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Tensometric measurements for static securing of historical buildings

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Abstract

Often during a reconstruction of historical buildings it is necessary to repair or replace damaged element of the structure by a new part. In such situation it is inevitable to reach a stage when the damaged part is not statically stressed. The deformation tensometric measurement was used to monitor and verify stress changes during reconstruction. Electric resistive strain gauges were glued mainly on the supporting metal structure or directly on repaired parts. In this paper some examples how this method was applied are demonstrated on the three structures:

- Reparation of the sandstone portal in the Prague Castle Picture Gallery
- Measurements of deformation changes in tensile rods for static securing of the lateral walls in the Wallenstein Palace
- Replacement of columns in the Czech National Bank building.

1 Introduction

Basic activity of the Department of Geotechnics of the Institute of Rock Structure and Mechanics is concentrated to experimental methods of rock mass stability and determination of rock and soil properties. Recently our department was asked to co-operate with the Static Office Křístek, Trčka & Comp. and with the Building Firm HOBST at re-development works on three historical buildings in the Prague's centre – Prague Castle Picture Gallery, Wallenstein Palace and Czech National Bank (Trčková et al.[2,4], Živor et al.[3]). This co-operation consists of

monitoring deformation changes during replacement, repair or removal of some construction parts. This paper does not discuss questions related to static problem, but only described a method and results of deformation measurement. This is a good example how the Institute providing rock and soil mechanics research can assist to save valuable buildings.
Electric resistance strain gauges were used for deformation measurements in all described cases.

2 Reparation of the sandstone portal

In 1965 Prague Castle Picture Gallery was adapted from former Imperial horse stables, which are a part of the northern wing of the Prague Castle. These buildings were built in the middle of the 16th Century in Renaissance style and in the Baroque period were re-built.
The horizontal lintel of the Baroque stone portal decorated by cornice and by tympanum was damaged by several joints in one of the gallery rooms (Fig.1). Fall of the lintel segment was expected. Therefore the lintel was secured by two tensile rods inserted in slots of the lower part of the lintel. The tensile rods were anchored by bolts glued inside the wall. Before the start of this work it was necessary to relieve the lintel. In order to lift the tone cornice with tympanum,

Figure 1: View on the Baroque sandstone portal in the Picture Gallery.

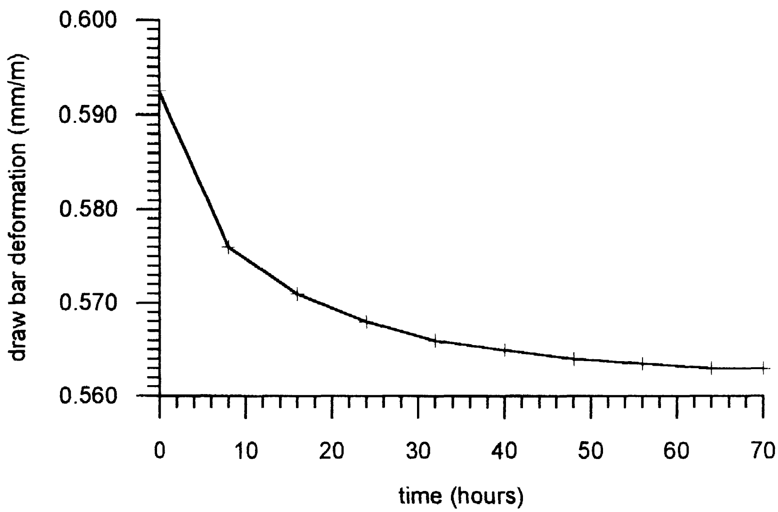

Figure 2: Time dependence of the deformation course after tensile rod activation.

steel construction was built. On this construction strain gauges were situated. During this work tensometric measurements indicating a deformation increase was recorded. When the deformation values (on the basic comparison with laboratory test of steel construction specimen) were equal to the mass of stone portal and masonry over the lintel, the lintel was relieved. Simultaneously stress changes on the upper cornice were observed. After several days the anchors were fixed. During anchor fixation no deformation changes of the steel construction were determined. After auxiliary construction was removed only its uniform unloading was observed. Stress measured on the cornice reverted to values found before the beginning of the work.

Except the described measurements, deformation of the tensile rods was observed during their tensioning on the calculated value of tensile force of 56 kN, which corresponds to the deformation of 0.592 mm/m. Observation was carried out for 70 hours after a given force was reached. During this time the value of the force decreased by about 5% and from the curve behaviour it is evident, that process of deformation nearly stopped (Fig.2). This way control of anchoring of the tensile rods was made.

