THE GENERAL SPATIAL SYSTEM OF ROCKY ENVIRONMENT FOR BUILDING PURPOSES

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Abstract

The paper summarizes and methodizes the necessary civil engineering knowledge for the consideration of interaction between the construction and its rocky environment planned from the point of view of both the construction and the earth's crust region. The rocky environment of the construction has been formed under natural conditions. This determines its properties. Models constructed by the selection of earth's crust elements of uniform properties and by carrying out the necessary and possible generalizations serve to evaluate the interactions.

1. The rocky environment of technical constructions

The conscious or spontaneous objective of human construction activity from the very beginning has been to build structures which transfer the load or other effects of the constructions (e.g. buildings, traffic lines) to the in situ formations of the earth's crust or to artificially created cavities, cuts of deeper layers so that the construction would have a stability corresponding to its proper use. In this also the stability of the environment of the building is included, which can be destroyed by the building if it is not suitably situated.

Correspondingly, to ensure stability, not only the character, loads, structure and mode of construction should be predetermined, but sufficient information should also be gathered on the properties of the earth's crust in the region in question, on its load bearing capacity and its variations as well. Thus, one of the most important tasks of engineering is to determine the interaction between the construction built or designed and the region of the earth's crust in its environment as well as its consequences.

The branch of science which deals with this interaction and the objective of which is to calculate these correlations quantitatively is called engineering geology or — in the nomenclature of several countries — geotechnics. This branch has helped construction for centuries, millenia, in an empirical way, and only recent decades provided the possibility for development on a theoretical-experimental basis, i.e. for the safe evaluation of interactions by using known material characteristics.

The designation of and attitude towards the region of earth's crust constituting the environment of constructions has significantly changed. The earth's crust range earlier called "subsoil" has been considered for long to be of a static nature, with unchangeable properties which has an effect only at a single level (in the so-called foundation depth) or only its compression has been taken into account. In this interpretation, the geological viewpoint played no role and the properties obtained or often only assumed were not brought into connection with spatial elements determined from the geological point of view.

The geological environment of a construction is a complex physical system, with numerous properties. These properties referring to the given geological environment of a construction will determine the cooperation and, consequently the interaction, of the geological environment and the construction.

Due to technical developments, the behaviour and properties of our buildings are known with increasing safety and as a consequence, we can design corresponding to economic and safety requirements. The tasks concerning the effects of the rock-environment are more difficult to solve, and these problems have not always been elaborated even at present.

The rocky environment is a region of the earth's crust whose dimensions depend on the distance in which interaction with the construction takes place. The region of the earth's crust to be analysed should be estimated on the basis of this definition, in the course of the analysis however. As the earth's crust cannot be considered a homogeneous element of space, unchanged in time from the viewpoint of constructions, it is necessary to determine also its real character.

The rocky environment is an element of space of the earth's crust formed under natural conditions according to geological laws whose momentary situation and state may be significantly influenced also by secondary, e.g. anthropogenic effects.

Space elements of geological origin can be formed according to three significant series of properties: heterogeneity, anisotropy and discontinuity (Table 1).

Geological effects, both those connected to the genesis of the rock, and those changing the already formed ones, result usually in the heterogeneity of the rock environment.

Heterogeneity in the study of the rocky environment means that there are volume elements within the rocky environment differing significantly from each other in their properties. Thus a number of properties of rocks belonging to the same genetic series but of changing quality may be significantly different, e.g. in the case of a sequence of lava and tuff layers of volcanic eruptions. Similar heterogeneity is observed if in an originally homogeneous region of the earth's crust (e.g. in a granite block) secondary weathering processes result in weathered volume elements with decreased strength.

Table 1

The character of heterogeneity, isotropy and continuity in model elements, in different approaches

Approch	Earth crust range	Geological unit	Rock body	Rock block
geological	heterogeneous anisotropic discontinuous	homogeneous anisotropic continuous or discontinuous	homogeneous anisotropic continuous	homogeneous isotropic continuous
settlement centric	heterogeneous anisotropic discontinuous	heterogeneous anisotropic discontinuous	homogeneous isotropic continuous	homogeneous isotropic continuous
petrographic	heterogeneous anisotropic discontinuous	heterogeneous anisotropic discontinuous	homogeneous anisotropic continuous	homogeneous isotropic continuous
engineering geological	heterogeneous anisotropic discontinuous	heterogeneous anisotropic discontinuous	homogeneous isotropic or anisotropic continuous or discontinuous	homogeneous isotropic or anisotropic continuous or discontinuous

Heterogeneity may be observed not only in the magnitude of the earth's crust region, but that of smaller regions (e.g. due to the change in the mineral composition) can be neglected from the engineering point of view.

