capabilities of RC. The objective was to develop new and innovative products some of which have architectural or urban design applications. In response to the applications developed through the practice elements of the research, two quantiative studies were conducted. New data on RCs resistance to freeze-thaw and slip resistance was generated both confirming that RC is fit for purpose in the proposed applications.

Throughout the research the RC industry has been an integral source of both materials and expertise. This collaborative relationship is seen as generating knowledge transfer opportunities between industry and academic research.

The research acknowledges the limitations of a single researchers approach and tackles this deficiency by engaging other professional artists and designers in the form of four case studies. The results of the case studies are evaluated using structured interviews.

The practice based elements of the research are combined with quantitive research conducted to demonstrate the viability of RC as both a material with creative potential in the ceramic studio, and in the architectural and design sphere.

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I. Acknowledgements and Thanks

This research could not have been completed or even started without the support of my family and I would like to thank them for the support and encouragement they have shown me since I first said, “I want to go to Art School”.

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Finally the project has also received support, both financial and intellectual from a number of companies and I would like to thank, Sheffield Refractories Ltd, DSF Refractories Ltd, HWR Refractories and Ceram for their assistance. I would like to thank specifically Tony Clarkson at Sheffield Refractories and Lynne Barnett at HWR for their assistance.

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V. Glossary of Terms

Alumina	Alumina, Aluminium oxide, corundum, Dialuminum trioxide, Al_3O_3 is an important material in ceramics, second only to silica. Occurs naturally as corundum with trace elements it is more commonly recognised as ruby's and sapphire's.
Bone China	Developed in Britain in an attempt to copy the properties of porcelain imported from the Far East. It has a similar translucency to porcelain, but is less plastic and more fragile before firing.
Binders	Are polymers or colloids that are used to impart strength to green or unfired bodies.
Brazing	To join two pieces of metal using a high melting point solder. A similar technique can be used with some advanced ceramics.
Calcite	$CaCO_3$ Crystalline calcium carbonate similar to quartz although much softer, often an additive to glaze.
Ceramic	A hard brittle heat resistant material made by firing a mixture of clay and chemicals at high temperature. Or more simply a class of inorganic, nonmetalic solid material that are subjected to high temperature in manufacture and/or use.
Ceramic studio	The place in which a ceramicist - normally engaged in creating one off objects works.
Chamotte	A type of ceramic aggregate.
Clay	Hydrated silicate of aluminium. A heavy damp plastic material that 'sets' upon dying and can be changed by heat in to a hard waterproof material
Enamel	A soft metal glass that is applied as decoration normally to the surface of a glaze where it is re-fired and absorbed into the surface of a glaze. Also referred to as on-glaze.
Extrusion	The method of forcing plastic clay or material through a die to form a shape
Fibre	Any particle that is three times as long as it is wide.
Firing	The process of applying heat to clay in order to develop ceramic bonds and therefore create a ceramic

Gel	In industrial ceramics A gel is a solid composed of liquid and solid phases, with these phases both highly dispersed and with an internal network structure.
Glaze	A layer of glass which is fused to the surface of ceramics to seal and increase the strength of the ceramic. It also has a decorative function
Green	Generally defined as the point at which clay is considered to be ‘leather hard’ before firing. Although it can refer to any body of clay or material before it has been fired.
Grog	A ground fired ceramic body added to clay bodies to increase handling properties and overall shrinkage. Sometimes referred to as chamotte.
HAC	High Alumina Cement a constituent of RC, forms the binder material.
Mesothelioma	A cancer that begins in the mesothlium and expands to invade other organs and tissue.
Matrix	A substance in which something is embedded or enclosed.
Piezoelectric	The unique quality presented by some ceramics in which an electric current is produced when the substance is under pressure. The effect also works in reverse i.e. when an electric current is applied to certain ceramics they are able to move.
Plasticity	Generally defined as the property that enables a material to be deformed without rupture during the application of stress.
Porcelain	A vitrified, white and translucent ware. Normally fired to 1300°C, commonly used in crockery and one off precious items.
Polymer	A natural or synthetic compound that consists of large molecules made of many chemically bonded smaller identical molecules. Starch and nylon are polymers.
Raku	Originally a Japanese word referring to a particular type of firing where localized reduction is used to create ceramic decoration.
Refractory	A material that resists high temperatures
Rheology	The science of deformation and flow of matter. Rheological descriptions usually refer to the property of viscosity and departures from Newton's law of viscosity.
Silica	A crystalline compound, SiO_2, occurring abundantly as quartz, sand, flint, agate, and many other minerals and used to manufacture a wide variety of materials, especially glass and concrete.

Sintered	An industrial term that is derived from the German *cinder*. To sinter is to form partially fused bonds in ceramics or metals. Normally achieved at temperatures above 1200°C but does not involve the melting of a given material.
Sol	A stable dispersion of very fine particles in a liquid phase in which the particles remain suspended indefinitely by Brownian motion.
Substrate	a substance that is acted upon, especially by an enzyme, in a biochemical reaction
Thixotropic:	Concerning materials that are gel-like at rest, but fluid when agitated. Having high static shear strength at the same time. To lose viscosity under stress.
Zirconia	Zirconia is a high purity advanced ceramic commonly employed because of its remarkable toughness. A highly refractory and relatively expensive material. It would have limited applications in studio ceramics due to the problems with processing.

Chapter 1

1.1 Introduction

This practice based PhD aimed to establish industrially manufactured refractory concrete (RC) as a viable creative material that has, to date, been ignored in the field of both ceramics and wider areas of creative design. The thesis outlines some of the possibilities that refractory concrete can offer to these fields by combining both creative practical work with quantitative research supporting the application of RC in architectural environments and applications that have not previously been considered for RC.

Practical work has been undertaken that demonstrates a range of applications in which RC can be employed. Where possible these practical demonstrations have been in live projects where the pieces were developed for specific and defined projects, each with individual aims and objectives. This personal practice is reinforced by case studies undertaken by other professional artists and designers. Combined, a case is made for broadening the use of refractory concrete in design and artistic practice.

This research has grown from a personal interest in the manipulation and application of novel and unique materials in the field of ceramics. The researcher's undergraduate degree investigated the addition of lime bearing materials initially to clay bodies and towards the end using RC. The objective was to create a series of pieces that were high-fired ceramic, but had a limited lifespan. In contrast to the general impression of ceramics as a material of permanence, that has recorded the social and cultural development of early civilizations. The researcher created a material that would, over the course of a week, slowly self-destruct. Paradoxically, in making 'temporary' ceramic objects, the researcher was exposed to the various advantages of refractory concrete and its potential for the manufacture of permanent and functional objects.

Figure 1.1.1 'Time-lapse 7 days' Degree Show 2002

From these beginnings, the research initially set out to investigate a range of advanced industrial ceramic materials to explore their potential application within a creative context. This approach was subsequently narrowed to focus the research solely on RC. This Initial review is discussed in Chapter 2[1].

1.2 Rationale behind the research

Refractory concretes have been used extensively in high temperature industrial applications for over 60 years. RC's are commonly used in the steel, glass and chemical industries where their ability to operate at high temperatures while maintaining their structural strength are the desired properties. Monolithic scale products are cast to very high specifications in terms of material and form, with individual RC's designed for very specific jobs and environments.

Figure 1.2.1 Monolithic RC products from DSF Ltd

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[1] Chapter 2, Section 2.1, page 8

However, their application in the sphere of craft, design, and in particular the field of ceramics has been limited to the purely functional; primarily in the construction of kilns and kiln furniture, where their ability to withstand high temperatures is the only property to be harnessed. The rationale behind this research assumes that this refractory property is not the sole property that could be harnessed by artists and designers. There are a number of further functional advantages that RC can offer and these properties formed the basis of the practical investigation.

The research focused on the aesthetic and structural qualities that RCs offer the ceramic artist and designer. It looked to establish methods of working with these materials normally associated with heavy industry, in a studio-based environment. Part of this process involved developing ways of using known ceramic surface techniques and methods to enhance the aesthetic appearance and surface quality of RC. These materials also offer novel structural properties in comparison with conventional ceramic materials such as:

- RCs will typically shrink less than 0.5% compared with up to 12% for some clays.
- RCs will not suffer from warping due to uneven drying and firing.
- Clay is brittle and easily damaged at a dry or green state making handling difficult while many RCs are as tough when fired as conventional concrete[2].
- Ceramic is inherently weak in tension, RCs are substantially stronger in tension and can be used for wide spans, impossible with conventional ceramics.
- There is no need for extended drying times or very slow firing as RC is specifically designed to cope with extreme temperature variance.

It is important to note that these perceived advantages of using RC over clay are not universal; indeed there remain many cases where using RC will not be suitable. Whilst professional ceramic artists and craftsmen are capable of amazing feats of manipulation using clay, this research identifies the potential of these materials in situations that would be impractical if made in clay using existing and known processes.

The research acknowledges that RCs also present a number of disadvantages: RC is not a malleable plastic body and therefore cannot be moulded in the same way as plastic clay can, resulting in the need for moulds to aid forming. RCs are tougher than

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[2] Chandler H.W., MacPhee D.E., Atkinson I., Henderson R.J., Merchant I.J. (2000) Enhancing the mechanical behaviour of cement based materials, *Journal of the European Ceramic Society*, 20 (8), p. 1129-1133

many ceramic bodies as the aggregates within the body are designed to prevent crack propagation. However, they share the same brittleness. Finally, the different composition of RC results in existing ceramic glazes behaving differently on RC bodies.

Aside from the purely functional properties of RC, other potential benefits for focussing the study on RC were identified, including:

- Refractory concretes are relatively cheap and are universally available.
- “Low tech” solutions to industry standards are feasible.
- The downturn in UK refractory production could mean potential new avenues of end use could be well received by the industry, thus presenting practical opportunities for knowledge transfer.

1.3 Research questions

The research seeks to identify how the properties of RC might be applied to spheres outside their intended industrial application. Specifically the research asks:

- How these materials might be used in the development of architectural embellishments and urban furniture?
- How might the structural and handling properties of RC’s be combined with the vast array of ceramic surface treatments available?
- What creative opportunities RC might present to designers and artists when the functionality of conventional concrete is combined with existing ceramic decorative processes?

1.4 Aims of the research

Primary Aim

The primary aim of the research was to prove RC as being a material viable for creative application and demonstrate its application through a number of practice-based examples.

Secondary Aim

Related to this primary aim it was felt that RC could be an alternative material for certain projects in a craft and design sphere. Therefore the aim was to prove that the material could be viable for small-scale production by designer makers. In order to prove that materials could be viably applied to small-scale, craft production, other artists were engaged in the research through a series of case studies.

1.5 Objectives of the Research

In addition to the defined aims of the research, a number of key objectives were defined to direct and focus the research:

- Design and produce artefacts that demonstrate RC in a range of applications.
- Enhance the aesthetic properties of RC using known ceramic techniques and decorative processes.
- Evaluate RC's functional suitability to operate in applications outside industrial application.
- Confirm personal evaluation of RC by conducting external case studies with other artists and designers

1.6 Scope and Limitations of Research

With an estimated 5000 brand names registered in the USA alone[3], the time scale available for the research necessitated a degree of selection of the materials for investigation. By collecting a range of products from different suppliers the aim was to represent a cross section of the materials currently available on the market. The sheer number of both RCs and possible ceramic surface treatments available has meant that only limited testing could be carried out on a selected range of surface treatment categories combined with selected concretes.

The practice-based work conducted by the researcher has concentrated on the more functional and applied sphere. However, this limited application of refractories is extended by case studies that were conducted by other artists and designers. The function of the case studies was to demonstrate the wide-ranging possibilities for refractories by engaging other artists in the project, who had previously never used these materials in their professional practice.

This selection of certain routes of investigation over others is not seen as detrimental to the rigor or depth of the project. In order to foster further research in this area, it was important that the material as a whole was demonstrated to have a practical application

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[3] http://www.streetinsider.com/Press+Releases/Examine+the+US+Refractories+Market/3392317.html

across a number of different fields and situations and so the research could not be narrowed to concentrate on only one area of investigation or a thorough investigation of all the refractories available. Furthermore, to understand what creative possibilities RC might offer, a more wide-ranging approach was required that examined a number of different applications in less depth.

Chapter 2 Literature Review

2.1 Introduction

The literature available on refractory concretes is extensive and much quantitative and scientific study has been devoted to improving and evaluating refractories in a variety of environments. However, in reviewing this literature it was established that much of the information available has very little relevance to this research project. All of the scientific research is narrow in it's focus and is solely interested in the industrial functional aspects of these materials, There are a number of academic journals, dealing with advances in the field of refractory products including but not limited to: Glass and Ceramics; International Journal of Refractory Metals and Hard materials and Refractories and Industrial Ceramics. Many of the peer-reviewed papers held within these journals discuss the results of experimental data and studies into the behaviour and ceramic structure of RC in a variety of industrial environments. However, after searching these journals (using academic journal search engines, EBSCO host + Science Direct) no paper could be found that referred to any investigation into creative application. The following terms were used in Boolean form: creative, aesthetic, artist, design, in conjunction with refractory and refractories. Aside from a number of references with a medical focus (refractory is also a term used in medicine to describe resistance to medical treatment), no papers in any of the online databases could be found that referred to the creative application of RC or even its application in situations outside industry.

Even including more open terms such as: innovative, imaginative and novel, that offer broadened search parameters only returned scientific papers that are again solely interested in the industrial application of these materials.

A similar search was undertaken of art and design sources and specifically within the field of ceramic design and craft. A search of the Art Full Text database using the words refractory, refractories or high alumina cement leads to 29 listed articles. Of these 29, only one has any mention of refractory concrete used in creative application. The citation is for an interview with Argentinian sculptor Vilma Villaverde. With the only mention of refractory being:

> My work there has allowed me to experiment with refractory materials which resist high temperatures; they are prepared especially for me. It also enables me to accomplish exhibitions in Europe, something which is not easy for those who live 12000 km from cultural centers in that continent. [4]

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[4] Villaverde, V. *Ceramics: Art and Perception* No. 45, 2001, p91

The article elaborates no more on the subject of refractory materials and does not indicate whether refractory concrete is actually the material in question. A subsequent search using the artists name returned no more information on the use of refractory materials.

The remaining articles can be divided into three main groups. The first is concerned with the manufacture and use of refractories in kilns specifically in relation to salt kilns and wood kilns or refractory fibre, 9 articles refer to this established application for refractory concretes. The second group contains 7 references to refractory materials as a mould making material in glass casting. Again here, the references in the text are concerned with refractory materials or aggregates and do not make specific mention of refractory concrete. The final group contains 5 references to refractory materials in relation to their use in glazes.

Of the remaining 8 articles, 3 contain references to critical film studies. 3 are architectural references concerned with the problems associated with high alumina cement as a deleterious material used in the construction industry. One is a historical article and discussion of 16th Century pottery and the final reference is a review of fine art practice at a London gallery where the refractory reference is not one connected to material.

A similar search of the Design and Applied Art Index (DAAI) resulted in 23 references to refractory or refractories. The mix of relevant and irrelevant material is similar to the art full text database and understandably shares some of the same references. The DAAI did result in one article with relevance to the research. Artist Walter Hall describes work using metal mesh and a refractory mortar. However, the article does not go into detail on the process or materials, instead concentrating on conceptual and artistic considerations[5]

The lack of any documented or published research in the creative application of RC lead to a more general review of advanced and industrial ceramics. The research project had initially identified industrial ceramic materials as a potential source for creative application. While these materials never formed an active part of the practical research, a review of these materials and processes is included here, in order to further illustrate the lack of research and adoption of industrial materials and processes in creative studio based application. A small number of creative projects, that have

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[5] Hall, W, *Refractory* and Mesh, *Ceramics Monthly*, vol. 35, no. 1, Jan. 1987, pp. 43, 2

used advanced ceramic materials or processes are discussed within this chapter and, while not directly related to the research they are useful in highlighting the possibilities that industrial materials, methods and processes present for creative application.

In many ways the full diversity of ceramics is still largely unrecognised by both the layperson and studio ceramicist. Ceramics is still most commonly associated with pottery and handicrafts, honesty and timelessness. There is, however, another side to ceramics, which has not yet been fully explored from a creative perspective. In the past decade ceramics have evolved from traditional stoneware and earthenware to become the material of the future. Advanced industrial ceramics are taking over from metals in numerous engineering applications such as jet turbine blades and high performance ball bearings. The unique qualities presented by advanced industrial ceramics might provide the impetus to begin exploring new creative opportunities and a unique aesthetic could be developed.

> Designers consider themselves autonomous artists and attach great importance to such notions as individual freedom, creativity and decoration. Craftsmanship and experimenting are central to the product development process preceding industrial manufacture.[6]

This puts the crafts person in the unique position to explore new materials and processes in a creative and imaginative way. The field of advanced and industrial ceramics can open many new creative and manufacturing possibilities that cannot be achieved with conventional clays. This somewhat simplistic hypothesis formed the basis for the initial research. It was felt that advanced materials and associated technologies developed for industrial application could be adapted for small-scale production by ceramic artists and designers.

A review of current ceramic materials and processing technology was conducted and the possibilities for studio application considered alongside potential applications, capabilities and limitations. The review gives a background to some of the most up to date manufacturing techniques and an overview of the science that lies behind advanced industrial ceramics.

There are, of course, a number of obstacles that render most of the technologies discussed unsuitable for the small studio ceramicist, whether it is by virtue of the cost of the materials themselves, by the machinery required in the manufacture, or the temperatures or kilns required. In very few cases artists or designers have applied

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[6] Erven, R (2005) Ceramics and Architecture: Ceramics with added value increasing attention to architectural expression and product development. http://www.ekwc.nl/ceramarch_121.cfm

these materials in non-industrial situations and their resulting work is also discussed here.

2.2 Advanced Ceramic Materials

This section will look at a selected range of advanced and industrial ceramic materials and processes; illustrating some of their unique properties and describing the potential opportunities they represent to ceramicists. Choices were made to limit the scope of the review to materials and processes that were identified as having potential for use in a low-tech studio environment. The initial aim of this research project was to evaluate advanced and industrial ceramics for potential adaptation to studio practice. It is therefore important to discuss the reasons why the materials investigated here were not explored further within this project and the focus was ultimately concentrated on Refractories.

Alumina

Alumina is one of the most widely used materials within advanced ceramics. Whilst it is a common material used in studio ceramics as a component in glazes and clays, its use as the main body of objects in advanced ceramics is unique. The combination of availability and low cost make it the natural choice for many applications. Alumina is a refractory material capable of resisting temperatures up to 2000°C. Many of its applications in industry make use of its electrical properties and high mechanical strength.

Alumina is processed in a variety of different purities for different applications from high specification circuit boards to the common spark plug. Alumina can be processed using a variety of different ceramic methods, commonly it requires a binder to hold the alumina together prior to, and during, the sintering process. Once fired, alumina is a brittle and very hard material allowing limited post fire working or machining, however the surface can be highly polished using diamond grinders.

Another unique property of alumina is that it can be bonded to metals and other ceramics by brazing. It is this ability that allows conductive metals to be screen printed to the surface of alumina, which could offer opportunities to explore the combining of electronics with ceramics.

One of the few artists or designers to utilise advanced ceramic materials within a creative context is Marek Cecula. Cecula researched the applications of corundum (alumina) at The Institute for Advanced Ceramics in Rzeszow, Poland. Collaborating with Daga Kopala, he created a series of designed objects that utilise both the incredible toughness of alumina and the aesthetic beauty found in its surface to create his nectar set. Cecula and his partner:

> Have come to explore, observe, question and finally create intensely compelling forms that fuse the hidden likeness not of science or art, but of science and art.[7]

The combination of science and art has yielded a series of objects that manipulate light in ways even porcelain is unable to achieve.

> 'Corundum is a material that contains a tremendous store of energy as light in a layer of matter not much thicker that the skin covering a kittens nose'[8]

The visual quality found in Cecula's work is created by a combination of the thin wall sections formed by slip casting and the atomic properties of corundum, Corundum occurs naturally in the form of rubies and sapphires where large single crystals are formed with trace elements giving colour.

Figure 2.2.1 Marek Cecula 'Nectar Set'

Cecula has harnessed the power of the material to create jewel like vessels. However in order to fuse the powdered alumina together to give a 100% vitreous body, the corundum needs to be fired to 1724°C which puts corundum beyond most ceramicists. What makes Cecula's research important is the broadening of the visual vocabulary ceramicists have access to. In the course of his research he successfully combined science and art in a unique way that represents possibilities for future developments involving advanced ceramics in applied art situations.

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[7] Beare, S, K (2003) Cecula's Splendour, *Ceramics Technical,* 17 pp75

[8] ibid

Glass Ceramic

Glass ceramic is a method of combining glass with ceramics to create a material with zero porosity, high mechanical strength and the ability to be machined using standard metal working tools, crucially it does not even require firing after processing although it can withstand temperatures up to 1000°C. Its most common application in industry is in the production of prototypes or short run component applications where high temperature is an issue[9].

Macor is the trade name for a particular type of glass ceramic commonly used in industry; it can be bought in pre formed shapes such as rods, bars and sheets. These can be joined using a variety of fixing compounds commonly used for joining glass. Perhaps where glass ceramics can be of most use to the ceramicists is in its zero shrinkage; Macor can be fired to 1000°C without any shrinkage or deformation allowing potential pieces to be constructed to tolerances impossible with conventional ceramics and the low maximum temperature of 1000°C will allow colouring, using enamels and other low temperature decoration. The technology required puts the manufacture of the material out of the reach of most ceramicists, and the tooling required to machine the material is far from within studio capabilities. However the technology used to create glass ceramics could offer opportunities to develop a material with lower tolerances that still maintain the zero shrinkage and relative workability.

Fibre

Ceramic fibre was developed in the Second World War by German scientists to protect V2 rockets from the extreme temperatures generated. In the sixties it was further developed for the American space programme. Most commonly made from molten Silica or Alumina and increasingly Zirconia. As the cost and availability came down, ceramic fibre started to make an appearance in the ceramic studio in the late 70’s as a light and cost effective alternative to firebrick. Unfortunately ceramic fibre turned out not to be the miracle material it was billed as; ceramic fibre, when inhaled, can cause a variety of lung illnesses such as lung fibrosis, cancer and mesothelioma[10]. It has been established that fibres released from a ceramic blanket, which are less than 3μm in diameter, but as long as 50μm, can enter the lung and cause damage. To put this in perspective the human hair is about 50μm in diameter so nearly 17 times as thick.[11] The research done into the hazards of ceramic fibre have highlighted the dangers it represents to ceramicists, also serving to demonize the material so that to the

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[9] http://www.technicalproductsinc.com/pdf/macor.pdf

[10] Tarrant, R (1997) Ceramic Fibre – Ceramic Caveat, *Ceramics technical*, 4, pp62-66

[11] ibid

researcher's knowledge there has not been any craft or artistic applications using ceramic fibre as a material.

Recent advances in fibre technology have meant the development of continuous fibre technology that can be processed so that they no longer represent the same danger. New ceramic fibre is available from a range of producers including 3M™ in the form of Nextel™ ceramic textiles, available in various forms from paper to yarn and woven blankets. Industrial applications of ceramic fibre include protecting jet engines, fire proofing buildings and for protective clothing.

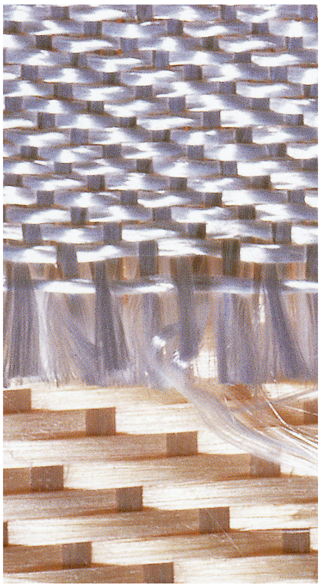

Figure 2.2.2 Nextel Ceramic Fibre

Ceramic fibres can operate at temperatures up to 1371°C and offer very high tensile strength. Using these fibres with a clay or refractory cement matrix, might offer opportunities to explore work on a large scale retaining a high level of control and structural stability in thin walled pieces. The flexible nature of these fibres will allow complex shapes to be moulded in much the same way as glass fibre has been incorporated with cement in the past. However, the vast range of surface qualities available to ceramics can still be employed from high temperature glazes to enamels and lustre effects. Furthermore oxides and salts may be introduced that will be drawn to the surface further expanding the possibilities.

Steel Fibres

Another new technology to emerge is stainless steel fibre that is similar in appearance to wire wool, but able to resist oxidation during firing.

Developed by Fibretech, Microtex[12] is a range of metal filaments suitable for application as reinforcement in various matrixes such as plastic, metal and ceramics. Designed to withstand aggressive environments such as car exhaust's and gasket applications, it has high temperature oxidation resistance allowing it to maintain its tensile strength after firing. Facilitating an even higher tensile strength than that of ceramic fibre it represents even more opportunities to work with super-hard, structurally sound, ceramics. This material is discussed in more detail in Chapters 5 and 6 as it was utilised in a number of practical applications within this project.

2.3 Advanced Manufacturing

There are a vast range of methods available for processing industrial and advanced ceramics, from the traditional and low tech to the very advanced and highly engineered. The aim of this section is to examine some of the more relevant and accessible methods, that could be incorporated into ceramic craft and art practice broadening the limitations of traditional ceramic applications.

Tape-casting

Tape-casting is used to create a very thin layer of flexible ceramic. The process involves the preparation of a slip combined with polymers such as polyvinyl butyral added, giving the tape the required strength when dried. Produced using the relatively simple “doctor blade” technique, where the slip is held in a hopper while a blade is dragged across the surface of a non porous support strip, leaving the required thickness of ceramic material to dry onto the carrier tape.

A variety of different materials can be tape cast from alumina to porcelain, depending on the required application. The tapes can range from 1mm down to fractions of a millimetre. Recent innovations have included the development of water-based tape casting techniques and the use of nano sized particles to produce tapes as thin as 5μm. Ceramic tapes are most commonly deployed in the electronic industry to produce electrical components such as semiconductors and multi-layer capacitors, where metal paths can be silk screened onto the surface of the tapes.

The tape casting process can open up new opportunities to work with ceramics that have a wall thickness unobtainable by traditional methods. The fine section thicknesses give a level of translucency impossible even with thin porcelain.

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[12] http://www.fibretech.com/products_exhaustsys_microtex.htm

Furthermore, with improved handling properties the possibilities of creating large scale translucent pieces can be achieved.

One project that has evaluated the creative potential of a tape cast product (Kerafol) was conducted by Professor Hubert Kittel, in the department of Ceramic-Glass design at the Burg Giebichstein University of Art and Design. The project gave students the opportunity to work with the company Keramische Folien GmbH (Kerafol) in the 2001-2002 study period. The project involved the exploration of a new type of porcelain, or rather a modification of unprocessed porcelain, using industrial tape casting techniques. The project aimed to explore the creative possibilities porcelain tapes might present for new products. The Porcelain tapes used in the project were produced using water-based organic binders added to the schools existing clays (soft paste porcelain and a bone china from KPCL). The results were a highly plastic rubber-like material ranging from 0.4 – 1.2 mm in thickness.

Figure 2.3.1 Susanne Bauer, Kerafol necklace

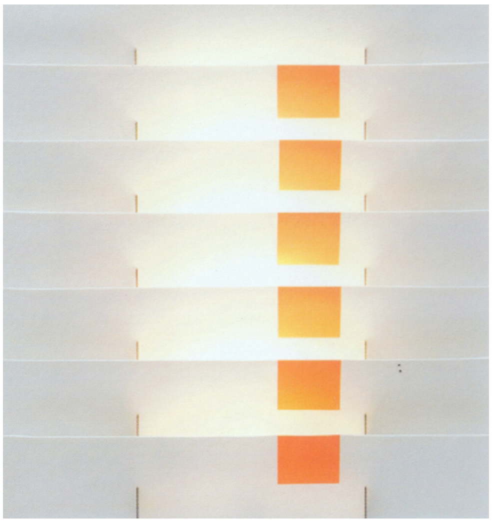

Figure 2.3.2 Johanna Hitzler, Kerafol wall piece with Silk print

Students from the department began experimentation with two and three-dimensional objects. Flat design objects presented various opportunities for cutting, punching, stamping and printing. However, large three-dimensional objects were subject to massive deformation and warping. The emphasis was therefore placed on small-scale 3-D forms and the processing of 2-D sheets. Various product designs were developed from jewellery to house lights and interior furniture. The scope of ideas ranged from mass production to one-off handcrafted artefacts. The intention was to:

> Present aesthetically ‘enchanting’ designs and studies of the material, as well as explore the possible effects of high fired, fine ceramic casting slips.[13]

It should be noted that the project conducted was on a relatively small scale and lasted around a year. However, what the research does demonstrate is that the integration of technology and industrial techniques with creative exploration can open up new product ideas and present an established material in a new light. Furthermore, it proves that by altering the known boundaries and rules of ceramics the scope and range of products can be broadened. In a review of an exhibition produced as part of the project, Design Report magazine noted “There appears to be some movement in the seemingly stagnant field of ceramics”[14]. The catalogue that accompanied the research project also offers information on companies that supply ceramic tapes and tips on how to cut and manipulate ceramic tapes but does not provide data on the material or the process.

Ceramic Substrates

The ceramic substrate is perhaps the most remarkable of all the advanced ceramics. It evolved from the widely practiced technique of extruding clay to create objects such as; the common brick, dinner ware, sewage pipe and electrical insulators. The relatively simple process involved clay being mixed with water to achieve the correct consistency, then using an auger or pugmill it was passed through a die to achieve the desired shape.

Developed by Corning Glass Works in 1985, the most widely used ceramic substrate today is the catalytic converter[15]. The material and process was developed to allow a large amount of metal catalyst to come into contact with the carbon monoxide and

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[13] Kittel. H, (2004) Kerafolien: Discovering a New Porcelain Landscape, *Ceramics Technical,* 18. pp36
[14] ibid
[15] Lefteri, C (2003) Ceramics: *Materials for Inspirational Design*, p20

nitrogen oxide produced by the car engine and convert them into water, nitrogen and carbon dioxide. The harsh environment of a car exhaust required a light material that was resistant to high temperatures and corrosive gases; ceramic proving to be the most appropriate. The only problem being, how to create a honeycomb structured ceramic with wall thicknesses only 0.14mm thick.

The ceramic chosen is cordierite a ceramic made from magnesium oxide (MgO), alumina (Al_2O_3) and silica (SiO), by combining these materials with an organic plasticizing compound called hydroxypropyl cellulose. The high viscosity of the mix was such that it is only able to flow or plasticize when under sheer pressure. The method developed by Corning involves mixing batches in twin auger extruders where the viscosity is carefully controlled along with the temperature of the mix. The mix is then passed through a die that forms spaghetti or chips into a de-airing vacuum chamber that forms billets. These billets are then ram pressed through a honeycomb die with an extrusion aid. After passing through the die the cordierite returns to its solid state, creating highly complex thin walled sections with no deformations.

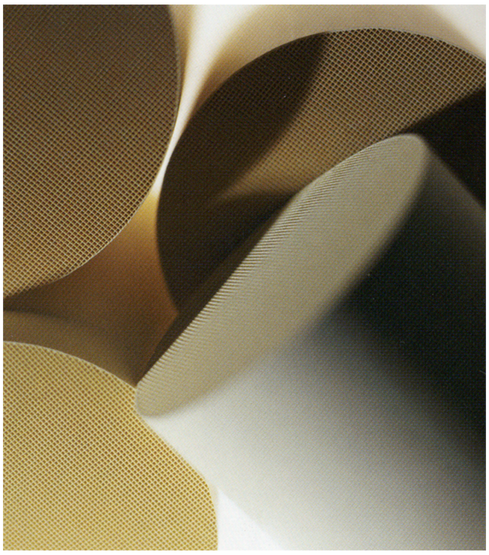

Figure 2.3.3 Ceramic catalytic converters

The forces involved in creating these high tech ceramic substrates are well beyond those possible using existing equipment in a conventional studio ceramic environment. Few, if any, practitioners will have access to a twin auger pugmill with a vacuum chamber. However, the technology developed could in theory be utilised in standard pugmills. Using organic binders and extrusion aids it could be possible to create far more complex extrusions than are currently possible with conventional clay materials.

Viscous Plastic Processing

Viscous plastic processing (VPP) is a process for eliminating the flaws and deformations present in ceramics. The flaws present in ceramics such as microscopic cracks, air pockets and lumps are what reduce ceramics ability to plastically deform or bend, illustrated by scoring the surface of ceramic tiles before breaking. If these flaws are removed then the plastic properties of ceramics can be enhanced.

The technique involves the creation of a very viscous plastic like substance, composed of extremely fine ceramic powder dispersed in a polymer and solvent gel structure. This material is then formed using very high sheer forces similar to those used in creating the catalytic converter. This high pressure breaks apart any collections of material creating a uniform ceramic body resistant to cracks. Ceramics formed using VPP are typically twice as strong as conventional forming techniques and have improved flexural strength. The material remains very strong in the green state and allows a wide variety of forms to be created, even allowing easy machining using conventional tools.

This method of processing has been used to create, among other things ceramic springs. The ceramic spring goes a long way to illustrate how far ceramic manufacturing technology has come. However, the ceramic spring has been something of a scientific novelty since it was achieved in the 1980's by ICI. For twenty years applications have been few and far between for the ceramic spring, until recently. Researchers at The Functional Materials Group at The University of Birmingham have also used piezoelectric materials to create revolutionary ceramic loudspeakers.[16]

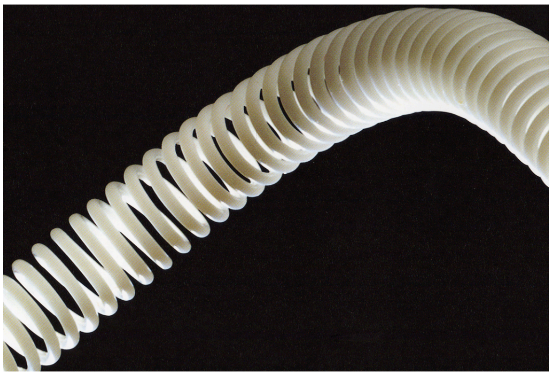

Figure 2.3.4 Ceramic spring

Again the technical difficulties in producing objects using VPP will limit its potential use in the ceramic studio. However, by using polymer as a binder some of the traditional limitations of ceramics can be overcome. The increased green strength and fine

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[16] Pierce, D (1999) Ceramic Springs, *Materials World*, Vol 7, Number 12, pp748-750

surface qualities that can be achieved using high purity ceramics may offer new applications and directions for the studio ceramicists.

Gel Casting

Gel casting is a relatively new process that has received particular attention in the past decade. Gel casting is a method of forming advanced ceramics originally developed in the USA by scientists at the Oak Ridge National Laboratory in 1985. The technique involves a suspension of a small amount of organic monomer and cross linker added to a ceramic aqueous solution (ceramic powder suspended in water commonly alumina or zirconia)[17]. The ceramic slurry is then added to a non-porous mould. In gel casting the suspension is hardened when heated in contrast to traditional casting methods where the porous plaster absorbs moisture from the liquid clay resulting in “leather hard” clay. Removing the water in an oven or low temperature kiln hardens the piece. The binder is then burnt out in the first stages of the firing.

The specific advantages of this method over traditional casting methods become apparent when using materials such as alumina without any other binder. In conventional casting uniform distribution of alumina is not achieved. In addition gel processing creates a strong cast object due to the network of monomers present in the body. However, it does, not have as strong a green strength as some other forming techniques as the density of the final piece is not as high and will have various surface imperfections.

Presently the gel casting process is almost exclusively limited to the production of high tech and speciality applications such as the electronics and optical ceramic industry. It has been included in this section to illustrate one of the most advanced processes in industry at this time. The chemistry is obviously very complicated. However, the materials used are readily available and low in cost. For the studio ceramicist the process would allow the working of previously unworkable ceramics such as alumina, to create objects with incredible toughness and transparency which traditional ceramics cannot achieve.

Conclusion to Review of Advanced Industrial Ceramics

The key finding to come from the review was to firmly establish that the most viable industrially developed material to form the basis and focus of the research was refractory concrete. The material was seen as offering the most potential for creative

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[17] Rak. Z.S (2000) Advanced Forming Techniques in Ceramics. *ECN Energy Efficiency Materials Technology*

application in a small-scale studio setting. RC was seen as having the potential for large scale and architectural applications and so a brief review of large-scale ceramics is covered in the next section.

2.4 Large Scale Ceramics

This section analyses conventional ceramics and their application in large-scale projects. While conventional ceramics are not a part of the research, the applications explored in the practical phase of the research discuss the advantages of RC over conventional clay. It is therefore important to discuss briefly the problems and issues associated with using ceramics to create large-scale work. The review here is not intended to be a complete and comprehensive review of large-scale work. Instead it serves to highlight some of the established difficulties and limitations of large-scale ceramics as well as illustrate some of the methods devised by artists to overcome them.

It should be acknowledged that large-scale works in ceramics have been produced far back in history. However, the problems of working with ceramics on a large scale are substantial. A number of ceramic handbooks for the ceramic artist have been published that document these issues. One such book, that is specifically devoted to this subject, is Large-Scale Ceramics by Jim Robison. Robison describes the main problems:

> Even uniform drying is essential to avoid distortions and disturbing cracks…tall pieces should be rotated frequently to avoid leaning.
>
> Edges of relief work must not dry ahead of the centre sections, as uneven shrinkage will create gaps.
>
> Loading the kiln may present some problems. Without a trolley kiln, it may be best to slide heavy work into the kiln… cardboard provides some cushion over uneven shelves and protects fragile corners of the unfired piece.
>
> Given the difficulty in handling heavy items and the expense of kiln firings it may be preferable to raw glaze and once fire.[18]

The two main concerns when working with large work are problems created from shrinkage and drying leading to warping and cracking. The second consideration is the fragility of the green ceramics and problems associated with firing the work. However, in the face of these problems, a number of artists with the skills have developed methods to create large scale works which work around these problems, Felicity Aylieff, Jun Kaneko, Tony Cragg, et al.

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[18] Jim Robison, Large-Scale Ceramics pp105-109

Felicity Aylieff completed ‘The Elusive Body’ her MPhil research degree in 1994 at the Royal College of Art (RCA)[19]. The research conducted was aimed at creating a clay body where form and colour are combined to create a uniquely textured medium. Various different clay bodies were tested with different aggregates to change tone and the dispersion of surface texture. Aylieff found that brick clays were the most suitable for accommodating large amounts of aggregate. By testing different glasses and clay based aggregates, such as borosilicate frits and coloured porcelain grogs, she developed a dramatic surface texture that challenged the traditional aesthetic of clay.

Figure 2.4.1 Felicity Alyieff, “Turmoil” 2001

The materials developed by Felicity Aylieff enable the construction of large-scale objects; the stability of the material is increased by the addition of the various aggregates and glasses.

David Binns is another ceramic artist that has looked to push the boundaries of ceramic materials often incorporating industrial ceramic aggregates in his work. For a number of years he has been actively engaged in research investigating the manipulation of clay bodies to create innovate surface qualities through the integration of added mineral aggregates to clays[20]. His work has, more recently, moved into the exploration of kiln cast glass combined with ceramic aggregates and begun to consider the possibilities of scaling some of his work to more commercial and industrial applications.

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[19] Aylieff, F. (1994) The Elusive Body. MPhil. Thesis. RCA

[20] Smith, P. (2002) *Aggregates in Ceramic Bodies – a Research Project*. Ceramics Art & Perception, Issue 46

Figure 2.4.2 David Binns ‘Glass Casting’ 2006

Binns states his research aim as:

> …to broaden the creative opportunities and aesthetic vocabulary of craft ceramics. I am particularly interested in exploring how ideas and technologies conceived within a craft context might be translated to industrial scales of production and application.[21]

As the researcher’s Director of Studies, Binns has collaborated in developing a number of the projects in this PhD and a more in depth discussion of process and techniques used by Binns can be found in Chapter 6, Section 6.4[22].

A material called Coade stone was developed in the later half of the 18th Century to replicate the appearance of carved limestone. The material was used extensively at the time for headstones and commemorative sculpture. The most famous example of its use are the lions on Westminster Bridge.

Figure 2.4.3 Westminster Bridge lions, Coade stone, 1837

However the sole manufacturers of the material fell into financial difficulties and the skills and knowledge required to make such pieces was lost. The material was developed by the Coade Company and is thought to have had the following recipe.

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[21] David Binns website <http://www.davidbinnsceramics.com/profile.html>

[22] Chapter 6, Section 6.4, page 126

> The formula used was 10% of grog - 5-10% of crushed flint. 5-10% fine sand to reduce shrinkage. 10% crushed soda lime glass. All these materials were then added to 60 to 70 % Ball clay from Dorset & Devon.[23]

The resulting material lacked any plasticity was therefore pressed into plaster moulds. The material was very stable and did not suffer from warping, provided the temperature was carefully controlled. It was also very resistant to frost damage and many of the pieces survive in a good condition today.

One solution to the problems of large-scale ceramics is to create modular structures that are combined in pieces and many ceramic artists have adopted this method. One such artist is Kosmas Ballis who works on a large scale producing slip cast sculptures, made from a number of single elements joined together to create pieces that appear to be both haphazard and carefully constructed forms. Various motifs are apparent in many of his pieces, overcrowding and mass production are often reproduced in several different forms. He concerns himself with “An underlying theme of balance that exists in the work for visual integrity and for actual physical sturdiness”.[24]

Figure 2.4.4 Kosmas Ballis “Evolutionary Bouquet” series 10 2003

Ballis’s forms are highly complex in which he attempts to give the viewer an impression of the fragility ceramics can offers. However the forms must be stable enough and structurally sound due to their sheer scale. Colour forms a critical element of his work; he uses vibrant colours to lead the eye around the elaborate sculptures exaggerating some elements and diverting attention away from others.

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[23] Kelly, A, (1990) Mrs Coade’s Stone, pp58

[24] Ballis, K, (2004) The Challenge of Abstract Sculpture, *Ceramics Technical*, 18, pp8-12

Ceramics are often limited by the size of the kiln available, Ballis overcomes this traditional barrier by building his own kilns. For his solo show at the National Council for Education in the Ceramic Arts (NCECA) 2005 he constructed two, 100 cubic foot kilns to accommodate his work.

Another ceramic artist that defies ceramic's problems is Paul Chaleff. In his exhibition "Re-engineered Vision" Chaleff constructed several pieces 6 feet in height and in a review of the exhibition reinforces the difficulties of creating large scale works:

> "But that is simply impossible," sputtered the visitor, a distinguished and accomplished potter. "Yes, it is," replied Paul Chaleff. "Almost."
>
> While not fully explaining all of the artist's techniques for building, drying and firing, I can repeat "internal cylindrical support", "straps and pulleys", and "monster gas kiln". Work on this scale in clay is rarely seen, and then it is generally achieved by connecting multiple, smaller units, rather than building and firing a monumental form as a single unit.[25]

This selected review of large-scale ceramics shows the capacity of ceramics on a large scale. If handled by a skilled craftsperson applying a variety of methods they are capable of defying the problems inherent with a material that shrinks and has very low strength at a green state. It is important to note that RC is not a material that will be suitable for every project. However, it can, in some cases be used to create work that is not possible with conventional ceramics and can make certain projects easier, involving less risk.

2.5 Refractory Concrete

This section offers a review of Refractory Concrete (also referred to as refractories) The intention is not to provide a material science perspective of refractory concrete. The aim is to give an overview of the development of RC's from their inception, discussing the most important developments and highlighting the main properties and functions of the material.

In very simple terms a refractory material is a substance able to withstand high temperatures without melting.[26] This means that all ceramics can technically be classified as refractory. What makes refractories stand apart from ceramics is their ability to withstand very high temperatures in some cases as high as 2000°C and their remarkable toughness at these higher temperatures.

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[25] Chaleff. P, *"Re-engineered Vision"* Ceramics Art and Perception, no. 63 (2006) p. 40-2

[26] Oxford English Dictionary

The term refractory is also commonly used in a ceramic craft context in relation to materials that increase the firing temperature of a glaze or resistance to fluxing.

Classification of Refractories

Most refractories will fall within the following three types as defined by the aggregates and binder used:

- Acidic Types (silica, high alumina)
- Basic Types (magnesium, chrome, dolomite)
- Special Types (silicon carbide, zircon)

The type of bonding can further classify refractory concretes. In practice many refractories will be a combination of the following 4 bond types, chemical, organic or hydraulic combined with ceramic:

- **Hydraulic** bonds harden in ambient temperatures (similar to clay).
- **Chemical** bonds, organic and inorganic, harden by chemical reaction in ambient temperatures. (Similar to conventional concrete)
- **Organic** bonds harden with organic compounds, which burn out in firing.
- **Ceramic** bonds harden during sintering or firing

Refractories can also be divided into two main categories: Shaped and Monolithics or Unshaped.

Shaped	Monolithics
Bricks	Castables
Kiln Furniture	Gunning Mixes
Pre-cast shapes	Self Flows
	Coatings
	Mortars

Table 2.5.1 Types of refractory concrete

This research does not look at the shaped category and is solely interested in the unshaped refractory concretes. It will be useful at this point to provide an overview of the main innovations in monolithics since their development in 1914. In 1923 the first patent was submitted for a castable refractory. This was followed in the 1950's by the development of a 'gun-able' refractory, where water is added to a dry mix at the nozzle of a high-pressure hose. The next major development came in the 1970's when deflocculated refractory concretes were developed. These refractories required vibration for instillation and resulted in a far denser and more stable concrete in application. In the 1980's self-flowing refractories were developed that could be installed without the need for vibration. The most recent major development came in the 1990's when shotcreting of refractories was developed. Shotcreting is similar to gunning, but instead of a dry material combined with water a wet mix is forced at high pressure through a hose.

Properties

The properties and constituents for individual refractories vary widely according to the intended industrial application environment. The following table provides a general guide to material ratios of refractories.[27]

Material	Percentage
Aggregate	40-80%
Modifiers	5-30%
Bond Agents	2-50%
Admixtures	<1%

Table 2.5.2 Average constituent percentages

To give an idea of the types of material that come under these components the following table is provided as a guide, it does not list the full range of materials used in refractories:

Component	Material	Mechanism
Aggregate	Fused Alumina, Mullite, Fused Silica	Effects rheology, density, shrinkage, overall mechanical strength at both green and fired states.
Modifiers	Alumina, Silica fume, Clay, Graphite, fly ash	Effects: Casting water addition, retards/accelerates setting, chemistry adjustment, storage behaviour,
Bond Agents	Calcium Aluminate Cement, Organic polymers, Colloidal Silica	Enables setting or hardening of RC prior to firing or sintering
Additives	Polpropylene fibres, metal fibres, lithium Carbonate, Sodium Carbonate	Reduces spalling from heating process and rheology modification

Table 2.5.3 Component properties and mechanisms

Aggregates

Aggregates form the bulk of refractory concretes. In the same way that conventional concretes function, the aggregates provide the strength within the concrete and serve an important function in the resistance to crack propagation. Careful consideration is taken to ensure that a range of different sizes are represented. The goal is to generate a good packing and particle distribution within the body of the refractory after casting.

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[27] Schacht, C.A, Refractories Handbook, pp 261

Modifiers

Modifiers are added to refractories primarily to adjust the handling properties of refractories, for example; the addition of clay materials will create a plastic mix that is suitable for ramming; Silica fume also referred to as micro silica, a by-product of the reduction of high-purity quartz with coke in electric arc furnaces in the production of silicon and ferrosilicon alloys, is added to increase both the strength of the material green and sintered and adjust the rheology, allowing vibration and self-flow refractories.

Bonding Agent

The most common bonding agent used in refractories is calcium alumina cement (CAC). CAC is by no means a recent invention. It was discovered as early as 1865 in France and was first commercially produced by La Farge using a fused mixture of alumina and lime.[28] CAC took the world by storm due primarily to its high initial strength, after one day CAC is stronger than Portland cement after 28 days. It was used in buildings around the world and dramatically reduced build times. However, during the 1970's it was discovered that concrete made using CAC lost a significant part of its strength over time. The result was a series of high profile structural collapses where CAC was deemed the culprit. The eventual outcome was a ban on CAC use in structural applications in many countries. This heralded a move for CAC away from the construction industry into monolithic refractory applications. In industry today the vast majority of refractories are used in the furnace and metal sector where their high compression strength and resistance to chemical attack at high temperature is utilised. Generally the higher the proportion of alumina in CAC results in higher operating temperatures and a whiter appearance.

The strength of CAC decreases as it is heated, however after 1000°C ceramic bonds are formed resulting in a concrete with higher compression and tensile strength than Portland concrete. Once CAC concrete has been sintered it does not suffer from loss of strength and will retain its properties indefinitely. For the ceramicists this temperature range puts a vast majority of ceramic glazes and surface treatments in reach whilst, at the same time, allowing forms to be constructed without the traditional ceramic barriers.

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[28] O'Driscoll, M, (2000) Alumina cements: Lining up against steel & sewage, *Industrial Minerals*, Dec pp35-45

Anja Bache is currently exploring the possibilities of Compact Reinforced Composite, (CRC) as part of a PhD at The Aarhus School of Architecture, Denmark. CRC is an engineering material that has been used previously for architecture projects in the Netherlands. Her project explores the materials potential in new architectural forms making use of its strength and low weight. CRC uses a binder system similar to CAC combined with fiber reinforcement enabling it to be fired, therefore opening the possibilities of combining with ceramic glazes[29].

Additives

The most common additives are fibre based. There are a number fibres that are added to refractories namely; organic fibres, ceramic fibres and metallic fibres. Organic fibres are added to reduce the risk of vapour build up during the initial phase of the firing of a refractory. They act like channels to aid the evaporation of water vapour held within the refractory.

Metallic fibres perform two major functions within a refractory body. The first is to increase the Modulus of Rupture (MOR) by again reducing crack propagation and act as reinforcing material, as described further in Chapter 5 Section 5.1[30]. The second is to increase the resistance to thermal shock. Importantly the maximum temperature that a refractory can be fired to when it contains steel fibres is 1200°C.

Finally ceramic fibres are occasionally added, normally to reinforce a refractory at temperatures over the 1200°C threshold of steel fibres. The main problem inherent with ceramic fibres is the integration with unshaped refractory products, i.e. achieving the uniform distribution of the fibres within the refractory body.

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[29] Bache, A. (2007) Visions for a New Architectural Form using New Concrete Technology in giant structures <http://www.anjabache.dk/artikler/NewConcrete.pdf>

[30] Chapter 5, Section 5.1, page 53

Chapter 3 Methodology

3.1 Introduction

For clarity and to contextualise the research methodology this chapter is written in the first person. The chapter will provide an analysis of my own personal research philosophy within the context of my practice-based research. The chapter will define practice-based research and place it within the broader research field. To introduce my personal philosophy I will then analyse three of the main philosophies that have informed my own approach. Firstly ‘inductivist theory’, secondly ‘falsificationism’ and the ‘argument against method’, and finally I will discuss ‘tacit’ knowledge and locate its importance within the scientific method and my research. It is important to note that it is beyond the scope of this paper to explore the intricacies in these extremely complicated philosophies. The aim is to provide a more selective overview that concentrates on specific philosophies that have a direct bearing on my own research philosophy.

Through this chapter I will demonstrate how the triangulation of these scientific methods can be used to generate a personal philosophy that is relevant to the specific aims of my project. The intention is to show that my research has integrated these seemingly opposing philosophies into a project that uses both empirical and traditional methods of data collection and induction, combined with a more open and creative methodology indicative of practice based research.

The methodology employed combines elements of scientific method specifically in the quantitative data areas of glaze and material investigation to give reproducible results. However, crucially the research recognises that to achieve the aims of the research as outlined in Chapter 1 a more holistic approach that is in many ways less systematic is required. For this reason a research methodology is adopted that allows more freedom in the practice-based elements and is more reflective and reactive to the experiences gained through practice.

3.2 Practice Based Research Overview

Before moving on to the main focus of this Chapter it will be useful to discuss practice-based research and locate it within the greater research community.

An element of confusion is evident within practice based research and it is perhaps no wonder considering the number of different terms that have been coined to label this particular method of research: practice based, practice led, practice as research (PaR), practitioner research, action research, theorised practice. The variety of terms is a feature of a paradigm that is still emerging, unsure of itself into academic scholarship.

However research in the art and design field has increased dramatically in the past 10 years. It may also be useful to highlight from the last Research Assessment Exercise, RAE (2001) report a number of important observations made that have a direct bearing on the field of practice based, and in particular, research in art and design.

> Some of the highest growth rates in doctoral provision between 1996 and 2000 are from the emerging disciplines, such as creative arts and design (138%), librarianship and information science (78%), and education (81%), that do not have a tradition of PhD training to build upon.[1]

The staggering increase in art and design research provides evidence of the importance of research in this field and the value it has. However, the field must beware that research conducted is of a sufficient standard, and that the objective of research does not become driven by the RAE; the criteria and evaluation of academic research by the RAE is quite different from the focused rigor of the PhD. Another observation that was identified by the last RAE was that a crucial part of research is collaboration and cross-fertilization of ideas and experience.

> Of particular concern are the needs of emerging disciplines – such as nursing and allied subjects, art and design, library and information management – where there may be insufficient numbers of academics or students to form effective collaborative arrangements.[2]

This highlights a number of challenges facing research in art and design. Very few academic staff in the field of art and design have completed higher research degrees,

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[1] UK Council for Graduate Education (2002) Improving Standards in Postgraduate Research Degree Programmes: A Report to the Higher Education Funding Councils of England, Scotland and Wales. p8

[2] UK Council for Graduate Education (2002) Improving Standards in Postgraduate Research Degree Programmes: A Report to the Higher Education Funding Councils of England, Scotland and Wales. p 27-28

resulting in few persons qualified to supervise research degrees and equally to examine them. A particular challenge faces the craft subjects. Partly as a result of the lack of intellectualization of craft and process, artists and academics practicing craft are reluctant to engage in academic research and rarely discuss the work they do in academic terms. In the craft world, output is mostly in the form of an exhibition and with many still following the traditions of the past by producing a catalogue with a short introduction often written by someone else and some glossy images. This results in limited documentation of activities and dissemination of results is often narrow. However, in order to be classed as research output it must be accompanied by supporting material, which is disseminated beyond the immediate audience of the show. This supporting material should document the process describing the rationale and the methodology for the work. This should be included in order for it to be classed as research. As Bayazit points out ‘an artist’s practicing activities when creating a work of art or a craftwork cannot be considered research’[3]

Practice based research is in many ways very similar to other more established forms of research in that: 1) it leads to new knowledge, 2) it supports this new knowledge with extensive and thorough evidence, 3) it documents the process by which the knowledge was arrived at, 4) it forms links between new knowledge and existing knowledge. However, it also differs from other forms of research because the researcher is required to engage in practice as an integral part of the research itself and so the researcher is not the observer, without influence on the outcome, as is the case in scientific studies. Furthermore where ‘traditional’ methods of research usually stop at the point where a situation or problem has been accurately described, sometimes suggesting how the situation might be addressed, action researchers take action and begin by asking, what can I do? How can I do it?[4]

As has been described, the lack of comprehensive and sustained academic research in practice based art and design leaves a vacuum in which there is little understanding of specific methodologies unique to art and design. To fill this gap various paradigms have been suggested, however, for the most part the trend has been to provide a framework of best practice. Malins and Gray propose that any Crafts-based research methodology should be developed with the following in mind:

- Initially to consider a range of research strategies (from all disciplines);
- Individually 'tailor' the research project in response to the nature of practice, the

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[3] Bayazat, N (2004) Investigating Design: A Review of Forty Years of Design Research’ *Design Issues,* 20, (1): p16

[4] Mc Niff, J, Lomax, P, Whitehead, J. (2004) *You and Your Action Research Project (2nd ed)*. p13

specific research project and the researcher's expertise as a Craftsperson;
- Carry out the research from the informed perspective of the reflective practitioner, as 'participant observer';
- Continually define and refine the research question in an iterative process, and allow methodologies to emerge;
- Acknowledge accessibility, discipline, rigour, transparency, transferability as the characteristics which distinguish research from day-to-day practice in the visual arts;
- Be aware of the critical context of practice and research, and to use the contextual review to situate the researcher and to help generate and raise the level of critical debate;
- Consider an interdisciplinary / multidisciplinary approach to research, using a 'multimethod' or 'triangulated' approach, acknowledging the complex nature of practice-based inquiry in a transient cultural and contextual framework.[5]

The model offered by Malins and Gray is borrowed heavily from other disciplines and includes methodologies from the social sciences, which lends an element of credibility in academic circles. However, the nature of craft practice means that there will be an element of subjectivity and required understanding of the aesthetic, which will always draw criticism from other ‘pure’ research advocates.

> Each view of professional practice represents a way of functioning in situations of indeterminacy and value conflict, but the multiplicity of conflicting views poses a predicament for the practitioner who must choose among multiple approaches to practice or devise his own way of combining them[6].

Indeed a multi-pronged approach seems the most relevant to practice based research and arguably the most obvious. Without an established method, the adopting of other’s methods is the most appropriate route.

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[5] Malins, J & Gray, (1995) Appropriate Research Methodologies for *Artists, Designers & Craftspersons: Research as a Learning Process, p3*

[6] Schön, D. A (1983) *The reflective practitioner: how professionals think in action*. p17

3.3 Scientific Method

The aims and objectives of my research require some scientific methods to be adopted, therefore it is important to examine scientific method and in particular look at two of the prominent theories of scientific philosophy that have had an influence on the philosophy of my individual research.

Scientific method is considered by many as fundamental to the facilitation of new knowledge that is based in physical evidence or fact. All scientific methods are designed to foster the creation of new knowledge. The methods employed in any scientific method must adopt the principles defined for the collection of data and designing of experiments such as: control experiments, replicated samples, Occam's Razor, Baconian methods. These guidelines and best practices have been developed over centuries to enable the reproducibility and transparency of experiments carried out as part of scientific research. It is the formulation of a hypothesis and subsequent experiment to prove or disprove the hypothesis that can be considered at the heart of the modern scientific method.

> Every hypothesis formulates a prediction that should represent a logical outcome. The hypothesis is formulated as a possible answer to a scientific question and it can anticipate the results. If the prediction is confirmed, then the hypothesis should be accepted. If the prediction is not confirmed, then at least two situations are possible: The hypothesis is not valid or the assumptions underlying the hypothesis and its predictions were misleading.[7]

Throughout the scientific method the practice of peer review is enforced to both validate and confirm results. It is important to note that scientific research is never conducted in isolation, a vibrant research community has been recognized over centuries as crucial to the advancement of any particular field.

Here it is interesting to compare the apparent transparency of the scientific community with the more subjective field of art and design. The reality is that science is, as Popper would attest not infallible.[8] Ethical research and accurate reporting is of course normal, however there have been recent and high profile unethical or willful falsification of data uncovered, most notably Dr. Hwang Woo Suk who, falsified data on human cloning experiments. Neither is the peer review process without it criticisms: namely that unorthodox work is stiffled or at other times considered too accommodating. Regardless of these 'problems' in comparison with the field of art and design the

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[7] http://www.sciencemag.org/feature/data/scope/keystone1/

[8] Chalmers, A.F (1999) *What is this thing called science?* p156

scientific method is far more conducive to the promotion and generation of new knowledge. The scientific method is more than simply a series of tools, a methodology or recipe for scientific success, that allows new discoveries to be repeatable, reliable and transferable. Scientific method has been developed and criticised for centuries and could be considered more as a network defined by the philosophical principles created by centuries of scientific investigation.

In order to understand more fully the complexities of the philosophy of science it is now pertinent to discuss two prominent theories that have a direct influence on the methodological considerations of my own research.

Inductivist Theory

The basic idea of the inductivist model assumes that by collecting large amounts of relevant data, and analyzing it, theories can therefore be derived or induced that have been borne from the 'fact' generated through the observations made. Inductivism was developed long before the twentieth century and is generally considered as being introduced by Francis Bacon (1561-1626). It is a testament to Bacons theory of scientific method that:

> …It was perhaps the dominant account of scientific method in the nineteenth. inductivism has been widely held and developed during the twentieth century as well.[9]

Expanding on the basic definition of Inductivist theory provided, we can refer to Bacon who provides a striking analogy with wine making.

> To make wine we first gather 'countless grapes...ripe and fully seasoned'. From these grapes the juice for the wine is 'then squeezed in the press' The grapes correspond to the observations from which scientific generalizations (laws and theories) are somehow squeezed out.[10]

Inductivism is concerned with the elucidation of knowledge from the facts that have been established through observation. It can thus be more clearly illustrated in the following diagram:

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[9] Gillies, D (1993) *Philosophy of Science in the Twentieth Century*, Oxford, Blackwell pp 3
[10] Gillies, D (1993) *Philosophy of Science in the Twentieth Century*, Oxford, Blackwell. p7

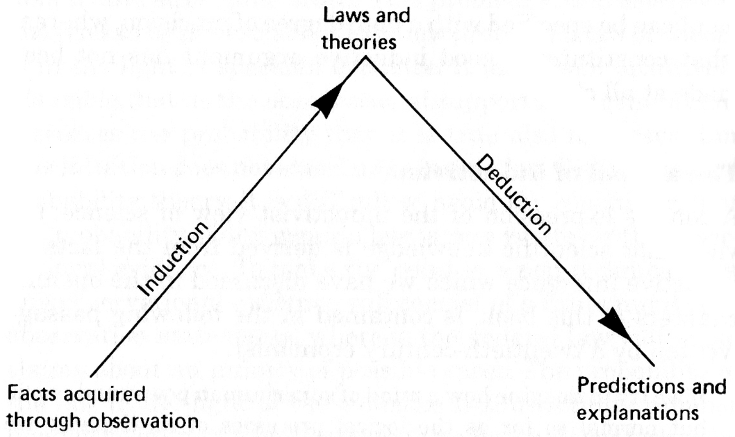

Figure 3.3.1 Diagram of inductive reasoning

Inductivism is in many ways an appealing theory of science, we can relate to the methodology and can understand the logic that is employed in the formation of theories and laws from verifiable and repeatable facts borne from the observation of experiments. However, arguments have raged over the philosophical issues of the inductivist scientific method and in direct opposition to induction is falsification.

Falsification

Feyerabend, Popper and Duhem all argued against inductivist theory in one way or another, claiming that it bears little resemblance to the practice of science. Instead they favour the theory of falsificationism, or in the case of the former, anarchistic theory. Falsification put simply:

> Amounts to the principle that a proposition or theory cannot be considered scientific if it does not admit the possibility of being shown false.[11]

This view of science presupposes that the inductive theory that results in a generalization or law is always open to doubt and refutation. The main argument that falsification advocates is that for any scientific theory or hypothesis to be truly scientific it must be shown to hold the possibility of being false. Supporters such as Popper believe that the only true way to advance science is by trial and error, by the mistakes made and proven to be wrong only to be replaced by a truth that still holds the same potential for being incorrect.[12]

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[11] Chalmers, A.F. (1999) *what is this thing called science?* p86

[12] ibid p67

The falsifications seems to hold water if we look at historical lessons. Newton's universal gravity and three laws of motion were held as being the correct theory for nearly 250 years until Einstein's theory of relativity proved them to be 'wrong'. It is the general impression that Einstein's theories proved Newtonian theories as 'wrong'. However, Kuhn provides a more accurate description.

> If Einsteinian science seems to make Newtonian dynamics wrong, that is only because some Newtonians were so incautious as to claim that Newtonian theory yielded entirely precise results.[13]

Kuhn goes on to explain that Newton in 1666 was responsible for inventing an approximation to explain the problem of motion. Kuhn argues that Einstein's General Theory of Relativity is in itself simply a more accurate approximation of natural phenomena. As such, scientific laws cannot be considered 'true', instead scientists have established what they believe to be the most accurate approximation for now. This assumes that in the future someone will come up with a better approximation of Einstein's General Theory of Relativity. This epistemological statement again highlights the uncertainty within the sciences and goes some way to explaining the preoccupation with the rules and laws established over centuries of study. The vast majority of science research is solely concerned with small details already defined by the paradigm in question.

> Closely examined, whether historically or in the contemporary laboratory, that enterprise seems an attempt to force nature into the preformed and relatively inflexible box that the paradigm supplies. No part of the aim of normal science is to call forth new sorts of phenomena; indeed those that will not fit into the box are often not seen at all.[14]

The concept of the predefined box is a rather alien concept to the artist or designer, the objective, for the artist is not to repeat and corroborate it is most commonly to explore and break rules. However, not all scientists prescribe to the rigid philosophy of inductivism as a methodology for scientific discovery.

The Argument Against Method

When Einstein famously stated: 'Only daring speculation can lead us further, not the accumulation of facts.'[15] He was expressing his disillusionment with the inductive method. He felt that one of the ways for science to advance was through the adoption

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[13] Kuhn, T.S (1962) *The structure of scientific revolutions* (3rd ed) p99

[14] Kuhn, T.S (1962) *The structure of scientific revolutions* (3rd ed) p24

[15] Ayer, J. A & O'Grady, J (1992) A Dictionary of Philosophical Quotations p125

of a more open and creative risk taking ideology. Einstein's theory of relativity was received with scepticism when he first presented it in 1915 because the entire theory was based solely on mathematical reasoning and rational analysis, not by experimentation and deduction from 'fact'. The philosopher of science Paul Feyerabend goes further by stating:

> The idea that science can, and should, be run according to fixed and universal rules is both unrealistic and pernicious, detrimental to science, for it neglects the complex physical and historical conditions which influence scientific change and makes science less adaptable and more dogmatic.[16]

Feyerabend proposed in his book Against Method: Outline of an Anarchistic Theory of Knowledge that scientists that wish to progress cannot follow the inductivist or positivist method. In his book, Feyerabend challenged all previous attempts to characterise scientific method as a superior form of knowledge by:

> Arguing that there is no such method and, indeed, that science does not possess features that render it necessarily superior to other forms of knowledge.[17]

Feyerabend uses a number of examples of scientific change and innovation, that were cited by inductivist philosophers as clear examples of the inductivist method in action, and demonstrated that the innovation in question could not have occurred if the theory proposed were rigidly followed as the Inductivist's attested. The case that Feyerabend built against method can be best described in the following passage:

> None of the methods which Carnap, Hempel, Nagel, [Three prominent Inductivists] Popper or even Lakatos[18] want to use for rationalising scientific changes can be applied, and the one that can be applied, refutation, is greatly reduced in strength. What remains are aesthetic judgements, judgements of taste, metaphysical prejudices, religious desires, in short, *what remains are our subjective wishes:* science is at its most advanced and general returns to the individual a freedom he seems to lose in its most pedestrian parts.[19]

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[16] Feyerabend, P (1975) *Against Method: Outline of an anarchistic theory of knowledge*. p 295

[17] Chalmers, A.F (1999) *What is this thing called science?* p150

[18] Imre Lakatos was a Hungarian mathematician that amongst his major contributions to the philosophy of science attempted to resolve the disagreements between Popper and Kuhn over a definition of science that was so lax and inclusive that almost any intellectual activity could be described as scientific.

