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Possible repair methods of concrete retaining wall

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Abstract This document gives instruction and information about remediation of transport retaining walls. Concrete and reinforced concrete retaining walls in terms of proposal and workmanship in comparison with many other structures can be considered less demanding. Unfortunately, this fact does not apply every time and we have to solve compromise proposals for remediation. Calculation of load would also not be problematic even for a less ambitious structural engineer. Also, design principles, and most simple form should not bother anyone. The ways of remediation described in this article can be applied to other concrete structures, whether they are retaining walls and noise barriers along roads or railways.

Keywords Static and structural defects in the retaining walls for transport structures, remediation, concrete walls, causes of defects, weathering, load, the assessment of defects, waterproof concrete, examples of remediation.

JEL L99 – Industry Studies: Transportation and Utilities - Other

1. Introduction

Concrete and reinforced concrete retaining walls in terms of proposal and workmanship in comparison with many other structures can be considered less demanding. Unfortunately, this fact does not apply every time and we have to solve compromise proposals for remediation. Calculation of load would also not be problematic even for a less ambitious structural engineer. Also, design principles, and most simple form should not bother anyone.

2. The main defects of retaining walls in transport (and other) structures

The main defects frequently encountered in retaining walls are mainly:

- Excessive length of expansion joints. It should be around 15 meters and can be designed for greater lengths, but this fact mainly increases the cost of a larger horizontal reinforcement.
- The base is designed with insufficient dimensions based on low quality soil survey. When faulty design and workmanship, there are several ways of remediation, which requires higher costs and thus it may also include other negative effects.
- When calculating the active pressure there is not considered surcharge for a retaining wall, which is then reflected inter alia in the lower stability of the wall.
- Small cover to reinforcement, taking into account weather conditions. In a short time unpleasant reinforcement corrosion is manifested.
- The designer suggests lower class concrete. An object is exposed to the weather and adverse impacts from all sides. With regard to the long-standing durability of the object, higher class concrete is appropriate.
- Construction joints are not sufficient. There are numerous tools that are not being used.
- Waterproof concrete is proposed at the expense of savings of waterproofing. Concrete does not often meet this requirement and so many problems have arisen by repairing these walls - see example.
- When designing there is lack of attention paid to shrinking of concrete. This problem can be recently considered the most significant.
- On the rear obverse of the wall (when working with waterproof concrete) it is desirable to place a foil DELTA and layer of gravel, which seduces the water to the base and into the drainage.
- Special attention is not usually paid to the upper obverse of the retaining wall, which is most exposed to the outside environment - temperature, rain water, etc.

3. Interesting examples of retaining walls remediation

There are a few resolved remediation cases of retaining walls; the most interesting are listed below:

- A retaining wall at the railroad with a length of 400mm, with distances of expansion joints up to 40m, with numerous vertical cracks.
- A retaining wall of low quality concrete. By sloughing of surface layers the reinforcement with advanced corrosion was uncovered.
- A retaining wall with expansion joints with a length of 33 m from low quality concrete and insufficient reinforcement (dimensions above the base strip).
- A retaining wall made of waterproof concrete (length of 60 meters), which has numerous cracks and completely insufficient horizontal reinforcement (diameter of 8mm by 200mm). Waterproofness is not guaranteed.
- Several retaining walls in Prague with low quality construction joints and insufficient reinforcement. Various possibilities for removing gross defects.
- An improperly designed and constructed concrete wall for reducing transport noise impact with many cracks. Remediation required, inter alia, with the creation of more expansion joints.
- Retaining walls at the entrance to the underground garage. Details are presented in the next part of this contribution.

4. Remediation of retaining walls at the entrance to the underground garage - example

Retaining walls at the entrance to the underground garage were built in 2001, which in a short time after demoulding began to show cracks, the cause was to be found in the shrinkage of low quality concrete. The cross section of the wall is shown in Figure 1, and cracks on the wall at one side are shown in Figure 2. This cannot be left in its current condition and, therefore, in 2005 the remediation process started; it consisted of grouting the cracks and leaking concrete that had to be waterproof. Detail of grouting is shown in Figure 4 and porous concrete is illustrated in Figure 3. This remediation process was not too successful and cracks, of course, to a lesser extent, began to appear later.

