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Settlement upholstery made of drainmats

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ABSTRACT: It is a description of the use of drain mats as a settlement upholstery between a projecting new building over a segment of the ca. 500-year-old town wall. Beside the safety-catch of a settlement upholstery between the historic fabric and the new bulding being in use only slight vertical deformations of the settlement upholstery could be detected during the concreting process. One describes the laboratory examination of the stress-deformation behaviour as well as the practical building operations and the check measurements in situ.

INTRODUCTION

During the demolition work in the urban area of Weimar the remains of the historic town wall (built in the 14th and the 15th centuries) und foundation parts of the former „Jacobsgate" were uncovered under a longitudinal wall and a gable wall of a building. The Department of Archaeological Preservation of Historic Monuments of the Federal State of Thuringia demanded the preservation of this historically valuable fabric. A simple cellar was intended for the new building. The remains of the town wall and the parts of the found gate-string foundations crossed the planned contour of the cellar (compare illustration 1).

The top edge of the town wall almost coincided with the bottom edge of the ground-floor floor. The foundation base of the town wall lay approx. 20 ... 30 cm under the planned foundation of the new building. Structure loads had to be transmitted by a fireproof floor slab. The settlement calculation for the new building /1/ forecast settlements from 2,5 ... 3.5 cm. The form of the bearing structure of the cellar was planned of impervious concrete. As statically planned, loads had to be collected and transmitted downwards by the exterior walls and a bearing centre wall. Bringing in of the town wall remains for load transmission was excluded after a masonry analysis. After that a structural designer and a subsoil expert have suggested a system of load transmission as presented on illustration 2. According to the plan loads will be collected by exterior walls downward up to the level of the ground-floor floor, however, from the cellar floor plane they will be transmitted by a cantilever down to the cellar wall lying inside. With that it was possible to preserve the town wall remains without serious interventions. From now on the zone between the cantilever bottom edge and the top edge of the historic town wall revealed itself as a problem point. On the one hand a settlement cycle of at least ≥ 3,5 cm had to be guaranteed here to prevent a supporting of the cantilever, on the other hand the bottom shuttering of the cantilever for concreting of the basement floor was to be loaded on the town wall with a very low deformation. The first considerations intended to build in polystyrene elements. However, that would have the disadvantage that although available polystyrene elements at extensive load distribution do have indeed a low deformation

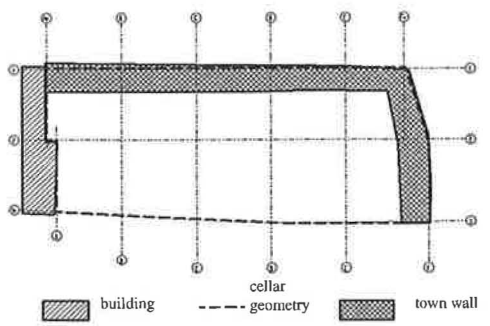

Illustration 1: wall remains and planned cellar geometry

potential allowing a concreting process with a low deformation, but the demanded settlement cycle of 4 cm were not realizable. A removal of the polystyrene elements after the fabrication of the basement floor wasn't possible for reasons of dimensions.

SETTLEMENT UPHOLSTERY

In section 2 one describes the deformation problems of drain mats in the construction state. The problems presented there were assessed as the beginnings of the solution for the present case. Drain mats own a marked stress-distortion behaviour and a deformation potential of up to 80 % of the starting-point. Following demands were to be guaranted for the solution of the problem referred to above:

CONSTRUCTION STATE: no change or very slight change in the position of the reinforcement of the cantilever segment above the town wall during the concreting process

CONDITION IN USE: possible settlement cycle between the cantilever bottom edge and the masonry town wall head of $s_{possible} \geq 40$ mm

