New Possibilities for Refractory Castable

This paper is not intended to provide a detailed report or demonstrate conclusions. It has been written to provide overall information on current M/Phil by Practice research activities being undertaken under the current title: **The manipulation of industrial ceramic materials to create new aesthetic qualities in contemporary studio ceramics.**

This paper has been adapted from a presentation made at the Atoms to Art Conference 2005 and will serve here to provide information for other Network members.

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Current Research

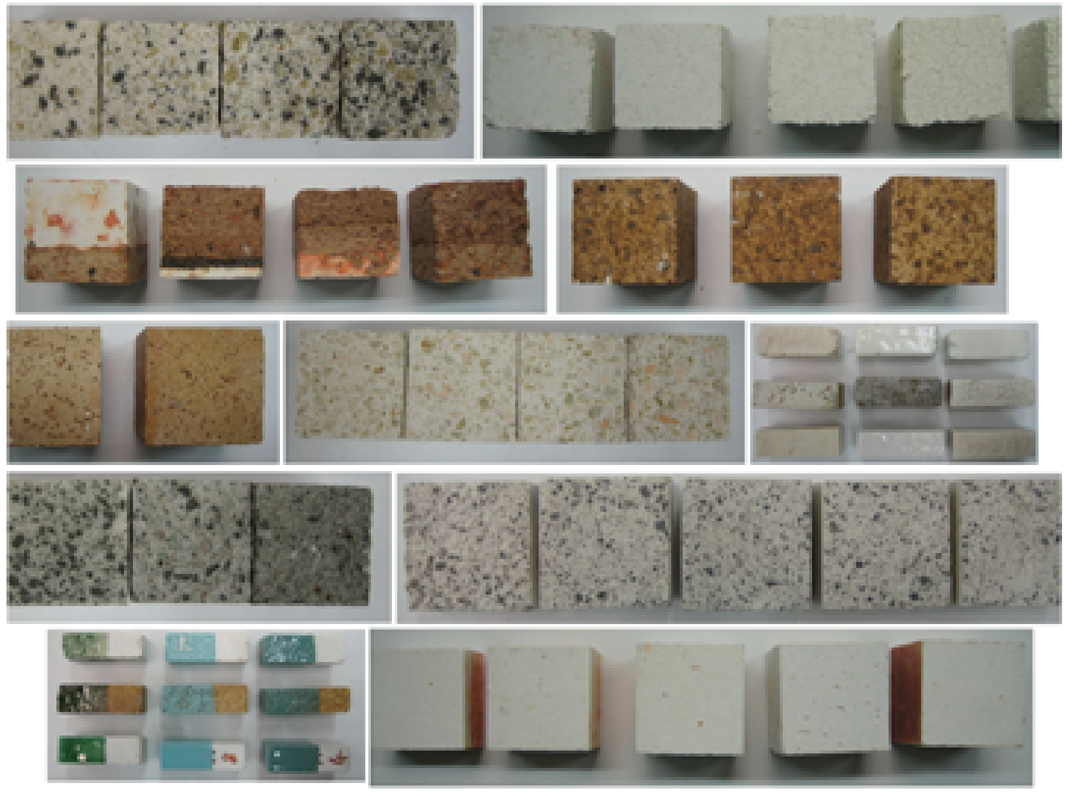
- What advantages can industrial refractory concretes offer the ceramicist?
- Can refractory concretes be used to broaden the potential for large scale ceramic works?
- What benefits can industrial collaboration present for both parties?
- What ceramic surfaces can be utilized on refractory concrete bodies?

Refractory concretes are well known to ceramicists but largely only for their insulating properties. My research focuses on the aesthetic and structural qualities that industrial ceramic materials offer to the ceramic artist and designer. It looks to establish methods of working with these materials normally associated with heavy industry in a studio-based environment. It will develop ways of using ceramic surface techniques to enhance the surface quality of refractory concrete. The research will identify industrial materials that offer novel handling properties and demonstrate them through the production of artifacts and potential products. It is not the intention of the study to discover new materials, but it will be to explore the possibilities that non-shrinking and increased green and fired strengths presents for studio ceramics and design.

The project will seek to catalog the huge range of industrial raw materials and compounds and make this information available to ceramicists and designers. At the same time it seeks to engage the refractory industry in the project and to the possibilities artists and designers might offer industry In terms of new avenues for end production. So while there is a strong connection between science and art in my research there is also a similar bond between industry and art.

What are refractory concretes?