Another significant property of elements of the earth's crust is *anisotropy*. It is mostly connected with the geological processes of genesis, and the role of secondary processes is here less significant. Anisotropy is more frequently in connection with the anisotropy of smaller units of the rock, e.g. with that of the rock texture. Anisotropy is a characteristic mainly of sedimentary and metamorphic rocks, in the latter case, even two "generations" of anisotropy may be present, if the parent rock has been of sedimentary origin.

The main direction of anisotropy often coincides with the present horizontal direction in young sedimentary rocks, but this is not of general validity. Anisotropy appears in different ways in the various properties. A rock, nearly isotropic concerning its strength, can be anisotropic e.g. in permeability or heat conduction. Constructions cause changes more often in anisotropy than in heterogeneity.

Properties in the often heterogeneous and anisotropic rocky environment do not change continuously, not even in the magnitude of our analysis. Between or inside the different earth's crust elements there are those carrying surface properties along which the properties of the homogeneous and isotropic crust elements also have a jump. This property is due to the discontinuity systems in the crust. Thus in the properties of the discontinuous rocky environment, besides material properties, surface ones also play a role, along the discontinuity surfaces gaps are also formed which are a new element in the analysis of interactions.

The discontinuity system, in its turn, influences homogeneity and isotropy as well: only the earth's crust region can be considered homogeneous concerning interaction, where the main properties of discontinuity (e.g. its extent) are also uniform. The anisotropy of discontinuity may cause the anisotropy of the whole space element.

The geological properties of the earth's crust region studied, together with its heterogeneity, anisotropy and discontinuity, are comprehensively called *deposit*. Thus in the concept of deposit all properties are included which are related to the spatial dimensions and the quality of the earth's crust region. The character of the bedding can be described and its individual sections represented by profiles.

The earth's crust region characterised by its bedding is a very complex spatial system, its properties can be determined only by lengthy studying. This process changed significantly with technological developments, but in estimating interactions in a particular case we have to use approximations, even at present.

2. Characterisation possibilities of rocky environments

A number of attempts has been made to characterize geological environments which have been applicable under certain circumstances. All of them mean simplification, idealisation. According to the way of idealization, they can be more simple or more complicated.

The geological environment was often substituted by the *infinite half space* of the horizontally limited surface. This method provided good results in numerous cases. The properties of the matter filling up the infinite half space can be determined by laboratory tests with a sufficient accuracy if the correlation is not disturbed by the tests or anisotropy of individual space elements. The use of combined models makes possible to take also anisotropy into account [e.g. Petrasovits, Soltész 1978]. Thus the model of infinite half space is a useful starting point for numerous analyses, but it does not provide appropriate results for more complex geological environments.

As opposed to the model of infinite half space not applicable for a variety of geological conditions, the development of spatial geological models following real geological relations seemed also to be possible. The characteristic of the *spatially ordered genetic-geological model* is that it differentiates between the individual space elements of the earth's crust with a geological attitude, but it is not concerned with the technical parameters of these space elements.

The naming of rocks in geological models is traditionally genetical, in which secondarily separated space elements (e.g. by weathering or due to tectonic effects) are rarely differentiated. The spatial geological model can be considered a suitable basis for analysis from the point of view of interaction if the space elements differing in interaction are separable also in the geological model.

In the interpretation of the homogeneous infinite half space, eventually in the spatial ordering specified by the geological model, analogous behavioural models have since long been developed. For the application of behavioural models, the reduced scale model of the space elements chosen is exposed to planar stress and the changes are observed visually or in some other way (change in the optical properties, analysis of photoelastic or deformation models).

3. The engineering geological model

In spite of the fact that simpler models may also provide results applicable from certain aspects, according to practice, we need models bearing the properties and their variations in addition to their spatial correctness, corresponding to the particular task to be performed. These requirements are difficult to satisfy, as the properties of the earth's crust elements cannot be determined by direct experiments. Therefore, we need a model system enabling us to preestimate the properties and their variations by mostly simple laboratory experiments, suitable also to point out space elements in the earth's crust whose behaviour can be considered uniform from the given aspect.