To be equally sufficient for both of the demands, the „settlement upholstery"- as presented on illustration 3 - was suggested, tested in laboratory and built in. The sandwich-like system consists of two drain mat layers (d = 20 mm) and three polystyrene layers (d = 15 mm). The polystyrene elements serve to distribute loads and to transmit local peak stresses.
For reasons of time only three products of a manufacturer could be tested in laboratory for use in the settlement upholstery. In the performed series of experiments one has ascertained stress-deformation characteristic lines for individual building stones of the settlement upholstery and the ones of the whole system. A 20 t distance controll press was used for the laboratory examination. The size of the test specimen was 0,5 x 0,5 m. The testing of the individual elements took place with a steady load increase and was broken off at the vertical stress of σ = 380 ... 680 kN/m^2 . The following relief took place at the same speed. Illustrations 3 and 4 present the drawn stress-deformation curves for stress ranges σ_v = 0...100 kN/m^2 and σ_v = 0... 300 kN/m^2. Significant differences were stated between the drainage 1 and the drain mats 2 and 3. The drain mats 2 and 3, in comparison with the drain mat 1, are laminated on both sides with a fleece. By fixing of the polymer thread of the drain mat on the fleece one achieves a clear stiffening. The drain mat 2 has in comparison with the drain mat 3 fewer of the polymer threads. Therefore the measured deformations lie at the same vertical stress in the drain mat 2 slightly (approx. 1 %) above the values of the drain mat 3. The polystyrene elements showed a marked non-linear stress-deformation behaviour. The deformations lay as expected clearly below those of the drain mats at the same vertical stress (approx. 50 ... 90 %).

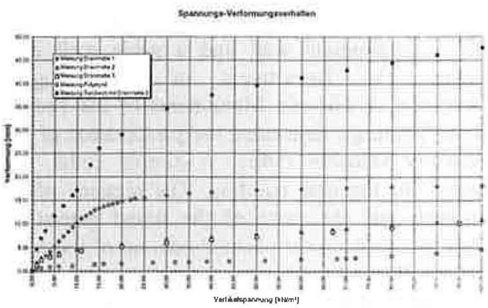
Illustration 3: stress-deformation characteristic lines of individual elements and settlement upholstery / σ_v= 0...100 kN/m^2

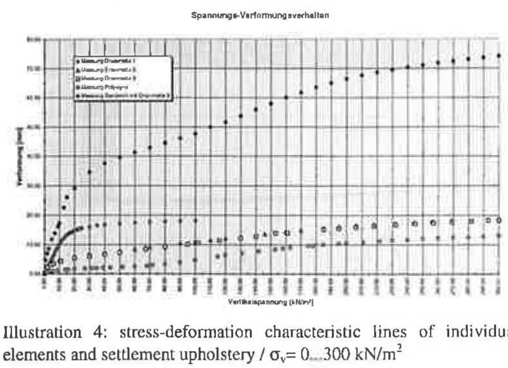

Illustration 4: stress-deformation characteristic lines of individual elements and settlement upholstery / σ_v= 0...300 kN/m^2

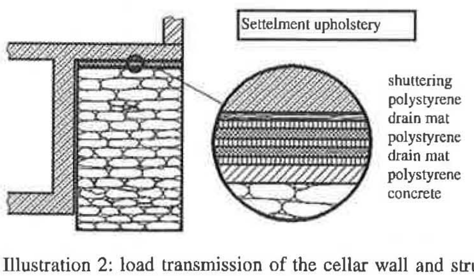

Illustration 2: load transmission of the cellar wall and structure of the settlement upholstery

After the promising single tests further tests with the sandwich-like system, as presented on illustration 2, were carried out. The tests took place exclusively with the drain mat 3, because it demonstrated in the stress range notified of the slightest deformations. It mattered to check with which deformation was to reckon during the concreting process. As concrete pressure was earmarked:

$$\sigma_v = \gamma_{concrete} \cdot d_{slab} + P_{manload} \quad (1)$$

$$\sigma_v = 25{,}0 kN/m^3 \cdot 0{,}30 m + 1{,}0 kN/m^2 = 8{,}5 kN/m^2$$

Illustrations 3 and 4 present the characteristic line of power deformation of the later built in settlement upholstery. At the vertical stress of $\sigma_v = 8{,}5$ kN/m^2 the deformation was measured with s = 15,5 mm . It corresponds to the sum of deformations of the individual elements (2*5 mm + 3*1,5 mm ≈ 15 mm). The test curve together with the polynomial of the 6th degree, as presented on illustration 5, can be approximated with a measure of precision $R^2 = 0{,}99$ for a vertical stress range $\sigma_v = 0 \ldots 100$ kN/m^2 (equation 2).

