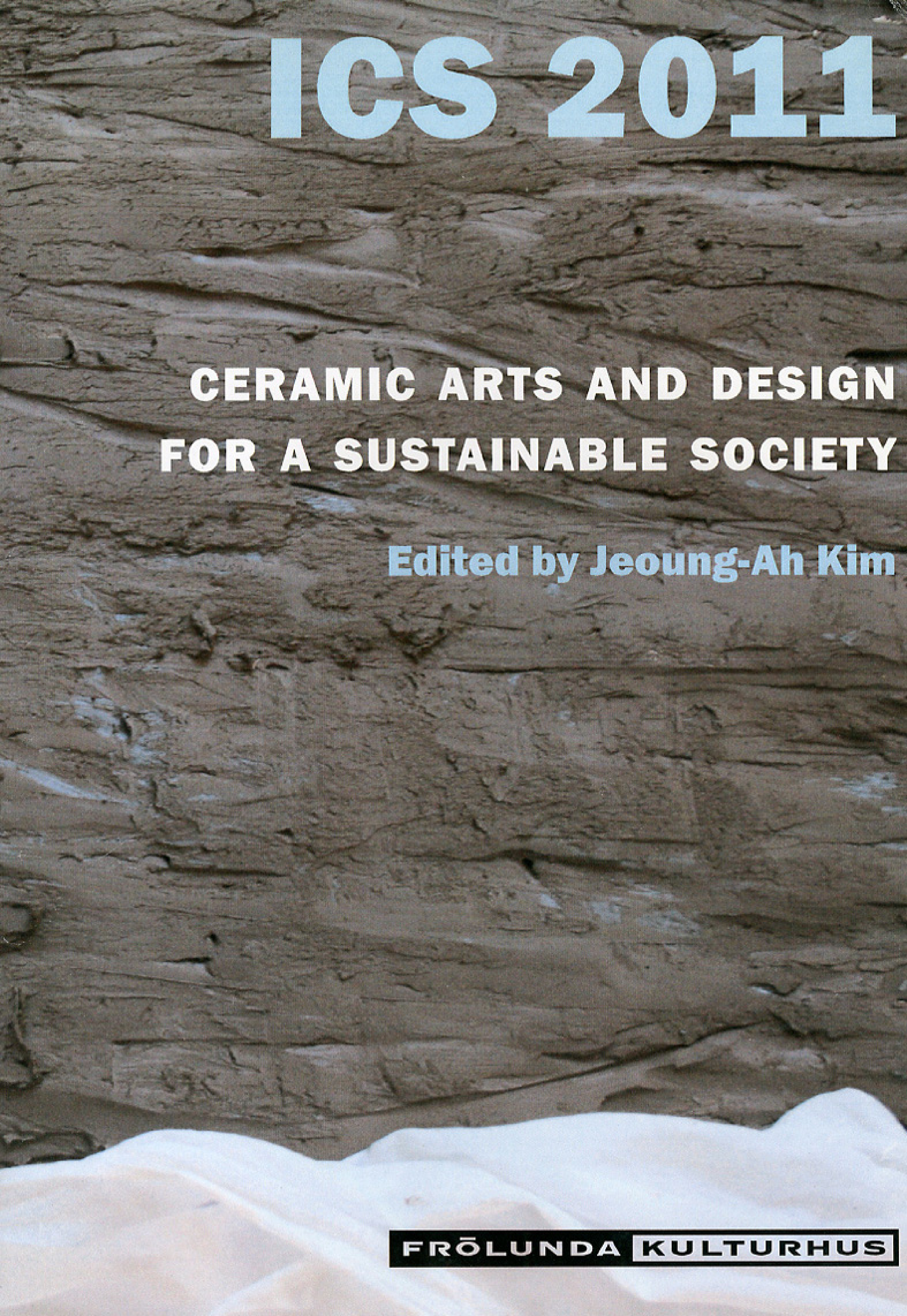


ICS 2011

CERAMIC ARTS AND DESIGN FOR A SUSTAINABLE SOCIETY

Edited by Jeoung-Ah Kim

FRÖLUNDA KULTURHUS

International Ceramics Symposium 2011

7–27 March 2011

Frölunda Culture Centre

Gothenburg, Sweden

www.ics2011.com

ISBN 978-91-633-8184-3

'WASTE & PLACE' – An Investigation of The Creative Potential of Re-cycled Glass and Ceramic Waste

David Binns

ABSTRACT

This paper outlines the development of a new ceramic-based 'Eco' material, with significant sustainable credentials. The material made through fusing recycled glass and ceramic waste, presents many new creative opportunities for artists, architects and designers.

