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DAAS-CLICKBRICK®: DRY STACK CLAY BRICKS FOR FACADES

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Abstract

In the Netherlands a new dry stack system for facades consisting of clay bricks has been developed. In this paper the application of the system is described. Because of the special way the system is connected with the load bearing structure, an experimental program was carried out to investigate the behaviour under wind induced pressures. The experiments and their results are analysed.

Key Words

clickbrick, clay brick, dry stack system,

1 Introduction

The Daas ClickBrick®-system is a façade-system, consisting of specially shaped clay bricks and stainless steel clips and wall ties. The system can be used as a veneer wall. During the last three years the system has been developed by a Dutch brick manufacturer, called Daas Baksteen. Dry stack systems are not new but not available for facing bricks. The first samples of dry stacked bricks were already very promising, but nevertheless it took another two years to finally end up with the present system. In the Netherlands the system is patented and an international patent is pending.
The Daas ClickBrick-systeem only needs to carry it's own weight, and at the same it should be able to transport the wind-loads to the backing wall. The behaviour of the system under wind-loads was investigated in a test-program carried out at TNO Building and Construction Research.
In this paper the materials and the system will be described, together with the experimental results. Finally an interpretation of the test-results and the conclusions will be presented.

2 Materials

2.1 Clay bricks

The Daas ClickBrick is a wirecut facing brick made by extrusion. After baking the

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bricks, they are sawn to more accurate dimensions. The usual dimensional tolerances on bricks are too large, because the dry stacking system requires more exact dimensions. The working height of the system is 100 mm, and the tolerance on the bricks is only 0,1 mm in this direction. The working length of the system is 240 mm. The bricks are produced with a length of 238 mm, which results in open head joints of approximately 2 mm. The length and the height of the bricks are corrected by sawing them. The thickness is 90 mm, and is not corrected. The amount of bricks per square meter is 41.7.
The compressive strength in accordance with NEN-EN 772-1 (2003) is 97.4 N/mm^2. Due to the fact that the bricks are 100 mm high, the normalised compressive strength is also 97.4 N/mm^2.
The bricks have grooves in the two bed faces parallel to the wall. In these grooves the clips can be placed for the connection of the bricks and for the connection of the wall ties. The grooves are positioned at a fixed position in relation to the face of the bricks. The grooves are produced during the sawing-process.
To be able to position the wall ties in the head joints of the system, it was necessary to create a profile at both heads of the bricks. At the face of the façade the head joint is the above mentioned 2 mm, and on the side of the cavity the head joint is at least 4 mm wide. The different stages of the erection of a ClickBrick-wall as well as the different products are described in Figure 1.

