Structural restoration of a farm wing of the Park Abbey at Heverlee, Belgium

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ABSTRACT: The final phase of the restoration and renovation of a part of the farm buildings of the Abbey “Abdij van ‘t Park” at Heverlee in Belgium has been started recently. It concerns the coach house and some stables of the extensive abbey’s farm. To prevent the buildings from further deterioration, a thorough restoration of the masonry and the wooden structure was urgently required. Preceding the restoration works, a preliminary structural investigation was performed to determine the critical points for conservation and consolidation. Based on the obtained results, the specific required stability measures were designed. The restoration works started in September 2003 and will be finished by the end of 2004. The paper describes the preliminary investigation and the required structural measures as well as the practical execution. The experiences at execution will be confronted with the findings from the preliminary investigation.

1 INTRODUCTION: SHORT HISTORICAL OVERVIEW

The Abbey “Abdij van ‘t Park” was founded in 1129 as abbey of the order of Norbertus (Stevens 2003). The abbey farm was constructed from 1653 to 1664. Therefore, several buildings were erected. A huge tithe barn was built to lay in stock one tenth of the harvest which had to be paid by the tenant farmers to the Abbey. Also a stable wing and a coach house were built, figure 1.

For that building, the arches under the pigeon house were recovered from the ancient guest house (constructed in 1494–1515).

Adjacent to the stable wing, the monumental Norbertus gate is situated. This gate forms the main entrance to the Abbey.

At the end of the 19th century, the stable wing served as house for the servants and the guards. This situation lasted to the first part of the 20th century. In 1940 the stable wing of the Abbey was listed as a historic monument. In 1949, the building was used as a coffee roasting house. A structural restoration was performed in 1967. Several leakages in the roof structure were sealed and the wooden structure was treated against further deterioration. Additional wooden supports were provided under the arches. Combined with a counterweight placed at the other end of the wooden beams (at the attic) they had to prevent further settlements of the pigeon house since large settlements had occurred here during time, due to the high weight of the pigeon house compared to the rest of the roof.

In 1990, the farming activities were stopped. From that moment on, until the start of the restoration works, the buildings were not in use anymore and the rate of deterioration of the construction rapidly increased.
At the end of the 1990s, the decision was made to completely restore and renovate the construction preserving as much as possible its historical and architectural characteristics, and to reconstruct parts of the facades that were altered in the 20th century. The restoration works started in 2003 and will be lasting until the end of 2004.

The new destination of the building will be the Belgian administrative seat of the non profit organisation “Kerk in Nood/Oostpriesterhulp” (Literally translated: Church in Need/Priest Aid for the East). This international organisation is founded and supported by the Catholic Church and takes care of pastoral activities and humanitarian aid, originally intended only for the former countries in Eastern Europe (behind the iron curtain). Nowadays the organisation is active worldwide.

At present, a masterplan for restoration and re-use of the abbey buildings and domain is under study, with collaboration of the city council of Leuven and the Monuments and Sites Division of the Flemish Government.

2 PRELIMINARY INVESTIGATION

In 1999, a preliminary structural investigation of the construction was executed by the Re Bryantens Laboratory, Department of Civil Engineering, K.U. Leuven (Schueremans et al. 1999). The goal of this investigation was to determine the stability problems and to gain an insight into the condition of the used materials, mainly masonry and wood. This information was used to compose adequately the final execution documents and the corresponding technical specifications.

2.1 Foundations

The situation of the foundations (condition, depth, shape) was investigated by digging a number of inspection pits, figure 2. The ground water level was varying from 700 to 800 mm below surface level.

The top part of the foundation masonry of the outer walls is located in the same vertical plane as the above-ground masonry. The second part of the foundation consists of a protruding (250 mm) foundation tooth.

The pillars supporting the arches in the middle of the building are founded on a foundation block of 1.5 m x 1.5 m (20th century).

The soil characteristics were determined by CPT (cone penetration test) tests. In total 11 CPT tests were executed.