[19] Chalmers, A.F (1999) *What is this thing called science?* p157

3.4 Tacit Knowledge

So far I have analysed scientific method and compared the two opposing theories of the advancement of knowledge. This Section will examine tacit knowledge and attempt to locate its place within both scientific method and my own research.

The acknowledgement of tacit knowledge is problematic for inductivists and scientists alike because their belief in knowledge, as something attained through empirical study, does not recognise practical knowledge as relevant. Furthermore, tacit skills exist, but if they cannot be separated into that which describes the world, or to that which is verifiable via experimentation, they fall out with the inductivists definition of knowledge. This exclusion from the hierarchy of knowledge led professions that advocate and deal in tacit knowledge to try to adapt themselves to the inductivist philosophy. Professionals in fields such as engineering felt that they could adopt the construct of inductivism if they could separate and define their practice into notional categories of research and application then they could describe their practice as scientific and technological.

> The hierarchical separation of research and practice is also reflected in professional school. Here the order of the curriculum parallels the order in which the components of professional knowledge are “applied’ the rule is: first the relevant basic and applied science, then the skills of application to real world problems of practice.[20]

As Schön points out the universities and colleges of the West then adopted this theory of practice as a method at the beginning of the twentieth century. As professions such as architecture and engineering became more scholarly the crafts and arts became more sidelined.

> For according to the Positivist epistemology of practice, craft and artistry had no lasting place in rigorous practical knowledge.[21]

The argument levelled against the craftsperson by the Positivist Philosophy is: he is unable to define and describe what it is that he knows, as the process and experimentation he is engaged with is often haphazard and intuitive. It therefore cannot be analyzed to provide empirical and confirmable data sets. As Schön points out, this cannot find a place within the inductivist epistemology of practice. We can illustrate with the following model of practice as seen by Schön.

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[20] Schön, D. A (1983) *The reflective practitioner : how professionals think in action*. p27

[21] ibid p34

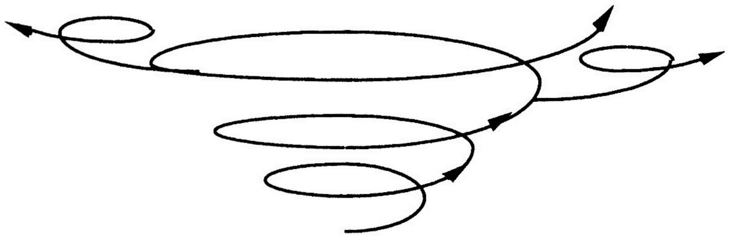

Figure 3.4.1 Action and reflection diagram

Understandably when this model is compared with that of the Inductivist (Figure 3.4.2) the difference is stark.

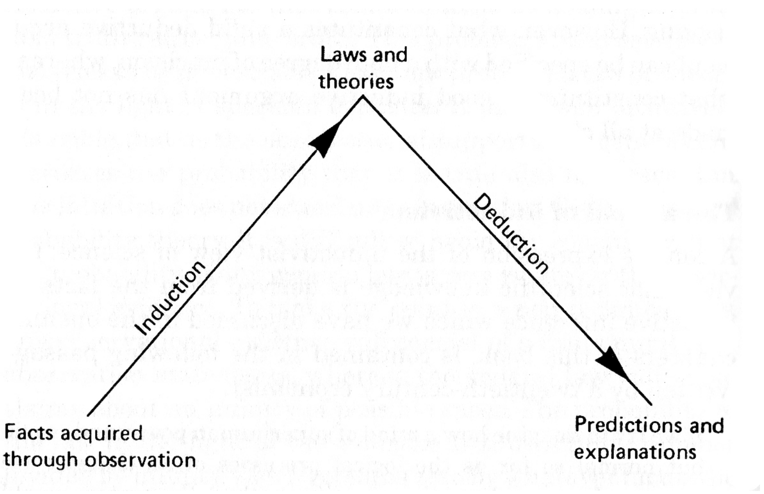

Figure 3.4.2 Diagram of inductive reasoning

The iterative process that is led by practice will inevitably be dismissed by practicing scientists just as the rigid model provided by the inductivist is impractical for practice based research. I would argue that the lack of 'concrete' empirical evidence does not indicate a lack of 'concrete' knowledge. In everyday life we engage in actions that Bernard defined as "non logical processes", which are not capable of being expressed in words or as reasoning,[22] Bernard cites a number of activities that involve tacit knowledge such as playing golf or throwing a ball. These activities implicitly involve the application of indefinable knowledge. These internal and split second decisions are made using internal judgement and we would have a difficult time answering the question: How do you know how far to throw the ball? without resorting to a vague description of intuition. This type of tacit knowledge is present in every field of endeavour, but I would argue that it is a more crucial part of any creative practice.

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[22] Schön, D. A (1983) *The reflective practitioner : how professionals think in action*, p51

Conversely Polanyi argues that is also a crucial part of a scientist's professional practice when he states, "Tacit knowledge is learned by doing science rather than by acquiring rules for doing it".[23] Tacit knowledge may well be an important factor in a scientist's success. However, as we have examined previously, the vast majority of scientific research and study is based around the fundamental rules set out within the various paradigms of science.

In contrast the field of art and design research, you could argue, is philosophically diametrically opposed. Artists and designers, in contrast to scientists, will learn the rules if they exist and will then consciously, if perhaps not systematically, attempt to break them. This epistemology of practice tends to instil a sense of suspicion from academics both within and outside the field. However, it is this reluctance to adhere to and obey the rules and think outside the box that could be said to drive creative practice. Practice based research necessarily involves a more holistic view of the problem. It involves the use of tacit knowledge, reflection in action and necessary adjustments and reactions to the problem under investigation. In addition, the researcher has a direct effect on the research as a 'participant' in the programme of research.

> Action research is more than problem solving, and involves identifying the reasons for the action which are related to the researcher's values, and gathering and interpreting data to show that reasons and values were justified and fulfilled.[24]

This fact is particularly relevant in any craft and design research concerned with the creation of objects and artefacts; the application of tacit knowledge in a craft based discipline is essential. In the same way as scientific research utilises the work previously completed by researchers in the field, knowledge learned through doing and instruction from others is utilized in the same way. It is important to note that this form of knowledge also has a very large impact on industry and commercial competitiveness. Tacit knowledge's importance has been recognised as an important element in innovation. However, the process does have its weaknesses, and comes under constant attack for its perceived lack of rigour from commentators and critics from both within and out with the field.

> When I speak of knowledge imbedded in shared exemplars, I am not referring to a mode of knowing that is less systematic or less analyzable than knowledge

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[23] Kuhn, T.S (1962) *The Structure of Scientific Revolutions* (3rd ed). p191

[24] Mc Niff, J, Lomax, P, Whitehead, J. (2004) *You and Your Action Research Project (2nd ed).* p13

> imbedded in rules, laws or criteria of identification. Instead I have in mind a manner of knowing which is misconstrued and reconstructed in terms of rules that are first abstracted from exemplars and thereafter function in their stead.[25]

The problem with tacit knowledge is inherent in the issue of how tacit knowledge can be explicated. The problem with explaining that which cannot be explained in words but is perceived as being 'felt' knowledge, will inevitably draw criticism from scientists that believe knowledge can only be implicitly quantifiable.

3.5 Methodology Conclusion

So far I have presented two philosophies of science that have an equal influence on my own research. I have also described the issues that surround tacit knowledge. In conclusion I will discuss how these seemingly disparate philosophies can inform on the methodology and philosophy present in the research.

Firstly if we take inductivism: the premise is that through applied data collection theories and hypothesis can be induced from the scientific fact. If we apply this theory to one area of my own research then through the evaluation and testing of refractory products for reaction of glaze recipes to specific products, we can create data that demonstrates in some cases a glaze will be suitable for one particular material and unsuitable for another. We can therefore induce that glaze recipes cannot be universal for all materials, however through observing the reaction of a number of glazes with a number of different materials commonalities can be identified.

This inductivist method will fulfil one aim of the research, providing it is successful (to acknowledge falsification). However, if we look at the aims of the research as a whole, then the rigidity of inductivist theory will not allow the freedom required to demonstrate the application of these materials in practice.

Similarly the falsificationist's advocacy of trial and error and the openness to failure also has a bearing on the research. I am not a materials scientist and have not completed undergraduate studies in ceramic engineering. Nevertheless given the aims of the project I do not need to be. Secondly, due to the scope and timescale involved, I could not conduct the amount of tests and experiments that I would be required to do

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[25] Kuhn, T.S (1962) *The structure of scientific revolutions* (3rd ed), Chicago, University of Chicago Press P193

to satisfy material scientists. The result was that a certain amount of trial and error is required that concentrated the work on different areas of investigation and discarded others. This process was necessarily an intuitive process that is informed by the empirical evidence combined with tacit knowledge as described above.

The conclusion arrived at, after considering the deficiencies that both the scientific methods have in practical and creative experimentation, was to develop a method of triangulation that involves a mix between the scientific method and the more subjective method of radical humanist theory as promoted by Feyerabend. The research involved the systematic analysis of materials utilising scientific methods of empirical data collection. Materials are in the first place categorised by industrial standardized methods. Many companies provide details on mechanical and chemical properties of the materials they supply, this initial information allowed informed choices to made about which materials might be suitable for further investigation. Information and advice was also received from experts at the company. Their more advanced knowledge of the materials learned over the years is invaluable. However, their knowledge is limited to the established applications the materials are designed for and their understanding of visual and aesthetic considerations is very limited.

It is here that the analysis in the workshop becomes more important. The materials selected from data sheets and consultation with industry experts were evaluated for their suitability to the workshop environment. This included health and safety considerations along with issues of how they are mixed and the effect low tech and small scale mixing has. Primarily this involved a possible adjustment of the industry recommended water content. The material was then evaluated for its ease in casting and the subsequent quality of cast. These are subjective experiments that involve intuitive visual assessment and of course tacit knowledge. However, here the intention is not to recreate the industry standard, this is not necessary as the materials will not be put into industry standard applications. It is, however, important to understand in empirical terms how far away from the standards of industry the methods employed in the workshop are.

The research does not simply involve the testing of materials in a low-tech environment and subsequent testing for suitability of glaze and traditional ceramic surface decorations. The hypothesis is that these materials offer unique and novel handling properties that could be used to enhance and benefit both the small-scale crafts person and the large-scale industrial manufacturer. For this reason, experiments into the practical application of the materials was seen as an important aspect of the research.

There have been a number of PhD research projects in the craft field over the past 10 years that have advanced the research base in the crafts. Katie Bunnell's 'Re: Presenting Making' which investigated the integration of new technology into ceramic craft practice resulting in a digital thesis[26] and Justin Marshal's research into the role of CAD/CAM technology in the crafts[27]. Within a wider craft sphere is Vanessa Cutler's work exploring the creative use of water jet cutting technology with glass[28]. However, these research projects have often concentrated on the role of technology and the impact it can have on the craft in question where my own focus is on the material itself.

One example of a practice based research project that has included materials research and used experiments to evaluate the materials capabilities is the "Mixing with the Best", a glass mould making research project completed at the Royal College of Art (RCA)[29]. The research investigated the variety of different recipes and materials used by different international glass artists. The aim was to test them all and establish the best in terms of health and safety, cast quality and ease of removing the sacrificial cast. This involved practical testing using standardized forms. This method allows for more transferable results and in the context of the research was the most appropriate method. My own methodology is different in that it attempts to demonstrate the possibilities of the materials through creation of artefacts and products that would be impossible if attempted using established methods. So, as a result, more adventurous forms and experiments were conducted.

While these projects have contributed to the methods and philosophy of this project. The realisation at the start of the research was that triangulation between the scientfic empirical method and application of intuitive and subjective judgements would be central to the philosophy behind the research. This approach was deemed the most suitable when dealing with the diverse problems presented by the research. It allows for corroboration between the two methods and perhaps most importantly allows for creative exploration not possible within the more strictly defined, traditional 'scientific' method. The practical elements of the research are used to explore the potential of the

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[26] Bunnell, K. (1998) *The integration of new technology into ceramic designer-maker practice*. PhD thesis, Robert Gordon University

[27] Marshall, J. (2000) *The role and significance of CAD/CAM technologies in craft and designer-maker practice; with a focus on architectural ceramics*. PhD thesis, Open University

[28] Cutler, V (2006) *Investigating the creative uses of waterjet cutting for the glass artist's studio*. PhD thesis, University of Sunderland

[29] Thwaites, A. (2002) *Mixing With The Best: Investigation and comparison of contemporary working methods and mould making materials for use in the kiln forming of glass.* RCA

materials for a number of applications. The applications developed are backed up and reinforced with quantitative research conducted that grounds the research firmly in reality, echoing the words of Croatian inventor Nikola Tesla:

> Today's scientists have substituted mathematics for experiments, and they wander off through equation after equation, and eventually build a structure which has no relation to reality
>
> Nikola Tesla (1856 – 1943)

Chapter 4 Materials

This chapter discusses advice and practical information on the use of RC in low-tech environments. A full database of the materials tested and evaluated can be found in Appendix 1.

4.1 Methods

It is first important to discuss the general methods that were followed while working with refractories throughout this research. It was felt that the thesis could constitute a form of handbook for artists and designers to refer to in the future. Therefore, this section includes general advice on a number of issues that are relevant to the research as a whole including:

- Mixing machinery
- Mixing Advice
- Casting and Mould preparation,
- Setting and Drying
- Firing
- Health and Safety Considerations
- Storage

The information here should be seen as a guide for most refractories. Specific advice from manufacturers should be followed if it is available.

Mixing Machinery

In the refractory industry the standard machinery used is capable of outputting up to a ton of concrete in one mix. For small-scale manufacture this type of machinery will be prohibitively expensive and impractical for ‘one off’ objects or short run batches. As such, one of the objectives of the research was to establish methods and materials that would be suitable for small-scale manufacture.

The mixer used in this project was a Hobart AE 200 planetary mixer with a 10 quart capacity bowl. Using the paddle attachment 10kg can be mixed in around 5 minutes. Single-phase mixers can be obtained for around £300. The majority of refractories can only be mixed using these high intensity mixers; ordinary concrete mixers will not sufficiently mix RC with low water contents.

Figure 4.1.1 Hobart AE200 planetary mixer

Specific Mixing Advice

Low cement self flow type materials

These materials generally have a very low water to material ratio. Thus the amount of energy required when mixing these refractory concretes is very high therefore standard rotary concrete mixers are unsuitable and a high intensity mixer is required for large scale pieces. For these materials mixing any more than 1-2kg of material by hand at one time is very difficult without dramatically increasing the water to material ratio.

Castables

Castables will normally have higher water to material ratio in comparison with self-flows and can therefore be more easily mixed by hand. For any moderately large-scale objects mixing machinery will be required. For high to moderate water to material refractories it is possible to use standard rotary mixers. Certain castables will require vibration during casting such as vibrate able refractories. For small-scale pieces manual vibration will be sufficient.

Insulating refractories

Insulating RC’s are generally much easier to mix, as they will have smaller aggregates and much higher water to concrete ratio. They can be mixed by hand or in a mechanical mixer.

Water

Water is very important in the preparation of any refractory concrete. Water added should be, where possible, as close to the recommended amount suggested by the manufacturer. The amount of water added has a direct bearing on a number of important structural and handling properties: Water controls the setting and dispersion of aggregates within a mix, affects the strength and density of pre and post fired refractory and directly influences the flow and thixotropic properties of refractories.

Water should be cold (around 10°c) and of drinking water quality, pH should ideally be between 6 and 7.5.

Hand mixing of refractories will in some cases (particularly with self-flows and low water ratio refractories) require additional water to enable mixing. Increasing the percentage of water by 0.5% increments is recommended until the desired consistency is achieved.

Casting

Obviously design requirements will define the construction of moulds. However, some general rules should be noted:

Moulds can be made from any number of materials E.g.: plastic, wood, polystyrene, RTV (Room Temperature Vulcanising) rubber or silicone, or plaster. However moulds must be watertight and waterproofed. Porous materials should be sealed with petroleum jelly.

Installation should be carried out as soon as possible after mixing. Ideally moulds should be filled in one mix. However, multiple mixes are possible provided each layer is rodded or disturbed to create a solid bond and avoid the possibility of lamination between layer.

Mechanical vibration using a vibrating poker will help to reduce air bubbles and increase cast fidelity. However, self-flow refractories should, as a general rule, not be subjected to heavy mechanical vibration in the mould, as this will cause uneven distribution of aggregates within the mix resulting in micro cracks. In most cases manual vibration of the mould will be sufficient.

Setting and Drying

Once cast the mould should be kept at an ambient temperature ideally at temperatures above 60°F (15°C) to set for 24 hours before heating. At lower temperatures setting times will increase and additional time should be allowed. De-shuttering of moulds should ideally be carried out after 24 hours when the material has gained its maximum green strength.

All products should be protected from freezing until it has been fired.

Firing

Published and recommended firing schedules as provided by suppliers are often specifically designed to reduce the risk of spalling or problems caused by escaping gasses and water from large scale monolithics. In many cases on a small scale these over cautious firing schedules with regular soaks at certain temperatures are unnecessary and can be substituted with more aggressive firing schedules. It is important to note that some materials can generate hazardous gasses during firing so specific industry advice where hazardous gasses are involved should be followed.

Refractories as a whole are very resilient materials and firing cycles can be faster than normally recommended for ceramic materials. The typical firing schedules used for the majority of tests conducted are listed below; all were in an electric kiln with an oxidising atmosphere (with the exception of the glaze tests discussed in Section 5.3[1]).

Firing Schedules

Schedule 1 (Normal bisque firing)	
Time (min)	Temperature (°C)
300	150
480	550
480	1200

Table 4.1.1

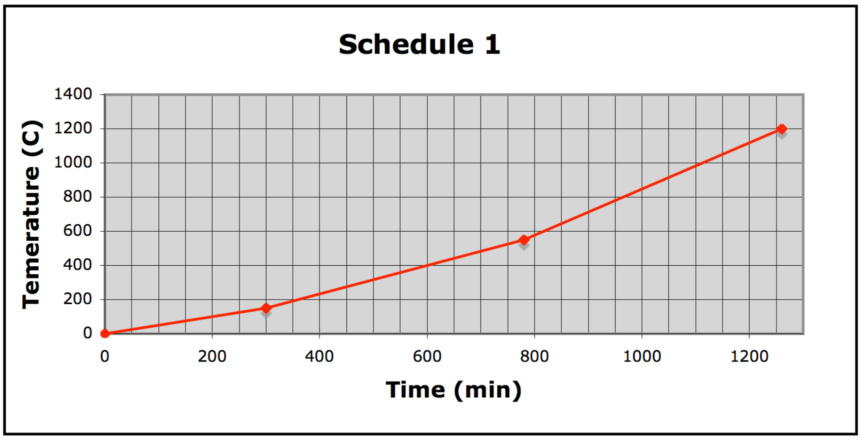

Table 4.1.2

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[1] Chapter 5, Section 5.3 page 81

Schedule 2 (Glass firing)	
Time(min)	Temperature (°C)
180	150
450	600
400	1180
20	1180

Table 4.1.3

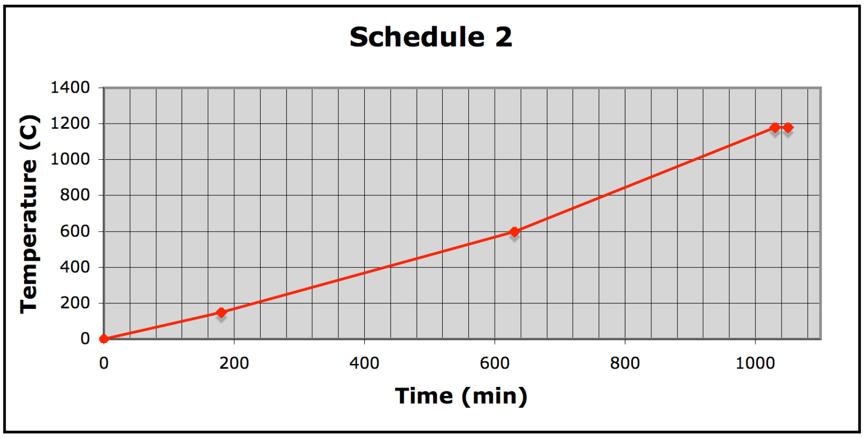

Table 4.1.4

Schedule 3 (fast thin work)	
Time (min)	Temperature (°C)
300	350
240	650
270	1200
30	1200

Table 4.1.5

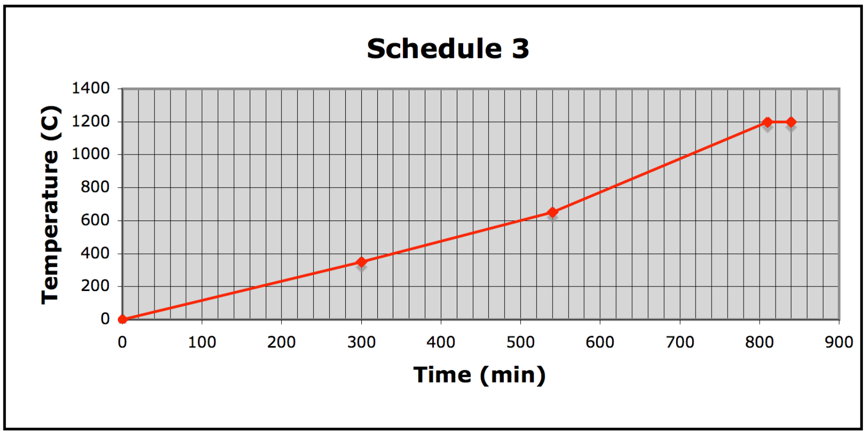

Table 4.1.6

Schedule 4 (Thick work)	
Time (min)	Temperature (C)
500	350
340	650
60	650
500	1200
60	1200

Table 4.1.7

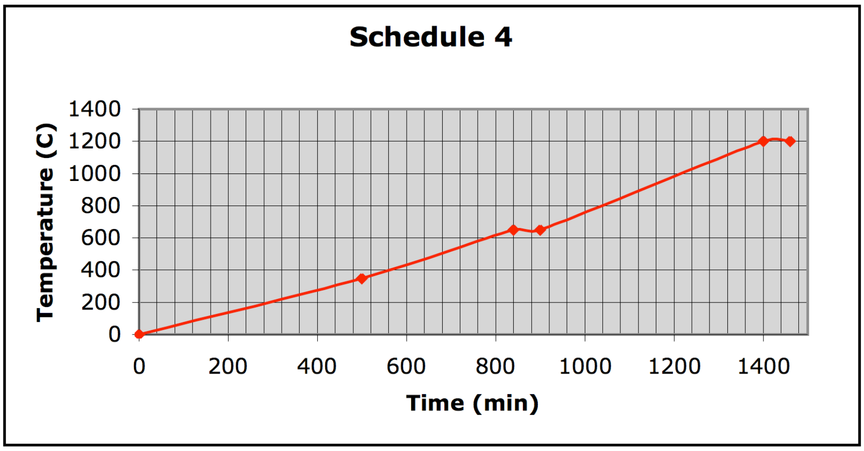

Table 4.1.8

These firing schedules can be used as a guide. Schedule 4 shows a typical cycle for thicker sectioned objects (over 10cm), a slower cycle with a hour soak at 650°C and at least an hour soak at top temperature is advised to guarantee a uniform firing, and reduce the risks of explosion from steam escaping. Some refractories will contain nylon or organic fibres to reduce this risk and so if using these refractories it is important to use well ventilated kilns.

Storage

All refractories should be stored in a dry place, free from frost. The majority of RC's can be stored for over 12 months in dry storage. Low cement and flow concretes will suffer a reduction in green strength if stored for a period over 6 months and additional water may be required to mix. The fired strength remains unchanged.

Finishing

The majority of RC's will set hard in 48 hours therefore consideration should be taken in reducing the amount of finishing required. Rough cutting can be carried out using an angle grinder and diamond cutting discs. Extraction should be used at all times while dry grinding.

Throughout this PhD wet grinding and polishing has been used to enhance and reveal the surface of the refractories used. In all cases a Flex LX wet diamond grinder has been used. The grinder uses various diamond pads to grind and polish the surface.

Figure 4.1.2 Flex Grinder and diamond pads

General Health and Safety Advice

Refractory concretes are not dangerous or hazardous materials. However, the following information is provided as general advice regarding refractory concretes and refractory raw materials. Manufacturers' advice referring to specific materials is provided with the rest of your information pack and should be followed.

Constituents

As a general rule refractory concretes will be 50><100% refractory granular aggregate material. 10><25% Calcium Aluminate Cement and will typically contain concentrations of between 1><2.5% Crystalline Silica.

Hazards

Prolonged long-term exposure to Crystalline Silica has been proven to cause Silicosis of the lung. Every effort should be made to reduce the hazard posed from airborne silica dust by using extraction, vacuum or wet cleaning wherever possible.

First Aid

Inhalation: Remove person to fresh air. If symptoms persist, seek medical attention.

Skin: Refractory concrete contains lime and other compounds that can dry out skin. Where possible prolonged exposure to concrete should be avoided.

Eyes: Flush eyes with plenty of clean water / saline. If symptoms persist, seek medical attention.

Ingestion: Wash out mouth with water and give plenty of water to drink.

Handling

Prolonged exposure to hands will cause drying of the skin. Protective clothing is recommended, including gloves, goggles and boots. Suitable respiratory protection should be worn when extraction is not being used.

Disposal

Small amounts of unused material can be disposed of in normal refuse. Large amounts of unused material can be disposed of in approved landfill sites in accordance with local regulations.

Refractory concretes will set hard in water so dry or large amounts of material should not be introduced into drains, sewers or watercourses. All equipment should be thoroughly washed with plenty of water.

5.4 Freeze Thaw Testing

The following two sections discuss two quantitative studies into the performance of RC in environments it has previously never been employed. The two studies were conducted with assistance from outside agencies and both independently confirm RC ability to perform in some of the applications and products developed and designed in the practice-based phase of the research. Firstly, freeze thaw testing conducted at Ceram will be covered, followed by slip resistance testing conducted by Lancashire County Council.

Refractory concrete is a material that as part of its normal industrial application undergoes rigorous tests to ensure that the material will be able to withstand the intended application environment. For this reason plenty of data is available on refractories properties as discussed in Chapter 2[1]. However, the intended application of the products and practical pieces constructed as part of this PhD are intended for application outdoors and are therefore subjected to very different stresses from those found in furnaces. For this reason it was decided that, to confirm the hypothesis that refractory concrete can be used as a creative material for outdoor environments, testing on the materials ability to withstand freeze thaw action was conducted.

The tests conducted are made up of the following materials and were designed to establish the materials individual behaviour in freeze thaw conditions and evaluate performance when combined to investigate the interface of glass and refractory. 4 materials were tested in two sets A and B:

- Set A
    - Jon Flo 90 (JF) To establish the behaviour of Jon Flo 90 on its own
    - Jon Flo 90 Glazed inlaid pattern (JFG) To establish whether revealed glazed sections would suffer damage.
- Set B
    - Jon Flo 90 Glass aggregate inlay (JFI) To establish whether inlaid glass sections would suffer damage at joints
    - Glass Aggregate composite (DB) To establish glass materials behaviour on its own

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[1] Chapter 2, Section 2.5, page 25

Tests JF, JFG and JFI and 3 were all cast using the standard recommended 4.5% water addition. Each cast was made in 6kg batches with lamination minimised by continual agitation of the surface. Only manual vibration was used in all cases to provide a homogenous cast, limiting separation of aggregates. It was decided the best option was to make a large slab of material that would be subsequently sawn on a diamond saw to the required brick sizes for the tests. The slabs were all fired in an electric kiln to 1200°C in an oxidising atmosphere. The firing cycle included a 10 minute soak at top temperature.

JF) The Jon Flo 90 was then ground and polished on the cast face to reveal the aggregates within. Between 1mm and 2mm of material were removed. All other faces were left unpolished.

JFG) was glazed with the standard earthenware copper transparent glaze (See Appendix 2 recipe E2) established as the most stable at this point in the research. This was then re-fired to 1080°C. Finally the glaze was then ground to reveal the incised pattern. Again between 1mm and 2mm was removed. All other faces were left unpolished.

JFI) was re-fired with the same aggregate glass mix used in test DB, packed into the troughs of the JF cast. Firing temperature 1200°C. Any raised areas were then levelled with the JF before 1-2mm was removed from the whole surface

DB) Consisted of:
Lead Bi-Silicate 20%
Nepheline Syenite 20%
Molochite 50%
Chamotte 10%
Copper porcelain grog 5%
Fired to a temperature of 1200°C

All test slabs were then cut to give brick dimensions 215mm x 65mm x 55mm. The width of the bricks was reduced from the standard 105mm with the agreement of Ceram and was done to reduce the amount of material used. It was confirmed by Ceram that it would not affect the results.

Testing Procedure:

Testing was carried out in accordance with the European method prCEN/TS772-22(April 2004). The test involves subjecting a panel of brickwork to repeated freeze-thaw cycles designed to simulate naturally occurring conditions. From the test the bricks are given a freeze-thaw resistance classification, which categorises the bricks as being suitable to withstand the following conditions:

F2 - Severe Exposure
F1 – Moderate Exposure
F0 – Passive Exposure

The test method is summarised as follows:

Sample Preparation

Each unit was examined and any existing defects on individual samples noted before testing. A 24 hour cold soak water absorption value was obtained for each sample before freeze-thaw cycling (see tables 5.4.2 and 5.4.3) Following this the samples were soaked at room temperature for 7 days before being constructed into a panel of brickwork.

Construction of Test Panel

A panel of brickwork consisting of 8 courses was built to give a panel of approximate dimensions: 590x660x55mm, using 10mm closed pore foam rubber as jointing material. (See Figure 5.4.1).

Freeze Thaw Cycles

The freeze-thaw apparatus subjects the main face of the panel to repeated cycles of freezing and thawing following an initial freeze at an air temperature of -15°C for 6 hours. The rear of the panel was insulated with a 50mm thick extruded polystyrene foam board and the sides insulated with a 25mm thick polystyrene board.

Figure 5.4.1 Test panel showing glazed and inlaid samples

A freeze-thaw cycle consists of 120 minutes (± 5 mins) of freezing to -15°C (± 3°C) air temperature, heating with re-circulated warm air to 20°C (± 3°C) for 20 minutes, two minute flood coat spray at a water temperature for 18-25°C followed by a two minute drain period. This gives 10 cycles every 24 hours, a standard test continues for 100 cycles.

Figure 5.4.2 Test panels in freeze thaw rig

Assessment of Freeze/Thaw Resistance

The panel was examined after 15 and 50 cycles. After 100 cycles the panel was allowed to thaw completely, removed from the apparatus and photographed. The panel was then dismantled and individual samples examined for frost damage as categorised in Table 5.4.1.

Categories/Types of Damage	Type
None	0
Crater (eg. lime burst)	1
Hair crack <0.15mm	2
Minor crack	3
Surface crack	4
Through crack	5
Chipping, peeling, scaling	6
Fracture	7
De-lamination	8

Table 5.4.1 Categories of damage

Sample Number	Water Absorption (%)	Sample Number	Water Absorption (%)
JF1	2.4	DB1	1.0
JF2	2.5	DB2	1.1
JF3	2.5	DB3	1.1
JF4	2.5	DB4	1.0
JF5	2.3	DB5	1.1
JF6	2.5	DB6	1.2
JF7	2.5	DB7	1.1
JF8	2.4	DB8	1.1
JF9	2.4	DB9	1.0
JF10	2.3	DB10	1.1
JF11	2.6	DB11	1.0
JF12	2.5	DB12	1.1
JF13	2.5	DB13	1.2
JF14	2.5	DB14	1.0
Mean	2.4	Mean	1.1

Table 5.4.2 Water absorption data for JF and DB

Sample Number	Water Absorption (%)	Sample Number	Water Absorption (%)
JFI1	2.2	JFG1	2.3
JFI2	2.2	JFG2	2.3
JFI3	2.2	JFG3	2.3
JFI4	2.3	JFG4	2.3
JFI5	2.2	JFG5	2.2
JFI6	2.2	JFG6	2.2
JFI7	2.2	JFG7	2.4
JFI8	2.4	JFG8	2.3
JFI9	2.2	JFG9	2.2
JFI10	2.2	JFG10	2.4
JFI11	2.3	JFG11	2.3
JFI12	2.2	JFG13	2.3
JFI13	2.4	JFG14	2.2
JFI14	2.3	JFG15	2.4
Mean	2.3	Mean	2.3

Table 5.4.3 Water Absorption data for JFI and JFG

Results Set A (JF & DB)

DB 11	DB 12	DB 13	DB 14
DB 8	DB 9	DB 10	
DB 4	DB 5	DB 6	DB 7
DB 1	DB 2	DB 3	
JF 11	JF 12	JF 13	JF 14
JF 8	JF 9	JF 10	
JF 4	JF 5	JF 6	JF 7
JF 1	JF 2	JF 3	

Table 5.4.4 Numbering diagram and layout (Set A)

Incidence of damage

Incipient de-lamination detected by taping the face of the panel with a metal rod is reported as **C** at 15 and 50 if de-lamination is confirmed at 100 cycles

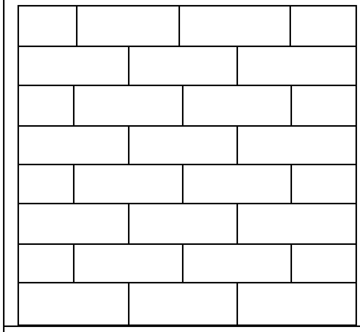
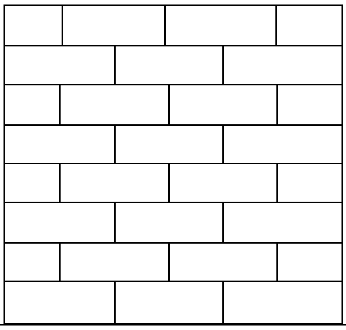
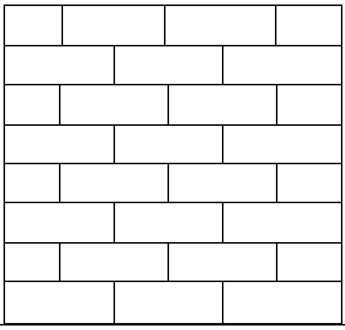
After 15 Cycles	After 50 Cycles	After 100 Cycles
		
Total No. of Damaged Bricks: 0	Total No. of Damaged Bricks: 0	Total No. of Damaged Bricks: 0

Table 5.4.5 Observed damage after 15, 50 and 100 cycles

Conclusion

From the tests carried out no damage greater than type 3 (Minor crack, see Table 5.4.1) was observed after 100 cycles and therefore the samples are classified as being F2 i.e. suitable for conditions of severe exposure.

Results Set B (JFI & JFG)

JFI 11	JFI 12	JFI 13	JFI 14
JFI 8	JFI 9	JFI 10	
JFI 4	JFI 5	JFI 6	JFI 7
JFI 1	JFI 2	JFI 3	
JFG 11	JFG 12	JFG 13	JFG 14
JFG 8	JFG 9	JFG 10	
JFG 4	JFG 5	JFG 7	JFG 8
JFG 1	JFG 2	JFG 3	

Table 5.4.6 Numbering diagram and layout of tests (Set B)

Incidence of damage

Incipient de-lamination detected by taping the face of the panel with a metal rod is reported as C at 15 and 50 if de-lamination is confirmed at 100 cycles

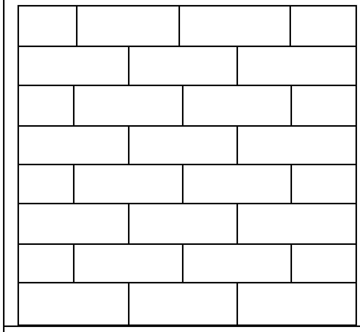
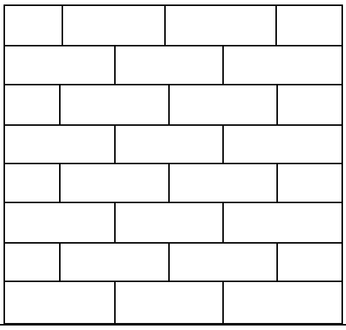
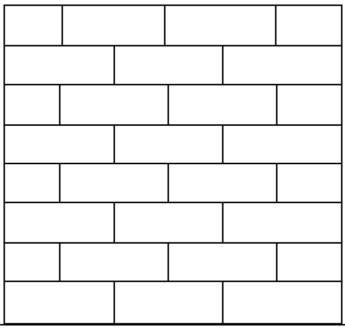
After 15 Cycles	After 50 Cycles	After 100 Cycles
		
Total No. of Damaged Bricks: 0	Total No. of Damaged Bricks: 0	Total No. of Damaged Bricks: 0

Table 5.4.7 Observed damage after 15, 50 and 100 cycles

Conclusion from freeze thaw tests

The results of the testing show conclusively that the material is capable of withstanding severe freeze thaw action. Importantly the tests showed no difference between the plain polished concrete and the inlaid glass samples, nor was there any cracking or damage to the glazed and polished incised samples.

5.5 Slip Testing

This section discusses quantitative research conducted into the slip resistance of refractory concrete. These tests were identified as necessary as a result of practical work investigating potential applications for RC as graphic floor pavers. Two practical investigations are discussed in Chapter 6, Section 6.6[2]. The practical project proved that the process of creating an inlaid graphic image into the surface of concrete pavers could be achieved economically and efficiently with a high level of detail. After establishing that the process and technique would be suitable for the designed application it was important to establish that the material and process would be ‘fit for purpose’. Following discussions with Preston City Council (PCC) and The Highways Authority it was decided experimental data should be generated on the slip resistance of RC.

Refractory concrete has, to the best of the researchers knowledge, never been used as pedestrian flooring material. Therefore, no formal testing had been done to gauge the slip resistance values of RC. It was estimated that the polished surface would be comparable with polished granite or marble, which are normally installed in indoor environments. The intended application for the RC pavers was for external pedestrian areas, therefore exposed to wet conditions, and could result in very low slip resistance values, making the deployment of RC in the intended site impossible. The need for slip testing to be conducted is reinforced when the situation of the proposed pavers is considered. In most cases when pedestrians come across an area of reduced slip resistance they adjust their gait to compensate for the reduced traction. However in the case of the proposed application site the differential between the surrounding material (sandstone) and the piece itself could increase the risk of slipping.

Prior to testing being carried out previous literature on slip resistance on concrete and natural stone was reviewed.

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[2] Chapter 6, Section 6.6, page 148

A number of studies have looked at slip resistance the most recent studies found were conducted by the Health and Safety Executive (HSE) in 2007. They are; ‘A study of the characteristics of cementious surface toppings and applied concrete’ and ‘A study of the slip characteristics of natural and manmade stone flooring materials’. The former refers to tests conducted on a range of in-situ concrete flooring in industrial settings and looks in particular at contamination and it’s relation to slip resistance. The latter looked at natural and manmade stones used commonly in commercial premises and compared surface roughness tests with the pendulum test.

As would be expected, in both studies a direct correlation between the surface roughness and slip resistance was determined. Therefore, surface finish has a direct bearing on the slip resistance value. The study with most relevance to the tests conducted on the refractory samples are the values obtained by the pendulum test on a variety of different natural and manmade flooring materials as the surfaces are similar to the polished RC the results of the HSE tests are shown in Table 5.5.1.

Ramp Board	Direction	Dry (SRV)	Wet (SRV)	Slip Potential in wet
Polished Marble	Direction I	99	6	**High**
	Direction II	86	6	**High**
	Direction III	90	6	**High**
Agglomerate	Direction I	72	7	**High**
	Direction II	76	11	**High**
	Direction III	73	9	**High**
Polished Granite	Direction I	113	6	**High**
	Direction II	95	9	**High**
	Direction III	95	11	**High**
Terrazzo Natural Finish	Direction I	89	5	**High**
	Direction II	81	8	**High**
	Direction III	85	6	**High**
Terrazzo Gloss Finish	Direction I	65	24	**High**
	Direction II	67	24	**High**
	Direction III	72	26	**Moderate/High**
Honed Limestone	Direction I	71	21	**High**
	Direction II	76	22	**High**
	Direction III	66	22	**High**
Polished Limestone	Direction I	71	26	**Moderate/High**
	Direction II	71	41	**Low**
	Direction III	66	25	**Moderate/High**
Rivan Slate Gloss Finish	Direction I	61	40	**Low**
	Direction II	62	43	**Low**
	Direction III	61	45	**Low**
Pebble Mosaic	Direction I	71	56	**Low**
	Direction II	71	64	**Low**
	Direction III	70	60	**Low**
Rivan Slate Natural Finish	Direction I	64	50	**Low**
	Direction II	60	50	**Low**
	Direction III	62	52	**Low**
Natural Stone	Direction I	72	61	**Low**
	Direction II	69	66	**Low**
	Direction III	70	66	**Low**

Table 5.5.1 HSE Pendulum results in dry and wet conditions for natural and manmade stones.

The UK Slip Resistance Group (UKSRG) guidelines on the interpretation of pendulum data are as follows:

Pendulum Value	**Potential for Slip**
Below 24	High
Between 25 and 35	Moderate
Above 36	Low

Table 5.5.2 Interpretation of pendulum data

As expected the pendulum values for wet materials are much lower in wet conditions than in dry conditions. However it is important to note that even polished materials and man made materials with a gloss finish can have a high SRV in wet conditions and therefore represent a low risk to slipping.

The second study of relevance to this research looked at the SRV of various concrete surfaces in-situ. It was noted that over time, and through passage of pedestrians over the surface of the pieces, that the surface may be subjected to manual polishing by pedestrians shoes and this would decrease the SRV of RC over time.

On the basis of these two reports it was felt that despite the highly polished surface of the test samples slip resistance may be high enough to be fit for purpose therefore testing was carried out on a polished sample that was as similar as possible to the surface of the intended final piece.

Test Sample Preparation

Two test designs were prepared that replicated the two main varieties of surface graphic on the prototype the first is designated "Teacher" and the second designated 'Dots' (See figure 5.5.1). Exactly the same techniques were used to create the test blocks as the full-scale prototype (See Chapter 6, Section 6.6[3]). 6 test samples were prepared with the following dimensions 100mm x 200mm x 50mm as seen in Figure 5.5.2. The blocks were finished as per the prototype (ground and polished using the flex grinder to orange). No surface sealer or wax was used on the surface.

Teacher Dots

Figure 5.5.1 Two test surfaces

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[3] Chapter 6, Section 6.6, page 148

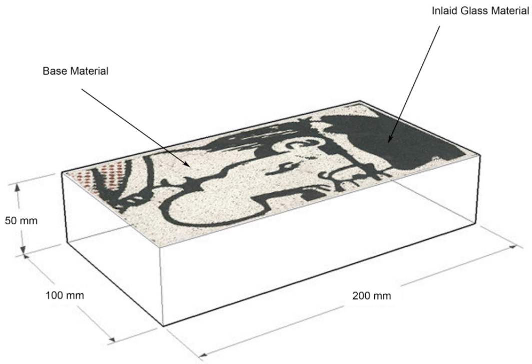

Figure 5.5.2 Test panel dimensions

Determination of skid resistance using the pendulum tester results

The testing results discussed here were conducted at the Lancashire County Laboratory, Highways Section in Preston under by J. Thorp and J. Walmsley.

The first tests were conducted using the block polished with the flex grinder through to DK holdings orange pad (12000 Grit, 1-3 micron) this is the standard finish and highest polish.

The tests were all conducted in accordance with BS EN 13036-4:2003 and BS 7976-2:2002. The pendulum tests were performed using wide slider assembly and TRL' CEN slider rubber prepared using 400 grade resin bonded paper.
Slip resistance test results 1 are shown in table 5.5.3

Test Sample	Material Surface/ Type	Mean Slip Resistance Value (SRV)	Wet Surface Temperature (°C)	Mean Corrected (SRV)
Teacher	Polished (Orange)	60	20	60
Dots	Polished (Orange)	56	20	56
Reverse Face (Teacher)	Polished (Trojan)	67	20	67
Reverse Face (Dots)	Polished (Trojan)	67	20	67

Table 5.5.3 Slip resistance testing results (1)

The minimum mean Slip Resistance Value (SRV) for public highways is 60. While this value is substantially higher than most of the wet SRV of natural stones and man made materials tested by the HSE, this value is set by LCC according to health and safety regulations. The higher value is required for outdoor highways and is in part to combat issues with differentials in the amount of surface traction in practice. In other words people automatically reduce their stride length when they experience reduced traction. Most problems with slipping occur when a person crosses from a material with a high SRV to one with a low SRV. Due to the design and concept of the finished piece this would be the case and so a value of over 60 and ideally over 70 was required. To obtain an increased value, surface treatments that would increase the traction on the surface were required. There were two main methods used to achieve this. The first was to sandblast the surface and the second was to simply not use the polishing pads on the surface and use the coarser grinding discs to introduce a texture to the surface.

These surfaces were then re-tested and the results shown in Table 5.5.4.

Test Sample	Material Surface/ Type	Mean Slip Test Value (STV)	Wet Surface Temperature (°C)	Mean Corrected (STV)
Dots	Sandblasted	67	21	67
Teacher	Sandblasted	62	21	62
Teacher	Polished (Green)	56	21	56
Teacher	Polished (Trojan)	70	21	70

Table 5.5.4 Slip resistance testing results (2)

Conclusions from Slip Testing

The results of the second test were different from what was anticipated. It was expected that the sandblasted surface with the greater texture would have an increased resistance to slip. In fact, the most resistant was the sample ground with the coarse diamond disc (Trojan). While the Trojan disc gives a surface that is not highly polished it is sufficient for the application. The visible surface scratches on the glazed areas would not be detrimental to the overall piece.

The tests conducted are sufficient to prove that the material is capable of application as outdoor flooring with appropriate treatment. However, the recommendation from the testing facility was that additional testing be conducted at a recognised facility that increased the number of samples tested prior to actual instillation of the full piece.

Simulated use and the polishing of the surface from pedestrian traffic requires testing, alongside research conducted into the abrasion resistance of the material and the issues that may be associated with cleaning and maintaining the piece over time. These tests have not been covered in this PhD but are planned for the future.

Chapter 5 Adapting, Manipulating and Evaluating

This chapter will discuss the various methods explored that can be used to adapt and change both the structural and visual qualities of RC. This chapter presents a broad investigation of these methods and outlines research conducted that evaluated:

- Increasing the strength of RC using metal fibres.
- Adapting RC surfaces through adding aggregates.
- Changing the colour of a refractory body using ceramic colouring oxides.
- The possibilities for glazing RC.

This chapter also documents two quantitative studies into the suitability of RC in outdoor environments by conducting standardized freeze/thaw testing and an evaluation of the slip resistance of RC.

5.1 Evaluating and Increasing Strength

The previous chapter looked at the range of refractories that were evaluated throughout the investigation. The aim was to represent a mix of the refractories available and establish the materials that might present the most potential in terms of structural properties, usability and visual appearance. After this initial period of cataloguing and evaluation it was important to establish the strength of the materials. From the initial materials collected 5 were selected for assessment in the three point bend apparatus[1]. These were:

(A) Jon Flo 90, selected as on visual and physical appearance seemed to be the strongest of all the materials collected.
(B) Linco Baxo Heavy, selected as it was a low cost generic castable.
(C) Molochite - 50% high alumina cement (Secar 71 La Farge) - 25% China Clay 25%. To evaluate how 'home made' refractory concrete would behave in testing.[2]
(D) Portland cement - 33% Molochite 66%. To offer a comparison with conventional concrete[3]

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[1] Three point bend testing is the established method for determining the breaking point of a material. Force is applied to a test sample from two points on one side with one bar on other side, force is applied until the sample fractures

[2] Tests C&D are both "home made" materials. Industry refractory concretes make use of complex ordered packing of aggregates involving very specific distribution of the aggregate sizes and binders. In practice this requires a very wide range of different aggregate sizes from micro silica upwards. The sourcing and sorting of these materials proved impractical in the scope of this project and so a simplified recipe was developed.

(E) Jon Flo 90 with 5% Microtex addition by weight

Literature based research revealed a company called Fibretech[4] supplying stainless steel metal fibres for high temperature applications. Fibretech sell a number of different grade fibres for different applications, including refractory reinforcement and automotive applications. After consultation with the technical department it was decided that a visit to the site would be beneficial. On paper it appeared that the fibre nails would be suitable as the maximum temperature rating was above the maximum operating temperature of studio kilns. However, on inspection it was clear that working with the sharp nails would pose health and safety problems. In addition the surface quality would be unsuitable for most aesthetic applications. After further consultation on site, it was decided that Microtex - a material designed for use in motorcycle exhausts would be more suitable. The only potential issue with the Microtex would be the maximum operating temperature of 1200°C

Jon Flo 90 was the hardest of the materials examined and therefore it was chosen as the material to test the anticipated increase in tensile strength that Microtex would bring in reducing crack propagation and thus increased strength. The Microtex was added at 5% by weight in the Jon flow matrix by layering alternating materials. These are identified as tests (E) each of the selected materials were cast into identical bars measuring 20mm x30mm x 135mm.

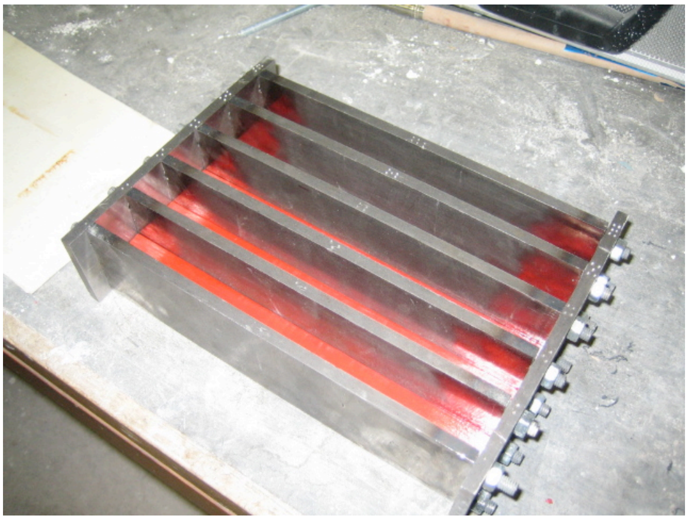

Figure 5.1.1 Test bar mould

10 bars of each material were prepared, and were all fired to 1200 c in an oxidising atmosphere using an electric kiln, with the exception of the Portland cement tests (D),

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[3] To gauge the difference between the HAC and Portland mixes and establish the strength of refractory relative to conventional concrete.

[4] http://www.fibretech.com/PDF/PRODUCTS/microtex_refractory_datasheet.pdf

which were left to reach full maturity (28days). The test bars were then tested in a Hounsfield Tensometer. The objective of the experiment was to establish the increase, if any, that the Microtex material had on the breaking strength of the refractory material. The test results clearly demonstrate that an increase in breaking point is achieved with a 5%, by weight, addition of Microtex. (See figure 5.1.2). With these initial tests completed it became clear that one material Jon Flo 90 presented the most potential in terms of its physical properties pre and post firing. This was confirmed by both visual and physical inspection and the quantitative data from the 3-point bend tests. The tests also demonstrate the considerable difference between the relatively low strength of the Portland tests (D) and the Jon Flo test (A). Furthermore the tests highlight the difference between a ‘home made’ refractory and the highly engineered industrial refractory and reinforce the decision to focus the research on “off the shelve” materials sourced directly from the refractory industry.

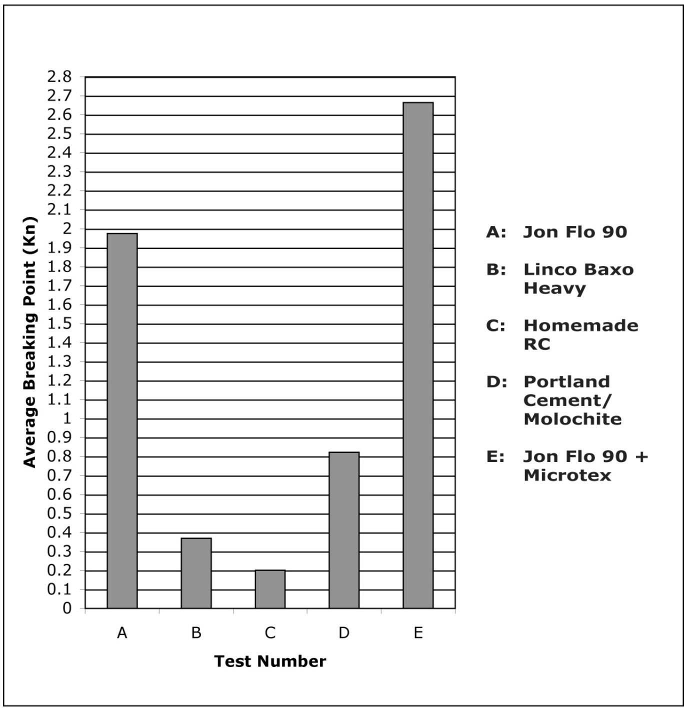

Figure 5.1.2 Average breaking point test results

Through the materials investigation phase of the research, and the research discussed above, one particular material was identified with unique properties that allowed a breadth of different applications to be explored. Jon Flo 90 was the main material used in the construction of the practice-based projects. While there may have been advantages in exploring applications with other materials sourced throughout the material testing, there were a number of factors that made Jon Flo 90 the material of choice for much of the research. The primary reason was the material’s clear strength advantage over other materials. Secondly it had a neutral fired white appearance that after initial glaze testing proved the most receptive to glazing. The flowing property combined with the high green strength would open up possibilities in the practice-based element of the research. Furthermore, it was decided that concentrating on one material would allow a more focussed exploration of the materials potential in applications. Finally, the manufacturer of Jon Flo 90 (Sheffield Refractories Ltd) had agreed to contribute to the research by supplying material free of charge.

5.2 Manipulating Refractory Bodies

One of the objectives of the research was to explore the ways in which the aesthetic properties of RC could be enhanced through the use of ceramic techniques. The investigations discussed here cannot claim to offer an exhaustive and entirely rigorous investigation, as many materials and additives have been left unexplored. The tests conducted can be seen as proving the concept and warrant further exploration.

One of the ways in which this can be achieved is by the addition of materials to the refractory body. There are two categories that fall under this technique. The first is the addition of materials, such as ceramic aggregates, organic matter and mineral additions. The second is the addition of colouring oxides to alter the colour of the refractory body.

The number of materials that can be added to RC is vast; all of those that are traditionally added to ceramic bodies could be effectively introduced to refractories. The scope of this project does not extend to testing all of these options for two reasons; firstly the sheer number of different materials available means a purely superficial investigation is all that could have been achieved, this is exacerbated when the number of different RCs are also considered. Secondly, the introduction of organic materials would have a detrimental effect on the structural properties of the concrete. Considering the practical phase of the research and the structural applications explored this was not deemed to be an appropriate area for research within this project. The research that was conducted focussed on the addition of mineral aggregates to alter the aesthetic quality of RC.

Addition of coloured aggregates

The range of different aggregates that could be added to concrete is again extensive and would depend entirely on the application and surface desired. Aggregates in the body of a concrete are only revealed through grinding and polishing of the surface. In most cases it would be more appropriate to select a RC with the aggregate colour or appearance as an existing part of the mix. For these reasons only one series of tests was needed to establish that ‘self-made’ and coloured clay aggregates could be added and what aesthetic this would achieve.

As has already been covered- RCs rely on specific percentages of different aggregate sizes for some of the structural properties that they present. Therefore, any additional aggregates will potentially have an adverse effect on the casting properties and the fired properties. For this reason it is recommended that any added aggregates be relatively low in proportion to the concrete itself.

The projects philosophy was, wherever possible, to keep the practical work grounded in real or live projects. The testing and experimentation for the addition of aggregates to RC was done for the Tatton Project (discussed in Chapter 6, Section 6.2[5]). The project required the addition of a dark porcelain aggregate. Copper oxide was used to stain the porcelain. Two different strengths of porcelain were used 5% and 2.5% to give a dark and a light aggregate respectively, these were thoroughly mixed when fired. Two stages were required to create the aggregate. This first stage was to fire the mixed clay to 800°C, this temperature makes the aggregate soft enough to crush easily but hard enough to give a variety of aggregate sizes (see figure 5.2.1). The crushed aggregate was sieved to remove dust and then re-fired to 1260°C. This temperature was higher than the final piece was to be fired to so that the porcelain did not shrink further in the Jon Flo 90 and did not break up in the high intensity mixer.

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[5] Chapter 6, Section 6.2, page 98

Figure 5.2.1 Crushing porcelain grog

The fired grog was added in the following ratios:

Test Number	1	2	3	4	5
Porcelain Stained Grog	2%	4%	6%	8%	10%
Jon Flo 90	98%	96%	94%	92%	90%

Table 5.2.1 Stained porcelain and Jon Flo 90 ratios

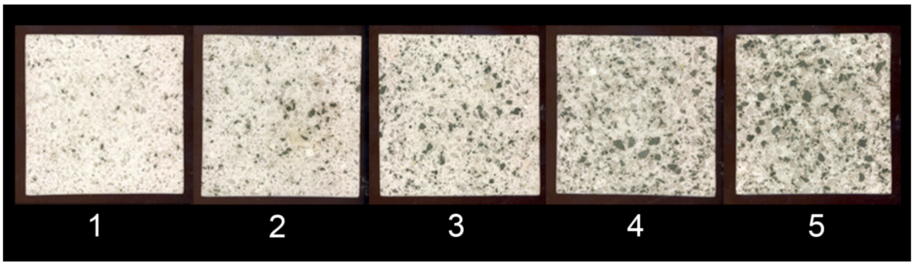

Figure 5.2.2 Stained porcelain grog and Jon Flo 90 tests

The aggregate tests established that a ratio of 6% copper grog to 94% Jon Flo 90 (3) gave the required aesthetic.

Staining Tests

The second area of investigation was the addition of metal oxides to refractories. The entire range of oxides that are available to the ceramic artist were not tested. However, it was felt that the oxides tested would give a clear enough indication of the interaction between RC and ceramic colouring oxides.

This method has long been used in ceramics to adjust the colour of a base clay for decorative purposes. Problems with blistering and fluxing of clay bodies can occur as higher percentages of oxide are added to give stronger colours, particularly at higher temperatures. The hypothesis was that higher percentages of oxide could be added to refractories without these issues being presented. The aim of the tests was also to establish how effectively the colour of a RC could be altered and whether the addition of oxides would have a detrimental effect on the casting process.

Three of the most commonly available, and economically viable for use on a large scale, were selected for line blend tests. The oxides were red iron oxide, copper oxide, and manganese dioxide. The percentages of oxide were introduced increasing in 2% increments and were kept constant for each of the tests. See table 5.2.2.

Test Number	1	2	3	4	5	6
Oxide (Dry)	2% (10g)	4% (20g)	6% (30g)	8% (40g)	10% (50g)	12% (60g)
Jon Flo 90 (Wet weight)	100% (500g)	100% (500g)	100% (500g)	100% (500g)	100% (500g)	100% (500g)

Table 5.2.2 Oxide to material ratios

The oxides were mixed with water to make a paste before being mixed with pre-mixed Jon Flo 90. The oxide paste was then added to the concrete and thoroughly mixed for 5 minutes before being cast in the 5cm^3 steel mould. The consistency obviously changed as higher percentages of oxide were introduced and the rheology of the material was changed. At the higher percentages of oxide the flow properties are exaggerated and a more fluid material is created. However, it seemed to have no effect on green strength (not verified through testing).

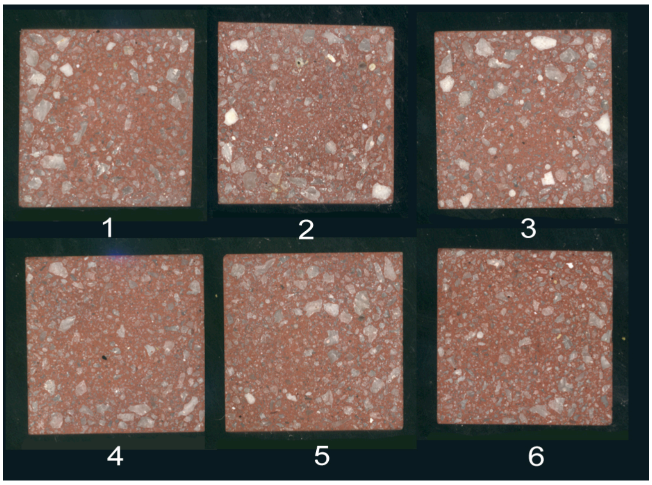

Figure 5.2.3 Red Iron Oxide tests

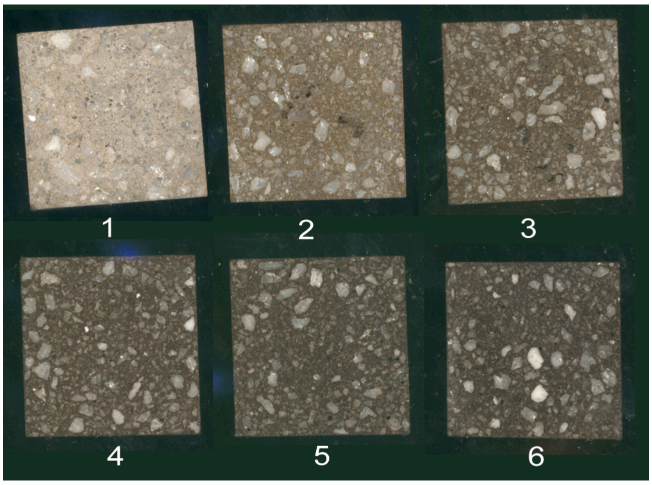

Figure 5.2.4 Manganese Dioxide tests

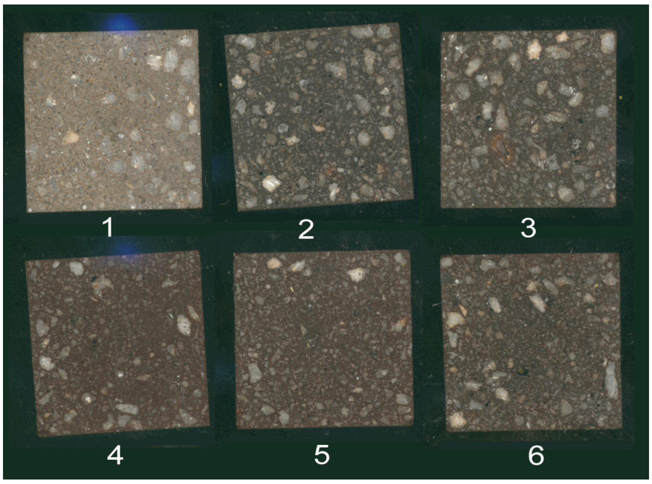

Figure 5.2.5 Copper Oxide tests

The fired results (Figures 5.2.3-5.2.5) showed no evidence of blistering or fluxing of the surface as might occur at high percentages in clay. In addition, while not tested, the fluxing effect of the oxides appeared to increase the fired hardness of the material. There was very little difference in strength of colour between the different red iron oxide tests. However, in both the copper oxide and the manganese dioxide tests a marked difference between the lower percentage and higher percentages was observed.

The addition of oxides to RC would prove expensive if applied on a large scale. However, it is conceivable depending on the mould construction and the piece in question that an outer skin of stained concrete could be created that would reduce the cost implications. Marbling of colours might also be an interesting avenue to pursue in the future and would also reduce the cost implications.

5.3 Glaze testing

Glaze was identified as one of the methods in which refractory concrete’s visual and surface qualities could be enhanced, at the same time taking the aesthetic of the material away from conventional concrete; opening up RC to the huge variety of ceramic glazes and surface treatments developed throughout the history of ceramic development.

The first stage was to establish that glaze could be applied and ensure that it would fit to the RCs. Within conventional ceramics, aside from aesthetic considerations, glaze also has a functional application sealing the porous ceramic, creating a more durable material, through development of a glaze/body interface.

Glazes, and the ceramic body they are applied to, have different expansion and contraction rates during heating and cooling; glaze fit being essentially a function of compression and tension. In the simplest terms the glaze and the ceramic body need to expand and contract at similar rates. An exact match is not necessary, however sufficient differences in the rates of expansion and contraction can cause glaze defects as outlined below.

The body expansion of a ceramic and indeed a refractory concrete are dependant on the amount, proportions and compositions of the glassy phases within the body and also the temperature at which it is fired. Similarly the glaze composition will affect the glaze rates of expansion and contraction. There are a number of glaze problems that can occur as a result of a poor match of these expansion and contraction rates and it was anticipated that some of these problems would be evident when glazing RC. The thousands of glazes developed over the years have been developed to fit on ceramic bodies, all of which have very different material compositions from RC.

For clarity the three main glaze defects that can occur in ceramics are discussed here and the symptoms outlined.

Crazing, where the glaze cracks on the surface. Caused when the glaze is in tension. Most common in Alkaline glazes due to a high rate of contraction on cooling.