3 Measurements for static securing of walls

Wallenstein Palace designed by Giovanni Pieroni was built between 1623 – 1630 on the boundary of Renaissance and Baroque (Fig. 3). Palace with large spaces covers an area 30306 m^2 formed by complex of buildings with "Sala-terrena", riding school, horse stables along with four courtyards and architecturally

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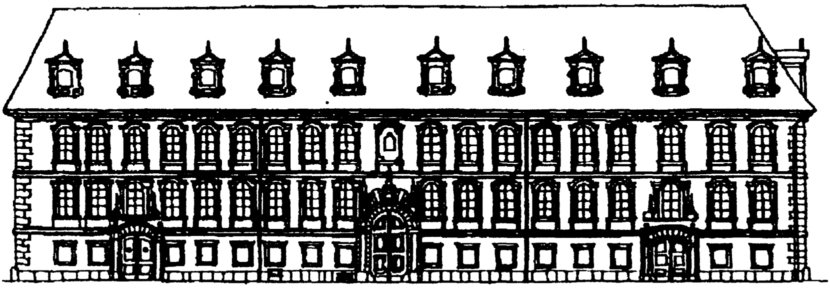

Figure 3: Facade front of the Wallenstein Palace (Staňková et.al.[1]).

designed garden. Stables were rebuilt in 18th Century. Original extensive space of the stables (60 x 8.6 m) was divided by built-in partitions on the several smaller rooms, which was demolished in 1943. The demolition of these partitions damaged static stability of the building and therefore side walls were secured by steel tensile rods, which intersected upper part of the hall about two meters under the ceiling.

Two years ago, it was decided to use this former horse stable for sessions of the Senate of Parliament of the Czech Republic. For this purpose it was necessary to removed one outer tensile rod on each side of hall which hampered the view to hall from elevated tribunes for government and public.

In the central part each of the outer tensile rod a special fixture with glued strain gauges was fixed (Fig. 4). Steel material of the fixture was tested beforehand for tensile loading in the laboratory. Following installation the tensile rod was cut and deformation of fixture was measured for determination tensile force in the tensile rod. In 60 minutes (resp. 30 minutes) the values of deformation were stablized (Fig. 5). Small intensity of force found by deformational measure made it possible to remove these tensile rods without any influence on the building static stability.

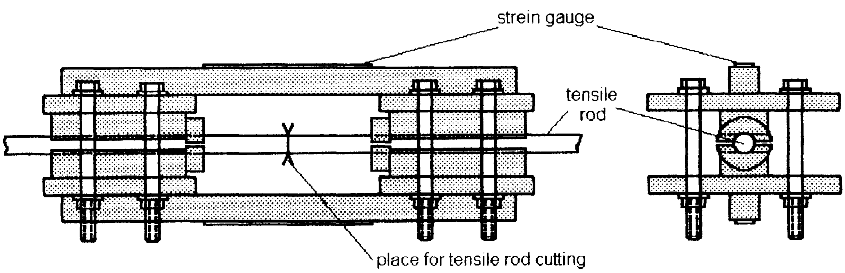

Figure 4: Scheme of steel fixture for placing on the tensile rod.

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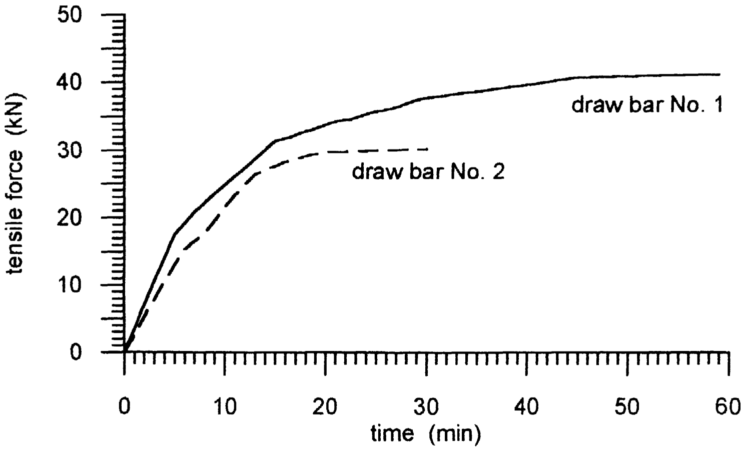

Figure 5: Changes of the tensile force in time after tensile rod cutting.

4 Replacement of the columns

Building of the Czech National Bank designed by Trantišek Roith was built between 1936 – 1938 and it is a one of the significant representative of Prague Monumentalism which binds elements of Funkcionalism with elements of national-historical architecture and culture (Fig. 6). It is a monumental palace with granitic facing, which was equipped by best technology in the time of its construction.

Figure 6: Part of the facade front of the Czech National Bank (Staňková et.al.[1]).