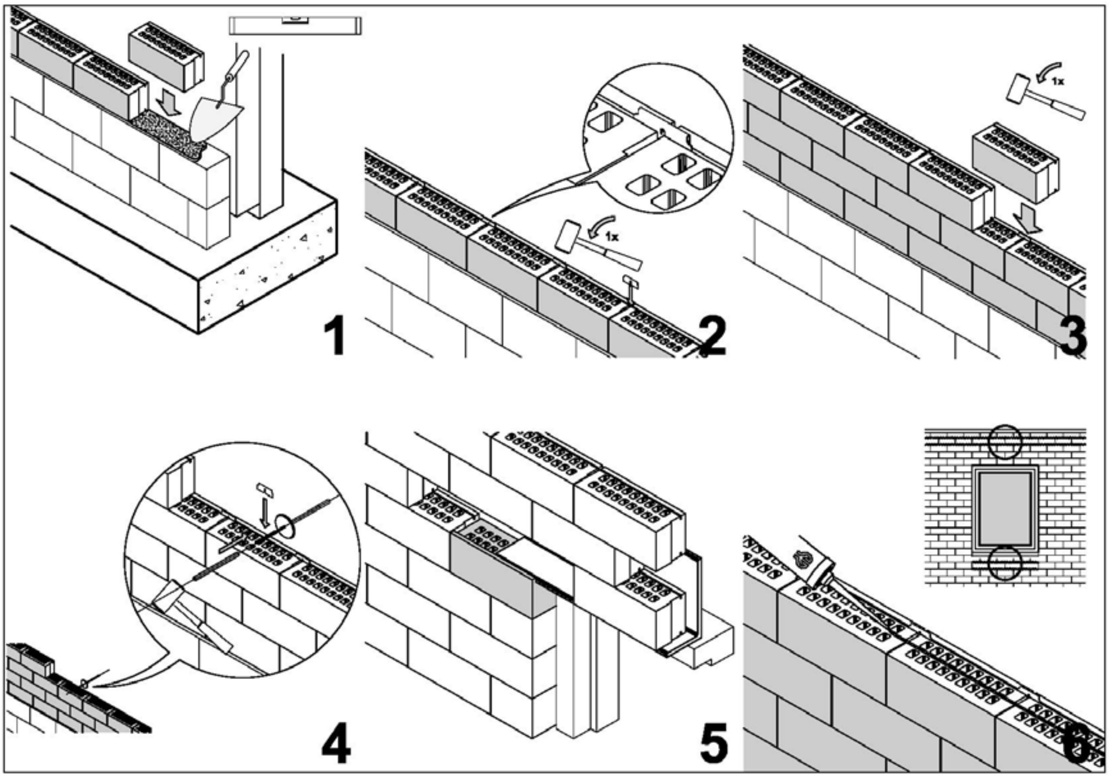

Figure 1 Several stages of the erection of a ClickBrick wall.

Besides the normal bricks, the ClickBrick-system also consists of standard corner bricks and standard bricks for positioning steel lintels. Every other shape of brick can be produced within the limits of the system, but are of course considered as specials.

2.2 Clips

The clips are made of stainless steel (AISI 316). The dimensions are 50 x 2.85 x 16 mm^3 (l x b x h). The clips are used for the connection of the bricks, which means that

also 41.67 clips are required per square meter. Besides these clips, also 4 clips per m^2 are required for the fixation of the wall ties.

2.3 Cavity wall tie

The wall ties are based on the traditional system of cavity wall ties for masonry. The difference is the connection of the wall ties to the veneer. This connection is provided by the above mentioned clips, which are placed over the special profile in the wall tie. The position of the wall tie is on top of the ClickBrick, exactly in the middle. This position ensures that the wall tie can not slip out of the clip. The wall ties have a diameter of 4 mm, and are also made of stainless steel (AISI 316).
Three different types of wall ties were developed based on the type of load bearing structure:

- wire anchor (drive-in type) in combination with pre-assembled plugs, used in combination with concrete and calcium silicate blocks;
- threaded anchor, used in combination with aerated concrete and wood;
- special anchor with an eye, used in situations with relatively small cavities.

2.4 Glue

The last three horizontal layers of a wall have to be glued together to ensure the transfer of the lateral load towards the wall ties. This is also necessary for the last three layers underneath openings. A one-component MSP sealant (SABA Fast 'n Sure).was selected because of its easy application and good test results. On small ceramic prisms several tensile tests were carried out in the laboratory of SABA, and in all tests the ceramic collapsed and not the glue or surface between brick and glue. This glue is particularly well suited for gluing, indoors and outdoors, of all materials commonly used in the construction and shipbuilding industry such as PVC, metal, brick, concrete and wood.

3 Experiments

3.1 Test setup

To be able to simulate the wind pressure, a representative part of a wall was (as one side) built in a box in which an overpressure or under pressure could be created, see Figure 2 and Figure 3.

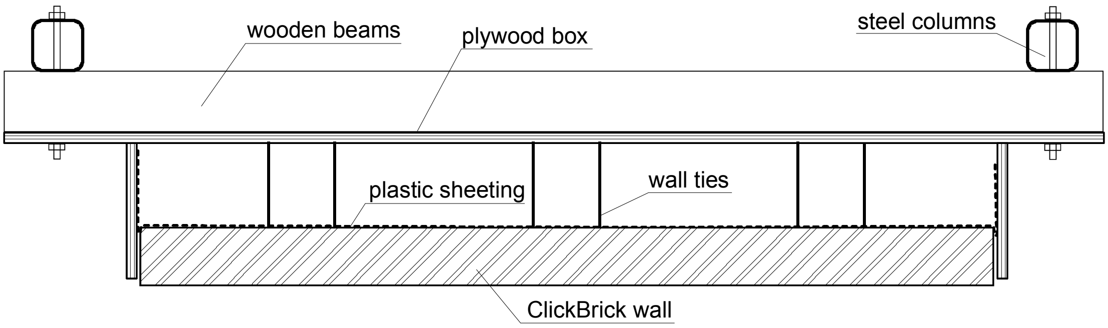

Figure 2 Schematic drawing of test arrangement

The ClickBrick-wall was connected to the plywood with wall ties. De wooden frame was connected to steel columns that were fixed to the floor of the laboratory. De bottom of the wall was placed on a strip of plywood, which resulted in minimizing the friction between the ClickBrick-wall and the ground. The friction is smaller than in real practice. After the construction of the wall, the two sides and top of the cavity were covered with plywood, in such a manner that the plywood was not supporting the wall.

