REQUIRED IMPLEMENTATION OF GEOFACTORS OF ROCK WORKABILITY AND PREQUATERNARY BASE TYPE INTO LAND-USE PLANNING

POTŘEBY IMPLEMENTACE GEOFAKTORŮ TĚŽITELNOSTI HORNIN A TYPU PŘEDKVARTÉRNÍHO PODKLADU DO ÚZEMNÍHO PLÁNOVÁNÍ

Marian MARSCHALKO[1], *Peter JURIŠ*[2], *Tomáš PĚŇÁZ*[3]

[1] *doc. Ing. Ph.D., Faculty of Mining and Geology, VSB-Technical University Ostrava*
tř. 17. listopadu, Ostrava - Poruba, tel. (+420) 59 732 3505
e-mail: marian.marschalko@vsb.cz

[2] *Ing., Faculty of Mining and Geology, VSB-Technical University Ostrava*
tř. 17. listopadu, Ostrava - Poruba, tel. (+420) 59 732 3505
peter.juris.st@vsb.cz

[3] *Ing., Ph.D., Faculty of Mining and Geology, VSB-Technical University Ostrava*
tř. 17. listopadu, Ostrava - Poruba, tel. (+420) 59 732 3505
tomas.penaz@vsb.cz

Abstract

The current technological means in geographic information systems bring new possibilities of implementation of important natural conditions into land-use planning. The paper focuses on two such geofactors, i.e. workability of rocks and Prequaternary base, which are very important for future foundation engineering. At the same time, the study presents the form through which it is possible to provide the information to authorized offices and developers, namely using analyses of the factors through geographic information systems. This helps to determine areas with specified conditions in terms of the geofactors in question and the relevant authorities may be able to provide the information to future developers or may take it in consideration during decision-making on future land use. The studied area (model area 2, determined by a topographic map 15-43-05 in 1:10 000 scale) is located in Ostrava, the third largest city agglomeration in the north-east of the Czech Republic (city districts of Slezská Ostrava, Moravská Ostrava, Přívoz and Petřkovice), which is however most affected of all Czech cities as well as cities in the European scale by anthropogenic industrial and mining activities.

Abstrakt

Současné technologické možnosti v geografických informačních systémem přináší nové možnosti implementace důležitých přírodních podmínek do územního plánování. Předložená studie má za cíl upozornit na dva takové geofaktory těžitelnosti a typu předkvaterního podkladu, které jsou velmi důležité pro zakládání budoucích inženýrských děl. Zároveň studie přináší formu, kterou je možno tyto informace kompetentním úřadům a uživatelům stavebníkům poskytovat pomocí analýz těchto faktorů prostřednictvím geografických informačních systémů. Vymezí se tak oblasti s vyspecifikováním konkrétních podmínek z hlediska řešených geofaktorů a příslušné úřady tak budou moci poskytnout tyto informace budoucím stavebníkům, respektive je mohou zohlednit při rozhodování o budoucím užití území v územním plánování. Studované území (modelová oblast č.2, vymezena topografickou mapou 15-43-05 v měřítku 1:10 000) se nachází v Ostravě třetí největší městské aglomeraci na severovýchodě České republiky (v městských obvodech Slezské Ostravy, Moravské Ostravy, Přívozu a Petřkovic), která je však nejvíce ovlivněna antropogenní průmyslovou a hornickou činností z velkých měst v České republice, ale také v evropském měřítku.

Key words: engineering geology, town planning, foundation engineering, GIS

1 INTRODUCTION

Land-use planning is an activity that permits rational utilization of the landscape. In order to make a multidisciplinary analysis, a natural part of this activity should be application of all available information, including natural information. A common part of the natural information should be as well information concerning rock workability and Prequaternary base. The objective of the paper is to show their possible application.

Workability is a significant limiting factor, which affects the used technology and financial demands of earth work. Especially in case of demanding constructions, the Pre-quaternary bedrock is a geological environment which will have to interact with and must be taken into account during selecting engineering foundation.

The overall project was divided into five model areas (1-5), while this paper evaluates a partial model area no.2, which is defined by a topographical map in drawing scale 1:10 1000 (topographic sheet No. 15-43-05). The area in question is located in the prominent conurbation of Ostrava, in the city districts of Slezská Ostrava, Moravská Ostrava, Přívoz and Petřkovice. The mentioned methodology was applied in the interest area for the first time.

