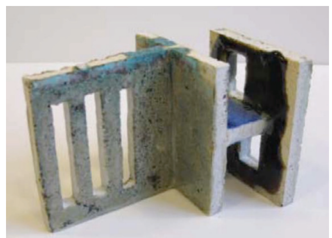
Glazed Concrete

Development of Large Scale Ceramic Glazed Concrete Sculptures in Public Spaces



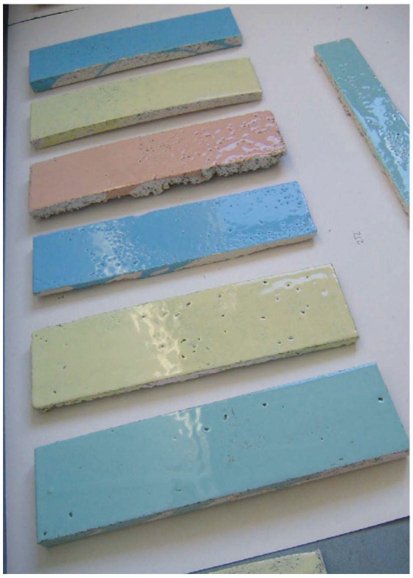
Anja Margrethe Bache discusses her architectural engineering research

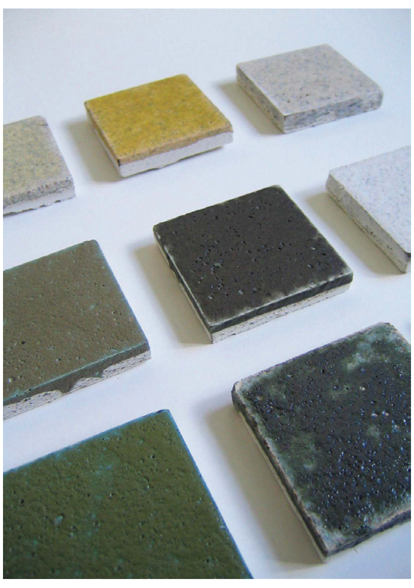
WHY GLAZED CONCRETE?

Concrete hardens and finds its strength at room temperature whereas clay products must first be fired before they achieve this strength. They are stronger and three times as durable as clay products, which is a weighty reason for choosing concrete.[5] Another reason, which is the one that I am working with, is the assumption that with the use of the packing theory Densit[6] and a fracture mechanical design concept for composite materials, Compact Reinforced Composite (CRC)[7, 8] can achieve high strength, which even for large-scale construction have high ductility. If this succeeds, it will be possible to manufacture thin, large-scale glazed concrete panels comparable in size to concrete sandwich construction and larger which, with or without back-casting, can work as load-bearing construction elements. Concrete surfaces are strong as well, can have high wear performance and can be beautiful

Left: ***Concrete Object 1.*** *Glazed with a feldspar glaze and fired at 1260°C.*
Top right, centre left and above right: ***Concrete Objects with Stoneware Glazes.*** *Fired at 1260°C.*
Above centre: ***Concrete Tiles with Stoneware Glazes.*** *Fired at 1260°C.*

with various texture and colours on the surface. They, however, have a tendency toward mortar efflorescence and sometimes an undesirable patina. The texture dies out when painted and the coloured surfaces are changed when they come in contact with the environment in often unpredictable ways. Ceramic glazed surfaces, on the other hand, can be strong and resistant to outside conditions, have a high wear performance and beautiful colour and texture expressions. They varnish the surfaces while also protecting them. They are easy to clean and maintain. These are the qualities wished to be transferred to concrete. With glazed concrete, I hope to be able to develop a dialogue between concrete and glaze that acknowledges the existence of both and thus contributes with new visual and aesthetic expressions. It is also a wish to achieve surfaces that remain as they were when manufactured and are easier to maintain.