The paper maps the background to the research, starting with the alteration of plastic clay bodies using aggregate materials, through to the introduction of recycled waste material.

The material offers in particular is a viable and sustainable alternative to traditional architectural materials such as quarried dimension stone and heavy clay products - tiles, cladding and facing bricks, together with other applications such as work-surfaces or counter tops.

In contrast to using traditional materials such as quarried clays, granite or marble, which often damages ecological habitats when extracted and contributes to global warming when transported huge distances, this material is produced from 97-100% locally sourced recycled waste. Further to its sustainability characteristics, the material is imbued with a number of unique aesthetic attributes, allowing colour and texture to be engineered to a client's specific requirements.

Materials have philosophically and historically engendered a strong association with 'place'. Traditionally, construction materials were sourced locally; not only meaning minimal energy was required to transport the materials, but also imparted a unique aesthetic character to any given location. Mineral waste sourced on-site or close by, e.g. damaged stone or masonry from demolished buildings, may form up to 50% of the aggregate within this new material, promoting a meaningful visual and philosophical connection between materiality and place, whilst also resolving embodied energy related drawbacks of imported materials.

Any waste generated within production may be directly returned into the production process, further enhancing the eco-credentials of the material.

This paper also outlines how the project started life within ceramic studio practice, developing into a structured scientific investigation; bridging the boundaries between art, science and industry.

The paper fits within the theme of the Symposium, as it outlines a research project that is driven by desire to develop a highly sustainable alternative to conventional ceramic materials - a material that is made almost entirely from recycled ceramic, glass and mineral waste materials.

Keywords: Sustainability, Architecture, Recycling, Ceramics, Glass.

INTRODUCTION

The root of this research began through the making of ceramic sculpture within a craft studio environment, over time evolving into a systematic, scientific research project, involving a defined methodology and collaboration with material scientists.

The research originated partly through accident, responding to observed phenomena, and partly a desire to say something new artistically. Over time however it became apparent that the processes being developed within the context of studio practice might have wider creative, functional and commercial possibilities, beyond the craft workshop. The paper maps this journey.

PROJECT AIMS

The project aim has been to: investigate sources of recycled glass and mineral-based, waste materials; explore how they might be combined within a kiln casting process for the development of material with unique aesthetic qualities; examine the creative potential of the material for architects, designers, artists and craft makers.

BACKGROUND TO THE RESEARCH

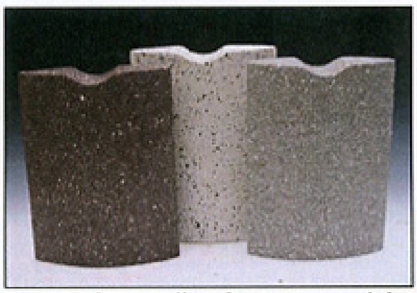
As contemporary ceramic makers have in most cases moved away from prospecting their own clay direct from the ground, they have come to expect standardised qualities in clay bodies supplied by the pottery supply industry. A vast range of clay bodies are now available, covering every possible firing temperature and making technique. Ironically however, standardisation has necessitated refining out many of the most interesting qualities found in naturally occurring clay. Impurities such as organic matter, larger granular materials and colour impurities are removed, more often than not resulting in bland clay, lacking any intrinsic visual or textural richness.

Maybe partly as a consequence of this, the aesthetic appearance and visual narrative of the majority of contemporary craft and art ceramics work relies on applied pigment or textural decoration, glaze application and/or the evidence of smoke or flame; all providing a 'skin' of visual enhancement across the surface of the work.

The fundamental principle driving this research has however been the notion that the inherent aesthetic properties of the body itself can provide the focus of visual interest, i.e. what is seen on the surface of the form extends through the entire core of the piece.

Initial investigations within the craft studio involved adding granular or 'aggregate' materials to clay bodies, with the aim of enriching the visual and textural properties of fired clay, without necessitating 'applied decorative treatment; seeking to extend the visual vocabulary of ceramic practice, (Binns 2006) [1].

