Analysis of risk assessment and law basis for construction of underground structures

Analiza ocene tveganja in pravni okvirji gradnje podzemnih objektov

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Review paper

Received: February 3, 2014
Accepted: March 1, 2014

Abstract

In the construction of underground structures are always present risks due to unexpected ground conditions, the most basic goal is to provide stability in the planning and construction phase. Due to influence of parameters, which are known as random variables, is expedient to develop risk analysis with probabilistic approach, which enable to research the reliability of groups of data from geotechnical investigations and safety against the failure. It is also important to have carefully determined contract relation and obligations between the client and the contractor. In this article there will be represented risk assessment for basic stability reliability of underground structure and general overview of valid legislation in the Republic of Slovenia for the field of structure construction, set of laws, international recommendations and guidelines and law harmonisation at construction of the underground structures and divisions of risk between the subscriber and the contractor.

Key words: underground structures, risk assessment, probability approach, reliability index, construction contract

Izvleček

Pri gradnji podzemnih objektov so vedno tveganja zaradi nepričakovanih hribinskih razmer, najosnovnejši cilj pa je zagotavljanje stabilnosti v fazi načrtovanja in gradnje. Zaradi vpliva parametrov, ki imajo lastnosti naključnih spremenljivk, je smotrno izdelati analize tveganja z verjetnostnim načinom, kjer se lahko preveri zanesljivost skupine podatkov iz geotehničnih raziskav ter varnost pred porušitvijo. Pomembno je tudi, da je natančno določeno pogodbeno razmerje ter obveznosti med naročnikom in izvajalcem. V članku bo predstavljena ocena tveganja za osnovno stabilnostno zanesljivost podzemnega objekta in splošen pregled veljavne zakonodaje v Republiki Sloveniji za področje graditve objektov, zakonikov, mednarodnih priporočil in smernic ter pravno usklajevanje pri gradnji podzemnih objektov in delitvi tveganja med naročnikom in izvajalcem.

Ključne besede: podzemni objekti, ocena tveganja, verjetnostni način, indeks zanesljivosti, gradbena pogodba
Introduction

Construction of underground structures is, because of its specificities, placed at the most demanding constructions with present risks due to unexpected ground condition. In spite of most contemporary knowledges and advanced global technology, construction of underground structures is an inimitable process with present risks. Unexpected ground conditions can cause rock mass failure during excavation, invasions of ground water, changes within structure and firmness of the ground, excess deformation and the injury of people and property. It is always the first and basic goal to ensure the stability of the underground structure in the planning and construction phase, stability must be ensured directly during excavation. Ground stability reliability, load-bearing support elements or system ground-support against failure or excess deformations must be adequately verified, evaluated and analyzed. Professional approach also depends on the principle of responsibility, conscientiousness and morality of the clients in the construction, because some risks can be expected but absolutely all risks are can't be expected. Due to the increased level of risk, and a large number of influences, ground and material characteristics, which have by physical laws properties of random variables, it is adequately to create a risk analysis with a probability approach. The statistical methods and tools can check the reliability of the geotechnical surveys data and measurements, reliability and safety against failure of individual structure or the whole system in interaction ground-support.

Risks at the construction of underground structures

Risk management means skill which represents making decisions with a certain degree of uncertainty. By the conclusion of the construction contract contractor undertake responsibility to achieve the final result which means to built the structure or other construction work, and he takes over the risk that this result will be finaly achieved[1]. Since the conclusion of the contract until its fulfillment passing a relatively long period in which it can occur a number of business risks. Therefore it is necessary to determine rules before the conclusion of the contract, about which client is involved to negative consequences of the realization of these risks[2].
Unforeseen events and underground structures stability

Correspondently with second paragraph of 653. part of OZ are (necessary) unforeseen works that which must be done urgently in order to ensure the stability of the structure or to prevent the damage, the main cause of that can be unexpected difficult nature of the ground, unexpected water or some other unexpected event. In the project documents unforeseen work are not provided because they are unpredictable emergency work. Correspondently with OZ contractor may carry out such works without previously acquired subscriber’s consent if such works have to be carried out immediately.