Top: ***Concrete Tiles with Earthenware Glazes.*** *Fired at 1080°C.*
Above: ***Concrete Tiles Glazed with Alkali Glazes (Above) and Ash Glazes (Below).*** *Fired at 1260°C.*

Glazes

"When you start developing glazes, you quickly realize that this area contains boundless possibilities. Many people spend their lives developing new glazes without being able to say that now they know everything. This is, naturally, what makes the area so intriguing; the fact that you are never finished." (Claus Domine Hansen.[1])

In this project I prefer to mix the glazes myself as the ingredients in the ready made glazes and products often are not provided. Furthermore, it is seldom that they are suitable for the selected concretes and they must therefore be revised. By knowing the recipes it is possible to adjust and modify them. Manufacturing glazes demands patience. Often times, the glaze does not behave as expected; they do not interact with the body, there are holes in the glaze, it chips, it does not achieve the desired colour, is dull where it should be glossy, and so forth. Then the glaze must be changed. This process demands several glaze tests and tries. It is a completely ordinary procedure for the ceramist who attempts to map the constitution of clay products, the glazes and the types of firing. It is essential with systematic, discipline and repeated registration of the experiments and results, so that it will be possible to revise or recreate the result afterwards. This is where the ceramist shows him- or herself to be a patient soul and that is what I, with a little less patience, attempt to do in this project.

Energy-wise and from an economic viewpoint, it will be favourable that the glazed concrete surface can be achieved with one firing. It has been successful with a few glazes but most glazes demand that the concrete has undergone a so-called first firing. This is due to the fact that the porosity of the selected concretes is low before they are fired, about 1 percent but it is increased to about 8-10 percent after the first firing, which creates better adhesion for the glazes. The focus of the project onward will be aimed at developing more glazes that are effective with only one firing. It should be mentioned, however, that the selected concrete demands a slow heating during the first firing, about 50ºC per hour, to keep it from breaking and exploding. It is not particularly advantageous for most glazes. Most of the examples shown in this article have been achieved through second firings of the concrete.

Glazes can be transparent, translucent, opaque or completely covering. Are they completely covering the concrete, the body technically can be of clay or another material invisible through the glaze. However, if the glazes are transparent, translucent or opaque they can enter into a visual dialogue with the body, its aggregates as well as potential visible fibres.

An expression and narrative about the colour and texture of the glaze may be created but also about the material and the glaze together. It should not be kept a secret that I find the latter most interesting, because this creates the possibility of developing new visual expressions. But since the object of the research is to present a palette of possibilities for future production and use, both the covering, the transparent, the translucent and the opaque glazes must be tested.

There are many ways of painting and decorating ceramic material. These can be:

1. Metal oxides, fired and pulverized.
2. Underglaze colours, which are applied to the raw or fired material before the clear glaze is applied.
3. Overglaze colours, where the glaze is first applied and is fired, whereupon the colours are painted on and the material is fired again.
4. Painted glazes, obtained by mixing metal oxides.
5. Gilding.
6. Coloured masses, engobes and clay colours.[2]

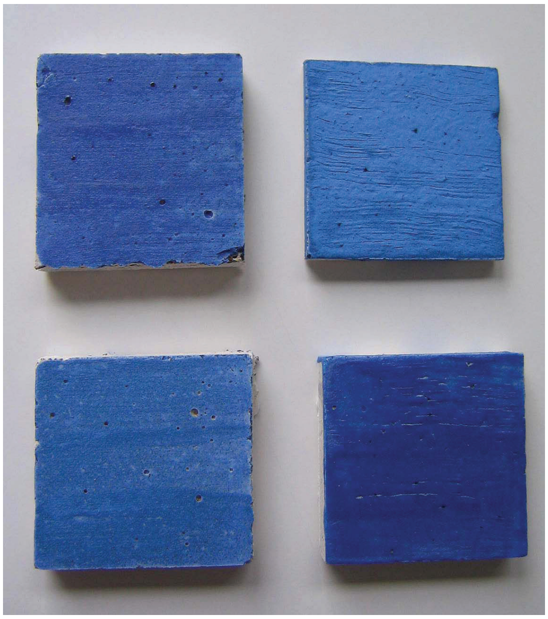
Of these processes, overglaze colours and gilding are not tested with the concrete, whereas the four other types are. Overglazing is not suitable, partly because it demands no less than three firings, partly because the colours used are often toxic and will come in direct contact with the environment, possibly contaminating it. Underglaze colours are tested in the form of engobes that, before being fired, are dipped in clear glazes. Gilding is not considered financially viable for large scale production as it is too expensive.