2 EVALUATION OF WORKABILITY OF ROCKS AND PRE-QUATERNARY BEDROCK

The evaluated geofactor of the study is ***workability of rocks*** which is one of the most important characteristics of rocks and at the same time has one of the most practical impacts in the engineering-geological practice. It is a resistance the rock puts up towards loosening, loading on transport means and during transport of the excavated material to the edge of the foundation pit. The workability measure is an amount of work needed to perform the required operations. According to the ČSN 73 3050 Standard there are 7 classes of workability of rocks, ranging from cohesive soils of soft consistency and cohesionless loose soils of the first class to solid, massive rocks belonging to the class seven.

It is a characteristics that makes a part of so-called special classification systems evaluating rock environments in terms of their suitability or utilizability for certain technical (engineering) activities. In this case the activity is earth work.

The following paragraphs present the results of a workability case study on a model interest area with map outputs that are recommended to be used as necessary information in land-use planning as areas with the workability of rocks over 4 afford less suitable conditions from the point of view of implementation and financial means for future engineering structures. In the interest area there are engineering-geological zones for which workability classes are characteristic within a certain range (e.g. 1 to 3 or 2 to 4), and thus an analysis cannot be determined strictly for each separate unit. Such an analysis has its own significance as it distinguishes areas with better or worse workability of rocks.

The workability class 1 is formed by fine soils of a soft consistency (e.g. top soil, loam, sandy loam, sandy and gravel soils), which is closely connected with getting characteristic method as soils of this class can be shovelled or loaded by a loader. The workability class 2 is characteristic for fine soils of a firm consistency (e.g. top soil, loam, silty loam, sandy loam, peat, etc.). The soils of this class are workable by a spade or a loader. Fine soil of a stiff and hard consistency, soft and firm (loam, loess, clay loam, sandy loam, sandy clay, clay) are characteristic for workability class 3. The rocks are defined as diggable, workable by a spade or an excavator. Solid rocks of workability class 4 vary from partially mouldered to mouldered ones. The soils are again of a fine, stiff and hard consistency (clay, sandy clay, clay loam, sandy loam). The rocks of this class are workable by a wedge or an excavator.

In the model area (Fig. 1) the most widespread classes of workability of rocks are classes *2-3*, which take up 70.2% out of the total area. The largest landscape element with this characteristic is built-up area (50.7%), followed by fields and meadows (25.5%) and forests (13.8%). The second most dominant are workability classes *2-4* (18.5 %). Also in this case the dominant landscape element is built-up area (33.5%), followed by anthropogenic shapes (23.3%), forests (21.6%) and fields and meadows (20.6%). The rocks of the workability class *1-3* cover 8.9% within the interest area. As for this characteristic the built-up area exceeds all the other landscape elements due to its area (78.4%), followed by fields and meadows (15.7%). The rocks of the workability class *3-4* concern a tiny area in the interest area (0.6 %), while the built-up area prevails there as well (72.8%). Apart from the built-up area, the workability of rocks was studied for landscape elements due to the future extension of development in those localities.

As mentioned above, it is very important to distinguish solid rocks and soils with workability class over 4, while rocks of workability of classes 4-6 are sparse in the model area (1.9% of the area). However, they must be localized due to more difficult loosening of the rocks. They are found in the zone of undiscriminated flysch sediments. The largest landscape elements are fields and meadows (56.9%), forests (33.8) and built-up areas (9.3%).

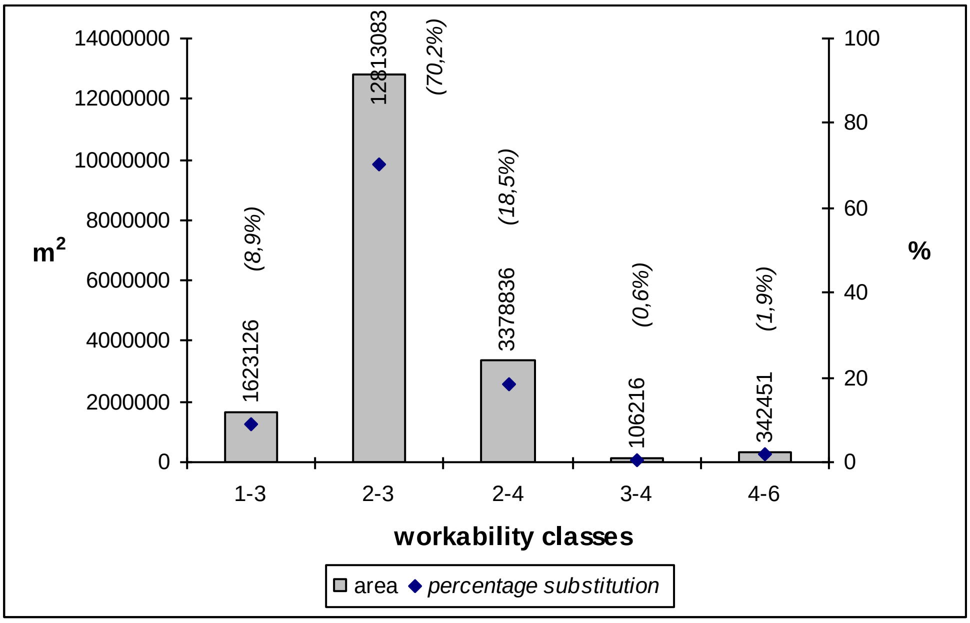

Fig. 1 Areal and percentage representation of the workability classes within the whole interest area