Conventional deterministic assessment of the stability of underground structures includes the calculation of the factor of safety and other indicators of stability. Limit state determines calculated boundary of structure, which must never be exceeded. The resistance of the material and the corresponding strength is never possible to identify with completely certainty. Limit state of the structure is divided into:

- ultimate limit state – a partial or complete failure and instability of the structure,
- serviceability limit state – exceeded conditions of the structure applicability which are for example excessive displacements and damage vibration.

Reliability analysis

Deterministic method for risk analysis is made only from the engineering data that are predetermined by the rules, terms and data. The method has no way of determining the probability of the limit values and the actual safety of the structure. Probabilistic method for the risk analysis is made on the mathematical models. The assumption is that all external influences and the strength characteristics of materials or structures are random variables, which are displayed as an appropriate statistical distribution, with a mean value and standard deviation. In this case, it is necessary to perform a series of calculations, in which each parameter systematically changing on the maximum possible interval for determination of the impact on the factor of safety ($F$) and on the stability sensitivity of each parameter.

In geotechnical engineering factor of safety and stability depends on the random variables and they all represents the strength parameters of the ground. Dependence of the stability are also a support system parameters, such as support pressure, steel or concrete strength. Then it is necessary to properly analyze and assess the distribution of factor of safety ($F$), reliability index ($\beta$) and consequentially probability of failure ($P_f$). Reliability index ($\beta$) provides more information about the reliability of geotechnical designing and geotechnical structures.

Risks management guidelines

Guidelines for the management of risks in the construction of tunnels and underground structures are prescribed by the International Tunnelling and Underground Space Association (ITA/AITES). The guidelines apply to all participants in the planning and management of risks in the construction of tunnels and underground structures. The guidelines are prescribed to subscribers and consultants, which are implementing risk assessment and taking into consideration the modern methods of risk assessment and describe the phases of risk management, from the initial to the final phase of the project.
The boundary that separates the safe and unsafe side or failure is the limit state, defined by the following equation\[3\]:

\[ G(X) = R - S = 0 \]  \hspace{1cm} (1)

The following equation is also called as the performance function \( G(X) \), determined by design engineer. Performed must be condition \( G(X) \geq 0 \) for the safe performance and structure stability. In the equation \( X = \text{vector of random variables} \). Mathematically, in case if \( R > S \) that means the safe side and failure happens in the case of \( R < S \).

**Approximation method First-Order Reliability Method (FORM)**

The analysis with FORM provides one or more following results\[4\]:
- reliability index \( (\beta) \),
- probability of failure \( (P_f) \) or probability of a worst case scenario,
- the most likely combination of parameters which are representing the degree of failure,
- sensitivity of the result in any change in the parameter value.

The first step in analyzing the probability of failure using probabilistic methods is the mathematically assumption from the engineer which determines performance function \( G(X) \) and impacts which causes unsatisfactory performance or failure. Calculations can be done with adverted FORM method in Microsoft Excel data sheet.

**Training example with FORM method**

Represented example of stucture reliability analysis is summarized from authors\[5\] and it was calculated in thesis\[6\]. Determined is performed function \( G(X) = 0 \) in case when support pressure \( p_i = 0.4 \text{ MPa} \) and under hidrostatic stress field. In the data sheet are shown the mean values \( \mu_i \) distributed by normal distribution and standard deviations \( \sigma_i \) of random variables which represents the ground parameters from which depents the design stability of underground structure. Improper combination of represented main geotechnical parameters can cause excess plastic zone of excavated area which could be the main reason for excess radial displacement and structure damage or failure. The values in bottom represented Excel column of \( x_i^* \) are initialy set on the mean values \( \mu_i \). The next step is calculation of design point \( x_i^* \) with Excel considering with numerical changing initial values of \( \mu_i \) under condition \( G(X) = 0 \). Finally calculated values in column of \( x_i^* \) are the most critical values of ground parameters on limit state, which are in this example represented like random variables. Design point \( x_i^* \) shows the most critical values of \( \phi, c, p_i, E_{ru} \) which represents a combination of parameters of a ultimate limit state. Parameters \( \phi \) and \( c \) are in this example pro-
posed with correlation coefficient \(-0.5\). Calculated combination of parameters in column \(x_i^*\) (\(\varphi = 21.09^\circ\), \(c = 0.2075\) MPa, \(p_i = 0.3542\) MPa, \(E_{rm} = 373\) MPa) are the most sensitive values which are representing the ultimate limit state. Performed function in this case is set as a criterion of plastic zone:

\[
G_1(X) = L - \frac{R_{pl}}{R} \quad (3)
\]

and second criterium is criterium of underground structure convergence:

\[
G_2(X) = \varepsilon_{max} - \frac{u_{trp}}{R} \quad (4)
\]

- \(L\) is the maximum ratio by \(R_{pl}\)
- \(R_{pl}\) is radius of plastic zone of underground structure [m],
- \(R\) is radius of cross section of underground structure [m],
- \(\varepsilon_{max}\) is maximum ratio by \(u_{trp}\)
- \(u_{trp}\) is total internal radial displacement of underground structure [mm].

Preliminarily proposed ratio for limit state of this example is:

\[
L = 2 \quad \varepsilon_{max} = 2\% 
\]

Calculations are based on performed function \(G_1(X) = 0\) and assumed Mohr-Coulomb model. For this example are afforded next random variables:

- radius of underground structure or a tunnel \((R)\),
- hidrostatic ground pressure \((p_0)\),
- Poisson ratio \((\nu)\),
- cohesion \((c)\),
- friction angle \((\varphi)\),
- reactive support pressure on the edge of excavation \(p_i\),
- Young modul of ground \((E_{rm})\).

### Table 1: Structure radius, ground and support pressure parameters

<table>
<thead>
<tr>
<th>Random variables</th>
<th>Dist.</th>
<th>(\mu_i)</th>
<th>St dev (\sigma_i)</th>
<th>(x_i^*)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(R/m)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(p_0/MPa)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\nu)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(p/MPa)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Calculated design point

<table>
<thead>
<tr>
<th>([x_i - \mu_i]/\sigma_i)</th>
<th>([x_i - \mu_i]/\sigma_i) T ([x_i - \mu_i]/\sigma_i)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-0.0012</td>
<td>-0.0012</td>
</tr>
<tr>
<td>-2.0930</td>
<td>-2.0930</td>
</tr>
<tr>
<td>0.7629</td>
<td>0.7629</td>
</tr>
<tr>
<td>0.0000</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

### Table 3: Correlation matrix

<table>
<thead>
<tr>
<th>(R)</th>
<th>-0.5</th>
<th>0</th>
<th>0</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>-0.5</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

### Table 4: Matrix system for calculating the reliability index \((\beta)\)

<table>
<thead>
<tr>
<th>([x_i - \mu_i]/\sigma_i) T</th>
<th>([x_i - \mu_i]/\sigma_i) T ([R^{-1}][x_i - \mu_i]/\sigma_i)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1.3970</td>
<td>-1.3970</td>
</tr>
<tr>
<td>-2.7915</td>
<td>-2.7915</td>
</tr>
<tr>
<td>0.7629</td>
<td>0.7629</td>
</tr>
<tr>
<td>0.0000</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

### Table 5: Limit state ratios and values of performed functions

<table>
<thead>
<tr>
<th>(L)</th>
<th>(\varepsilon_{max})</th>
<th>(G_1(X))</th>
<th>(G_2(X))</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>0.02</td>
<td>0.000022782</td>
<td>0.001594784</td>
</tr>
</tbody>
</table>

Results of \(G_1(X)\) and \(G_2(X)\) are values from Excel analysis when \(G_1(X)\) and \(G_2(X)\) are by numerical calculating approaching to be equivalent to 0. For calculating needed condition \(G(x_i^*) = 0\) was used function Solver in Excel.