The glaze can be applied to the body by dipping it in the glaze, by pouring the glaze on it or through spray-glazing, which demands that the body has been heated to 100-200C.[4] Glaze can also be painted on the concrete using a brush. In this project both painting, dipping, pouring and spray glazing are tested, as they all will be usable for the large scale.

A glaze firing can take place in an oxidizing oven environment, meaning where there is air (oxygen) but also in a reducing oven environment, where there is no air. Usually the colour and texture will vary greatly from one type of firing to another. Firings can take place in electric ovens, gas ovens or other types of ovens. The type of oven likewise effects the expression of the glaze. Electric ovens are primarily used in this project, as they are available at DTU, but also because they are the easiest to control in terms of firing curve, maximum temperature and holding time.

If one desires the same result repeatedly, the firing should follow the same firing curve each time. That curve must be determined through experiments of the various glazes, such as speed of temperature increase and decrease based upon experiments. The glazes used in this project are selected based upon whether they:

1. Contribute palettes of desirable colours and textures, even on a large scale.
2. Work together with concrete, including aggregates and fibres.
3. Are durable inside or outside.



Top: Concrete ***Tiles with Engobes and for the Tile Below at the Right also with a Transparent Stoneware Glaze****. Fired at 1260°C.*
Above: ***Concrete Tiles Glazed with the Same Stoneware Glaze.*** *The tile on the right has no fibres while the one on the left does which can perhaps be utilized aesthetically. All objects and photos by Anja Margrethe Bache.*

4. Are not unhealthy or hazardous.
5. Are easy to maintain and repair.

Practically all glazes can provide desirable colours and textures, also on a large scale. Furthermore, it turns out that some glazes can work together with concrete, including those selected here, while not all glazes are wear resistant, crack resistant or durable in an outside climate where they can be exposed to acids, thermal shock and frost.

There are many types of glaze. Some need low temperatures to melt, while others melt at high temperatures. Stoneware vitrifies at high temperatures, which also means that it is necessary to fire stoneware glazes at high temperature; 1200-1400ºC.

Stoneware glazes have a strong binding to the body. When the glaze melts at higher temperatures, the surface of the material vitrifies as well and a strong inter-layer is created, which is a combination of the glaze and the body. Therefore, for some applications, stoneware glaze and high-fired glaze are preferred.

There are glazes besides those mentioned that can be fired at even higher temperatures than stoneware glazes. These have not been included in this project as the body is not expected to handle such high temperatures. Stoneware glazes can be divided into several types, such as alkali glazes, ash glazes, crackle glaze, salt glazes, feldspar glazes and crystal glazes. I have only chosen a few of these for their colour and texture due to their relevance and because I am curious as to whether they can work with the selected concrete. The glazes that have been chosen are alkali glazes, ash glazes and feldspar glazes. Furthermore, stoneware engobes and a few earthenware glazes are tested. The latter is included to point to possibilities for other function areas than those covered by this project.

