Specific problems of engineering geological survey of sewer constructions

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Abstract. Sewerage constructions, unlike other types of constructions, require a certain specific methodological approach based on the fact that we have to deal primarily with the issue of earthworks related to the extraction of soils. Furthermore, it is necessary to deal with the hydrogeological conditions that affect the implementation of sewerage structures from multiple angles. The presence of water changes, for example, the physical-mechanical parameters of soils. The actual implementation of sewerage structures can change the flow of groundwater in the case of poor implementation of the backfill. All these specifics are pointed out in the presented publication.

1. Introduction

Sewer constructions are a special phenomenon in various types of civil engineering. Since one of their dimensions is significantly dominant, this first boundary condition determines their specific engineering geological research and implementation. The second boundary condition is the fact that there will be no load on the engineering object because we place the sewer pipes in the excavation, which we fill. Therefore, we do not have to solve the issue of load capacity, which is a basic condition for the implementation of most engineering structures. However, we must address the issue of settlement in a narrow specification for uneven settlement, because often there are road constructions above the sewer structures. This would cause inequalities on roads that are not in demand. Many aspects of sewer constructions are dealt with by many researchers [1-6]

2. Engineering-geological needs for sewer constructions

One of the most important boundary conditions for the implementation of sewer constructions are geomorphological conditions, which determine several specifics of their design and implementation. This means that if we have flat terrain, then it is more likely that the extractability will not change as significantly as in the case of terrain with a bigger slope. For sloping terrain, the geological structure tends to be more heterogeneous. At the same time, this condition applies to hydrogeological conditions, because in flat terrain their change is less likely. Conversely, flat terrain is more likely to have an aquifer with a free surface, and there is also a higher probability that the groundwater level may be closer to the surface. The more the geomorphology is fragmented, the higher the costs of the construction of sewers, because there is a greater probability that there is a change in geological and geomorphological conditions, which ultimately leads to an increase in the cost of construction.
A very important specification of sewer constructions is the material that is used for pipes. These are mostly plastic materials that are not subject to corrosive influences. However, if for some reason we have to use metallic materials, then we must take into account the aggressiveness of water for metal constructions. In such cases, the chemical composition of rock materials plays an important role, which directly determines the aggressiveness of water.

The most basic subject of engineering geological or geotechnical survey of sewer constructions is the feasibility of earthworks. This is given by the extractability class of the rocks. This property is typical for certain countries such as the Czech Republic, but in some other countries, it is not used and is expressed by rock detachability. Extractability class determines the method of the feasibility of excavation according to the type of mechanization in direct connection with the energy required to perform this work and in connection with the wearing out of tools for disconnection. This means that it is the most important characteristic in terms of determining the price of earthworks. In this case, it is very important to determine the prices of individual classes of extractability with a large volume of earthworks because it can be a very significant part of the price of construction. In the case of sewer constructions, this is a clear fact, because most of the price is earthworks. It is very important to distinguish whether the foundation soil can be excavated with an excavator or not. If possible, soils are dredgerable and if not, they are nondredgerable. The price of earthworks may be cheaper in the case of dredgerable soils and may also be carried out by a larger group of companies. The reason for this statement is simple because the excavator is the most widespread machine for earthworks.

A very important aspect of the implementation of sewer constructions is to ensure the stability of the trench walls. If we evaluate the factors that are important in this context, the most important aspect is the nature of the soil material forming the walls in combination with hydrogeological conditions and the depth of the groove. The greater the depth, the greater the demands on stability. If the hydrogeological conditions are such that the groove is partially or completely underwater, then the difficulty of ensuring stability increases. From the point of view of hydrogeological conditions, their change has the greatest influence. This means that if there are rapid changes in the groundwater level, the effect on stability increases. Of course, the physical-mechanical properties of the foundation soils are very important. The lower the shear strength of soils, the more difficult it is to ensure stability.

Another specific feature of engineering geological research in sewer constructions is the acquisition of a sufficient amount of material for the backfilling of pipes. If there is no suitable material for this purpose in the excavation, then it is necessary to obtain another source of material from adjacent land which will provide such material. The backfill and backfill must comply with the fact that the pipe overburden must not be deformed when it is compressed, and therefore sandy soils are usually used for this purpose. The pipeline must not be laid on sharp-edged fragments, both in connection with the soils used and in connection with the remnants of the fragments, which were created by blasting work in the rocks. These can subsequently cause damage to the piping.