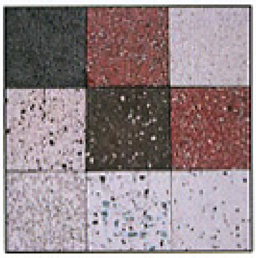
The process itself was hit upon almost by accident, refining a previously fired surface with sandpaper, revealed the fine grog / chamotte inclusions within the body, offering a contrasting 'geological quality' to architecturally inspired sculptural forms. This simple discovery led the researcher to consider the inherent visual properties of the clay; if rich enough, it might be capitalised on to provide the primary focus of visual interest.


Group of 3 standing forms – porcelain with added pigments & aggregates (Binns 2005)

Initially the aggregates added to the body were pre-fired chamotte and molochite, obtained from ceramic suppliers. It was then realised it was possible to produce aggregates to a pre-determined colour and size. Ceramic pigments and metallic oxides were mixed into a plastic porcelain body, broke it into smallish pieces and fired it to 900'C. Once fired, the porcelain was crushed then graded through various mesh sizes, in order to control particle size and remove any fine dust. The crushed aggregates would then be hand wedged into the base clay; usually porcelain or terracotta – the amount and size of aggregates to clay determining the desired visual effect.


Hand wedging aggregates into plastic clay body

Having created the aggregate bearing body, the piece would be formed, either through pressing into wooden or plaster moulds, or free built from small pieces of clay, consolidating each piece as it was added. Once complete the piece would be allowed to dry thoroughly. Due to the thickness of the pieces, the work was fired very slowly over a number of days. Rarely did any cracking occur, as the amount of aggregate inclusions within the clay meant the body was able to 'breath' easily, allowing moisture to escape without any catastrophic cracking.


Examples of differing aggregate additions in clay bodies

Progressing the investigation led to considering the possibility of adding 'found' materials gathered from a specific geographic location; developing work that has a direct association with a particular place. A memory or locational narrative of a place (or journey) being embedded in the work, by the fact it partly comprises of materials collected from a particular place; replicating the geological process and 'freezing' the mineral material in a ceramic permanence.

Sources / Types of Aggregate for Inclusion in Plastic Clay:
Made Aggregates
Coloured grogs - stained with varying %'s of oxide or stain
Pre-fired to 900'C, crushed and graded

Industrial Materials
Colour - oxides or stains

Molochite	Chamotte
Sintered Mullite	Corzac
Fused Magnesia	Fused Silica
Dense Fused Mullite	Mulcoa
Perlite	Vermiculite

Found Aggregates
Beach Shingle
Slate spoil
Granite chippings
Sandstone
Pre-fire and wash to remove soluble material

In order to realise the full richness of the matrix of clay and aggregate inclusions, it was necessary to investigate an efficient method of grinding back the top surface layer; when working with a body containing a high percentage of large aggregate material, the finer base clay tends to migrate to the surface, leaving the interesting aggregates hidden beneath the surface. As the material was extremely hard following firing and with the anticipation of developing relatively large works, it was necessary to find a power tool capable of removing the top layer of fired material, efficiently. The machine found to be most appropriate was a Flex Angle-grinder, commonly used within the granite and glass industries. The process involves working through a series of diamond pads, from very course to fine polish. The grinding process was also important in refining forms to the exact geometry desired – giving crisp architecturally inspired shapes, that carried, but did not conflict with the visually rich surfaces.

Flex Angle Grinder used to grind and polish fired forms

Once a basic set of processes had been established, the project involved extending the repertoire of potential aggregate inclusions and simultaneously developing an appropriate vocabulary of forms - the grinding process itself determining to an extent the shapes that are possible. This basic set of technical processes, combined with simultaneously developing an appropriate vocabulary of form, shaped all future research.


Two piece standing form – porcelain with added pigments & aggregates (Binns 2008)

Glass Inclusions

A desire to amplify the visual drama of the conglomerate material led to an exploration of other more reactive materials, including crushed virgin glass. Ratios of clay, aggregate and glass were systematically tested. A clear correlation emerged between increased visual interest and gradual elimination of clay content – the most visually dramatic results being derived from a blend of aggregates, combined with the glass.

As the ratio of glass inclusions within the body was increased, it became apparent that the form started to melt and distort, with the molten glass flowing from the body.