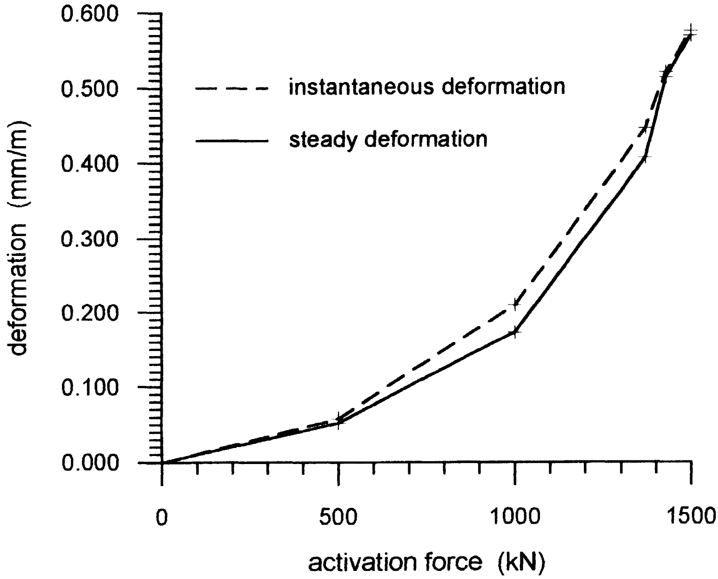

Figure 7: Dependence of the deformation on activation force.

At the present time a total re-development of the building is carried out. The re-development was implemented to preserve exterior of the building, but interiors have to be adjusted to new requirements of the modern bank.

During reconstruction two neighbouring reinforced concrete columns located in bank basement had to be removed and one of them replaced by new steel column. On the upper part of the columns an iron girder was fastened for ceiling supporting and for follow-up relieving lower part of the columns by hydraulic jacks. During activation of the relieving a deformation (extension of the column) was measured in the lower part of both of the columns. Strain gauges were glued on steel reinforcement on the opposite sides of the columns. Deformation changes provided data about decrease of loading. Forecasted value of the total deformation was determined by calculation on the basis of estimated properties of the reinforced concrete. The measurement was carried out continuously during whole relieving of the columns. Forces, applied to the hydraulic jacks, were increased to the final calculated deformation of column by several steps (Fig. 7). At Figure 7 both instantaneous and steady (after some time pause) deformation on the one of the columns are demonstrated. Time dependence of the deformation during particular relieving steps on the same ones is illustrated on the Figure 8. Required value of deformation was reached at force of 1430 kN. Owing to a hydraulic jacks arrest the decrease in deformation were observed. Therefore the activation force was increased to 1500 kN. After arresting the deformation dropped again to the required value.

In case of the second column the same procedure was used.

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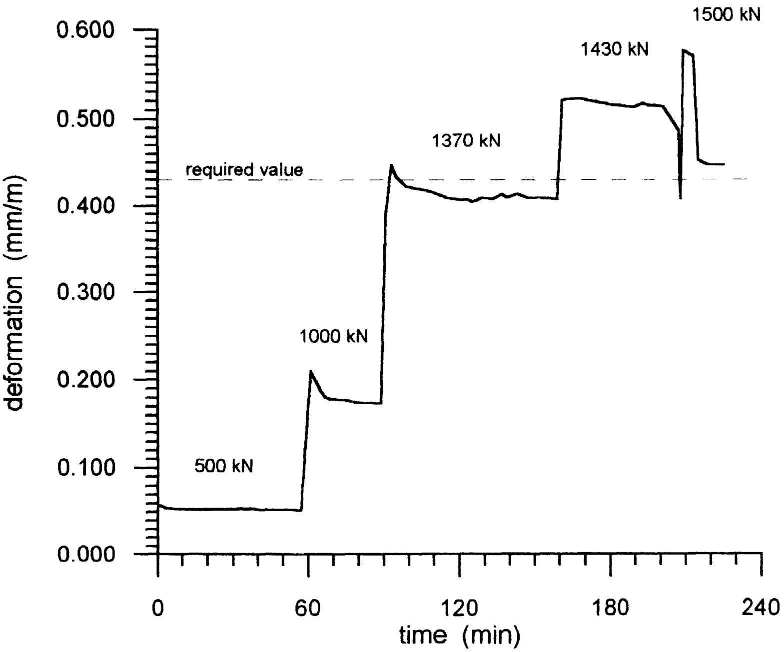

Figure 8: Time dependence of the deformation during particular relieving steps.

Correctness of the tensometric measurement for sufficient unloading of columns was confirmed when no complication following removal of the lower parts of the columns were noticed.

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