Figure 3 Test arrangement

The simulation of wind suction on the wall was created by creating an overpressure in the box. At the inner side of the ClickBrick-wall a plastic foil was placed, and the wall ties were pricked through the plastic foil. The simulation of wind pressure on the façade was realized with an underpressure in the box. For this situation the plastic foil on the inner side of the cavity was removed and a new plastic foil was applied on the outside of the wall. The load was applied with a fan. The fan could supply a gross pressure of 10 kN/m^2, but due to pressure loses, the maximum load was restricted to approximately 5 kN/m^2. The deformation of the wall was measured at the outer surface of the wall at the position of a wall tie and in the middle between two wall ties, see Figure 4. The pressure and deformation were measured electronically with an interval of 1 s. The tests were carried out on a wall of approximately 1560 x 1400 mm^2 (l x h), with 4 wall ties per square meter and a cavity width of 120 mm, see Figure 5.

Figure 4 Deformation measurements with LVDT's

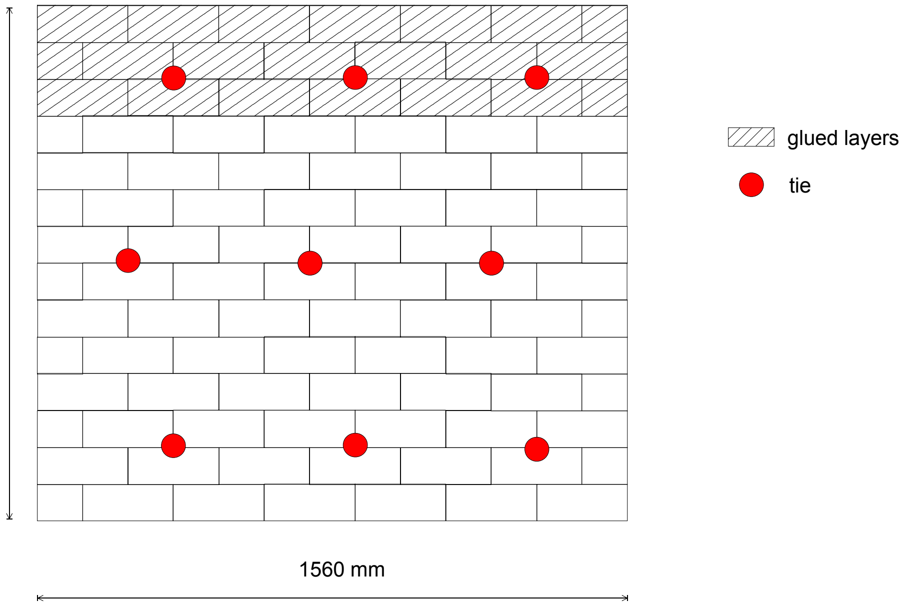

Figure 5 Dimensions of tested wall with the positions of the wall ties

The wall was first loaded in 3 cycles with overpressure in the cavity and afterwards with 3 cycles with underpressure in the cavity.
The observations during the tests can be easily described. Due to the strength of the clips the stiffness of the total wall is very high, and hardly any deformations arise. After the tests the wall was 'demolished', to be able to check the connection of the wall ties in the wall. Hardly any appreciable damage could be observed.

3.2 Test results

In this section some graphs show the deformations of the walls due to the overpressure (see Figure 6) and underpressure (see Figure 7) in the cavity.