The theoretical analysis revealed that the bearing capacity of the foundation was sufficient for all parts excepted for the south/east corner of the building, figure 3.

In this zone, the building was constructed on a filled up canal, formerly used for water evacuation of the site.

Due to this, the ultimate capacity of the foundation was exceeded causing differential settlements of the construction and hence cracking of the masonry.

To evaluate the actual deformation rate of the structure, the variation of the crack width was measured using “Tell tale” plates, figure 4. The advantage of this technique is that the crack variation can be measured in a very easy way, eventually by non technical people. However the accuracy is rather low and depends on the ability of the operating person.

Parallel to the “Tell tale” measurement, the crack width variation was measured using a “Demec”- measuring device (in this case with a 4” basis). With this device, a strain is measured from which the elongation can be calculated. This technique is much more accurate but it requires special equipment.

The long term measuring campaign was started in March 1999 and lasted until October 2003 when the measuring devices were removed during the restoration works. Figure 5 shows an example of the crack width measurement for crack no 7 (located in the SE corner).

From these results, the seasonal variation of the crack width can be noticed very well. Due to the shrinkage of the building materials with lower temperature, the crack width will be larger during winter time. During summertime, the crack width will consequently be smaller.
However, besides this seasonal variation, a global trend of an increasing crack width can be observed (straight line on figure 5). From the experimental results, an average crack width increase of 0.12 mm/year could be derived for crack no. 7. For the other cracks in the SE corner, a similar behaviour was found. This means that the insufficient bearing capacity of the foundations in the SE corner was confirmed experimentally by the crack measurements and that the settlement of the structure was still going on.

The crack widths of cracks located in other parts of the building were measured as well. These measurements showed an analogous seasonal variation but no long term trend of crack increase. These results correspond with the theoretical analysis of the bearing capacity of the foundation in these parts.

2.2 Arches gallery

The middle part of the farm wing, consists of an arches gallery. Above these arches gallery at the front side of the building, a pigeon house was built, figure 6.

Due to the relatively high weight of the masonry pigeon house compared to the rest of the roof structure and the relative weak soil characteristics, large settlements occurred in the course of time. The theoretical differential settlement of the middle pillar equals 45 mm. These large settlements can be observed visually by the slope of the joints in the masonry, figure 7. These joints were initially oriented horizontally, but during time, the orientation changed caused by the
deformation of the masonry. Besides the orientations of the joints, no further damage to the masonry could be observed. This proves the very specific and flexible behaviour of lime mortar/brick masonry.

With the structural renovation in 1967, additional wooden supports on concrete foundation blocks were added behind the stone pillars, figure 8.

Together with these new supports, the wooden beams had to be stiffened with a steel girder on top according to figure 9.

Finally, at the other end of the wooden beams, large contrevweights consisting of steel girders were added at the attic. All these measures should have lead to a cantilever construction which has to unload the stone pillars in the case of additional settlements.

However, with the preliminary investigation in 1999, no stiffening element on top of the wooden beam could be found. This means that the wooden beams did not have enough bending stiffness to fulfil their role in the cantilever construction. Hence, for the actual restoration, a new appropriate solution had to be designed.

3 STABILITY MEASURES AND EXECUTION

3.1 Foundation SE corner

The insufficient bearing capacity of the foundation at the South/East corner was improved with a construction of 2 concrete ring beams and 5 transversal concrete beam supported by ten 200 kN micropiles, figure 10 (Brosens et al. 2002). The concrete beams were integrated in the masonry wall below ground level. Figure 11 shows the drilling of the micropiles. The concrete ring beam is shown in figure 12.

3.2 Arches gallery

The further settlements of the stone pillar at the arches gallery are prevented by new steel supports situated between the old wooden supports and the stone pillars, figure 13. Each wooden beam is supported by two steel supports, which are founded on a concrete beam supported by two micropiles. Afterwards the new steel supports will be integrated in a glass wall.