Such a model can be developed as a complementation to the genetic-geological model, but it is usually the result of an independent activity and may be called engineering geological (geotechnical) model. The engineering geological model consists of two parts: 1. General correlations are to be determined between the different space elements of the geological environment that can be considered uniform from a geological point of view, the so-called model elements for the analysis of the behaviour and property variations of the earth's crust element. 2. Model elements should be chosen from the system which can be taken into consideration from the given aspect and a spatial geotechnical model is to be built with their aid in the earth's crust region in question. To this latter task belongs also the determination of the borderlines of the earth's crust region, i.e. the distance up to which the interactions should be analysed for the given task.

3.1 *Demarcation and pointing out of model elements*

We can start the demarcation of model elements either at the smallest dimensions (e.g. at rock-forming minerals) or at the largest, the crustal range in question not yet encircled (Table 2).

Table 2

Elements of the engineering geological model

Spatial model element	Characteristic spatial system	Surface model element
Geological unit	settlement	
		rock boundary (borderline between different kinds of rocks)
Rock body	structure	
		discontinuity (discontinuity surface)
Rock block	texture	
		(particle-)bonding (chemical bond or fitting)

3.1.1 *The geological unit*

A part of the earth's crust under study but not yet analysed is the in situ rock mass (in the case of loose rocks it may also be called soil mass). The in situ rock mass has been formed by the superposition of different geological effects and processes in time and space and can be separated into parts or geological units according to the nature of these processes.

The rocky environment may consist of one or more geological units. Though the main conditions and regularities of their formation are identical, their properties may differ significantly (e.g in a volcanic unit, the properties of andesite and andesite tuff). Geological units are separated from each other by geological borderlines which may also change gradually, but they are usually sharp lines corresponding to the geological processes participating in their formation. The geological units are connected in a gradual manner if the formation conditions have also changed gradually, and this connection is sharp if the phenomena have been of a dynamic nature, or if the borderlines have been formed subsequently by e.g. tectonic changes. The spatial system of the geological unit is described by its geological feature.

3.1.2 *The rock body*

Within a geological unit, various kinds of rocks, various modifications or variants of rocks occur. Parts of them, which have identical geological names and are uniform in their behaviour and properties are the rock bodies. They are separated from each other by the surface of the rock boundary. The quality of rocks changes along the rock boundary. This change may be sharp (e.g. a boundary between two different rocks), or gradual (e.g. a gradual rock boundary between sand and gravel). In gradual transition, the rock boundary cannot be drawn along a well-defined geological surface, to point out a boundary is possible only by a decision based on consideration.

From the geological point of view, the rock body is a homogeneous element of space, however, it is not continuous, but discontinuous. The properties of this discontionuous rock body are the superposition of the appropriate properties of

— the continuous. rock block and
— that of the discontinuity system.

Thus, inside a rock body, both the character of the block and the properties of the discontinuity system should be uniform. If the rock body is continuous its properties differ from the properties of the block only to the extent of the size effect. Therefore, the properties of the rock block do not appear separately inside the continuous rock body.

The properties of the rock body cannot be determined by laboratory tests, in situ studies are necessary to characterize them.

The spatial character of the rock body is determined by its structure and discontinuity.

The properties of the rock body can be established by a laboratory examination of the rock block and the results of in situ and/or laboratory experiments concerning the discontinuity system.

3.1.3 *The rock block*

The rock block is the basic model element applicable for the analysis of properties. Thus a laboratory test piece is equivalent to the rock block in this system. The rock block corresponds to a geological name, its properties and their variations can be described by well-known laboratory methods with sufficient accuracy. Property-analysis may necessitate the determination and analysis of the property-bearing elements inside the rock block.

The properties of a rock block are determined by the geophysical, textural properties of the rock-forming components. The rock texture is a spatial system defined by the nature, structure, packing (bonding), size, orientation and porosity of the rock-forming components. In the properties of a rock block, the texture plays a decisive role.

3.1.4 *Water in the geotechnical model*

The nature of rocks is determined by the joint effect of solid rock-forming components and the water occupying the pores, gaps and voids. In the model, a separate element is the coherent, movable water body.