The analysis of the workability of rocks in terms of the *present built-up area* shows (*Fig. 2*) that the present built-up area predominantly lies on the rocks with the workability classes 2-3 (72.1%). This means that this dominant class has suitable properties for excavation work. In the built-up area of this class there is for example the Mining Museum Landek in Petřkovice and Zoological Garden in Slezská Ostrava. Then there are rocks with the workability classes 1-3 (14.1%) and 2-4 (12.5%), while in the area with the workability classes 2-4 in the built-up area a historic landmark of Hubert Mine in Hrušov and Hrušovská chemická společnost are located. The workability classes 3-4 (0.9%) and 4-6 (0.4%) are represented only slightly.

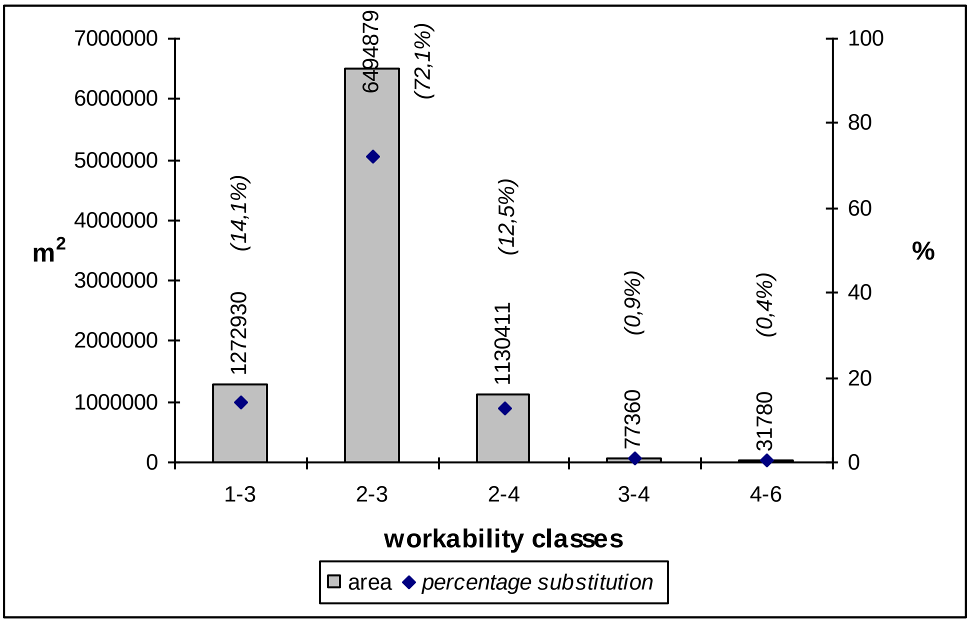

Fig. 2 Areal and percentage representation of the workability classes within the current built-up area

In case of the *newly built-up area (implemented since 1946)* the results were similar to the previous analyses, i.e. also the newly built development lies on the rocks with low rocks workability classes (*Fig. 3*). The most newly built-up area concerns the rocks with the workability classes 2-3 (69.3%), followed by classes 2-4 (17.7%) and 1-3 (11.1%).