### Table 6: Results of reliability index \((\beta)\) and probability of failure \((P_f)\)

<table>
<thead>
<tr>
<th>(\beta)</th>
<th>(P_f)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.704</td>
<td>4.415</td>
</tr>
</tbody>
</table>

Analysis of risk assessment and law basis for construction of underground structures.
Training example for three cases of support pressure scenario

Input data and concept for this example was summarized from authors\textsuperscript{(7)}. Performed function $G(X)$ in this case is set as a criterium of plastic zone, where is assumed equation (3). Analysis is made for circular tunnel under hydrostatic stress field. Method for calculating this results are the same like in a previous example. Following results and diagrams are summarized from\textsuperscript{(6)}. The objective of following results is to represent the relation between $p_i$ and $\beta$ and between $p_i$ and $p_f$.

\begin{table}[h]
\centering
\caption{Assumed support pressures}
\begin{tabular}{|c|c|}
\hline
Assumed support pressure & $p_i = 0.0\ \text{MPa}$ \\
\hline
Assumed support pressure & $p_i = 0.3\ \text{MPa}$ \\
\hline
Assumed support pressure & $p_i = 0.8\ \text{MPa}$ \\
\hline
\end{tabular}
\end{table}

\begin{table}[h]
\centering
\caption{Calculated values of $\beta$ and $P_f$ for different support pressures $p_i$}
\begin{tabular}{|c|c|c|c|}
\hline
$p_i$ /MPa & $G_i(X)$ & $\beta$ & $P_f$ /% \\
\hline
0.0 & $-0.000001\ 0$ & 0.707 & 23.989 \\
\hline
0.3 & $-0.000000\ 6$ & 3.238 & 0.060 \\
\hline
0.8 & $-0.000000\ 9$ & 8.844 & 0 \\
\hline
\end{tabular}
\end{table}

From diagrams above it is visibly, when $p_i$ increases also reliability index $\beta$ increases and the probability of failure $P_f$ in this case declines. Diagram functions are linear specialy for this case, because only three different points were taken into consideration.

Law basis and construction contract

The definition of the legal obligations in the following sections proceedings within the wider formal sense, especially are exposed regulations relating to the construction of underground structures. Following represented law basis for construction of underground structures are summarized from\textsuperscript{(6)} where they are closely considered.

Legal rules are divided into:
- basic rights and obligations of the participants, the rules in the case if the participants agree otherwise,
- enforced rules from which the participants can not resign, this rules protects certain fundamental values of contract law.

The basis for the creation of obligations contracted for the construction and construction contract in Republic of Slovenia are Obligacijski zakonik (Code of Obligations; hereinafter OZ), which replaced Zakon o obligacijskih razmerjih (Law of Obligations; hereinafter ZOR) and Zakon o graditi\v{r}i objektov\textsuperscript{(8)} (Construction Act; hereinafter ZGO-1) (Ur. l. RS 110/2002)\textsuperscript{(9)}. In the first phase of the contract proposal shall be reviewed general terms and in the second phase shall be drawed special or tender conditions.

Regulations and legal obligations

\textit{Obligacijski zakonik (Code of Obligations)}

Obligacijski zakonik in Slovenia determines the relationships of the obligation law and in the field of commercial contract law contains the basic principles and general rules for all obligations. It is a branch of civil law, which governs the legal law relations and as a result means an obligation\textsuperscript{(1–10)}.
**FIDIC - General conditions for construction contracts**

FIDIC (Fédération Internationale des Ingénieurs-Conseils) is a French acronym for the International world alliance of consulting engineers, which has been established in 1913. FIDIC publishes guidelines used by consulting engineers. General provisions includes guidelines, standard forms, contract documents and the contracts between the subscriber and the consultant. In the Slovenian language is in printed form available 10 FIDIC recommendations. "FIDIC contract" means: a contractual agreement, a letter of tender acceptance, tender letter, the general and special conditions, census (specification), drawings (plans), and all other documents (if they are available) which are listed in the "contractual agreement" or in a "letter of tender acceptance"[11]. FIDIC general contract conditions are the same for all contracts around the world, but special conditions are always based on the individual contract or on a single specific object[11].

**Special cases**

In accordance with the 2. term of Obligacijski zakonik participants can arrange their contractual obligation on the otherwise than it is determined in OZ, unless if the specific provision of this legal code (OZ) or of its meaning does not show anything else. In accordance with the 3. term of OZ participants are free to regulate obligations, but they should not edit them in conflict with the constitution, with the mandatory provisions or with the principles of morality.