3.1.4.1 *Water as a property-changing element*

In model elements, the water content of pores and voids should be taken into account as a property-changing element. Thus the properties of the rock body and rock block should be determined in a state with a given water content or in several states around the value expected and the rock property corresponding to the assumed (or e.g. to the unfavourable) water content should be considered. The surface properties are particularly water-dependent, thus in their analysis a special care should be taken. The property-changing effect of the water content is the cause why rocks under ground water and above the level of ground water should be treated as separate rock bodies, if the variation of the property in question is significant.

3.1.4.2 *The subsurface water body and its effect*

Water should be considered an independent water body, if the property of water and not that of the rock modified by water is decisive in the given engineering geological problem. Thus the water body may be static or dynamic and its variations determine also the changes in the engineering geological model. The specific properties of the water body (e.g. temperature, composition) should be treated identically with those of the rock body.

In the geological environment of a construction the effect of water may be very important for two reasons: one of them is that the construction may change the motion and penetration of surface water. The harmful consequences of this should be eliminated by engineering.

The other important effect in connection with the former one is the variation in the water balance of subsurface waters.

Rock bodies of variable saturation due to the motion of subsurface water can usually be pointed out, too. This cyclic change in the water content may endanger the safety of the construction in the case of a rock sensitive to this effect.

The variation of the water balance of the geological environment is a planned geological operation, it cannot be left to chance. Thus the original water balance should be accurately known. The type, percolation surface, pressure relations, characteristics of its cyclic changes, and last but not least, the chemical nature of the subsurface water should be known.

An important aspect in the demarcation of the geological environment of a construction is to what extent and in what area the construction will change these characteristics.

3.2 *The nature of the engineering geological model*

In every approach of getting acquainted with the complex system of earth's crust we prepare or use a model. The model may be a simplified, clear-cut, realized in practice or only imagined, magnified or reduced as to proportions, mathematically treatable, idealized reproduction of complex physical systems, which correctly demonstrates the geometrical, kinematic, dynamic or other physical or stochastic properties of the system or process under study corresponding to the given task. The correlation between the model and reality is expressed by model laws and belongs to the formulation of a model, as the model is not identical with the systems or processes studied. The engineering geological model is a material model; in the model we want to follow the spatial structure of reality, and real space elements are endowed with parameters determined by material testing. This generalisation may be direct or indirect.

In direct generalization we generalize the results obtained from specimens taken from the homogeneous, continuous rock body, and the parameters thus obtained are considered valid for the rock body by also taking size effect into account. The different kinds of permissible stresses (e.g. systematic, extreme, special) are calculated from these parameters.

The generalization of the model property is indirect, if the properties of importance are created by some interpretation, e.g. the parameters of the rock body are determined from the parameters of the continuous rock block and the discontinuity system.

Thus from the engineering geological model it is required that its model elements or the total of the model should provide sufficient information for calculation, dimensioning or other (e.g. comparative) engineering activities within the available time and cost limits. The elements of the engineering geological model are analysed and chosen according to a geological, petrological and rock-physical attitude. In soil and rock mechanical models which are simpler than the engineering geological one, the model elements are chosen exclusively on the basis of soil or rock mechanical parameters without the analysis of geological data.

3.3 *The development of the engineering geological model*

The engineering geological model should be developed so that the geological units or rock bodies should be placed sterically into the earth's crust region in question. The selection of geological units is independent of the construction, however, in demarcating the rock bodies, uniformity should be established from the viewpoint of properties important for the given construction and the interaction to be studied. Thus the engineering geological model may be different from one construction to the other or from properties to properties.

The most difficult task in constructing the engineering geological model is to define the range of earth's crust of interest from the point of view of the given task, or the interacting rock mass, the rocky environment. As a concerned earth's crust range or real geological environment, we take the part of earth's crust which plays an important role in at least one interaction. As the definition "important" is not sufficiently unambiguous, in general we formulate it by considering the role of the important earth's crust region, where the neglection results in an unpermissible deviation in the sudy of the interaction. The real meaning of "unpermissible" concerning deviation also depends on the construction and its character.