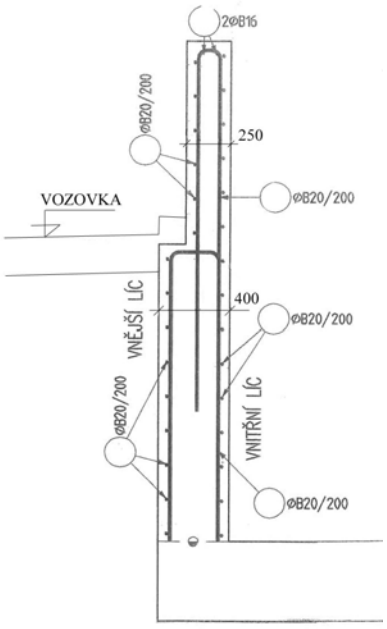

Figure 1. Cross section of a retaining wall

As particularly on the upper inclined surface more cracks were formed through which water penetrated into the walls, and on their both sides unpleasant white efflorescence appeared, possible ways of remediation were proposed.

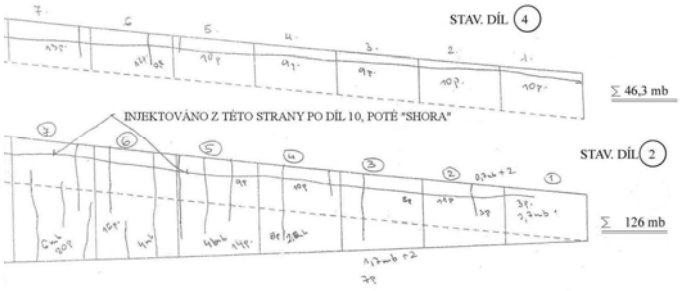

Figure 2. Technical record keeper of cracks on the internal face of the wall (cut)

Variant 1

It consists of extending transverse cracks on the upper face of the wall to the width of 12-15 mm, to a depth of cover layer, ie 20-25 mm. These gaps should then be filled with a flexible sealant (color of concrete). Remark: it is recalled that the recommended width of the cut is necessary because of volume changes when the small width of the gap is not able to exercise the flexibility of the material in a gap.
Filling the cracks will prevent water penetration into a greater depth and the creation of efflorescence on the wall sides to a depth of about one meter will be prevented. The effectiveness of this fix can last several years, but not on a long-term or permanent basis.

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Variant 2

With this method it is advisable to perform grouting of current cracks of width larger than 0.3 mm with customary epoxy resin. Subsequently, on the upper face of both parapet walls the following steps should be performed:

a) Attaching the foil of a thickness of 2-3 mm (color of concrete) about 10 mm wider than the width of the wall.
b) Attachment of metallic strip of a thickness of 2 mm on the upper face of the wall with overlapping and bending on each side of 20 mm. The plate is metalized color of concrete, or otherwise modified.

In both cases the penetration of water into cracks and formation of efflorescence on the walls will be prevented.

Figure 3. Low-quality waterproof concrete

Variant 3

This is a radical and final variant, comprising:

- Cutting through the parapet wall at two points, ie thirds of the length of the walls to create expansion joints at a distance of 33/3 = 11 m, and to a level of the lower wider wall.
- The elimination of the top layer of concrete to the existing reinforcement.
- The addition of transverse and longitudinal reinforcement in a degraded part.
- Concreting the missing part using non-shrinking cement. In the case of interest a new layer could be extended with the overlap of 2-5 cm with the eaves edge.
- Correction of newly formed expansion joints in cutting areas.

Variant 4

A compromise solution would also be laying the concrete slabs with a transverse gradient in quality mortar and overlap over the wall, just as it is done by common fence walls. Modification of transverse joints between prefabricated components requires special attention.

Figure 4. Grouting of low-quality concrete

Variant 5

This method consists in keeping the walls in the current state, ie., all cracks and damage. The walls and the upper face is topped with glued toughened polystyrene of a thickness of 30 mm, fitted with structural plastic net and a layer of a plaster of epoxy in a good quality and weather resistant. In other anticipated changes in volume of concrete will show cracks in a limited extent under the abovementioned cladding, which is satisfactory because defects are not visible. The core of this proposal is to create a long-lasting quality wall surface without cracks and the paint is the same color as concrete, which was the investor's wish.

5. Conclusions

The article describes several ways in which constructions can be remediated and their life can be extended. The aim of the article is to draw attention to common and quite unnecessary gross defects in projects and implementation of concrete retaining walls.

Incomprehensible is the fact that even new constructions immediately after the build require remediation. Note that not always it is worth to design the structure only for ultimate limit state and design must take into account the durability of structures. To avoid the necessity of remediation shortly after the construction of retaining structures, care must be taken primarily on their professional construction according to the static design, in compliance with the structural principles and guidelines for the implementation of concrete and reinforced concrete structures. We recommend that new structures are designed not only to ultimate limit state, but also to limit state and serviceability limit state of cracking.

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