**Construction supervision**

Building legislation of the Republic of Slovenia supervisory role in the construction defines the manual Priročnik za nadzor pri gradnji issued by Inženirska zbornica Slovenije (Slovenian Chamber of Engineers). The contractor is obliged to allow to the subscriber the constant control over parts and control over the quantity and quality of the used material[1]. Slovenian legislation in the field of construction provides the following participants at construction of structures: investor - the subscriber which orders and finances the project and the services, design engineer, superintendent for construction works, and the contractor carrying out the work and builds the structure. In the case of complex structures construction is also present the reviser. Construction supervision has control of tasks and responsibilities to oversee compliance of the construction with the project documentation, approvals and regulations.

**Good business practices**

Morality do not provide the content of required conduct, but the extreme limits of permissible conduct. The prohibition of conduct that opposes to the morality is protecting the fundamental social values. Conscientiousness and honesty of the participants requires that the conclusions and implementations of the rights and fulfilling their obligations do not only strive to achieve their own interests, but also to the interests of the other party.

Prohibited are dishonorable treatments, and treatments that are contradicted to the morality, and practices that are dishonorable to the interests of the counterparty. For example, in
the German legal system are general restrictive standards of good practice (gute Sitten, comparable to the standards of the morality by OZ) and the loyalty and trust (Treu und Glauben, comparable with conscientiousness and honesty by OZ). Restrictive standards of the U.S. economic contract law are good faith and the injustice or unfairness (unconscionability). General restrictive standards of autonomous rules are good faith, fair dealing, inconsistent behaviour[10].

**Careful treatment of a good specialist**

General contract law also refers to careful treatment. When participants complete their obligations under their occupation, they must deal with a greater degree of careful treatment – careful treatment of a good specialist. Economic activity is a professional activity. The rules of the profession are not the average knowledge, but that means a narrow business area knowledge of the participants. The most important criteria for assessing careful treatment of a good specialist are rules and practices of the profession[10].

**Business practices**

Business practice is the conduct that is expected from persons of certain properties between the economic subjects. Their defined elements are[10]:

- determination of conduct,
- expectedness and
- qualification of subjects to which it relates.

Rules of business practices shall apply in every case. Correspondently with the OZ business practices have a normative nature[10].

**The responsibilities of project participants**

**The contractor’s liability for defects**

Construction works contractor which takes the part of the project works, which was submitted by the investor as the subscriber shall be responsible only for the professional and technical mistakes and defects in the project, if the investor was not adverted from contractor, although the contractor as an expert knew or should have known the project mistakes and defects. But the contractor is not responsible as well for economically rashly performance which is proposed in the project[1].

The contractor of construction works can not figure out the mistakes and errors in static calculations, which were the basis for the preparation of project documentation, resulting in a too small quantity of steel reinforcement which depends from a load capacity which must be ensured for the building structure. Based only on the basis of a of project documentation review this cannot be figured out. But this can be determined when during construction works the consequences are shown – for example, when cracks on the construction are starting to show up[1].

**Responsibility for the object errors, which are caused by deficiencies of the ground**

In view of the ground complexity, the terrain must be necessary investigated with the geological and geotechnical studies. Nature of the ground must be taken into consideration by design engineer. The findings of such deficiencies of project documentation exceed the contractor’s obligations in connection with the project documentation[1].

During construction (for example, during excavation pit excavation) circumstances may arise (such as intrusion of groundwater) that even when the contractor (depending on experience and knowledge that contractor has) can wake doubt about it that these (actual) properties of land are properly taken into account in project solutions (such as the depth of the foundation). In this case (and only in this case) is to these shortcomings contractor obliged to warn the subscriber, because otherwise its liability for defective building will not be able to relieve[1].

Under English law is one of general obligation on the design engineer to review the ground, whether it is appropriate for the construction of the facility by the subscriber needs. Error of project documentation goes so well that they have been used in the design of irregular baseline specifications and load capacity of the ground, or if the latter is based on the false static calculations[1].