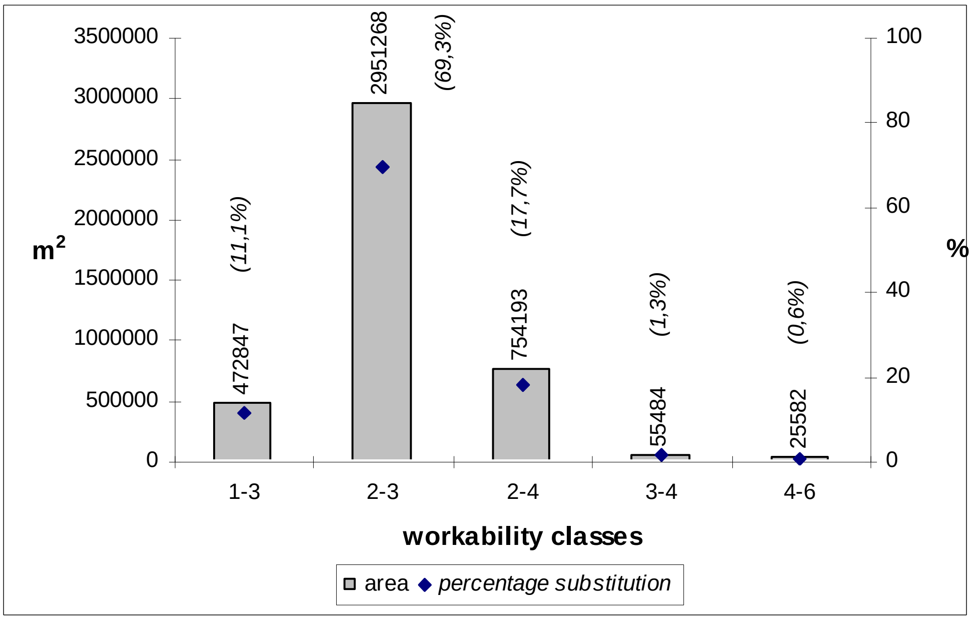

Fig. 3 Areal and percentage representation of the workability classes within the newly built-up area (1946 – present)

