

MODELLING OF SENTAB TYPE HIGH PRESSURE WATER PIPES AFTER DETERIORATION

György L. Balázs, Olivér Attila Czoboly, Éva Lubláy, Péter Zimmer

Summary

In Hungary the production and application of the Sentab water pipes started in 1969. These pipes have a very important part in the water supply system of Budapest and numerous other places. Overall 360 km Sentab type water pipes were installed in Hungary. In our research we analysed the production technology of the water pipes, to locate the main possible causes of the deterioration. We carried out non-destructive tests on uncovered Sentab water pipes that are still in use. We also carried out destructive tests on Sentab pipes that are out of use. In our research we analysed what kind of processes are the main causes of the deteriorations.

We carried out finite element modelling of the Sentab type water pipe in order to determine the load bearing capacity of the pipe, in case some of threads of the spiral tendon were damaged. So we can estimate the residual load bearing capacity from the visual observation of the rust spot at the concrete surface.

Keywords: Deterioration of Water Pipe, Sentab Pipe, Prestressed Concrete, Non-Destructive test, Destructive Test, Modelling.

1 Introduction

Overall 360 km Sentab type water pipes were built in Hungary (Szentendre Factory of the BVM Concrete and Reinforced Concrete Works) between 1969 and 1988. The Sentab type water pipes were constructed from prestressed concrete with relative large (500-1200 mm) inner diameters. These pipes were used as parts of the main drinking water lines, so it is very important to prevent any kind of failure. The failure of the pipe can disrupt the drinking water supply and it could make a significant financial damage or endanger human life too.

In 2012, when a 1000 mm diameter Sentab water pipe failed, and because of the high pressure water leakage, a 15 meter wide and several meters deep hole was created (Fig. 1). Parts of the road pavement were carried away 20-50 meters by the water.

In the last years we tested 8 elements of uncovered but still in use Sentab water pipes and 10 elements already out of use [1]. We summarised this experimental study in this work.



Fig. 1 The failure of Sentab type water pipe in 2012

2 Production of Sentab type water pipes

The Sentab type water pipes were constructed in Hungary with Swedish licence and Soviet technology. The Swedish SENTAB-Trickrör firm has developed the vibrohydraulic compression technology for the production of prestressed concrete pressure pipes [2].

The pipes were constructed from B500 (in this time it is C30/37) grade concrete using $500\text{--}550\text{ kg/m}^3$ cement and a water cement ratio between 0.35 and 0.38 [3].

The length of the pipes was approximately 5 meters. The designed concrete cover was 12 mm [4].

Longitudinal and spiral tendons were used during the production of the water pipes. The longitudinal wires were tensioned to the outside of the moulded shell. Then the spiral wires were wound onto the eye bars. First the pipes were compacted by vibration in an upward position. Then tensioning of the spiral wires and compaction was carried out by leading cold water under 30-35 atm. Pressure between the inside mould core and a rubber sleeve. Constant water pressure had to be maintained during the whole curing process, and hot water was used for the inside heating [2]. The pressure was maintained until the strength of the concrete was more than 40 N/mm^2 .

3 Detected location of failure

In Fig. 2 we summarized the observed typical failure locations on the Sentab type water pipes. We observed typical rust spots at the end section of the pipes close to the end of the longitudinal wires (Fig. 2.a). The size of the rust spots were approximately $4\times 4\text{ mm}$ on the concrete surface near the longitudinal tension members. We experienced numerous small rust spots on the $100\times 1000\text{ mm}$ area, close to the mould joints (Fig. 2.b). During the experiment we found the sealing tape approximately 10 mm deep under the surface at the mould joint. After laboratory tests we concluded, that the cement slurry may have leaked out near the sealing tape, so the porosity of the concrete was higher close to the mould joints compared to other places on the pipe. On most of the pipes close to the end of the sheath there was a specific rust spot (Fig. 2.c). During the destructive tests we discovered the anchor plate of the spiral wire under the rust spot.