Shivering, where a glaze shells and flakes on the surface, the opposite of crazing. Caused when a glaze is in compression. More prevalent in stoneware glazes where the glaze and body mature at the same time.

Crawling, where a glaze peels and pools on the surface. Caused by high surface tension when a glaze is at its molten stage, normally due to high percentages of aluminium oxide in the glaze recipe.

It was decided that earthenware glazes would be the most suitable starting point for a number of reasons: there is very little interaction between glaze and body, earthenware glazes mature at a relatively low temperature (1060°C-1160°C) and are therefore less likely to suffer from the defects described above, the low temperature makes them far more economical in terms of the energy expanded in their firing. Finally, the colour range is far more predictable and standardized using stains.

The first glaze tests used a green copper glaze (E2) and two factory opaque earthenware glazes (glaze constituents and recipes not available) The refractory materials tested were: “Homemade” RC, Linco Baxo Heavy and Jon Flo 90(See Figure 5.3.1)

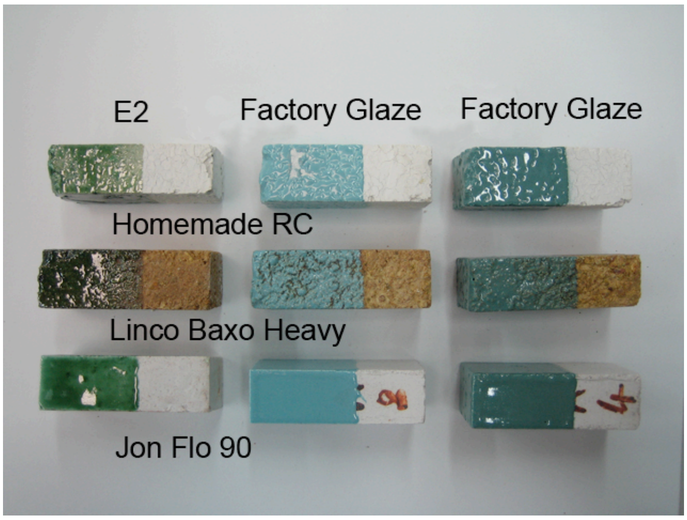

Figure 5.3.1 Earthenware glaze tests

It was clear from this initial test that the most successfully glazed sample was the Jon Flo, the white body posing no problems with creating a clear shiny glaze similar to what would be expected of a clay sample.

After establishing that a glaze could be used successfully without any of the issues highlighted above, it was decided that a small sample of stoneware glazes should also be tested on the same set of materials to give an early indication of the performance of these more durable glazes. Three glazes were tested with the recipes chosen at random. (Recipes for the stoneware glazes (S(a) S(b) and S(c)) can be found in Appendix 1). The test tiles were bisque fired to 1200°C and then fired to 1260°C in an oxidising atmosphere. The results are shown in figure 5.3.2.

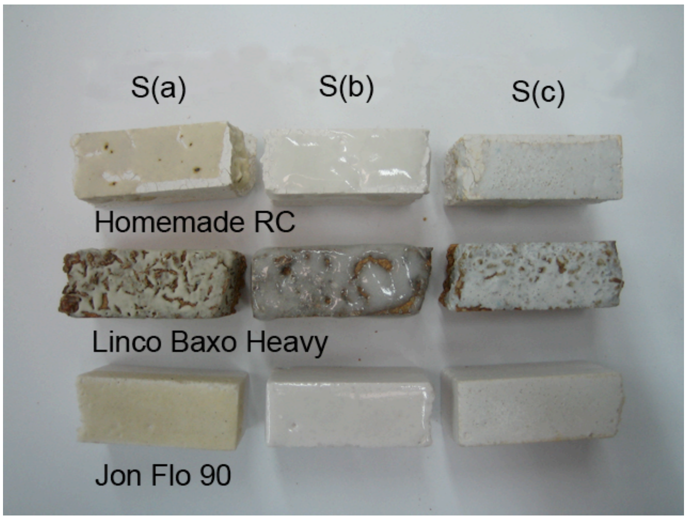

Figure 5.3.2 Stoneware glaze tests

Following these initial investigations it was decided that expanding the glaze testing to include some other earthenware glazes would confirm that a range of earthenware glazes would work regardless of the constituents.

Comparative study of different refractory bodies and glazes.

After this initial testing a more systematic approach was used in which 7 RC's were tested with line blend glaze mixes. For each RC two tiles were prepared. One of the tiles was pre fired to 1000c before glaze application, the second was left green.

There were three main objectives for these tests; the first was to establish whether once firing of glazed RC would be feasible and what effect this would have on glaze compatibility. This is important from an economical point of view, as it negates the need for two firings. The second objective was to determine any change in glaze fit by altering glaze constituents. It was anticipated that this data would enable some general rules to be generated that could be applied in adapting glaze fit for RCs. The third objective was to establish the differences or similarities between the glaze results over 7 different RC samples.

The 7 Materials selected for glaze testing were:

- Jon Flo 90
- Narco Gun SiC
- Accelerate ABR plus
- Ultra Green 45
- Ultra Green 80
- Mizzou
- HTC

Line Blends

Two different line blends were formulated, both were base glazes without colouring oxides. It was anticipated that increased percentages of china clay would have an adverse effect on glaze fit due to the increased shrinkage this can cause. The first line blend (A) kept flint as a constant 15% with decreasing percentages of lead bi-silicate in 2% increments and increasing percentages of china clay in 2% increments. See table 5.3.1

	Line Blend (A)									
Test Number	1	2	3	4	5	6	7	8	9	10
Lead Bi-Silicate	83	81	79	77	75	73	71	69	67	65
Flint	15	15	15	15	15	15	15	15	15	15
China Clay	2	4	6	8	19	12	14	16	18	20

Table 5.3.1

Line blend B looked to further verify the effect of china clay on glaze fit and quality. The first line shows combined lead bi-silicate 75% flint 15% and china clay 10% as decreasing in 2% increments and with additional china clay increasing in 2% increments.

	Line Blend (B)									
Test Number	1	2	3	4	5	6	7	8	9	10
Lead Bi-Silicate:75% Flint:15% China Clay:10%	98	96	94	92	90	88	86	84	82	80
China Clay	2	4	6	8	10	12	14	16	18	20

Table 5.3.2

Test Procedure

Each of the test numbers were measured out as dry weight and then mixed individually with water before being passed through an 80 mesh sieve. Both sets of glazes were then applied to both sets of tiles using a brush to create a uniform thickness of 2mm ± 0.2mm. (See Figure 5.3.3)

Figure 5.3.3 Tiles prepared and ready for firing

Results of Line Blends

The following pages show the glaze results with the raw glazed tile at the top of the page and the bisque or pre-fired tile on the bottom

Jon Flo 90

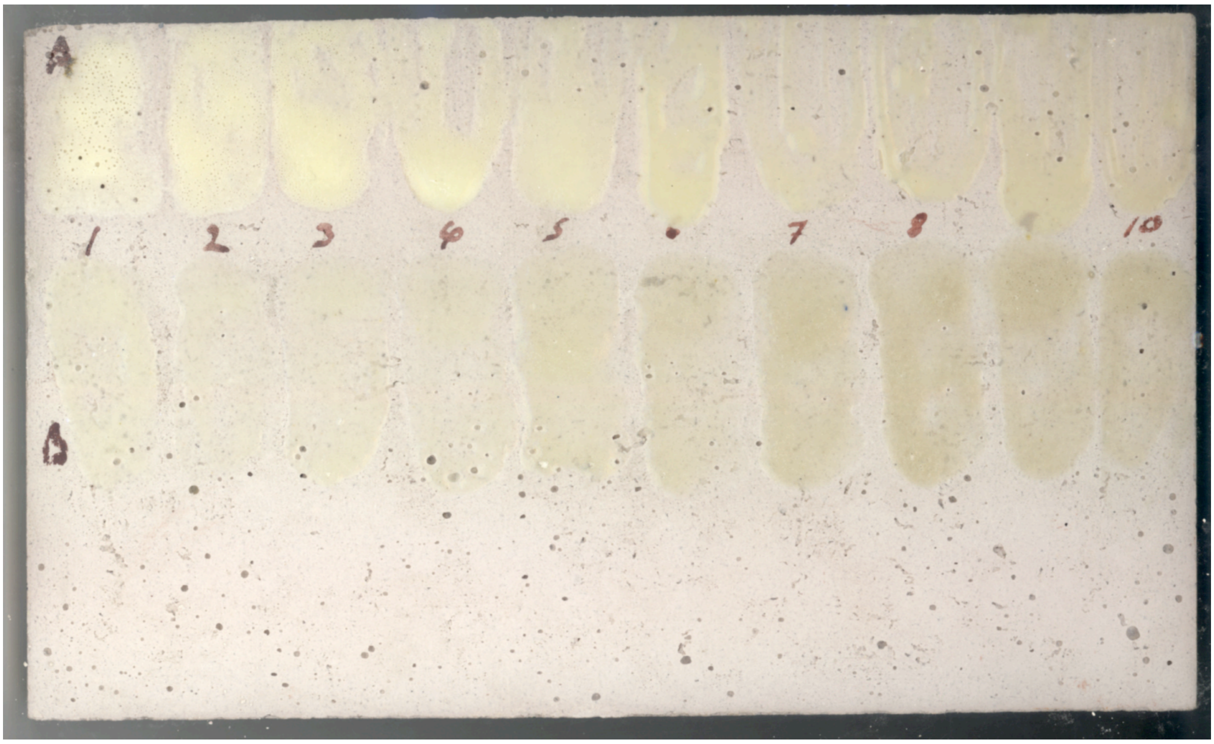

Figure 5.3.4

Figure 5.3.5

Narco Gun SiC

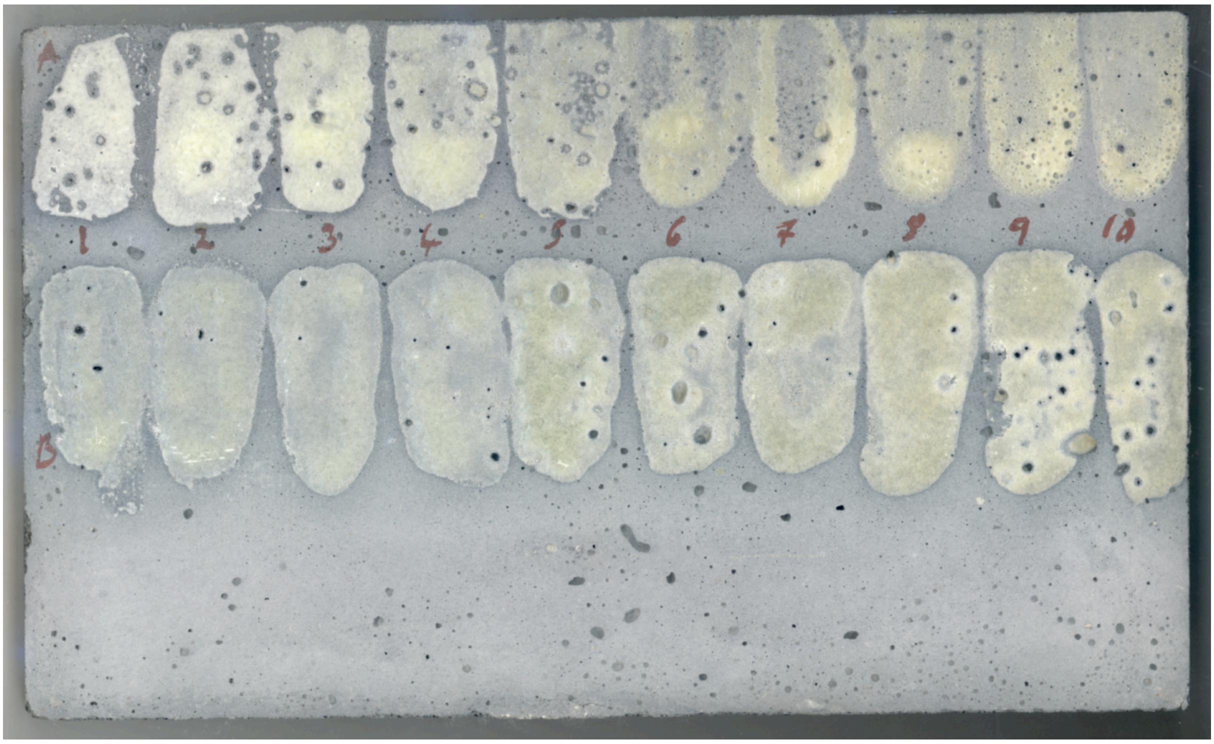

Figure 5.3.6

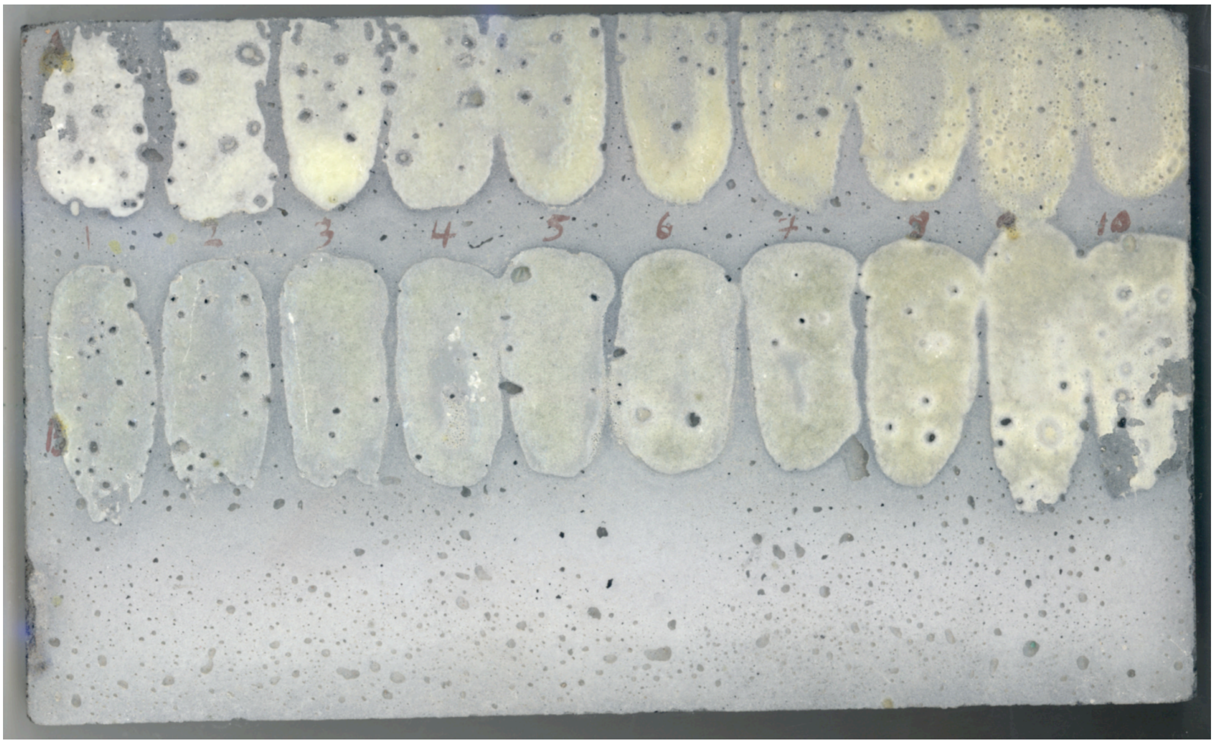

Figure 4.5.3.7

Accelerate ABR plus

Figure 5.3.8

Figure 5.3.9

Ultra Green 45

Figure 5.3.10

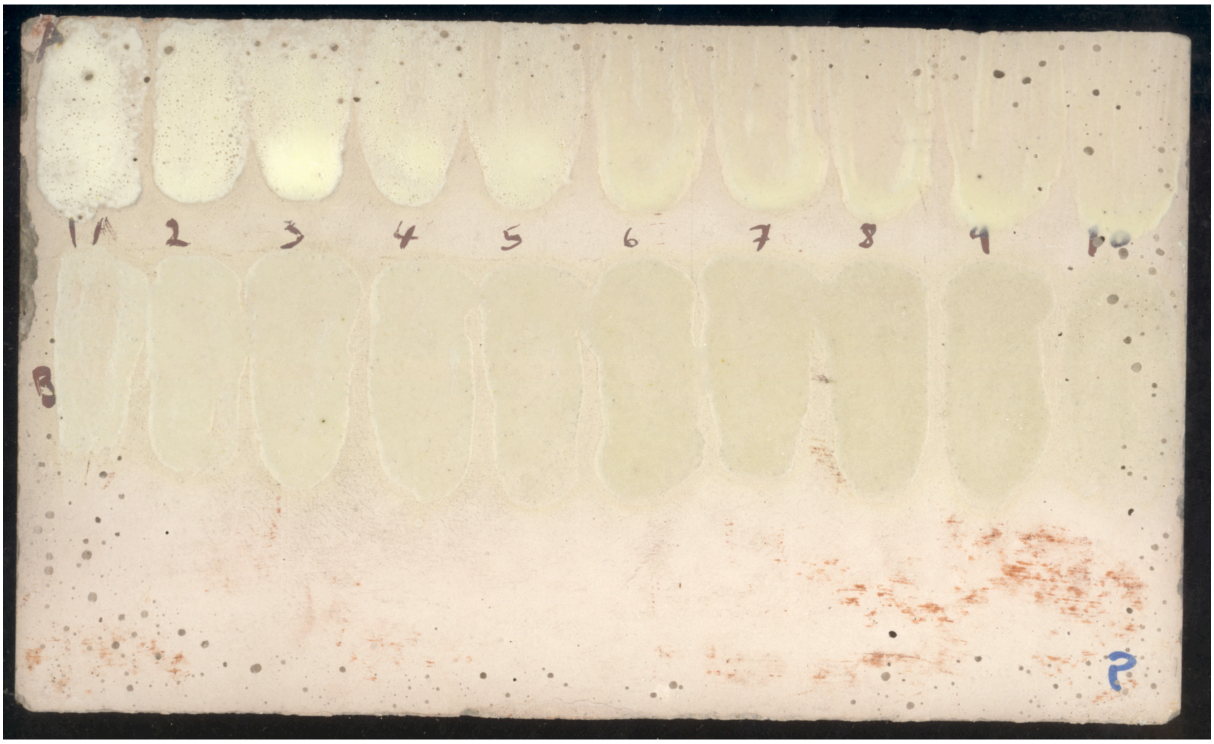

Figure 5.3.11

Ultra Green 80

Figure 5.3.12

Figure 5.3.13

Mizzou

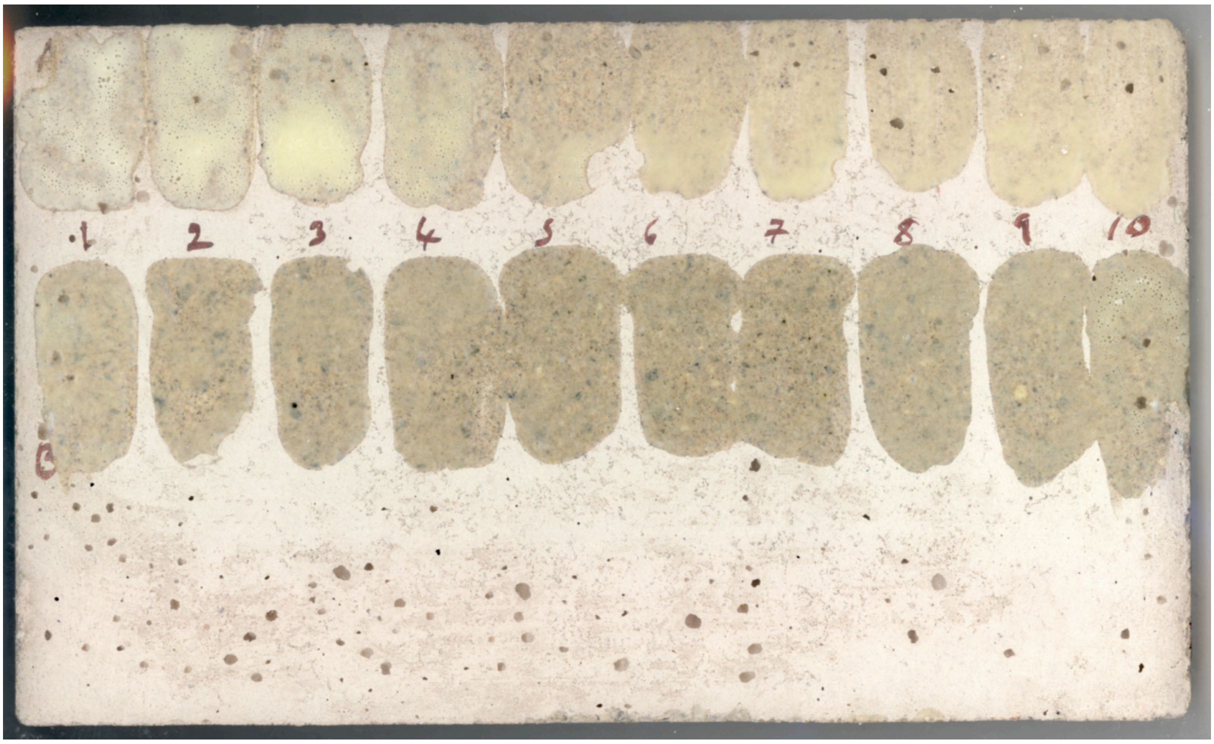

Figure 5.3.14

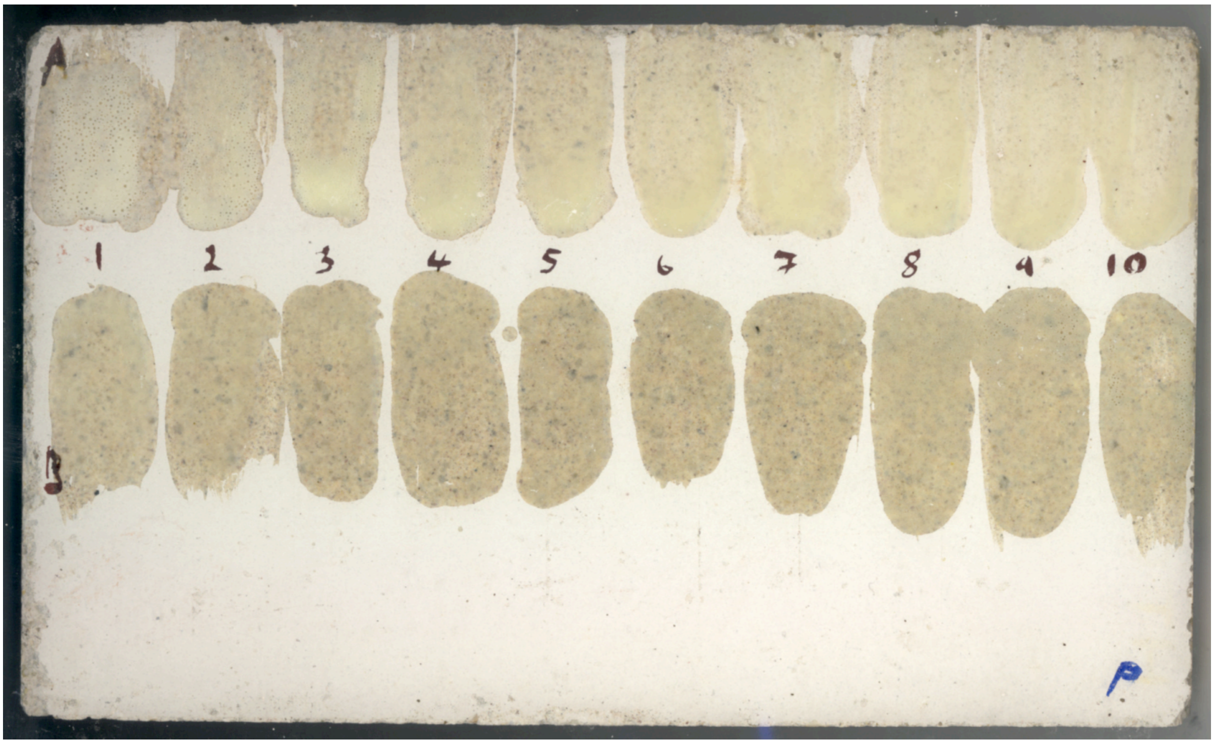

Figure 5.3.15

HTC

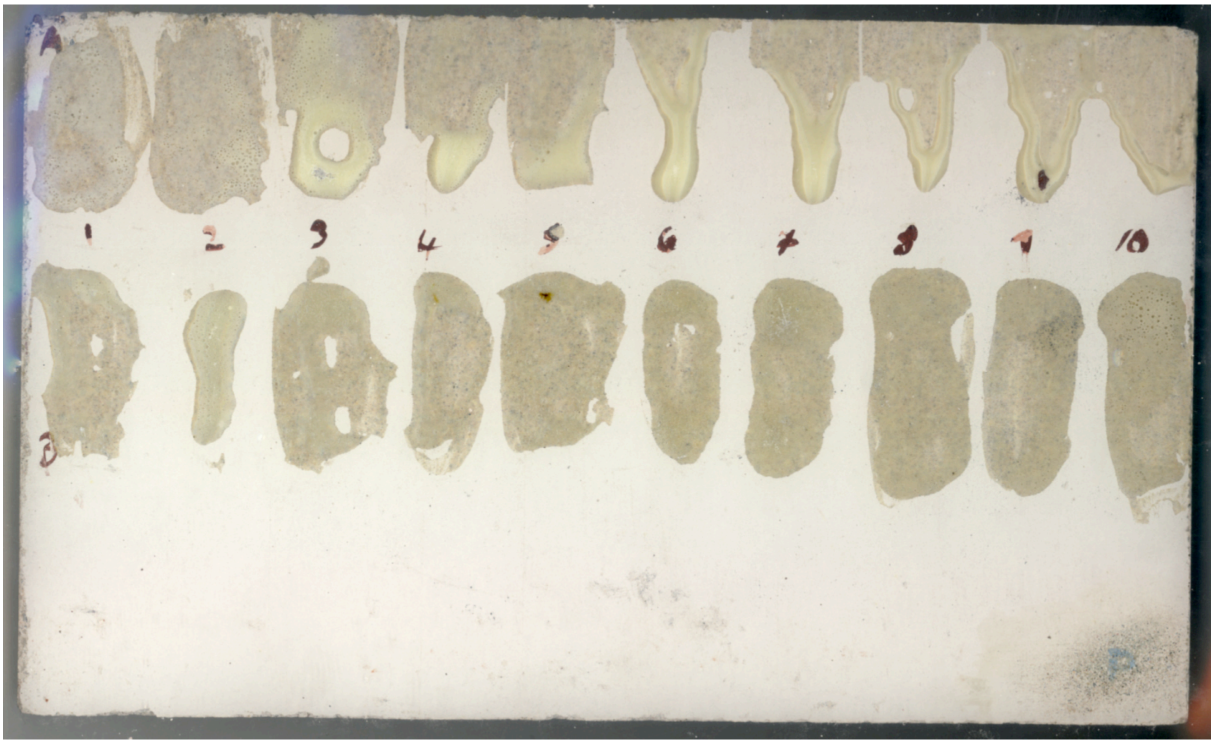

Figure 5.3.16

Figure 5.3.17

Conclusions from Line Blend testing

The first objective of these tests was to establish whether once firing of glazed RC would be feasible. It is clear that in some cases there is very little difference between the pre-fired and the raw fired tests. The four materials that had the least problems in glaze fit across both tests were: Jon Flo 90, Accelerate ABR Plus, and Mizzou. The remaining materials show a clear difference between the pre-fired and raw glazed tests. In general the bisque or pre-fired tests have a higher level of shine and less surface bubbles. So whilst once firing is possible it is the researcher’s opinion that in most cases pre-firing would be recommended.

The second objective of the tests was to evaluate glaze fit and the effect a change in the glaze constituents had. The function of china clay in glazes is to both make the glaze more durable in handling before firing and to increase the expansion coefficient. The line blends both had an increasing percentage of china clay from 1-10. In both blends the higher percentages of clay particularly over 12% resulted in poorer glaze fit and in many cases the glazes were more prone to crawling.

The third objective for the line blend tests was to establish the differences in glaze fit across a number of different materials. The results show that the glazes behave in a different way on a number of different materials. More importantly, the variety of results shown in the tests means that in practice for each individual material, individual glaze testing would need to be conducted.

However, there are a number of findings that can be drawn from the line blends. UG80 and HTC have very similar reactions from glaze A in test numbers 6-10, however this is only evident in the raw fired test. In both line blends a stable glaze resulted from the pre-fired material. Taking the example of UG 45 and UG 80. Both materials have very different fired compositions: with UG45 having 47% alumina and 47% silica. UG 80 has a fired composition of 81% alumina and 14% silica. However, when examined, the glaze tests display very little difference between the two RC materials. Certainly less than would be expected when the difference in composition is considered. This result demonstrates that far more complex interactions are taking place, making the prediction of a glaze performance from the published compositional data impossible, without further testing beyond the scope of this project.

Stoneware Glaze Tests

Following the earthenware glaze tests it was decided that an investigation of stoneware glazes should be conducted. Stoneware glazes have far more interaction with clay bodies, potentially making them more susceptible to glaze fit problems. However, this increased interaction creates an interface layer ultimately making stoneware glazes more durable. Finally stoneware glazes offer an increased pallet of colours and textures. Instead of testing on a number of different concretes it was felt that the stoneware tests should concentrate on Jon Flo 90.

The first phase of testing was to test 20 stoneware glazes collected from various sources including ceramic glaze books and from journals. To make firing easier the firing range of the glazes was limited to between 1240°C and 1280°C. Full details of the recipes can be found in Appendix 2. The glazes were all mixed according to standard ceramic practice and applied by dipping on to a raw concrete test tile (see Figure 5.3.18) (left) and a bisque fired tile (right). To allow for comparison the glazes were also applied to standard bisque fired stoneware clay test tile (top).

Figure 5.3.18 Stoneware tests S1-S20

The stoneware tests aimed to demonstrate that a wide range of different stoneware glazes can also be used to enhance the aesthetic qualities of RC. The test results show that the fit of stoneware glazes to the RC body is good and in none of the 20 tests were crazing, shivering or crawling observed. In comparison with the clay tests a slight difference is observed in the majority of glazes. While not immediately obvious from the images shown here, the surface has a less glossy appearance and has less depth.

With the stoneware tests a difference between the bisque fired (right) and the raw glazed RC (left) is evident; some of this difference can be attributed to a difference in the thickness of the glaze applied, due in part to the difference in porosity of the two materials. Even taking this into consideration, there is still a difference in the glaze surface with most of the tests having a duller appearance, showing again that while once firing is desirable from an economic standpoint, it has a detrimental effect on the glaze quality.

Following these tests 12 glazes of the 20 tested initially were selected for a series of Triaxial line blends. These tests were applied to only the bisque fired RC and clay tile for comparison. The results of which are shown in figures 5.3.20-5.3.24.

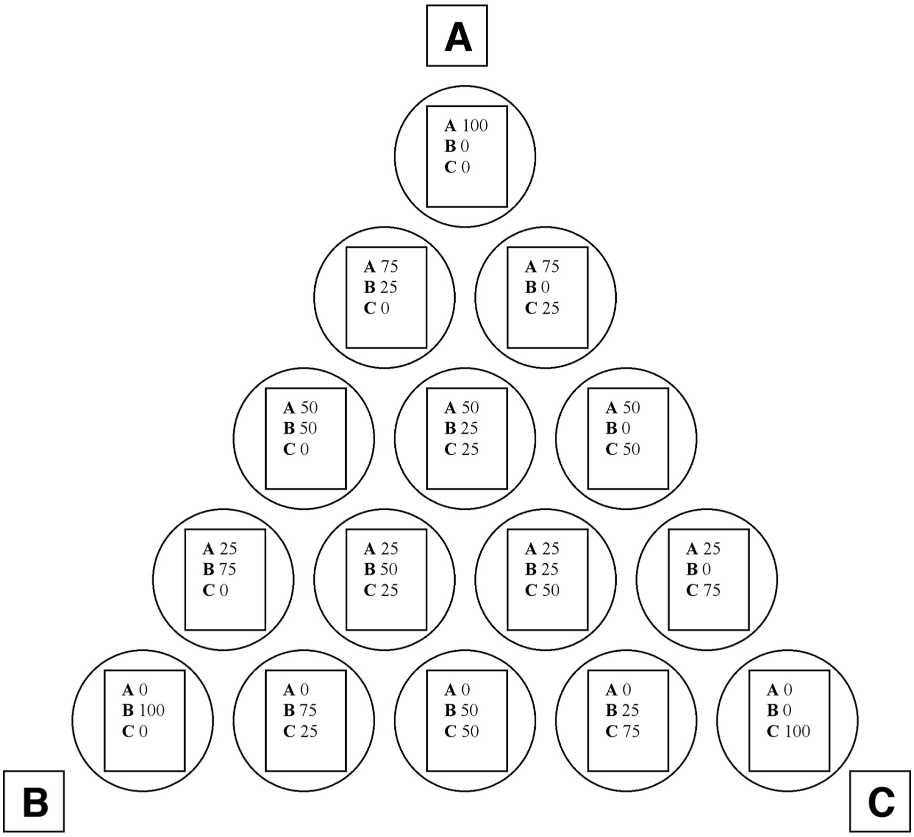

Figure 5.3.19 Triaxial line blend diagram

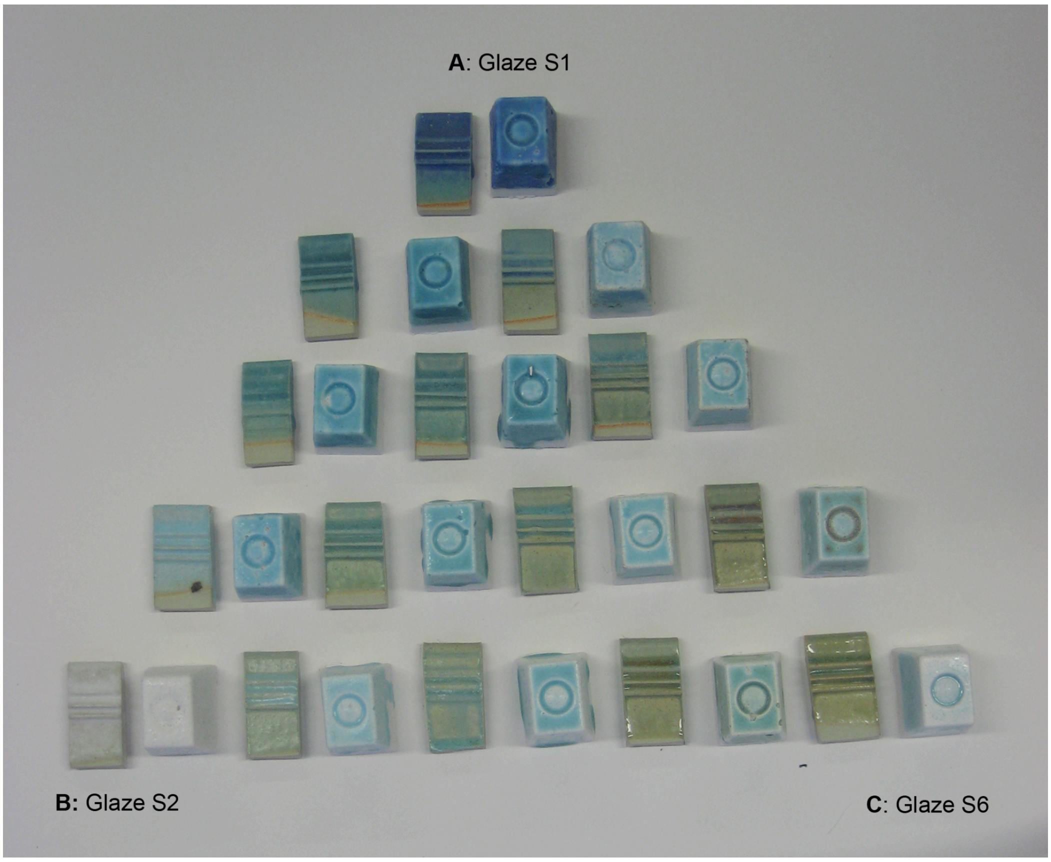

Figure 5.3.20 Triaxial blend 1

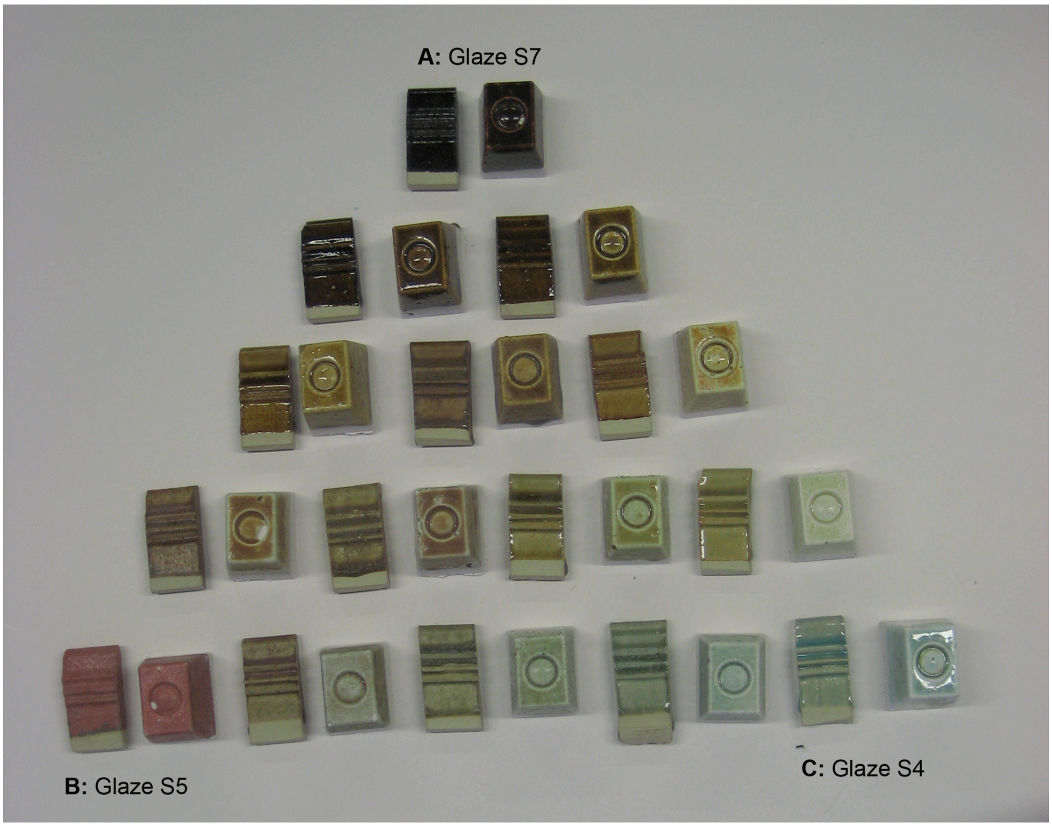

Figure 5.3.21 Triaxial blend 2

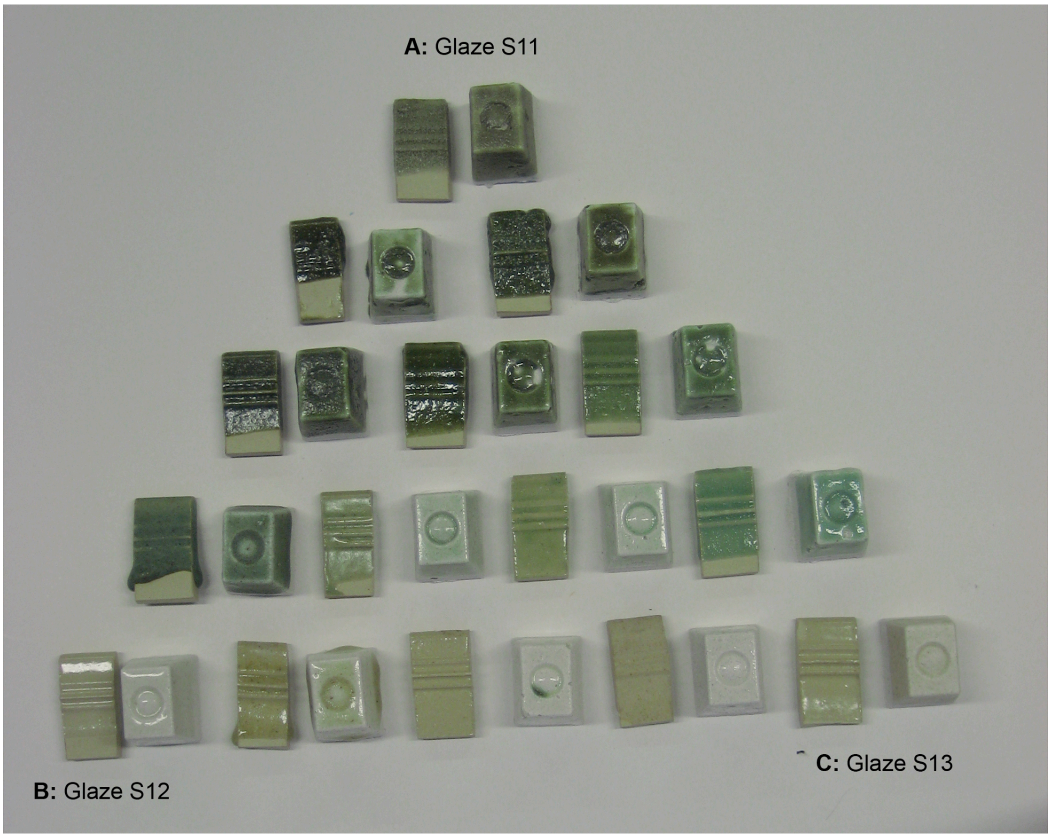

Figure 5.3.22 Triaxial blend 3

Figure 5.3.23 Triaxial blend 4

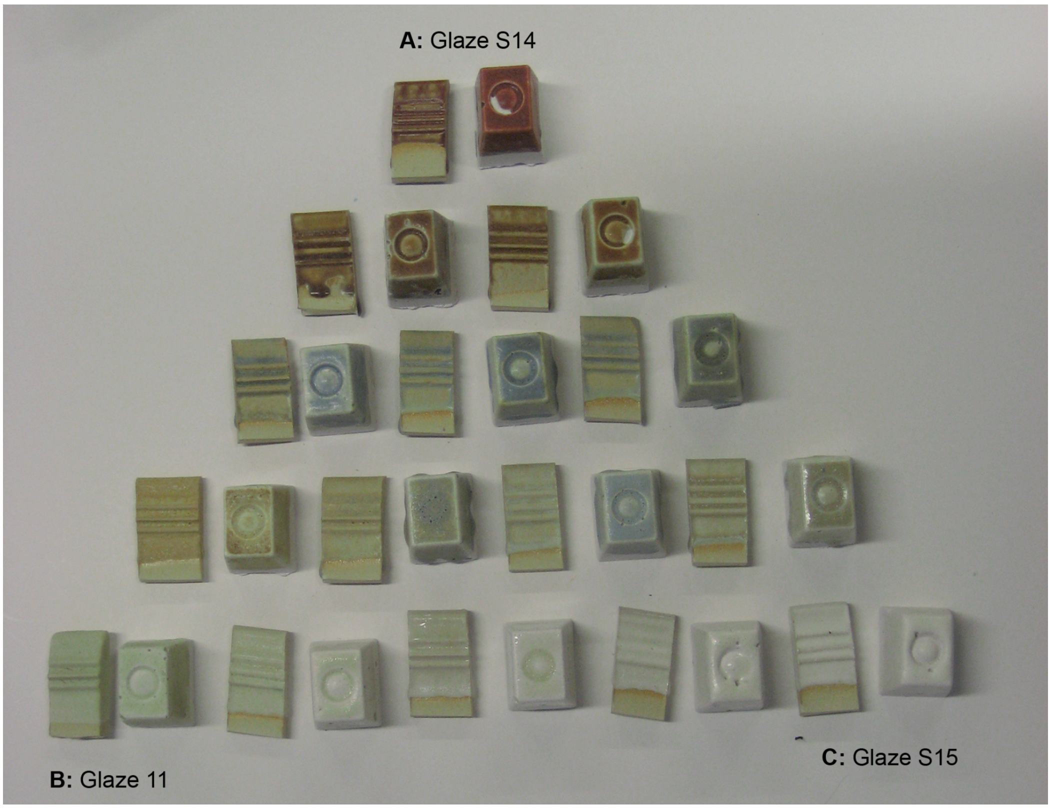

Figure 5.3.24 Triaxial blend 5

The triaxial line blend tests were designed primarily to identify differences that might be encountered through changes in the composition of the glazes. It widens the number of materials interacting and illustrates the compatibility of RC for glazing. Triaxial blends are also one of the ways in which ceramic artists develop and adjust glazes and so it was important to demonstrate that this method can also be adopted when working with RC.

Conclusions from Glaze Testing

By far the most consistently behaving glaze category were earthenware glazes. Their overall ability to perform consistently means that they have been the most tested and utilized in the practical case studies. This has been for two reasons: namely the lack of risk in using them, secondly the kilns available in the department for firing pieces of any real scale are limited to a maximum temperature of 1200°C in an oxidising atmosphere, so practicality has played a part in the glazes utilized. It is, however, important to note that there are disadvantages to using earthenware glazes including: the low temperature and the glaze constituents means that earthenware glazes are much softer and therefore much less durable compared to higher temperature stoneware glazes, the lack of interaction between glaze and body results in a week interface layer, which in turn can result in easier chipping of the glaze surface.

The research conducted has established that ‘once’ firing is possible, and while from an economic standpoint the glazing of raw RC is desirable, there are a number of issues that make once firing problematic. The porosity of the concrete when raw is very low; therefore generating sufficient glaze thickness is difficult. Secondly the fired glaze surface suffers from a lack of depth and can result in a more matt glaze. Finally, the residue from the release agent used when casting often remains on the surface of the object so care needs to be taken to fully remove this when once firing. Pre-firing the RC before glazing ensures that any such residues are removed.

In some cases and the effect of changing constituents can affect different RC in different ways depending on the raw materials present in the RC body: as is proved in the earthenware line blend tests. What has also been established through these tests is that a wide range of glazes, from both of the main ceramic glaze categories, can be utilised on RC demonstrating the potential for creative application of RC.

The glaze tests were not designed to explore the full range of ceramic glazes available; the sheer number of glazes would make this impossible within the scope of this project. In practice individual testing and adjusting of glazes would be required for each specific project as in any clay based project and so, it is debatable whether any more detailed glaze testing would be useful. However the tests here are purely concerned with the aesthetic qualities and glaze fit. The research has not looked at the interaction layer between glaze and body and more detailed investigation of the interface layer using techniques, such as electron microscopy from material science to examine interaction of glaze and RC, would be beneficial and would warrant further research.

Chapter 6 Practice Based Work

6.1 Introduction to Practice Based Work

As stated in the introduction, the research aimed to demonstrate a number of different applications and products in which RC could be employed. The intention was to show a breadth of applications and objects or products that would be impossible or extremely difficult if attempted in alternative materials.

The research is based around a number of advantages that RC can offer to the artist and designer over other materials. Primarily it sees the unique properties of RC as having advantages in a number of applications.

Many of the advantages outlined below were identified at the start of the research project and were hypothetical, drawn from the established industrial application of the material. The perceived advantages RC would offer were explored in a studio context and are demonstrated in the practical projects discussed in this chapter. However, others were revealed as a result of the practice-based work and were tested and verified through quantitative testing.

Strength: RC is considerably stronger than clay at a raw or unfired state, where it sets with a similar strength to conventional concrete. This strength is also transferred into fired objects where the strength of the material is also considerably stronger than fired clays.
Shrinkage: RC's in general have very low shrinkage and in most cases linear change from cast to fired will be zero. Compared with clays, which can shrink up to 12%. This allows dimensionally accurate pieces to be achieved.
Fired Stability: The lack of shrinkage also means a substantially lower risk of warping during firing.
Thermal shock resistant: As a result of their engineering and industrial heritage RC is designed to cope with rapid and uneven changes in temperature.
Compatible with ceramic surface decorations: The material allows for the introduction of a variety of ceramic surface decoration.
Colouring and Adaptable: RC can be manipulated with the addition of aggregates and metal oxides in the same way ceramics can. However RCs do not suffer from blistering or fluxing at higher concentrations.

Freeze Thaw Resistance: Data generated through this research demonstrates RCs ability to withstand severe freeze thaw conditions.
Slip Resistance: As an exterior flooring material, providing correct finishing, RC has a high slip resistance value.

Having discussed the advantages above it is also important to note that RC is not a material ideal or suitable for every application and in many cases other materials will be more appropriate. Therefore, there are a number of disadvantages that can similarly be listed:

Non-Plastic: RC has no inherent plasticity and therefore cannot be modelled or manipulated in the same way as clay, therefore requiring moulds to create forms.
Dense material: The materials density makes it considerably heavier than ceramics.
Decorative processes: certain ceramic surface decoration cannot be applied

Where possible the practice based elements of the research were live or real projects with specific and defined outcomes; rather than purely speculative or theoretical projects. This was seen as further grounding the research. Each of the practice-based investigations or experiments described within this chapter can be seen as individual projects that were designed to exploit the various properties of RC in practice.

The first project was titled **Tatton Monoliths.** The green strength of RC is considerably higher than that of a clay based material. This project looked to use this property to enable the construction of a large solid cast piece in a studio environment using equipment accessible to the average artist or designer. The high green strength combined with very fast drying and firing makes large-scale work both more manageable and achievable in short time scales.

The second project titled **Architectural Cladding** again drew upon the high green strength but also made use of the thixotropic effect or flowing property in some higher end refractories. Large format glazed sheets that could not be achieved in clay were created that were designed for possible architectural application. In the same project an open fretwork panel was created that further demonstrates the strength of the material.

The third project was developed within the framework of a larger project initiated by the European Ceramic Work Centre (EKWC) in the Netherlands and is titled **Brick.** The near zero shrinkage and potential for mass production were explored within this project. The potential for combining RC with kiln cast glass was an additional outcome to be explored.

The fourth project is titled **Graphic Panels.** Following on from the work in the previous projects, this project capitalized on the high green strength and RC’s ability to cast intricate surface relief on a large scale to create graphic panels based on encaustic tiles.

The **Urban Furniture** project looked to make use of the high modulus of rupture (MOR) presented by Jon Flo 90 to create urban furniture that could bridge gaps that clay objects cannot.

The final project is the **Time Capsule Project**, which looked to utilise the ability of RC to create dimensionally stable ceramic panels to tight tolerances.

The personal practice within this chapter has a clear functional focus, this is balanced by the case studies (Chapter 7) conducted by other artists where a number of other creative applications are explored.

6.2 Tatton Monoliths

The Tatton monolith project was the first large-scale practical piece to look at answering one of the main questions posed by the research project: Could large scale work with RC be achieved using small scale machinery. The project also provided an opportunity to evaluate the problems and advantages that RC might have over attempting to do the same piece using clay.

In May 2005 David Binns (Director of studies) was approached by a garden designer to commission a large-scale piece for a show garden at the RHS Show at Tatton Park. Working together with garden designer Paul Hensey (Elysium Design) we devised a design that we felt would complement the gardens planting. It was important that the visual effect of the pieces would not overshadow or dominate the garden but instead create a harmonious addition to the garden as a whole. The idea was to create a piece which could be composed within the space to be used to separate and divide the garden or create a focal point. The objective was to create two identical pieces with a similar aesthetic to Binns previous work based around a semicircular sweep. The pieces were to be 100cm x 90cm x 50cm

The project presented a valuable early case study of the problems presented in using these materials on a large scale, using only machinery and techniques available in an average ceramic studio. It also helped to confirm a number of the perceived advantages RCs had over clay. This chapter will describe the process of creating the pieces and evaluate the advantages and disadvantages observed by using RC. It is important to note that the perceived difficulty in making the same pieces in clay, such as: construction, drying time, firing, and warping have not been tested. In other words the pieces were not attempted in clay and so the problems imagined are theoretical. However, these theoretical problems are informed by experience and tacit knowledge built over time, of the capabilities and limitations of clay.

The main problem was the existing methods and materials used by Binns would be wholly unsuitable for the scale of the piece required for a number of reasons: Thick sections of clay material require long drying time prior to firing; clay is fragile prior to firing and would have been liable to breakages. The stresses and shrinkage of such a large clay object would have produced warping resulting in extensive post firing machining to achieve the tolerances required.

Jon Flo 90 was identified as the most suitable material to reproduce or emulate the qualities present in Binns previous work. Firstly its density and hardness made it suitable for the grinding and finishing required for creating the desired piece. Secondly, the materials hardness and structural strength pre and post firing made it the ideal choice. Thirdly, its ultra low shrinkage would eliminate the chance of any dramatic changes during the firing. Finally its fired colour (white) was suitable for adapting to the design.

The Alternatives

Before discussing the process and methods of creating the Tatton pieces, in order to justify the use of RC, it is important to first discuss the alternative materials that could have been employed in creating the piece. In many ways the most obvious choice of material would have been conventional concrete. Taking out the need to fire the piece would have made the piece more economical. However, the need for a mould would have remained and the same finishing techniques would have been required. However the density of the refractory concrete is far higher and the surface quality when fired and polished has a definite ceramic quality. It was felt that the ceramic quality of the finished material was important, but if clay had been used to create this quality a number of other issues with making this piece in clay would have arisen.

Many ceramic bodies are susceptible to cracking and can even explode when subjected to rapid changes in temperature, or where physical water has not been fully eliminated before firing. This is particularly true in thick walled pieces. The Tatton pieces were 15cm thick at the widest point. This thickness would have required an estimated drying period of around a month prior to firing. Theoretically the piece could have been made as a hollow object and so the need for a complex, and time consuming, mould would have been removed. However, despite the openness of a clay body with a large percentage of aggregate, problems with warping during drying and firing would have occurred. These could have been hidden in the grinding process, however the design relied on two identical pieces and as such, substantial grinding would have made this objective difficult to achieve if considerable warping occurred. Further issues would have occurred in a kiln prior to firing the piece. The sharp edges and base would have presented considerable risk of chipping and breakages.

Stages of Construction

- Form development
- Testing
- Aggregate production

- Mould construction
- Casting
- Firing
- Polishing and Finishing

Form Development

The objective of this piece from an aesthetic point of view was to create a focal point for the garden. The intention was to both define a space within the garden and allow for some flexibility in the placement of the sculpture to fit with the design of the garden. There was also a requirement to echo the style and form of Binns previous work, normally done on a smaller scale, to demonstrate that scaling up of smaller scale ceramic and table top work could be achieved using refractory concrete. In collaboration with Paul Hensey and David Binns, the form developed worked along the principle of a large sweeping curve that narrowed at one end. Various profiles were developed through drawing before the mould was constructed.

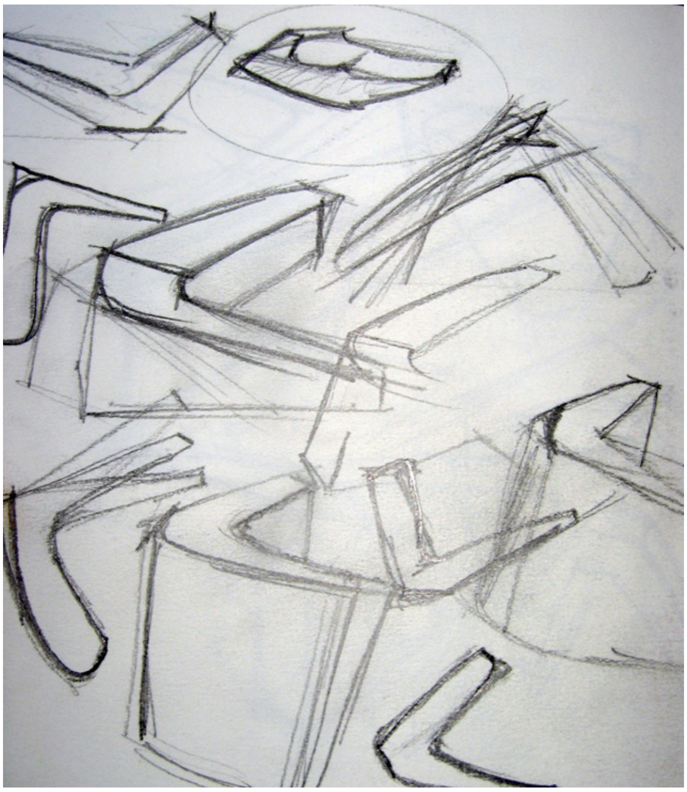

Figure 6.2.1 Sketches of Tatton piece

Testing

With the form decided, the next stage was to conduct testing on the Jon flow body itself. At the outset the surface quality specified by the client was to duplicate in a similar way the surface of Binns previous work. Where copper stained clay aggregate is introduced to a porcelain body to create sharp contrasting “jewels” in the surface when the piece is polished. The challenge here was to adapt this same technique to the Jon Flo 90 material and avoid disrupting both the structural and flow properties of the refractory. The first step was to establish the percentage of grog that would give the visual effect required. In Binns normal practice this percentage is often determined through tacit knowledge and gaining a feel for what is enough, due to the nature of the clay material this can be adjusted intuitively throughout the making process. However, in the case of the refractory, this decision needed to be made in advance as each form would take multiple castings to complete and so parity between mixes was essential. The testing procedure is covered in Chapter 5 Section 5.3[1].

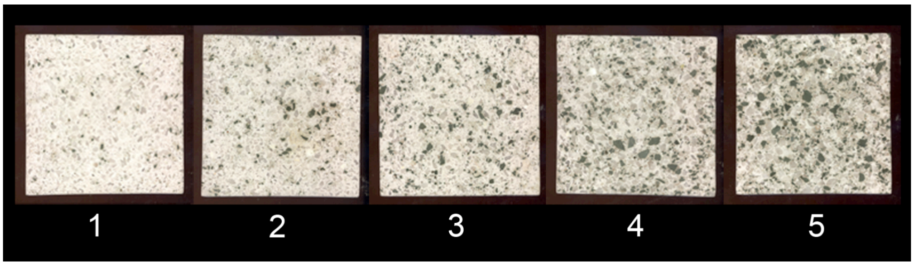

Figure 6.2.2 Stained porcelain and Jon Flo tests

From these blocks the decision was taken to use test block 3. This offered the aesthetic that was desired, where an even and sufficient amount of copper grog was present and the properties of the refractory were unchanged.

Mould Construction

There were two viable methods that could have been employed to create mould; the first was to cast the piece on it’s back, and the second to cast it vertically. While both had advantages and disadvantages, the first option would mean that the mould would only require one face profile to be constructed. However, it meant that the mould would require the affixing of shuttering during the casting process thus increasing the risk of trapping air in the cast. Furthermore, the piece would have to be moved from its back to a standing stance to be fired. The second option involved the construction of both sides of the form, fitting neatly together and being able to sustain the pressure of the concrete as the piece was filled from the top. The casting process would however be simpler, without the need for placing shuttering and increasing the risk of trapping air. An additional advantage would be that the piece was already standing after casting, thus putting less stress into the piece.

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[1] Chapter 5, Section 5.3, page 61

It was decided that casting the piece on its back would be the most economical method and would take the least time to construct the mould, the risks to the cast were judged to be acceptable and would prove valuable to the research, particularly in considering the maneuverability and strength of the green state concrete on a large scale.

The mould was constructed from plywood with the profile cut by hand using a band saw. The spars defined the shape and a sheet of flexible ply installed over the top.

This formed the main structure of the mould. Polystyrene sheet was then secured to the plywood to create an impermeable layer to cast from. The base of the mould therefore defined the outside curve. However, the inside curve of the mould is defined by shuttering added subsequently during the casting.

Figure 6.2.3 Tatton mould construction prior to casting

Casting

Due to the size of the pieces in question a number of mixes were required to fill the mould. The porcelain aggregate was added to the dry Jon Flo and mixed dry in the mixer for 30 seconds before the water was added. To avoid any risk of lamination between mixes the surfaces were tamped and subsequent pours combined thoroughly with the previous.

Figure 6.2.4 First pour of concrete, trowel used to tamp the concrete into the mould

When the level had reached the top of the inside curve the shuttering was screwed to the apex of the curve. Additional pours were then added with the shuttering gradually secured on both sides.

Figure 6.2.5 Top shuttering added and secured, more spars added as the level increased.

Throughout the casting a vibrating poker used more commonly in the building industry was used. Vibration technology is used commonly with castables. However, it is not normally needed for a low cement refractory like Jon Flo 90. The poker was employed to reduce the risk of air entrapment under the shuttering

Figure 6.2.6 Conventional concrete vibrating poker used to reduce air entrapment

The cast was left for a period of 24 hours before removing from the mould. Due to a low ambient temperature in the room used for casting a heat lamp was used to reduce the setting time.

Figure 6.2.7 Infrared heat lamp used to aid setting

The piece was then removed from the mould and carefully raised to a standing position. And the ends of the cast trued up using an angle grinder.

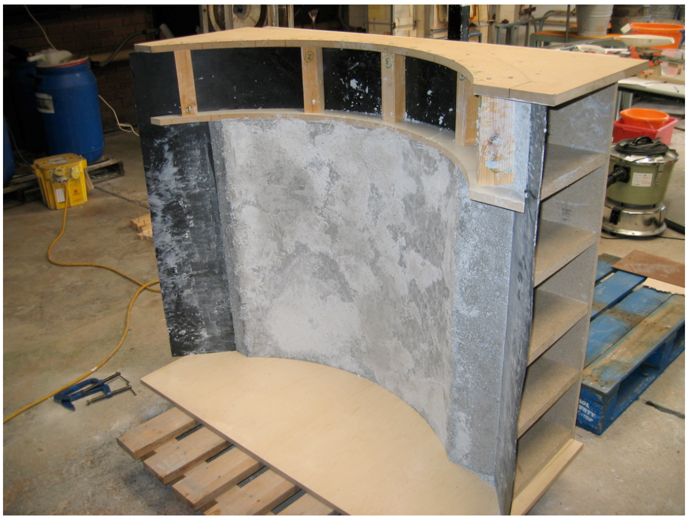

Figure 6.2.8 Raised to a standing position prior to removing mould.

Figure 6.2.9 Finished cast allowed to dry for further 24 hours before firing

Firing

From a standing position the pieces were easier to manoeuvre, with each piece still weighing over 150kg the task of placing in the kiln remained a considerable challenge. However, the hardness of the green concrete is far more forgiving than that of clay and the pieces could be pushed into the kiln without worrying about chipping the surface.

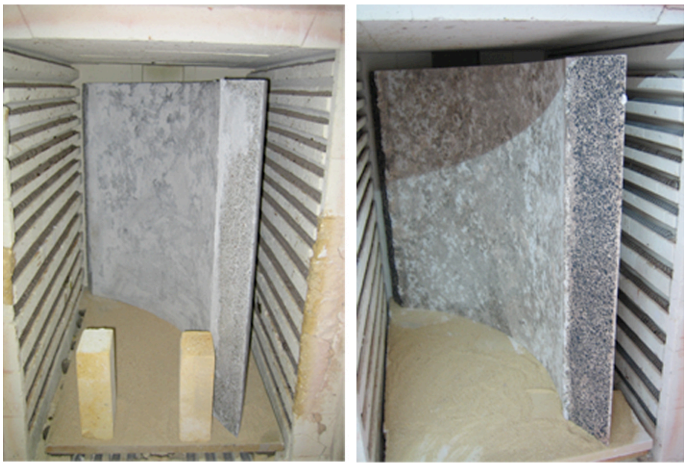
Figure 6.2.10 Piece in kiln (left unfired, right fired)

Each of the pieces were fired according to firing schedule 1 (See Chapter 4) with an added soak at top temperature of 2 hours to ensure a uniform firing to the core of the piece.

Finishing

The pieces showed no sign of warping and, after measuring, no linear change was observed. After removing the pieces from the kiln they were ground and polished using the flex grinder. This process reveals the aggregates held within the body of the piece and creates the unique surface quality.


Figure 6.2.11 Wet Polishing

Figure 6.2.12 Tatton pieces installed in the garden.

Figure 6.2.13

Conclusions drawn from Tatton project

The Tatton project was designed to demonstrate that large-scale monolithics could be achieved in a studio environment. There are a number of advantages RC has for a project of this type. The lack of shrinkage in the material results in no noticeable warping or distortion of the shape either in drying or firing. The second is in the time taken to achieve the piece. While the mould construction is time consuming the actual casting and firing was achieved in one week, whereas clay (even a relatively open body) would require an extended drying time and very slow firing. The third advantage is in the manoeuvrability of the pieces. The high green strength allows the pieces to be moved easily prior to firing and can be loaded into the kiln without the risk of chipping and breakages.

The garden itself was awarded a gold medal and attracted considerable public and media interest including the national press.

6.3 Architectural Cladding

Within the Tatton project a number of advantages were identified and have already been described above. It was thought that RC could offer additional advantages when utilised to make thin fragile objects. Following on from the success of the Tatton project it was decided that a dramatic change in the final product produced using the same material would further illustrate the versatility of the material in question. Jon Flo 90 has, as its name suggests, a unique self-flowing property. This ability to flow was seen as an opportunity to produce large format sheets that would perhaps present the most dramatic and clear demonstration of the materials unique properties. In addition to the investigation of sheet products, fretwork panels on a smaller scale were developed that have a deep relief and are a demonstration of additional possibilities of RC in architecture application.

The sheets and fretwork panels were designed and made as prototypes for potential application in architectural cladding. As noted by Architect David Beana there is increased interest in the use of ceramics in architecture as a cladding material.

> There is no doubt that the arrival of large formats has represented a qualitative and quantitative change in the use of ceramics. Especially in the case of wall coverings and claddings. But I think it is even more important to retrieve the three-dimensional aspect of the material…Research should now be carried out into the textures and the relief of the pieces, not so much with the idea of joining pieces together to form three dimensional pieces but rather so that the pieces themselves present textures on the basis of the moulding process. The industry should be able to produce forms and mouldings with elements and ceramic pieces in three dimensions. The ability to create textures would benefit the image of ceramics.[2]

A number of different pieces were constructed that investigated not only flat sheets, but also contoured or three-dimensional sheets. The project also looked for the first time at how glazing and pattern might be applied to the concrete to create an innovative aesthetic.