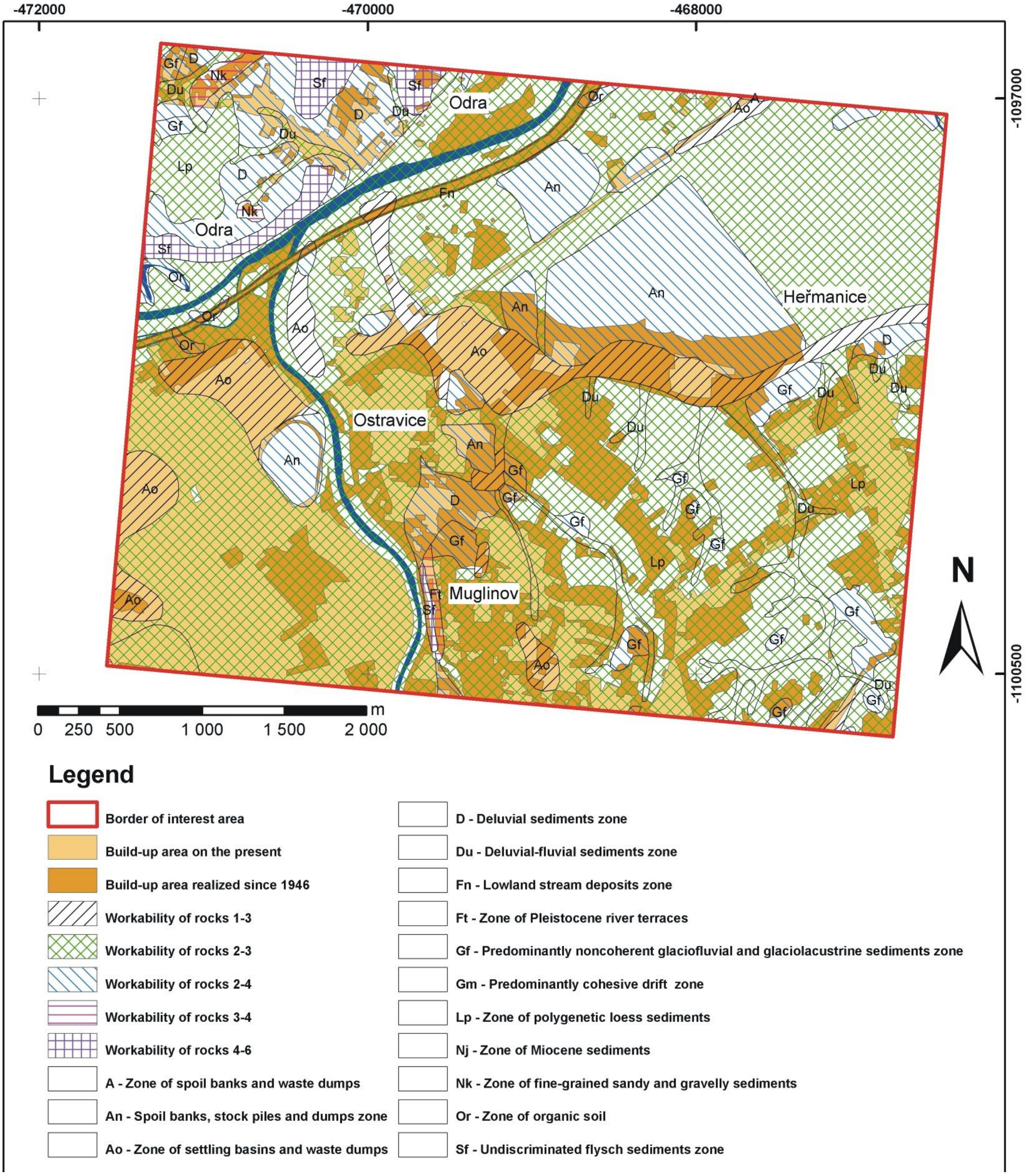

Fig. 4 Workability classes on the built-up area

Currently in the area of engineering geology and foundation engineering of demanding structures the second important evaluated geofactor of the study is the characteristic of ***Prequaternary base rocks*** in terms of division into soils and solid rocks as well as in terms of ***depth***. The depths are important where foundations of the demanding structures are laid, especially depths of 5 – 20 m below terrain surface (e.g. in the centre of Ostrava on the base of a valley terrace – 8 – 12 m, in the central part of Ostrava – Mariánské Hory, Vítkovice, Zábřeh on the base of a main terrace 10 – 16 m). In future there will be more motives to lay foundations deeper, not only in case of the above mentioned demanding structures (lack of area in the centres of city agglomerations, underground garages, municipal infrastructure, etc.). In the end, these are cases when the characteristics of the Quaternary overburden are insufficient for foundation engineering and it is necessary to lay foundations in the above mentioned Prequaternary base, and cases when the own geometry of the implemented structure interferes with the geological structure.

Another problem is the fact that the information is not implemented in land-use plans and future developers do not have preliminary information on its character, while this limits the implementation as for design, technology as well as finance especially in case of demanding structures.

The largest type within the whole interest area (Figure 5) is the type of alternation of cohesive and cohesionless soil at the depth of 5-10 m (50,6%), followed by the identical type at the depth over 10 m (29,9%) and the depth over 5 m (11,4%).

In the interest area solid rocks and semi-rocks are present only on a very small area. The solid rocks and semi-rocks with a base depth over 10 m take up only 0.1% of the total area. They occur in the zone of cohesionless glaciofluvial and glacial sediments (Gf). As for the same type with a depth below 5 m (7.5%), they lies in the undiscriminated flysch sediments zone (Sf), zone of polygenetic loess sediments (Lp), deluvial-fluvial sediments zone (Du) and deluvial sediments zone (D). The next type with depth 5-10 m (0.1%) is situated in the zone of cohesionless glaciofluvial and glacial sediments (Gf).

From the point of view of the methodology of depth determination there are three categories of depths (below 5 m, 5 to 10 m, over 10 m) and their combinations as the above mentioned combination of the second and third categories, whose result is a depth over 5 m. This classification is conditioned by various alternations of pre-Quaternary bedrock depths affected by geological structure, quantity and character of surveys which were the ground for their identification (with certain test holes there was no need for the foundation engineering to go as deep as the pre-Quaternary bedrock).

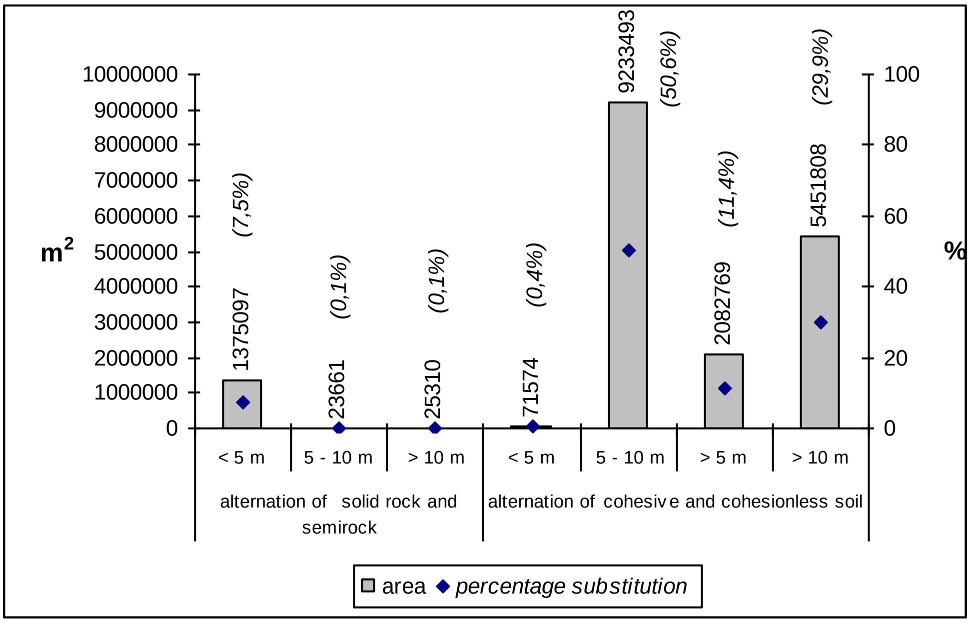

Fig. 5 Areal and percentage representation of the types of pre-Quaternary bedrock rock within the whole interest area

The evaluation of the geofactors in the *present built-up area* showed that the largest type found under the current built-up area is the type of alternation of cohesive and cohesionless soils with a base depth of 5-10 m (56.5% of the built-up area). This is followed by the identical type with an overburden depth over 10 m (24.7 %) and with a depth over 5 m (14.5%). This manifests that the minimum built-up area is on the type of alternation of solid rocks and semi-rocks; the most built up is the type with a base depth below 5 m (3.5%) (*Fig. 6*).