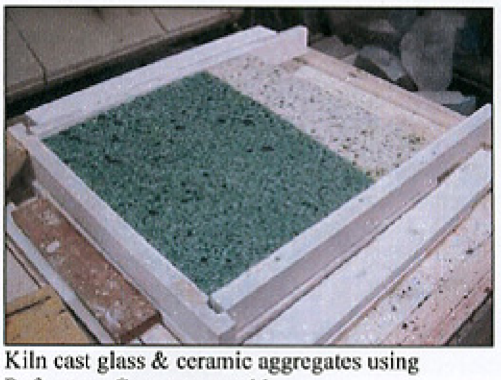
Observing this led to the need for a containment mould. Research was required into appropriate mould mixes. Initial finding examined gypsum moulds with a variety of inclusions to allow higher temperatures to be attained without the mould breaking down; based on research undertaken at the Royal College of Art (London), Thwaites, A. (2002) [2]

Whilst tests proved successful, gypsum based moulds were found to have a ceiling temperature of around 1100° C. As the optimum temperatures for the process were 1170° C, it became necessary to investigate other possible mould materials.

PhD research into creative applications of Refractory Concretes (RC's), undertaken by Alasdair Bremner (2008) [3] within the School of Design, led to an examination the potential of this material as a high temperature casting mould formula. RC's are almost exclusively used as refractory linings within the steel and chemical industries, as high temperature, hot face furnace linings, both as castable and pre-cast monoliths. Certain castables were found to be very appropriate as either sacrificial moulds or in some cases re-useable mould casings.

Working in collaboration with Bremner, a process was developed that involved forming the basic shape in clay; casting RC around the clay form, then removing the clay leaving a negative void of the desired final shape.

The mould is then filled with the appropriate blend of glass and ceramic material and fired in a conventional intermittent ceramic kiln. Following heating and cooling, the mould is cut away from the cast, then cold worked (cut, ground and polished), in order to complete the piece.



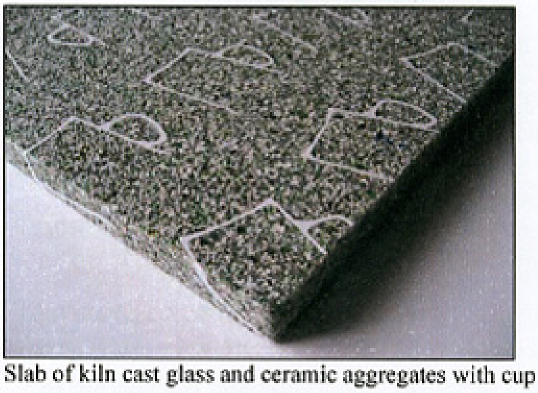
Kiln cast glass & ceramic aggregates using Refractory Concrete mould

Pair of pierced forms made from kiln cast glass and ceramic aggregates (Binns 2007)

As with the previous clay/aggregate work, the research involved steadily increasing the repertoire of visual and textural properties, through testing numerous combinations of glass and ceramic aggregates.

Following further investigation, it was found possible to introduce increasingly large particles of pre-fired material, to the point where the fragments retained a recognisable form (> 5mm). Broken fragments of waste tableware were the primary area of investigation. Adding large fragments of non-plastic material to a plastic clay body is impractical, causing the plastic clay body to shrink and excessively crack around the unforgiving inclusion.

It was discovered however that the significant amounts of glass-forming material meant the material had flow properties, allowing it to accommodate larger fragments with the mix. The visual appearance of adding large aggregate inclusions gave the impression of geological fossils encapsulated within the matrix, opening up many new aesthetic possibilities, not possible with plastic.



Slab of kiln cast glass and ceramic aggregates with cup 'fossils' (Binns & Bremner 2008)

CONTEXT FOR FURTHER RESEARCH

Designers, architects and artists continually strive for new forms of expression and innovative solutions to problems. A consequence of this is a hunger for new materials to sustain their creative aspirations. This relentless demand for new materials is however placing unsustainable demands on the finiteness of many mineral resources. Simultaneously, higher standards of living are creating ever-greater amounts of waste material that more often than not end life as landfill.

Whilst the arguments for embedding sustainability throughout the construction and design industries are well established and firmly embedded in the consciousness of architects and designers, it often conflicts with their desire for materials that offer new aesthetic properties. It is therefore becoming increasingly important that alternative products are developed that both offer a new aesthetic, are less reliant on virgin raw materials and are environmentally sustainable.

Concern over sustainability of resources is echoed in both UK Government and European Union strategy, stating the need to increase the breadth of applications for recycled materials.