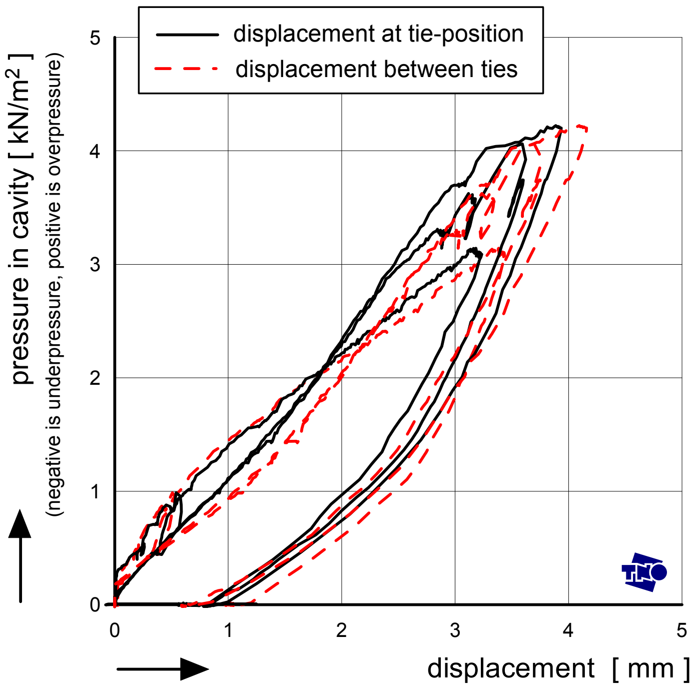

Figure 6 Overpressure versus deformation (all cycles)

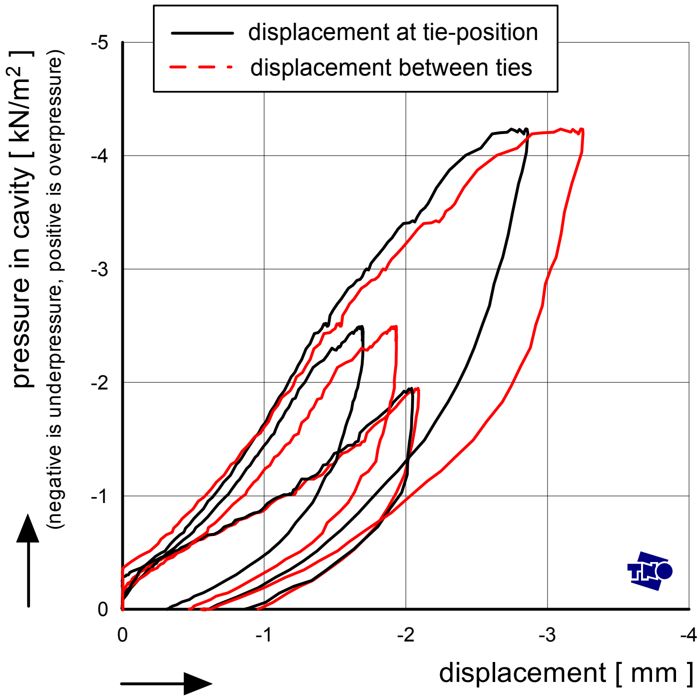

Figure 7 Underpressure versus deformation (all cycles)

In general the figures demonstrate the relatively small deformations. The deformation between the wall ties is bigger than the deformation at the position of the wall tie. The difference between the two measurements is small. The deformations that are measured are mainly the result of tensioning the clips. The resulting deformation s after a load cycle were also limited. It is true that every cycle is influencing the following cycle, but this is mainly due to the fact that the system is settling itself. The permanent deformation after one cycle is limited to a maximum of 1 mm, while after unloading the wall the difference in deformation between the two measurement points is neglectable. The maximum difference in deformation between the two measurements is 0.4 mm. This means that the wall itself is hardly deforming and only a little reduction appears at the position of the wall ties.

4 Wall tie anchoring

Dimensioning of the wall ties loaded in compression (wind pressure) is possible according to the design rules of CUR Recommendation 71 (2000). The approach is conservative: the ties are supposed to be 2 mm deformed from the axis and the fixations in the walls is schematised with hinges.

The tensile strength of the wall ties in the case of wind suction on the wall can be divided in the strength of the fixation in the ClickBrick-system and the fixation in the load bearing structure. On the fixation of the wall ties in the ClickBricks several pull-out tests were carried out, in accordance with NEN-EN 846-5 (2000). The fixation in the bricks failed at an average load of 2.43 kN. The standard deviation on the ten test results was 0.15 kN and the coefficient of variation was 6%. In all the tests the clip where the tie was connected to, caused a typical cone-failure of the brick in combination with large deformations of the clip, see Figure 8.