One of the most important problems of sewer constructions is the provision of suitable soil material (a type of material and physical-mechanical properties, especially density and loosening) into the embankment of the sewer trench. The reason why this issue is so important is that if we inappropriately change the embankment of the trench compared to the original state before the excavation, then we can cause a change in groundwater flow. This change then causes the land to get wet or dry out. Which, if we do not want to, we consider the situation to be an inappropriate intervention and at the same time a legal problem. We must not change the hydrogeological conditions of the land without the consent of the owner or without the need to change them. However, there are also cases when we use the trench of the sewerage object and its embankment as a drainage element. This case is the second extreme of the mentioned issue. This means that we must pay important attention to this aspect because if this is not the case, the consequences can be serious.

If we are doing a sewerage project, it is appropriate to perform geological mapping on small scales such as 1: 1,000 to 1: 5,000. It would also be appropriate to perform geophysical measurements in a longitudinal section located in the sewer route (in fact this rarely happens and survey it is carried out on
the basis of boreholes or excavated probes, or in certain states on the basis of penetration probes). Based on the interpretation, then perform a drilling survey or excavated probes, which would be located in the places of the detected quasi-homogeneous blocks. Based on this, a longitudinal engineering geological section will be compiled, in which the individual geological bodies (layers in the case of sedimentary rocks) would be displayed with the designation of the foundation soil class (especially the extractability class) and with the designation of hydrogeological conditions. Unfortunately, in practice, this rarely happens. Excavators often dig without any project and the actual price is then determined according to the identified extraction classes during the construction of sewers. However, this approach is very risky and uneconomical in areas where the geological construction is complicated, which will cause the following problems between the construction and the investor of the construction.

From the point of view of soil extractability, the most important thing in the survey is to find out the distribution of rock and weak rocks and soils, both vertically and horizontally. This paragraph deals with the geological conditions and properties of the rocks on which the extractability depends. A major problem for the implementation of sewer constructions is the existence of rocks because the construction is significantly more expensive due to the high resistance of rocks to disengagement. In the case of weak rocks, the size of rock fragments plays an important role. The principle is that the larger the rock fragments, the worse the extractability. All this is related to the character and distribution of discontinuities in the rock massif. In the case of soils, it is very important whether they are sandy, gravelly, or fine-grained rocks. For fine-grained rocks, the consistency of the soils is decisive. This means that hard and solid soils have a much more difficult extractability than, for example, a soft consistency.

Within this issue, it is important to focus (what to focus on during the survey) on what needs to be addressed more in engineering, geological, or geotechnical survey. First, it is necessary to focus on the sections where it rises to the surface of the rock. Here, construction will be more expensive and technically demanding (for example, the use of blasting works, hammers). Another important aspect is to find out whether there is a rock base in the route under construction to the depth of the excavated sewer trenches. The closer the rock base is to the surface, the more expensive the construction. If there is a rock base, then of course it makes the construction more expensive and it is also necessary to adapt the chosen technique of excavation work. The bedrock is often related to the pre-Quaternary bedrock, but this is not always the case. Sometimes the pre-Quaternary substrate may be formed by soils. The thickness of the soil cap and its character is related to this issue. The more powerful and weathered the soil cap, the lower the cost of earthworks.

Another aspect that we need to focus on is the hydrogeological conditions, especially we need to focus on sections where the groundwater level is located near the surface (shallow groundwater level). The principle is that the closer the surface is to the surface, the more difficult and expensive the implementation. It is often necessary to use sheeting and the increase in load is also associated with pumping during implementation. It is also necessary to distinguish whether it is an aquifer with a free or tense surface. If we have a section somewhere where there is a tense level, then the implementation is even more complicated and is technically more demanding and expensive. For hydrogeological conditions, we still have to consider the possibilities of potential inflows. Another thing that we must consider is the fact that if we reduce the level during pumping, then it is necessary to determine the impact on the environment in terms of possible damage.

As part of the design and implementation of sewer constructions, we must take into account specific complications, which are partly different from most other types of constructions. This generally applies to all line structures, but sewer systems all the more, because excavations always take place in the geological environment. Based on this fact, combined with the fact that the sections are long, the sewerage structures have to deal with a huge number of conflicts of interest, intersections with other line networks, product pipelines, buildings, etc. This thing needs to be given great attention, because for example Optical, electrical cables can cause large financial losses, damage, but also endanger human safety. Therefore, the project preparation of a conflict of interest must be very careful. Other conflicts of interest are also potential excavations of archaeological or natural monuments.
The realization of construction sewerage requires the following engineering geological findings. These are the feasibility of earthworks, hydrogeological conditions, stability of the area along the route, navigability of the terrain, the possibility of obtaining soil material for backfilling and backfilling, demarcation of extremely low bearing soils at the bottom, excavation, assessment of the nature of the excavation and the need to pipeline. Some of these parameters have already been discussed in the previous text, so only those parts of the parameters that have not yet been described will follow.