The dimension of the earth's crust range to be considered may change between several cubic meters and surfaces of several square kilometres with depths of several hundred metres, i.e. several cubic kilometres. For determining the dimension of the rocky environment the usual calculation procedures may be used in simpler cases (e.g. in the case of a decreasing stress exerted by the foundation body towards deeper layers or in the case of a spreading stress).

An increase in the earth's crust region to be considered as homogeneus means at the same time also an increase of homogeneous space elements. The volume of the earth's crust range in question is just about 100 m^3 in magnitude for the foundation of a smaller building, for a barrage it is a few km^3-s in magnitude, whereas in designing a settlement it may take a surface of several km^2-s and for regional tasks (e.g. for locating a highway) it may include several hundreds of km^2-s.

In solving our task, rock bodies built of rock blocks and discontinuity systems are the model elements by means of which the geological environment can be taken into account corresponding to the real interaction of effects.

Consequently, the properties of the rock body can be determined mainly by "in situ" experiments, whereas those of rock blocks by laboratory studies. In dimensioning or extrapolating, the discontinuity properties should be considered carefully, as they serve for determining the properties of rock bodies from those of rock blocks.

For model elements, the analysis of the properties and their changes affected by some external effect has to include the model elements of which it is built. A basic model element, also from this point of view, is the rock block, in which crystalline and amorphous rock-forming components are embedded in a certain texture by chemical bonding or only by temporary fitting.

It has already been mentioned that the concept "rock" as used in geology cannot be completely identified with either model element. The term "rock" includes space elements identical concerning genesis and material properties, independently of discontinuity, mainly based on the *texture* and the *rock-forming components*. Thus the term rock can be related to rock body or rock block, not distinguished in the geological description. However, when analysing properties from the viewpoint of engineering geology, the rock-forming components, their bondings and their spatial arrangement, i.e. the *rock texture* within the rock block should also be considered as model elements. In their use as construction materials, these model elements are decisive.

In analysing the rocky environment, the model element most significant for technically important properties should be taken into consideration. Thus e.g. in quarrying, such a model element is the rock block (its size and properties are most important factors), in the analysis of the equilibrium of discontinuous rock-splays, the properties of the rock block are negligible as compared to discontinuity properties (direction, extent, shearing strength along the surface or friction). In engineering activity, however, usually the properties of the rock body are needed that are, in general, extrapolated from the properties of the rock block (specimen) is the case of continous rock bodies (e.g. loose rocks–soils, volcanic tuffs, coarse limestones–) whereas for discoutinous rock bodies they are derived from the properties of the rock block and discontinuity (e.g. permeability as a function of the extent of discontinuity and its width deformation as that of the deformation of the rock block and the void volume of discontinuity).

3.4 *An example for the construction of an engineering geological model*

Figure 1 shows the end result of the process of model construction in the rocky environment of one of the engineering structures of the weir at Nagymaros, that of the lock. In this region, there are older rock bodies formed in the Oligocene and Miocene epochs near the surface, and young rock bodies sedimented from the Danube river.

The demarcation of rock bodies was carried out in accordance with the genesis process of the rock based on the results of studies concerning discontinuity and on petrophysical studies. In the rocky environment of the engineering structure, miocenic volcanic activity on the one hand, lifted up the oligocenic sediment and on the other, by tearing it up and sedimenting on it, created a so-called strato-volcanic formation. On the surface of the rising and solidifying subvolcanic andesite body, the oligocenic layers suffered strike-shifts, proven by the shift planes on the drilling cores. Of course, this region is not free of effects of subsequent structural motions either. Due to these, fault zones have been formed along which the rocks are discontinuous to different extents.

Based on geophysical and drilling prospection, rock bodies of different material quality and degree of discontinuity were unambiguously distinguishbale. By evaluating the results, in both the subvolcanic and strato-volcanic andesite rock bodies a more and a less discontinuous andesite rock body could be distinguished (in the neighbourhoodof the lock the less discontinuous subvolcanic