This section will describe the practical experimentation and processes involved in creating large format sheets and fret work panels that are only limited by the size of the kiln available.

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[2] Moulding Assembling Designing, Ceramics in Architecture, pp3

The Alternatives

It is important to note that while it is possible to make large sheets in clay, it is another matter getting them from the workshop bench and into the kiln without breaking them. Because RC has the same strength as conventional concrete even before it has been fired, it can be manoeuvred far more easily than large fragile clay pieces. RCs once fired, are substantially harder than conventional Portland based concrete and are generally found to be tougher than ceramics, at least in part due to the large aggregates ability to arrest crack propagation[3]. Refractory concretes do not suffer from the same problems as they set with a chemical reaction, which is subsequently sintered to create ceramic bonds. This is particularly true when working with large format sheets at the elevated temperatures required to vitrify the body. It is important to note that existing methods have been developed capable of producing large format sheets of clay and conventional concrete.

Two Italian porcelain companies Provenza[4] and Cotto D'Este[5] have developed a method for manufacturing large format sheets of porcelain. Porcelain is a notoriously problematic clay body due to its high shrinkage and therefore susceptibility to warping; both are able to produce very large format tiles under the trade names Endless and Kerlite respectively. While the 3m x 1m sheets are impressive, the machinery and technology required put it far beyond the realms of the small-scale ceramic designer maker. In addition, the rigid requirement of the machinery at the time of writing means output is limited to 2 dimensional tiles with no surface pattern.

Thin sheets of concrete have been available for a long time. Materials such as Eternite[6] have been around since the mid 1950's, a concrete composite reinforced by various fibres, initially asbestos but later replaced with cellulose. Eternite has found applications from furniture to wall cladding where it's lightweight and high tensile strength make it an attractive material to designers and architects.

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[3] Bradt RC. 'Fracture of Refractories', CA. Schacht (eds), *Refractories Handbook*, p28-29

[4] http://www.italytile.com/news_events/summer2004/TileNewswinter0405.pdf

[5] http://www.infotile.com.au/magazines/tiletoday/past/2005/48/article.pdf

[6] http://www.eternit.co.uk/Cladding/cladding.html

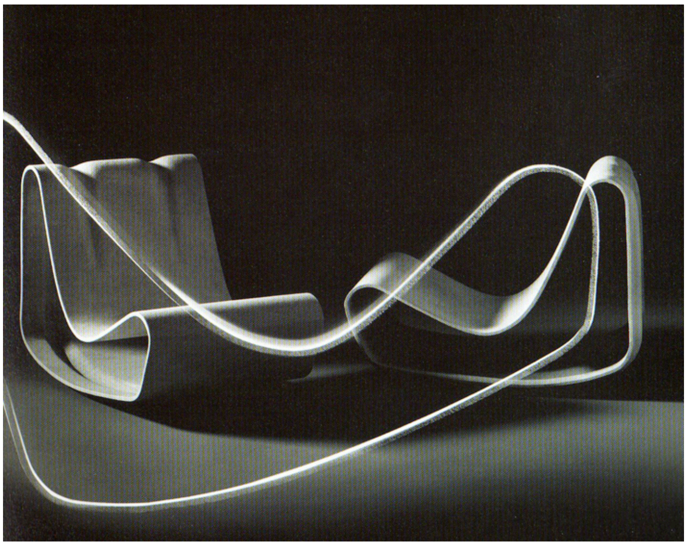

Figure 6.3.1 Willy Guhl 'Loop Chair' 1954 Eternite[7]

Where this research differs is in both the material being used and its treatment post casting. The introduction of ceramic glazes and ceramic surface decoration introduces a different aesthetic quality not possible with any other material. In addition, the manufacture of other large sheet materials, such as the large format porcelain tiles and Eternite concrete, involve the use of expensive machinery. Here the research has used low-tech machinery and easily available and safe materials to create similar results. It is hoped that larger pieces can be attempted in the future with assistance from industry and the use of a large trolley kiln.

Large Format Sheets

As with any practical piece, a number of initial investigations were trialled before attempting the large sheets described later in this chapter. These trials centred on a number of problems identified as causing potential issues in creating the proposed large sheets. The first of these issues was the integration of the reinforcing metal fibre.

The initial testing proved that the introduction of metal fibre (Fibretech) to refractory concrete increased the modulus of rupture in the 3-point bend tests (Chapter 5). It was in the construction of the large format sheets that this knowledge was applied in practice. The fibre performs a dual role – prior to firing it forms a support mechanism for the refractory matrix and enables the material to be manipulated into formers and manoeuvred more easily. Secondly, after firing, it increases the overall strength of the piece and reduces the risk of crack propagation. The challenge when using the wire is to ensure that the wire is held in the middle of the sheet so as not to be revealed in the

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[7] Gaventa, S. (2001) Concrete Design p73

subsequent grinding process. To ensure this problem did not present itself, a number of simple tests using different percentages of wire and varying methods of introducing the wire to the refractory concrete were conducted. The result of these tests was to establish that a layer of refractory placed on the mould and the wire worked into the RC offered the least chance of wires being seen on the finished and polished side. The one disadvantage with this method on a very thin sheet of approx 5 mm was that some wire was left protruding from the surface which required grinding afterwards.

Stages of Construction

- Mould construction
- Casting first layer
- Adding reinforcing wire into surface
- Manipulation of cast
- De-moulding
- Firing
- Glazing
- Grinding

The Tatton project had looked at manipulating the surface quality of Jon Flo using an addition of copper stained porcelain aggregate. Within this project a decision was taken to explore the possibilities of glazing refractories. It was also felt that pattern should be incorporated into the surface of the piece. These decisions were made for both aesthetic reasons and also to demonstrate something that is currently not possible with the two alternative materials and processes described above.

Mould Construction

To generate a large and cost effective relief pattern on the pieces, flock wallpaper was chosen. A number of different designs and patterns were looked at, however one with the required variety in depth and open areas was chosen for the first full scale casting. The image below shows the Perspex base used because its flexibility was required when removing the cast from the mould. A number of glues and methods for affixing the wallpaper to the Perspex were examined. The most suitable ‘glue’ was a silicone-based sealant. Its flexibility and the ease with which it could be removed from the mould after casting were seen as advantageous.

Figure 6.3.2 Mould prior to casting

With the paper secured to the Perspex sheet the surface of the paper is lightly coated with Vaseline to seal the surface. Care was taken to ensure that the entire surface is coated in a fine layer of Vaseline. The first layer of concrete was then poured onto the surface of the mould.

Figure 6.3.3 Pouring first layer

Casting

The first pour was levelled using a trowel and manual vibration of the surface until a uniform layer was created. The wire was then introduced to the surface and tamped into the first pour. most of the wire remained on the surface of the concrete. However the majority was subsequently covered in the next pour leaving the wire embedded in the centre of the concrete matrix.

Figure 6.3.4 Casting sheet

With the second pour added the cast was again levelled by tamping and manual vibration. At this stage the first full scale sheet to be cast was left to set. However as mentioned previously the potential for the refractory to achieve forms that could not be achieved in conventional ceramic materials was one of the main aims of the sheet experimentation. Therefore, the next stage was to explore the potential for creating three-dimensional forms. Through previous practical experimentation, the ability of the concrete to have a ‘plastic like’ quality had been observed as the concrete went through the first stages of hydraulic setting. This property was utilised to form the basis of the series of pieces that explored the potential for pieces that had a 3D profile.

Manipulation of Sheet

In the first 20 minutes after casting a skin forms on the concrete; the underlying concrete remains fluid and so the flat sheet could be carefully manipulated in pre-prepared formers. The time it takes for this skin to form varies according to ambient temperature and so careful observation of the cast is required: moving the cast too early into a former would result in the cast being too liquid and continuing to flow in the new former. If too long is taken to move into the former then cracks in the cast will be introduced. It was found that the wire helped to reduce both cracks at this stage and provide a form of framework to hold the concrete and prevent flowing.

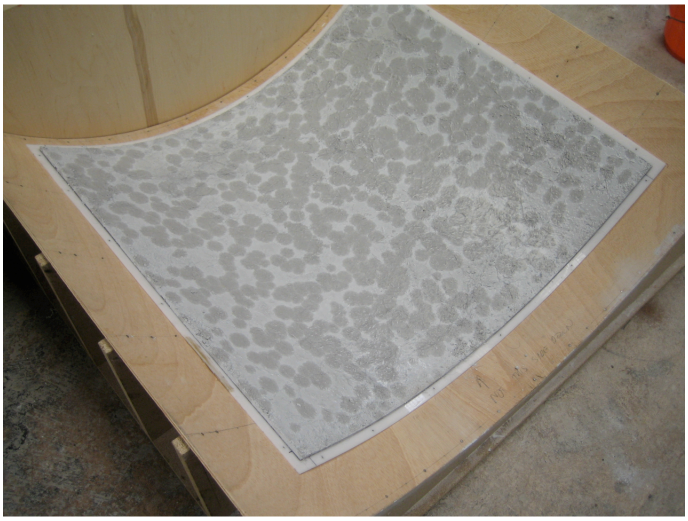

Figure 6.3.5 Sheet placed in former and allowed to set

De-moulding

After the standard 24 hours setting time had elapsed, the piece was carefully removed from the mould. While the concrete is considerably stronger than clay enabling its handling, care still has to be taken, as at 5mm thick the pieces are fragile and liable to fracture.

Figure 6.3.6 Cast prior to removing the mould

Figure 6.3.7 Corner snapped in removing mould backing

In the picture above (Figure 6.3.7) a broken corner was created due to overzealous removal of the mould. Fortuitously this offered the opportunity to explore the possibilities of repair. By mixing a small amount of Jon Flo that had been passed dry through a common sieve to remove large aggregates the broken piece was re-attached in the same way that paper-clay[8] can be joined when dry.

Figure 6.3.8 Repaired corner

Firing

With the mould removed the piece can be bisque fired. In this case the piece was fired vertically in the kiln. This was done to both maximise the size of the piece due to the kiln available, and as a further demonstration of the stability of the Jon Flo and its resistance to deformation during firing. Figure 6.3.9 shows the raw piece in the kiln on the left and the fired result on the right.

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[8] Paperclay is a material that combines paper pulp with clay and allowing the material to be joined even when the material is dry.

Figure 6.3.9 Sheets prior to firing in the left and fired result on the right.

The bisque firing was done according to schedule 2 (See Chapter 4) and the glaze was then applied. In this case the piece was glazed with low temperature earthenware glaze E4 See Appendix 1. Again the piece was fired vertically in the kiln.

Figure 6.3.10 Glazed sheet

Finishing

The last stage of the making process was to grind the surface using the flex grinder. This process reveals the inlaid pattern as green glazed areas. The surface was only partially polished to give a gradient effect.

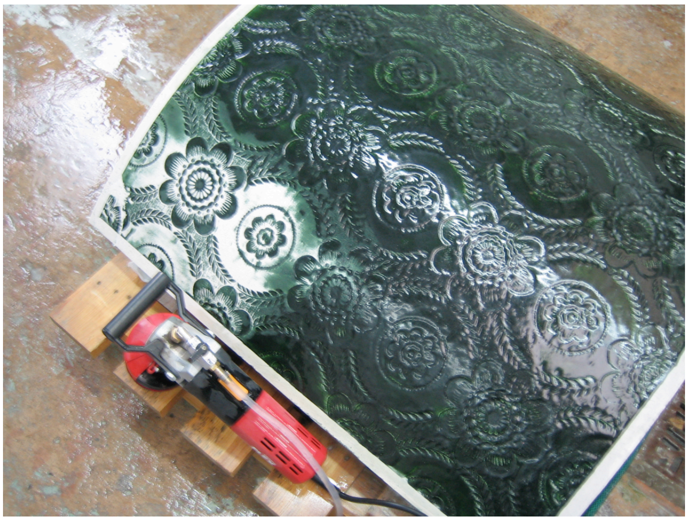

Figure 6.3.11 Polishing of the surface with flex grinder

Figure 6.3.12 Close-up of polished surface

It is important to note that more dynamic surfaces are generated by a variety of depths in the mould, where different depths give darker and lighter areas of glaze when polished, due to the translucency of the chosen glaze.

Figure 6.3.13 Finished piece

Figure 6.3.14 “Concrete peel” sheets using same technique

Fretwork Panels

In addition to the creation of the large format sheets, the creation of open fretwork panels was also tackled. The pattern from the large sheets was used to create the form of the piece. The intention was to demonstrate that intricate forms could be created and was an opportunity to explore re-usable rubber as a mould making material. Vinamould is a hot melt re-usable rubber and can be poured onto plaster or clay models. In this case it was felt to achieve an accurate rendering of the design. The model should be made from plaster. Using Herculite (hard plaster), a sheet was made that was cut using waterjet technology.

The design was first transferred into a vector line drawing using adobe illustrator before being cut by waterjet.

Figure 6.3.15 Image of cutting path areas for waterjet cutting

The cut out plaster was left with a slight texture on the cut faces, which were sanded smooth. The plaster was then soaked in cold water before being placed in a wooden frame and the rubber poured over the surface. The resulting mould can be seen in figure 6.3.16

Figure 6.3.16 Vinamould mould

Jon Flo 90 was then poured and tamped into the mould level with the top of the mould before being allowed to set for 24 hours. The piece was then removed from the mould and fired to 1200°C.

Figure 6.3.17 Cast piece removed from mould prior to firing

The fired piece was then removed from the kiln and the edges ground to remove any casting marks and imperfections in the surface.

Figure 6.3.18 Fired and polished piece

The final stage in the construction was to glaze the piece. The form of the piece made spray glazing impractical and so it was decided that the best option would be dipping.

Figure 6.3.19 Glazed piece prior to glaze firing.

Figure 6.3.20 Glazed fretwork piece.

Figure 6.3.21 Close up of fretwork piece

Conclusions drawn from architectural cladding project

The project was initially designed to demonstrate the strength of refractory concrete on large-scale thin-sectioned forms and also investigated the possibilities of creating fretwork and deep relief work. The green strength of RC allows the creation of these forms without the technology that is required in other alternative ceramic methods, where the fragility of conventional clay would render these forms impossible. The creation of the large format sheets and the relief fretwork pieces are a further demonstration of the capabilities of the material.

The stability of RC during firing is also further demonstrated through this project. The non-shrinking and non-warping qualities of the material mean that dimensionally accurate pieces can be created. The development of three-dimensional sheets that defy the current possibilities for ceramic cladding products show clear potential for further development and experimentation and would require investigation into the various methods of fixing cladding materials to buildings. It is also clear further development of the moulding process, as well as building regulations and practical concerns, would require substantial research before a commercial product could be developed.

However, what the project has shown is that RC puts bespoke architectural products within reach of small studio makers using low tech and inexpensive machinery, also demonstrating the potential for commercial application and industrial mass manufacture. The intended application for this project was architectural cladding, and of a functional nature, however it could also be employed for more expressive projects. Importantly, the nature of both the material and methods developed allow for a great deal of flexibility in generating surface decoration and relief pattern.

6.4 Refractory Concrete and Glass

The concept of combining refractory concrete with kiln cast glass came about as a result of attempting the opposite. The intention was to use RC as a reusable glass casting mould material. The impetus for this came from observing David Binns glass casting methods. For a number of years Binns had been using a plaster, flint and sand mix, used commonly by glass casters as a mould material. The mould material is sacrificial and is chipped from the piece after firing (See Figure 6.4.1).

Figure 6.4.1 Breaking off sacrificial plaster mould

Importantly the firing temperatures used by Binns are far higher than those used by conventional casting and this increased temperature causes a number of problems. These include: a fracturing of the mould case with the fissures filling with the glass mix resulting in poor cast definition; larger pieces require substantial wall thickness in the mould to reduce the risk of complete fracture of the mould, thereby filling the base of the kiln with molten glass; furthermore this increased mould thicknesses has the effect of insulating the glass from the heat of the kiln causing uneven firings. It was felt that RC might offer a potential solution to these problems.

RC is commonly used in industry for the processing and manufacture of glass products, so it's application as a mould material was not unprecedented. Angela Thwaites conducted a comprehensive review of craft and design glass casting in 2002. The review, titled 'Mixing With the Best'[1] was funded by the AHRB (now the AHRC). The project involved canvassing a large number of glass artists from around the world to establish the materials and methods used. The intention was to establish from this

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[1] Angela Thwaites, Mixing With the Best, RCA Ceramics and Glass, 2002

information the optimum mix materials and methods for glass casting. The research report does not make any mention of RC as a material used by glass casters, it does discuss various refractory aggregates but not RC as a mould material. This is primarily because RC cannot be used for fragile pieces. As the strength of the RC would cause damage while attempting to remove the piece from the mould, it could be employed for the less fragile ‘blocks’ of Binns work. In addition most glass casters will cast at far lower temperatures and so will not require the additional stability provided by the RC.

Figure 6.4.2 David Binns, Glass and aggregate pierced forms (2006)

The initial tests attempted to use RC as a mould material that could be reused. The theory was that a release agent on the surface of the refractory would enable the cast glass to be removed from the mould. The first tests used a simple one-piece mould filled with Binns glass/aggregate mix. The release agent used was a standard “bat wash” consisting of 50:50 china clay and alumina. The result of these two tests using Jon Flo 90 on the left and Linco Baxo Dense on the right are shown in figure 6.4.3.

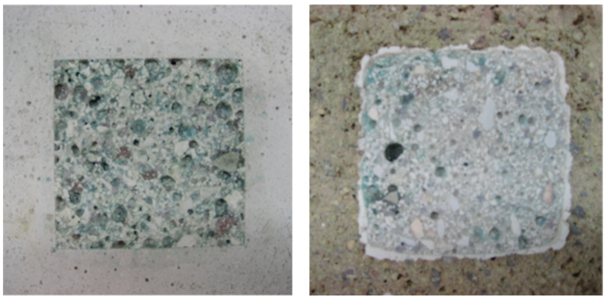

Figure 6.4.3 Initial RC and glass tests

These simple initial tests were not successful, as a reusable or even sacrificial mould, as in both cases the mould was fused to the glass mix. In both cases the release agent was insufficient to prevent the bonding of the glass to the concrete and the density and strength of the fired concrete made breaking away the mould extremely difficult. This, therefore, opened up the possibilities of using RC and the glass mix together to create a unique aesthetic. This failed ‘experiment’ was to form the basis of further experimentation and working prototypes in the EKWC project discussed in the following section[2].

The objective of obtaining a working, reusable RC glass mould remained and the next step was to experiment with a multipart mould. The three-part mould was constructed using standard plaster working techniques with plaster substituted for Jon Flo 90. Vaseline was used as a release agent between the cast sections of the mould.

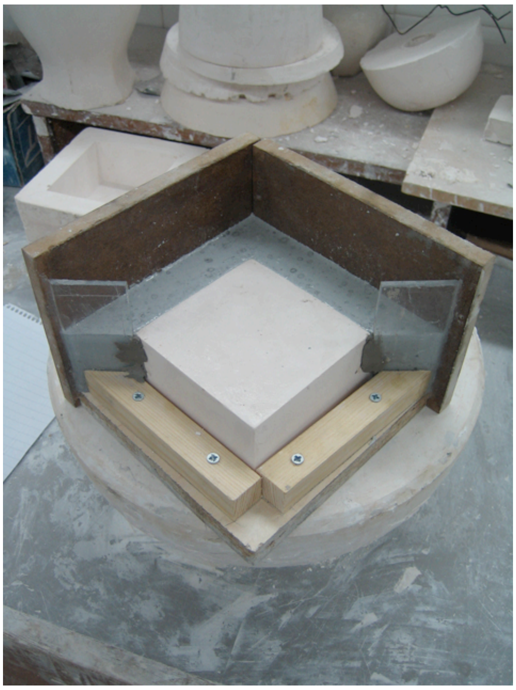

Figure 6.4.4 Three part mould in production

For the three-part mould the release agent used was graphite powder. Graphite is a commonly used release material in glass casting, as it does not bond with glass.

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[2] Chapter 6, Section 6.5 page 130

Figure 6.4.5 Graphite powder coating mould

With the graphite applied the mould was filled with the same material and secured together with nichrome wire.

Figure 6.4.6 Filled Mould

The test was fired according to firing schedule 3 see Chapter 4, Section 4.1[3].

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[3] Chapter 4, Section 4.1, page 49

Figure 6.4.7 Removing piece from mould

Figure 6.4.8 Removing glass from mould

While there was an element of success with this test, in that the glass did partially come away from the mould, there were problems with localised reduction in the kiln as a result of the graphite, clearly showing that graphite, while a good release agent, was unsuitable for this sort of application. The conclusion was, this sort of mould was too complex to enable the glass piece to come cleanly from the mould. It was also thought at this stage that a larger scale would be more successful. Multi-part moulds were successfully developed as part of larger scale projects, namely within the EKWC project which is discussed in the next section.

6.5 EKWC Brick Project

Introduction

The EKWC is an internationally recognised centre for ceramic research located in Hertogenbosch, the Netherlands. Its main aims are to broaden ceramic practice and design by promoting ceramic artists and facilitating access to workshops and experts. More recently, the centre has concentrated on attracting visual artists from other fields to work with ceramics through a series of structured programmes.

In June 2005 the EKWC initiated an international research project to investigate potential new brick products and to develop new and innovative uses of existing brick products. In collaboration with David Binns, a proposal was submitted which was selected by the international selection committee to be one of the 16 participants. The project culminated in an exhibition and accompanying publication in May 2007.

The previous section has described how an attempt was made to use RC as a reusable glass mould however through the project it became clear that the two materials could be married together. The proposal was based around developing a way of combining both research interests in one project. Binns has developed, through his own extensive research project, a unique ceramic and glass hybrid material. The intention was to develop a way of combining the visual effects of the glass hybrid, discussed in the previous section, with the structural strength and aesthetic of RC, to create innovative architectural features.

Before developing the finished pieces a period of experimentation and less scientific investigation was carried out looking at ways in which the material could be combined to create a material that would morph from glass to RC.

Three pieces were made that attempted to achieve this goal, they each used a reusable three part Jon Flo mould. The previous attempt at a reusable mould had resulted in discolouration of the glass and so the graphite power as a release agent was dropped in favour of a 70% alumina and 30% china clay mix.

These experiments were designed to be diagnostic, in other words they attempted to establish if it was possible to achieve before more quantitative and verifiable experiments were conducted.

The first experiment mixed Jon Flo 90 and a clear glass mix, made from a lead frit also containing sieved and washed aggregate from the Jon Flo 90, so that the aggregates would match. Both were gradually combined wet with the percentage of glass increasing as the mould filled.

Figure 6.5.1 Experiment 1

Experiment 1 saw the aggregates settle out in the concrete mix as combining both wet materials resulted in a water-saturated concrete, this led to crazing of the glass. For the second experiment the Jon Flo was mixed as standard but the glaze aggregate mix used in previous work was added in a dry state.

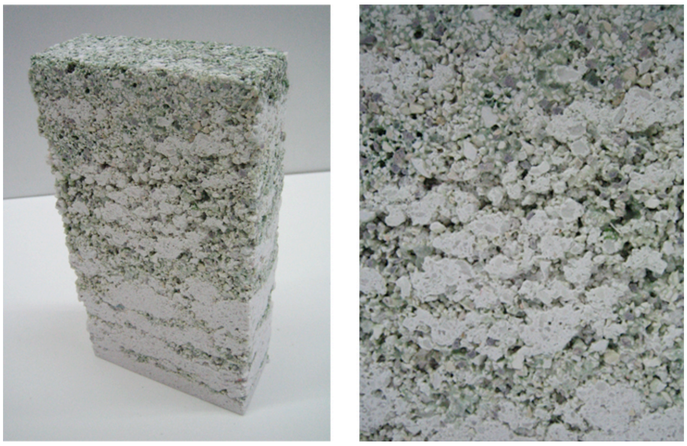

Figure 6.5.2 Experiment 2

This second experiment resulted in a patchy and stratified piece. The third experiment was a compromise between the first two and involved mixing the concrete with just 3.5% water and the glaze/aggregate with just enough water to create a paste. These were then combined in batches before being poured into the mould. Time was allowed between batches to allow a skin to form.

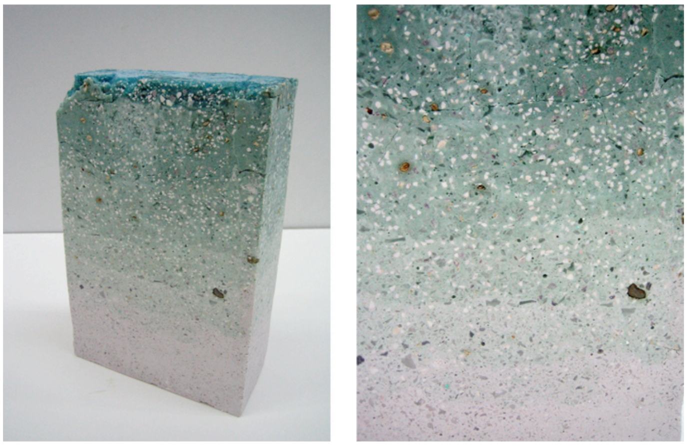

Figure 6.5.3 Experiment 3

This third experiment was the most successful but still resulted in settling and insufficient transparency at the top of the brick. The level of research that would be required to create the pieces, and the restrictions on time for the project, meant a repeatable product would not be achievable, therefore this approach was left in favour of other routes.

The pieces developed for the Brick Project can be broken into two primary solutions: Facing bricks and Cladding solutions. This section will describe the process and methods employed in creating the works. Firstly looking at the facing bricks before examining the three different cladding solutions developed.

Facing Bricks

Refractory concrete will never be able to compete with conventional clay bricks or concrete for economic reasons, therefore facing bricks were seen as the most appropriate application for the brick project. One major consideration of the design and manufacture of the bricks was that the methods used could be scaled to mass manufacturing.

A number of designs were considered for the bricks: the main features incorporated into the design were a repeating pattern and the need to demonstrate glass as a distinctive decorative element within the bricks. For this reason the bricks were asymmetrical with one side lower than the other. An important aspect of the design chosen was that it could be used in a variety of different arrangements.

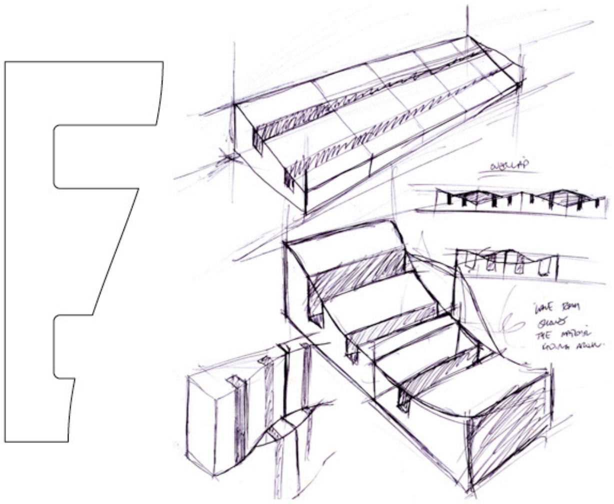

Figure 6.5.1 Design sketches and brick profile

Main Stages of Construction

- Former laser cut in steel
- Sledging in plaster
- Vinamold poured over the plaster form
- Casting blocks
- Filling with glass mix
- Grinding
- Cutting

From experience gained in using the Vinamould in previous pieces plaster was chosen as the material for creating the model. It was important that the model to be used to create the rubber mould was accurate as, when it was repeated any inaccuracies in the form would be magnified. Sledging a profile was settled on as the most appropriate method for creating the model. To ensure an accurate form the profile was laser cut in steel.

Figure 6.5.2 Sledging profile

Figure 6.5.3 Sledging the model

The model was trimmed to size to allow for two bricks to be cut subsequently from each cast, and then a Vinamould mould created. It should be noted that when pouring Vinamould, or any hot melt rubber, the plaster model should be soaked in cold water prior to casting. This will help to minimise air bubbles in the rubber mould.

The mould was coated with a concrete release agent with any excess release agent removed before the Jon Flo 90 was poured into the mould and standard vibration applied.

Figure 6.5.4 Casting concrete in Vinamould

Each cast was allowed 24 hours before de-moulding. This process was repeated to give 8 identical blocks.

Figure 6.5.5 Bisque firing bricks

The blocks were all fired in the same electric kiln to 1200°C using firing schedule 3. (See Chapter 4 Section 4.1[4])

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[4] Chapter 4, Section, 4.1, page 49

The bisque fired blocks were then set in the kiln at an angle for filling with the glass mixture consisting of:

70% Mixed recycled glass
10% Molochite
5% Terracotta grog
5% Chamotte
5% Lead Bi-Silicate
5% Potash Feldspar

To reduce the risk of the glass mixture settling below the level of the refractory bricks, clay walls were built to hold a reservoir of glass.

Figure 6.5.6 Filling bricks with glass mix. Clay walls were used to give a reservoir of glass to allow for settling.

The bricks were then fired to 1200°C using firing schedule 3 (See Chapter 4, Section 4.1[5])

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[5] Chapter 4, Section, 4.1, page 49

Figure 6.5.7 Close up of glass after firing

Most of the reservoir clay walls could be easily chipped off. Each of the bricks were then ground taking the glass back to the level of the refractory less than 1mm was removed uniformly over the top surface to reveal the aggregates in the concrete. Careful attention was taken to avoid altering the profile of the bricks. The ends were not ground as they would be cut and trued up in the next cutting stage.

Figure 6.5.8 Bricks polished and ready for cutting.

The cutting of the bricks was always considered a crucial point of the project as it would guarantee a close fit between the brick elements. The bricks were cut at a local granite worktop workshop.

Figure 6.5.9 Cutting bricks on wet diamond saw

Figure 6.5.10 Finished facing bricks

Figure 6.5.11 Visual of facing bricks

Conclusions from Facing Bricks

The facing bricks project further proves the versatility of RC. The prototype bricks made within this project provide an example of how RC can be combined with glass to create a unique aesthetic. The use of recycled glass in these pieces, as a way to visually enhance RC, increases the visual vocabulary of RC and demonstrates the potential for further work combining these two materials.

The methods employed in manufacturing these pieces in a studio context would require modification if applied for mass manufacture. The mould itself could be easily scaled up in length to create a long block that would subsequently be cut back to form the bricks. However, the piece here has an uneven top face and this design introduces unique problems that would cause major hurdles when mass manufacture is considered. These would include: the filing of the glass into the brick, the impractical reservoir system could not be easily scaled for mass manufacture. In addition the grinding and polishing of a contoured face would be impractical, so some modification of the profile would be required to simplify the production.

The advantages of using refractory in creating this piece lies with the repeatability of the pattern, no shrinkage or deformation of the form in any of the firings meant that the close fit and tolerances required by the design could be achieved.

Cladding Solutions

The second series of prototypes developed within the Brick Project was the development of cladding solutions that again combined the refractory concrete with the recycled glass. The cladding solutions can be divided into 3 different products:

- Recycled Glass and Mineral Waste.
- Refractory and Glass Wave Form.
- Refractory and Inlaid Glaze.

Recycled Glass and Mineral Waste

One of the aims of the Brick project was to attempt to include as much recyclate (recycled materials) into a cladding prototype as possible. Using the research previously conducted by David Binns with glass and mineral combination (See Section 6.4[6]) the previous facing bricks had utilised glass as the decorative element within a RC structure. For the first of the cladding solutions the concept was to use this glass and mineral mix as a “skin” over a “structural base” of refractory concrete. This method allows the refractory base to incorporate the method for hanging the piece on to the building.

The base (Jon Flo 90) was cast as a 1cm thick sheet that was covered in a recycled glass mixture which also included waste stone and ceramic aggregates. For these pieces the RC base was not bisque fired, as bisque firing seemed to have no effect on the fired quality of the glass.

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[6] Chapter 6, Section 6.4 page 125

Figure 6.5.12 Glass mixture cast on green RC bases

Clay barriers were placed around the edge to hold the molten glass. The pieces were then fired according to firing schedule 3 (See Chapter 4, Section 4.1[7]). Two glass panels were made with one being ground and polished and the other left in the fired state (See Figure 6.5.12.)

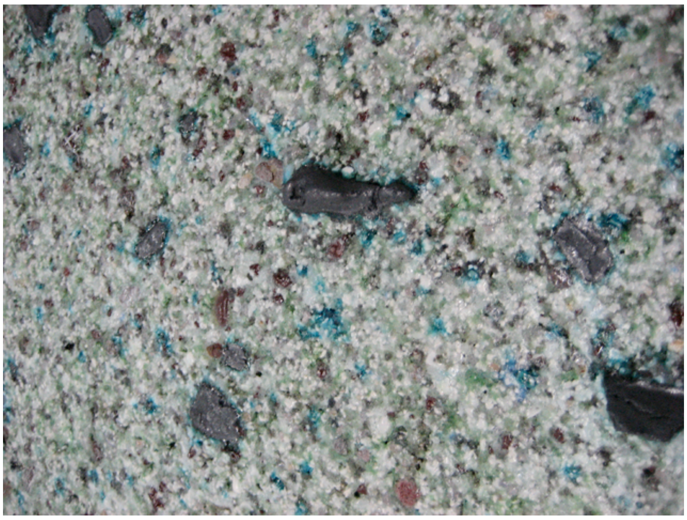

Figure 6.5.13 Fired glass surface

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[7] Chapter 4, Section, 4.1, page 49

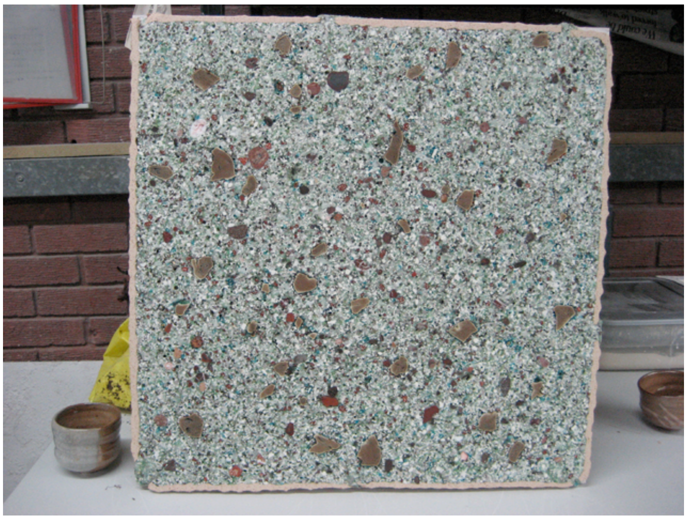

Figure 6.5.14 Glass panel after polishing

Finally the edges were trimmed on the wet diamond saw.

Refractory and Glass Wave Form

The second cladding solution to be developed was the creation of a graphic wall panel that combined the two materials so that the contrasting textures and visual effects would be displayed. The secondary aim for the wave form pieces was to establish if it would be possible to have the glass mix pass through to both sides of the refractory. It was felt that it would be an advantage to have a two-sided prototype that could be used in interior applications where both sides would be visible. It should be noted that the particular method of construction described here would not be suitable for mass production. However, the method could be adapted to make use of rubber casting thereby making mass production feasible.

Main Stages of Construction

- Pattern development
- Creation of plaster model
- Mould for plaster waves
- Concrete mould construction
- Casting of mould and sacrificial backing.
- Glass inlay
- Grinding
- Cutting

The pattern was designed to be a repeating pattern allowing a number of different arrangements that also contained a simple optical illusion effect. The pattern was initially developed using simple computer software.

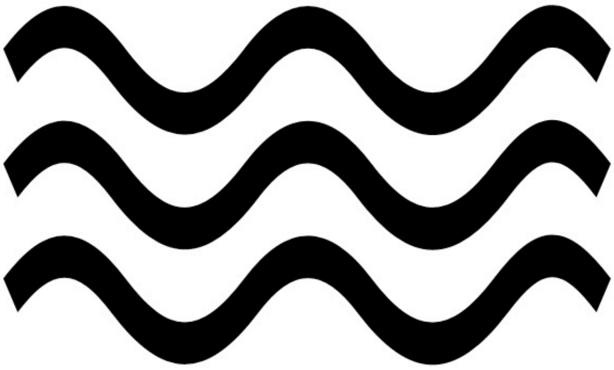

Figure 6.5.15 Photoshop image of waves

One wave was scaled up and a plaster model created that matched the profile of the initial design. A plaster mould was created to enable multiple plaster waves to be generated.

Figure 6.5.16 Mould with plaster shapes secured to wood mould.

The plaster waves were then attached to the base of the RC mould and sealed with Vaseline. Jon Flo 90 has next to zero linear change from cast to set state, therefore the plaster waves can be left in the mould without the danger of cracks forming due to shrinkage.

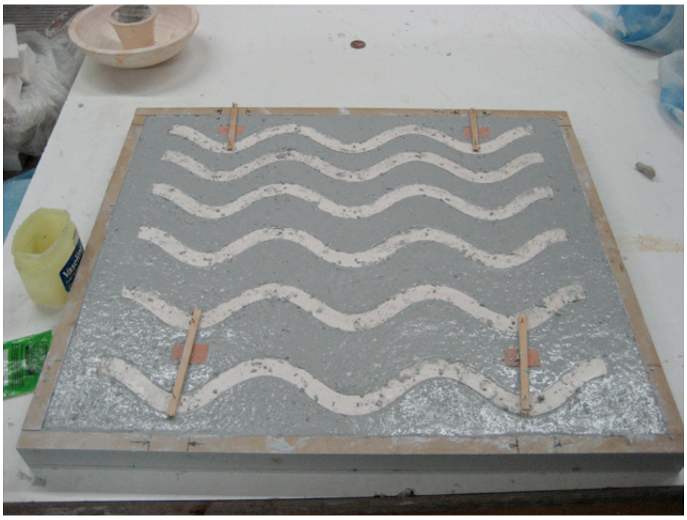

Figure 6.5.17 Concrete cast in mould level with plaster forms, the 4 orange blocks visible are for hanging.

Jon Flo 90 was poured into the mould into the areas between the plaster waves and manually vibrated to remove air bubbles. Expanded foam shapes were inserted in the back face of the casting to provide locations points for hanging the piece on the wall. The hanging method here is simple and for industrial manufacture more complex methods would be required.

After 24 hours the surface was coated in Vaseline again to prevent the next layer of RC from sticking. The final casting stage was to cover the mould block with a 1.5 cm layer of Cast-o-lite. This layer acts as a sacrificial layer; its purpose was to give a tight fitting backing to the piece that could be easily removed after the glass casting stage. After the Cast-o-lite was fully set the piece was de-moulded and the plaster wave forms left in the concrete.

Figure 6.5.18 Casting Cast-o-lite on top of Jon Flo 90 base

The block was then fired using firing schedule 1 (See Chapter 4, Section 4.1[8]) the plaster waves shrink and are then easily removed from the refractory piece.

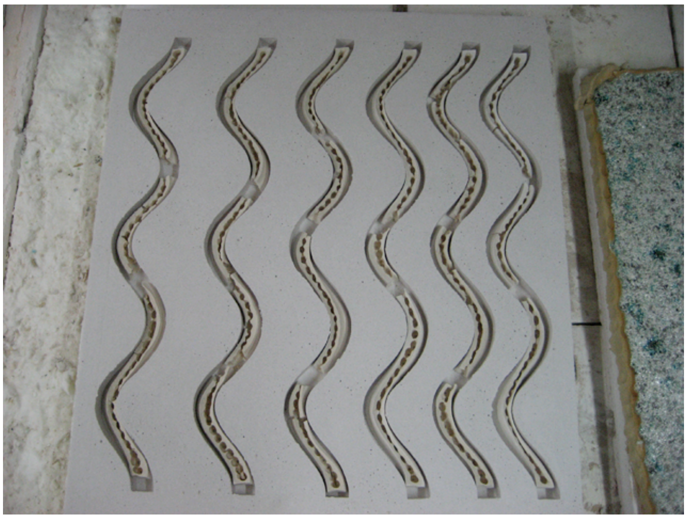

Figure 6.5.19 Plaster shrinks and can easily be removed

With the plaster waves removed voids were left that were filled with the recycled glass and aggregate mix. As with the majority of the glass filled pieces, the glass was overfilled to allow for settling and homogenisation of the glass mix during firing. The second firing was then performed according to firing schedule 2 (See Chapter 4, Section 4.1[9])

As with all other glass filled pieces the fired piece requires grinding and polishing. The piece was ground on both sides before the sides were trimmed on the diamond saw.

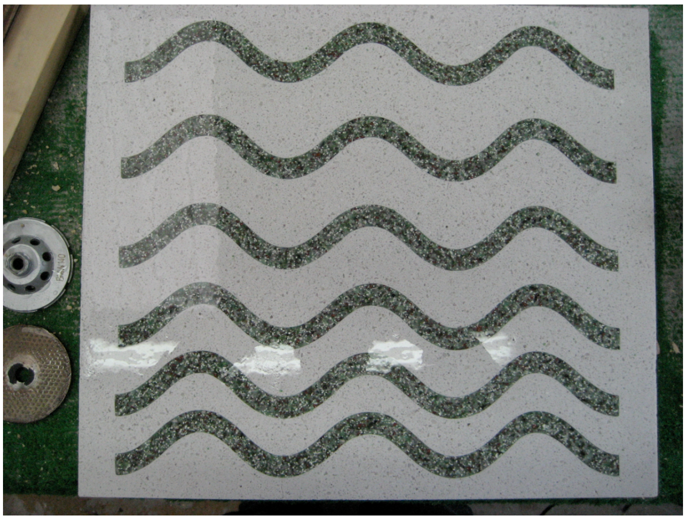

Figure 6.5.20 Ground and polished panel

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[8] Chapter 4, Section, 4.1, page 48

[9] Chapter 4, Section, 4.1, page 48

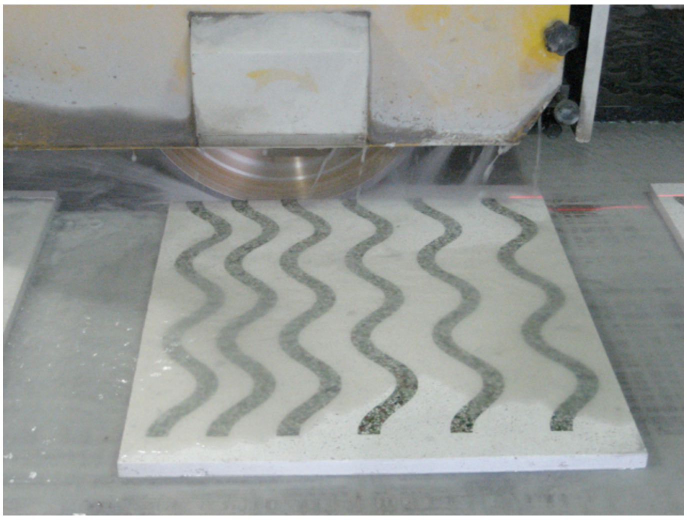

Figure 6.5.21 Trimming the sides with wet diamond saw

Refractory and Inlaid Glaze

The final pieces created within the brick project were the inlaid glaze pieces. These pieces used the same technique developed in the previous sheet project (see Section 6.3[10]). However in this case the project looked at a more graphic application for the glaze inlaid pieces.

The process and methods are discussed in more detail in Section 6.3[11] and very little is different in these products in terms of process or method. An existing relief was used to create depressed areas that were subsequently glazed and polished back.

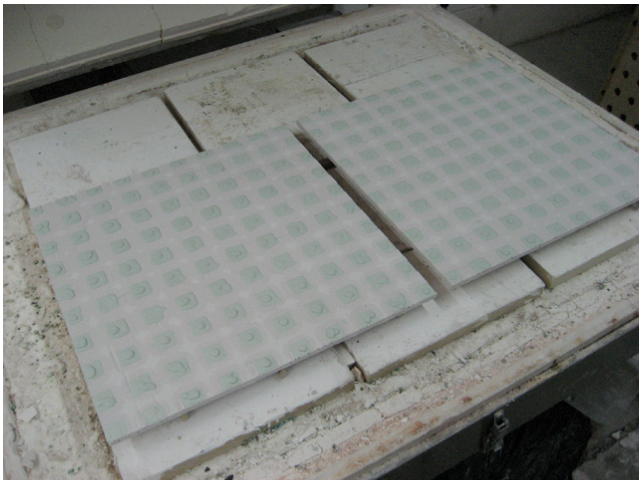

Figure 6.5.22 Glaze applied to cladding panels

Scale was not the objective in creating these pieces as the creation of scale pieces had been fully investigated in the previous large format sheets work. The decision was

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[10] Chapter 6, Section 6.3, page 109

[11] Chapter 6, Section 6.3, page 109

taken to use the final cladding project as an opportunity to further refine the casting process to produce more highly finished products.

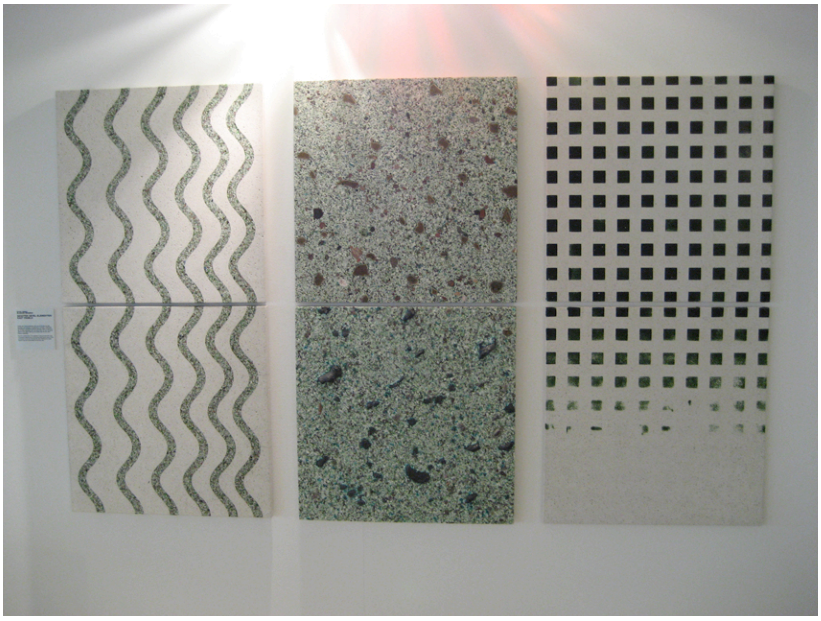

Figure 6.5.23 Finished panels from left to right: Inlaid glass, RC and waste glass and minerals, glazed panels.

Conclusions from Cladding Solutions

Each of the pieces produced within this project offer a different aesthetic and could not be achieved without the core use of RC. The integration of recycled glass with a structural RC base is perhaps the most promising element to come from this part of the research and has real commercial potential. As with other cladding projects within this research, further work should be done that looks at how the pieces can be secured to buildings with the method built into the mould. Figure 6.5.24 illustrates some of the many different methods of fixing cladding to buildings that could be adopted.

Figure 6.5.24 Cladding fixing solutions[12]

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[12] Tardiveau, A. (2006) *Moulding Assembling Designing: Ceramics in Architecture*, p62

6.6 Graphic Floor Pavers

The concept for the development of graphic floor pavers was first envisioned following the sheets project. The clear potential for graphic imagery to be used, as surface embellishment, had been proven possible on a large scale within the sheets project and further developed within the brick project. However the sheets project had used pre-existing materials to generate the relief pattern. To be feasible on a more commercial basis, and allow more freedom for the creation of imagery on the concrete, a way to develop the relief pattern had to be found that would allow the economical creation of relief moulds adaptable to a number of different situations and designs, while opening the project to also look at graphic flooring.

The concept is based on clay encaustic tiles, or inlaid tiles, first developed in the 13th Century and used widely in the Victorian era. These tiles used inlaid coloured clays to create patterns. The depth of inlay meant that even with significant wear the pattern remained. In this project this method has been transferred to RC and utilised Rapid Prototyping (RP) and glaze was also substituted for the clay used in traditional encaustic tiles.

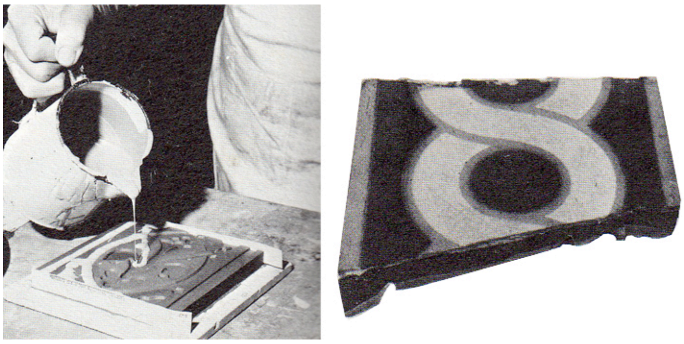

Figure 6.6.1 Encaustic tiles by Minton

Alternatives

A number of different methods are already widely available for the creation of text and imagery on floor products. These can be categorised as falling within one of the following three groups.

Engraved concrete

Where solid concrete or natural stone is engraved by removing material and subsequently filled with contrasting concrete, or, in some cases, resin may be used.

Impressed Concrete

Bomanite is a concrete flooring material that is impressed with a texture at the casting stage, which can then be in filled with a contrasting concrete to give patterns. Bomanite is ideal for large areas but not suitable for intricate and detailed work.

Printed tiles (Kerajet)

Kerajet uses inkjet technology to print directly to a glazed tile or ceramic substrate. The technology can be used to create wall and floor tiles. Kerajet is capable of reproducing very intricate and detailed graphics. However it cannot be applied in exterior applications.

Figure 6.6.2 Kerajet ceramic inkjet printing

Waterjet cut concrete or tiles

Sheets of stained concrete or ceramics are cut using a water jet to form a mosaic, which is then installed. Idea for large areas again this technique is not suitable for detailed designs and has a mosaic effect.

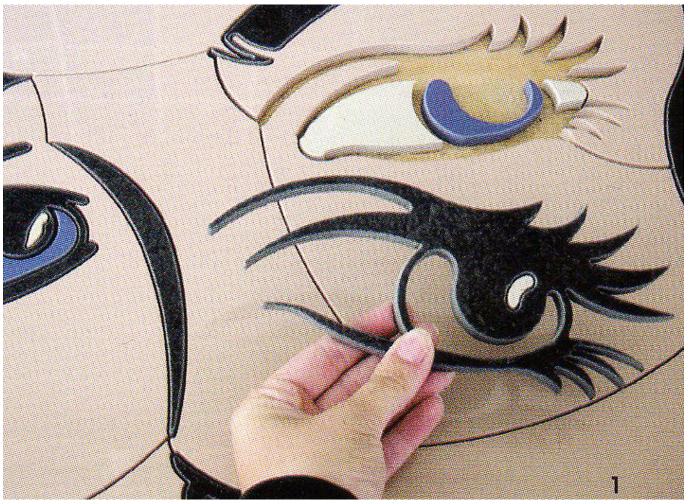

Figure 6.6.3 Waterjet ceramic tiles

The graphic pavers project can be broken into two related projects. First the development of a prototype for the Leo Baxendale comic strip commission. The second involved applying the process to a corporate identity and more commercial application.

“The Bash Street Kids Project”

This project came about after a presentation to the CityBrand Project being run within the University of Central Lancashire. CityBrand is a design led project that was tasked with developing a number of design-based enterprises and proposals that would enhance the city of Preston in a positive and dynamic way. The group are funded by the North West Development Agency and led by designer Bryn Jones.

One of the proposals forwarded by the CityBrand group was for a rendering of a comic strip from “The Bash Street Kids” by Leo Baxendale to be installed as a functional floor material in an outdoor site within the city. The initial design developed by CityBrand proposed the use of etched stainless steel to render the comic strip (See Figure 6.6.4).

Figure 6.6.4 Initial metal design by CityBrand

Following a presentation of work completed as part of this PhD, RC was proposed as a material that could fulfil the design requirements and offer a longer lasting and more appropriate rendering of the comic design. Together with the City Brand team and Leo Baxendale himself, the comic strip ‘The Circus” was selected. Figures 6.2.5 and 6.2.6

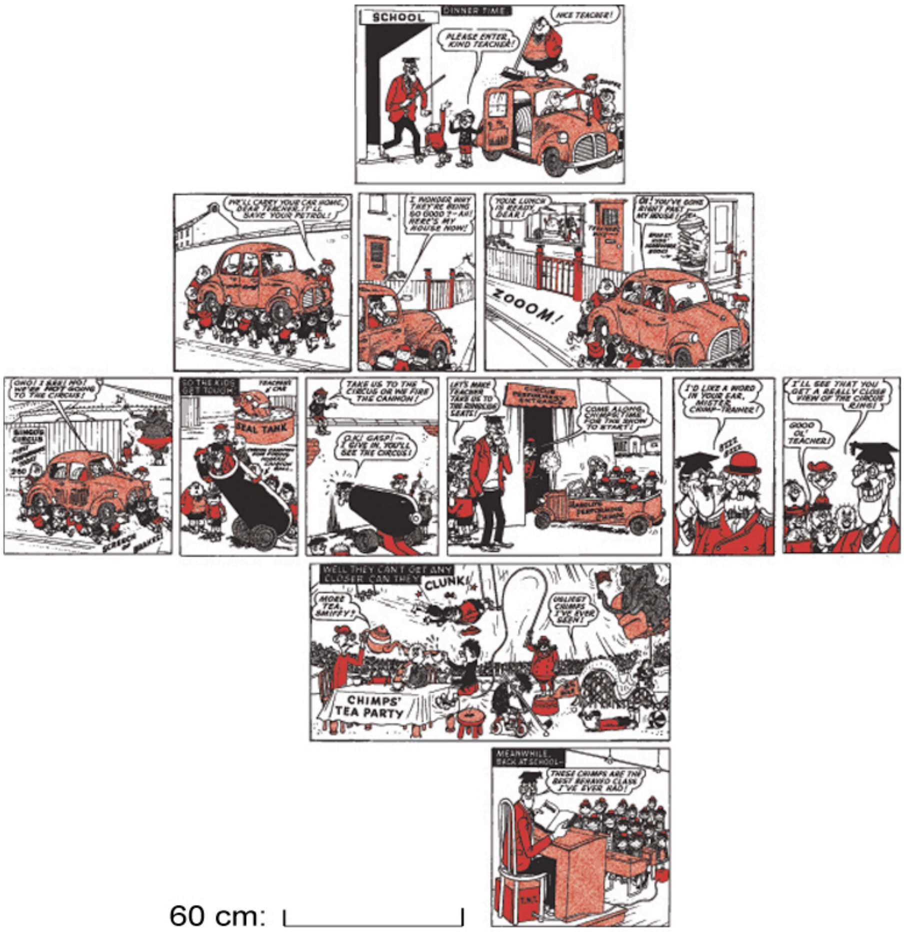

Figure 6.6.5 Plan view of Leo Baxendale's "The Circus"

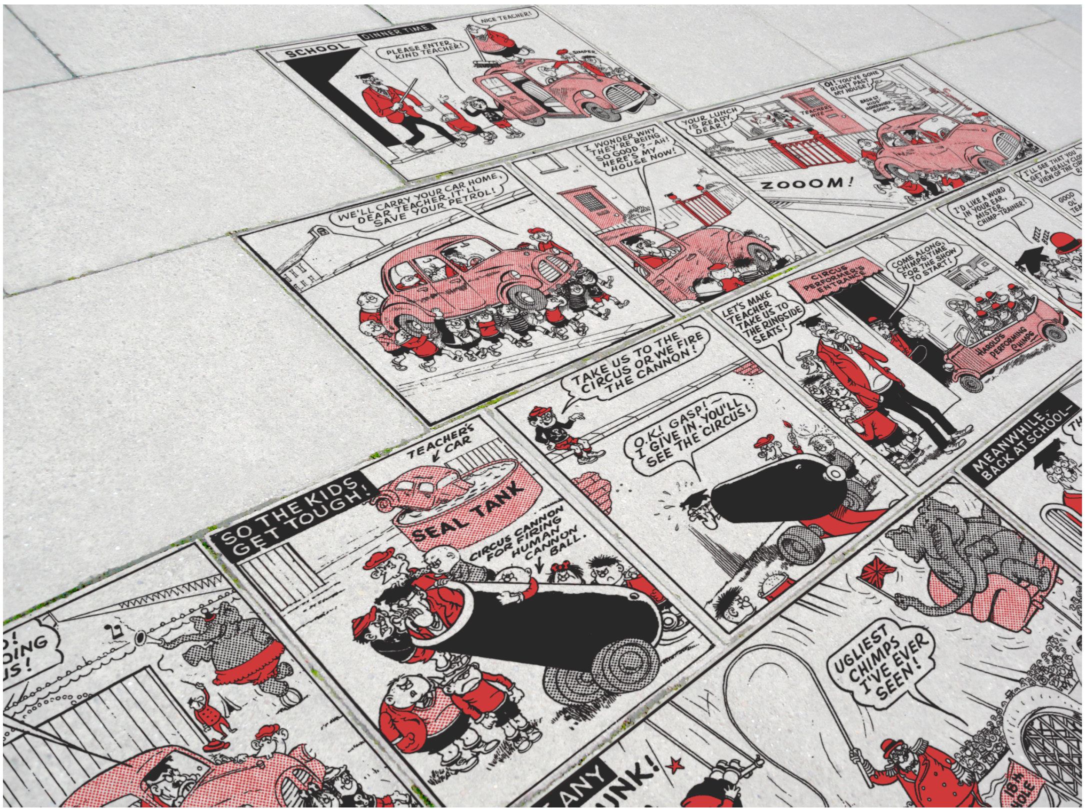

Figure 6.6.6 Visual showing proposed panels in situ

The initial problem presented by the project; was how to create the mould that could replicate the level of detail required by the design. The most practical and ultimately efficient method of construction was to use rapid prototyping (RP) technology to create the mould. The technology available within the University mills forms from a dense foam material. This technology is commonly available and is often referred to as Subtractive RP or Computer Aided Manufacture (CAM) milling machine (See Figure 6.6.7).

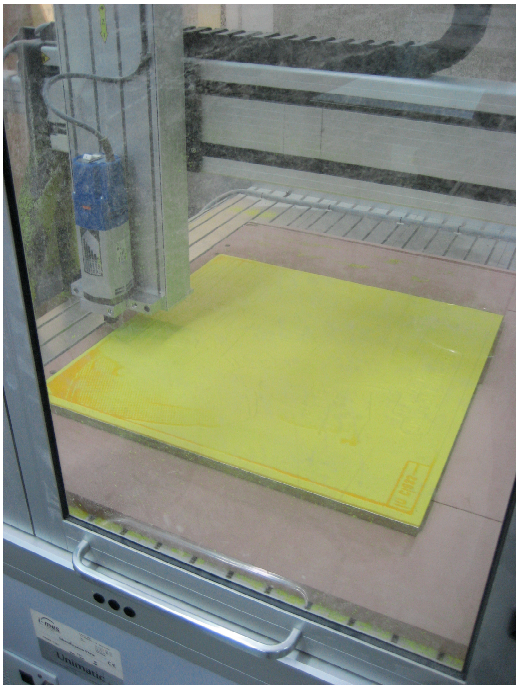

Figure 6.6.7 CAM milling machine

Image and software processing

While there will be differences between different CAD/CAM manufacturers and software the basic principles remain the same.[1] Before discussing the specific project it is useful to discuss the process used to import images and graphics into the CAM milling machine used to generate the relief mould.

The imagery or graphic to be used must be converted to black and white and be of high contrast value. The first stage was to import the desired image into Adobe Illustrator to create an image with clear definition between black and white areas. This can be easily achieved using the live trace application. Because the majority of the pieces created in this project contained imagery and text and the casts were taken directly from the milled material, all images were reversed.

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[1] There is a great deal of literature available on CAD/CAM technology including it's impact on the crafts but these issues are not of concern in this thesis, the technology is simply seen as a means to an end.

Figure 6.6.8 Illustrator image reversed

This image was then imported into the CAD software that defines the heights and cutting paths for the CAM Milling machine. The CAD package used in this case was called EDUCAM. The black and white image is imported and height values assigned to black and white. In the example below white is assigned as -1.5mm and black as 0mm. This converts the black and white image into a relief with any black areas in the image raised and white areas removed (see Figure 6.6.9).

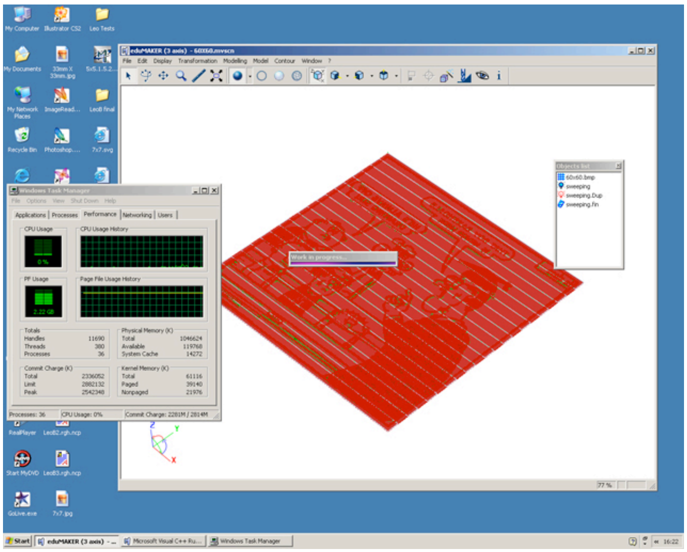

Figure 6.6.9 Educam software defining cutting paths

The tool paths are then relayed to the CAM milling machine. The problem with the materials used in these machines is that they are inflexible and this causes issues when removing the mould from the concrete where chipping would be inevitable with the intricate designs being used. The immediately obvious solution to this problem would be to use a rubber to create a mould from a pattern cut in the dense foam material. Unfortunately, on further inspection this presents a number of problems:

- The foam cannot be used with the vinamould (a re-usable rubber) as the temperature of the rubber will melt the foam.
- Using the foam as a sacrificial mould material (burnt out of the concrete piece during firing) would be expensive for one off pieces.
- The foam can be used with cold cure rubbers however the cost for these rubbers is considerable and considering the sizes required and the one-off nature of this particular piece the cost could not be justified for prototype development.

So to solve these problems it was decided that an inexpensive semi-flexible material that was stiff enough to allow processing in the RP be used. A number of sheet rubbers were initially considered before settling on lino. Prior to the creation of the full-scale prototype a number of tests were conducted to establish the definition that could be achieved through using the lino. The main issue with using the lino was creating enough depth in the relief and retaining structural strength of the lino to enable it to be peeled from the concrete following casting. The first tests adjusted the depth of cut in the lino and established the 3mm ball end cutter to be the most suitable cutting tool for removal of material and retention of definition while ensuring that the mould could easily be removed from the cast piece. (See Figure 6.6.10)

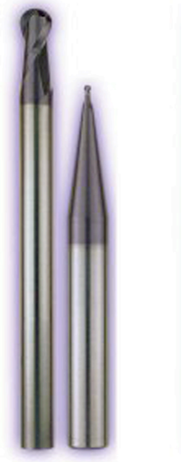

Figure 6.6.10 Cutting tools

In addition it was important to establish the depth of cut to allow the final grinding of the surface and still retain the inlaid pattern. 1mm, 1.2mm and 1.5mm were all tested with the 1.5mm proving to be the most successful. The only problem with the lino was to get this depth of cut in the lino it came very close to the full thickness of the lino (2mm) making the lino post milling very fragile.

Figure 6.6.11 Lino mould (top) and the cast result bottom.

While the technique worked very well on the test piece on a limited scale it was unsuitable for the scale required of 600mm x 600mm as during the removal of the mould the lino was liable to tearing and deformation and the material had a tendency to blunt the cutting tool. The experimentation with the lino was not a full failure as it had resolved the ideal depth of cut and so the search for a more robust and easily milled material led to using a sheet material called Forex, a dense PVC plastic.

Forex is a similar material to the foam designed for use in the RP device and could therefore be milled easily however it comes in sheet form and therefore is far more economical in comparison with the foam stock. The only issue with using the sheet material was to ensure it could be peeled from the concrete cast.

Having established previously that the 3mm ball end cutting tools ensured that the mould would release from the cast but had insufficient detail, the next concern was to increase the definition on the cast using a smaller cutting tool. Through a number of tests it was established that using a 6mm bull nose cutter to a depth of 1.5 mm to rough out the shape first followed by a 2mm diamond rounded burr was found to be the best tool to increase the definition while keeping the rounded edges so the cast comes easily away from the mould.

Figure 6.6.12 Finished relief mould

The milled foam board was then placed in a wooden box to form the finished mould. The relief was then sealed using the standard method of Vaseline and the Jon Flo 90 cast in the normal manner (see Figures 6.6.12 and 6.6.13).

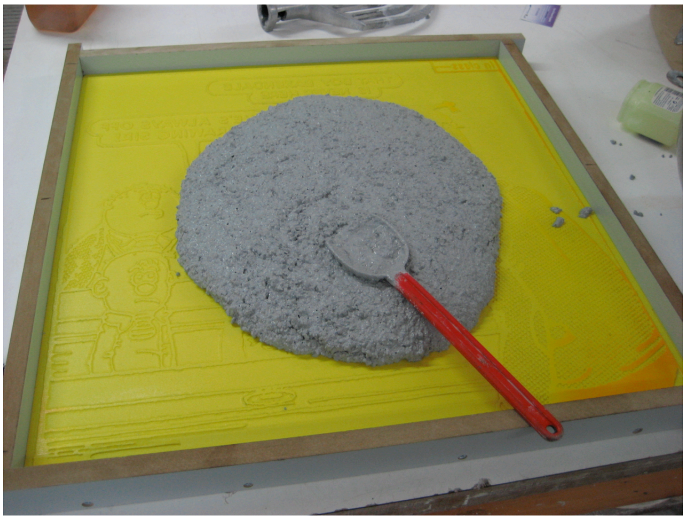

Figure 6.6.13 Casting concrete into mould

Raised areas on the mould were thus transformed into negative areas that form the coloured areas of the paver. After releasing the piece from the mould the surface is inspected and any imperfections in the cast filled with sieved and mixed Jon Flo 90. The concrete was then bisque fired according to firing schedule 1 (See Chapter 4, Section 4.1[2]). The bisque fired piece was then ready for glazing and filling of the negative areas.