Refractory concretes are by definition materials which are resistant to high temperatures, mechanical stress, thermal stress, chemical and abrasive attack. They are designed for specific applications predominately in the metal industry, but are also used extensively in the chemical, cement and glass industries. Refractory concretes rely on a complicated mix of aggregate and binder, the most common binder being High Alumina Cement (HAC). Aggregates used will vary depending on the intended application. Refractories come in two general types: preformed and monolithics. Preformed includes bricks and large-scale monoliths. Monolithics are generally described as gun mixes and castables used as linings and coatings normally fired in situ.



Shown Above are some of the different concretes that have been generously donated from several refractory companies, I have experimented with a range of concretes all with different intended applications. Each concrete has its own qualities in terms of strength, cost, surface and ability to accept glaze. It is anticipated that the results of the tests on these materials and glaze compatibility will be available in early 2006 via an online database.

Advantages of refractory concretes over clays

Shrinkage:

When working with clay we often encounter problems with warping during drying and during the firing. Refractory concretes do not suffer from the same problems, as they will set with a chemical reaction, which is subsequently sintered to create ceramic bonds.

Green Strength:

Because refractory concrete has a similar strength to conventional concrete even before it has been fired it can be maneuvered far more easily than large fragile clay pieces.

Fired strength and toughness:

Once fired, refractory concretes are substantially harder than conventional concrete and are generally tougher than ceramics due to the aggregates ability to arrest crack propagation.

Drying time:

Once set they require a short drying cycle to drive off any physical water. In addition the high alumina cement used as a binder in many refractories has a far shorter setting time than conventional portland cement.

Thermal shock

Refractory concretes are specifically engineered to cope with rapid and substantial changes in temperature during normal industrial application, therefore fast firing and even raku firing is possible.

The Disadvantages

Reduced workability:

Obviously refractory concretes cannot be molded in the same way as plastic clay and therefore require moulds.

Limited glaze compatibility:

The chemical composition of refractory concretes is different from clay bodies and therefore the interaction between glaze and refractory concretes is different.

Limited availability:

Conventional ceramic suppliers do not stock refractory concrete and Industry standard batches are generally in the region of several tones.

Unconventional Machinery:

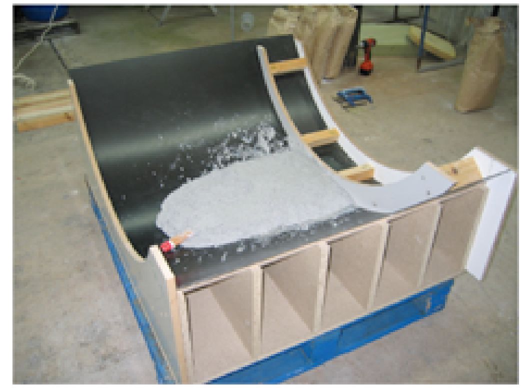
Refractory concretes require some unconventional machinery, namely specialist mixing machines not normally found in the average ceramic studio.

Practical Application

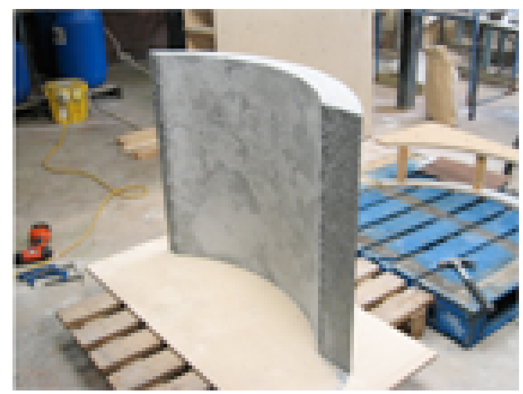
Two very different practical exercises have been conducted using the same refractory concrete. It is my hope that together they illustrate the versatility and the potential of this family of materials. The first describes the casting of two large-scale monoliths for the RHS Tatton Park show 2005 and the second shows the process behind forming large thin sheets of refractory castable.

While I had completed great deal of testing on a wide range of materials, all of the work had been on a relatively small scale. It was important to see how the materials might be put into practice on a large-scale project. An ideal opportunity to do just this was presented by garden designer Paul Hensey.

Paul had seen some of my director of studies David Binns work and was looking for a large-scale piece with a similar quality for his garden at The Royal Horticultural Society Tatton Park Flower Show 2005. The problem was achieving the scale he required using David's existing methods. It seemed that refractory concrete might be able to provide the scale and surface quality required.