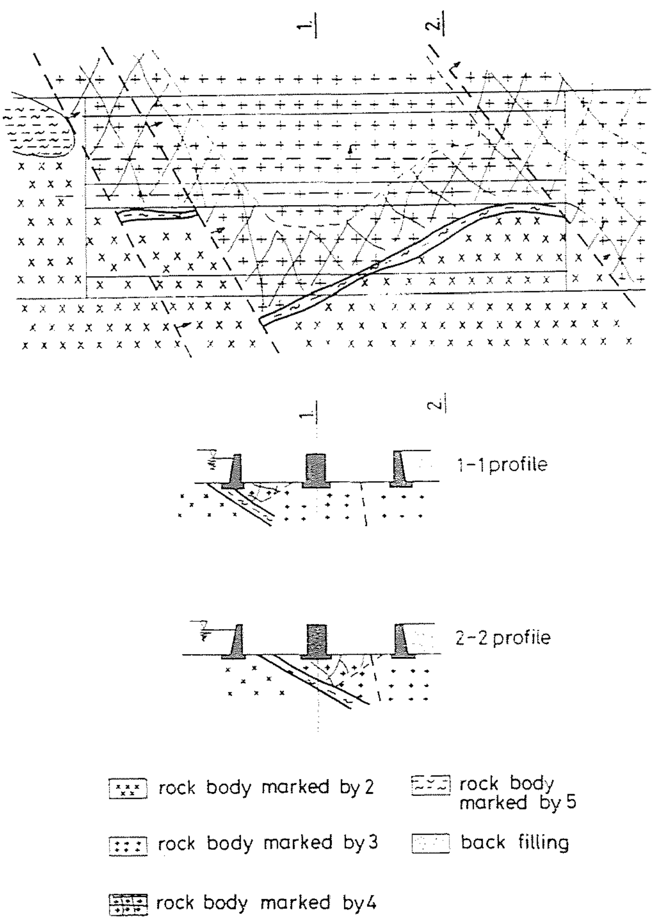


Fig. 1. The engineering geological model of the rock environment of the Lock at Nagymaros

rock body was not present), with the loamy, yellowish, marly oligocenic rock body having a high carbonate content between them.

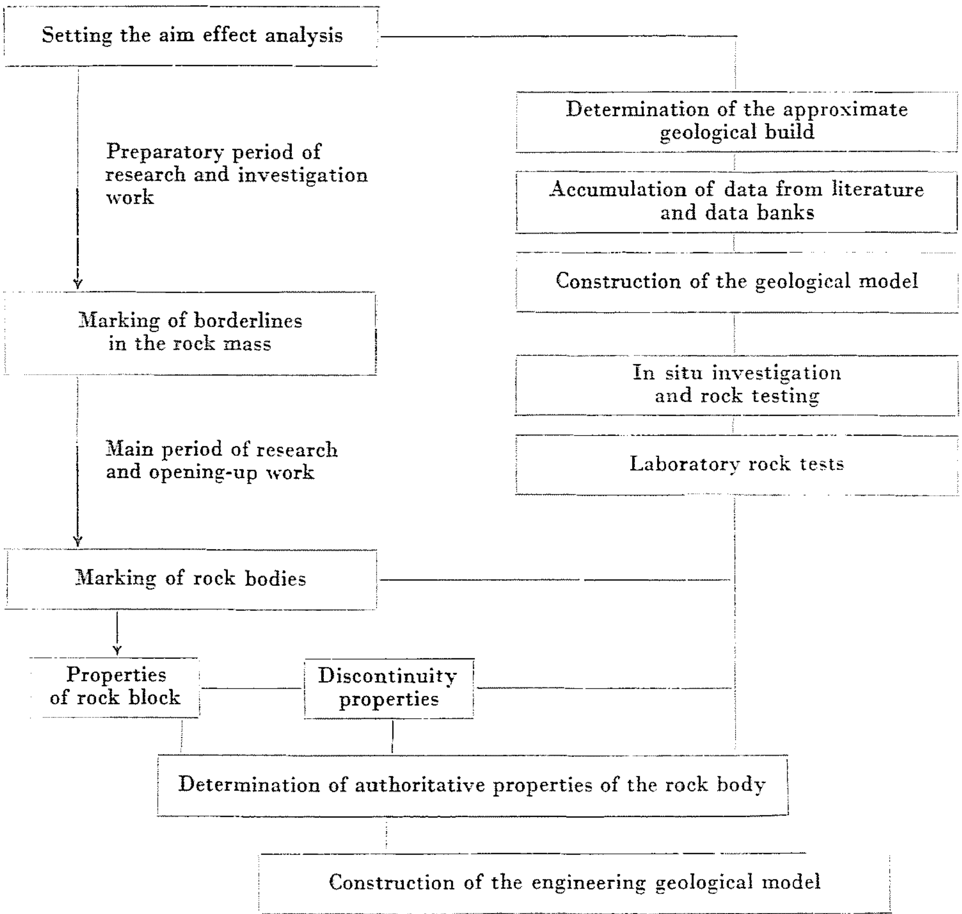
In the Figure 1. rock bodies distinguished in the rocky environment of the lock are shown, by the assigning the appropriate material characteristics to them, dimensioning and stability calculations can be performed for projecting and controling.