Of the selected glazes, only feldspar glazes are in fact suitable for industrial production. The others have, besides splendid colours and textures, some disadvantages such as a lack of scratch resistance and durability. Stoneware glazes, due to the high firing temperature, often provide more subdued colours than earthenware glazes. The alkali glazes, however, are an exception. They provide clear and pure colours. Alkali glazes, meanwhile, are not scratch resistant and have a tendency to crackle easily. They are therefore primarily used for decoration, which is also the reason that they have been chosen. Ash glazes are forceful, with aesthetic associations to the colour and surface of bark on trees. Their expression is dependent upon what kind of ash is used. It can be difficult to control during mass production since the colour varies depending upon the type of wood, the origin of the tree, its age and what part of the tree has been used. It is used because its colours and textures differ from the others and due to the fact that there can be a structural context where its diverse character is appreciated. Feldspar glazes are, according to Finn Lynggaard, a collective name for the type of glaze regularly used in stoneware production. They are strong and reliable. By adding other basic metal oxides one creates a basis for a boundless line of glazes with varied expressions and characteristics.[2]

Concrete tile glazed with a stoneware glaze. Fired at 1260 degrees Celsius.

Stoneware engobes are not glaze but can be the cause of several desirable colours and surface characteristics. Normally, engobes are used on leather-hard, yet unfired clay objects. It is difficult to use on objects that have been fired, which is why the latter, according to Peter Hald[3] should usually be avoided. Experiments with engobes on the selected concrete demonstrates, however, that these conditions are different where it seems to be the opposite. Here I have not yet succeeded in making the engobes work together with non-fired objects, while fine results have come from using fired concrete objects.

Concrete body, fibres and glaze

The fracture mechanical design concept creates a concrete body with fibres. Steel fibres, however, affect the visual expression and are seen as graphical black lines in the relatively white concrete body. Also, in glazed concrete, they will be seen as black or darker markings. Steel fibres can also contribute to the glazes being different in colour and texture than they would be if the fibres were not present. This is illustrated by the example on page nine and below. The glaze, the thickness of the layer, the oven environment and the temperature are all the same but there are fibres in the tile to the left and none in the tile to the right on page nine. The visual effect of the steel fibres can be minimized by polishing the object to half aggregate. They will then be seen as small spots in the object and will only sporadically affect the glaze.

Concrete body and aggregate materials

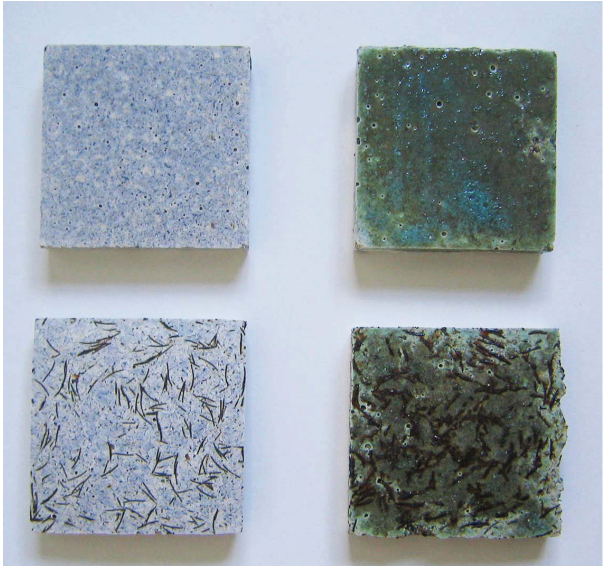
The break mechanical design concept also requires close packing of particles and aggregates, chosen in more size differentiations than conventionally. It is a tale you can choose to tell through the visual expression or to entirely hide, by respectively polishing the object or not. If the object is polished or a transparent or translucent glaze is chosen, the diverse living colour play as we know it from terrazzo will enter into a dialogue with the glaze and, as such, tell us about the body that carries it.

Glazed large-scale form work maintenance and repair

Not everything lasts forever. So despite the fact that designs are aimed at being durable, both as to body and glaze, normal use will entail various changes and possibly even destruction of the lasting form work. It must, therefore, be possible to replace or repair them, which will be investigated in the project also.

Final note

The goal is to achieve qualities that are not known for concrete and at a scale that has not been achieved using ceramics. The project is still in its initial phase and the deeper I dig into it the more I discover as, indeed, it is in any development project.



Glazed Concrete Tiles. *These tiles used the same glaze but the two lower tiles contain steel fibres. Glaze fired at 1260°C.*

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All objects and photos by Anja Margrethe Bache.