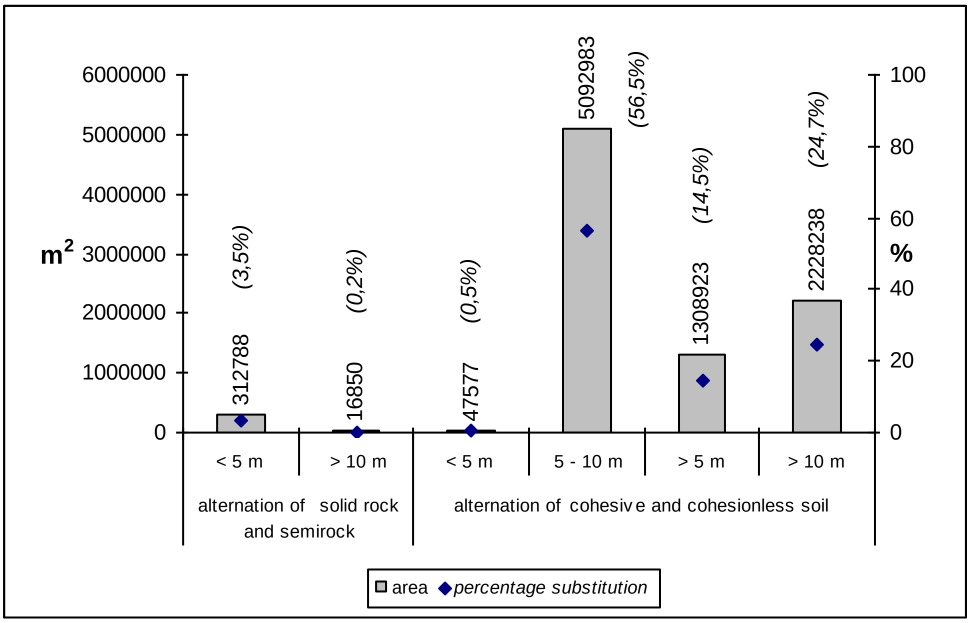

Fig. 6 Areal and percentage representation of the types of pre-Quaternary bedrock rock and soils within the current built-up area

The analysis of a newly built-up area (1946 – present) implies that since 1946 building activities have been carried out predominantly on the type of alternation of cohesive and cohesionless soils. Also here the type with an overburden depth up to 5 – 10 meters prevails (41.4%). The area grew in case of overburden over 10 metres (32.2%) and over 5 metres (22.6%). Solid rocks and semi-rocks were built up scarcely during the monitored period, especially the type with a depth below 5 m (2.9%) (*Fig. 7*).