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[2] Chapter 4, Section, 4.1, page 47

Figure 6.6.14 Filling depressed areas with glaze using slip trailer.

According to the design requirements the piece required two colours both black and red. Careful application of the glazes ensured that there is no overlap between the two colours where they meet. (see Figure 6.6.14)

Figure 6.6.15 Glazed panel ready for glaze firing.

The glazes used were both based on the standard earthenware base glaze E1 (See Appendix 1) with a black and red commercial stain added. Testing had been conducted to establish the optimum percentages to give the required colour while minimising the air bubbles that were revealed as the glaze is polished. The final stage was to polish the surface to reveal the inlaid pattern (see Figure 6.6.16).

Figure 6.6.16 Polishing surface to reveal inlaid design

Figure 6.6.17 Finished prototype

The prototype was presented to the City Council and a commitment received that the project will be installed as part of a wider outdoor museum within the city in the future.

UCLan Campus signage

In tandem with the Bash Street Kids Project a proposal was forwarded to utilise the same technique for signage and campus marking for the UCLan campus. The proposal involved the instillation of floor pavers with the University logo, strategically located in the campus to demarcate the campus from the rest of the city. The project aimed to demonstrate the potential for more commercial application as corporate signage for interiors and exteriors (see Figures 6.6.18 and 6.6.19).

Figure 6.6.18 UCLan panel mould

Figure 6.6.19 Visual showing panel placed in the campus.

Conclusions from the graphic floor panel project

The project showed that intricate and complex graphic imagery could be applied to the surface of the concrete using very basic CAD CAM technology, making the technique economically viable even for one off pieces. The process is also proven as transferable to graphic logos and signage. Together with the quantitative data generated from the slip resistance testing the project demonstrates the material as being both commercially viable for graphic flooring interior and exterior applications and suitable for application in the exterior spaces.

It should be noted that the legislation surrounding installation of graphics and text in the public highway is problematic and could have implications for more commercial products.

6.7 Urban Furniture

One of the hypotheses at the start of the project was that the increased strength of RC would enable the material to be used for applications where bridging large gaps was possible. Again here the intention was to evaluate the material in a real situation by making a full-size working prototype. Research into ceramic furniture revealed a project for the city centre of Stoke-on-Trent. The project involved the creation of 4 metre ceramic tiles placed on a concrete base and was designed by MUF architecture (see Figure 6.7.1). The intention was to:

> Use a material that is associated with fragility and bring to the public street a scale of domestic intimacy and delicacy where there is unfounded anxiety about the town centre as a meeting place.[3]

Figure 6.7.1 Ceramic benches Stoke-on-Trent 1999

The bench project looked to play on the same theme by creating something, which had a ceramic surface. However, instead of being tiles on a concrete base the bench would have a monolithic quality that displayed strength and durability as well as a ceramic surface.

Within the project two benches were made. Unfortunately, both attempts failed to produce a working prototype. Nevertheless, it is important to discuss the process,

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[3] Tardiveau, A. (2006) *Moulding Assembling Designing: Ceramics in Architecture*. Pleasure Garden of the Utilities, p132

particularly discussing where the bench project failed, why and what can be learned from the experiments.

Before discussing the possible reasons for the failure of the bench project a description of the processes and methods used in their construction and development is given.

Bench (1)

The first bench was originally designed as a prototype piece for the City of Preston incorporating one of the local Horrocks mill print designs in the surface decoration and pattern embossed on the surface. The concept involved a number of benches being made that shared the same form and design but adopting different patterns from the Horrocks range. It was hoped that funding could be sourced to complete these benches in the future if the prototype could be proved to work (see Figure 6.7.2).

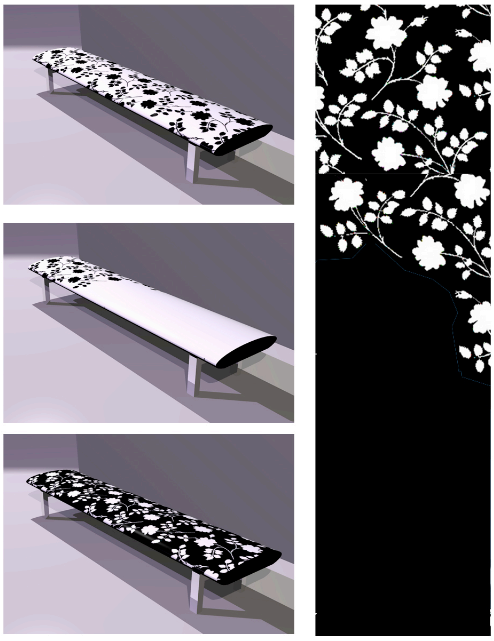

Figure 6.7.2 Visuals of Horrocks Bench

Stages of Construction

Mould manufacture

Casting

Firing

Mould Manufacture

The construction of the mould can be broken into two areas. The first is the construction of the wooden mould structure. With the second area being the construction of the relief pattern.

Mould Structure

Experience from the first Tatton project was utilised in the construction of the bench mould. The complexity of the mould meant that waterjet cut mould components from plywood would be both the most economical in terms of time. The mould is designed to be a three-part mould allowing the removal and reuse of the mould.

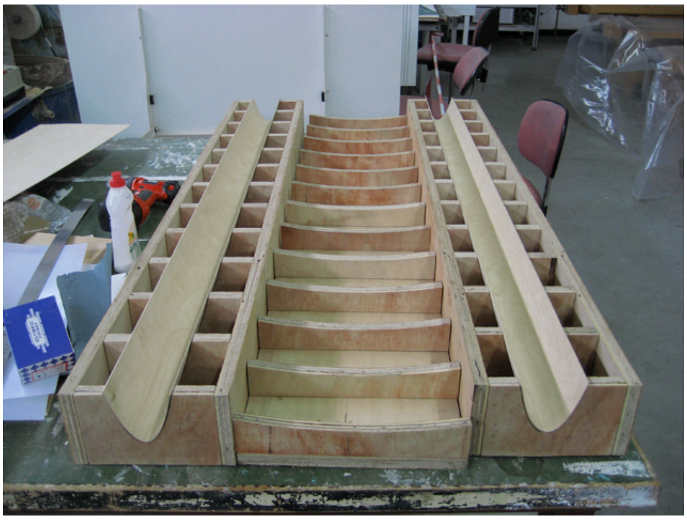

Figure 6.7.3 Mould construction showing three individual parts

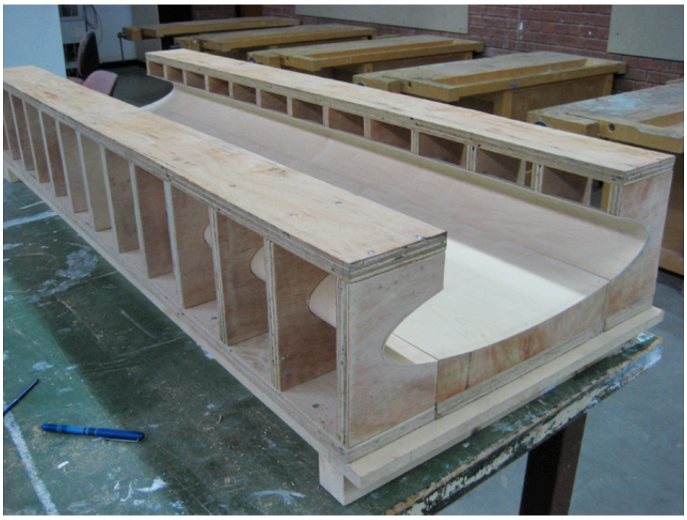

Figure 6.7.4 Complete mould

The first bench measured 150cm x 45cm x 10cm. These dimensions are larger than any of the kilns available in the department therefore the bench had to be taken to a local architectural ceramics company for firing (Shaws of Darwen). This provided an opportunity to evaluate whether RC was indeed tough enough at a raw state to withstand transportation to another site and the rough handling that this would entail.

Mould Relief

The original plan was to use the Horrocks pattern as shown in the visuals. However the costs involved in creating a rubber mould meant that for the prototype it was impractical to develop the Horrocks pattern. To save time the established method of using flock wallpaper was used. The pattern was secured to a silicone sheet using a spray adhesive and then simply laid into the mould without being secured to allow a degree of movement (see Figure 6.7.5).

Figure 6.7.5 Mould with pattern sheet

Casting

The bench was cast in Jon Flo 90 with standard 4.5% water. The bench weighs approximately 150kg and was cast in 10kg batches, with each batch tamped and integrated with the previous mix.

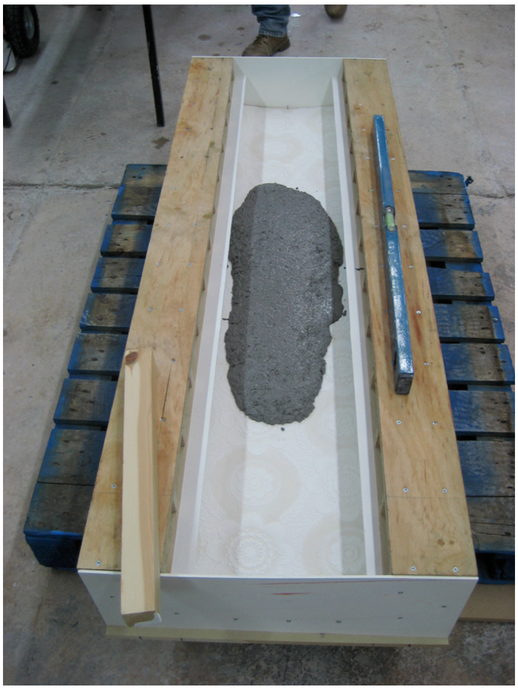

Figure 6.7.6 First concrete pour

To cut down on weight, two polystyrene lengths were cast in to the reverse of the mould. Wooden dowels were also cast into the base to facilitate attaching the legs of the bench after firing (see Figure 6.7.7).

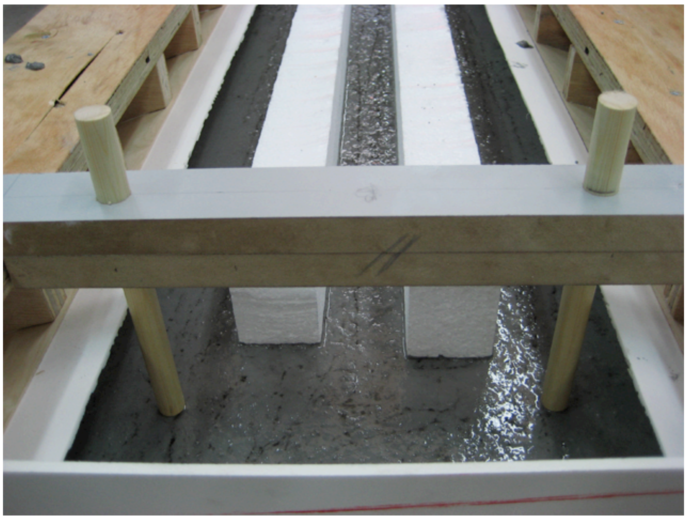

Figure 6.7.7 Polystyrene and dowels added

After casting, the bench was left for 48 hours before the mould and the pattern sheet were removed (see figure 6.7.8).

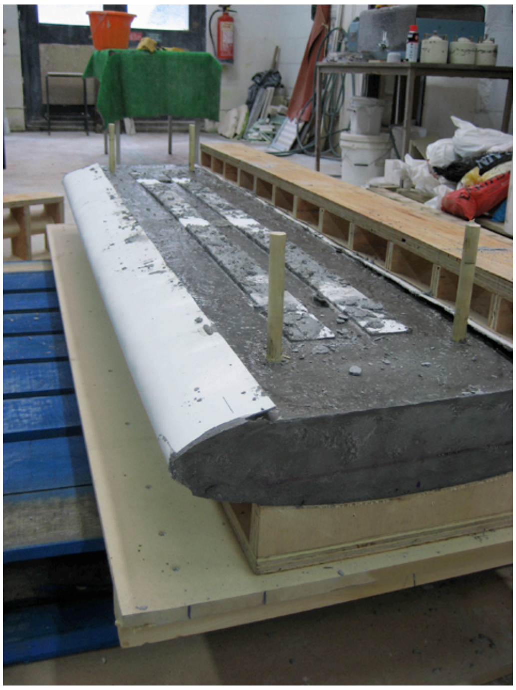

Figure 6.7.8 Removing from the mould

The bench was transferred to Shaws of Darwen in a raw state before being bisque fired in a gas kiln to 1100°C. This lower temperature was required for the piece to fit within the standard programme at Shaws of Darwen.

Figure 6.7.9 Piece on forklift at Shaws of Darwin

The bench survived the bisque firing and was glazed on site with the standard earthenware glaze.

Figure 6.7.10 Glazing by brush with earthenware glaze

On removal from the kiln by workers at Shaws of Darwen, the bench suffered a full and clean break in the centre of the piece (see Figure 6.7.11).

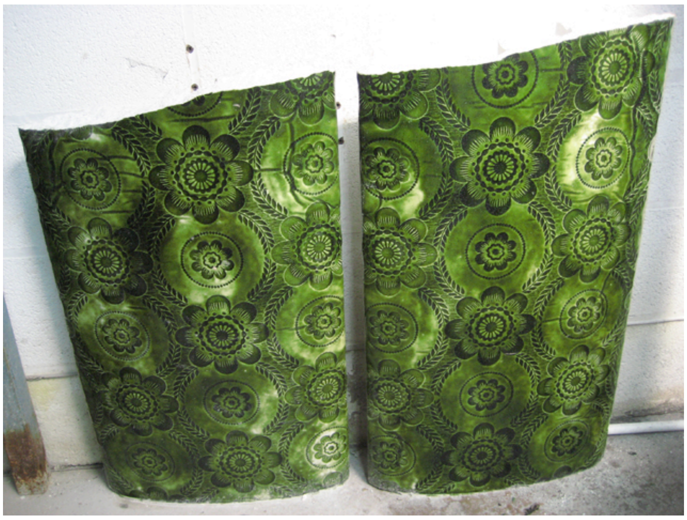

Figure 6.7.11 Broken piece on removal from the kiln

The reasons for the breakage remain unclear. The piece showed no sign of surface or structural damage at the point of glazing and had been handled without problem at this stage. Workers at the factory stated that the piece had been supported along the length of the piece in the same way for each firing.

The lower firing temperature and gas kiln could be to blame. However, equally possible, and perhaps more likely, was that the handling of the piece at a green stage and transportation, firstly in a car and then on a forklift truck over uneven ground, could have introduced structural damage not apparent after the bisque firing.

Previous work on a similar scale (Tatton project) showed no sign of structural damage and so the decision was taken that a second attempt should be made, this time altering the length of the piece to allow firing in the kilns available in the department, thereby eliminating the transportation issues.

Bench UCLan (2)

For the second bench attempt a number of changes were made that it was hoped would result in a successful casting and finished prototype. The changes included: no polystyrene sections; Fibretech stainless steel wire would be used in an attempt to increase the green strength and reduce the risk of cracking. Finally the smaller piece would be fired in the department and would not require transportation.

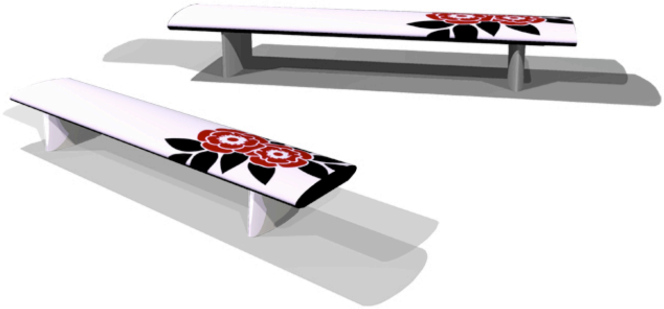

Figure 6.7.12 Visuals of UCLan bench

Mould

The second bench used the same wooden mould structure, as this was not deemed to be the cause of the failure of the first bench. However, the pattern on the surface of the bench was changed to incorporate the bench prototype into the UCLan campus proposal (see Figure 6.7.12).

To create the relief pattern an economical method of creating a flexible and versatile mould was required. Instead of using technology and pour-able rubbers cutting sheet rubber was selected as being the fastest and cheapest method available. Very simply the pattern was cut from a sheet and affixed using contact adhesive. This method is ideally suited to other less complex moulds and could be applied in a variety of other creative applications (see Figure 6.7.13).

Figure 6.7.13 Cut rubber mould

Casting

The same method was used for the second bench with some differences. While it was not thought that the polystyrene was the cause of the breakage it was felt that a solid cast, reverting to the previous monolithic casting method would be appropriate. In addition, it was decided that introduction of the metal fibre would reduce the risk and increase the tensile strength of the piece, particularly at the green stage where it was thought the cracks has been introduced due to handling and transporting the piece.

Figure 6.7.14 Casting without polystyrene and using metal fibre

The piece was fired in the department using the flat bed electric kiln. The bisque was to 1200°C and fired according to firing schedule 4 (See Chapter 4, Section 4.1[4]).

Figure 6.7.15 Mould removed and rubber relief peeled from surface

Figure 6.7.16 Placing bench in the kiln

Unfortunately this second bench also suffered two severe cracks evident after the initial bisque firing (see Figure 6.7.17). While the cracks did not travel all the way through the piece it was decided that the pursuit of a working prototype should be abandoned at this point.

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[4] Chapter 4, Section, 4.1, page 49

Figure 6.7.17 Image of one of the cracks (centre of image)

Conclusions drawn from failure of bench project

The bench project was designed to test refractory concrete in tension on a full-scale working prototype. Unfortunately the failure of both pieces before this could even be evaluated, makes the use of RC for this type of application impractical and unsustainable.

Even after two attempts there remain questions over what the root cause of the cracks is. In industry, forms of a similar and larger scale with similar spans are regularly cast without such problems. The Tatton project proved that large-scale monolithics could be achieved in a studio environment and the methods were not changed between the two projects.

The failure of both benches in a similar manner in different kilns and with different methods used in each bench, has lead the researcher to narrow the reason for the breakages to stresses introduced to the piece at a green stage. It is the researcher's opinion that the cracks are introduced at the point of removing from the mould when the piece is at a green state. The sheer weight of the piece and the span introduce micro cracks, which are not visible prior to firing and become visible and spread through the firing process. However, without further research this hypothesis cannot be confirmed.

6.8 Time Capsule Project

The final practice based project conducted within this research was designed to evaluate RC's abilities to create precise and dimensionally accurate forms.

The Time Capsule project is different from the other projects in that the design concept and development was done entirely by an outside agency. The researcher was approached by a design firm to create ceramic tiles for a Time capsule for the Saint Anne's Square Shopping centre in Belfast. The concept and project is perhaps best explained by the original designer Jonny Miller:

> I am currently working for a design agency in Belfast, and I've designed a Time Capsule for one of our client that has a ceramic component. I've attached a PDF document that shows the idea in 3D. Essentially, the design consists of a steel cube incased by 6 Black ceramic plates. To house these plates, there is a series of 12 flanges protruding from each of the cubes edges at an angle of 135 degrees. These steel flanges also create a visual key line around the finished cube. Access is gained to the interior of the steel cube by means of a recessed aperture, located below the top ceramic panel. The ceramic plates will be fixed to the surface of the steel cube by means of a suitable bonding agent, including the top, which will be tacked on once the contents of the time capsule are in place and any ceremonies regarding the project have taken place.
>
> The reason for the use of Ceramic in this application is because the development, for which the time capsule has been designed, is located in the middle of the area that during Victorian times was the ceramic centre of Ireland.
>
> Each tiles measure 400 mm x 400 mm x 20 mm and because the design relies on the relationship of the tiles and the steel frame a very high level of precision is required. The top tile is to be embossed with the logo. I realize that there are the elements of shrinkage and warping but I am hoping that these can be accommodated for.... My main problem is Time. I've just received the go ahead from our client but they need the finished Capsule in 6 weeks!! I have been in talks with a local ceramist, but once I told him about the time scale, he was a lot less enthusiastic.
>
> There are other routes I could go, other materials, but I truly believe that the Ceramic element brings integrity to the design that I would be reluctant to lose.

The initial concept drawings and visuals of the piece can be seen below (Figures 6.8.1 and 6.8.2).

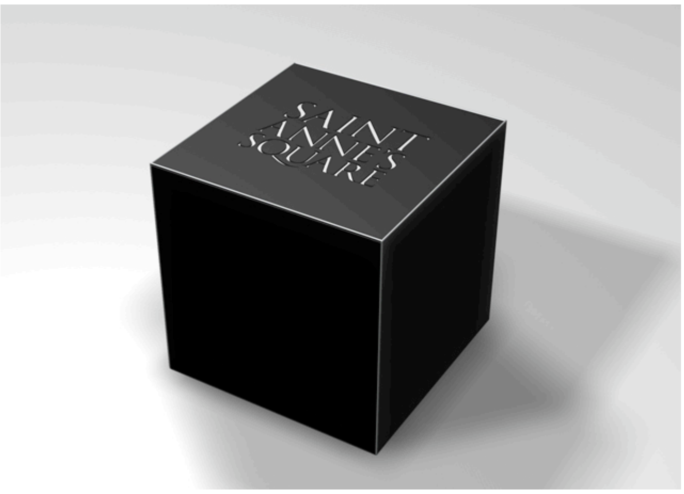

Figure 6.8.1 Time Capsule visual

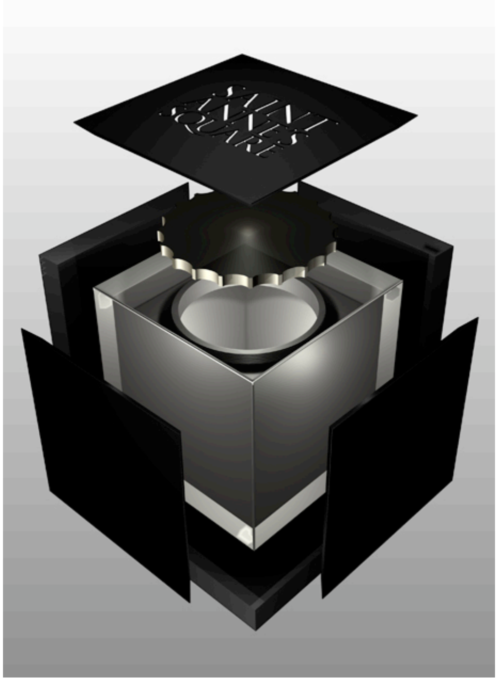

Figure 6.8.2 Time Capsule exploded construction

The project represented an ideal opportunity to evaluate the ability to work with RC with precise tolerances of ± 1mm and is also a further demonstration of the stability of the material in terms of its lack of warping and shrinkage.

Stages of Construction

Mould
Casting
Firing
Polishing and Finishing
Glazing

Mould

As with all of the other projects the first stage was the creation of a mould. The mould in this case was constructed from a number of materials and has a number of key features to enable accurate casting of a number of duplicates.

Mahogany was used to form the mould frame, chosen because the hardwood would not warp or change throughout the project. The casting frame was secured using pins to enable the removal of the piece and ensure that they were secured in exactly the same place for all subsequent castings. The wooden frame was varnished and coated in Vaseline before each casting to allow easy release (see Figure 6.7.3).

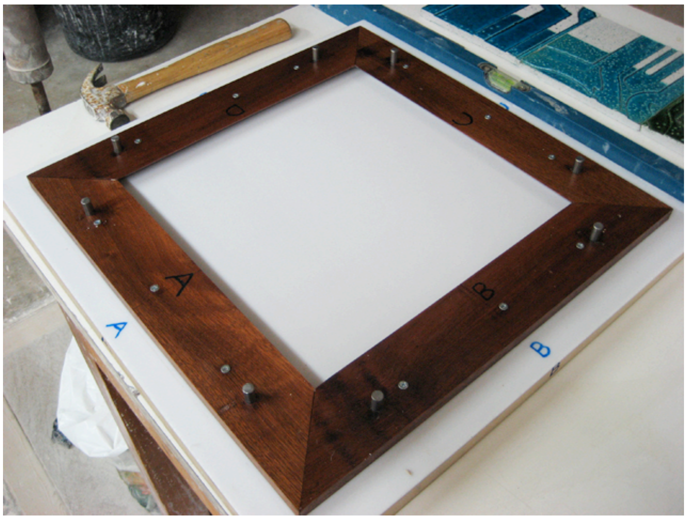

Figure 6.8.3 Plain panel mould showing pins with Perspex base

A Perspex base sheet allows the fragile cast piece to be removed from the mould.

Logo Text

To create the negative text the same method was used as developed in the graphic panels project with a slight increase in the depth of the cut to 1.8mm. The letters were waterjet cut stainless steel and inserted after glazing. The result is the appearance of stamped letters. Several tests were conducted to establish the depth of the cut to ensure that the steel lettering would fit taking glaze thickness into consideration.

Figure 6.8.4 Text relief mould

Casting

The sharp edges of the piece meant that the casting had to be a more fluid mix. The standard 4.5% water was increased to 4.8% by volume to ensure that the concrete would flow into the corners. In addition the more fluid mix is better at avoiding trapped air in the overhangs of the mould.

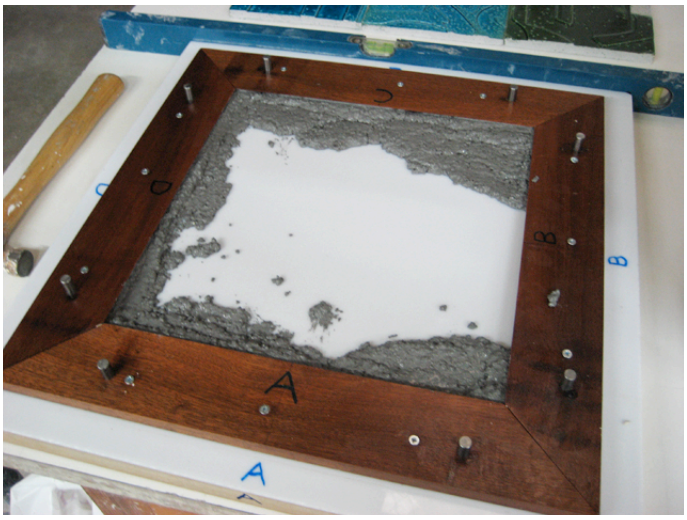

Figure 6.8.5 Pouring concrete into mould

Firing

The pieces were bisque fired flat on the outside face to 1200°C using firing schedule 1 (See Chapter 4, Section 4.1[5]). The stability of the material is again tested here, as any warping would cause real problems with final fitting in the steel case.

Polishing

While the outside faces require no polishing or grinding, the fired pieces still retain sharp edges and in some cases are slightly chipped from handling at a green stage. The design requirement was for rounded edges. The flex grinder was used to sculpt a rounded edge. The polished panel was then checked for fit and tolerance in the steel tray provided by the metal workers. Figure 6.8.6 shows clearly the level of accuracy achieved.

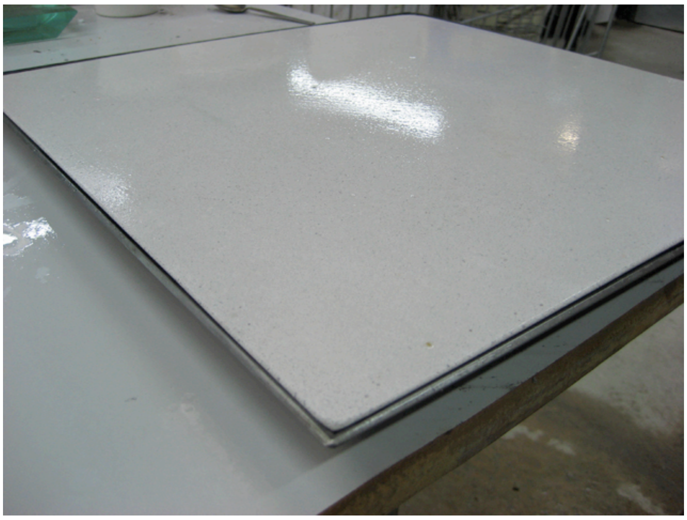

Figure 6.8.6 Polished edges of the panel placed in steel tray to check fit

Glazing

The surface quality of the piece was defined by the client, the requirement was for a matt black glaze that would be durable. It was decided that a copper saturated glaze with very small amounts of glass flux to provide durability would offer the most appropriate solution. In total 4 tests were conducted to establish a glaze that would satisfy the brief. The recipes can be found in Appendix 1 (E3-E6). The fired tests are shown in Figure 6.8.7.

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[5] Chapter 4, Section, 4.1, page 47

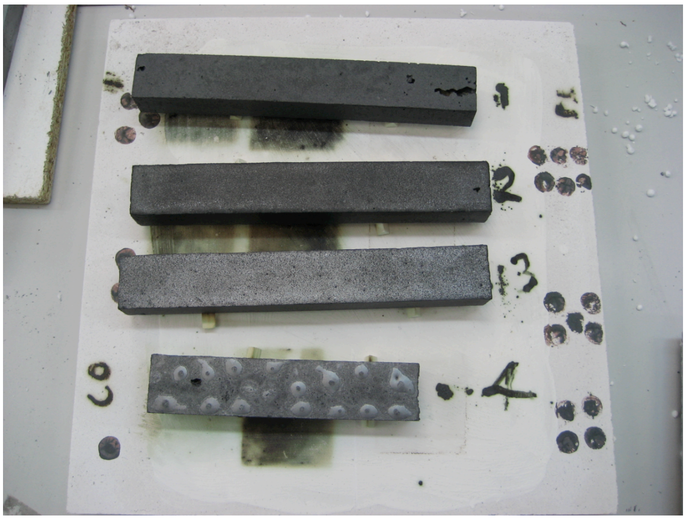

Figure 6.8.7 Glaze tests (top: E3 bottom: E6)

The selected glaze was glaze (E4) and was applied with a spray gun and fired to 1170°C.

Figure 6.8.8 Glazed panels prior to firing

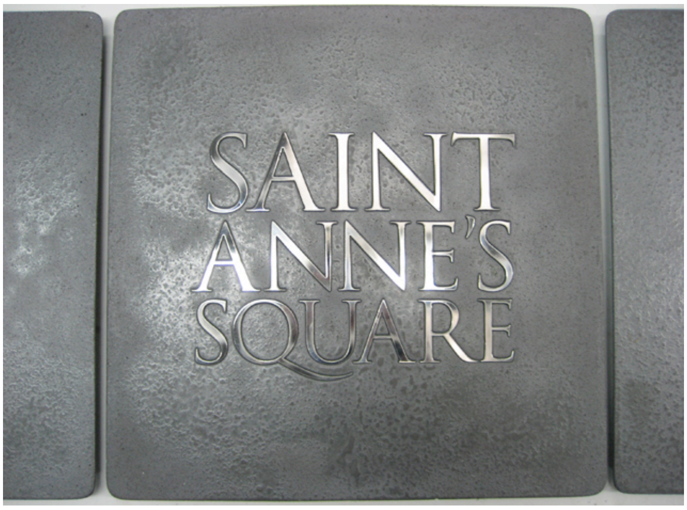

Figure 6.8.9 Glazed panels with stainless steel lettering

Figure 6.8.10 Finished Time Capsule

Conclusion from Time Capsule Project

This project set out to demonstrate the ability of RC to operate in very high tolerance applications. The pieces all fit perfectly within the steel trays and there was no need for any grinding or polishing to alter the fit. The material proves it is suited to applications where multiples are required and there is no risk to warping and shrinkage issues.

Chapter 7 Case Studies

7.1 Case Studies Introduction

The objective of the case studies was primarily to engage other artists in using refractory concrete. The case studies aimed to either confirm or deny the findings discussed in Chapter 6. A selected number of artists with different backgrounds, expertise and experience within the field of ceramics and design were approached to participate. This approach was employed to demonstrate the potential for both creative use and design in a number of applications that had not been investigated or conceived by the researcher. It was anticipated that the case studies would broaden the findings of the research and suggest areas that warrant further investigation. The case studies can also be viewed as a pilot study to explore the potential for running a symposium or workshop based on the use and manipulation of RC with invited artists.

5 artists were invited to conduct case studies. Due to unanticipated commitments one case study was not completed and is not discussed. This chapter will discuss the 4 case studies that were conducted during the final year of the research. The artists in alphabetical order were: Ken Eastman (UK), Tavs Jørgensen (Denmark) Sandor Kecskemeti (Hungary), Geoff Mann (UK). In each section the artists professional practice and area of expertise will be discussed and outlined before the case study experiments conducted by each of the artists are described. Finally the results of a structured interview with each of the artists will be reviewed. Full transcriptions of the interviews are available in Appendix 3[1].

Case Study Methods

Each artist was asked to complete the case study over a period of 3 months. This time limit was imposed to avoid the project being seen as a long-term burden on the participants and to enable a more immediate and intuitive response. In practice all of the case studies were conducted over a far longer period with work done, in many cases, when it could be fitted around other jobs.

Each of the 4 artists was provided with 25 kg of material. As the bulk of my personal practice utilised Jon Flo 90, it was felt that half of the participants should be supplied with Jon Flo 90. Except in the case of Sandor Kecskemeti who was initially supplied with 25kg of Jon Flo and requested additional material to conduct experiments at his

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[1] Appendix 3, page 31

second studio in Hungary. To broaden the results of the case study further he was provided with a different material: 25kg of Green tech. In addition Geoff Mann was first supplied with Greentech 170 and after initial experimentation asked if a stronger material was available. He was subsequently supplied with 25kg of Jon Flo. The result being that all 4 case studies utilised Jon Flo 90 in their study.

Instructions

Instructions provided for case study participants were limited to very basic information to avoid influencing the results of the experiments. Basic advice with regard to Mixing, Storing and Health and Safety precautions were all supplied along with standard material data sheets and industrial advice from the suppliers. Each participant was also supplied with a “lab book” in which they were asked to record their experiences and notes. All participants were asked to photographically record their experiments.

Structured Interviews

To evaluate responses to the materials provided, the research made use of structured interviews with all the participants, to both understand in more detail what work was conducted in the course of the case study and attempt to elucidate the participants true evaluation of the materials they were working with. The same questions were asked of the 4 main case studies. Full transcripts of the interviews can be found in Appendix 2.

In many ways the interviews conducted also gave an opportunity for the participants to revisit and reflect on the case study and the work that was done.

7.2 Ken Eastman

Ken Eastman is a ceramic artist with over 20 years experience of working in clay. He is a member of the International Academy of Ceramic artists (IAC) and is currently Academic Research Lecturer at the Glasgow School of Art.

Ken Eastman studied at Edinburgh College of Art (1979-83) and at the Royal College of Art, London (1984-87). He exhibits widely internationally and has won many prestigious awards in the field of the ceramic arts, including the 'Premio Faenza', Italy in 1995, the 'Gold Medal' at the World Ceramic Exposition 2001 Korea and the 'President De la Generalitat Valencia at the 5th Biennale International De Ceramica, Manises, Spain. In 1998-99 he was awarded the Arts Foundation Fellowship in Ceramics.

His work is held in numerous public collections including The Shigaraki Ceramic Cultural Park, Japan; The Museum of Fine Arts, Houston, USA; Musee des Arts Decoratifs de Montreal, Canada; Shepparton Art Gallery, Victoria, Australia; Museum Boijmans van Beunigen, Rotterdam; Landesmuseum, Stuttgart; Museu de Ceramica de Manises, Valencia and the Victoria & Albert Museum, London. Ken Eastman was elected as a member of the International Academy of Ceramics in 2003.

Eastman is best known for his work with large sheets of stoneware clay and has recently started to collaborate with Royal Crown Derby creating a series of bone china forms. The core of his work centres on the idea of the vessel. He has never made functional work, but rather uses the vessel as a subject, to give meaning and form to an expression. Working through the medium of ceramics, Eastman is both builder and painter handling shape and structure, as well as exploring tone and colour. Alison Britton has written of his work:

> "Not being at all bothered about function, Eastman's work with the pot form has been a consistent route into increasing abstraction, playing both with form and surface. That is what is potentially special about ceramics- you can have body and dress, sculpture and painting, essentially connected. Painting has always been a strong card for Eastman; he can be lyrical on the sheer walls of his objects. The gestures that are made with the brush are fluid and sensual, the colours rich and quiet."

Figure 7.2.1 “Abermawr” (2006)

Eastman’s work in pushing the boundaries of working with clay was one of the reasons for engaging him in the project combined with his eagerness to explore unfamiliar materials and ways of working also contributed to this.

> Part of the reason for making (in fact a very large part of the reason) is to see things that I have never seen before- to build something that I cannot fully understand or explain.[2]

Figure 7.2.2 Birches Series (2006)

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[2] http://www.keneastman.co.uk/profile.html

Figure 7.2.3 “Goya” (2006)

Approach taken in Case Study
Material Supplied: Jon Flo 90

Eastman’s way of working with ceramics involves working with stoneware clay in its plastic state- rolling, shaping, cutting building. To explore the potential of Jon Flo 90, Eastman was required to change and adapt his approach to making. The focus for his research was to cast various flat slabs of material and explore the strength, sensitivity and, in particular, colour responses of the new material. For the case study Eastman decided to collaborate with another artist. Helen Cass is an artist who works in the area between painting and sculpture, between 2 and 3 dimensions. Her stitched and painted canvases project as three-dimensional relief several inches out from the wall. The canvases are stretched on hand made stretchers, giving the panels undulations and sway. Her work is very subtle and reliant on the most minute surface details and texture. Eastman felt using Cass’s work would highlight Jon Flo 90’s strengths and weaknesses. Two examples of Cass’s Work can be seen in figures 7.2.4 and 7.2.5.

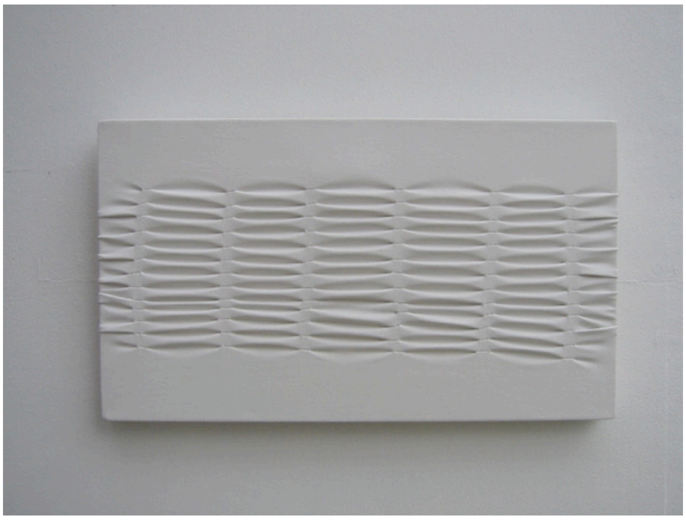

Figure 7.2.4 Helen Cass stitched canvas

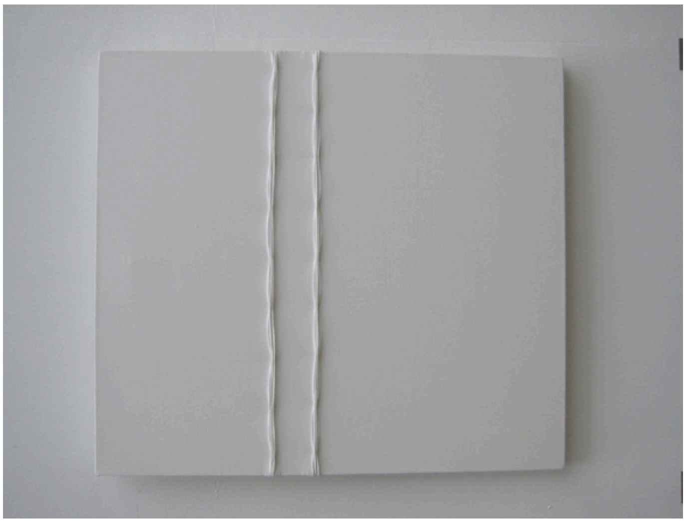

Figure 7.2.5 Helen Cass stitched canvas

A short biography which is taken from Helen Cass's website is included here.

> Helen Cass graduated from the Ruskin School of Drawing and Fine Art at Oxford University, before undertaking an MA, and most recently a PhD, in Fine Art at the University of Wales. Her work focuses on surface, texture and repetition and she is intrigued by the minutest variations of fabric and light. The combination of monochrome colour and the repetitive folding or stitching of the canvas surface creates an almost hypnotic quality and whilst the majority of Helen's paintings have no obvious focal point, they continue to demand our attention. The eye is happy to dance over the surface of the paintings following the lines Helen creates, leaving the viewer feeling calm and centred, as if in meditation. Cooly abstract and beautifully composed, Helen's work combines a deep sense of purity with a quiet sensuality. Precise, immaculate and perfectly proportioned, her artworks display common themes of patience and spirituality. Helen's work has been exhibited widely throughout England and Wales and she continues to receive an ever-increasing number of commissions, including paintings for the Calvin Klein Head Office in London and various pieces for a growing number of private collectors.[3]

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[3] http://www.harris-interiors.co.uk/new_page_3.htm

Moulds

Eastman worked directly from Cass' canvas relief panels and used them as formers and the basis for the moulds used within the case study. Considering the weight of the mixed Jon Flo 90 all the canvases were built up underneath for support using plastic clay and other supports. Moulds and shuttering were built up around the panels using wood. All the moulds were sealed with plastic clay and finally light oil, prior to pouring the mix.

Figure 7.2.6 Canvas mould prior to casting.

Casting

In the "Lab Report" Eastman describes the casting process:

> Pouring the material was carried out as soon as possible after mixing – usually within 5-10 minutes. Always only one pour was required. The material was found to be very heavy at all times but it did nevertheless 'flow' to a degree. The material was worked into the recesses of the mould by hand and the mould shaken vigorously to aid settling and remove any air bubbles.[4]

Eastman stated in the interview conducted after the case study that he followed the instructions provided at the start of the project and only slightly increased the water volume to aid the mixing. However, judging by the following, the water to material must have been higher than the recommended 4.5% as water on the surface of the cast is a clear indication of too much water.

> The material began to harden quite quickly. It was found that there was not too much time for working before the material began to go off. Water rose to the surface during this period and increased the particle accumulation at the 'back'

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[4] From Ken Eastman's "Lab Book"

> of the casting. Whether this was a result of poor mixing or lack of grinding of material or whether this is just a feature of the material I do not know.[5]

This high water to material ratio is I believe responsible for the observed weakness in the material after the pieces were removed from the mould.

> However at this stage the material is still quite fragile as sheets of raw unfired concrete. On one occasion a slightly too rough handling caused the sheet to break into several pieces. I realized I should be thinking and treating the material as clay rather than as a concrete.[6]

This is not to say that the results of the experiments conducted by Eastman and Cass were not successful. As Eastman observes, the desire and aim of the case study from their point of view was primarily to reproduce the detail and qualities in Cass's paintings in RC.

> Once removed the casting of the canvas with its minute details of stitching could be examined. Despite the heavy rugged nature of the material and the various difficulties of working the concrete, I was very impressed with the finesse and sensitivity of the cast. Tiny details were clearly picked up and where required, a precise and smooth surface produced.

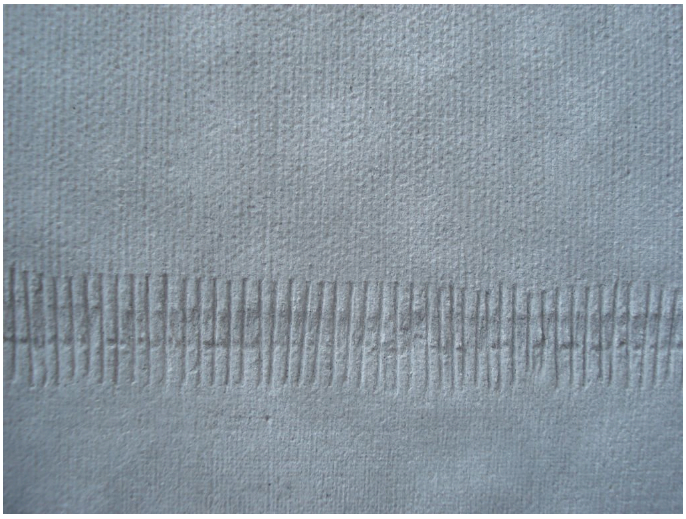

Figure 7.2.7 Fired cast clearly showing the level of detail achievable.

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[5] From Ken Eastman's "Lab Book"

[6] ibid

Painting, Colour and Firing

Following on from his ceramic work Eastman was keen to explore the colour response of RC when using ceramic slips and engobes. As mentioned earlier this is a technique he has perfected in his ceramic work and so he decided to focus the experiments on attempting to achieve the same results with RC.

> Colour being a primary concern and subject for my own ceramic work, I was particularly interested to see how the material could be painted and how it would handle colour through the subsequent firings. I usually paint coloured ceramic slips and oxides onto leather hard and also fired clay, building up layers of various patinas to reach a degree of depth and resonance.[7]

Slip application and fired results

Eastman painted skins of ceramic slips and oxides onto the surface of the cast pieces. Concentrating on a cobalt blue and green colour palette of slips used commonly in his ceramic work. He noted the lack of shrinkage for Jon Flo 90 and so adapted his slip recipes to minimise the shrinkage.

> I used a ceramic slip with high flint content and using calcined clay as filler. I found it was best to build up layers of colours leaving the slips to dry for several minutes between coats and then adding more. Approximately 6 layers were added before a really good depth was obtained and then the cast was left to dry prior to the first firing.[8]

Figure 7.2.8 Slip on the surface of Jon Flo

Eastman experienced mixed results with the application slips and oxides and describes his experience as follows:

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[7] From Ken Eastman's "Lab Book"

[8] ibid

> After the first firing, whether it was to 1000°C, 1100°C or 1200°C and despite using very low shrinkage slips I found quite bad cracking of the coloured skins. It was clear that I would need to develop a range of mediums which have virtually zero shrinkage if I was to produce any finished work with the material. The colour skin tended to 'sit' on top of the Jon Flo rather than be absorbed into it. However, the colour mostly bound well onto the refractory and was quite hard to chip off. Where there was heavy cracking though the slip had lifted slightly from the underlying Jon Flo and could be levered off with a chisel. (See Figure 7.2.8)

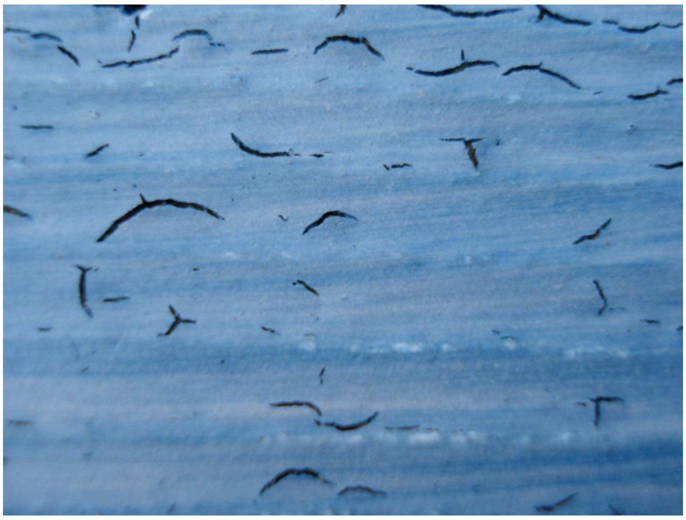

Figure 7.2.9 Slip cracking on surface

The shrinkage issues combined with the refractory body that remains un-vitrified at the temperatures used by Eastman was always going to pose problems with application of slip and is noted by Eastman in the concluding statement from the 'Lab Report':

> The Jon Flo 90 absorbed much of the colour and left the surface very matt. Colour response was quite muted but it did build up to a richer surface after the second and third subsequent firing of the same pieces. There was some iron spotting. I have not been able to develop colour, which sinks into the refractory and becomes part of the material. The Jonflo90 always felt quite 'inert' compared to the volatility of ceramic. I am used to firing material, which moves shrinks, condenses, but responds and becomes combined with the ceramic colour. With high-fired stoneware clay, the oxides sink into the clay and interact with it. However the basic tonal range of the Jon Flo 90 offers a lot of potential by itself for further experimentation- I just need to able to fire it a lot hotter than I can at present. (See figure 7.2.9) [9]

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[9] From Ken Eastman's "Lab Book"

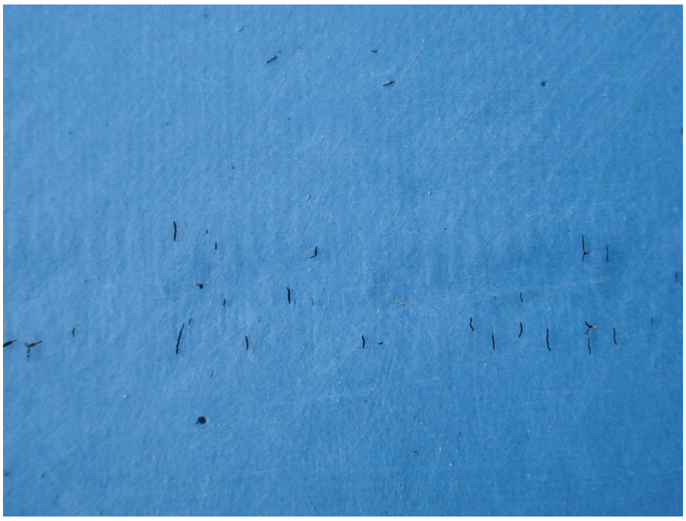

Figure 7.2.10 Blue slip covering the embossed detail

The final series of experiments conducted were in a way a response to the tests conducted using slips. One of the stated aims from Eastman was to explore the surface definition recorded by the concrete. However through the application of multiple layers of slip much of this definition was lost. There was also a need to evaluate the material in its natural, uncoloured state, as much of Cass's work is monochromatic, working within a range of canvas tones sometimes painted black or a variety of white. The result was the decision to conduct some experiments that left the surface unpainted, designed to evaluate the potential colour range of the raw material at various different firing temperatures. Eastman observed the results of the unpainted fired Jon Flo at several temperatures: 1000°C, 1100°C and 1200°C.

> I used a long firing schedule, which I use with my other ceramics- taking about 10 hours to reach temperature. There were no firing faults or problems. The material remained still and did not appear to move, warp or shift at all. A slight condensing of the material was noticed at higher temperatures. The colour became rather lovely at the higher temperature- quite white and icy. The material was obviously stronger but even at 1200 still surprisingly breakable, where the casts were quite thin. Perhaps it really needed to go to the much higher temperature, which I know it, can sustain (1600) to produce really hardened effect.[10]

Discussion of results and interview

After Eastman had conducted the case study, a structured interview was conducted to establish how the material had performed and generate an understanding of the findings, observations and difficulties that were encountered. It should be noted that Cass was unable to attend the interview.

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[10] From Ken Eastman's “Lab Book”

The ability of the RC to reproduce the detail of Cass's canvas work was a clearly defined aim for this case study and as was discussed in the Lab report there was clear success in this aspect of the project. Although Cass was not present for the interview Eastman expressed her satisfaction with the qualities achieved:

> She was very impressed with the way this incredibly lump and sticky, hard; viscous stuff was very responsive to tiny subtle surfaces of different canvases. She liked all that. I think the jury's out a little bit I mean maybe she has to hang them on a wall in a galley.[11]

This was expanded upon later in the interview as Eastman discussed the properties of the material,

> …Things that have been of interest is the strange incredible sensitivity to casting that the material seems to have. This great, heavy lump of thing that you have to move and mix and it won't rot, it has the half-life of five hundred thousand years. You can't break it, but you can take a fingerprint off it, and I'd like to do more of that…[12]

One of the main observations made by Eastman was that rather than offering specific opportunities for pieces or objects, not considered achievable in conventional ceramics, RC also offers the possibility to move into new areas away from the fine art or craft sphere. Eastman describes concrete as a material with very different preconceptions from that of ceramics.

> I kind of had expectations of it because I know what you can do with concrete… What are those? Well I suppose it would be extremely weighty and extremely strong and there would be a huge density to it and an architectural quality to it. So I suppose it would move me into an area, which I quite liked. This material although I was working with it on a desk somehow had the ambition and the…capability to move me out into the world, out into the architectural space.[13]

However Eastman observes a paradox when this theory is applied in practice.

> …I have found out that maybe I need to do something different here and actually I need to take on those thoughts more. Possibly, maybe working with Helen is kind of a contradiction to that because it's drifting the work back onto the wall and back into a fine art world…Where as I have actually been saying that the attraction is taking it off that, out the gallery door, into the high street into the square and yet there I immediately withdrew to someone who worked with pictures that you place on the wall… because of the word concrete and what we mean by its different ambitions and this material can take me somewhere, it can take me somewhere I can't go with my bit of canvas I can't go with T-material. I have nothing to contradict that, I still think it probably can,

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[11] Interview Transcript, Appendix 3, page 32

[12] ibid page 38

[13] ibid page 36

> but I think having just put my toe in the water I need to have some help, and I need to have some more. I still think it probably could…[14]

Despite the moving back to so called ‘gallery’ or ‘fine art’ work within the case study, in the interview there is a clear message that where the material is at its most exciting is where it has the potential to take work, the visual language and rules established through practice in one material are still available to the artists but do not mean the same thing when using RC.

Another observation from Eastman reinforces the view that working with new material, tests and forces new directions; skills learnt on one material are not necessarily transferable to a different material. Eastman uses the following analogy:

> It was a bit like: I have got quite eloquent in Spanish and you have just dumped me down in Shanghai and I am trying to sort of… alter my accent a bit. But I now realise that Spanish is not the language here.[15]

As a result of the case study Eastman changed his impression of the material and perhaps regretted the approach taken. This is to be expected when dealing with an entirely new material and was in some respect one of the sub aims of the case studies; to see how a new material might affect an artist’s work.

> My work is about illusion and skins, and volume, and emptiness and looking through a veil of two dimensions. So to be able to make one of these pieces absolutely solid, everything about mass is not an area I explore, I explore illusion and skin and idea. But mass in that old sculptural way I don’t know anything about, that solidity, that density that sheer weight.[16]

However as is expressed in the other case studies, there is the suggestion that any future work in the area might be better conducted with assistance either from the industry or the researcher.

Eastman requested additional material after the cases study was formally completed and has since continued with the work done with Cass. Using the experience learned through the case study to explore the concrete qualities of RC. As is noted in the other case studies, the case study experience was described as positive, albeit with a number of barriers to future adoption of the material.

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[14] Interview Transcript, Appendix 3 page 36

[15] ibid page 42

[16] ibid page 39

One of the clear problems that Eastman found was a lack of strength- he describes the material as being weaker than he imagined and experienced breakages. It is the researchers understanding that this is a direct result of a higher than recommended water to material ratio. This was discussed in the interview; in some cases the casts were as large as 4kg and were mixed in one batch.[17] In my experience manual mixing of this quantity of Jon Flo would be impossible using 4.5% water. Again here the need for a mechanical mixer when doing larger scale work is reinforced.

The experiments conducted into applying slip have already been discussed above and these observations were also highlighted in the interview.

> I tried to chip [it] off and it's quite on. But in another way it didn't work, it didn't seep into the material and it didn't absorb any of the colour it sat on the surface… even more after the firing than it did before, it kind of floated above there and it didn't go into the material.[18]

The move away from the application of slip was also discussed and the reasoning behind leaving the material in an undecorated state expressed.

> In fact I covered the material up like putting cloth over the material and all the qualities of the material I hid. So, at the end of doing some colour tests I am coming round to Helen's position really and if I am going to do some concrete work I'd quite like it to look like concrete than look like a painting.[19]

This seems to have been a common view in the cases studies, instead of applying a glaze or surface decoration, the majority of participants express an interest in retaining the qualities of the concrete.

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[18] Interview Transcript, Appendix 3, page 34

[19] ibid page 34

7.3 Tavs Jørgensen

Tavs Jørgensen is an artist and designer from Denmark that has worked in the UK since 1991. Jørgensen's work has, for a number of years now concentrated on the integration of digital tools within creative practice. He is currently lecturer at the Royal College of Art in London and a member of the (a)utonomatic research group at University College Falmouth.

Jørgensen has been running his own design consultancy since 1995. Throughout this period Jørgensen has been closely associated with Dartington Pottery, operating as the pottery's senior shape designer. He continues to work as an independent designer and researcher.

Figure 7.3.1 "Origami Vases" (2002)

Much of Jørgensen's work is functional in its nature but combines a mix of technology and craft processes. Jørgensen has extensive knowledge of ceramics and in particular mass manufacture. Equally he would also consider himself a product designer often engaging in projects that utilise a range of manufacturing technology and materials. This knowledge of advanced technology and his interest in a variety of materials were seen as important factors in involving him in the project.

Figure 7.3.2 “Contour Bowl” Bone China (2003)

Approach Taken for Case Study

Material Supplied: Jon Flo 90

Jørgensen’s first step was to evaluate the material by mixing some small 200g samples with two different water ratios 11ml and 16ml the samples were placed in a simple mould and free cast onto a flat surface, see figure 7.3.3-4.

Figure 7.3.3 Initial cast samples.

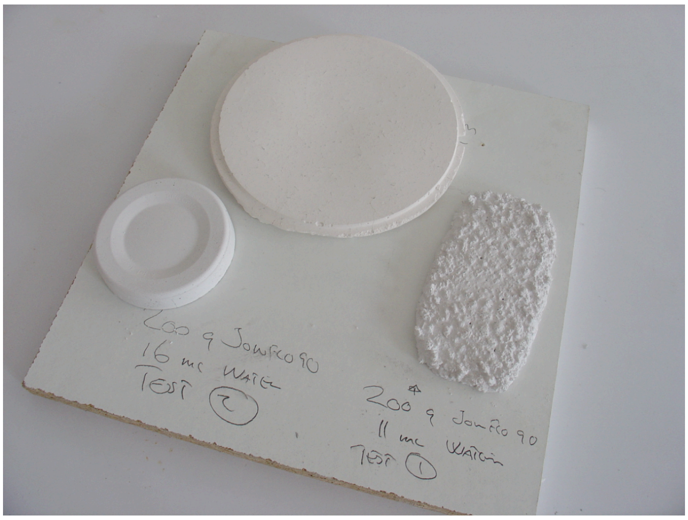

Figure 7.3.4 Fired tests.

His initial observations are recorded in the lab book as:

> The material is strangely sticky and thixotropic, the material is stiff yet “runny” on the bat the material likes to spread… moulds needed to keep shape…The fired tests are fine and hard very white in colour.

Jørgensen’s current area of interest is in the manipulation of glass sheets through heat, incorporating a number of innovative mould making techniques. Jorgenson describes the process as using digital tools to create with, specifically a digitizing arm, micro-scribe G2.

Figure 7.3.5 G2 Microscribe

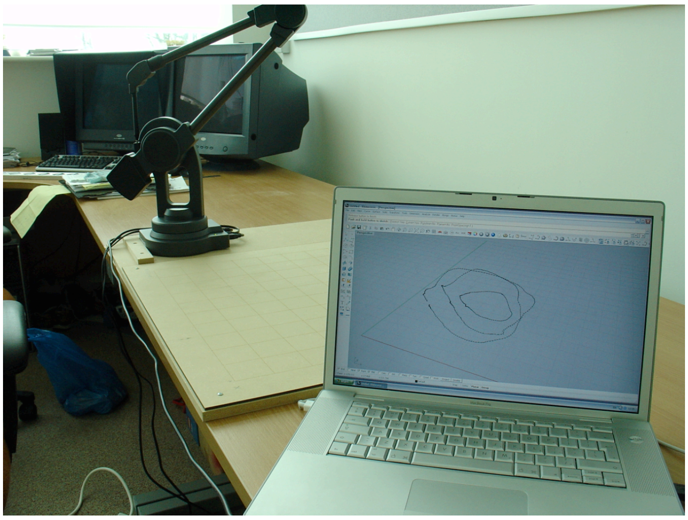

Figure 7.3.6 Microscribe showing recorded lines

> The G2 Micro-scribe can perhaps be most usefully described as a conventional computer mouse but with an added Z-axis so the input becomes three-dimensional. Coordinates are entered by pressing a foot pedal or activated automatically by a preset distance of movement (stream line). Instead of entering coordinates of existing objects, experiments revealed that the digitizer could be used to record freehand movement in space, and so be used as a highly intuitive three-dimensional drawing tool. During this process data from the Micro-scribe was fed directly into a CAD program to create three-dimensional linear paths. [20]

The micro-scribe records where a line would be defined in space free hand in mid space, recorded directly into a Computer Aided Design (CAD) package. From this recorded line the intention was to make a former to create glass pieces.

In many ways the approach taken by Jørgensen is different from the other case studies as Jørgensen saw the concrete material as a support material, or rather as a “means to an end”, instead of as a finished object in itself. Prior to using the concrete Jørgensen had used a glass casting plaster mix and stainless steel sheet to define the line. Instead of using the sheets for this project Jørgensen used pins for the formers. The idea with this was to use the genuine data of the recording from the micro-scribe.

The loop or the rim defined in space as points in space so the pins would be set in a laser cut pattern and the heights were defined by unrolled 2D representation of the height value of the points in the recording. So the pins were set into a cardboard collar (see Figure 7.3.5).

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[20] From ‘Binary Tools’ a paper written by Tavs Jorgensen available at http://www.autonomatic.org.uk/downloads/binary_tools.pdf

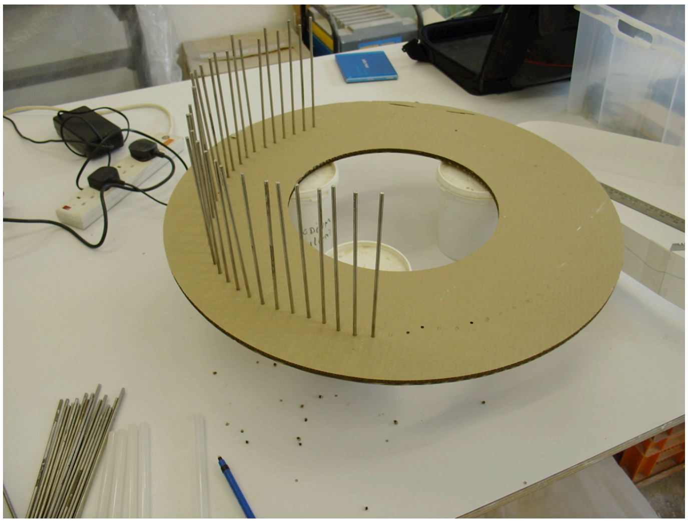

Figure 7.3.7 Pins are inserted into the cardboard collar

So the refractory concrete was cast around the bottom of the pins so to hold them in place. Clay walls were used to create the mould for the concrete.

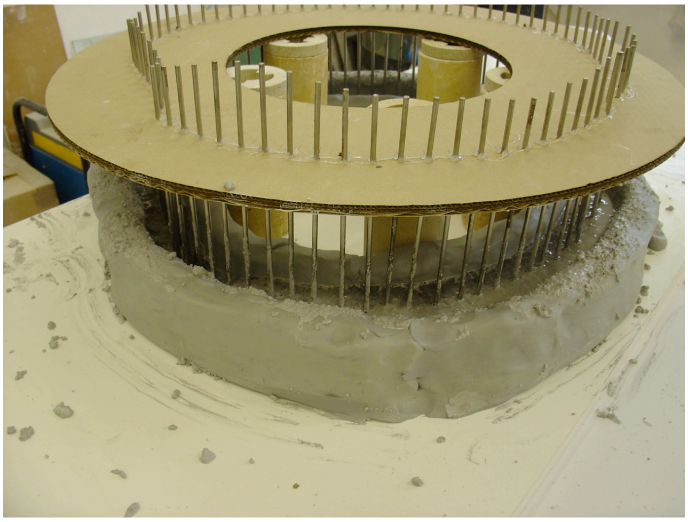

Figure 7.3.8 Concrete poured into the mould.

The glass disc is placed on the top and the heat increased so that the glass domes and create a vessel reflecting the points.

Figure 7.3.9 Initial “bisque” firing of concrete.

Figure 7.3.10 Sheet glass “domes” during the firing

Figure 7.3.11 Finished glass piece.

Discussion of Results and Interview

The approach taken by Jørgensen means that little investigation or discussion of the creative potential in terms of finished objects is possible.

The application of Jon Flo 90 as a tool, rather than as a creative material is perfectly valid. This application was explored in the practical projects and in particular as a replacement for the high temperature glass casting plaster moulds used by Binns (discussed in Chapter 6 Section 6.4[21]). The findings and practical uses of RC in a glass-casting context are confirmed by Jørgensen's experience in the case study.

> Because the issue with this process, obviously you pointed it out, I used this as a replacement material for the plaster and plaster is brittle when you fire it. Now I want a mould I can re-use. So the idea was to use this material for the mould so it would be far more durable. I mean plaster cracks after the first firing, and goes very brittle.[22]

This is reinforced when he was asked what the potential advantages of RC are in his opinion.

> I think the advantage is, it seemed to be quite durable, you know, it can take heat. But the fact that I can use the mould again and again and that it seemed far more durable than the plaster.[23]

Jørgensen's views the durability of the material as the major advantage combined with the potential for re-use of a mould is clearly identified as an advantage. However this is heavily tempered by the problems with mixing.

> Yes, very strange thixotropic characteristic, I mean, more than any other material I have ever come across. So it's very difficult to mix, very coarse. Mixing by hand is difficult.[24]
>
> Well we have covered the mixing, and it can be a little bit difficult to pour, compared to the plaster… it's heavy, but would you describe that as a disadvantage, I don't know, I mean that's the material.[25]

This is a common complaint from participants, and really other than the use of a mechanical mixer this is a difficult problem to overcome. However in this case there is no need to use Jon Flo 90 and the subsequent difficulty of mixing manually. Whilst Jon Flo 90 is suited to the application, there are far more suitable RC's that cost less and are easier to both mix and install.