If we evaluate the stability along the route, an important aspect is the occurrence of existing slope deformations or the possibility of their possible activation, for example, by digging a trench. We cannot always avoid slope deformations. It is evident that it is not possible to build a building in active landslides. If we perform work in stabilized slope deformations, so the rule applies that the implementation of sewerage facilities must not reduce the stability of the slope. On the contrary, it should increase it, for example, by lowering the groundwater level. The solution to improve stability is to place drainage in the lower part of the sewer trench. When guiding the route over a slope deformation, the variant guided by the slope always takes precedence. However, this needs to be done following the landowners, who may have a well in this area. Or there are often springs with sources of drinking water on slope deformations, which means that it is not possible to change the hydrogeological conditions in this case.

Another factor that we must address in sewerage constructions is the navigability of the terrain surface. We have to deal with this in connection with the approach to the sewer line, which means that the equipment manipulates here in a certain lane along the route. Here we must define sections that are extremely unbearable, such as swamps, peat, or sections that are unbearable during the season. This occurs, for example, at the beginning of spring when the snow melts in combination with precipitation when the consistency of fine-grained soils is changed. This causes trucks to sink and the soil to stick to the wheels, which increases the cost of subsequent landscaping and pollution of the surrounding asphalt driveways.

Although sewerage structures are not demanding for bearing capacity, there are certain exceptions, which are extremely low bearing types of soils. Such sections can be swamps, peat, organic sediments near streams and rivers, both recent and fossil. In such sections, we must ensure the replacement of foundation soils or other improvements in the properties of foundation soils.

We solve another factor of route accessibility from 3 points of view. The first point of view is to choose the approach to avoid terrain impassable sections caused by geological causes. Such sections are sections of morphologically fragmented rocks. Another case is sloping with an extreme slope, which is mostly genetically linked to the occurrence of rocks. The next case may be sedimentary soils such as organic compressible foundations, etc. The second point of view is to distinguish the arrival of different types of equipment because excavators can overcome certain low-bearing soils thanks to their support systems, while trucks sink easily in such terrain. The third point of view is the correct timing of arrival in relation to climatic conditions. If we can influence the arrival of technology in time, then it is necessary to choose a drier period.

The penultimate factor is the assessment of the nature of the excavation of the sewer trench. The excavation is a material that we extracted during the excavation of the sewer trench. Here, the principle applies that we cannot use the excavation in the upper part anywhere, because it is necessary to assess it in terms of its further agricultural use. This part of the soil needs to be managed following the protection of agricultural land. These are especially the sections in which it is found in Aeolian loess sediments, which are valuable agricultural land.

The last factor is the possible need to extrude the pipe. This is used in sections where we cannot excavate a sewer trench. In general, the feasibility of these technologies is related to the extractability and detachability of rocks, the lower the extractability and detachability class, the easier and cheaper the application of extrusion technologies. Another principle is that the maximum extrusion force of the station must be greater than the maximum resistance of the soil on the cutting edge in combination with
the maximum friction on the casing in the realized soils. Furthermore, we must ensure the stability of the face, both at the start and during the implementation, so that there is no flooding and subsidence of the terrain. It is also necessary to ensure the feasibility of the starting shaft, for example using sheet piles, piles or a sloping excavation.

3. Conclusions
Sewerage work in comparison with other types of buildings is a relatively simple engineering object. However, they require a specific approach in which it is necessary to apply the empirics from previous implementations. This means that if companies implementing this type of construction should choose engineering geologists, geotechnicians or designers who already have this empiricism. A major shortcoming of the implementation of sewer constructions in the Czech Republic is the fact that many sewer constructions take place without prior engineering geological or geotechnical surveys. However, this brings several difficulties, which cost the investor and the implementer increased efforts and costs, and in some cases, it causes a number of damages. Another common shortcoming is the fact that excavators do not use the results of the survey and carry out excavation work only out of knowledge of conflicts of interest, which only consider the location of certain existing networks. If the engineering-geological survey is carried out well, then cities or municipalities can use it for certain other needs. For such purposes, it may be possible to drain certain plots that are wet and cannot be used. In the case of the combined use of the sewerage structure and the drainage system, there is a cheap possibility to make more useful use of the ongoing construction of the sewerage system.

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