The first step was the construction of the mould, which was made from wood backed with plastic to prevent the cast from sticking to the mould. While the material can be mixed by hand, due to the volume required a high intensity mixer was used. A second plastic sheet was then secured over the mould to hold the flowing mixture in the mould while subsequent mixes were added.



As is standard in industry a vibrating poker was used to reduce air entrapment. The mould was allowed to set overnight, before the mould was removed and the piece allowed to dry for 24 hours at room temperature. The castable will set after only 4 hours but HAC does not reach its maximum strength until 24 hours have passed.

On the left the piece before firing and on the right after firing to 1180c. You can clearly see that there is no change in size or shape.

In order to reveal the aggregates within the cast, water fed diamond grinders were used to skim off the surface. The refractory concrete is very dense and is very hard to grind, however it does allow a high shine to be produced on the surface. Finally to transporting and installing in the garden, as ceramicists we are often used to working on a relatively small scale, and forget that moving 170 kg pieces can be quite a challenge.

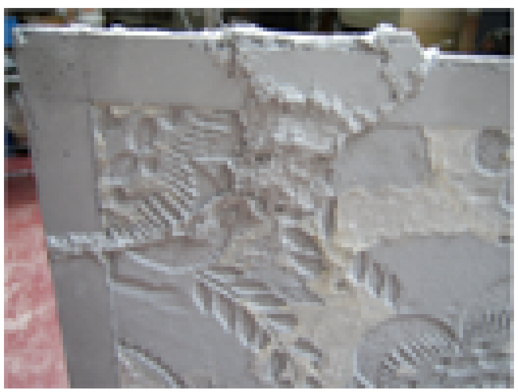
The pieces in position at the Tatton Park show 2005. The Garden was awarded the gold medal in the Back to Back category.

Refractory concrete sheets

The next set of work looked to draw upon the success of casting the monoliths. I wanted to demonstrate the unique properties of refractory concrete and explore more commercial applications. In this case the potential for use as wall cladding and decoration.

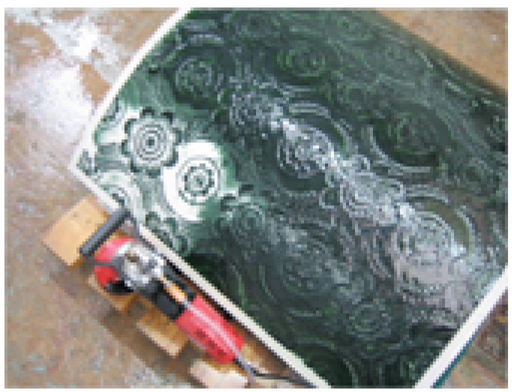
To the ceramicist large thin sheets of clay are a challenge for a number of reasons. 1. They are liable to warp during drying 2. They are brittle and delicate prior to firing. 3. During firing they are liable to further warping and often require a support structure. The objective was to test the theory that refractory concrete would suffer from none of these difficulties even when cast in large sheets only 6mm thick.

The first stage was to create the mould. A flexible plastic was used to form the base, which was then covered with textured wallpaper. Wooden formers were used to define the depth of refractory. The amount of water is critical in creating the right flow properties. In this case just 4% water by volume to material. Or to put this into perspective - For every Kg of material just 80ml of water is added. With gentle vibration the mix gradually settles to form a solid layer. With half the mix poured. A special stainless steel fiber that is resistant to oxidation is pressed into the refractory matrix. And then covered with a further skim of concrete. The fiber provides a support for the cast when it is placed into the former and more importantly it increases tensile strength of the cast piece.



Before the sheet has been allowed to fully set it was placed within the same wooden former used in the Tatton project, here the former is a simple concave shape that demonstrates that the material need not simply be cast in flat sheets. However, the material is very resilient and could theoretically be placed into more complex formers. After the piece was fully set the mould was gently removed. I stress gently as the material is substantially stronger than clay it is not without weaknesses. Unfortunately, in my haste to see the result I managed to break off one corner. However, it can be easily repaired using a technique similar to that used to when working with paperclay. The sheet was then fired on its edge to 1180c without any support mechanism.






The piece was then thickly glazed with an earthenware glaze. In the limited amount of testing completed so far it has been found that earthenware formulae are generally more successful than stoneware. This is primarily down to the lack of interaction between earthenware glazes and body. The piece was then re-fired to 1080 c. Finally the glaze was ground off to reveal the incised pattern. The result is a piece that would be impossible if attempted using conventional clay and methods.

With thanks to industry sponsors

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