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[21] Chapter 6, Section 6.4, page 125
[22] Interview Transcript, Appendix 3 page 50
[23] Ibid page 50
[24] Ibid page 48
[25] Ibid page 50

7.4 Sandor Kecskemeti

Sandor is a Hungarian artist currently working in both Hungary and Germany. Relatively unknown outside of Hungary and Germany he is a prolific maker turning his skills to a vast range of materials including clay, stone, bronze and glass. Perhaps best known for his large-scale commissions in Germany. Keckemeti was invited to be an artist in the project because he has a clear interest and talent for exploiting materials. Furthermore, input from an artist based outside of the UK was seen as important to broaden the perspective of the case studies.

Sandor Kecskemeti's work derives its power from the clarity of his vision. A clarity based on his particular sensitivity to the materials he exploits. In this sense he is certainly a leading figure in ceramic sculpture in Europe. Michael Flynn has said of Keckemeti's work:

> His best pieces are a synthesis of technical, formal, aesthetic and intellectual elements, which goes beyond the sum total of these parts. He is an artist who is exploiting as his prime medium the versatility of ceramic to develop and express his ideas. [26]

Figure 7.4.1 ‘Sculpture” Clay 25x27x8 cm (1982)

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[26] International Ceramic Studio Kecskemet, Hungary. ‘Heroes 2000’ http://www.icshu.org/symposia/heroes2000/ks.htm

Figure 7.4.2 “Sculpture” Porcelain 18x19x10cm (1997)

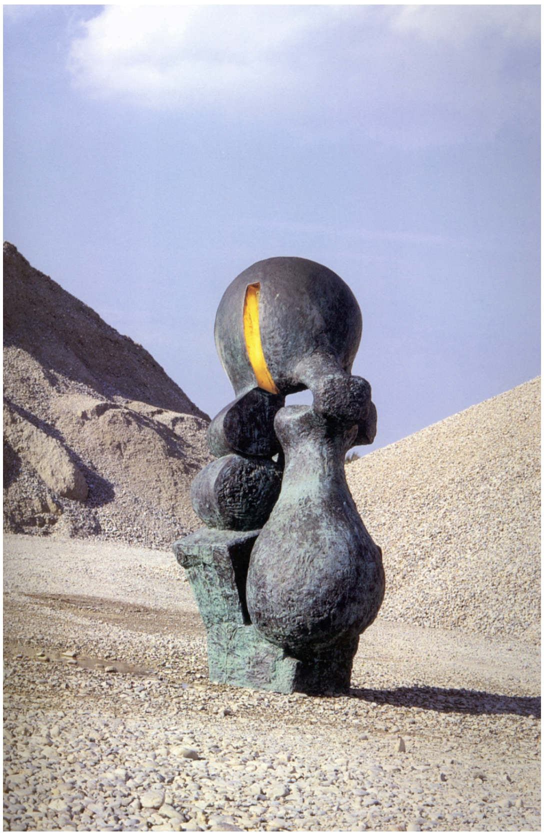

Figure 7.4.3 “Power” Bronze sculpture 320x120x100cm (1994)

Approach Taken for Case Study

Material Provided: Jon Flo 90 and Greentech 170

Kecskemeti's approach to the project was somewhat different than the other participants. His eagerness to evaluate the material in the full range of different firing and finishing techniques he uses when working with clay gives a more rounded and in depth investigation into the material and its potential surface manipulation possibilities. Drawing on his extensive experience in ceramics, Kecskemeti set about the project as a series of experiments aimed at exploiting a different surface finish on a number of pieces.

Creating forms

Keckemeti used Hungarocel/Syropor or Styrofoam in English (a hard insulation material). The material was cut with a hot wire and the desired form was shaped either by a template or by free hand design.

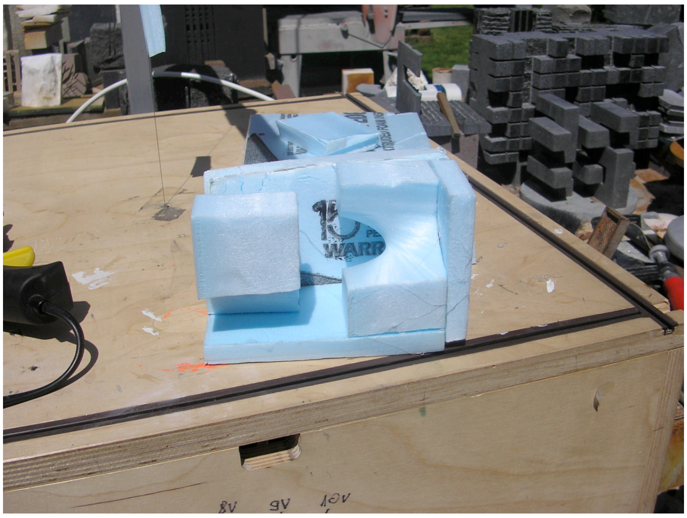

Figure 7.4.4 Cutting Styrofoam with hot wire.

Figure 7.4.5 Casting in moulds

The possibility of making hollow objects with a Styrofoam core was also explored (see Figure 7.4.6).

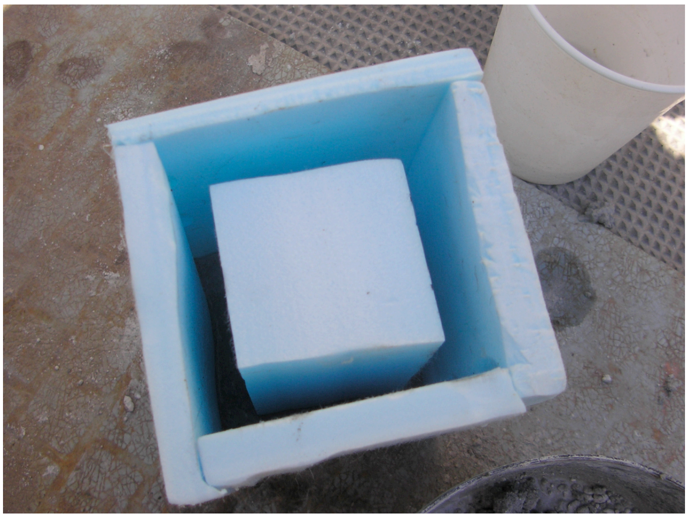

Figure 7.4.6 Hollow core mould

Firing

Keckemeti chose a very aggressive way of firing in a small test kiln. The objects were in direct contact with the gas flame, reaching the maximum temperature very quickly, holding the temperature for a long time and in his own words: “ brutally quick cooling. My experiences have been great, the material is perfect for heat shock!” he also observed the colour of the concrete after oxidation or reduction firing is featureless and shows no difference. However, combined with a number of oxide salts he observed the following:

> I fired in a reduction [atmosphere] and coloured them with Cobalt Chloride soak (of course just after the second firing) to achieve the typical cobalt blue. I assume that surfaces treated with different iron salt soaks (Iron Chloride, Copper Chloride etc) would produce the typical colours.[27]

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[27] Taken from translated copy of Lab Book

Figure 7.4.7 Fired cobalt soak piece.

Kecskemeti also conducted *Raku* firing, cooling pieces to 600°C and locally reducing in a bed of sawdust in the standard *Raku* technique.

Figure 7.4.8 *Raku* firing

Figure 7.4.9 Raku fired piece

Glazing the RC was only lightly touched upon by Kecskemeti. The result of which can be seen in Figure 7.4.10

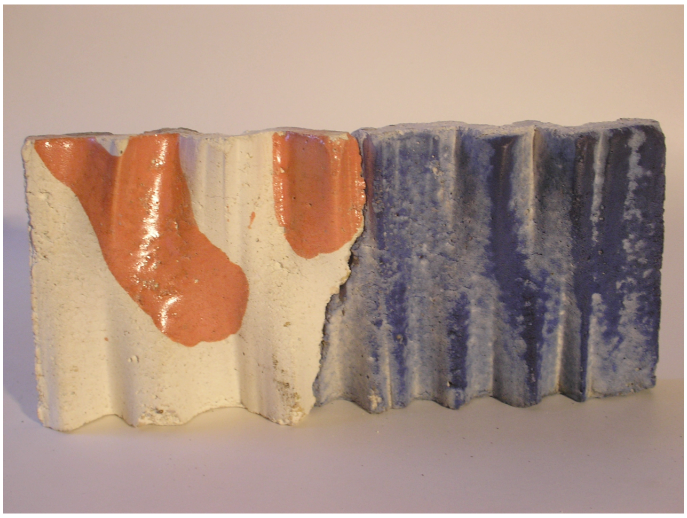

Figure 7.4.10 Glazed and cobalt salt treatment

Glazed work has never been a part of Kecskemeti's work in clay and so the testing was limited to one glaze (recipe and temperature not recorded). The results were successful and are evaluated by Kecskemeti in the interview as:

> SK: I don't like the glaze, you know the glaze is like the clothes, and it's not organic with the body and the form. I want to find this organic.
>
> AB: So you want to see the surface come from the body.

> SK: Yes coming from the material. And you know if you put the glaze, and put in the kiln, then melts, but what, maybe its ok, maybe not. But if you can think about what you can mix in the material to give the glaze. Because the glaze is a very complicated thing. [28]

The final series of experiments conducted by Kecskemeti involved the use of a welding torch to locally 'fire' the surface at a very high temperature with the flame tip being over 2000°C.

> I made the welding flame surface treatments, the "clean" concrete didn't react to the very high temperatures, but the ones with the Cobalt treatment did react as I expected and produced the required effect. It is likely that it is the melting material or the material applied on the surface that produces this effect not the material itself. [29]

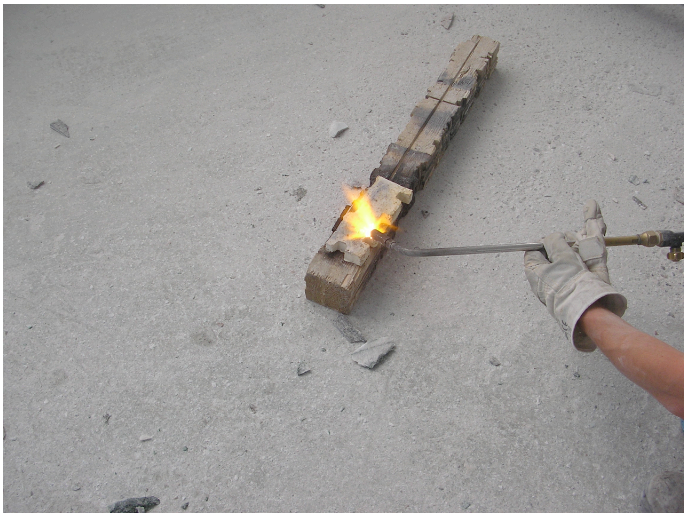

Figure 7.4.11 Working the surface with acetylene torch

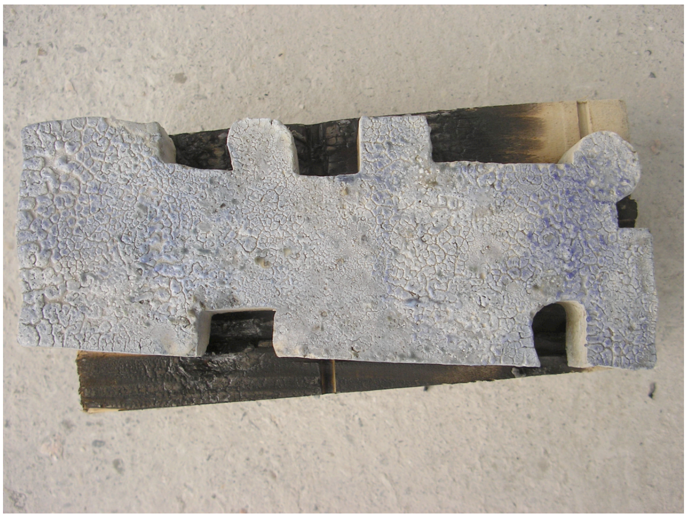

Figure 7.4.12 Surface after treatment with acetylene torch

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[28] Interview transcript, Appendix 3, page 63

[29] Taken from translated copy of "Lab Book"

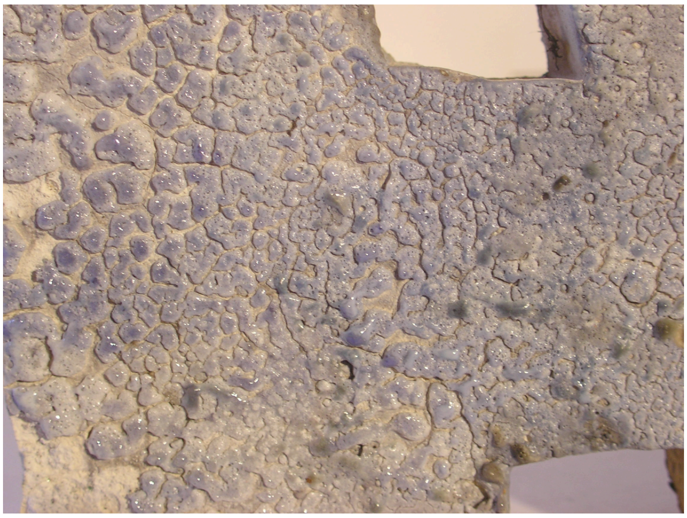

Figure 7.4.13 Close-up of acetylene torch piece

Kecskemeti notes this local surface firing as a technique that he had previously experienced in Hungary.

> Like this my assumption is that in the future there is a possibility for a surface shaping with an external flame treatment. (There have been experiments with this 25-30 years ago in Hungary with a similar refractory concrete on an industrial scale).[30]

However, despite extensive searching and referring back to Kecskemeti in the interview for a source for the experiments no information or written record could be found.

Discussion of results and interview

Kecskemeti conducted the most experiments and tests during the case study. The aesthetic he achieved in the case study is in many ways very similar to his work in clay. In this respect the case study can be considered the most successful, in that clear benefits and potential for future work is demonstrated through both the physical work produced and through the interview. This is not to say that the experience was entirely positive for Kecskemeti as there were some negatives identified. As with all the other case studies mixing proved to be the biggest problem.

> Ahh… My biggest problem, I write it for you… the biggest problem was the size, because the mixing of this material. This is the biggest problem. If you are mixing with very small cup. You know, I know I mixed with your advice. I did this, I don't know 4%, 2% water this is impossible. If there is [Machine] then it is mix then after this material is open then you can be. If you can use a factory then your thinking is different.[31]

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[30] Taken from translated copy of "Lab Book"

[31] Interview Transcript, Appendix 3, page 53

This problem of mixing was resolved by Kecskemeti by dramatically increasing the water content, for the solid and less fragile objects that were cast this increase proved not to have too detrimental an effect on green strength and it was noted that the fired strength was, in Kecskemeti's opinion the same as the samples mixed at the recommended water ratio.[32]

Kecskemeti shares with Eastman reservations with RC in the change from plastic clay material that offers immediate responses and familiar processes to the more rigid mentality required when working with RC.

> The casting material of course you must be thinking of something completely different. I had some idea with the concrete that I heard, you can be blowing, or you can casting. But, modelling, nothing!
>
> If I am working with the ceramic, the ceramic is unbelievable nice material because if I put my finger in the material this is my question, if I put out then answer is the next minutes the next seconds, I can see. This material the ceramic clay [refractory concrete] is the one material in the world that gives the very fast answer to the question. If you are working with the stone you can put your finger in the stone and nothing. No answer… [33]

Kecskemeti also struggles with the problem of why use this material? A reason for using this material over alternatives is important as he correctly points out, the material and process are far more expensive than conventional concrete.

> I understand, this is only the concept question, for example if I had, somebody come to me that wanted from this material the big sculpture, of course I must change my meaning, I must build the concept, it is without firing this material is normal concrete without firing it is functional, you can painting, everything. This material you must fire and this is very expensive. Then I must be thinking about this material is so *edel* so *edel* [coarse] The quality of the material, maybe stone or…[34]

Kecskemeti's dismisses the ability to glaze the concrete as an answer to this question as his own aesthetic does not look for this quality.[35] His real interest in the material was concentrated on the experiments with the acetylene flame. While he points out that similar effects can be achieved with natural stone and in particular with granite, the surface can be worked with a high temperature flame in a similar way to the experiments conducted on RC. However, with any natural stone while the material itself is cheap, forming the material is expensive and time consuming and ultimately less flexible than RC.

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[32] Interview Transcript, Appendix, page 53
[33] ibid page 57
[34] ibid page 62
[35] ibid page 62

From the interview the materials thermal stability and strength emerges as a clear advantage.

> Very… rough, or very brutal, very aggressive. Working with the material, with the water with the mixing and with the firing too. I fired to the end… And nothing happened.[36]

Keckemeti sees the materials stability and reliability, as having potential in mass manufacture, primarily from a lack of risk point of view where cracking during firing is not an issue.

> Yes, but I am thinking if I have this material at home and I have this architectural work then I can use it for these really exact forms, where can I build before the casting forms and I must produce 5 or 10 pieces then I will use this, because it is more easier than clay…Yes, because there is no *riskant* [risk].[37]

This is further reinforced by his view that RC is more suited to multiple production than one off art objects. The problems and restrictions that time-consuming moulds introduce make sculpture impractical. In his view the potential for using the material in multiples is far more suited to RC. This is expanded into the possibilities of using monolithics or pre-cast modules used in industry and adapting and working on the surface with either glazes or with the technique as described previously, thereby combining industrial forms with a more expressive and free approach to surface. [38]

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[36] Interview Transcript, Appendix 3, page 54

[37] ibid page 54

[38] ibid page 55

7.5 Geoffrey Mann

Geoffrey Mann describes himself as a product artist. He graduated from the Royal College of Art in 2003 and has since been regularly exhibiting his unique work that, in his own words are ‘ trans-disciplinary objects that cross the traditional boundaries of art, craft and design’. Mann’s work has, for some time been interested in the capture of motion and physically representing motion using technology and unique materials. Often Mann uses rapid prototyping to create finished pieces combined with the use of light and animations to convey the feeling of movement and action.

Mann was awarded the New Designers Bombay Sapphire prize in glass in 2005 and was short-listed in the International Bombay Sapphire prize. He has recently exhibited at MOMA New York as part of Design and the Elastic Mind.

Since October Mann has been part-time product design lecturer at Grays School of Art, Aberdeen. Mann is also involved in the AHRC research commission through the Past, Present and Future Craft Practice (New Craft, Future Voices). The research intends to explore and extend articulation of ‘visual thinking’ as thought itself (rather than a skill), thereby demonstrating the capacity of craft to contribute to future economic development.

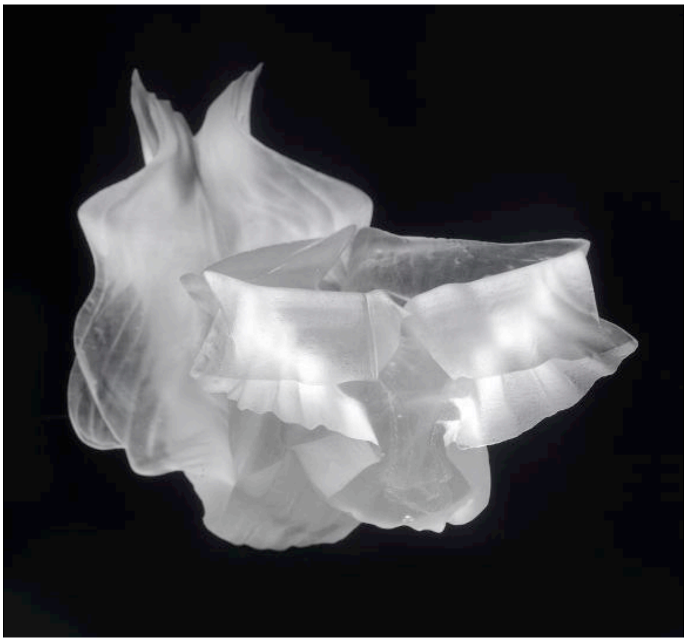

Figure 7.5.1 “Flight” Kiln cast glass, (2005)

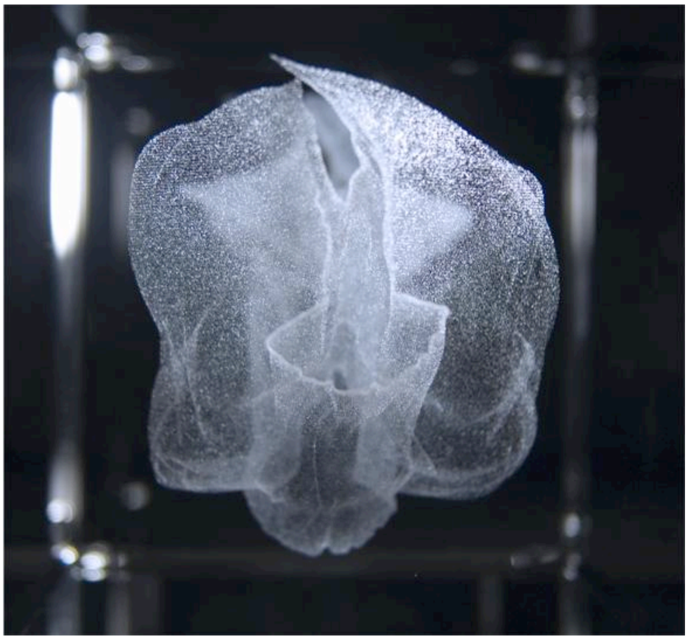

Figure 7.5.2 “Flight Echo” Laser sub surface engraving (2006)

Figure 7.5.3 “Attracted to Light” Nylon rapid prototype (2005)

Approach Taken for Case Study

Material provided: Jon Flo 90 and Greentech 170

The main focus for Mann's experimentation was to explore casting in rubber moulds. With experience in this way of working from a previous project Mann was keen to explore the cast surface against the rubber. In his own words the main aim of the project for Mann was to establish how the concrete would cast in very intricate moulds, how the strength of RC would cope with very thin cast sections and ultimately to explore how the material might be applied to larger scale projects.[39] Without access to a kiln it was difficult to explore the properties of fired refractory and so the focus was to look at green strength and the casting capabilities of RC.

Mould

After some initial testing, experimenting with water to material ratio and the casting procedure, Mann elected to use an existing silicon rubber mould from a previous project titled 'Flight'. 'Flight' stemmed from his work at the RCA where he created rapid prototyped representations of a bird in flight, one of which was created by kiln casting glass see figure 7.5.1. One of the largest solid cast glass pieces made at the RCA to date, the final piece displays a solidity and mass combined with almost ephemeral qualities where the wings taper to fine points. The initial test models from this project were used for the moulds in this case study. For each of the casts Vaseline was used as a release agent.

Mann initially experimented with Greentech 170 evaluating the water to concrete ratios and exploring the handling properties of the concrete by running a series of tests gradually increasing the water amount.

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[39] Interview Transcript, Appendix 3, page 67

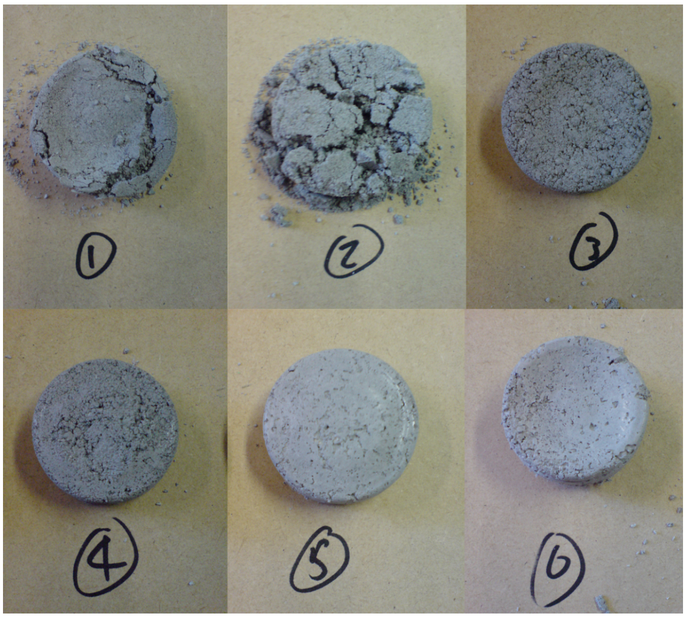

Figure 7.5.4 Initial tests with increasing water content.

After these initial tests Mann moved on to testing on the rubber mould. Mann thought the material would provide more flowing properties and was less than satisfied by the initial tests. Stating in the “lab book” “the main problem is: more water creates a more fluid body but less strength and stability”

Figure 7.5.5 Mould with Greentech cast

Mann explored adding a concrete plasticizer (Aqua 150 from Grace Construction) used in conventional concrete in an attempt to increase the flow properties of the concrete. However, the plasticizer had limited success and the Greentech, despite the reinforcing polyester fibres, was too brittle and resulted in breakages in the cast piece at the fragile wings.

Figure 7.5.6 First cast showing breakages on fragile wings.

It was at this point that Mann requested an alternative material, something with more green strength and the ability to flow into intricate forms. He was therefore supplied with 25kg of Jon Flo 90. The same safety information and advice was supplied as with all other case studies. Mann followed the industry standard water addition ratio of 4.5% water to material casting in the same rubber mould used in the first tests. The result was a much better cast surface and no breakages when removing from the mould. Some air bubbles are evident as a result of insufficient vibration during casting.

Figure 7.5.7 Jon Flo 90 cast

Discussion of Results and Interview

The initial experiments conducted with Greentech 170 proved unsuccessful for the application chosen. While Greentech has high green strength due to the polyester fibres added, it lacks the ability to flow and is considerably weaker than Jon Flo 90. This again is evidence that more consultation at the start of the case studies would have been beneficial. Time and energy could have been focussed more on a suitable material.

The potential for scale manufacture was one of the main focuses for Mann's work; the intention was to evaluate the material for scaling up work for public commissions and large-scale projects.

> …That was looking for an outdoor piece I could create and put, maybe not in the public sector because it could be snapped, but somewhere outside. I knew glass and ceramic. I know in ceramic it would be very difficult, and in glass it would not be cost effective. Bronze was a possibility but even that is very costly. Concrete was a possibility because I had seen it used outside, and it was quite successful, but I was unsure if it would work. So the main reason of doing this was to up scale everything.[40]

Mann saw the possibilities for RC as a replacement for other more expensive materials, such as glass and bronze. He felt that RC would offer the functionality of concrete. The limitations of the case study, in terms of the material provided, meant that large-scale investigation would not be possible. However, the aim for Mann was to evaluate the surface and the possibilities for casting the intricate shapes he would require if pieces were to be scaled up.

> Yes, in terms of the green strength. Even when it gets to that thickness, if you use a architectural plaster which is very hard, it's still very fragile at certain points, thin is thin at the end of the day, but this had a very strong integrity to it.[41]

Similar problems with mixing were also noted by Mann. However there is also an interesting observation regarding knowing the material. He points out that, while it is difficult to mix, by manually mixing you gain an understanding of the properties and behaviour of the material far more than would be possible if a mechanical mixer was used.

> The amount of effort you put in for a very small amount. It's not a hand mixing material at all, but it's very interesting because I now know more about that

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[40] Interview Transcript, Appendix 3, page 69

[41] ibid, page 71

> material than if I put it in a mixer. In a mixer, you wouldn't know when it was going to set, and you would not get the touch and feel of it. And I got that with the second one.[42]

The second material Mann worked with was Jon Flo 90 the very high green strength of the material proved to be ideally suited to the very intricate moulds that were used.

> But the issue again is, why treat it the same as ceramics if it's not ceramics? If I created a form that could be slip cast. Those bird things can't be slip cast. You can use a press mould but they just look stupid. So that's when concrete would just become its own material, because it can flow into these things, and it has its own integral strength to get de-moulded, that’s the most important part of it.[43]

Another important point, raised by Mann in the course of the interview is the quality of the concrete itself. Where the concentration in my own practice has been to enhance the visual quality of concrete through the application of ceramic techniques. Mann is less concerned with this issue and views the concrete more as an individual material with it’s own meaning and therefore an individual and unique aesthetic should be used.

> I don't see it as an advantage, because it's using a ceramic technique but it's glass. I would like to keep the concrete itself very pure. If you're adding colour to it, it's not pure but as you're polishing it, you're making what it's got. There is an honest material in it.[44]

Mann freely admits in the interview that he could have explored further options and at the end of the interview, after reflecting on the process, considers a number of other avenues that he considers worth investigation.

> The weight of the material is a negative. It depends where it's going. The possibilities are that it could be coloured as well, which I don't use in my practice at all. I use white or clear. That could be interesting, the surface quality as well, for me. Polished, unpolished...there is lots of finishing that I never got the chance to do; that’s another thing it would interest me to try, just try finishing the material.[45]

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[42] Interview Transcript, Appendix 2 page 71
[43] ibid page 75-76
[44] ibid page 74
[45] ibid page 73

7.6 Additional “AdHoc” Studies

During the course of the research two artists who visited the department were invited to use RC to create some work in the department. While not strictly case studies these two relatively short investigations provide additional evidence as to the creative potential of RC. The format of these studies followed a far less controlled methodology and interaction and support from the researcher was provided. No formal interviews were conducted and so much of the results discussed here are from informal discussion with the artists. The two artists were Wendy Lawrence and Gavin Webster.

Wendy Lawrence

Lawrence draws inspiration for her work from the rich textures found in eroded rock, together with the evidence of ancient peoples imposition on the landscape; the work explores the inter-relationship of these contrasting elements.

Lawrence works with ‘volcanic’ glazes to create highly textured and dynamic surfaces on vessel and wall hanging forms. These glazes rely on granular silicon carbide within the glaze therefore this case study therefore offered the possibility of using a silicon carbide bearing concrete (Narco Gun SiC).

Figure 7.6.1 Wendy Lawrence bowl form close up

Lawrence made one wall piece in the department using cut polystyrene as a base mould to create a deep relief and textured mould.

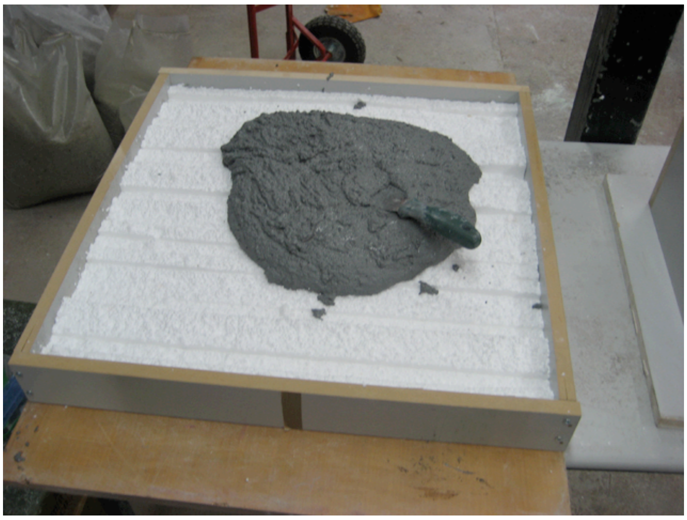

Figure 7.6.2 Casting large sheet on polystyrene mould

Figure 7.6.3 Removing polystyrene

Narco Gun SiC is a gun mix refractory and unfortunately has a very short shelf life of just over 3 months. The material that was available in the department at the time of Lawrence's visit was over 1 year old and was therefore softer at the green stage. This softness resulted in the piece breaking at a week point after the polystyrene was removed. The piece was glazed and once fired to 1240°C.

Figure 7.6.4 Glazing flat piece

Figure 7.6.5 Glazed and fired flat piece

Figure 7.6.6 Close up of ‘volcanic’ surface

Clearly the textures and glaze qualities achieved by Lawrence are very similar to her established practice. Polystyrene proved to be an effective, cheap and quick method of creating a mould. Lawrence noted the density of the material makes it very heavy and this is a consideration when thinking about hanging. However she felt there was clear potential in creating large pieces easily and sees the ability to once fire the pieces as an economical advantage.

Gavin Webster

Webster was an MA student at the University of Central Lancashire. Webster works in a number of mediums but concentrates primarily in clay.

Webster’s clay works are often unplanned and can involve an element of performance and reflection in action. He works in a very immediate and intuitive way, preferring to respond to the material without clearly defined directions or final outcome.

Webster had not previously used RC and opted to use a variety of concretes together in one single piece. Using a simple box mould to contain the material he worked in a free moulding manner, exploring the handling properties by adjusting the water content to adjust the malleability of the concrete. Webster also incorporated a number of additional materials including: plastic clay, natural stones, mineral aggregates, oxides and organic materials. The materials themselves are not important and were not recorded. The intention here was not to experiment with the view to repeating the experiments but to see if the material could be used in a free and more expressive way that would respond in a more immediate manner (See figures 7.6.7 – 7.6.9).

Figure 7.6.7 Selection of added materials

Figure 7.6.8 Mixing and manipulating different refractories and clays.

Figure 7.6.9 Piece prior to firing.

Figure 7.6.10 Close up of piece prior to firing.

Figure 7.6.11 Fired piece

Figure 7.6.12 Close up of fired piece

While the approach taken by Webster is far from scientific, the results clearly demonstrate a material that is capable of manipulation in a considerably freer manner. In this case a box mould was used to maintain the shape and create a sharp geometric form in contrast to the organic and expressive textures generated by Webster. However, the use of plastic clay combined with RC clearly points to the possibilities for using selected refractories in a free manner, this more plastic body could be used to model pieces without the use of moulds.

It should also be noted from a health and safety point of view, working with these materials using exposed hands is not recommended and is a significant hurdle to its deployment in this situation.

7.7 Conclusions from Case Studies

The case studies hoped to expand the number of approaches, methods and applications that could be explored by just one person. From the range of techniques and the work presented, combined with the responses from the interviews conducted, a clear demonstration is made that a wide range of creative applications are viable. The case studies also give evidence that future work by other artists and designers has potential and would benefit from future research that looks to both expand the number of materials investigated and the number of participants involved in a study.

A number of key findings can be drawn from the case studies that are concerned with both the methodology and the results of participants experiences and experiments. Examining the methodology of the case studies, there is an argument that perhaps the material provided to each of the artists should have been chosen and tailored to the application and vision of the artist. Some form of consultation with the participant may have been beneficial prior to starting the case study. This is particularly true in the case of Geoff Mann and Tavs Jørgensen’s projects. In the case of Mann’s project, considering the intended application, Greentech was wholly unsuitable and a simple discussion of the aims prior to starting the case study would have identified Jon Flo as a more suitable material. In Jorgenson’s case study the aim was to use the refractory as a more stable replacement for a plaster mix. The supplied material (Jon Flo 90) was considerably stronger than was necessary. In addition, the time consuming and strenuous mixing required for Jon Flo could have been easily substituted for a lighter weight and more easily mixed material such as Cast-o-lite.

The case studies were all conducted in isolation, i.e. there was no contact between any of the case study participants or with myself. As discussed in the introduction to this chapter the reason for this was to avoid the researcher influencing the result of the case study. However, from the interviews it became clear that some kind of technical support and consultation would have been beneficial to the case studies. This is particularly the case in the Eastman study where the researcher's experience with RC would have avoided the over watering of the material by advising a splitting of the mixing to smaller batches.

Prior to starting the case studies there were no pre-planned expectations as to what the participants would choose to do and the main aim of the cases studies was not to create finished artworks or designs.

The objective of confirming the findings from the researchers personal practice was achieved and demonstrated by the physical product of the case studies and in the subsequent interviews. In many cases the product of the case studies has offered up more questions than answers. All participants felt the case studies were a positive experience. This response could be attributed to the fact that the interviewer was the researcher and so a reluctance to express disaffection or scepticism of the benefits of the project, material or case study openly to the initiator of the project. However, it should be noted that in all of the case studies, through the interview process, there were clear reflections and enthusiasm of the possibilities. In most cases a desire to experiment further was expressed, other options and routes that could have been explored are described. All of the participants expressed an interest in conducting future work but in most cases there was no definite direction or project in mind. All participants expressed the need for more experimentation and exploration in order to both understand more fully the properties, and gain a tacit understanding of what might be achieved. Again this can be seen as more evidence that some form of follow up to the case studies would be beneficial.

For the three artists that considered the material as a solution and material for the manufacture of art-work or designed objects, one key intellectual or conceptual issue mentioned by all was: what is the material's meaning? Kecskemeti, Eastman and Mann each express this issue in a different way, each describing how the preconceptions of the material being an industrial concrete clearly impact on the thinking and approach taken. The different connotations and pre-conceptions associated with a material called concrete are clearly felt as impacting on the work. In Ken Eastman's case the 'meaning' is seen as a benefit and in many ways a positive attribute, allowing separation and freedom from the preconceptions of the ceramic field. However, in Mann's view, while this is an advantage, it can also been seen as having negative connotations.

> In my mind the major hurdle was that it's concrete. That's the biggest hurdle of this whole project. It's refractory concrete. It's not just what it says on the tin. It's got this new thing. That applies to any applied art or craft: anything new coming into it automatically gets pinpointed with old parameters.[46]

Mann goes on to explain that, while the material has these industrial roots with its implied low value, there is scope to enhance and add value through the application of creative forms and approaches.

> They need to understand that concrete perhaps does have a value. That value has to be found. The value comes from its context.[47]

Both Eastman and Kecskemeti looked at surface decoration of the concrete. Interestingly, while both explored very different techniques and materials, they seem to share the view that application of a surface to cover the refractory concrete was not desirable and the qualities of the concrete were in fact covered and not enhanced. Kecskemeti used a number of techniques, however, after conducting the experiments, came to the conclusion that the concrete should not try to be ceramics but should have its own aesthetic. This view is shared by Eastman as he also comes to the conclusion that using slips in a manner designed for ceramics cannot offer the same qualities and is detrimental to the unique qualities of the RC.

The case studies provide a clear indication that even with limited experience with the material, creative applications are feasible. However, in many cases further experimentation is needed to both understand and familiarise themselves with the material and to look further into applications and uses for the material. The breath of work produced as a part of the cases studies demonstrates that there is creative potential in RC. The range of applications and techniques that have been investigated in the case studies verifies the question of whether artists and designers can make use of RC in a creative sphere. The case studies are able to demonstrate a number of areas that do warrant further experimentation and show that there are a number of creative avenues that warrant further exploitation.

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[46] Interview Transcript, Appendix 3, page 75

[47] ibid page 75

Chapter 8 Conclusions and areas for further research

8.1 Outcomes in relation to the aims and objectives of the research

This Chapter will restate the aims and objectives of this research and define where and how the research has achieved these as outlined prior to starting the project.

Primary Aim

The broad and primary aim of the research was to prove RC as being a material viable for creative application and demonstrate its application through a number of practice-based examples. This aim was achieved through the demonstration of a wide range of practical pieces that were produced through the project discussed within Chapter 6. The practical projects each demonstrate a unique and novel approach in a number of areas outlined in Section 6.1[1].

Secondary Aim

The secondary aim was to demonstrate concentration on applications with a design focus by the researcher is balanced by the case studies conducted by other practicing artists discussed in Chapter 7[2].

Research Objectives

Design and produce artefacts that demonstrate RC in a range of applications.

The applications explored within the practical elements of this research demonstrate RCs clear potential for creative and design applications. A range of applications were explored through different practical projects, each exploiting a different property of the material. Architectural and design applications were extensively explored by the researcher and provide evidence for the suitability of RC for mass manufacture and new and innovative architectural features.

Enhance the aesthetic properties of RC using known ceramic techniques and decorative processes.

Glaze was identified as one of the most appropriate and suitable ways of achieving this objective and was investigated in a series of quantitative experiments. Both earthenware and stoneware glazes were tested[3]. At this stage, however, insufficient

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[1] Chapter 6, Section 6.1 page 95

[2] Chapter 7, pages 187- 227

[3] Chapter 5, Section 5.3 page 61

data is available to generate rules to allow the adaptation of existing ceramic glaze recipes for application on a number of different RCs. The tests conducted have led to the establishment of a number of glazes that are suitable for application on Jon Flo 90 and a number of other RCs.

Two investigations into the adaptation of RC using staining oxides and coloured aggregates show the potential for altering and adjusting the colour range of RC.

Evaluate RC's functional suitability to operate in applications outside industrial application.

The fact that these materials have never been used in outdoor environments in either architectural or urban contexts, led to a number of tests being conducted to establish the ability of the materials to cope in these environments. Two qualitative studies were conducted[4]. The experiments conducted on freeze thaw resistance prove that Jon Flo 90 is more than capable of withstanding severe conditions and therefore passed the British standard for clay products.

Experiments conducted on the slip resistance of Jon Flo 90 established that with a slight adaptation of the polishing process the slip resistance value was over 60 and therefore is suitable for outdoor application as public highway. Both these tests confirm RCs ability and suitability to perform in the applications proposed in the practical phase of the project.

Confirm personal evaluation of RC by conducting external case studies with artists and designers.

The case studies were conducted and successfully prove that the material can be used for a broader range of applications than those investigated in the researcher's practical projects without the necessity of extensive knowledge of RC. The case study results demonstrate a number of possibilities for RC in craft applications that warrant further research.

8.2 Dissemination of research

The intention at the start of this project was to engage other artists and ceramicists in the project. The aim was to seek to expose other artists to these materials that have

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[4] Chapter 5 Sections 5.3 and 5.4, pages 81-94

not previously been utilised in a design or craft context. In a direct way this was achieved through the case studies.

Increasing the exposure of the material has been achieved through the dissemination of the project in a number of ways. The Silicate Research Unit website[5] was launched in the middle of the research project to indirectly disseminate the project and other research within the department. To reflect the full range of the materials and research conducted within the department the term silicate was used to encapsulate clay, concrete, and glass by virtue of them all containing the element silica.

The Silicate Research Unit website is the only source on the web that refers to the creative possibilities for RC. In a google.com search using the terms refractory concrete and creative, the silicate research unit website is, at the point of submission, the first hit.

The research has been presented at a number of relevant conferences. At both Research Network for Science and Art in Ceramics and Glass (RNSACG) conferences[6], papers were presented. In addition papers were also presented at a number of postgraduate art and design conferences.[7]

Two international exhibitions displayed the physical results of the research. The EKWC Brick Exhibition, Rotterdam, The Netherlands and the accompanying publication disseminated the practical results of the 'Brick project'. In addition, one of the large format sheets 'Concrete Peel' was shown at The Object Factory, a major review of industrial ceramics at the Gardiner Museum, Toronto, Canada, May-September 2008.

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[5] Silicate Research Unit http://www.silicateresearchunit.org/
http://www.uclan.ac.uk/facs/destech/design/sru/index.html

[6] 1st Ceramics and Glass Science and Art Network Conference, Manchester Art Gallery, *'New Possibilities for Refractory Concrete'* 12th and 13th September 2005
2nd Ceramics and Glass Science and Art Network Conference, University College London, '*Art, Industry and Architecture: A Collaborative Research Project'* 27th-29th June 2007

[7] National Postgraduate Conference in Creative Arts, Film and Media, University of Portsmouth, UK, 26th November 2005
Parallels & Connections – Ceramics & Glass Research Conference, University of Sunderland, *Refractory Concrete Applications* 1st -2nd March 2007,
Post Graduate Conference, '*Refractory Concrete in Novel Applications'* UCLAN, 14th Oct 2006

8.3 New knowledge discovered as a result of the project

Through the research conducted, a number of novel processes and products have been developed. Alongside the creative and practice led investigations two important quantiative studies were conducted to generate new data on the performance of RC in creative applications.

Creative outcomes

- The development of architectural products that combine novel processes and materials.
- The creation of large format tiles in a low-tech environment.
- Development of graphic RC flooring products.
- Demonstrated a wide range of ceramic glazes can be used.

Technical knowledge

- Resistance to freeze thaw action determined
- Data on slip resistance of RC gathered

The practical pieces that were achieved through the pursuit of this project demonstrate that RC can be used for a wide range of situations. The examples provided by the researcher, combined with the case studies, make a case for RC as a material suited for both designer maker and as a material with potential in industrial manufacture such as architectural cladding and urban design.

In addition to the creative endeavours, the research has produced new data as a result of two quantitative studies. The freeze thaw resistance data on RC is new knowledge and has never been previously evaluated, while the data set is limited to only one material, this knowledge is clearly relevant to the applications proposed.

The innovative techniques developed through the practical phases of the research in the creation of graphic floor pavers is reinforced by new knowledge on the slip resistance values of polished RC. The practical pieces, combined with the data, demonstrate RC as a viable material for both exterior and interior flooring.

The case studies that were conducted show results that reinforce the assertion that RC can open new avenues of creative expression, not feasible with conventional clay. While the researcher acknowledges that the material will not be suitable, or appropriate, for every creative idea or project, the pieces of art work produced by the case study participants can be seen as the first steps for RC as another material in the ceramicist's repertoire.

8.4 Areas for further research

Whilst a significant number of glaze testing was undertaken, the infinite permutations of RCs and glaze formulae have made it possible to establish only broad principles. In reality the most appropriate solution would be to run tests for each individual case. The lack of any information on the interaction layers between RC and glaze is an area that would warrant more investigation, however this is perhaps more the domain of material scientists and not of creative practitioners.

The addition of organic materials, and other materials, to concrete to enhance the aesthetic was not explored fully in this project. Any additions to a RC product will inevitably have an adverse effect on the strength of the material, however it may well have a positive effect on the aesthetic of the concrete.

The freeze thaw data generated by this project proves that RC can cope with exposure to severe freeze thaw conditions and is therefore suitable for application in the various applications presented, however, the test samples were limited to just one RC material. Additional research may be needed on a number of different materials to confirm these findings.

Slip testing was conducted on a number of samples with varying surface finishes. However all of the tests conducted do not take into account the effect of pedestrian traffic and the polishing in use. In order to employ RC as a commercial flooring product, further research would be needed namely, wear resistance over time and the materials resistance to dirt and the development of cleaning methodologies.

The project has investigated a number of architectural applications, from building cladding and bricks to flooring products. However, these have not been developed to the point of being functioning prototypes and more research would be required that looks at how cladding materials are bonded and fitted to buildings.

The Bench project failed to produce a working prototype bench. The reasons for the failure remain unclear and further research is needed to understand the causes of the failure and therefore enable the development of a successful prototype.

Whilst the case studies demonstrated the potential of RC in small-scale studio practice, further research would extend the creative possibilities of RC. The number of case studies should be increased to give more varied results and a more structured and directed case study may prove more conducive to the development of more innovative options for the future deployment of RC in the creative sphere. This has led the researcher to consider the possibility of running a symposium in the future that would allow access to machinery and facilitate the discussion and sharing of knowledge, thus further confirming the creative potential of the material.

8.5 Concluding comments

This research project has examined the material of RC and demonstrated it as a viable creative material that offers new possibilities in manufacturing and in the realisation of projects that would be difficult or impossible if attempted in alternative materials.

The research is not purely a material based investigation. Instead the approach adopted by the research, looks more holistically at a material that has not been previously used in the creative sphere. What this approach sacrifices in terms of in depth investigation is balanced by exploring a wide range of applications and has led to the identification of many avenues that warrant further investigation.

The project has led directly to a number of live projects that will be completed in the future further enhancing the profile of RC as a creative material. In addition, a PhD student based in the department (Mr Fahad Alkandari) has begun investigating RC for his project titled: Islamic ceramic ornamentation and process: a new aesthetic vocabulary in contemporary architectural embellishment. As part of his investigation he will use RC to realise large-scale tiles incorporating Islamic imagery.

The researcher believes the findings of the project contribute significant new knowledge to the field of ceramic practice, potentially leading to numerous further creative and commercial opportunities.

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Appendix 1 Refractory Materials Database

At an early stage it was recognised that industry expertise and access to materials would be a key factor in the successful completion of the project. At the beginning of the project a number of site visits to refractory concrete manufacturers were made with the dual objective of accessing and sourcing materials and to attempt to engage industry in the project. Three companies were willing to support the project including two refractory producers and an industrial research development and diagnostic company with extensive knowledge of refractory materials. The majority of the materials tested in this PhD were obtained from two refractory companies: Harbisson Walker Refractories and Sheffield Refractories, with some additional raw materials coming from DSF Refractories and some technical assistance coming from Ceram Ltd. While the range of materials tested and evaluated is small in comparison to the number available from manufacturers across the globe (estimated to be over 5000), many of these mixes are variations on materials available from HWR. In addition, within the time frame available it was deemed impractical to broaden the range beyond those available locally.

Each material was first examined using literature made available by the manufacturer thus determining which held the most potential for structural and creative application by eliminating those with either: too low a maximum service temperature (MST), low fired strength or Modulus of Rupture (MOR).

Mix Procedure

Materials selected for testing were then mixed using the manufacturer’s suggested water addition, if this was available. (Some materials are designed as gun mixes and thus the water addition is manually determined by the operator depending on the desired application). In some cases the recommended industry water addition was insufficient for hand mixing and additional water was introduced in increments using a syringe. For all materials the intention was to generate a good casting consistency without over watering, thus reducing the strength of the castable. Hand mixing was continued for 5 minutes after a suitable consistency was achieved to ensure uniform mixing.

Figure 0.1 Steel test cast mould for material database

Casting and Firing Method

Each material was tamped and manually vibrated into 5cm x 5cm x 5cm steel mould (see Figure 1), these dimensions are considered standard industry practice for sample testing of batches. Prior to each cast the moulds were thoroughly cleaned dried and oiled with excess oil removed using a rag.

A minimum of 24 hours was left before de-moulding and firing. In the interests of standardization in all cases the materials were fired using firing schedule 1 (See Chapter 4, Section 4.1) to 1200°c in an oxidising electric kiln. Post firing, the cast blocks were ground using a Flex wet diamond grinder. Only one surface was ground to reveal the aggregates within the body. The resulting material samples were then visually inspected and evaluated with observations recorded to form a materials catalogue.

Refractory Materials Catalogue

The following pages describe each of the materials evaluated in the course of the project. Information varies according to the usefulness of the material in terms of its use ability in a studio context.

The following information is covered for each material, some information is not listed as it was not included in the material data sheets provided by the suppliers. Secondly, the materials come from different suppliers and so have been tested according to different criteria; this is particularly the case with MOR and cold crushing strength:

Fired Composition

Experimental elemental analysis from a fired sample.

MOR (Modulus of Rupture)

Modulus of Rupture is the value at which a pre prepared bar of material breaks under a bending force. Normally determined by 3 or 4 point bending apparatus.

Cold Crushing

Is the value at which a material deforms under a crushing force. Measured in MPa

Density

Measured in Kgm^3

Maximum Grain Size:

An estimate of the average largest grain or aggregate in the material

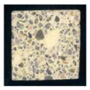
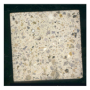
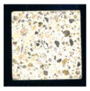
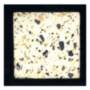
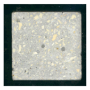
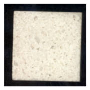
Permanent Linear Change

In most refractory concretes shrinkage or expansion in some cases, will be in the order of 0%-0.4% this is the value from casting to fired value.

Material Catergories

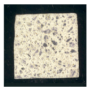
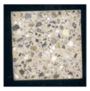
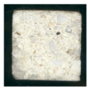
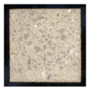
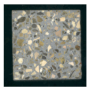
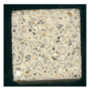
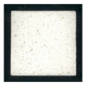
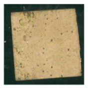
Low Cement Materials

Low cement materials generally have a low water to material ratio and have carefully controlled rheology. This makes them good for stuctural applications particularly for fragile work.

	VersaFlow Harbide 80	p56		Greentech 170	p59
	Armourkast Adtech	p57		Accelerate ABR plus	p60
	Thor AZ SP Adtech	p58		Jon Flo 90	p61

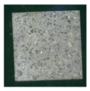
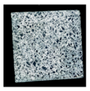
Castables

In most cases castables will have a higher water to material ratio and are generally easier to mix, often requiring vibration to give good cast fidelity they are ideal for large scale work

	DSF Durocast 15	p62		Ultra Green 80	p66
	JonCast SR2	p63		Ultra Green 45	p67
	VersaFlow 70 CU ABR	p64		Mizzou	p68
	Fusil	p65		Linco Baxo Heavy	p69

Silicon Carbide

Castables that contain Silicon Carbide as a major constituent material

	Thor Castable 30 ADT	p70		Narcogun SiC 90	p71

Light Weight/Support Applications

Light weight refractories that can be used in suport applications, not suited for finished objects.

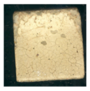
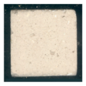
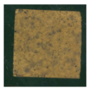
	Linco Fest Light	p72		Cast-o-lite Si 30	p74
	Linco Fest Medium	p73			

Figure 2 Materials tested and covered in the material database

Versa Flow Harbide 80

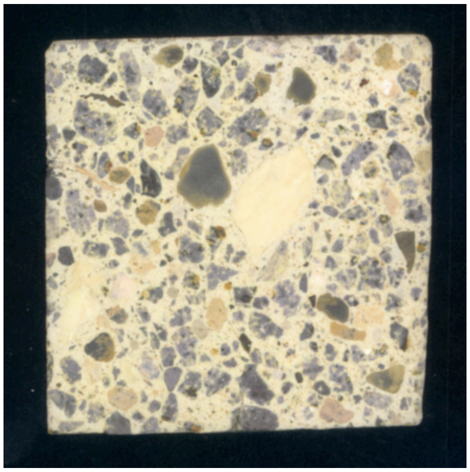
Material ID: VH80

Short Description: A hard refractory with large aggregates and a very high green strength

Manufacturer:
HWR

Industrial Application: A steel industry refractory that makes use of the large aggregates to reduce crack propagation in high impact areas.

Fired and un-ground



Fired and ground using Flex

Technical Info

Recommended Water addition 1kg: 55ml
Manual preparation 1kg: 60ml-65ml

Fired Composition:

Silica - SiO2	12.9%
Alumina - Al2O3	80.9%
Iron Oxide - Fe2O3	1.1%
Titania - TiO2	2.6%
Lime - CaO	2.3%
Magnesum Oxide- MgO	0.1%
Alkalines - Na2O + K2O	0.2%

Published Properties:
MST: 1650°C
Cold Crushing Strength (MPA) @ 1000°C: 90
Cold MOR(MPa) @ 1100°C: 8-12
Density (Kg/m^3): 2800
Max Grain Size: 15-20mm
Permanent Linear Change @ MST: 0-0.3%

Observations

Versa Flow Harbide 80 would initially seem to be an ideal material for structural applications. The large aggregates and the added polyester fibres make the material extremely strong at the green and fired stage. It has a very low percentage of silicon carbide which may make glazing problematic.

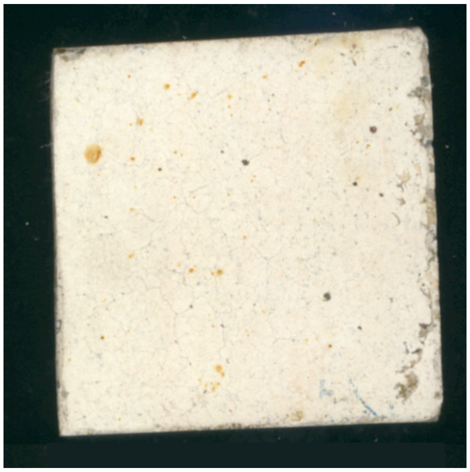
Armorkast Adtech

Material ID: AK

Short Description: An 90% alumina, low cement, low moisture castable characterized by its high density and low porosity.

Manufacturer:
HWR

Industrial Application: Primarily used in the aluminium industry



Fired and un-ground

Technical Info

Recommended Water addition: 1kg: 50ml
Manual preparation: 1kg: 65ml

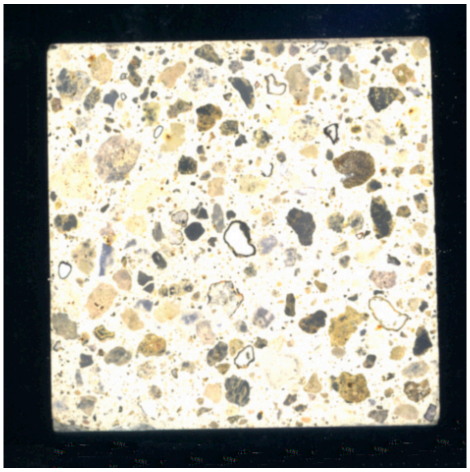
Fired Composition:

Silica (SiO_2)	0.8%
Alumina (Al_2O_3)	90.8%
Iron Oxide (Fe_2O_3)	0.1%
Titania (TiO_2)	1.7%
Lime (CaO)	3.2%
Magnesia (MgO)	0.2%
Alkalies (Na_2O + K_2O)	0.1%
Other Oxides	3.1%

Published Properties:
MST: 1371°C
Cold Crushing Strength (MPA) @ 1000°C: N/A
Cold MOR(MPa) @ 100°C: 10.3
Density (Kg/m^3): 3140
Max Grain Size: 5mm
Permanent Linear Change @ MST: N/A

Observations

Armor kast as its name suggests is a very tough and dense refractory. Easily mixed by hand in smaller quantities and gives very good cast fidelity. A very varied aggregate mix in this castable gives it a unique polished surface.



Fired and ground using Flex

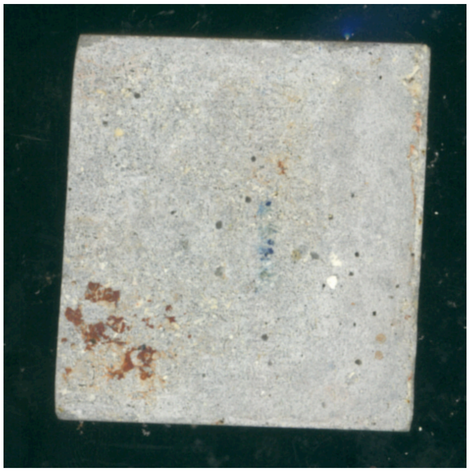
Thor AZ SP Adtech

Material ID: THOR

Short Description: A premium and expensive refractory with fused zirconia and mullite aggregates

Manufacturer:
HWR

Industrial Application: Has good abrasion resistance and is often employed in the cement manufacture industry



Fired and un-ground

Technical Info

Recommended Water addition 1kg: 55ml
Manual preparation 1kg: 60-65ml

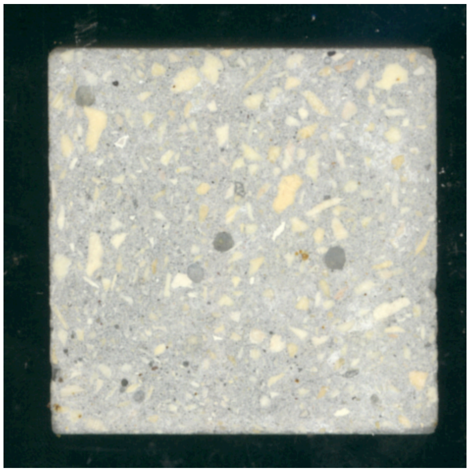
Fired Composition:

Silica - SiO_2	19.2%
Alumina - Al_2O_3	50.9%
Iron Oxide - Fe_2O_3	0.2%
Titania -TiO_2	0.1%
Lime - CaO	1.5%
Alkalines- Na_2O+K_2O	1.4%
Silicon Carbide- SiC	4.9%
Ziconia - ZrO_2	21.8%

Published Properties:
MST: 1538 °C
Cold Crushing Strength (MPA) @ 1000°C: 70-100
Cold MOR(MPa) @ 1100°C: 20-30
Density (Kg/m^3): 2950
Max Grain Size: 5mm
Permanent Linear Change @ 1093: 0.3%

Observations

A strong and stable refractory with the light mullite aggregates set in a grey matrix the material is attractive when polished. Unfortunately the silicon carbide in the mix will cause problems if the material was glazed.



Fired and ground using Flex

Green Tech 170

Material ID:GT

Short Description: Greentec 170 LG is a unique, truly low cement gun mix, exhibiting high hot strength.

Manufacturer:
HWR

Industrial Application: Suitable for use in any arduous environment eg. petrochemical industry, incineration, cement kilns and steel applications.

Technical Info

Recommended Water addition: N/A (Gun mix)
Manual preparation:

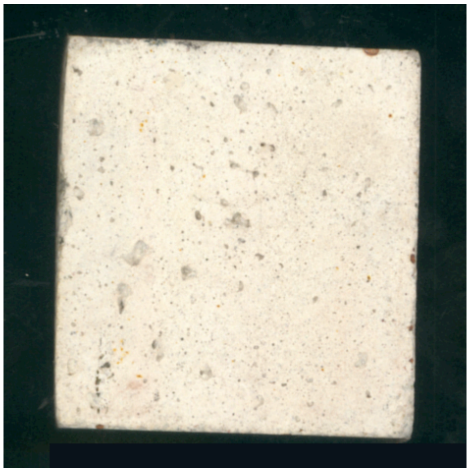
Fired Composition:

Silica – SiO2	22.6%
Alumina – Al2O3	72.7%
Iron Oxide – Fe2O3	0.8%
Lime – CaO	2.1%
Others	1.8%

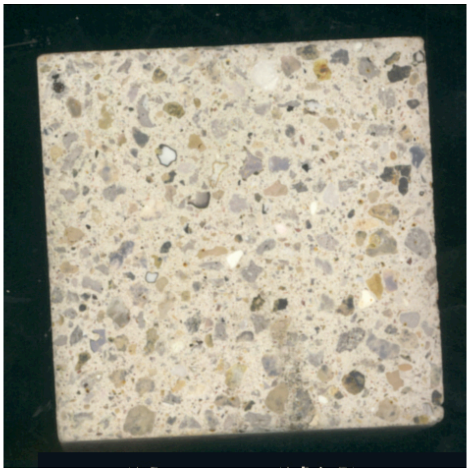
Published Properties:
MST: 1700°C
Cold Crushing Strength (MPa) @ 1000°C: 40 - 60
Cold MOR(MPa) @ 1100°C: 8 - 15
Density (Kg/m^3): 2250 - 2350
Max Grain Size: 5mm
Permanent Linear Change @1300°C:1.5% Expansion

Observations

Green Tech 170 is a gun mix refractory and therefore has no recommended industrial water addition. Despite the low cement classification it can easily be mixed by hand and gives very good surface fidelity. Sets quickly and should be placed in the prepared mould as soon after mixing as possible.



Fired and un-ground



Fired and ground using Flex

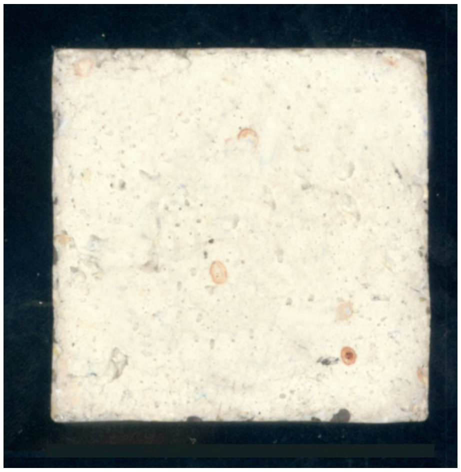
Accelerate ABR Plus

Material ID: ABR

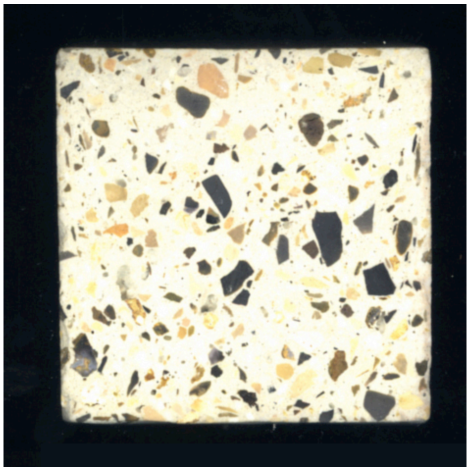
Short Description: A lower MST refractory. Can experience melted material breaking the surface even at 1080°C. Accelerate has a very quick set at around 4 hours.

Manufacturer:
HWR

Industrial Application: Described as a general purpose material and also used as a repair material



Fired and un-ground



Fired and ground using Flex

Technical Info

Recommended Water addition 1kg: 72ml
Manual preparation 1kg: 75-80ml

Fired Composition:

Silica - SiO_2	8.0
Alumina - Al_2O_3	78.7
Titania - TiO_2	2.7
Iron Oxide - Fe_2O_3	1.1
Lime - CaO	2.6
Magnesium Oxide -MgO	1.4
Alkalines - Na_2O+K_2O	2.1
Phosphorus Pentoxide - P_2O_5	3.4

Published Properties:

MST: 1316°C
Cold Crushing Strength (MN/m3) @ 1000°C
MOR (Heated to 1200°C and cooled) (MPa): 18.6
Density (Kg/m3): 2740
Max Grain Size: 5mm
Permanent Linear Change @ 1100°C: 0-0.1%

Observations

According to published data from suppliers the material can be fired 4 hours after casting so could be useful for repeating a number of casts.

Mixing by hand is possible with small amounts and the water content can be increased to aid mixing if necessary. Accelerate has a relatively low MST and as such after firing at 1200°C it shows signs of vitrification. This in turn gives a good polished surface. The material has a very varied polished surface with highly polished black and kaolin aggregates making a unique surface quality.

Jon Flo 90

Material ID: JF1

Short Description: A very hard in green and fired state refractory concrete with unique flow properties, fires to a white finish with clear aggregate.

Manufacturer:

Sheffield Refractories

Industrial Application: Used as furnace lining in hot face applications, predominately in the steel industry.

