CC Höganäs Building Ceramics

Exterior ceramic wall facings

CC HÖGANÄS
RICCHETTI GROUP

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During later decades wall facings of the above mentioned kind have undergone a considerable development both with regard to products and structural designs. This has been well received by architects and consultant engineers.
This paper, which is directed to the last mentioned category of technicians in the first hand, comprises **ordinary** structural designs including new modifications–**special** ones eg. tiling with metal fittings are here discussed only to a limited extent.

Durability, Safety, Requirements

In Sweden ceramic exterior wall facings, as well as outdoor wall facings of all other kinds, are extended by a National Precept known as BFS 1988. This concept should not be concidered as norms but as sets of general requirements covering all types of buildings and their components. In this case Durability and Safety are of particular importance.
Insurance companies, consultants, contractors and suppliers are expected to construe this concept and propose solutions which can be generally accepted as good building technique. All under the supervision and approval by the state. Optimal technical/ economical solutions are what is aimed for. They can be specified and their fields of application can be encomposed.

Influences, Loads

The influences which directly or indirectly cause loads in exterior ceramic wall facings are: **shrinkage** and **creep** in materials or products, **moisture** and **moisture variations**, **temperature variations** and **frost**. Note, that load due to the wall facing's own weight is negligible.
Loads imply strains. When strains cannot develope themselves freely stresses occur–bending-pressure, bending-tensile and shear stresses. Especially, the first two mentioned arise in tile layers whilst shear stresses are located over boundary surfaces and in adhesives.
It can be mentioned that ceramic wall facings (also floors for that matter) belong to the multilayer systems. The mechanical behaviour of such systems are far from fully examined in Building Mechanics and Strength of Materials. This is why earlier Höganäs and later CC Höganäs have taken such an interest in this field of technology, not only in research and development and by experience, but also theoretically.
Shrinkage in concrete and other cement based products cannot be avoided but it can be reduced to a minimum with well proven techniques. Stresses are in general fairly limited: However, in a prefabricated concrete panel with one face of cast-in tiles a slight arching of the panel can be observed due to the restraining effect of the tile layer. Shear stresses between the tile layer and the panel concrete occur.
It is a clear difference in this case between manually carried out units and prefabricated ones as cement mortars and adhesives do not generate such a shrinkage force as concrete can do. Simple precautions avoid possible errors (see under Principals of Structural Designs).
Creep in wall facings themselves need not to be taken into consideration. However, this strain will occur in load bearing structural concrete and can be transmitted to wall facings unless meassures are taken. So called solid bedding of tiles of the simpliest model V20 (see under Structural Design Models) should be avoided on newly cast and highly loaded concrete building structures.
Shrinkage and **creep** are both "time dependent". Shrinkage takes place immediately after the application of the concrete and cement based adhesives but is completely finished after a few months. Creep reaches its maximum after several years and is also load dependent. The total strain due to these loads can be 0.5-0.8‰.
Moisture and **moisture variations** cause volume changes in porous products. Free volume change in CC Höganäs tiles are 0-0.3‰ in pure water. In acidified water, say pH 4, or in alkalified, say pH 11, the upper limit will be appr. doubled. The volume changes are not reversible, that is, a drying out following a completely saturated porous tile will not lead to the original volume.
A remaining strain of appr. 1/3 of max. possible is usual in porous ceramic bodies. Further moisture variations have less importance. Note that volume changes due to moisture refer to laboratory tests of tiles and strains cannot without further additions being converted into stresses of in-situ and/or cast-in tiles.
Temperature variations mean both increase and decrease of volumes. Estimations of these changes require an assumed original medium manufacturing temperature, either in-situ (manual tiling) or in factory (prefabrication).
The thermal strain of usual building ceramics is low, $\alpha \approx 4.5 \times 10^{-6} K^{-1}$ or appr. 1/3 of the concrete's. Favourable.
In the northern hemisphere, exterior ceramic wall tiles facing south and west, get larger temperature variations than those facing north and east. During bright winter days, the solar radiation can increase the surface temperature of a ceramic off-white wall facing 8-10°C (south Sweden). Temperature changes take place morning and evening and are repeated every time a cloud temporarily shadows the sun. It does not take more than 10-15 minutes for a massive outer wall to adopt a new stationary thermal condition.
Frost is a special kind of influence and is relevant in large parts of the world. The volume increase of the water when ice is forming is near 10%. This causes considerable pressure inside porous systems. Glazed tiles must be frost resistant when used outdoor, that is, having a water absorption not exceeding appr. 0.5% of dry weight. It should be born in mind that a fully covering glaze is a barrier through which no moisture can escape, once moisture is absorbed in the body. This is why the body must be practically nonabsorbent.
Unglazed tiles, although having fairly porous qualities, can be used outdoor without risk of damage. All experiences show this and depend on the fact that moisture escapes from the tiles as easy as it is absorbed due to physical and climatic conditions. Here a comparison with outdoor coverings (staircases, terraces, balconies) should be of interest. In such coverings water is collected in joints, bedding mortars and in concrete renders due to rain, melting snow and ice. The tiles are constantly fed with water during the cold seasons. Therefore frost resistant tiles must be used.
Exterior wall facings have far better conditions. However, this is not relevant for outdoor parapet walls in temperate climats or worse. The conditions should always be considered unfavourable unless these parapets are sheltered by roofs.

