Interaction of Historical Structures with Undermined Territory

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Summary

Floods and undermining have analogous destructive effects on building structures and decline their lifetime. Load may also result from impeded strain of historical concrete and masonry structures. The paper reports the design of the FEM model for solving interaction between foundation and subsoil. Influence of groundwater level changes on settlement and tensile stresses of structures are taken in account. Settlement of structure with changes of mechanically - physical properties of subsoil, and cracks in masonry and foundation structures are various damages. Cracks and tensile stresses may be eliminated by prestress and grouting. Comparison of Czech and European standard specifications for solving interaction problem, examples of strengthening and static provision of cracked historical buildings and extension their service life are presented.

Keywords: Historical structures, foundation, undermined area, soil – structure interaction, rheological slide joints, post-tensioning

1. Undermining impacts

In order to describe the landscape deformation intensity in the subsidence trough boundary parts, the mining industry uses following geometrical quantities

- s - subsidence [mm],
- v - horizontal shift [mm],
- i - inclination [rad],
- R - radius of bending [km],
- ε - horizontal relative deformation [-].

The inclination (i) and horizontal shift (v) have peaks in the subsidence line inflection point (s) above the working face edge. The horizontal relative deformation (ε) and the landscape bending ($\rho = 1/R$) reach the maximum at about + 0,4 r from the working face edge. Most dangerous for buildings are the horizontal relative landscape deformations (ε). They are positive, if above the subsidence line inflection point (landscape elongation), or negative, if under the subsidence line inflection point (landscape compression) [4].

2. Subsoil model

The proposal of the European pre-standard ČSN EN 1997-1 provides a similar, though less suitable, definition of the deformation zone as ČSN 73 1001. The depth where the compressible soil layers still need to be taken into account depend on the size and shape of the foundation, changes in the soil compressibility, depth, and location of foundation components. This depth is usually the depth where the effective vertical tension caused by the foundation load achieves 20 per cent of the effective tension from the overlying rock. In accordance with ČSN 73 1001, the structural strength coefficient is m = 0.2 for this case. The informative attachment D to the standard ČSN EN 1997-1 provides also examples of possible methods used to subsidence evaluation. The so-called modified elasticity method employs in fact the current subsidence calculation method as given in ČSN

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73 1001, see details in [1], [2], [3].

3. Increase of structure stiffness

Reinforcement of the foundation structures and additional prestressing of the bearing walls in their foundations is of key importance for elimination of tensile stress in the carrying system and creation of other cracks, if any. Before prestressing, it is however essential to reinforce the existing foundation made from the rubble masonry. For that purpose, the injection is placed into the joint between the rubble masonry, and the new concrete foundation ring is combined, using the stud connectors. Uses of piles with the aim to increase the load-carrying capacity of the foundation on the undermined area entail other little-investigated-into risks:

- positive horizontal deformation of the landscape (elongation) results in partial loss of the skin friction
- vertical relative deformation in both directions have been measured in past years in the underlying rock of the buildings. The deformation of this kind is more pronounced that the horizontal relative deformation. The vertical deformation creates negative skin friction, damaging possibly the designed function of such pile.

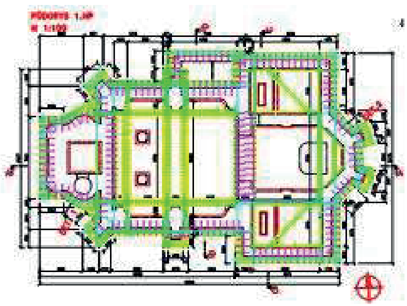

Fig. 1.: Layout extension, reinforcement, and combination of original with new foundations of St. Cross Church

If the combined prestress continuous footing is used, it is not necessary to provide pile foundations generally, or to increase the load-carrying capacity of the underlying rock by injection. The extended continuous footing decreases considerably the contact stress in the footing bottom, and, in turn, the friction between the foundation and underlying rock.

4. Acknowledgements

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5. References

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