Technical Info

Recommended Water addition: 4-4.5%
Manual preparation: 5-5.5%

Fired Composition:

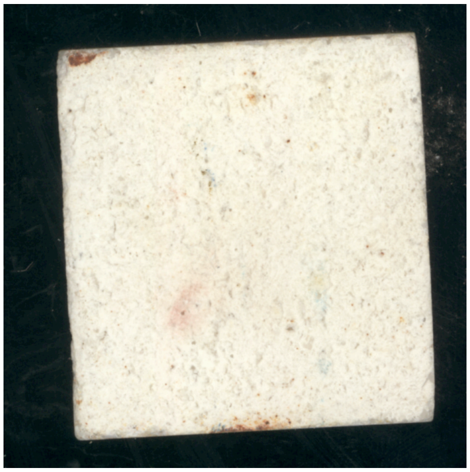
Alumina - Al_2O_3	90.2%
Silica - SiO_2	8%
Fe_2O_3	0.1%

Published Properties:
MST: 1800°C
Cold Crushing Strength (MN/m3) @ 1000 c: 135
Density (Kg/m^3): 3200
Max Grain Size: 5mm
Permanent Linear Change @ 1100°C: 0-0.2%

Observations

Jon Flo 90 has a very low water to material ratio and so requires very intensive mixing. The material should be mixed dry for a few minutes prior to adding the water to the material.

Mix time will be between 30-60mins for manual and 5 mins in High Intensity Mixer (HIM). Mixing large batches by hand is to be avoided. The water added will quickly be absorbed by the material and will still appear ‘dry’. After mixing over time it will begin to re-hydrate and will begin to flow, it should then be mixed at this stage for 5mins to get maximum flow properties. When poured into the mould the material can form a ‘skin’ and so to avoid lamination when more than one mix is used agitation of the surface is recommended. Will set hard between 6-8 hours after casting depending on the ambient temperatures. De-moulding should not be attempted before 24 hours.



Fired and un-ground

Fired and ground using Flex

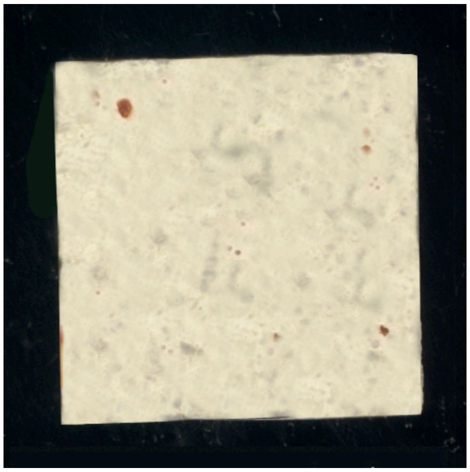
DSF Durocast 15

Material ID:DSF15

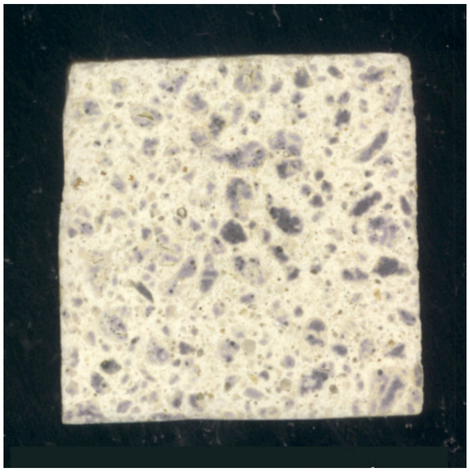
Short Description: Unsuitable for most structural applications at normal ceramic temperatures unless addition of flux to firm surface. A Purple aggregate is revealed on grinding.

Manufacturer:
DSF Refractories

Industrial Application: Multipurpose refractory used in the steel and glass industry



Fired and un-ground



Fired and ground using Flex

Technical Info

Recommended Water addition: 1kg: 105ml
Manual preparation: 1kg: 120-125ml

Fired Composition:

Alumina - Al_2O_3	53.6%
Iron Oxide - Fe_2O_3	36.8%
Titania - TiO_2	2.15%
Lime - CaO	5.18%
Magnesium Oxide - MgO	0.12%
Alkalines - K_2O	0.33%
Alkalines - Na_2O	0.05%

Published Properties:
MST: 1500°C
Cold Crushing Strength (MPa) @ 1000°C: 14
Cold MOR(MPa) @ 1100°C
Density (Kg/m^3): 2100
Max Grain Size: mm
Permanent Linear Change @ MST: 0 - 0.3%

Observations

Mix time will be between 4-15mins for manual and 2-3 mins in High Intensity Mixer (HIM). Mixing large batches by hand is to be avoided. Can be effectively mixed by hand. Has an attractive purple aggregate that is revealed on polishing. However fired to 1200°C the material is too soft for grinding. The concrete contains an attractive purple aggregate that is revealed on polishing but the difficulty in grind makes the material impractical for practical experimentation.

Joncast SR2

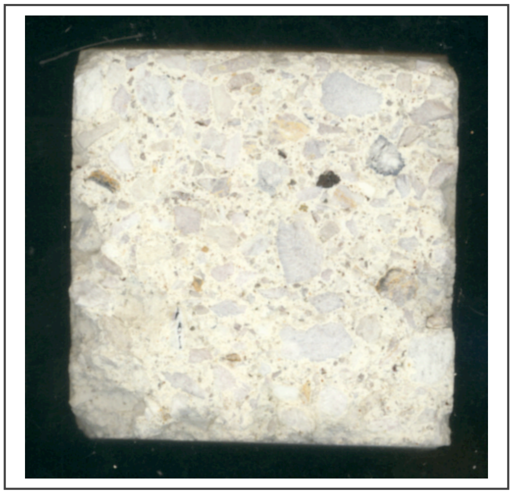
Material ID: SR2

Short Description: A solid refractory castable with an attractive polished surface

Manufacturer:
Sheffield Refractories

Industrial Application: A steel refractory primarily used for furnace bases.

Fired and un-ground



Fired and ground using Flex

Technical Info

Recommended Water addition: 1kg: 90ml
Manual preparation: 1kg: 110-115ml

Fired Composition:

Iron Oxide Al2 O3	47.5%
Silica - Si O2	47%
Iron Oxide - Fe2 O3	0.7%

Published Properties:
MST: 1600°C
Cold Crushing Strength (MPa) @ 1000°C: 20
Cold MOR(MPa) @ 1100°C: N/A
Density (Kg/m^3): 2200
Max Grain Size: 5mm
Permanent Linear Change @ MST: 0.25% Shr

Observations

Jon Cast is a high temperature versatile refractory with a high MOR. The high water percentage makes mixing by hand easy. Easy to cast and gives a good cast finish. The material is hard enough to polish and gives an interesting surface with a variety of aggregates.

VersaFlow 70 CU ABR

Material ID: VF70

Short Description: A coarse 70% Alumina low cement castable Versaflow 70 C Adtech features high impact resistance, excellent abrasion resistance, high hot strengths.

Manufacturer:
HWR

Industrial Application: Steel Industry – Ladle covers, tundish covers, tundish safety lining and precast shapes.

Technical Info

Recommended Water addition: N/A
Manual preparation 1kg: 80ml-85ml

Fired Composition:

Silica – SiO_2	22.5%
Alumina – Al_2O_3	72.5%
Iron Oxide – Fe_2O_3	1.0%
Titania – TiO_2	2.4%
Lime - CaO	1.3%
Magnesia - MgO	0.1%
Alkalies - $Na_2O + K_2O$	0.2%

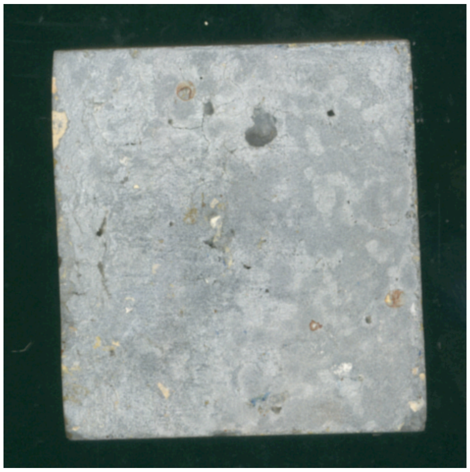
Published Properties:
MST: 1700°C
Cold Crushing Strength (MPA) @ 1000°C: 45.0 – 70.0
Cold MOR(MPa) @ 1100°C: 8.0 – 15.0
Density (Kg/m^3): 2550 - 2700
Max Grain Size: 6-7mm
Permanent Linear Change @ 820°C: 0.2%

Observations

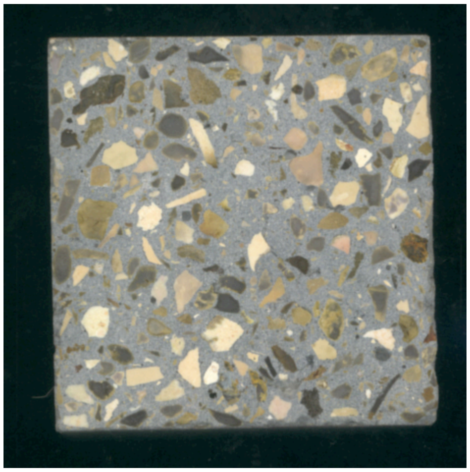
This is a versatile refractory that can be used in a number of ways in industrial application. Its coarse nature and the high percentage of aggregate in the mix make it both strong and stable but it is difficult to mix and pour in moulds.

The material is designed to be used as a gunite and so has no recommended water addition as this is added at the head of the gun.

The high percentage of large light coloured grain size aggregate gives it a unique polished surface that is contrasted by a dark matrix.



Fired and un-ground



Fired and ground using Flex

Fusil Castable

Material ID: FS

Short Description: A fine grained refractory concrete useful for casting into small narrow openings and delicate casts. Displays very good resistance to thermal shock.

Manufacturer:
Sheffield Refractories

Industrial Application: Chemical refractory linings, Discharge rings, Stack linings and kiln car tops.

Technical Info

Recommended Water addition: 1kg: 90ml
Manual preparation: 1kg: 110-115ml

Fired Composition:

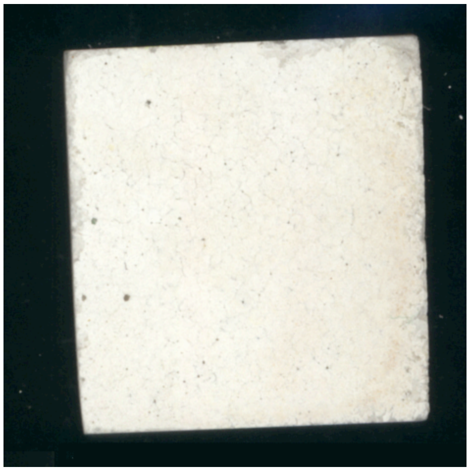
Silica – SiO_2	64.5%
Alumina – Al_2O_3	28.8%
Iron Oxide - Fe_2O_3	0.1%
Lime - CaO	6.3%
Magnesia - MgO.	0.1%
Alkalies - $Na_2O + K_2O$	0.2%

Published Properties:
MST: 1093°C
Cold Crushing Strength (MPa) @ 1000°C: 30-50
Cold MOR(MPa) @ 1100°C: 4.0 - 10
Density (Kg/m^3): 1810
Max Grain Size: 1-1.5mm
Permanent Linear Change @ MST: 0.2% Shr

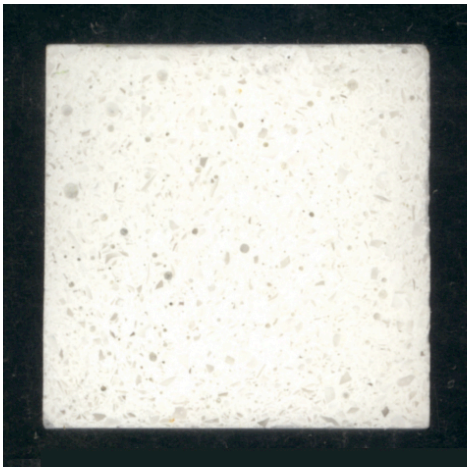
Observations

This material has one of the lowest MST (1093°C) of any of the materials tested. However having been fired to 1200°C the material retained shape and showed no ill effects from this higher firing.

The white appearance and the small grain size allows for intricate casting and gives a very good cast fidelity. This a material that could be used further in creative applications.



Fired and un-ground



Fired and ground using Flex

Ultra Green 80

Material ID: UG80

Short Description: A very robust refractory with very strong green strength and fired properties.

Manufacturer:
HWR

Industrial Application: Ultra Green 80 is used in most industrial markets as a general purpose vibro cast ultra low cement.

Technical Info

Recommended Water addition: 1kg : 50ml
Manual preparation: 1kg: 65ml

Fired Composition:

Silica - SiO_2	14.0%
Alumina – Al_2O_3	81.0%
Iron Oxide – Fe_2O_3	1.2%
Titania – TiO_2	2.5%
Lime – CaO	0.8%
Magnesia - MgO	0.1%
Alkalies – $Na_2O + K_2O$	0.1%

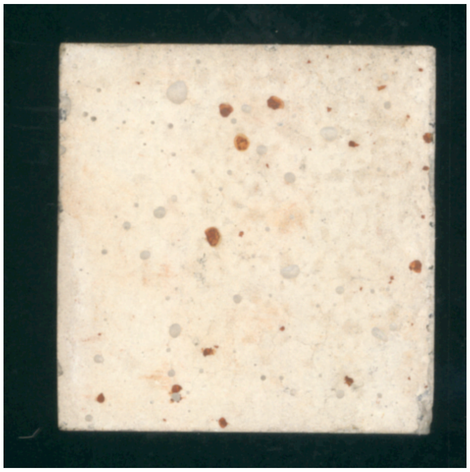
Published Properties:

MST: 1760°C
Cold Crushing Strength (MPa) @ 1000°C: 60.0 - 100.0
Cold MOR(MPa) @ 1100°C: 14.0 – 22.0
Density (Kg/m^3): 2650 - 2800
Max Grain Size: 4mm
Permanent Linear Change@ 1100°C: 0.2% Expansion

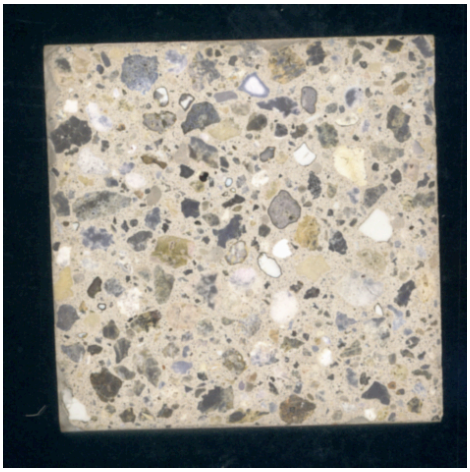
Observations

Mix time will be between 5 -10 minutes for manual mixing. As with many refractories; for large volume mixing mechanical mixing should be used. This refractory has organic fibres that will burn out in firing, they increase the green strength of the material but make mixing harder and casting fidelity does suffer. This refractory is designed for use with vibration casting technology for this reason the water ratio should be increased to give a good surface cast to avoid voids.

On another note the stiffness in the mix provided by the fibres makes it potentially suitable for moulding in a more plastic manner.



Fired and un-ground



Fired and ground using Flex

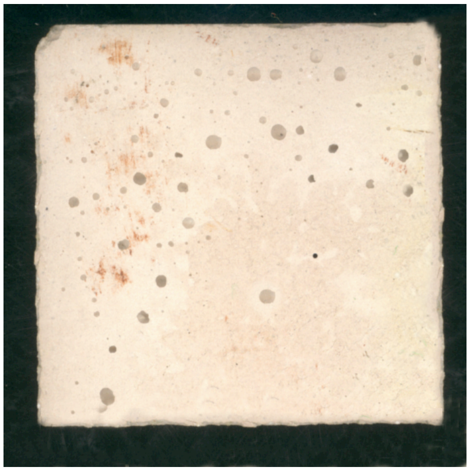
Ultra Green 45

Material ID: UG45

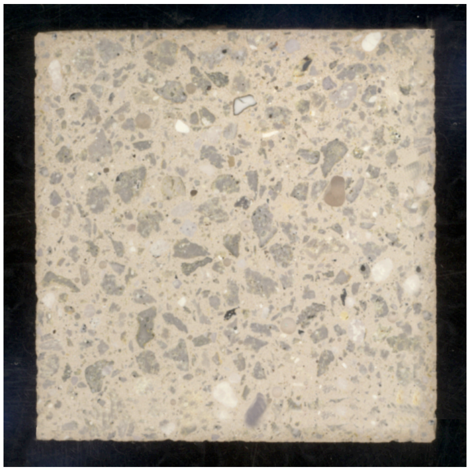
Short Description: Has a very low porosity value so can be difficult to glaze but is very hard and durable refractory.

Manufacturer:
HWR

Industrial Application: Used in the steel industry for pre-cast shapes but is also used as a repair material in existing furnace linings.



Fired and un-ground



Fired and ground using Flex

Technical Info

Recommended Water addition: 55ml
Manual preparation: 60-63ml

Fired Composition:

Silica – SiO_2	47.0%
Alumina – Al_2O_3	47.0%
Iron Oxide – Fe_2O_3	1.0%
Titania – TiO_2	2.5%
Lime – CaO	1.0%
Magnesia – MgO	0.3%
Alkalies – $Na_2O + K_2O$	0.5%

Published Properties:
MST: 1650°C
Cold Crushing Strength (MPa) @ 1000°C: 70.0 - 90.0
Cold MOR (MPa) @ 1100°C: 9.0 - 16.0
Density (Kg/m^3): 2200 - 2370
Max Grain Size: 5mm
Permanent Linear Change @ 1100°C: 0-0.6%

Observations

This is a versatile and robust refractory that has a very low porosity value when fired to 1100°C or above, this could have its advantages in application as it is less likely to absorb dirt. Unfortunately the low porosity makes glazing more problematic.

In industry this material is sometimes used as a repair material for patching and joining other refractory products. This particular application could be investigated. Unfortunately this has not been investigated within this research project.

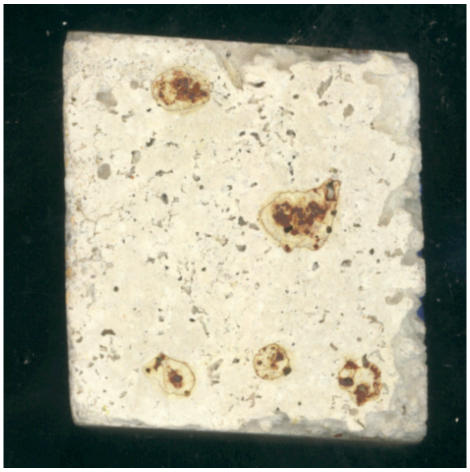
Mizzou

Material ID: MZ

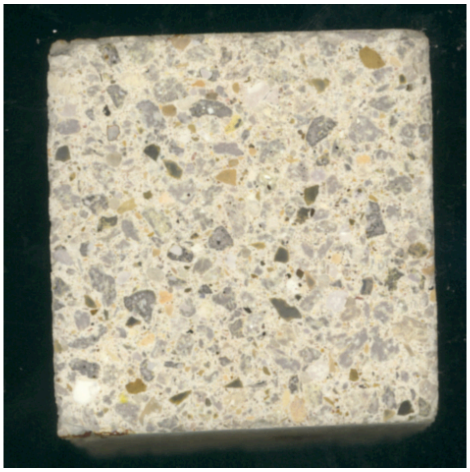
Short Description: Mizzou is a very stable refractory that is easy to mix but is not hard or durable when fired.

Manufacturer:
HWR

Industrial Application: Mizzou castable is used where its resistance to vitrification make it an ideal castable for the higher temperature applications.



Fired and un-ground



Fired and ground using Flex

Technical Info

Recommended Water addition: 1kg - 94ml
Manual preparation: 1kg - 100-110ml

Fired Composition:

Silica – SiO2	32%
Alumina – Al2O3	60%
Iron Oxide – Fe2O3	1.5%
Titania – TiO2	2.5%
Lime - CaO	2.5%
Magnesia – MgO	0.5%
Alkalies - Na2O+K2O	0.5%

Published Properties:
MST: 1650°C
Cold Crushing Strength (MPa) @ 1100°C: 13.0-28.0
Density @ 820°C (Kg/m^3): 2145 - 2305
MOR (Heated to 1100°C and cooled) (MPa): 10.0-27.0
Max Grain Size: 5mm
Permanent Linear Change @ 1100°C: 0-0.4%

Observations

This refractory is one which resists vitrification. While this is an advantage in industry it results in a refractory that has a very dry surface when fired making it not very useful for structural or final pieces. It is prone to chipping when fired to 1200°C.

The material is easy to mix by hand, due to the high water content.

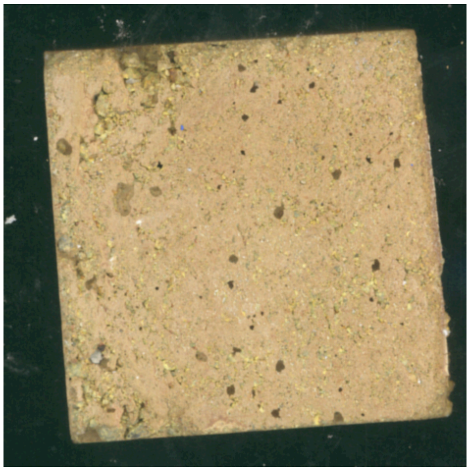
Lincofest (Heavy) HT

Material ID: LH

Short Description: Limited technical information is available on these lower end refractories. There one advantage is the low cost

Manufacturer:
Linco Baxo

Industrial Application: Essentially a low cost multi-purpose refractory.



Fired and un-ground

Technical Info

Recommended Water addition 1kg: 110ml
Manual preparation 1kg: 110ml

Fired Composition:

Alumina - Al_2O_3 -	44%
Iro Oxide - Fe_2O_3 -	3%
Others (Not provided) -	53%

Published Properties:
MST: 1350°C
Cold Crushing Strength (MPa) @ 1300°C: 30
Cold MOR(MPa) @ 1100°C: N/A
Density (Kg/m^3): 1990
Max Grain Size: 4mm
Permanent Linear Change @ MST: N/A

Observations

High in iron, this refractory has very little use for structural applications. A very low quality refractory with very poor physical properties. For a refractory concrete it has a very low maximum temperature of 1350°C. In addition in a reducing atmosphere will be susceptible to vitrification. A relatively soft material that does not grind or polish very well, so no picture is provided.

Could find application as some form of sacrificial material.

It has a high water to material ratio that makes it easy to mix and the low cost per kilogram are the only real advantages.

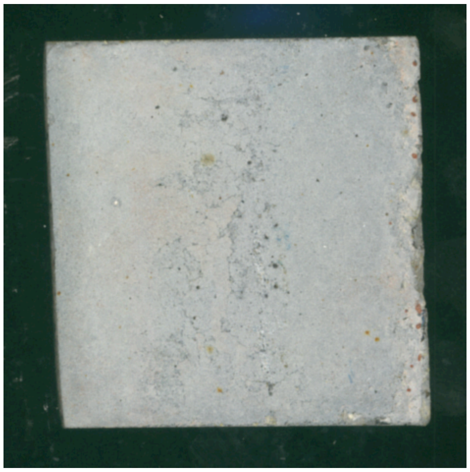
Thor Castable 30 ADT

Material ID: TC30

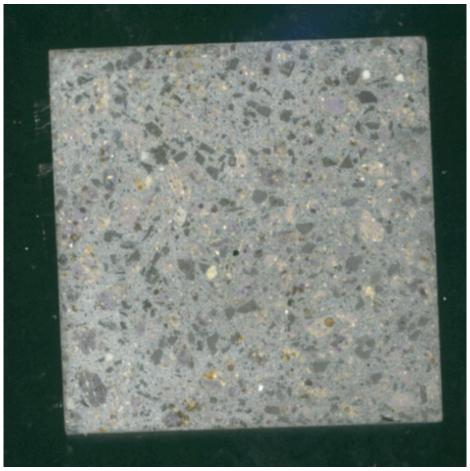
Short Description: Refractory containing silicone carbide, makes it unsuitable for most glazing, has an attractive ground surface.

Manufacturer:
HWR

Industrial Application: Designed for use in kiln preheater towers where its resistance to alkali build up is utilised.



Fired and un-ground



Fired and ground using Flex

Technical Info

Recommended Water addition: 1Kg: 71ml
Manual preparation: 1Kg: 75ml

Fired Composition:

Silicon Carbide - SiC	29.6%
Silica - SiO2	31.1%
Alumina - Al2O3	35.2%
Titania - TiO2	1.2%
Iron Oxide - Fe2O3	0.6%
Lime - CaO	2.1%
Magnesia - MgO	0.1%
Alkalies - NaO + KO	0.1%

Published Properties:

MST: 1540°C
Cold Crushing Strength (MPA) @ 1000°C: 60 - 90
Cold MOR(MPa) @ 1100°C: 20 - 30
Density (Kg/m^3): 2350 - 2500
Max Grain Size: 3mm
Permanent Linear Change @ 1095°C: 0-0.4%

Observations

Another refractory that contains fibre to increase the materials green strength. It is important to note the material contains silicon carbide as an aggregate constituent therefore of limited use in glass or glazed applications due to the silicon carbide content.

Narco Gun Sic 90

Material ID: NG

Short Description: A black refractory with a very high silicon carbide content that gives the material a striking appearance when ground and polished.

Manufacturer:
HWR

Industrial Application: A gunite material used for furnace and steel applications

Technical Info

Recommended Water addition:
Manual preparation:

Fired Composition:

Silicon Carbide – SiC	79.7%
Alumina - Al2O3	14.2%
Silica - SiO2	2.7%
Lime - CaO	2.5%
Magnesia - MgO	0.1%
Iron Oxide - Fe2O3	0.2%

Published Properties:
MST: 1649 °C
Cold Crushing Strength (MPa) @ 1093°C: 77.5
Cold MOR (MPa) @ 1093°C : 19.7
Density (Kg/m^3): 2370
Max Grain Size: 2-2.5 mm
Permanent Linear Change @ 1100°C: 0-0.4%

Observations

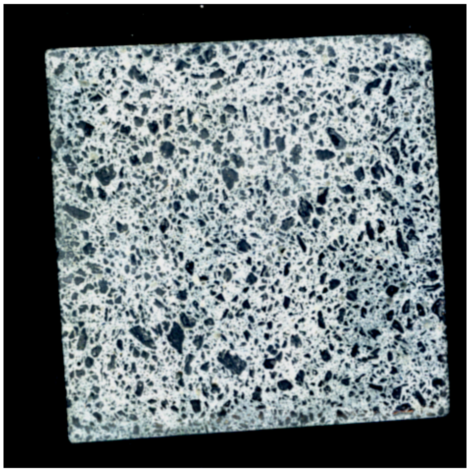
The overall small aggregate size makes this an easy refractory to mix. Has good green strength and fired strength. The silicone carbide in the mix makes grinding and polishing difficult as the material is very abrasive. However these same properties make it a very hard wearing refractory.

When polished the surface is a grey matrix with the polished silicone carbide giving a highly polished black.

Glazing this type of refractory is not recommended as a crater glaze will be generated as gas is released from the silicone carbide.

It should be noted the shelf life of Narco Gun is lower than the normal 1 year at just 3 months.

Fired and un-ground



Fired and ground using Flex

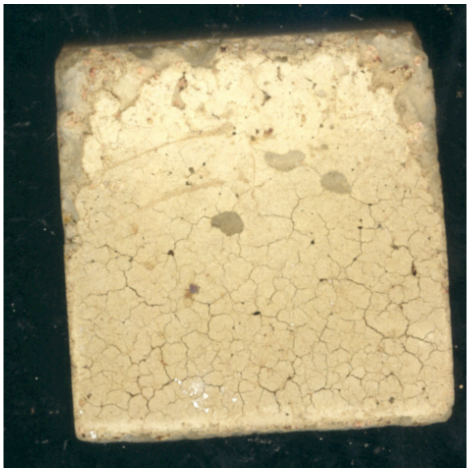
Lincofest (Light) L

Material ID:LL

Short Description: A light weight and very cheap refractory concrete high iron content limits practical application combined with the low MST

Manufacturer:
Linco Baxo

Industrial Application: Insulating applications predominately in low cost and less critical furnaces



Fired and un-ground

Technical Info

Recommended Water addition 1kg: 120ml
Manual preparation 1kg: 120ml

Fired Composition:

Alumina - Al_2O_3	44%
Iro Oxide - Fe_2O_3	4%
Others (not provided)	52%

Published Properties:
MST: 1200 °C
Cold Crushing Strength (MPa) @ 1000°C: 6
Cold MOR(MPa) @ 1100°C: N/A
Density (Kg/m^3): 980
Max Grain Size: 4mm
Permanent Linear Change @ MST: N/A

Observations

A very light and cheap refractory with a high iron content designed for use as a back up insulating material. Not of any real application in practical projects. The low temperature and high iron content make the material liable to fluxing at ceramic temperatures.

Too soft to grind so no picture is provided.

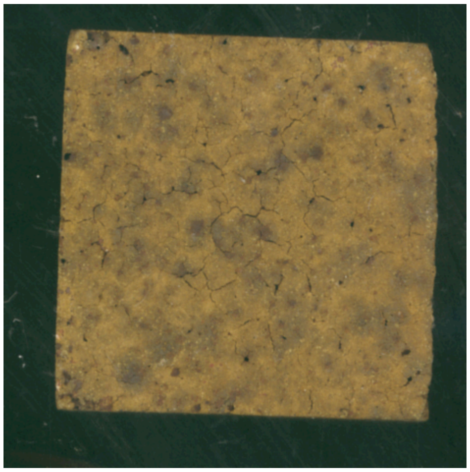
Lincofest (Medium) FL210

Material ID: LM

Short Description: Limited technical information is available on these lower end refractories. Their one advantage is the low cost.

Manufacturer:
Linco Baxo

Industrial Application: A Multi-purpose refractory used in a variety of less critical applications.



Fired and un-ground

Technical Info

Recommended Water addition 1kg: 115ml
Manual preparation 1kg: 115-120ml

Fired Composition:

Alumina - Al_2O_3	36%
Iron Oxide - Fe_2O_3	6%
Others (Not provided) -	58%

Published Properties:
MST: 1250°C
Cold Crushing Strength (MPa) @ 1100°C: 11
Cold MOR(MPa) @ 1100°C: N/A
Density (Kg/m^3): 1350
Max Grain Size: 4mm
Permanent Linear Change @ MST: N/A

Observations

This refractory has very little use for structural applications. A very low quality refractory with very poor physical properties and therefore low strength. The MST of 1250°C further limits its creative applications. Even approaching this temperature the material has a tendency to vitrify.

Lighter than Linco fest heavy but still retains some strength, possible applications include use as sacrificial material and for support applications.

Lincofest Medium has a high water to material ratio that makes it easy to mix and the low cost per kilogram is the only real advantage.

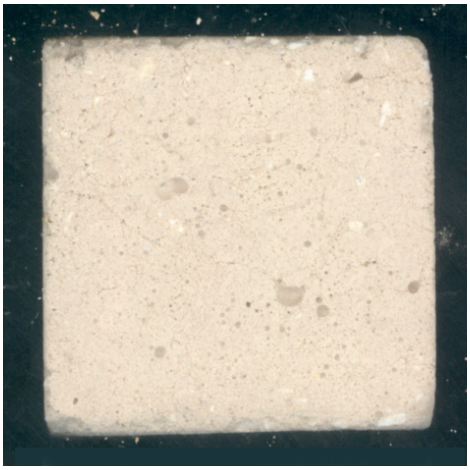
Cast-o-lite 30 Li

Material ID: CA

Short Description: A light weight refractory concrete that has small aggregate size and very low iron content making it useful for glass casting.

Manufacturer:
HWR

Industrial Application: Used as an insulating refractory in the glass and petrochemical industry.



Fired and un-ground

Technical Info

Recommended Water addition:
Manual preparation:

Fired Composition:

SiO2	35.0%
Al2O3	57.0%
Fe2O3	0.8%
TiO2	1.5%
CaO	4.0%
MgO	0.4%
Na2O + K2O	1.0%

Published Properties:
MST: 1650°C
Cold Crushing Strength (MN/m3) @ 1000°C: 7-14
Density (Kg/m^3): 1650
Max Grain Size: 1mm
Permanent Linear Change @ 1100°C: 0-0.3%

Observations

Can be easily mixed by hand as the water ratio is fairly high and the aggregate size is small.

Cast-o-lite is an insulating refractory with a very low iron content making it useful for glass casting moulds. It can be tamped into moulds to create a good cast surface. In addition it is a stable castable that can be easily removed from the glass after firing.

The material is too soft to grind or polish therefore no image is provided.

Appendix 2 Glaze Recipes

Earthenware

Glaze Number	E1
Glaze Name	Transparent Base
Source	Not provided
Colour and Description	Stable earthenware glaze, can be coloured by adding stains and oxides
Firing Temperature	1060-1120C
Ox/Red	Ox

Glaze Recipe	
Material	**Percentage (%)**
Lead Bi-Silicate	60
China Clay	10
Flint	10
Whiting	5
Potash Feldspar	10

Glaze Number	E2
Glaze Name	Transparent Green
Source	Not provided
Colour and Description	Stable wide temperature range green transparent glaze
Firing Temperature	1060-1120
Ox/Red	Ox

Glaze Recipe	
Material	**Percentage (%)**
Lead frit	60
China Clay	10
Flint	10
Whiting	5
Potash Feldspar	10
Copper Oxide	4%

Glaze Number	E3 (1)
Glaze Name	Black
Source	N/A
Colour and Description	Matt black glaze
Firing Temperature	1170
Ox/Red	Ox

Glaze Recipe	
Material	**Percentage (%)**
Borax Frit	25
China Clay	10
Copper Oxide	65

Glaze Number	E4 (2)
Glaze Name	Black
Source	N/A
Colour and Description	Matt black glaze
Firing Temperature	1170
Ox/Red	Ox

Glaze Recipe	
Material	**Percentage (%)**
Borax Frit	20
Potash Feldspar	30
China Clay	15
Copper Oxide	35

Glaze Number	E5 (3)
Glaze Name	Black
Source	N/A
Colour and Description	Matt black glaze
Firing Temperature	1170
Ox/Red	Ox

Glaze Recipe	
Material	**Percentage (%)**
Borax Frit	20
Potash Feldspar	20
China Clay	10
Copper Oxide	50

Glaze Number	E6(4)
Glaze Name	Black
Source	N/A
Colour and Description	Matt black glaze
Firing Temperature	1170
Ox/Red	Ox

Glaze Recipe	
Material	**Percentage (%)**
Borax Frit	20
Whiting	10
Potash Feldspar	10
Copper Oxide	65
China Clay	10

Stoneware Glazes

Initial Stoneware tests

Glaze Number	S(a)
Glaze Name	Hippie White
Source	N/A
Colour and Description	A satin white glaze
Firing Temperature	1060-1080
Ox/Red	Ox

Glaze Recipe	
Material	**Percentage (%)**
Potash Feldspar	27.78
China Clay	38.33
Dolomite	32.04
Whiting	1.85

Glaze Number	S(b)
Glaze Name	Meloy Clear
Source	N/A
Colour and Description	Transparent Clear Glaze
Firing Temperature	1060-1080
Ox/Red	Ox

Glaze Recipe	
Material	**Percentage (%)**
Potash Feldspar	39
China Clay	11
Flint	31
Whiting	16

Glaze Number	S(c)
Glaze Name	Titanium White
Source	N/A
Colour and Description	A dry white earthenware glaze
Firing Temperature	1060-1080
Ox/Red	Ox

Glaze Recipe	
Material	**Percentage (%)**
Potash Feldspar	34
Whiting	30
Flint	11
Talc	3

Stoneware glazes S1-S20

Glaze Number	**S1**(JC+JR)
Glaze Name	Turquoise- Blue Matt
Source	The Potter's Book of Glaze Recipes, p119
Colour and Description	In oxidation a rich turquoise matt, blue green
Firing Temperature	1200-1260C
Ox/Red	Ox

Glaze Recipe	
Material	**Percentage (%)**
Nepheline Syenite	40
Barium Carbonate	35
Whiting	5
China Clay	10
Flint	7
Copper Carbonate	2

Glaze Number	**S2** (JC+JR)
Glaze Name	Shocking Pink Glaze
Source	The Potter's Book of Glaze Recipes, p 179
Colour and Description	A bright nickel pink when thick, blue mauve when thin
Firing Temperature	1250-1280C
Ox/Red	Ox

Glaze Recipe	
Material	**Percentage (%)**
Feldspar	35
Barium Carbonate	40
Zinc Oxide	15
China Clay	5
Flint	5

Glaze Number	**S3**(JC+JR)
Glaze Name	Silky Jade Glaze
Source	The Potter's Book of Glaze Recipes, p 159
Colour and Description	A silky jade glaze yellow and creamy in oxidation
Firing Temperature	1250-1280C
Ox/Red	Ox

Glaze Recipe	
Material	**Percentage (%)**
Feldspar	35
Barium Carbonate	10
Calcium Borate Frit	7
Dolomite	8
Talc	20
Bentonite	4
Flint	16

Glaze Number	**S4** (JC+JR)
Glaze Name	Red Green Glaze
Source	Glaze Recipe Book?
Colour and Description	A rich green turquoise in oxidation
Firing Temperature	1250-1280C
Ox/Red	Ox

Glaze Recipe	
Material	**Percentage (%)**
Nepheline Syenite	35
Whiting	20
Zinc Oxide	5
Barium Carbonate	10
Flint	30
Tin Oxide	5
Copper Carbonate	2

Glaze Number	**S5**(JC+JR)
Glaze Name	Shocking Pink Glaze (Variation)
Source	The Potter's Book of Glaze Recipes, p 179
Colour and Description	A bright nickel pink when thick, blue mauve when thin
Firing Temperature	1250-1280C
Ox/Red	Ox

Glaze Recipe	
Material	**Percentage (%)**
Feldspar	35
Barium Carbonate	40
Zinc Oxide	15
China Clay	5
Flint	5
Nickel Oxide	1.5

Glaze Number	**S6**(JC+JR)
Glaze Name	Semi Clear Crystal Glaze
Source	The Potter's Book of Glaze Recipes, p110
Colour and Description	Clear turquoise glaze with frothy green crystals
Firing Temperature	1200-1260C
Ox/Red	Ox

Glaze Recipe	
Material	**Percentage (%)**
Nepheline Syenite	40
Dolomite	15
Whiting	8
Barium Carbonate	7
Flint	27
Bentonite	3
Copper Oxide	1

Glaze Number	**S7**(JC+JR)
Glaze Name	Tenmoku Glaze
Source	The Potter's Book of Glaze Recipes, p198
Colour and Description	In oxidation semi-matt black which breaks a tan brown on edges
Firing Temperature	1250-1280C
Ox/Red	Ox

Glaze Recipe	
Material	**Percentage (%)**
Feldspar	43
Whiting	10
Ball Clay	8
China Clay	5
Flint	26
Red Iron Oxide	8

Glaze Number	**S8** (JC+JR)
Glaze Name	Dark Mauve
Source	The Potter's Book of Glaze Recipes, p73
Colour and Description	A shiny runny glaze, mauve/purple where thin and purple where thick
Firing Temperature	1200-1260C
Ox/Red	Ox

Glaze Recipe	
Material	**Percentage (%)**
Feldspar	43
Barium Carbonate	30
Zinc Oxide	7
Flint	1.5
Bentonite	3
Nickel Oxide	1.5

Glaze Number	**S9** (JC+JR)
Glaze Name	Blue Glaze
Source	Ceramic Review Issue 216, p 18
Colour and Description	Blue glaze
Firing Temperature	1250-1280c
Ox/Red	Ox

Glaze Recipe	
Material	**Percentage (%)**
Soda Feldspar	50
Calcium Borate Frit	10
Whiting	15
China Clay	5
Flint	20
Rutile	4
Red Iron Oxide	1
Cobalt Carbonate	2

Glaze Number	**S10** (JC + JR)
Glaze Name	Bens Cone 5-8
Source	http://www.ceramicstoday.com
Colour and Description	
Firing Temperature	1200-1260
Ox/Red	Ox

Glaze Recipe	
Material	**Percentage (%)**
Feldspar	40
Gerstley Borate	30
Ball Clay	15
Flint	10
Whiting	5

Glaze Number	**S11**
Glaze Name	Green Matt Textured
Source	The Potters Book Of Glaze Recipes, Page 116, no221
Colour and Description	A soft green coloured semi-matt
Firing Temperature	1200-1260
Ox/Red	Ox
Glaze Recipe	
Material	**Percentage (%)**
Cornish Stone	45
Zinc Oxide	3
Dolomite	6
China Clay	17
Flint	27
Copper Carbonate	2%00.

Glaze Number	**S12**
Glaze Name	Frosty Matt White Glaze
Source	The Potters Book of Glaze Recipes, P68, no90
Colour and Description	Suitable for a light coloured body this matt frosty white glaze is broken when thick
Firing Temperature	1200-1220
Ox/Red	Ox
Glaze Recipe	
Material	**Percentage (%)**
Nepheline Syenite	40
Wollastonite	15
Barium Carbonate	25
Red Clay (powdered)	15
Flint	5

Glaze Number	S13
Glaze Name	Volcanic Glaze
Source	The Potters Book of Glaze Recipes, P90 n 148
Colour and Description	
Firing Temperature	1200-1260
Ox/Red	Ox

Glaze Recipe	
Material	**Percentage (%)**
Feldspar (soda)	38
Whiting	14
Zinc Oxide	12
Ball Clay	6
Flint	30

Glaze Number	S14
Glaze Name	not provided
Source	The Potters Book of Glaze Recipes, P72. no 103
Colour and Description	Pink Brown, blue spotted glaze. A decorative runny matt glaze with bright blue areas when thick
Firing Temperature	1200-1220
Ox/Red	Ox

Glaze Recipe	
Material	**Percentage (%)**
Barium Carbonate	35
Zinc Oxide	10
Alkaline Frit	15
Lithium Carbonate	2
Ball Clay	20
Flint	18
Nickel Oxide	1.50%

Glaze Number	S15
Glaze Name	Not Provided
Source	The Potters Book of Glaze Recipes, P96, n 165
Colour and Description	White to tan glaze
Firing Temperature	1200-1260
Ox/Red	Ox

Glaze Recipe	
Material	**Percentage (%)**
Nepheline Syenite	60
Dolomite	25
Whiting	10
Bentonite	5
Tin Oxide	6%

Glaze Number	S16
Glaze Name	Not Provided
Source	The Glaze Book - A visual Catalogue of Decorative Ceramic Glazes, P167
Colour and Description	Satin Gloss speckled grey/green
Firing Temperature	1240-1248
Ox/Red	Ox

Glaze Recipe	
Material	**Percentage (%)**
Potash Feldspar	33
Talc	21
Flint	16
China Clay	15
Whiting	12
Zinc Oxide	3
Titanium Oxide	7.5
Copper Oxide	2
Tin Oxide	1

Glaze Number	S17
Glaze Name	Not Provided
Source	The Glaze Book - A Visual Catalogue of Decorative Ceramic Glazes, P126
Colour and Description	Glossy Matted Light Ochre/Brown
Firing Temperature	1200-1280
Ox/Red	Ox

Glaze Recipe	
Material	**Percentage (%)**
Potash Feldspar	33
Talc	21
Flint	16
China Clay	15
Whiting	12
Zinc Oxide	23
Titanium Oxide	7.5
Vanadium Pentoxide	6
Tin Oxide	2

Glaze Number	S18
Glaze Name	Not Provided
Source	The Glaze Book - A Visual Catalogue of Decorative Ceramic Glazes, P126
Colour and Description	Textured matt gold metalic glaze
Firing Temperature	1240-1260
Ox/Red	ox

Glaze Recipe	
Material	**Percentage (%)**
Manganese Dioxide	70
China Clay	23
Copper Oxide	7

Glaze Number	S19
Glaze Name	Semi-matt Base Glaze (Dark Green)
Source	The Potters Book of Glaze Recipies, P120, n 231
Colour and Description	Semi matt base glaze(Dark Green)
Firing Temperature	1200-1260
Ox/Red	Ox

Glaze Recipe	
Material	**Percentage (%)**
Nepheline Syenite	30
Whiting	20
Lithium Carbonate	5
Ball Clay	30
Flint	15
Copper Carbonate	2%

Glaze Number	S20
Glaze Name	Semi-matt Base Glaze (Light Green)
Source	The Potters Book of Glaze Recipies, P120, n 231
Colour and Description	Semi-matt Base Glaze(Light Green)
Firing Temperature	1200-1260
Ox/Red	ox

Glaze Recipe	
Material	**Percentage (%)**
Nepheline Syenite	30
Whiting	20
Lithium Carbonate	5
Ball Clay	30
Flint	15
Copper Carbonate	1%

Appendix 3 Case Study Interview Transcripts

Ken Eastman Interview Transcript

6th November 2007

Alasdair Bremner: AB
Ken Eastman: KE

This is not a verbatim transcript

AB: Ok, so first of all I just have to read out the following statement, for the research: The objective of this interview is purely about trying to understand the processes you have followed while you have been doing the case study. And establish your response to the material as a material and so perhaps establish what are, in your opinion the creative opportunities for refractory concrete.

There are no right or wrong answers to any of the questions posed; in order for the interview to be valid it is important that you answer the questions as honestly as possible. There is no pre-conceived idea of what is a positive or a negative experience and or answer.

So I mean you already started going over the first question, but could you just give a brief overview of what you and Helen did?

KE: Ok yes I suppose because I work in clay usually, and I slab build and I work with the clay in a very plastic state. It didn't seem that I would be able to… but I didn't know anything about the material and I thought ok I am going to have to do something completely different for this. And it came about at a time when I was beginning to work and talk with an artist: Helen Cass who is an artist that lives 20 miles from here. She is a painter and she does painting/tapestry/sculpture, they are 3 dimensional canvases and she does drawing as well they are very laborious and time consuming, they are very subtle surfaces involving stitching and sowing and overlap and folding and also drawing as well. But she was coming to a point where she was needing to think about mass production… no, not mass production, but reproduction. Being able to cast some of the surfaces. She was coming at it having looked at resins and polymers and she was working with wax and thinking about bronze and other metals. So, anyway it came and I thought that might be a good way to explore the surface. And so started to work initially with one or two of her canvases, her folded and stitched canvases and using the material to cast very flat two dimensional surfaces so that was the first thing… and that's where we started.

AB: Ok, I mean obviously tried to look at colours and slips was your sort of interest… and…

KE: Yes, she was very interested to see the degree of precision and just what it looks like, her work looks like. What a painting looks like when it's in concrete, it's not a painting anymore…

AB: Yes

KE: But her work is always on the borders anyway, because she thinks of them as… as paintings but they are kind of tapestries, she actually stitches the canvases. So it sort of overlaps disciplines, I am not really sure what she is or what it is she does, but she is an artists and it doesn't really matter. But when its made in concrete this mundane, this architectural everyday, hard cold, stuff that we are used to that carries a load of other meanings and associations she kind of quite liked that and to take it to this rather rarefied art world that her work is…

[Break]

4:03

KE: …So she was very interested to see that, what actually her work looked like in concrete… which is what I was interested in as well. Because, I like the associations of the material, clay has lots of associations with it and although this stuff looks a bit like clay, it's a concrete and what does that mean? I haven't been able to make any pots or anything like that… but I would quite like the idea of being able to make some pots in concrete just like I would make them in bronze. So I suppose the material carried a bit of meaning. She also likes the range of concrete, as she knew them, I mean the sort of grey hues she was quite keen to just… that would be really nice because she leaves the canvas pretty bare. I mean sometimes she paints it black or stains it white but on the whole her colour range is fairly monochromatic. So a grey concrete was quite good for her. So she was looking at that, I guess, she was looking at the receptiveness to her surfaces, that are very subtle, she was looking to see how the meaning changes when you actually… how a canvas that you can touch is spring and its soft and its lightweight and it carries all those ramifications of you know the associations that it has. And when you hang a lump of concrete on the wall what is it?

AB: And does she feel…I mean it… is difficult for you to speak for her, but does she feel that it reflects those qualities.

KE: She was very keen on that, she loved that, she though it was very precise, and she was very impressed. I think I was as well until I covered it all up mostly with a load of slip. She was very impressed with the way this incredibly lump and sticky, hard; viscous stuff was very responsive to tiny subtle surfaces of different canvases. She liked all that. I think the juries out a little bit I mean maybe she has to hang them on a wall in a gallery, she is still exploring the resins and she has been to a foundry and there are all sorts of ramifications associated with the bronze and the intrinsic value. She is kid of drawn to the concrete thing, whether the market stands it, I don't know.

AB: Yes that is a different market altogether.

KE: But, no she was very pleased with the visuals of it and with her experience of it and the weightiness of it. I mean anyone who works with painting I am always surprised how these visually heavy weight things are so float away…they just float up…

AB: Yes

KE: I mean it's quite nice for someone to work with stuff, I mean I think she quite felt that her work is, are objects more than illusions, they do stick out from the wall some two or three or five inches… some she shapes the stretcher before she stretches the canvas, so over the years they have become more sculptural, some of them are flat and some don't go on the wall. So I think it does move it towards a more sculptural world… and I think she quite likes all that, she has been pleased with it.

AB: Ok

KE: I kind of went off on a tangent after I did that, not a tangent, but I took it on to try to see…. I would like to know what I can do with the shapes and I suppose I haven't been able to find that out very much I have just been able to find out about the surface and I wanted to know if I could colour. Because a lot of my work is about colour, so I wanted to know if I could paint pictures on it in ways that I can with clay and I suppose I have found out that I can't… do the same thing this is a different material and I have to re-learn it and I have just started to re-learn it I suppose…

4:14

AB: Ok that's great… well that gives us an idea….

KE: Ask away…next…

AB: Sure Ok, so what sort of knowledge of refractory concrete did you have before you started on the project?

KE: Very little really, what I have seen of your own work, I guess and what has happened at Glasgow School of Art over the last couple of years out the corner of my eye…people have told me things I guess that this stuff is extraordinary and this stuff can do things that… and I guess for people that work with clay…it does a lot of things that we can't and it doesn't shrink and you can fire it very thin and you can join it wet… all these things that are no no's. So we are in wonderment of it before I open the bag.

AB: Yes but the flipside is that it can't do things that clay can do, so it is a different mindset.

KE: I suppose I came at it with that really thinking that this is an interesting material and for somebody who is always trying to look for ways of expanding what I do. I have been working in bone china; I have been working in bronze, a little bit because it enables my work to go outside. So I am always trying to think laterally about… changing the material a little bit and how that changes the same object made in different materials becomes a completely different meaning, so I like that, I have always liked that. To be able to make the same things in… so I could see opportunities personally, selfishly for me this that it might be able to do things for my work.

AB: Well that was really the whole idea of the case study.

KE: Yes, of course I suppose I keep forgetting that I am talking to you Alasdair and not the tape…I kind of like that idea and I still do like that idea but I think I need a lot of help. But, I think the shapes and forms, I think, I don't quite know how I would do it… I think. I have faith I think it can be done, it I think it would be possible to make one of these. [Gestures towards open slab built form] I am just not quite sure how you would do it, but it would be nice because it would be solid or it could be paper thin, it could be inside it could be outside, I like the combinations, it would be nice to have one in bone china and the other half in concrete, you know, both sides of a window I mean so many options and I have begun to think of those things in a way that I wasn't before…I suppose, I kind of realised that I don't quite understand this stuff and things that I am so used to working with clay and I am so used to being able to handle the stuff that… I can control it I can do everything to it and I know this stuff came with particular instructions, but… I think I know.

AB: Oh yeah!

KE: But I realised I can't just wing it… I mean I can wing it, you see with the bone china, that's an alien material to me, completely different material, never worked with it in 25 years, and people say…oh you can't slab build with it, you know. But, I thought; I bet I can. And, so I can because I can work with clay and 27 years with a rolling pin you get quite good at rolling so I can roll out slabs of clay and I can build with things and so I have confidence that my fingers will be able to invent the way forward and find out an answer to the problem and this stuff didn't work like that… At least maybe I haven't done enough of it and maybe I need to do more of it. I haven't cast things before, well that's not true…but anyway it was just different and I thought I have to work out new ways of working with this.

AB: Yes

KE: Its not an instinctive thing and for someone who is so instinctive, a real old campaigner! You know who has been making and making and making, I now just follow me fingers and suddenly you have to follow rules.

AB: Well I don't know if I agree that there are rules, I mean… I guess like clay there are certain rules that you think about…

KE: Maybe it's that it's that early stage with a new material.

AB: Yes, I think so, but if you think about the things you are taught… that you cant do that with clay and there is always a way around.

KE: indeed, I have come away from it after doing some colours, I mean I did quite a few colours, some in Glasgow too. When I was painting onto the material when it was… leather hard… before I put it in the kiln and subsequently afterwards… In a way, I mirrored my own methods and I thought I will do what I have always done and I'll carry on and see if it works…and it sort of did work because there they are bits of concrete that are blue, I mean it's not painted, well it is painted but its painted with ceramic colour and it fired on and its… I tried to chip [it] off and it's quite on. But in another way it didn't work, it didn't seep into the material and it didn't absorb any of the colour it sat on the surface… even more after the firing than it did before, it kind of floated above there and it didn't do into the material. In fact I covered the material up like putting cloth over the material and all the qualities of the material I hid. So, at the end of doing some colour tests I am coming round to Helen's position really and if I am going to do some concrete work I'd quite like it to look like concrete than look like a painting. That seems to be the point really. Clay its possible because I don't know, because I like to be able to make clay look like a painting because I know how to make it clay as well as a painting but…with this I am maybe would from here on stop using colour altogether and start exploring… and my firing I have only gone up to 1200°C

AB: Well that's the sort of temperatures that we fire to too.

KE: Does it get a lot stronger from 1200°C…1400°C?

AB: Yes, I mean it does get stronger but not a huge difference.

KE: Ok, and what about the colour?

AB: We have fired one… it starts to go a little translucent when it goes really high.

KE: Really

AB: We fired one in a salt kiln and it went translucent so…

KE: So, it's not really that high…maybe 1300°C

AB: No but the salt… it didn't have any salt on the surface and I think the salt sort of went into the body… so…

KE: Yes

AB: And Sandor [Kecskemeti] did a lot of work with soaking the concrete in salt solutions and then working on the surface with a high temperature flame…on the surface

KE: On the dry salt?

AB: Well on the surface of the concrete to create quite reactive surfaces…because the point of the flame is maybe 2000°C so you can…

KE: indeed

AB: Yes and you don't have any problems with the heat shock, because that's what it's designed for.

KE: Yes that's a weird quality that I am not used to… that's very…

AB: So if you are looking to get a higher temperature that's maybe a way.

KE: And what shapes was he making?

AB: Well he did things which were…he did thing with this high density foam that you get for house insulating…not the polystyrene but you know…

KE: I know, like the Styrofoam.

AB: Yes, and he was cutting it with a hot wire and building shapes with the foam.

KE: So they were 3D things?

AB: Yes

KE: And so they were solid or…

AB: Some were solid and some were hollow… I mean I can show you some pictures…

KE: It would be nice to see…

AB: Yes at some point you will be getting the thesis…

KE: So how many have been…

AB: There are four, well there were 5 but one hasn't managed to get things done, with commitments…

KE: So there are 4, right ok

AB: Yes, well 5 if you include Helen in that…

KE: Yes

AB: So did you do any additional research about refractories, or did you just use the…?

KE: No just the information there…

AB: So you talked earlier about preconceptions…so could you give us an idea of the preconceptions you had about this material when you started?

KE: Well I suppose it was everything that I had learned out the corner of my eye at Glasgow. But it was also everything that concrete is. So I kind of had expectations of it because I know what you can do with concrete… What are those? Well I suppose it would be extremely weighty and extremely strong and there would be a huge density to it and an architectural quality to it. So I suppose it would move me into an area, which I quite liked. This material although I was working with it on a desk somehow had the ambition and the…capability to move me out into the world, out into the architectural space. This is something you can make houses with, you can build bridges with it… so I was thinking of it like that… This is a kind of gateway to something, which would take it off the plinth, of the shelf, out the door, out there… actually I could make the building with it itself… so I had those sort of ideas because of the word concrete… because of what it means. I did think that, and do think that really and I find that quite interesting.

AB: So where those…

KE: I mean it's the same as with the [bone] china I mean you are shoving yourself back into the world of etiquette and chinaware and department stores and the dresser and everything. But with concrete suddenly you are moving out and up and bigger and potential. So although I was working on the table and working small and working flat…I kind of thought that if I could explore this there was the possibility that in the future there was bigger and greater and stronger and this could be done with this thing, that was quite nice.

AB: And so where those preconceptions proved right when you started to use the material…I mean its quite difficult to answer when you have been working on a bench.

KE: yes it's very tricky… I have certainly learnt nothing to contradict it…I have learnt that because I am still aware of what you are doing with the material so I can see that there are possibilities out with and beyond… but I have found out that I would just need to rethink how I approach it, really. And I quite like its associations and maybe it's human nature, you go into something and you use the approach that you know. Because that's all that you can do and I have found out that maybe I need to do something different here and actually I need to take on those thoughts more. Possibly, maybe working with Helen is kind of a contradiction to that because it's drifting the work back onto the wall and back into a fine art world.

AB: Yes

17:08

KE: Where as I have actually been saying that the attraction is taking it off that, out the gallery door, into the high street into the square and yet there I immediately withdrew to someone who worked with pictures that you place on the wall. Which, is where my own sort off work drifts, my own ceramics drifts onto the wall. So I saw this chance of actually, ah, I can really go down that route. But, Helen was coming the other way and I think she saw a desperation to get off the wall and into things. So we all came at it with slight…different… because of the word concrete and what we mean by it different ambitions and this material can take me somewhere, it can take me somewhere I can't go with my bit of canvas I can't go with T-material. I have nothing to contradict that, I still think it probably can, but I think having just put my toe in the water I need to have some help, and I need to have some more. I still think it probably could…

AB: Yes, There is a grant in there somewhere.

KE: I don't know, grants, yes another game. No I think there is, maybe that is why I said I would do it, for the last few years I have been trying to broaden things, I have done the bone china, done the bronze, I did some paintings. You know because, you have to. You can't just make this stuff in a shed, in a field, in a stable. You can't just take the cheques because it doesn't work, you have to think a bit sideways, we all have. So any way that can take you there…. yes…

AB: Sure.

KE: I would like to know how I would go about, simple I would just go about making a mould, that's what I would have to do, but from my experience of the material…I would need a mixer.

AB: Yes its all a question of the right technology, you would need to use Silicone or a rubber mould… and back it up… I mean it's a labour intensive thing and if you are making one off pieces and you want them to look like that… then clay or T-material is the way to do that and not with concrete.

KE: Yes that's so often the way…

AB: If there is a way… you know this material has to find its own way… It's not going to emulate clay, its not going to emulate the forms that you make in clay. Because clay is much more suitable for that sort of thing, so I guess that's where it starts to become something that's interesting…

KE: Yes I can see that

AB: If you were making lots, well not lots but short run batches of the same thing where you have more risk and its solid and…

KE: Yes as you say you can't really do the one off piece on the off chance and there is no substitute if you want to make something quick cheap and easy.

AB: yes sure

KE: it's a different material and therefore it need a different response and I guess that just need time and who knows if I worked with this material for another 6 months. And I would be quite interested to do that because, for all the reasons that we have just hinted at. I know just enough to know that I can't do it. But as you say, what it would look like… I am sure it would probably not look like that, that would be an error, that would be a foolish thing to do, why would you do it? Unless you had some kind of commission to make 50 of them for out side Sainsbury's… other wise your work would end up looking very different, or possibly not, it's a question of being able to play with it and see where it can go…

AB: I mean 3 months is not enough time really… well I don't know how much time you managed to spend on it?

KE: Well yes bits and bobs here and there, here and in Glasgow, I have various pokers in the fire and it was enough just to see…

AB: Yes and that was really the point of doing them, was only to allow people to see and find out they could do something in the future, perhaps that might … be more beneficial in terms off…

KE: I think what you do is… you just start, for god sake just start, it doesn't really matter and if anything's of interest then you follow it.

AB: Yes

KE: And the things that have been of interest is the strange incredible sensitivity to casting that the material seems to have. This great, heavy lump of thing that you have to move and mix and it won't rot, it has the half-life of five hundred thousand years. You can't break it, but you can take a fingerprint off it, and I'd like to do more of that… I don't know what it would look like but I would probably go with that, that's the hint that would get me going, Rather than thinking; I am going to build this, you would be fighting it. So I would probably go with that. I would mix it better

AB: Yes a mechanical mixer would be the key, much easier.

24:17

KE: yes, scale is of interest to me because I realise this would be possible to work… even just twice as bigger as I am at the moment.

AB: Several tonnes are possible.

KE: Indeed, then anything is possible. That's a very interesting thing… that you have this potential hugeness and potential resistance to the weather and everything, the elements. You have this incredible minute sensitivity, like a whisper, like a fingerprint. Now with those two qualities you have got to be able to do something.

AB: Well I would hope so.

KE: But I don't think it would be about painting a picture.

AB: So the slip on the surface is not something that…

KE: No, not the way to go. Before I put the slip on the surface I was finding quite a difference in the colour ranges. Between 1000°C and 1260°C. You know just the little fluctuations there. Never mind all the slip, so that would be the range.

AB: Yes

KE: Also I think… I believe there are other materials, which I haven't even touched on, I had the Jon Flow 90, but there are other ones and they might have more colour ranges.

AB: This has the best definition. It will give you the best surface cast… I guess also the whiteness of the material I felt… with your work in mind, perhaps I felt that having a white material would be the best… I didn't think one with silicone carbide would be suitable for your self.

KE: No… the other think that I couldn't do because I couldn't mix it and I didn't have enough material, you know I have to e quite mean with this… was to make the things… maybe that's why I made skins… you know because I couldn't mix it up. I mean I could quite like to make solid things

26:13

AB: Yes of course, that is one of the things that has come up from others… the question of I have 25kg and I have to do these things… so do I do one piece or… whatever… and that has been a common thing. From my point of view what would be interesting would be; to run some kind of symposium in a factory setting, so you don't have the

KE: That would be great, and Again, the thing is… my work is about illusion and skins, and volume, and emptiness and looking through a veil of two dimensions. So to be able to make one of these pieces absolutely solid, everything about mass is not an area I explore, I explore illusion and skin and idea. But mass in that old sculptural way I don't know anything about, that solidity, that density that sheer weight. That's an unknown world to me and I would quite like to know a bit about it… again I always think of playing one idea off against another. That would be a nice thing to do and maybe with the bag you brought down there, combined with the sensitivity, you see I haven't even done that… you see the one at the back there, the black canvas and she has a lot deeper ones. In a way the whole point would be to make that in concrete so that it's solid. I haven't done that, we just too skins of it… But… to have that combination of very subtle stitch work and yet you can hardly lift it. That suddenly becomes something different…

AB: Yes…that… is the…

KE: I mean a thin skin… its concrete I am not going to break it… but I drop it and It broke… so

AB: Yes when it's thin it is brittle… and also the more water that you put in the weaker it gets overall…

KE: Yes you did say that, I don't think I mixed more than 4 kg, I think that blue one is 4 kilos, I mean real you need a mixer for that really.

AB: Yes I mean I don't really mix anything by hand any more, I mean more than 1kg… but since I have had the mixer I don't do it by hand anymore.

KE: How much will the mixer… mix?

AB: About 10kg at a time

KE: How long?

AB: 5… 10 minutes and with that time frame you can…

KE: You are ahead of yourself.

AB: Yes you can cast one then the next and you are going to have problems with it by hand, you will have noticed that it starts to skin up, you get that plastic skin… you know.

KE: Yes… yes

AB: I mean the mixer is the thing and they are not that expensive really

KE: Well how much are they?

AB: you can pick one of for less than £200

KE: So not that expensive really, less than a tractor then…

AB: Yes much less than a tractor….

30:57

KE: Yes

AB: Anyway moving on. You have already sort of answered this question. But do you feel that you have tried to use the material in a way, in the same way as your normal working practice?

KE: In a similar way, I mean it is different, you know I don't do that. But in a way the goal…

AB: Yes the approach

KE: Yes I was thinking of those, I was already thinking abut where I wanted to be, I was thinking if I could get all those qualities that are in my work, but do it in concrete… then…well. And already you have decided where you wanted to be. Maybe in hindsight I wouldn't even think that… forget those qualities, lets just look at the material and start again.

AB: Yes exactly it is not the same; you have not got the same results.

KE: No, I mean I kind of tried to. I went a sort of circuitous route and end up with a similar sort of end product, and it was a bit like trying to pull it back on course when it didn't want to go. So I guess… my natural instinct, in hindsight was to stick with an aesthetic that I understood, because I had let go of everything else. I had let go of my methods and my techniques and my material. So I tried to keep hold of at least the aesthetic…

AB: Some comfort…

KE: But in hindsight I would just let go of it all. Start again and say this is me, that is the material and lets see where we get together. That's what I would do…

AB: So this lead on form that, so have the materials properties given you the opportunities to do things that you hadn't previously considered?

KE: I suppose the short answer is yes I haven't done those things but I could see things that I have not previously thought about, those are the things that we have discussed.

AB: Yes we have covered those things.

KE: About solidity and mass and scale and environment and all those worlds that I have a glimpse into… I guess I have considered them. Which, is why I have started to explore bronze, I have started to think…

AB: Yes I would like to see these bronzes.

KE: Well they are in London, I am afraid.

AB: Oh right

KE: Yes I have worked down at a foundry called Bronze Age down in London, but it costs a lot of money, bloody hell! So you can't make a lot of those on the off chance.

AB: Yes indeed

KE: So I have begun to think in the past year that I want to move off the plinth and out the gallery. Because the galleries are closing down and the collectors are dwindling.

You have to move out and on… its no good… my nightly lecture… that I talk to my self about…

AB: So do you think refractory concrete might be a way into a new world…is that…

KE: No… I do, I think realistically there are options there. It does open up other possibilities. I can see that enough… to know that there are those possibilities but I would need to invest time and equipment or to share time and equipment or something… In a way I think it's a very good time in the world of ceramics for those things to happen. We have to do those things at the moment. It's just the nature of things that are happening in our world, we have to move outwards and sideways. The world I have inhabited for 25 years is changing. I do think there are ways it could go… I also think its an affordable way to go too…

AB: Hmm indeed

KE: But it's a new material, it's a different material, it's not just an extension of what I have been doing, it's start again. It's like working with wood… I need to unlearn a lot of my rules

36:27

AB: Yes or break down and eve establish some of the rules that you think are there with refractory. I mean think about the first time you started to use clay. You think it can do this and you think it can do that, but when you do it, often it can't….