Principals of Structural Designs

Ordinary solutions

Having considered the above mentioned influences and their consequences regarding loads, it should be obvious that an overall structural design principal must be to reduce their total effect, even avoiding certain of them entirely.
Frost and increase of volumes due to moisture can be avoided by using dense tiles. Creep in load bearing structures and temperature variations can be avoided by adapting the structural designs of exterior ceramic wall facings.
Now, this is far from necessary in many cases as it is in fact allowed to make use of the strength of the products, provided a reasonable margin of safety is left. However, this safety margin cannot be satisfactorily calculated for the time being.
But, experience comes to help. Two basic structural design principals of the actual kind of wall facings are available: **solidly bedded** and **moveably fastened** systems.

A solidly bedded ceramic wall facing is directly fixed on a mechanically dominant load bearing structure and has to take part of the strains of the structure. Stresses arising in the wall facing due to shrinkage and creep in the structure mentioned cannot be avoided. Nor can it be avoided that the wall facing's own strains (temperature variations, moisture and moisture variations) are hampered.
A consequence of the uncertainty of the magnitude of the stresses is that the fields of application of the solidly bedded system are reduced (ground skirtings and appr. one-storey wall facings).
However, it is quite possible to increase the safety of a solidly bedded system by adding to it a net reinforced c-mortar under where the net is mechanically anchored backwards (see under Structural Design Models).
Moveable fastened systems (often precast) provide that these are released from strains originating from the load bearing building structure. Other strains can develop freely. This design principal means a somewhat higher cost but is superior regarding safety which is reflected by its fields of application (multi storey city buildings and comparable).
Under Influences, Loads it has already been mentioned that simple meassures can be taken in order to improve the mechanics of moveable systems, in the first hand prefabricated concrete panels with cast-in tiles. Both in practice and in theory it has been proved that open joints between the tiles spread shear stresses favourably. Furthermore, the intencities of such stresses can be reduced between 17 and 40 times due to the size of the tiles used, compared with filled joints carried out at the same time as casting the panel concrete.
Within a concrete panel with one face of tiles an uneven shrinkage will take place due to the restaining effect of the tile layer. A slight arching of the panel can arise. By leaving the joints open until the main part of the shrinkage of the panel concrete is finished, this arching practically disappears. This is simply a proof of a favourable stress distribution. Width of joints may be 15 mm or more.
Naturally, open joints changes the character of an outdoor ceramic wall facing, but often for the better. Interesting shapes are available. Depth of open joints = thickness of the actual tile model. Another favourable meassure to be taken would be placing the field reinforcement of a tiled panel, as near the back of it as possible, with regard to a reasonable protection layer.
The above mentioned does not at all contradict to full joint filling, which is by far the most common and traditional. The simpliest measure to be taken with regard to low stresses and good stress distribution is casting the panels with open joints between the tiles (normal joint width) and then store them in this shape by the manufacturer for curing as long as possible. Then, manual joint filling takes place, only a week or so before delivery. In this matter the architect can help, namely, by looking into that manufacture of tiled panels takes place on an early stage. A resonable delivery time implies a minimum of total costs and perfect products.

Special solutions
Exterior wall facings where tiles are fixed with metal fittings are few. It should be required that tiles can be replaced individualy. In these systems the tiles are not supported by a solid concrete or an adhesive, why they will be vulnarable at least near ground because of possible vandalism. So far, the costs per sqm for the fittings are fairly high due to the limited sizes of tiles and sheets. Exterior tiling on light infill walls is not excluded but experience is limited. Considerations from case to case is recommended.

Products

Ceramic tiles
Suitable tiles for exterior wall facings are all glazed and unglazed ones stated frost resistant in the CC Höganäs range but also unglazed in the series 11, 12, 13, 20, 21, 22, 23 and 52.