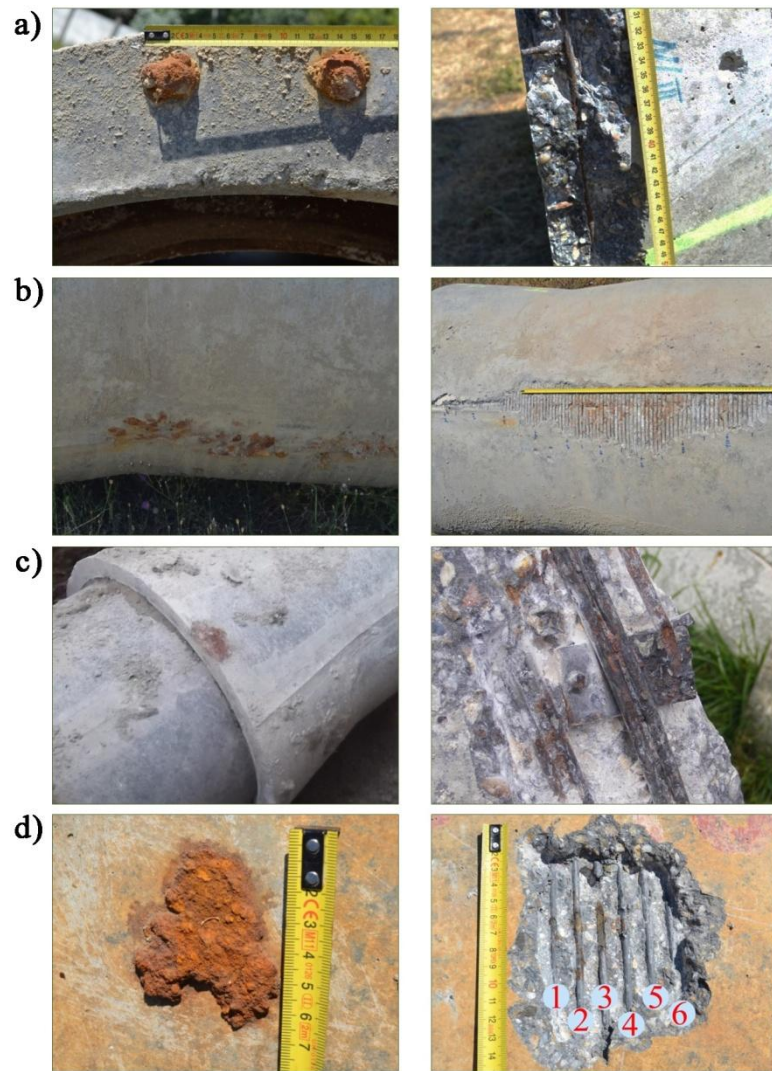


Fig. 2 Typical types of deterioration of the Sentab water pipes before (left column) and after (right column) destructive tests, a) corrosion of the end of the longitudinal wires, b) rust spot close to the mould joint, c) corrosion of the anchor plate of the spiral wire, d) specific rust spot on the surface

4 Modelling of Sentab type water pipes after deterioration

Based on our experimental studies and the production technology we made the finite element models of the Sentab type water pipes.

We used SOLID 185 finite element (Ansys software) with 8-node three-dimensional elements. Three degrees of freedom of displacement were used by the nodal points. We defined 5 layer through the wall of the pipe, so the average finite element size was fifth of the wall thickness. In the models we varied the number, the location relative to each other, and the location of the completely corroded wires in the pipe walls (Fig. 3).

We summarized the results of the finite element modelling on diagrams. The diagrams specify the critical water pressure when cracks appear as a function of the state of the corroded tendons.

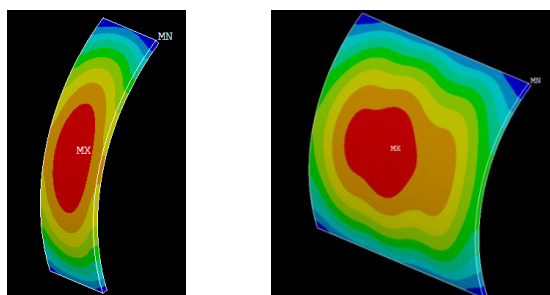


Fig. 3 Stress distribution in the surround one rust spot (left) and three rust spots (right)

5 Conclusions

Overall 360 km Sentab water pipes were installed in Hungary between 1969 and 1988. The monitoring of these pipes due to soil and pavement coverage is difficult. It is very important to prevent any collapse of the Sentab type high pressure water pipe.

In our research we analysed what kind of processes are the main causes of the deterioration of the Sentab water pipes. We realized that the locations of the failures were where the concrete cover, due to production errors, was thin and had high porosity.

Numerical analysis of Sentab water pipes were carried out by linear elastic finite element modelling. Based on the calculations we can estimate the residual load bearing capacity from the visual observation of the rust spot concrete surface, which is a significant help at maintenance of the drinking water system.

References

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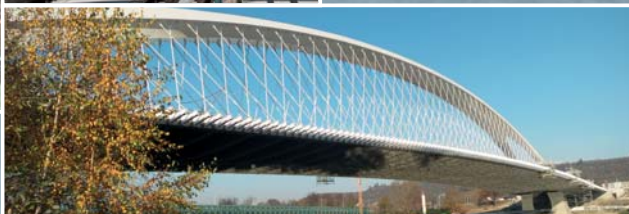
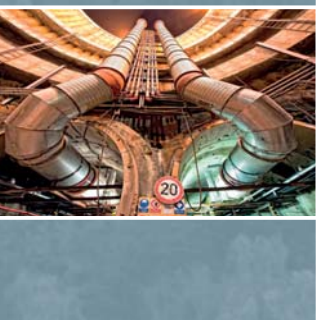
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