KE: Yes and I think that because my work grows out of the world of ceramics and lives within the world of ceramics, responds to it. That's the subject matter; the question is clay, really. This is what my work questions when I work I explore what clay means, to us, and the world. All those questions go out the window really and it's not as if I have a point to get across and I happen to chose T-material to get that across. I don't know what I mean until I make it. So when I start making… the question I am trying to ask is: T-material. My answer is that [gestures to piece]. That's how it ends up at the moment and it relies on this whole world, these parameters, the ways of looking at, history, reference and knowledge of the world of ceramics. All those are….

AB: Gone, yes

KE: Suddenly the question becomes Jon Flo 90 and I have to start going to the Jon Flo 90 department of the V&A to find out what I want to say.

AB: And there is not one

KE: Yes so I am a bit screwed really so I have to think out in a new way and it's a new challenge. But, it's not a bad one and I can see sort of echoes of what I have done… but I think that it's much more different than I thought and maybe that's… I thought that it was an extension of what I was doing but it didn't have any of the problems. I mean it doesn't even shrink… I am laughing… I can make it really thick or thin… fantastic. So it had all these advantages yet it was this grey stuff. But its not, it's completely a different material all together. Its like… Ok forget you are in clay, you have moved into the silversmithing department, start again boy. I am a bit humbled by…

AB: So you would say your knowledge of working in clay for 25 years was obsolete, or… perhaps not obsolete…but it doesn't apply.

KE: Yes… it was a bit like: I have got quite eloquent in Spanish and you have just dumped me down in Shanghai and I am trying to sort of… alter my accent a bit. But I now realise that Spanish is not the language here.

AB: That's a nice analogy…You started to talk about the advantages there… so what would you perceive to the advantages of this material… and this is not the advantages you thought before but what you now think are the advantages.

KE: Well speaking with you now… sort of clarifies a lot of that. I suppose the advantages would be that it does exactly what I have just said. Which is and me in Shanghai and that would be an interesting place to be and we should unlearn as much as we learn all the time. That is my personal advantage because you have to keep… What you do as a maker, I make to think and I think to make and that is the way I solve problems and work things out. I have been making so long that I think to make so to be able to plunge myself into a new material to make that would be very challenging and it would put me on my metal. I suppose that would be one advantage, it would be kind of like coming out of the world I am living and put me in a different world. Where it might go would be an unknown. I suppose one other advantage I found is… more material based. Like its sensitivity and its… I don't eve know the cost of it…

AB: It's about £20 per 25kg back

KE: Well that's maybe not as cheap as I thought

AB: Yes well this is quite an expensive one… because of the flow and the aggregate so… but it depends on how much you are buying really.

KE: I don't know about advantages or the disadvantages because I don't really know what the advantages or disadvantages are of my material. It's just a material and you find a way of working with it and certain things work and certain things don't.

AB: Yes, I mean its all tied to application really.

KE: So from the beginners point of view, looking out. The advantages would be that it moves me, moves me on.

AB: On to Shanghai…

KE: Yes or it would move me out, and you would keep it alive because you would possibly, hopefully see things you hadn't really thought about before… by working with this material. I could work with it because it is the sort of thing I know, I mean it's grey stuff that you mix up with water. Its not like learning silversmithing where I have to apply loads of technique, I could work with it tomorrow so that's… quite good from that point of view… and it's concrete and which is quite known… and that's a big advantage because if you mention the word ceramics it leaves people cold, most people haven't a clue what you are doing. But with concrete well at least that has a bigger profile people know what concrete is. Fair do's they might not like, might think its rather boring, dismal and heavy and grey and it but at least they know what it is.

AB: yes but when you say you work with refractory concrete then they have no idea again.

KE: Yes I suppose.

AB: So, what would you say are the disadvantages?

KE: Well…

AB: That it puts you in Shanghai

KE: Yes you are right, yes the disadvantages would be that I have to spend time exploring and time is ever more valuable and precious. I would have to spend time in possibly exploring whether I can find anything I want to fid out in this material. It's possible that you could put in a month or two and think maybe…no… maybe…no. So, I suppose, there is a sacrifice there that you have give out a bit before you get anything back. An obvious disadvantage would e that I would have to move out my shed, in my field with my solitude and my rolling pin and engage other people. Even to make relatively small table work I would have to get involved in a load of other things and dependence and I have always cherished the lightness… I need a knife and a rolling pin and that's all I need. But then that's an advantage as well… I mean you go mad, stuck in a shed… and I would quite like to be involved in architecture I mean my work is all about architecture, I went to study architecture. I like architects, some of them! So to be able to work with architects and I guess there are ways here that you can be involved at the beginning or the middle of a project rather than be the person that comes along at the end. I mean I have always really like the idea of that I have never really been able to do it with clay because of its associations. So maybe concrete might give you a head start on that because it means something to people… its not the icing on the cake, it's the cake it's self. In fact maybe that's it maybe there is a body of work in that….

AB: So you have already answered this question because I have brought you down more material… but is there anything in particular that you have in mind.

46:47

KE: Well the next thing in mind is to do the pursuit with Helen some more because it has gone enough for her to quite like what is happening but we need to see what is happening… You see even for me to make that solid form is quite a bit of mixing… and this is a small one.

AB: Yes I think honestly, I think if you had a mixer then I think the whole idea would….

KE: Yes that was the whole idea of where I was going to go with this… but it is possible that I might not do that. I mean speaking with you just now… has made me think quite a lot about what I have done so that has been quite good so I might do something else with it that is not that… although I think it might be quite good to do that… I have to talk to her about it and find out how she got on with the resins and… if she…

AB: So that might be more…

KE: There might be advantages to that, I mean you could do these in ceramics and it might be easier than doing them with concrete… so maybe I will go down the density route… I certainly won't be colouring with them… I will jut be firing them…. Yes so I don't really know.

AB: But, there is some kind of plan and intention…

KE: Yes the reason for asking for the bag was because I wanted to do more with Helen. But, talking with you just now has made me think, also that there are other things that I would quite like to do and I can't do all that with 25kg but. The answer to the question is I would quite like to pursue a bit more. But I think I just need to be a bit more reckless… it's getting into that whole, being able to test things and it's difficult to be in that experimental way of thinking.

AB: Yes and it’s difficult when you have had a long period of time in one way

KE: Yes and I make for exhibitions I am making and making, it’s finished work, you get something out and that is how it is. So to actually think that I might spend a month and not get anything out that just changes your mind set for a maker.

AB: Yes, so would you say that the case study has been a positive or a negative experience?

50:03

KE: It’s been a positive experience. It has been a good thing. For a start it has got me working with Helen and that has been a nice thing as well. I mean, I liked her work anyway but we never really found a way of working together so the collaboration, and any collaboration is a good thing.

AB: Yes and it is interesting to bring in other routes. Because I even had preconceptions about what I thought each of the participants would do…so…

KE: I am sure

AB: So for it to go into textiles and…. the stitching and to explore that… wasn’t the sort of area that I didn’t think you would explore… the ability to take on surface was not really where I thought…you…

KE: I didn’t know when I accepted the thing I didn’t know I would do that either… that it would go there… so that was a really positive thing.

AB: Yes

KE: And I think even if you never touched it again then… It’s just like foreign travel, you know again, it makes you look at your own world differently. I am just making things in T-material because it happens to be convenient, I know how to handle it and it doesn’t shrink that much, its white and... But, there are another load of other meanings that are flying around with this stuff and it’s not until you start working with something else you think… actually this hasn’t got al those meanings. So all this stuff that I think I am not even taking any notice of. They are so ceramic they are so about the world of ceramics and I don’t think Helen and I took the concrete on board we just thought concrete; heavy, grey, inert, no meaning. This is a material with no meaning, its empty its void of associations

AB: it has history though

KE: Yes of course it has history, it’s steeped in it, it’s just a load of different ones and it is not until you make something that you realise: this means something completely different than I thought just because its made in… ebony… or glass if you make the same thing in different materials they mean completely different things and that was an interesting thing. So it changed what we both… I wish she was here actually.

AB: No that would have been good… but that’s the thing people have other… no it is great that she was involved in the first place.

KE: I will tell her what we talked about.

AB: I will send you the transcript.

KE: That would be great and I will let you know where she gets on with it. I kind of learnt a lot I think I will do more and I will let you know what we get on with. I have kind of learnt that you can't just do the same think and expect it to be just y own work but just a bit stronger. So…

AB: That would be great, keep me posted. Well that's it, kind of… I just have a few more sort of technical questions that you have pretty much answered in… and in the notes you sent… but, what sort of temperature did you fire to…?

KE: The lowest was 1000°C and the highest was 1260°C.

AB: And how long were you leaving between casting and firing?

KE: Oh, it was a good week or two.

AB: And were you consciously leaving them?

KE: Just what I do, I was consciously leaving them and I guess that is a kind of habit thing; I just wait until things are dry ad then I wait another week or two. That's just the way I do things… I probably didn't need to but…

54:33

AB: I think, yes, it's a physiological thing.

KE: Well I had no reason to do it any other way, I mean, I just fired them with the other things, like this glaze firing.

AB: The only other thing that would be quite useful is perhaps to document the slip recipes you used.

KE: Yes I basically used my own one that I know off by heart but I altered it slightly, I haven't got it written down here but I can e-mail them to you. I was trying to lessen its shrinkage so I added… I used calcined china clay and I put a bit more flint. I will send it to you.

AB: Ok

KE: Yes here I used my recipe but it's cracked to hell, and here I was using the calcined china clay to stop the shrinkage and it sort of works.

AB: but you are starting to get similar effects there with the slips…

KE: you can see here that the cast was so perfect it was a beautiful cast and I hadn't realised how good it was until I had covered it up and I lost all Helen's qualities altogether. Having said that it is on there for good I mean it will come off but you have to really go at it.

AB: yes sure

KE: I put it on thick and but in several layers, that is how I do it… but it worked… I mean in this instance it didn't work because I covered everything that I liked abut it. But in a sense it did work because there is a piece of blue concrete and it's fired on.

AB: Perhaps the other interesting thing with the textiles is that it doesn't need to be cast flat and so you could have more flexibility.

KE: We didn’t really go down that way because we didn’t really know how to go about that so…

AB: Yes sure no… you can see here the…[gestures to texture on the surface of test piece]

KE: Yes you can see how high it is floating of the surface it is almost like floating a millimetre of the surface and you see some and there is a great crater. But I was putting on really washy slips to make it seep in. but it seems to have almost lifted. It’s on there but if you chipped it off the material would be white under there and I am not used to that because usually it goes in and here it has raised up and that’s really weird. So I didn’t quite know what to do with it and in hindsight I wouldn’t do anything with it and I would leave it white. In many ways this is the best example, this little fragment [refers to white un coloured piece]

AB: sure, here you can even see the different weave of the canvas,

KE: Yes, because she uses different kinds of canvas. Her work is so subtle, her work is so unbelievably subtle and she has these drawings that are these ink lines and she will be playing this piece of Bach, and its like 4 hours…

AB: I would never have the patience for something like that.

KE: extraordinary, and people don’t even see it.

AB: No, that is great I think we have everything, o you have anything else to add?

KE: No… I think that is everything

61:02

End of Interview

Tavs Jørgenson Interview Transcript

3th December 2007

Alasdair Bremner: AB
Tavs Jørgensen: TJ

This is not a verbatim transcript

AB: Ok, so first I just have to read out the following statement: This interview is purely about trying to understand the processes you have followed while you have been doing the case study. And establish your response to the material as an artistic material and so perhaps establish what are, in your opinion the opportunities for it.

There are no right or wrong answers to any of the questions, in order for the interview to be valid it is important that you answer the questions as honestly as possible. There is no pre-conceived idea of what is a positive or a negative experience and or answer.

Ok so can you first give us a quick overview of what it was that you did, I have your notes here and some images that might help.

TJ: Ok, yes the images can help, well this played a very much a supporting role in a big research project. This is to do with, using digital tools to create with, specifically a digitizing arm, micro-scribe G2 where a line would be defined in space and free hand in mid space, recorded directly into CAD [Computer Aided Design] and from that line the intention was to make a former to create glass pieces. Initially prior to this the material I used was plaster and stainless steel sheet to define that line using CNC laser cutting. Instead of using the sheets for this project I used pins for the formers. The idea with this was to use the genuine data of the recording from the micro-scribe. The loop or the rim defined in space as points in space so the pins would be set in a laser cut pattern and the heights were defined by unrolled 2D representation of the height value of the points in the recording. So the pins were set into a cardboard collar. So the refractory concrete was cast around the bottom of the pins so to hold them I thereby creating a refractory mould for a glass piece to be made by putting the mould in the kiln, place the glass disc on the top and you turn up the heat and the glass will dome and create a vessel reflecting the points.

AB: So it was very much that you used the refractory concrete as a replacement for or instead of the plaster type material that you normally use. We will cover some of the questions with regards to that as to whether it was better or worse….

AB: Could you just describe what knowledge of Refractory concrete you had before you started work on the project?

TJ: Only really third hand knowledge, a couple of friends of mine have used it, I know of a few people using it, I new of existence but that was pretty much it.

AB: Ok so you knew it existed, so, did you do any other additional research about refractories before you started to use it, or did you just use the information that was provided?

TJ: Well, I went a little bit out on a limb with it; I started mixing it with plaster.

AB: Right.

TJ: Because the issue with this process, obviously you pointed it out, I used this as a replacement material for the plaster and plaster is brittle when you fire it. Now I want a mould I can re-use. So the idea was to use this material for the mould so it would be far more durable. I mean plaster cracks after the first firing, and goes very brittle.

AB: sure

TJ: But, I did a number of investigations, I think I did 3 or 4 mixing plaster and Jon Flo in various proportions first.

AB: how did they go?

TJ: Well, it didn't work, at all.

AB: And what were the problems that you encountered, I mean I can imagine them, but could you….

TJ: It just cracked and broke probably much more than either material on its own.

AB: ok so when you normally use the plaster are you using the sort of normal glass makers mould mix, I mean with sand and….

TJ: I mix in quartz, fibreglass strands to try to keep it together, sometime armature in terms of steel.

AB: Sure ok, So could you describe what preconceptions you had abut the material from the literature and instruction you received from myself. I mean did they suggest to you a route for you to use.

TJ: I did read the instructions. I was surprised how it did sound like it was quite difficult to mix. And I thought that can't be so. So, I tried it and I found that the instructions were pretty accurate. It was very difficult to mix, so no I did read the instructions and also the addition of the water and I did adhere very strictly to the guidelines, at least initially. I was surprised how little water was needed. But they were useful the guidelines, I mean they were clear and readable enough so, I did read them.

AB: Good, I'm glad, ok, so could you give a description of the materials properties, so could you just give a description of how you would describe it as a material?

TJ: Doing the mixing it's incredibly coarse and abrasive…its very strange properties in terms of the, I suppose the thixotropic is that the right..

AB: Yes thixotropic

TJ: Yes, very strange thixotropic characteristic, I mean, more than any other material I have ever come across. So it's very difficult to mix, very coarse. Mixing by hand is difficult.

AB: Yes all the strapping lads were given the Jon Flo, so, anything else?

TJ: What else was there?… I mean I had hoped or I had expected that… Even though I had a very defined project in mind with it just doing that project. I was pretty certain it could perform the task I wanted it to perform, but kind of just working with the material as a supporting role in another research project. I thought it would give me information to do maybe use the materials different aspects. I mean I expected the material to be more sort of plastic, more like clay, but, it wasn't, it flows even when it is very dry which is a characteristic that I didn’t expect. I mean I am sure it can be used for something, but It surprised me.

AB: I mean that characteristic allows the material to copy detail a lot better than a more plastic or something that requires tamping.

TJ: yes sure.

AB: So do you feel that you have tried used the material in the same working process?

TJ: yes well, I mean it was replacement, because the plaster is not really giving me the performance.

AB: so was it successful as a replacement for the plaster?

TJ: it was actually, I mean doing the mixing and I mean it is hard to work with but it has held together fine, there is no armature in there.

AB: I mean one of the things that has come up again and again with this material is the mixing. But I guess if you use a mechanical mixer it takes that away.

TJ: yes, less of an issue, yes. I mean I wasn’t too hopeful initially; just this mixing issue that was so hard and pouring, it is very very stiff when you pour, if you go by the guidelines. But it does surprise you that it does pour even so.

AB: Yes, even with the 4.5% water

TJ: I mean you kind of think; this is never going to work, but it did.

AB: But it does your arm in, I mean you know. Anything more than a couple of kilos and it hard work. So, did the materials properties give you the opportunity do thinks that you had previously not considered?

TJ: This case probably, no. But I am kind of racking my brain trying to think what exactly to do with it.

AB: I mean I have always considered it as a material, I mean you have used it as a sacrificial, or perhaps the wrong word.

TJ: As a kind of tool making maybe

AB: Yes, as a kind of step on the route to a final piece. But had you considered using it to make a final piece in itself?

TJ: Yes…. I did… but I didn’t have any appropriate project at the time where I really thought I could give it due attention. I didn’t want to just do something for the sake of it. I really wanted to do something where it was really considered in its application. And I was doing this project at the time and I was having the problem with the other material.

12.01

AB: No, I mean it’s a perfectly valid way of using it, but I just wondered if you had though of using it as a final material. I mean that’s what we use it for a lot, as a reusable glass mould material, if you know what I mean.

TJ: do you really?

AB: Yes, but do you think there are any projects in the future that you might use it for. I mean I guess it can be difficult to think but if you can think of a project that you might use it for.

TJ: I certainly think there must be other projects that I might use it for. I mean the properties of it; I mean you have to get your head around it. It's a flowing material so you really have to make moulds for it. I don't think you can just sculpt with it in any way shape or form so…

AB: I mean I can be directly cast onto RP foam and it can be cast onto silicone moulds and so on, these things are no problem. It was just, I know it's difficult but if you could think of something in the future.

TJ: I can think of anything specific.

AB: And would you use it again for the application you used there, if you could solve the mixing issue?

TJ: Yes I mean it is certainly something that is there. I am thinking of its strange properties with the thixotropic as a flowing material, there must be an application somewhere, where that those properties are really useful I mean beyond just pouring into mould.

AB: We did some rough experiments early on, using it as a dipping material to create a piece. But you have to mix up large volumes to get any kind off scale. So it's a very wasteful method.

TJ: ok, that does sound interesting.

TJ: I quite like the look of it, the aggregate, whatever, the aggregate is, I quite liked the look of it.

AB: ok, so what would you describe to be the advantages of the material, if you can provide any?

TJ: I think the advantage is, it seemed to be quite durable, you know, it can take heat. But the fact that I can use the mould again and again and that it seemed far more durable than the plaster, so it kind of worked.

AB: and could you describe the disadvantages.

TJ: well we have covered the mixing, and it can be a little bit difficult to pour, compared to the plaster… it's heavy, but would you describe that as a disadvantage, I don't know, I mean that's the material.

AB: And could you say whether the case study has been a positive or a negative experience?

TJ: I would say a very positive experience, I think I'd always had an idea of refractory concrete and what it could do, and I think it has been very useful to get an understanding at least one refractory concrete and its limitations and its strength rather than just presuming.

AB: you do get, that one that you were given is very much a high end type, but there are, for the purposes you require much more suitable materials.

TJ: ok, well that would be very good.

AB: Yes we use Cast-o-lite for the sort of job you were doing, so it is much easier to mix by hand, we can certainly get you the details for that.

TJ: that would be great, I would be very interested in that.

AB: Well we can certainly put you in touch with the people who supply that, no problem.

TJ: Ok, that would be great.

AB: So, just some technical questions, if we can quickly run through them. What temperature were you firing them to?

TJ: I can’t remember, I have the notes here,

AB: Yes your notes say 760°C

TJ: yes that would be the temperature that I did, all of them were about the same, I just put it through the normal cycle that I would do.

AB: so you never fired above this temperature?

TJ: No, this was it.

TJ: I was surprised to read that it does get stronger with the firing.

AB: and how long were you leaving the cast before firing, were you consciously leaving them?

TJ: Yes I did dry them?

AB: You dried them?

TJ: Yes some I left on the top of the kiln, but I took it slowly.

AB: Well that is one of the things that is not really a problem, you can even fire them from wet, and what about the firing schedule, can you remember?

TJ: I seem to remember we took it through a slow drying cycle then, slow maybe 50°C per hour.

AB: Ok, well that is pretty much it, the rest of the questions relate to glazing so….So do you have anything else to add?

TJ: Its interesting, mixing it with plaster obviously it didn’t work at all, but it was probably worth doing some stupid experiments at the time and seeing if it works, and it didn’t. I think it’s a very interesting material to be put in touch with, also whether you use it as a creative material or a supportive material. There are lots of roles in creative practice, it could either play the final material for exhibit or sale or you know, it could play all sorts of supportive roles either making the tools or eve bits of the machinery that you use. I mean, I am certainly very happy to have a bag of that hanging around so that I can have a bit of fun using it in the kiln or what.

AB: in many ways the limiting factor with that material is the mixing, but after you have that out the way it can be more open.

TJ: but also this thixotropic, this flowing, I mean I had ideas to use the material as a kind of press moulding material, pressed into a silicone mould, something like that. But I can see that now that probably couldn’t work.

AB: I mean, I guess I wanted you to be involved in this project because of this relationship with technology, which is quite different and this willingness you have to use things in a different way from what they were originally intended. But I guess I say this material as more of a final object material, I was particularly thinking of the RP seats that you did, and I was kind of thinking that that might be a direction.

TJ: Yes, I would certainly think about that,

AB: That’s just, I mean without me, phoning you up and telling you, by the way, do it like this, that was one of the things that I thought you might use it for.

TJ: I think it could work very well in that aspect, because ceramics becomes tricky when you go up in scale, and all the issues revolving around drying and cracking, and if you can have a material that you can cast and use without having those problems, but unless I am going to glaze it I would probably use concrete. I mean it needs a bit of thought to find the exact application for it. But it certainly expands the range of materials I have in my head. I am pretty sure I will be using refractory concrete in the future.

AB: but maybe not this one?

TJ: Yes, maybe not this one, but further on cause the possibilities of firing it and putting on a glaze and taking the seats as an example you are talking public outside seating which you can glaze and this gives a much better surface, you know you have to seal a concrete surface, to make it not get dirty.

AB: yes to stop the porosity.

TJ: yes porous, it could be potentially interesting for this.

AB: Ok, great, I think that is us pretty much done there. Thank you.

TJ: Ok great, thanks

27:01

Sandor Kecskemeti Interview Transcript

9th October 2007

Alasdair Bremner: AB
Sandor Kecskemeti: TJ

This is not a verbatim Transcript.

AB: Before we start, I must first tell you. This interview is purely about trying to understand the processes you have followed while you have been doing the case study. And establish your response to the material as an artistic material and so perhaps establish what are, in your opinion the opportunities for it.

There are no right or wrong answers to any of the questions; in order for the interview to be valid it is important that you answer the questions as honestly as possible. There is no pre-conceived idea of what is a positive or negative experience.

I have some questions

SK: I used this Styrofoam, this plastic material, its absolutely OK…you can put in the oven.

1.19

AB: So you where firing the foam, or removing it first?

SK: No, you can, of course for nature its not so good but it's nothing really. If you are casting so big things then, but small things then it's small thing for to worry about?

AB: So could you give a brief outline of what it is that you did with the material, could you just say what you did? Try to be as brief…. or as short as possible. I have your notes here if they can help.

SK: Ahh… My biggest problem, I write it for you… the biggest problem was the size, because the mixing of this material. This is the biggest problem. If you are mixing with very small cup. You know. I know I mixed with your advice. I did this, I don't know 4%, 2% water this is impossible. If there is [Machine] then its mix then after this material is open then you can be. If you can use a factory then your thinking is different.

At home I have 25kg of this material, if I mix this material one or maybe I mix 10 times.

4.06

AB: Yes, mixing 25 kg is very difficult by hand.

SK: Yes
AB: Yes

SK: I was very interested to see what I can be doing, but my firing possibilities are not so bigger.

AB: Of course, yes.

5.28

SK: I am not really, I make ceramic here at the studio in Kecskemet, but in Germany I have possibilities to do the burning but in the little size. My experiment was, the thing with my experiment was. Very…. rough, or very brutal, very aggressive. Working with the material, with the water with the mixing and with the firing too. I fired to the end…. And nothing happened!

AB: yes that is one of the properties that the material is designed to have!

SK: you know my kiln was, from the outside was so very white, good and on the inside the material is then after nothing happened. Then after I put it out, I put it in the water (inaudible) every time it's the same, nothing happened. The new ones that I writed for you it was with the gas flame, I writed for you.

AB: yes I have your notes here if they can help, I have had them translated.

7.00

SK: Yes, here I write here it was before 25 years one experiment, it's the same idea.

AB: yes you mentioned these experiments in your notes, but I couldn't find any information on these experiments, did you manage to find any information about that, I couldn't find it, I mean written information. I mean I think that in the past this material has been used, but I couldn't find any real written documentation. And that in as sense is the reason for this project. And I think you touched upon a point that I think is important, and that is its not really suitable for small objects but it's in the making of really large objects that maybe where its possibilities are… ?

SK yes, its possible but these factories, these days every factory is closed.

AB: sure

SK its privatization, it's sold and nobody is thinking about from these things.

AB: yes it's a problem.

SK: I remember its very big panels. Maybe 2 metres, by one metre. [SK draws illustration] maybe 5cm and then there is casting. And here is coming gas flames. Very high temperature. And the surface is like… I send for you.

AB: yes I have some of the pictures that you took during your experiments, I have some of them here if it can help.

SK: yes here I am talking about this.[refers to image of glazed and pitted surface of refractory] this was with the gas flame. This material can take the high shock.

AB: the thermal shock.

SK: yes the thermal shock.

SK: so here, [SK draws illustration] this is melting here, so the surface melts here, this makes very important, you know in the ceramic.

AB: Yes, sure

SK: This means that the glaze is going into the body. And this is doing here the same

AB: yes

SK: And this is giving the very solid surface, and you can influence this with different kinds of oxide or glass or glazing. This is giving the same… thermal moving. If you fid this special glaze or oxide this moving with this material is not broken. Never. In this industrial in the big big flats is possible to doing.

AB: And this was a company that was doing this commercially?

SK: This was 30 years ago, you know my professor, he died maybe 20 years ago. And he was very interested in this concretes work.

AB: I mean the idea of the project is to see if it can be used to talk away from industrial application.

SK: it was for industrial.

AB: yes but I think this material can be used for things away from industrial application, so the objective of the project is to see how it can be used for different projects …. for more free art or for sculpture for ceramics for furniture, whatever. So I want to see how it can be used for different things. Large scale work but not industrial use.

SK: It was the planning, or schedule for industrial use. It was absolutely design. He wants to build, you know on the building, on the surface front, on the front everything to build with these big plates. And then after [inaudible]

12.57

AB: so it never really took of, I mean it wasn't used?

SK: Yes it did not happening.

AB: ok

SK: [refers to images of case study] so this is a normal glaze, it was only the test. This is with the cobalt chloride, this is with the [inaudible] I this is good, then you have the red or brown.

AB: yes it gives some interesting effects.

SK [refers to images of case study] This is with the flame, the gas flame.

AB: ah yes with the hand held burner

SK: This is very beautiful, I casted this whole.

AB: whole, do you mean solid?

SK: no not full, hollow, this is very thin, very thin wall

AB: ah ok.

SK: I took to the Raku, absolutely ok! You can put it out, you can put it back again. Nothing happened.

AB: yes sure its good no?

SK: yes its absolutely ok!

SK: and here I started to polishing, is going well.

SK: [refers to images of case study] and this is the raku, reduction. But. It is interesting, very very interesting. It is very very black.

AB: yes

SK: I am putting in my garden, maybe….staying half year, and the colour is not change. But maybe in this material is iron?

AB: yes so this material is the white one… the eh.. Jon Flo material?

SK: yes this one, this is the same material [refers to images of case study]

AB: ah so this [refers to Jon Flo 90]. Ah, but this one has maybe very small amounts of iron. It should be small.

SK: Yes, but this is not the smoke, the smoke is not. The smoke colours nothing. The reduction, here if I put the piece, maybe 900 degrees to the reduction space, this is a very simple top with the wood planes [sawdust]. Then this takes the O two.

AB: the oxygen?

SK: the oxygen, and this takes this material out and the best reduction is from the F E

AB: Yes, from the Iron, sure.

SK: From the iron is coming two is FEO the two is never more. This is having the iron.

AB: I am not sure, but I think it is having the very low iron, I can check.

SK: Ah yes, but it is having the iron,

SK: [refers to images of case study]I have no thermometer, but I think I went so to 1380 or 1400.

AB: Ok

SK: So I was the full power with the gas. And, no nothing [gestures action of moving or warping].

AB: Yes it has a temperature 1600 a maximum of 1600.

SK: Ah, ok

AB: So its not moving at this temperature

17:05

[break]

19:34

AB: So can I ask, did you have any knowledge of refractory concrete before?

SK: No never, well, when I was building for my father, the house.

AB: Ok so, ordinary concrete but not this material type?

SK: no, never.

AB: So did you do any searching or research on the material before you started, did you only use the information I gave you?

SK: No

AB: But you were aware of this other project, yes?

SK: Eh, yes, but I am working in the home, I am not having this industrial possibility, but I am very open. I must be thinking from one material, what is your question. If I am working with the clay, I have one question from this material. I am not ceramic artist, I am just artist. So…

SK: If I am working with the ceramic, the ceramic is unbelievable nice material because if I put my finger in the material this is my question, if I put out then answer is the next minutes the next seconds, I can see. This material the ceramic clay is the one material in the world that gives the very fast answer to the question. If you are working with the stone you can put your finger in the stone and nothing. No answer.

AB: Sure, I understand.

SK: The casting material of course you must be thinking of something completely different. I had some idea with the concrete that I heard, you can be blowing, or you can casting. But, modelling, nothing!

AB: Yes, very difficult to work with in the same way as clay.

SK: You can use this material, but your thinking, your concept must be organised for one way, ok, I have the two or one or the two possibilities to be working with this material, and then you must build your concept for this material and then after you can ask this material and you have the answer.

AB: Sure

SK: In the small size, I think I not want working with this material.

AB: No

SK: But if I have this big wall, this big

AB: Large commission, or public project

SK; Large public space, what I can think about, ok, this material can give me one answer for my meaning. Then I'm open

AB: Yes

SK; the most I am thinking, I think the 2D has the most possibility. Because you have more possibility. Because if you have the 3D work then you must build construction, you have many, many technical problems, and the firing too.

AB: yes I suppose if you are only making one off piece, then it's a lot of energy invested in a mould that is used once.

SK: Yes, I think this material is for the applied artist is most ok, not the fine artist.

AB: So you would think its most applicable for applied artists.

SK; Yes, for example for the façade and for the front of the building.

AB: For tiles and….

SK: Yes or for the floor… it's good.

AB: This is what I am using the material, this is my intention…

SK: You can, with this material, for example, in the kiln or this firing space, I put the oxide and the glaze. I can put everything on the surface, and no problems.

AB: Yes fired together and no problems

SK: Yes, no problems.

SK: I had much more new idea, if you have a very large box cast and you can today cut with the water.

AB: Yes we tried this with the water jet too, but it is not so good. And you have the not clean cut. The problem is the aggregate or the stones are harder than the body and so the water cuts around the stones and you get a kind of lace effect.

SK: So you can cut 3 cm

AB: We tried 1, 2 and 5cm and none worked very well.

SK: Ok, so no.

SK: But we are thinking of the big mural, you can think about the big size with this material. For example if you are using the big sheet and then using the flame on the surface you can work spontaneous. With many different colours, you can change the colour.

SK: You know many years I started to work with this gas flame, I am finding this technique that you see. And, you know i am coming with the copper and I am getting the many colours, you know the spectrum. I worked with this very much and you can be doing the same here.

AB: Ah ok, so you can use the same technique on this material, but on very large pieces?

SK: Yes, it is so easy, so if I am casting one very big plate and putting in the channel oven.

AB: tunnel kiln?

SK: Yes the tunnel kiln, can be fired to 1200, then after I am the artist and I have this big place.

AB: A canvas?

SK: Yes, then everything is pre-paired for the montage, then after I have one tool, very simple tools, the gas flame, here the burner.

AB: Ah ok

SK: So this flame is coming 2000c I can give to the surface 1600.

AB: Sure

SK: So I can work on this surface with the glaze, the oxide, I am absolutely free.

AB: Yes

SK Or if the surface is not flat, then is the same, this is very primitive what I did for you here.

AB: No, not at all. This case study was only intended to let you see the possibilities. I never intended for you to make a mural from 25kg! but it is to make you think, maybe what can I do.

SK: True.

SK: Absolutely, with this you can do everything, you build here one 3D sculpture, you must now think what kind of form, you must build the form from gypsum, (plaster) then you are making a mould and split the form into many parts. Then you put it together, you can connect every part.

30:37

AB: And the material is not moving so no problem with them fitting together.

SK: Maybe you can find me one very big public sculpture then I can…

AB: Yes of course I can find a large commission then give the job to you. (laughs)

SK: (laughs)

AB: Or maybe I keep it for myself, no (laughs)

SK: (laughs) Yes this is all round the world, is big business not.

AB: Indeed

SK: But it is possible,

AB: Yes it would be very interesting.

SK: And if you find a good factory, of course I am not so young artist but I have much experience behind me. Maybe:

AB: Of course, it could be a possibility. I mean the possibilities for large work is very good.

SK: Very, very simple things, very good.

AB: I do have some contact with companies, and they have no big ideas. When I first started this project, 2 years ago I was visiting these factories and they have all around the place these huge pieces that are really sculptures, I mean 3 tons pieces and they are sculptures they have beautiful forms. But the people in the factory they are just not interested in them. To them they are just a block for a job in a furnace. But you could take them and put them in a gallery and they are art!

SK: Hmm, yes you know you can cast the very big monoliths.

AB: Yes they do I mean the factories cast very big objects around 2 tons.

SK: For where?

AB: For furnaces, for the steel industry.

SK: I have a very good idea, you must. We will be working from this, I want to see the factories forms and from the factories forms we can make the colour on the surface. And we build from these industrial forms.

AB: Yes, construct from the pieces, join them.

SK: Something, so very sculpture, big ones. You know why. I worked very long time ago in the very big concrete, not concrete, chamotte…. You know… this chamotte.

AB: Yes grog, ground fired clay.

SK: Yes this was a factory in Budapest, but this factory is no more, but it was very interesting because this factory made furniture for the kilns. Very big forms and tiles for the casting industry.

AB: Ok

SK: So after I started to work in this factory, they would put the chamotte and the clay in this large forms with the wood form with a big hammer, and it was solid. And so I was thinking about. My god, if it is going in kiln. If made my sculptures why are they hollow, because we learnt in the school that it must be thin. But with this material I can be making solid.

AB: So this is where you first started to make large objects solid and not hollowed?

SK: Yes here I started to work solid, with the porcelain, with all the materials, because it was possible.

AB: So with the slow firing though?

SK: No to 1300.

AB: Yes, but slow firing, so slow.

SK: No fast, like normal.

AB: Ok, but these are the thinks that you are taught in school are not always the only way to do things.

SK: I give you this advice, you must be starting to work with these factory forms, this is a big possibilities.

AB: And just work on the surface of these forms?

SK: Yes because this industrial form is most interesting, this high tech material is very interesting. But you can be spontaneous with the surface. Very interesting.

AB: Yes this could be a very interesting route.

SK: I am very interested in working with this high tech. because with the stone there is many many opportunities now for the working with high tech.

AB: Yes?

SK: Yes with the cutting things and some stones with this very much iron you can cut with this magnetic tool.

AB: Ahh very interesting, I have not heard about this technique before.

SK: Yes this is very new.

42:23

AB: Can I ask, do you feel that you have tried to use this material in the same way as you normally work, in clay or in stone or…..?

SK: I understand, no I think no, I wanted to casting of course. And then I find this Styrofoam, and this was giving me the way, the simplest and the fastest. So it is very different.

AB: Ok, so do you think that the results of your experiments are similar to your other work. The forms are certainly similar, but about the surface, were you satisfied with the surface?

SK: No, I am sorry, but I did not have the time that I wanted to do this. Of course it was not a money question but a time question. But I have the half the material left, maybe, maybe next spring I can start to do something for me. Because this is not shrinking. Does not shrink then after of course my meaning is going much wide because I am thinking where can I use this material? If I build big ceramic piece and I have crack then I can put this in, its absolutely ok, *helf* material

AB: Help material?

SK: Yes, help material.

AB: For repairs?

SK: Yes I can make and sell this to ceramic artists, I can make good money with this, absolutely good material, I tested this.

AB: Yes, we used this material as a glue to stick two fired pieces together and fired in a salt kiln.

SK: You see nothing happened, very good material. So you can thinking 10 places to use this material. But in the big pieces, this is the question!

AB: So have the materials properties given you the opportunity to do things that you hadn’t thought possible with ceramics?

SK: I understand, this is only the concept question, for example if I had, somebody come to me that wanted from this material the big sculpture, of course I must change my meaning, I must build the concept, it is without firing this material is normal concrete without firing it is functional, you can paining, everything. This material you must fire and this is very expensive. Then I must be thinking about this material is so *edel* so *edel* [coarse]? The quality of the material, maybe stone or…..

AB: More suitable material ?

SK: I think so, you know the mix material one stone is 2 million 10 million years is not the same the quality is different. I am asking what I can doing with this. This material is expensive.

AB: Yes, there has to be a reason to use this material.

SK: Yes, why?

AB: I think you touched on it, and it is this ability to colour the material to work on the surface.

SK: Yes but you can work with the face on the granite too and the basalt, you have the same effect.

AB: Yes, but I guess you don't have the same ceramic glaze effect with granite.

SK: Yes but what will be if you have this form and on the surface you put the different granite or the basalt, and you can have the nicest surface with the flame.

AB: Yes this is an interesting possibility, always too many possibilities.

SK: Ahh, yes this is always the problem.

AB: Ok so, what would you describe as being the advantages of this material.

SK: What is this advantage?

AB: What are the good things?

SK: Ok, the not shrink, I think it is frozen ok. I put it into the Frigidaire. I tested, change not the colour.

AB: Yes, we have done tests too and it was fine in 150 cycles to -50.

SK so it is absolutely ok, what was the temperature fired?

AB: to 1200

SK: Its not so high, its ok.

AB: Yes, but it was fine and came with the highest rating in the test.

SK: And in the cold countries for example this material is absolutely good. For the fountains, you know it never frozen. This is good.

AB: Yes this is great possibility.

SK: You know in the art and design possibilities you can do everything, thi is different question. I mean in your diploma, you must find where can I use this. We were just now in the very important point because this is not freezing, in the different countries France, Germany, Hungary everywhere, in the wintertime every fountain is covered.

AB: Yes wrapped in plastic.

SK: This you can leave, and you can let the ice over it because nothing can happen.

AB: Yes this could be amazing with the water on the fountain, making another sculpture, a natural sculpture.

SK: This could be a great possibility.

AB: Yes, and with the glaze it is even safer.

SK: Yes, in these tests I did just this little glaze, But my idea, I am not interested for the glaze. Because when I arrived at this material then came this old idea with the flame.

AB: Ok

SK: I mean the material must self build and give the surface

AB: I see

SK I don’t like the glaze, you know the glaze is like the clothes, and its not organic with the body and the form. I want to find this organic.

AB: So you want to see the surface come from the body.

SK: Yes coming from the material. And you know if you put the glaze, and put in the kiln, then melts, but what, maybe its ok, maybe not. But if you can think about what you can mix in the material to give the glaze. Because the glaze is a very complicated thing. You see if it is frozen then here it is ok but the water is getting here to the body and after up comes the glaze [referring to sheering of the glaze in freeze thaw conditions].

AB: This was one of the things we tested with the glaze and exposed body. And it was ok, no problems.

SK: I am not sure.

AB: Well the whole idea of doing these case studies was to see other points of view that was the intention. To see peoples feelings about this material.

SK: Ok

AB: So, can you tell me what are the disadvantages of the material, I mean what are the bad things about it in your opinion?

SK: The mixing

AB: Ah yes the mixing by hand is difficult.

SK: Yes this is bad.

AB: And was this the only disadvantage?

SK: Yes, I think so. You need machines and if you have them, then….. you can write it in you diploma. I think I would like to use this material, I think in 1 metre 2 metres big sculpture then my biggest problem is the mixing, I need the special mixing.

AB: Yes you need to have mixer.

SK: Yes but the normal concrete mixer does not work, with this very small amount of water, its impossible.

AB: No you do need a high intensity mixer to do the job, normal is not good.

SK: This small amount of water is crazy, impossible.

AB: No, its not impossible, just difficult, or hard and takes maybe 30 minutes.

SK: No please, if I have the time now I take you and you do, 1 kg and you see.

AB: I know, I know, I have spent a long time mixing this material, and I know how hard it is!

SK: Ok, but after the firing it makes no difference. With many more water than you said is fine, it was fixed and hard.

AB: Yes it can be ok for small objects to have this much water but if you are making very large objects, you need to have the 4.5% water to have the strength.

SK: Yes ok, but this is different, in the small size this is the biggest problem, but if you have a mixer, it’s ok.

AB: I think you have already answered this next question, but can you think of any project that you might use this material. Would you use it again if you had a mixer.

SK: Yes,

AB: Yes?

SK: Yes, I think, because for relief and the tiles for the architectural, then this could be good.

AB: Ok, so for architectural work, but not for sculptural work?

SK: It is for sculpture too, but for flat work not for 3D work.

AB: And why would you not use it for 3D work?

SK: If I have a big commission, the maybe after I am thinking about it.

AB: So it would depend on the project?

SK: Yes, but I am thinking if I have this material at home and I have this architectural work then I can use it for these really exact forms, where can I build before the casting forms and I must produce 5 or 10 pieces then I will use this, because it is more easier than clay.

AB: Yes, easier, but why?

SK: Yes, because there is no Riskant [Risk]

AB: No risk?

SK: Yes no risk, this is very important.

AB: An advantage?

SK: Yes, because you have no crack, no nothing, nothing happened!

AB: Yes, of course.

SK: And you can wait one day, two days and the you can put it in the kiln.

AB: Yes straight into the kiln, no waiting.

SK: I am sorry, I forget, but last week I fired the very high temperature porcelain kiln I Kecskemet, I did not put one piece in… next time sometime.

AB: Yes, that would be interesting to see.

SK: Yes I am very interested to see the 1380 with the cobalt chloride, this must be very beautiful!

AB: Yes, I think that would be very interesting. the possibilities.

SK: You must, I thin it could be good in one year, two years to do something with this, in the factory, you must organise.

AB: Yes, I agree what would be good would be to run a small symposium in a factory or in the studio.

AB: So the final question is: would you say that the case study has been a positive or a negative experience.

SK: Absolutely positive, and I wish this material for the young people too.

AB: Yes?

SK: You, must be working maybe… maybe, my thinking is not so progressive, or not so new but maybe from the young artist you can open one window.

AB: Yes this is I guess the whole idea of this project.

SK: Yes, this is absolutely important.

AB: So, I think that we have covered everything, in a round about way, I guess, but do you think you have anything else to add?

SK: No I think that this is everything,

AB: Ok, good, thank you.

SK: If you need anything more from me then……

AB: Yes and if you find any information about this 30 year ago project.

SK: I am open to everything, I am interested in every material but I am busy, but….

AB: Yes I know this was why I hoped that you could do this.

SK: I go back, to this, my concept I must find for every material, one language. And this material needs one language, and it was a very very short time. And there was not enough time to think about this.

AB: Yes, I understand, but it was felt that the less time would give you a chance to focus and not have the project run away, and,…… go on for a long time.

END

102:00

Geoff Mann interview transcript

30 August 2007

Alasdair Bremner: AB
Geoff Mann: GM

This is not a verbatim transcript

AB: This is the case study. First of all the objectives for this interview are to understand the processes being followed by conducting the case study, to establish your response to refractory concrete as a material, and to understand what, in your opinion, are the creative opportunities for refractory concrete. There is no right or wrong answer to any of the questions posed but it is important for the case study that you answer all questions honestly. There are no preconceived ideas of what is a positive or negative experience.

First of all just a brief overview of the experiments, so you can sum up what you would describe you did.

GM: I was looking at how thin I could cast the concrete with different extremities. So at one point, with an object I was using, we'd see how the 1 millimetre thickness...but in the same form it would have four or five inches. The concrete would have to be similar to how you cast glass. It was very difficult to do that. I was casting very small objects, because if it works on small objects it will work on large ones. Casting into silicon, a silicon mould, the same one I cast glass into. Because I was interested in having this comparison between materials. I used different concretes...

AB: The first one was Greentech.

GM: Yes. I had never cast concrete in my life before. I was talking to people and trying to understand it because it is a weird material in my mind. I liked that. It was a brand new experience. I was trying to do [INAUDIBLE] with plaster, and that doesn't happen. A lot of experiments were trying to figure out how concrete flows, how you mix it, and getting a decent material quality. The first one was interesting and did work, but I had a preconceived aesthetic I was looking for. I was very interested in the smooth forms. Concrete has a really negative stereotype of what it is used for: why can't it have a luxurious feel to it? You get it on concrete floors. So I was trying to get that, but it was too bitty. It was like a grog - too much stone in it.

2:55

The second one was a pain in the arse. It was not a hand-mixable material.

AB: Right, this gives us an idea of what you do. With the images we'll be able to see. Could you give an estimate of the time you spent on the case study, if that's possible?

GM: About three and a half weeks, of thinking, doing, making mistakes...

AB: Okay. Could you describe what knowledge of refractory concrete, specifically, as opposed to ordinary concrete, you had before embarking on the project?

GM: Absolutely none. I'll be honest about it. I thought concrete is concrete.

AB: Did you conduct any additional research about refractory concrete, or refractories and concretes, before commencing the study?

GM: I did. When we started using the first concrete, I couldn't get the thing to flow. It was nothing. So I contacted a company which I will tell you about, and they sent me this agent to drop in. It wasn't a good thing to use at all. I also contacted a builder friend who said to use plasticiser liquid and all these different things to put into it. And none of them work. I kept on trying to push concrete...

AB: This was advice given by professionals?

GM: Yes. A professional as a concrete manufacturer, who also had some knowledge for refractory, and the second one was from a builder.

4:55

AB: So you did set but you didn't...

GM: No. I only did enough research for what I was trying to do with the concrete, because at the end of the day I was trying to make concrete another material I had [INAUDIBLE] with, but concrete isn't that so why should I do that?

AB: You mentioned the preconceptions you had about the concrete. Could you describe the preconceptions you had about the material, from the literature I provided for you? Did you get an idea of anything that was...

GM: It was daunting from the literature you gave me, because I don't do scientific numbers. I don't do reissues. With plaster, your thumb is an inch. You can measure the water. You can plaster a peach in water. Concrete doesn't work that way. So that was quite daunting. It took two or three days realising in my head, that I was going to make a mistake. And also being sacrificial at the same time. The first couple things I did just crumbled. It was quite demoralising. It was really trial and error. When science is involved, and you are given stringent guidelines, it's just getting your mind around it.

AB: Would you say the instructions you were given hindered...

GM: It didn't hinder the process; it was more of a mental thing, coming from an area where I do use a lot of maths with a computer, where I don't physically do it myself.

6:55

AB: So I guess the next question is, if you had any preconceptions, were they proven right or wrong?

GM: Not at all...

AB: The first question is, what did you think the material could do?

GM: I wasn't sure. I thought concrete was concrete. I had worked with concrete once before but not directly. I worked with snowcrete, which works differently. It's almost just like a liquid you pour and it's very easy to use. Refractory concrete works differently, and I didn't really know what to expect from it.

AB: Can you give a description of the material properties as you've experienced them - how it behaved for you? I know the first one wasn't that successful for you, but can you give a description of how you experienced it?

GM: I would describe them both the same way. The first one was more of a stoney mixture or material. I understood that if I was going to cast this...I agitated it with this mixing thing I made...I knew it would create a stoney surface. I knew that already. The other one is a finer powder, which I new from experience, because it was silicon mould, would make a nice plasticy shiny finish.

8:55

But it got to the point where it didn't matter what happened because I was more interested in the process of mixing. What was weird is that with both materials, you don't use the water to actual material, to refractory concrete mix, is hardly anything. It's phenomenal. I was watching time happen and seeing this chemical reaction. It got to the stage where I was more interested in doing that. I just mixed it and didn't pour it into anything because I wanted to watch this thing happen.

That got my attention more with both materials, especially the second one, because that was a magic fast thing.

AB: It kind of goes plastic as it sets. Did you feel you tried to use the material in the same was as your normal working practice? Did you adapt the material to fit with that?

GM: I knew I was trying to make a variation of this bird form using refractory concrete, because this form had many different levels and thicknesses of material. But as the stage went on I cared less about the actual form and more about the surface finish and with the sander agitating on all sides, how one side what the other side would do. So I was more interested in the process from it. I started with the preconception and intention of what I was doing, and that withered away as my knowledge of the material became stronger.

10:55

AB: So you mentioned the thicknesses and thinnesses, being able to have thin alongside very thick sections...that follows on with your work with glass and so on, so that was the main thing?

GM: That was the main thing. The biggest thing which I could never do because of lack of money, time and facilities, was looking for an outdoor piece I could create and put, maybe not in the public sector because it could be snapped, but somewhere outside. I knew glass and ceramic. I know in ceramic it would be very difficult, and in glass it would not be cost effective. Bronze was a possibility but even that is very costly. Concrete was a possibility because I had seen it used outside, and it was quite successful, but I was unsure if it would work. So the main reason of doing this was to up scale everything.

The only negative I had with the concrete as well is that the process I use was probably quite primitive, but because it doesn't flow naturally, you have to agitate it and push it down and compact it.

AB: This was the second one?

GM: Yes, but even in the first one, you have to compact it into the edges. That would be very different if I was doing a two-metre mould, or had twisted it. This was also something I was interested in, knowing what would happen if I didn't do it at all, and it would come back to the surface texture.

AB: That goes back to the scale of technology, and mixing technology by hand is very different.

12:55

The properties of the material when mixed mechanically give a far more fluid...

GM: You could agitate it on a very large scale, which would make it compact. Do you compress it as well?

AB: You could use vibrating technology like a vibrating sander.

GM: Could you put it in a vacuum chamber and take out all the air from the water? Would that compress it harder?

AB: You need the water in there in order for it to set. You wouldn't be able to vacuum cast. You have to have the water in there for it to set. Certainly when they cast large objects over several tonnes in industry, that's done with vibrating pokers, or on a vibrating surface, and it's a very regulated frequency in order to make sure there is no separation of the aggregates and matrix. These are things that would come out when you applied it on a larger scale, from tabletop stuff to monumental... So do you think the results of the experiments are similar to your other work? The forms are obviously the same...

GM: The forms are the same but the approach would be different. It's just an interest in the material.

AB: Is the surface quality what you expected?

GM: I think it's not as good as I expected, but that goes back to me hand mixing it. If it had not been hand mixed, on a large scale, it would have been an absolute sweet finish. If I'd have fired it as well, it would definitely have been what I expected.
15:00

In that case, I'm glad I didn't do it because I don't like doing something for which I know the end result; there is no point.

AB: Have the refractory concrete properties given you the opportunity to do things that you had not previously considered?

GM: That is to do with the scale issue. More research has to be done involved in how large you can take the piece out, how secure, how strong can it be, the inside of it being cast, perhaps a skeleton membrane, a skeleton inside of it to strengthen it as well.

All different things have to be researched.

AB: In your opinion, you would say that the possibilities it would open up is more to do with scale, as opposed to its properties on a smaller scale?

16:00

GM: For me, that was my intention. My intention was to try to up scale my work to the point that it did equal realistic realism.

AB: But you would need more research in order to...

GM: Yes, more research has to be connected directly with industry. With certain materials, you have to put your hands up and say 'I can't do this on my own anymore' when it gets to a certain point.

AB: That's kind of obvious. Could you describe what you perceive to be the advantages of the material you were provided with? You had two so we can take them one at a time. The first material was Greentech 90, or 170.

GM: The advantages: it's very malleable. I could put it anywhere I wanted to, and there was a long setting time which was quite interesting.
17:00

Though it's not meant to be, it's quite a hands-on material as well.

AB: And what advantage do you think a long setting time would have?

GM: For me, making sure you get it into all the crevices in the mould. If it's a short setting time, you're screwed. The second one, though it had a long setting time, there was almost a peak time, which was perfect to put it in the mould, then after that it got hardened too much. Before that, there was not much moisture in the mix. So I suppose it had a peak time, but once you learnt it, it would be quite good.

The advantage was that it was very, very strong; you could release it from the mould with no releasa agent obviously. It could come out of all the crevices without popping it off. That's a big advantage. You can't do that with wax; it will move. So that was a very good thing for me to use.

18:00

AB: So is this the quality in terms of the strength, or even the very thin sections?

GM: Yes, in terms of the green strength. Even when it gets to that thickness, if you use a architectural plaster which is very hard, it's still very fragile at certain points, thin is thin at the end of the day, but this had a very strong integrity to it.

AB: Following on from that, what would you perceive to be the main disadvantages of the material, or both materials, starting with the first one?

GM: The first one was the quality of the mix itself. It was very interesting but coming off a silicon mould, it defeated the purpose of the silicon mould in the first place. That was the main disadvantage to me. The disadvantage for the second one was the mixing time.

18:59

The amount of effort you put in for a very small amount. It's not a hand mixing material at all, but it's very interesting because I now know more about that material than if I put it in a mixer. In a mixer, you wouldn't know when it was going to set, and you would not get the touch and feel of it. And I got that with the second one.

AB: So you mean with the second one you had to know how long...

GM: Yes, it was more responsive. In the first one, it was, chuck it in, mix it around, that's good. The second one - it controls you. It was more of a patience game between you and the material, which was quite nice. [INAUDIBLE]

AB: The mixing for you was the only disadvantage?

19:55

GM: Only because of scale. If I started making larger pieces and twisting to shape, there probably would be other disadvantages arising perhaps: getting agitators, getting these poker things into the right crevices as well. It pulled away from the sides of the silicon mould quite a lot, which was quite annoying.

AB: You mean the cast...when you were taking it out of the mould, it wasn't...

GM: It wasn't as tight as I wanted it. There was a shrinkage.

AB: A shrinkage on the Jon Flo (?) ?

GM: Yes. Very minimal. It was probably due to the process of me putting it in more than anything else. But that kind of helped, so you could de-mould it in sections. If it was too tight in, I think it would have snapped, but it kind of worked.

AB: I'm surprised you found any shrinkage. Can I ask a technical question? How much were you following the percentage of water, or did you add in because of the difficulty of mixing?

21:03

GM: No, I kept it quite... The first one, when I first used it, an hour was gone and I was still mixing, and nothing, and then in about five minutes it became very fluid. But with the second one, I understood now, it took an hour. On the sheet I was informed it could take up to 45 or 50 minutes, and I thought, rubbish, that's not going to happen. And it did. So the second time I actually stuck to it, and it was to the percentage of what was covering it, maybe even less. I was very interested in creating quite a strong mix.

AB: We already covered it, but what was the most important advantage and the most important disadvantage in your opinion? I know we've already covered it but could you confirm for the record?

21:59

GM: The most important advantage was the strength. The most important disadvantage was the mixing time. That's for the second one - the one I would use.

AB: So the first one isn't something you would use?

GM: The disadvantage would be the surface texture but the advantage would be the quick mixing time.

AB: Excellent. Would you use the material again in the future for any project, or could you see any project in the future that might be a possible application for this material?

GM: Unsure. The application I intended to use this for, yes, I would look into it. When I first was approached for the project, this material wouldn't have been right for it. It's the wrong type of material completely.

22:55

AB: So what you ended up doing is different from what you intended in the first place?

GM: Yes, I first intended to look at large slabs and tiles, that would replace existing concrete slabs. This didn't really lend itself to what I was using it for. So I was interested in just the most challenging material, what it was... That, to me, seemed an easier cop out of using the material. So I literally used the same method of challenging the material as I had previously done with glass and ceramics, using a very difficult mould to get something out of it. And that's the reason why I turned to what I was using.

AB: So you felt the concrete would have done that job, but it wouldn't have challenged it?

GM: It would not have made any sense for me to do it, because I knew it would work, because it was concrete, so I didn't see the point of doing it.

AB: So you feel it could do that job?

GM: Very easily. All that would be doing is changing the form and the surface texture, so I didn't see the point.

AB: Would you say the case study has been a positive or negative experience? Could you explain why, if it's been either?

24:20

GM: It's been a positive experience because it's another material, although in my practice, I don't really stick to one specific material. I try to mix it round. The material doesn't control me; I control the material to what I use.

Concrete does require specific tools to be used. It's a very difficult thing to do, especially when you can't be sitting in a corner making a grinding noise all the time. It does require specific facilities, which is fair enough. Everything does.

I would use it again. It's not a bad thing. It's opened my mind up. Going back to the first question, I thought concrete was concrete. And now I know it's not. I'm very interested to fire it. The green strength is strong. If it gets stronger when it's fired, that's when it gets interesting to me, because that's when I can understand it can hold its own weight. Things can happen from here.

AB: What would you say was the major hurdle to using it in a project? You mentioned earlier on in the interview about using it for scale.

26:00

GM: That is what I see as one of the possibilities for it - it's easy for making large stuff and the transport of that material. The weight of the material is a negative. It depends where it's going. The possibilities is that it could be coloured as well, which I don't use in my practice at all. I use white or clear. That could be interesting, the surface quality as well, for me. Polished, unpolished...there is lots of finishing that I never got the chance to do; that’s another thing it would interest me to try, just try finishing the material.

Maybe not glaze, just because, though material can be fired in glaze, I understand that. I do that with ceramics. Just because it can be done, I'd rather try and make that material, kind of being true to the material.

26:55

I would rather make that material as good as it can. You get a good understanding of what the material is. You'll see the grain, the body and what it's actually made from.

That's why I wouldn't perhaps borrow any of our discipline's processes and [INAUDIBLE].

AB: So the glazing is not something you see as an advantage or it would allow you do combine the both? That's probably a leading question, so...

GM: I don't see it as an advantage, because it's using a ceramic technique but it's glass. I would like to keep the concrete itself very pure. If you're adding colour to it, it's not pure but as you're polishing it, you're making what it's got. There is an honest material in it.

I don't see it as a disadvantage. I don't see why it shouldn't be done, but to me, if it's been glazed, why have we used concrete instead of ceramic?

28:15

Then it would go back to form. If the form is very technical, you go, 'that's why you used that'. So it's questioning why it would be there.

AB: The idea of having a very large-scale solid casting, that gives that strength of being able to transport... But you don't see combining the ceramic aesthetic, whether that's glaze or all sorts of other treatments?

GM: I'm not dismissing it, but for that form or shape I wouldn't do it. I don't do it now, so...

AB: So that's more of an aesthetic decision on your own.

29:03

GM: Perhaps it would follow what I do in glass. I would polish ends and mat the form. Because if I glaze any part of it, it would take away the point of what I was doing. It depends on what I was doing. If it was a large [INAUDIBLE] sculpture, I wouldn't do it, because it wouldn't require it, unless I glaze the ends, which is the same thing. But glazing the ends is just as good as highly polishing the ends.

AB: The next question is to do with firing, which doesn't apply to you but I'll just say: did you fire the refractory?

GM: No. I will try to persuade Lucy to do it one day.

AB: There was no glazing or surface treatment applied either. Maybe we can talk about if you had the opportunity to fire, and then surface treatment? You mentioned you wouldn't do glazing, but...

30:06

GM: I would try, as an experiment, perhaps sandblasting the ends and sides, to see how... Because once it's fired it becomes very, very strong. I wouldn't sandblast it before, because if you sandblast a path you get a lot nicer finish and texture. So perhaps depending on what the form was, sandblasting a path right into it. Then perhaps sandblasting the path and then polishing the bits of sand plaster (?), so you're kind of getting a mix of both. Etching into it, working into the material, depending on how strong it was. This is something I don't know. I don't know how responsive it is to secondary texture.

AB: Maybe if you could try it in the future, it would be good. The last thing is if there is anything else you want to add, that has not been covered in the questions.

GM: It's a very difficult material. In my mind the major hurdle was that it's concrete. That's the biggest hurdle of this whole project. It's refractory concrete. It's not just what it says on the tin. It's got this new thing. That applies to any applied art or craft: anything new coming into it automatically gets pinpointed with old parameters.

31:48

Everyone else tries to apply it with what's happened previously in other disciplines. Then concrete jumps into the thing. Is it design? Is it applied craft? Same old story. Almost any hand material gets adopted into craft, and gets the stigma of craft attached to it.

The main problem with me is that concrete in my mind is highly industrial. Industrial doesn't mean uncreative, because many beautiful buildings are created with concrete flooring, and they are amazing. I've done a little bit of research on it, not much. I'll be honest.

There is not a lot of form created out of concrete. Three dimensional objects don't exist.

AB: Why would you suppose that is?

GM: Because there has been no research into it. Concrete requires a lot of research to get into it.

AB: I would perhaps say it's because it's concrete. The idea that it's such an everyday material, and it has no preconceived idea of its own aesthetic.

33:11

GM: But in a professional sense, if I say I'm making this piece of work out of concrete, why are you not making it out of bronze? It's the perceived value of concrete - it has none. That's a very difficult thing for people who are working for themselves.

They need to understand that concrete perhaps does have a value. That value has to be found. The value comes from its context. If it's an amazing form, with pieces I've done, the glass bird is one thing, and [INAUDIBLE]. I did different forms with the same idea in that prototype. Everyone wants to see the glass piece because it's technically difficult to do. It's phenomenal forms but maybe not [INAUDIBLE].

The concrete has a preconception of being industrial, and easy to use, but it's not. It's now being used in a creative fashion.

AB: Say you wanted to make the bird form in clay. If you were to try to do that with a glaze, so it was clearly made from clay, whether slip casting or whatever. If you think about the difficulties in doing that, compared with what you might have been able to do with the concrete, perhaps? If you didn't call it 'concrete'?

35:00

GM: It would be a very interesting experiment to do that, to make a form... But the issue again is, why treat it the same as ceramics if it's not ceramics? If I created a form that could be slip cast. Those bird things can't be slip cast. You can use a press mould but they just look stupid. So that's when concrete would just become its own material, because it can flow into these things, and it has its own integral strength to get demoulded, the most important part of it.

I did a plaster version, and it cracked at certain points, so that proved that it could work.

AB: So the concrete was better than even the harder plasters.

GM: Yes, the harder plasters were brittle. Brittle when it gets to thin inches. I could see it, as long as I gave it enough time and enough agitation it would easily set and be able to remove away.

36:00

But then if you made two of the same objects, one cast, one ceramic, one concrete... I don't know the surface texture, and also the finishing... Glaze them both, why? The only difference is when you lift them, one would weigh a tonne and one wouldn't weigh a tonne. Maybe the whole issue of this isn't the material issue; it's the name.

AB: It's the fact that it's called 'concrete'?

GM: And the stigma attached to concrete. It's a completely different issue. What else would you call it?

AB: It's a name like any other name, but it has associated connotations, 'concrete'.

GM: [INAUDIBLE] in different guises.

AB: It's a valid point. I just need to think up a new name for it.

36:57

GM: Don't call it girly concrete.

AB: No. Is there nothing else?

GM: That's all I've got out of the material as of yet. It's a material that creates a lot of questions and it's an intrigue for a practitioner to work with.

AB: You mentioned that it was like, removes one section...

GM: A major plus point is that if I was doing any other process, like glass, you go from model to wax and moss (?) wax casting, to final finished piece. Bronze does the same thing. There is always this wax element. Concrete is the finished material. You're missing a phase out, which bodes well for major reasons. A major vocation (?) is financial. If you don't have to use wax, it's a bonus.

AB: Also, it would be a lot less, in terms of how your silicon mould would be less pieces than it might necessarily have to be...

GM: Not at all really, because wax has more malleability; you can move it and bend it. And concrete, you would probably want to make more pieces for concrete. So perhaps there is a negative, that you would have to... Your one mould couldn't do concrete and wax moulds. You would probably have to do them differently. At the same time, you don't know what you're using the mould for.

There are pros and cons here, but it's a massive thing if you don't have to have the wax material. Every time you make waxes, unless you make the [INAUDIBLE] every time.

38:32

AB That comes down to repeatability as well. If you were to make a number of objects...

GM: The negative point about it is the erosion that the concrete itself would get from the silicate mould. You change the type of silicate you're using [INAUDIBLE].

AB: Much harder than a compound, or even a rubber.

GM: You would have to then look at...the soft silicate works for my objects very well because of the intricacy of them. If I hardened the compound, perhaps it would snap and pull out. Perhaps where you give up the wax, you might have to give up the longevity of the mould. So there are pros and cons, but they are things you have to take into account. That's a major issue.

It's an interesting material, which has got a lot of scope for different ways, outcome, process. It works everywhere else. It's more the fusions of the materials, trying to get more fusion. The colour thing would be quite an interesting issue, if you could get a purity. I hate marble [INAUDIBLE] colour.

AB: If you fire it, it goes absolutely white, all over white. The only thing is, you get a slight oil thing, but that disappears when you polish or sand or whatever. It's just on the very surface.

GM: These are the things I'm highly interested in doing. I like white purity. But also I'd like to see a black concrete.

42:22

AB: If you were sandblasting back you could think about altering what aggregate was in it. There is obviously more than one kind. You have one kind that is hard and white, but if you were going to sandblast the pattern in, you could have an aggregate in there that would show up stronger when you sandblast. It could give it a different colour or tone or value.

GM: If you aggregate the ends differently to the polish you come up with.

AB, Yes well that is true….

[Break]

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1:00

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2:01

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3:18

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4:00

GM: If you aggregate the ends differently to the polish you come up with.

AB: I don't think there is anything else.

End of Interview