$$y = 2{,}981E\text{-}10x^6 - 8{,}300E\text{-}8x^5 + 6{,}809E\text{-}6x^4 + 7{,}321E\text{-}5x^3 - 3{,}848E\text{-}2x^2 + 2{,}101E\text{+}0x \quad (2)$$

One can calculate the settlement upholstery deformation for practical constructional engineering with the aid of equation 3 with a sufficient precision (validity range $\sigma_v = 0 \ldots 20$ kN/m^2).

$$s_{calculated} = 2{,}101\sigma_v - 3{,}848E\text{-}2\sigma_v^2 + 7{,}321E\text{-}5\sigma_v^3 \quad (3)$$

where $s_{calculated}$ = calculated settlement of upholstery [mm] and σ_v = vertical stress [kN/m^2]. The vertical deformation calculated with equation (3) amounts to $s_{calculated}$ = 15,1 mm .

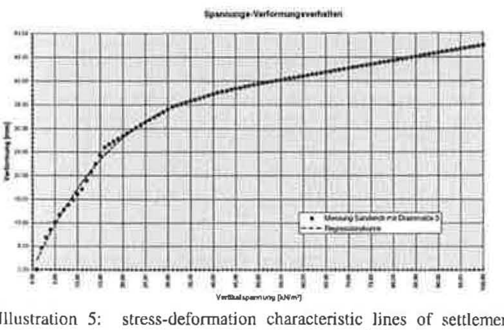

Illustration 5: stress-deformation characteristic lines of settlement upholstery and regression curve / $\sigma_v = 0 \ldots 100$ kN/m^2

The settlement owns a total deformation potential of about 100/300 kN/m^2 unit pressure from approx. 56/88 % of the starting-point. That corresponds to 4,8/7,5 cm. Up to the vertical stresses of 20 kN/m^2 increase the deformations almost linearly. It guarantees a settlement cycle at stronger loadings. The behaviour of the system at complete relief is interesting. The residual test level after relief lay only slightly below the starting-point test level (lasting deformation).

BUILDING CONSTRUCTION & RESULTS OF BUILDING SUPERVISION

The forecast 15,5 mm of vertical deformation of the settlement upholstery under fresh concrete pressure would mean a shift of the reinforcement out of its statically required position. For this reason one has put on a 15 mm thick permanent plywood shuttering upon the settlement upholstery. This planned superelevation had to ensure the position of the reinforcement during the hardening of the concrete. An advantageous secondary effect was to be seen in the load distribution effect of the open shuttering. In parallel with the concreting work the deformation measurements were taken. The measured, calculated and determined in the laboratory deformations are compared on table 1.

The actually arisen deformations correspond to the values determined in advance by the test. 7 days later on the stripped and exposed cantilever edges there was carried out a visual checking of the settlement upholstery condition. Nowhere deformations exceeding the set limit were noted.

Table 1: results of test / calculation / measurements in situ

	Test	Calculation	Measured in situ
Settlements [mm]	15,5	15,1	15.0

CONCLUDING REMARKS AND PREVIEW

The tested settlement upholstery has proved itself successfully in the practical construction work. This built in system is being controlled at present by technology of measurement. For brief loadings one can use the mentioned equation to predetermine vertical deformations of a settlement upholstery. An examination of the stress-deformation behaviour under long-term loading is being prepared at present. The „sandwich" made of drain mats and polystyrene meets demands which can't be met with usual settlement upholsteries made of polystyrene.

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