The stiffness of the wooden beams is increased by means of an externally bonded steel plate on top of the wooden beam, figure 14. This steel plate will be subjected to compression stresses. To prevent local buckling due to the compression force in the steel plate, additional mechanical anchors are placed every 400 mm. Four mechanical anchors provided at the plate end, must prevent premature debonding failure (Brosens et al. 2002).
3.3 Masonry rehabilitation

The deteriorated and damaged masonry was treated and/or restored. The following treatments were applied:

- Injection against capillary moisture
- Stitching of cracks with U-shaped anchors
- Bridging of cracks with horizontal anchors
- Anchoring of inner walls
- Injection of voids with a ternary grout
- Application of a salt buffering rendering

The principle of stitching of cracks is shown in figure 15. By providing U-shaped anchors across the crack, further crack deformations are limited and force transfer over the crack will be possible. The anchors
Figure 15. Stitching of cracks: principle.

Figure 16. Horizontal anchors for bridging cracks.

Figure 17. Anchoring of inner walls.

consist of stainless steel bars or glass fibre reinforced plastic bars (GFRP) glued in with an epoxy resin. An analogous technique is bridging the crack by means of a horizontal anchor. This technique is more appropriate for thinner, single leaf masonry walls, whereas the stitching technique will be more appropriate for massive, multi leaf masonry walls. Figure 16 shows the application of horizontal anchors after finishing of the cut in joints.

Another problem was the crack formation between outer and inner walls. To restore the connection and the integrity between both walls, mechanical anchors were provided every 350 mm, figure 17. After the placing of the anchors, the bore hole was filled with a cement grout.

Large holes and voids in the masonry were filled by injecting a ternary grout. This grout is a lime-pozzolan-cement mixture (Toumbakari et al. 1997).

Each ingredient has its specific properties. The addition of lime is required to keep the very important and specific plastic behaviour of the injected masonry. Pozzolans are added to limit unrestrained carbonation of the lime and hence a continuous increase of the strength of the grout. The cement will give an early strength which is needed to allow a certain progress of the injection works. Special attention must be given to the fluidity and the stability of the grout (Van Rickstal 2000, 2001; Ighoul et al. 2003).

3.4 Wood restoration

The wood restoration consists of
- Strengthening of wooden floor structure
- Application of epoxy mortar prosthesis
- Replacement of wooden elements
- Curative and preventive treatment of wood

The theoretical analysis revealed that the wooden floor structure did not have sufficient bearing capacity. Especially the deformations under service load were too large. Therefore the floor structure was strengthened and stiffened with U-shaped steel girders bonded and bolted to the secondary wooden beams, figure 18 and 19. These steel girders are applied above the boarding of the ceiling. Afterwards the new wooden floor was built on the steel girders.
Deteriorated wooden beam ends are replaced by an epoxy mortar prosthesis, figure 20 (Ignoul et al. 2000). The force transfer between the beams and the prosthesis takes place by means of mechanical anchors chemically bonded into the wood, figure 21. Since the epoxy mortar prosthesis is built in an oak wooden formwork, the intervention will be nearly invisible. Too severely deteriorated wooden elements are completely replaced by new ones.

Finally, the complete wooden structure is treated curatively and preventively against insects and moisture attacks.

Figure 20. Epoxy mortar prosthesis.

Figure 21. Anchors as reinforcement for the epoxy mortar prosthesis.

4 CONCLUSIONS

The restoration of the farm wing of the Abbey “Abdij van ‘t Park” in Heverlee, Belgium, started in 2003 and is still going on.

Since it concerns a historically valuable building, an extensive preliminary structural investigation has been executed in order to be able to choose the most appropriate restoration options.

As shown in the paper, a number of modern and scientifically well founded restoration techniques are used to perform a high quality and sustainable restoration without loosing the specific characteristics of the construction. These techniques were only used where strictly needed, and as much as possible in a reversible way.

The end of the restoration works is scheduled for the end of 2004.

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