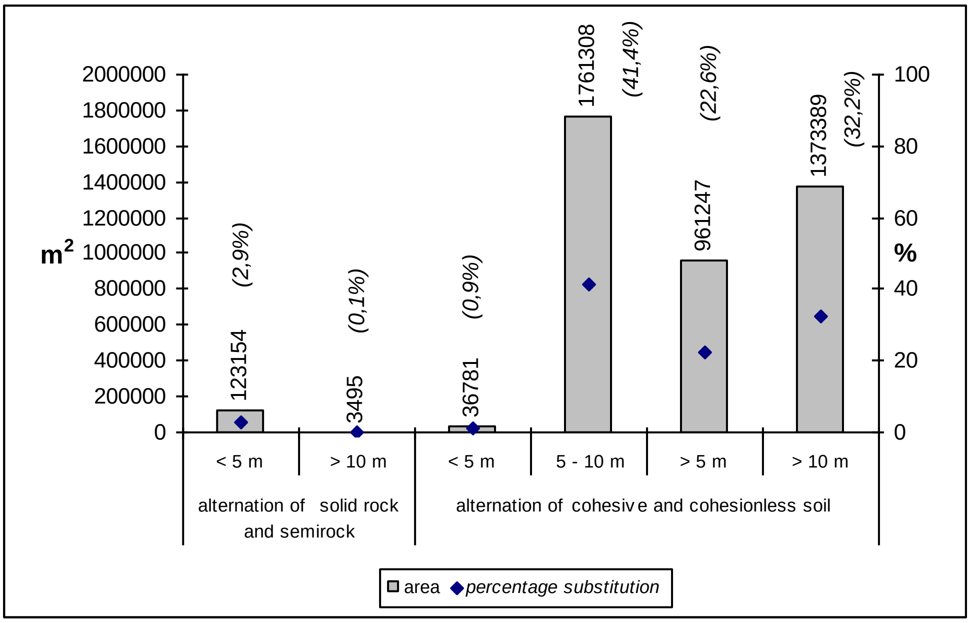

Fig. 7 Areal and percentage representation of the types of pre-Quaternary bedrock rock and soils within the newly built-up area (1946 – present)