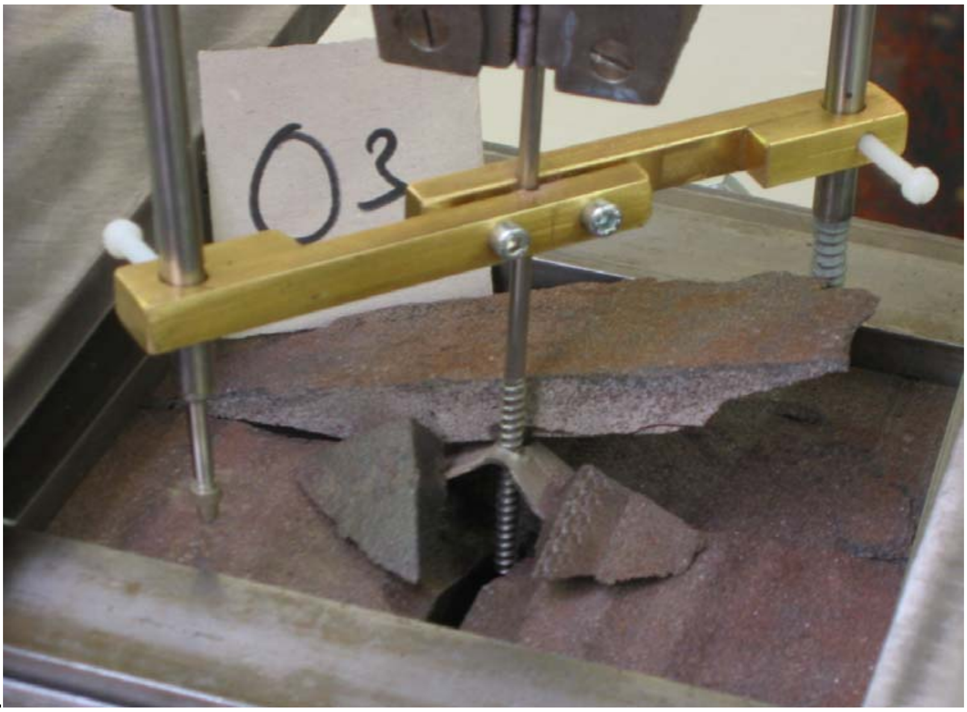

Figure 8 Failure mode of anchorage of tie with a clip in the ClickBrick-system.

Due to the fact that the position of the grooves in the bricks is moved more to the centre of the bricks since the tension test on the ties have been carried out, the strength of the present anchorage is even stronger. In view of the fact that the strength of the fixation of the wall ties in the bricks is very high, means that the fixation to the load bearing structure will be decisive in most cases.

5 Conclusions

At the moment the ClickBrick-system has been applied in the facades of approximately twenty projects in the Netherlands, and as far as we know is prescribed in another seventy to eighty projects. Figure 9 is showing the construction of the first ClickBrick-wall in a project in Velp, as well as the final result.

Figure 9 ClickBrick-project in Velp (NL) during construction and final result.

The research has shown that the Daas ClickBrick-system can be applied safely in high-rise buildings. The exact height of the building is depending on the design and the geographical position. The main conditions are the amount of wall ties and dimension of the cavity. It is important to know that in the research the pressure equalization in

the cavity has been neglected, because of the use the plastic foil. This means that the results of the research are conservative, because in real practice all head joints in the system are open leading to a lower but unknown pressure difference over the façade.
With an overpressure of 4.2 kN/m^2 and an underpressure of 4.2 kN/m^2, it was not possible to see any deformation in the stacked wall with the naked eye. The difference in deformation at the position of a wall tie and in the middle of two wall ties was only 0.4 mm. In real practice the deformations will be much smaller, not only because the loads will be smaller, but also because of neglecting the settlement of the wind pressure in the cavity.

References

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NEN-EN 845-1, 2003, Specification for ancillary components for masonry - Part 1: Ties, tension straps, hangers and brackets

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CUR Recommendation 71, 2000, Constructive aspects of the design, dimensioning and execution of masonry facades (in Dutch).