4. Process of the development of an engineering geological model

The construction of the engineering geological model is a process where the steps may eventually lead to the goal only by a several-fold repetition (Table 3). The process of model construction is influenced by the complexity

Table 3

Correlations in the construction of the engineering geological model



of the rocky environment and by the possibilities and methods of data accumulation, i.e. by the possibilities for increasing our knowledge about the circumstances. In the environment of the earth's crust element to be studied, all the properties should be taken into account that influence material quality, together with geological processes causing changes in it (Table 4). The construction of a model may have several phases differing from each other in their accuracy, i.e. in the level of knowledge about the rocky environment. Corresponding to the nature of the task (e.g. preparatory activity, operation) a lower or a higher level of knowledge is required. An improving of knowledge has higher time and material consumption the extent of which depends also on the complexity of the earth's crust element in question.

Table 4

The properties of interacting earth's crust regions

Properties originating from material quality	Geological properties
— high textural or structural anisotropy	— flowing underground water
— loose, water-sensitive	— weathering surface
— organic	— accumulation surface
— artificial	— migrating materials
— tendency to deliquescence	— motions of the fault zone
— tendency to freezing	— earthquake danger
— corrosive	
— underground water under pressure	

Table 5

Properties originating from the nature of the construction

From the structure of the construction	From the use of the construction
sensitive to subsidence	dynamic effect
interactions between structures	alternating load
dynamic effects	special thermal effect
	extraordinary load

The properties of the interacting earth's crust range are thus connected with their material on the one hand, and with the geological processes continuously changing the material quality and appearance on the other.

When studying the interaction of a construction and the earth's crust range in interaction with it, we should take into account the characteristics of the construction originating partly of its structure and partly from the effects it is exposed to in the course of its use. These characteristics are summarized in Table 5.

4.1. *The development of a geological-genetical model*

The rocky environment of engineering structures is usually well known from geological literature. Thus the geological series of events in the region is known roughly, as is also the quality and borderline characteristics of the rock bodies generated by it.

This general geological model has to be developed further for the crust region in the neighbourhood of the construction so that the boundaries of rock bodies participating in the interaction may be accurately set. For this purpose, the particular environment should be investigated. The geological evaluation of these concrete sites complements the general pattern, its local modification leads to the development of a new hypothesis (model). In order to check this model, a new investigation should eventually be made. This successive approximation results in a more and more accurate geological model which reflects local reality to an ever increasing extent (see Table 3).

As a result, the geological model contains the genesis and changes of the direct rocky environment, the material quality of the rocks, their secondary alterations, the borderlines between rock bodies, their characteristics, the results of significant tectonic processes that occurred in the past and the interactions to be expected as a consequence of recent internal and external geological forces. For this latter, the earthquake category of the region, recent crust motions and the geomorphological analysis of the region may be informative.

The material used for the development of the geological model can naturally be utilized also for the study of the materials for the geotechnical model and partly also for the laboratory determination of the technological quality of rock bodies. Thus any opening-up should be designed in a way that by developing the geological model, the parameter system for the geotechnical model be simultaneously available.

4.2 *Establishing the properties of model elements*

In the process of modelling the rocky environment, the demarcation of model elements, the determination of their place and role in the system which at the same time means also the determination of their dimension, requires serious preparatory work, but in the possession of thorough engineering geological knowledge, it is a simple task as compared to determining their properties. Naturally, in the process of modelling these two work phases are in a close connection with each other, and play identically important roles in their interaction.

Numerous properties belong to the complete model or to individual model elements from among which the person constructing the model should select the properties determinative from the viewpoint of modelling. There is a dialectic connection between the multitude of properties and the personal responsibility of the constructor. Though the constructor, when selecting the properties, sets the primary aim to building the model, subjective factors originating from the knowledge of the constructor corresponding to the technical standard of his epoch, from his professional experience, aptitude and synthesizing ability may also become very important.