**Reduction and exclusion of liability**

The contractor shall not be relieved of liability if the error has occurred because the implementation of each part of the work by demand
of the subscriber. However, if it is before the implementation of each part according to subscriber requirements contractor puts his attention to the risk of errors, contractor’s liability is reduced, in the circumstances of the each case can also be eliminated\[1\].

Construction contract

Construction contract is a work contract between the subscriber and the contractor and must be made in writing shape specially to protect the interests of the participants and evidentiary purposes\[1\]. Both clients must be unanimous in all links of the contract. The subscriber does not require from the contractor to use of certain means and method of construction, but the subscriber is interested in the result of this work\[1\]. Business relationships in which this task relates primarily to contractual relationships of certain persons – economic subjects, addresses the economic contract law, which is a part of commercial law and in most legal systems recognized the existence of this specific law branch\[10\]. At the conclusion of the construction contract occurs bilateral contractual obligation.

The importance of the principle of contract clients conscientiousness and honesty

The principle of conscientiousness and honesty requires that contract client in the exercise of the rights acquired by the conclusion of the contract, and the fulfillment of contractual obligations not only seeks to achieve its own interests, which concluded the contract, but with the right amount and in an appropriate manner is also responsible for the realization and protection of the interests of the other contract client\[1\].

In concluding construction contracts under Austrian standards following provisions shall apply:

- ground is the property of the subscriber and also represents a subscriber’s risk,
- the contracts are determined and applied in unit prices,
- the means and methods for unchanged ground conditions are contractor’s risk.

Special terms in construction contract which are related to the excavation and support system of a tunnel

The subscriber and the contractor mutually agree about the main steps in the progress of the excavation and primary tunnel support. The subscriber puts special attention to ensure the stability of the underground structure and the contractor has to put special attention to safety work and to the workers health. The contractor shall be responsible for technically correct and timely installation of appropriate support elements\[12\]. Contractor shall not be entitled to additional payment for better features of built-in material if such be installed, otherwise it is not a mistake, even if such material is not intended to project documentation. However, if the properties of the material are worse than anticipated with the project documentation, there is a mistake and contract unrespecting. The contractor in this case can not be held responsible for mistake\[1\].

Conclusions

The advantages of the presented FORM method approach is simple use comparing with other standard mathematical approaches. Level of mathematical computing depends from project pretentiousness and determined limit state function. When structural analysis are computing there is investigated the design point \(x_i^*\) which represents the most probably point of structural failure on limit state. There must be performed a condition which means \(G(x_i^*) = 0\). Summarized experiences from other authors which were the references for thesis and this article are representing that gained results with this method are almost equivalent to the results from standard mathematical approaches. Design point shows also the sensitivity of the ground parameters, which is very important characteristic of reliability analysis. The analysis with FORM provides the calculation of reliability index (\(\beta\)) and consequentially probability of failure (\(P_f\)) which can also show a worst case scenario of underground structures designing.
Slovenian legislation in the field of construction provides the following participants in the construction: investor - the subscriber that orders and finances the project and the services, the design engineer, supervisor which overseeing work, and the contractor carrying out the work and builds. The contractor by signing and conclusion of the contract undertakes responsibility to carry out the necessary work or built underground structure, thereby assumes the risk to be successful and to reach the ultimate goal. The subscriber has the right to executes the professional supervision of the contractor’s parts to verify and ensure their proper implementation, in particular concerning the kind, quantity and quality of work, materials and equipment and on schedule. Conscientiousness and honesty of the participants require that the conclusion and implementation of the rights and fulfilling their obligations not only strive to achieve their own interests, but also to the interests of the other contract client. When determining the legal rules is important to consider the enforced rules, which both clients must take into consideration, and the optional basic rules which may clients agree otherwise. Potential risks can be reduced or avoided with next approaches:

- designing in more appropriate location of underground structure or a tunnel road,
- material designing with appropriate mechanical and geometrical characteristics,
- appropriate dimensional designing and reliability analysis,
- professional, conscientious and honest work,
- good communication of all participants in the project,
- supervising, measurements and monitoring,
- protection of surrounding objects, environmental and machines protection,
- with the timely measure in foreseen, unforeseen and critical situations.

References