Frost resistance is not a product property but is an expression of the interactions between several product properties, environment and structural design. However, this does not exclude the use of the designate "frost resistant tiles" and their examination in laboratory by different methods predicting their capability to withstand real loads.
The following so called frost dilatation test shows convincingly the difference in behaviour between **a non-frost resistant** glazed tile (water absorption appr. 4.5% of dry weight), fig 1, and a **frost resistant** one (water absorption appr. 0.5% of dry weight), fig 2.

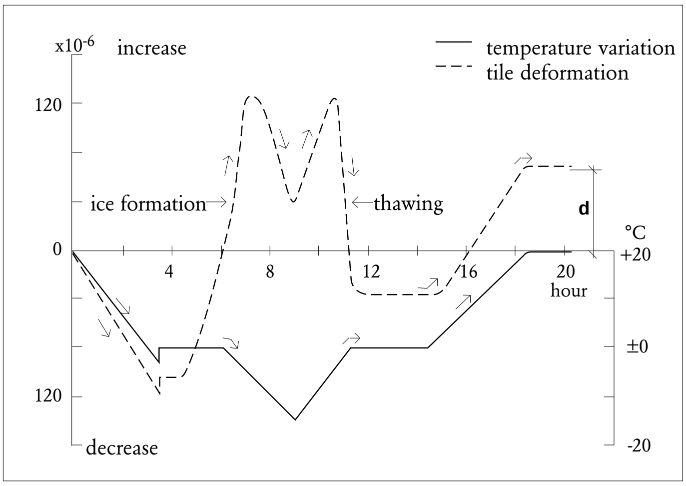


Fig 1.

Note which drastic deformations the non-frost resistant glazed tile has undergone to end with a remaining deformation **d** already after the first test cycle. Pore walls have been broken.

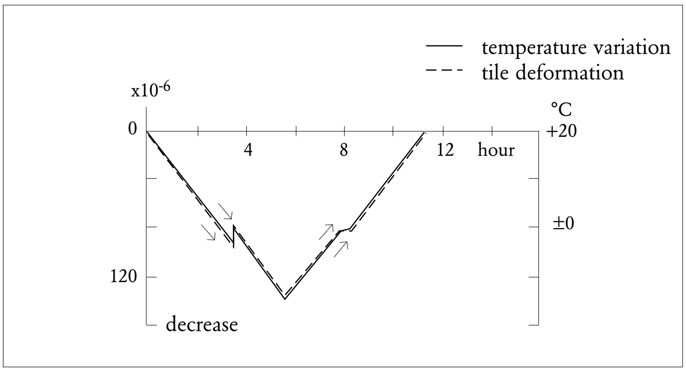


Fig 2.

In this case the dense frost resistant glazed tile follows the temperature change very good and shows no remaining deformation.
Frostresistant glazed tiles have no meassurable volume change worth mentioning at complete saturation (vacuum method).
Absorped (in reality adsorped) moisture is located in micro surface pores whilst it is fairly evenly spread in porous tile bodies.

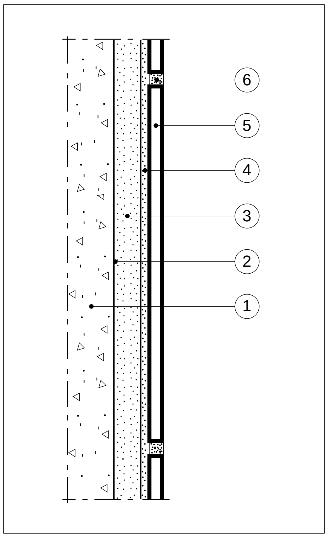
Cement based products
These are relevant for exterior ceramic wall facings. Their behaviour under frost influence can be studied the same way as for ceramics. Building and research during generations have taught us to formulate cement products with good properties for outdoor applications.
Organic additives as in CC Höganäs FB 13 have a favourable effect on adhesion and on flexability. The products let themselfs be strained viscosiously and do not generate stresses of the same order as cement mortars. Though, in CC Höganäs
litterature the E-modulus (static) at short time loading is given for the sake of simplicity and comparison.

Structural Design Model V20.

Solidly bedded exterior ceramic wall facing, fixed by hand, in adhesive on wood floated render on structural concrete, bricks and light weight concrete.

Fields of application: Ground skirtings and appr. one storey high wall facings.