When speaking about properties, we must not forget that in the course of modelling, the concrete properties of the system studied are selected from the abstract properties of matter. The properties chosen may be given either by a

Table 6

POINTING OUT THE INTERACTIONS TO BE CONSIDERED	Caused by the load of the construction	Deformation, soil failure
	caused by a load acting of the construction	structure development
	caused by buildings or caves	terrain subsidence
	caused by the deformation of surface	mass motion
	caused by load, surface deformation, cave-opening or water draw-off	variation in the water system (surface or underground)

DETERMINATION OF AUTHORITATIVE PROPERTIES AND THEIR CRITICAL LIMIT VALUES FROM THE VIEWPOINT OF INTERACTIONS

MARKING THE BORDERLINES OF INTERACTING ROCK MASS DETERMINED BY ESTIMATING INTERACTIONS AND AUTHORITATIVE PROPERTIES AS BASED ON THE CHARACTER OF THE MODEL

The border-line is a natural one existing independently of the construction	The borderline depends on the construction, it is a surface established by engineering geological considerations
terrain surface morphological boundary rock boundary layer boundary divide (surface or subsurface) fault zone	boundary of the settlement to be studied isosurfaces of the critical values of the distribution of load and deformation critical value of the discontinuity system critical value of the water balancing process

ANALYSIS OF INTERACTIONS AFTER THE CONSTRUCTION OF THE MODEL WITHIN THE LIMITS MARKED

description, or numerically. The ambition of technical practice is unambiguously to provide the property-carrying material characteristics or material constants numerically or by functions for a further use, such as the preparation of decisions, dimensioning, effect analysis, etc.

The modelling of a geological environment is an imaging process of a complex material system, the generalization of its static-dynamical behaviour cannot be carried out on the basis of a single property or property-group. The process of modelling means to reveal properties and property groups in connection with each other assigning them to model elements. The properties revealed are, of course, not of the same importance, there are several of them determining all the others and forming a basis for the elaboration of the correlations between the properties, and there are those needed only for the solution of a single partial task.

In modelling the geological environment, the basic properties include all the effects originating from the genesis of the given piece of earth crust and those exerted on it later, which means that the properties of the geological environment are functions of the genesis, composition, build and momentary physical state of the environment.

The multitude of properties is taken into consideration by explanatory descriptions and by supplying numerical material characteristics and constants. In the course of this process, a contradictory ambition exists to provide most accurate results with utilizing the least number of properties. They are the so-called authoritative properties. These properties are determined by studies and investigations. Their outstanding importance is well illustrated by the flow diagram of model construction.

To mark the boundaries of the earth' crust range in question is an analytical task. Its surface area may be determined a priori by the nature of the task (e.g. in a development of settlements the area which can be covered by buildings), whereas in other cases a volume element should be chosen outside of which the interactions are negligible by an analysis of the interactions, eventually by repeating this analysis several times. The edge surface may be geological, or a rock boundary, a borderline determined by geomorphological relations, or an edge surface marked by considerations based on the results of investigations (Table 6).

The model construction is a process the course of which, described in Tables 3 and 6, may be modified according to the actual circumstances, its individual steps may be repeated or omitted when necessary, the whole model construction process may be started anew with new data or attitude.

5. Summary

The engineering geological rock model is suitable for selecting elements with uniform properties which can be provided numerically as results of studies in both compact and loose sedimentary rocky environments for the purpose of technical tasks. These units are then utilized in further work.

The units of the engineering geological rock model — geological units, rock body, rock block, discontinuity — are built upon each other. Homogeneity, isotropy and continuity are interpreted by their use in the interaction of the geological environment and construction.

Data needed for the spatial construction of the rock model can be obtained by geological research and the determination of authoritative properties usually by laboratory, or more seldom by in situ studies. Thus the possibilities of model construction depend on the results of these studies and those of investigations: the reliability of the model increases with the number of investigations points if the geological hypothesis on which the plan of the prospections is baseds i close to reality. Different engineering geological models may bed eveloped on the basis of identical data corresponding to the objective set, if they are systematized with different attitudes; thus the engineering geological model bears also the attitude of its constructor.

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