DEFRA UK (2006) [4], whilst acknowledging waste is a fact of life, states: "...sustainable management of waste, optimising recycling and re-use", as a core aspect of Government policy.

Government strategy goes further, emphasising the importance of 'value added' opportunities from recycled materials, i.e. high quality products that have a value beyond those already present in recovered materials. DEFRA state: "Glass containers should not necessarily be returned to container glass manufacture, but could be recycled into a variety of other products in a range of industrial sectors", (DEFRA Chapter 5.3) [4].

Concern for diminishing natural resources is leading designers to seek environmentally responsible and sustainable solutions: how re-cycled materials might be integrated within the design process. Evidence can be drawn from the existence of re-cycled material databases, set up to support designers in their search for new materials. An example is the on-line database of 'Ecosmart' materials, (Re-materialise, 2006) [6].

Much use is now made of recycled waste glass within contemporary design as worktops, façade cladding and as decorative aggregate in concrete and cast resin. These materials have gained significant commercial interest, due to the materials offering a new aesthetic, whilst satisfying environmental concerns. Cold casting of glass aggregates within epoxy resin or concrete, holds the aggregate particles in permanent suspension, but leaves the fragments of material inert, in their original chemical and physical state. At the end of life however, materials formed using synthetic resins or cement binders, have little use or value beyond land-fill.

Whilst a proportion of glass waste is used within these 'design-led' applications, and also as aggregate for roads construction and drainage bedding, much still ends up as landfill.

CURRENT RESEARCH

Initially investigations were limited to the use of virgin glass cullet and the making of one-off art objects. However, concern over the demand new materials and products place on non-replenishable mineral resources, led the research towards considering how re-cycled mineral waste might be used to replace virgin materials within the process

Having found that recycled glass waste (mainly from domestic container glass), combined with crushed waste from the ceramic industry, performed in exactly the same way as virgin materials, the emphasis of the research changed to focus entirely on recycled waste.

Following a successful application for a research grant from the Arts & Humanities Research Council (UK) in 2008, a significant amount of research has since been undertaken into fusing varying combinations of glass, ceramic and other mineral waste.

Materials tested have included domestic waste container glass, waste from the ceramic tableware and sanitary-ware industries, iron and steel industry waste and quarry spoil. For the new material to have any long-term commercial future, it has been necessary to ensure that the sources of waste are sustainable, in order to maintain quality.

Industrial waste from the heavy clay industry – pipes and sanitary-ware

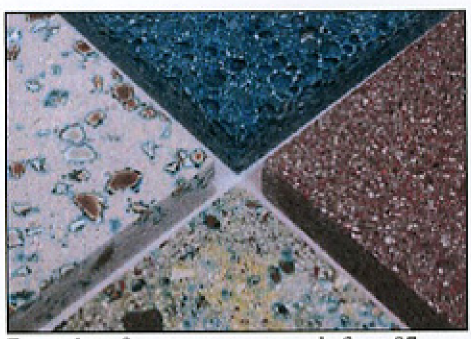
Slate quarry waste – North Wales, UK

The research has involved working in collaboration with Dr Richard McCabe from the University of Central Lancashire (UK) Centre for Material Science. McCabe's involvement in the project involves predicting the performance of individual materials and examining the microstructures of test samples. The material has undergone a series of tests, to ensure it meets European standards for construction materials. These

include modulus of rupture, porosity, freeze-thaw, stain resistance and metal leaching tests.
As the research has progressed, as wide range of colour and textural qualities have been developed. Where a specific colour has been required, tiny proportions of ceramic pigment have been included in the mix (never more than 3% of the total mix). In most cases however, the material is made from 100% recycled content.

MATERIALITY AND PLACE

As well as providing a sustainable alternative to traditional dimension stone cladding and clay products, the material offers a number of other unique aesthetic attributes. Materials have philosophically and historically engendered a strong association with 'place', the origins and configuration of such materials being increasingly germane to genuine sustainable aspirations. Traditionally, the majority of construction materials were sourced locally to the site of construction; not only meaning minimal energy was required to transport the materials, but use of local materials (stone in particular), imparted a unique aesthetic character to any given location, strengthening the sense or identity of place. Using local materials therefore, clearly plays a crucial role in helping characterize "placeness", contrasting with repeated use of the same imported stone that offers no localized identity, rather creating a repetitive, bland uniformity across many developments.
Mineral waste sourced onsite or close by, e.g. damaged stone or masonry from demolished buildings, may form up to 50% of the total primary aggregate within this new material. Utilizing local mineral waste promotes a meaningful visual and philosophical connection between materiality and place, enhancing notions of identity and ownership, whilst also avoiding 'standardization' and resolving the embodied energy related drawbacks of imported materials.
The aesthetic properties of the material are unique. Colour and texture can be engineered to a clients specific requirements; to either blend or contrast with existing materials, fine or course in texture or embedded with of larger 'decorative' fragments of mineral waste. The creative potential of the material for architects and designers is further enhanced, as the material can be made in a variety of bespoke shapes, either during the initial forming process, or through machining, post production.