Note: When tiling outdoors the backs of the tiles must be coated with a thin but fully covering layer of the adhesive prior to the tiles being pressed or knocked into the previously applied adhesive (the so called buttering/floating method).



Explanations

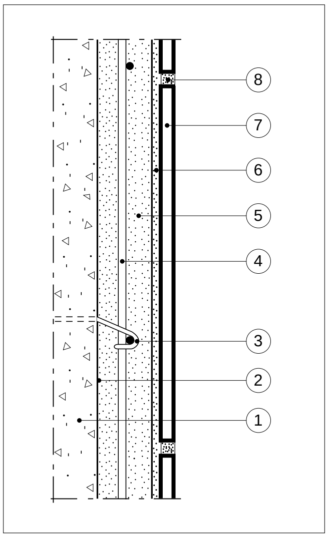
1. Building structure.
2. Coarse render.
3. Wood floated render.
4. Adhesive (CC Höganäs FB 13).
5. CC Höganäs tiles (pl. see under Products).
6. Grouting mortar (CC Höganäs FB 20).

Structural Design Model V21.

Solidly bedded exterior ceramic wall facing, fixed by hand, in adhesive on wood floated, reinforced, mechanically anchored render on structural concrete, bricks and light weight concrete.

Fields of application: Wall facings higher than 4 m above ground and in cases where safety precautions are asked for.

Note: When tiling outdoors the backs of the tiles must be coated with a thin but fully covering layer of the adhesive prior to the tiles being pressed or knocked into the previously applied adhesive (the so called buttering/floating method).



Explanations

1. Building structure.
2. Coarse render.
3. Anchoring of stainless steel thread ø 2-3 mm, 3-4 pcs/m^2.
4. Reinforcement net ø 4 mm, # 150 mm.
5. Wood floated concrete, thickness appr. 40 mm.
6. Adhesive (CC Höganäs FB 13).
7. CC Höganäs tiles (pl. see under Products).
8. Grouting mortar (CC Höganäs FB 20).

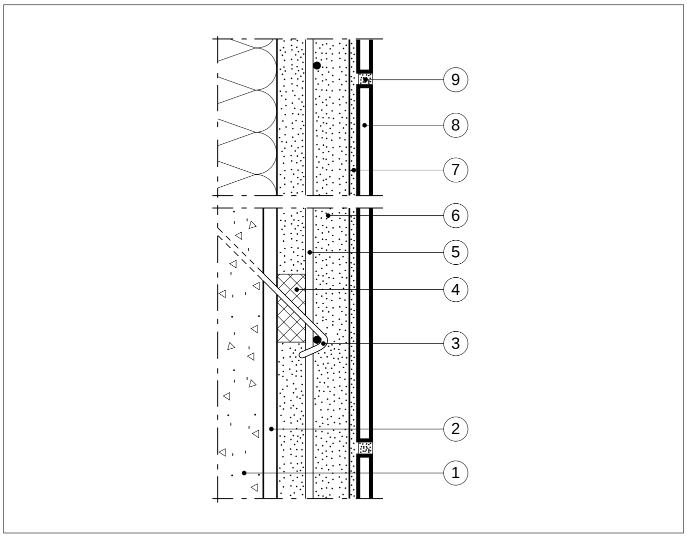
Structural Design Model V25.

Moveably fastened exterior ceramic wall facing, fixed by hand, on solid building structure with air spacing material or on mineral wool without air spacing material.

Fields of application: Larger, multi storey wall facing where pre-fabricated panel systems are considered unrational due to unfavourable exterior meassures and/or number of panel shapes.

Note: When tiling outdoors the backs of the tiles must be coated with a thin but fully covering layer of the adhesive prior to the tiles being pressed or knocked into the previously applied adhesive (the so called buttering/floating method).

Generally: The wall facing should be divided into sections of up to 6 sqm with expansion joints both horizontally and vertically. Width of the expansion joints 10–20 mm. They should go through the wall facing to the external surface of the building structure. Grouting compound and shaping of the expansion joints are the same as for concrete panels.
Shapes and essential details are shown on architects drawings.



Explanations

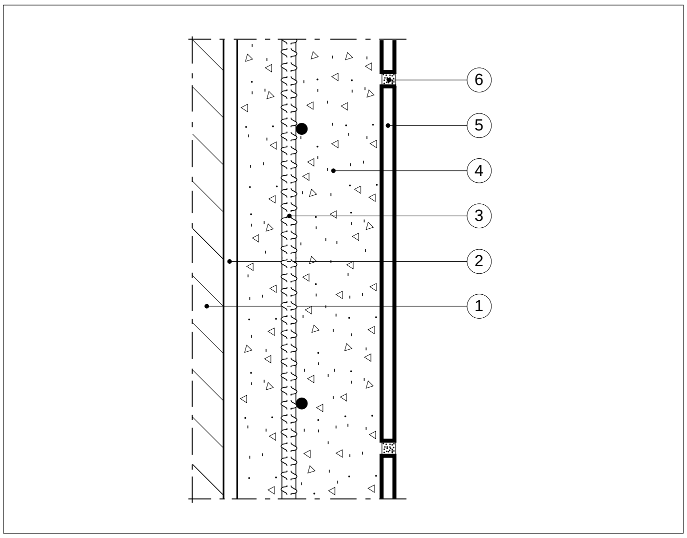
1. Building structure.
2. Air spacing material connected to open air.
3. Anchoring of stainless steel threud (cast in or bolted) ø 3-4 mm, 3-4 pcs/m^2.
4. Piece of celllular plastic or rubber, surrounding threuds.
5. Reinforcement net ø 4 mm, # 150 mm.
6. Wood floated concrete, thickness appr. 40 mm.
7. Adhesive (CC Höganäs FB 13).
8. CC Höganäs tiles (pl. see under Products).
9. Grouting mortar (CC Höganäs FB 20).

Structural Design Model V26.

Moveably fastened exterior ceramic wall facing in shape of pre-fabricated concrete panels, cast-in tiles.

Fields of application: Larger, multi storey city buildings or equal. The exterior should have suitable modul(-s) allowing rational manufacturing.

Generally: The panels are structurally designed by a consultant engineer (manufacturer). Very often, the panels are storey high. Moveable fastening can be made in several different ways and are best selected with regard to the individual case. The panels are separated from each other by means of expansion joints, width 10-20 mm. Grouting compound and shaping of the expansion joints are the same as for concrete panels.
Shapes and essential details are shown on architects drawings.



Explanations

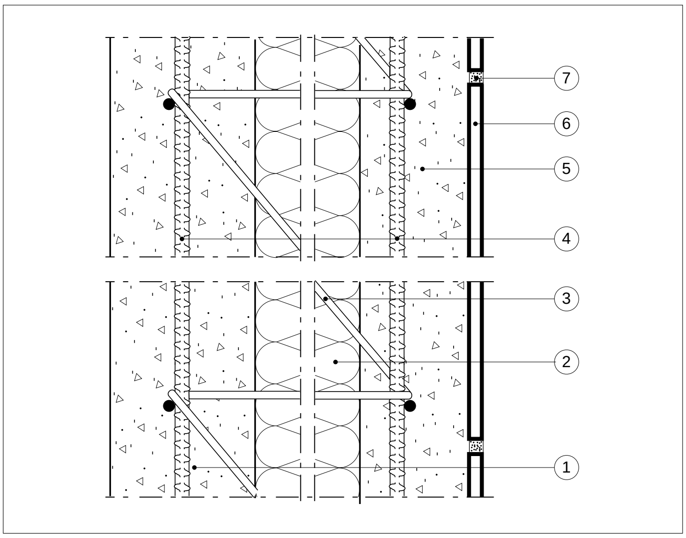
1. Massive building structure or infill wall.
2. Air space with connection to the open air.
3. Field reinforcement.
4. Concrete.
5. CC Höganäs tiles (pl. see under Products).
6. Grouting mortar CC Höganäs FB 20 (manually executed, see also under Principal of Structural Designs).

Structural Design Model V27.

Moveably fastened exterior ceramic wall facing in shape of so called sandwich elements, cast-in tiles.

Fields of application: Larger, multi storey city buildings or equal. The exterior should have suitable modul(-s) allowing rational manufacturing.

Generally: The elements are structurally designed by a consultant engineer (manufacturer). Very often, the elements are window to window high (outer panel). Reinforcement is welded, and the zig zag rods of stainless steel. These zig zag rods should deliberately be dimentioned flexibel. The inner panel transmits load to the structural slab and can be solidly fastened. The outer panels must be separated from each other by means of expansion joints, width 10-20 mm. Grouting compound and shaping of the expansion joints are the same as for concrete panels.
Shapes and essential details are shown on architects drawings.



Explanations

1. Inner concrete panel.
2. Heat insulation.
3. Zig zag reinforcement.
4. Field reinforcement.
5. Outer concrete panel.
6. CC Höganäs tiles (pl. see under Products).
7. Grouting mortar CC Höganäs FB 20 (manually executed, see also under Principal of Structural Designs).