Examples of cast prototypes made from 97-100% glass, ceramic and mineral waste (Binns & Bremner 2010)

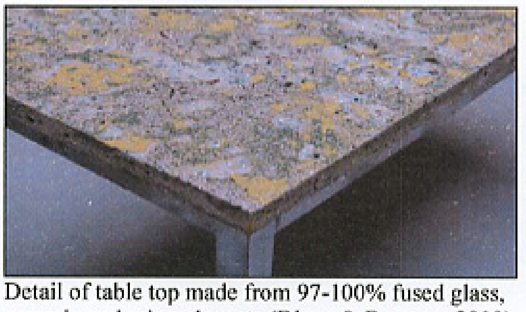
Test samples made from 97-100% fused glass, ceramic and mineral waste (Binns & Bremner 2010)

Recycling waste trimmings from the manufacturing process – 'closed-loop manufacturing'

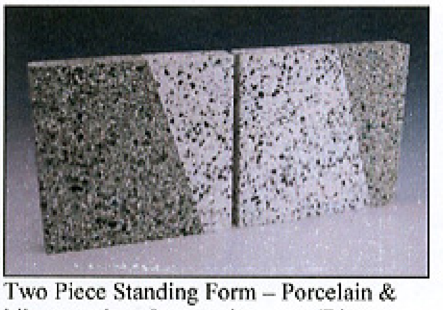
RECYCLEABILITY
It has been found that any second-quality casts or waste trimmings and sludges from machining may be directly returned into the production process, avoiding any manufacturing waste, thus satisfying the desirable objective of 'closed-loop' manufacturing.

Through testing, the material has been shown to have a life cycle similar to existing construction materials such as common brick. If however dismantling was necessary, the product may either be re-used or easily recycled. This would entail simply re-introducing it into the original manufacturing cycle as a raw material rather than the more common process of 'downcycling' to less valuable products; further enhancing the eco-credentials of the materials.
Whilst the material will inevitably incur energy consumption within production, transportation of waste to point of manufacture, processing and return to site, the embodied energy is predicted to be significantly lower than imported stone, with the advantage of zero production waste.

The project highlights how research that started life as essentially, supporting art practice, has led to embracing more formalised systematic scientific methods of investigation; taking the research from the familiar craft studio to the alien environment of the science laboratory.
It is the researchers hope that this material may offer architects, designers and artists, the opportunity to use a durable, versatile silicate-based material, with considerable eco-credentials, that has unique aesthetic properties, forges a strong link between material and place and contributes to a more sustainable society.



Detail of table top made from 97-100% fused glass, ceramic and mineral waste (Binns & Bremner 2010)



Two Piece Standing Form – Porcelain & kiln cast glass & ceramic waste (Binns 2008)

REFERENCES

[1] Binns, D (2006) Additions to Clay Bodies: A Research Project, Ceramics Technical, (23), pp 57 – 62 (AHRC Small Research Grant 2003 – Aggregate Additions to Clay Bodies).

[4] DEFRA, Department of Environmental Food and Rural Affairs (1999), Report Of the Market Development Group, Department of the Environment, Transport and the Regions (DETR), Chapter 5. Available from: <http://www.defra.gov.uk/environment/waste/strategy/mdg/report/5.htm#2> (Accessed10/10/2006)

[5] Re-materialize (2006) Creative Re-source, Design and Development of Materials from Waste University of Kingston, London. Available from: <http://www.kingston.ac.uk/~kx19789/rematerialise/html_and_flash/searchwelcome.htm> (Accessed 1/11/2006)

CD Publication

[2] 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. London, RCA

PhD Thesis

[3] Bremner, A (2008)
An investigation into the Potential Creative Applications of Refractory Concrete. PhD Thesis, University of Central Lancashire, Preston, UK