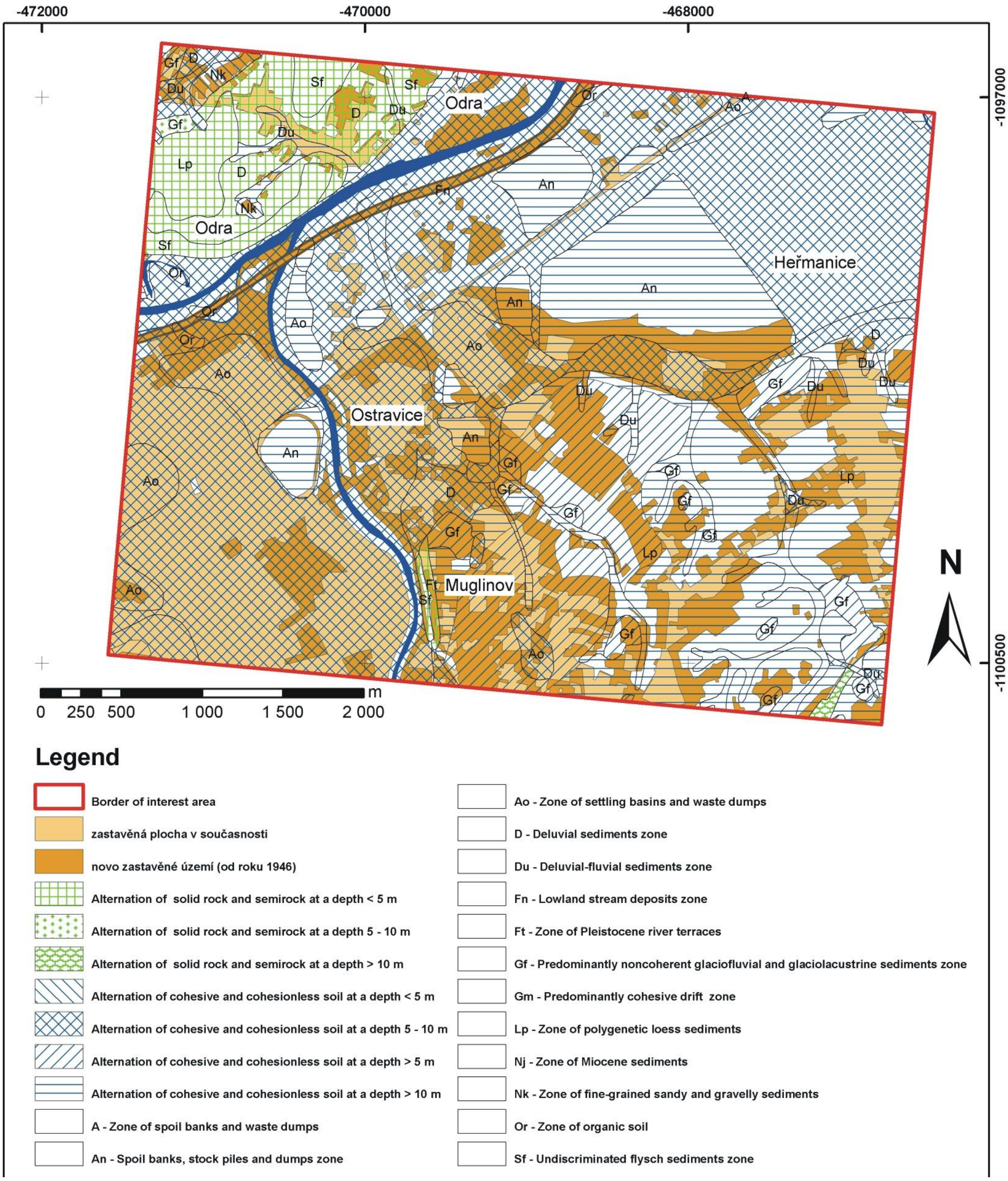

Fig. 8 Type of pre-Quaternary bedrock on the built-up area

3 CONCLUSION

One of the most important characteristics of soils and solid rocks, which has far-reaching consequences in design and implementation of engineering structures is workability of rocks. Its character influences the price of earth work performed, technology of its execution as well as relation to a whole number of physical-mechanical properties and stability of foundation pit walls or cuts of linear structures, etc. A method how not to take chances with the factor is to implement it in land-use planning, which is better than identify it during own building or during an engineering-geological survey. It is then important to remember the necessary and useful information service and provide it to future developers, investors as it is a limiting condition in terms of proceedings at the land-use planning departments and building offices. An example of its application is the case study in the chapter above with a map output presenting areas with identical workability classes, representing built-up areas and required mention of areas with solid rocks with higher workability classes bound to the undiscriminated flysch sediments zone in this particular case.

The result of the evaluation of the workability of rocks in the interest areas is the determination of sites in terms of more suitable or more difficult workability and quantification of the area sizes of the individual rock workability class ranges. It was discovered that the dominant workability classes in the interest area are classes 2-3 (70.2%), followed by classes 2-4 (18.5%) and 1-3 (8.9%). It can be stated that the occurrence trend of the mentioned classes is similar overall to the interest area both in the present built-up area as well as in the newly built-up area. In total, more suitable rock workability classes 1 to 4 prevail. The workability classes 4-6 are limited in the interest area, but their localization is substantial. For such purposes detailed maps of workability of rocks were prepared (covering the built-up area as well as the newly built-up area).

The second evaluated geofactor was the character of the Prequaternary base rocks and their depths, which is very important for future foundation engineering.

In virtue of a lot of constructions it is necessary to found them down to the level of pre-Quaternary bedrock, especially in cases of more demanding structures when the load must be transferred into the bedrock or in cases when the thickness of the Quaternary cover is small and in terms of foundation the depth is insufficient. Another reason is the fact when the Quaternary layers are not sufficiently bearing for the construction load transfer.

The analysis of the Prequaternary overburden type showed that the largest type (as much as a half of the interest area) is the alternation of cohesive and cohesionless soils at the base depth of 5-10 m (50.6% of the area). The alternation of solid rocks and semi-rocks in the interest area represents 7.7%, while the most widespread type is with a base depth below 5 m (7.5%).

4 ACKNOWLEDGEMENT

The publication was supported by the grant project GAČR - 205/07/1313.

REFERENCES

[1] Dopita, M. a kol.: Geologie české části hornoslezské pánve. *Ministerstvo životního prostředí, Praha 1997*

[2] Hack, R., Azzam, R., Charlier, R.: Engineering Geology for Infrastructure Planning in Europe A European Perspective. *Series: Lecture Notes in Earth Sciences, Vol. 104, XIX, 803 pp., Hardcover, ISBN: 3-540-21075-X, 2004*

[3] IAEG: Engineering geological and environmental maps and plans. 6th Intern. *Congress, Amsterdam, Vol. 1, pp. 23-281, 1990*

[4] Macoun, J. et al.: Kvartér Ostravska a Moravské brány. *Ústřední ústav geologický. Praha, 1965, 420 s.*

[5] Macoun, J., et al.: Geologická mapa ČSR. List 15-43 Ostrava, *1:50 000, Ústřední ústav geologický, Kolín, 1989*

[6] Malgot J., Baliak F., Čabalová D., Bartók J., Kopecký M., Satina J.,: Analýza inžinierskogeologických príčin porušenia stavebných objektov. *Katedra geotechniky SvF STU Bratislava, 1993*

[7] Marschalko M., Juriš P., Peňáz T.: Insufficient Utilization of the Impacts of Floodlands and Radon Hazard in Slezská Ostrava, Vítkovice and Radvanice for the Landscape Planning Purposes. *Proceedings of the XVIth International Scientific Symposium on Ecology in Selected Agglomerations of Jelšava – Lubeník and Central Spiš, October 25th to 26th 2007, Hrádok, Slovakia. Ústav geotechniky SAV Košice, 2007, s. 158-166*

[8] Matula, M., Pašek, J.,: Regionálna inžinierska geológia ČSSR, 295 str. Alfa, Bratislava, *1986*

[9] Motlík, M., Hofmanová, A.: ČSN 73 3050 Zemné práce. *Nahrazuje ČSN 73 3050 z 21.8.1963, účinnost od 1.9.1987. Vydavatelství ÚNM, 1987. 36 s.*

[10] Sloboda, J., et al.: Mapa inženýrskogologického rajonování ČR. List 15-43 Ostrava, *1:50 000, Ústřední ústav geologický, Kolín, 1990*

[11] United Nation: Integrating Geology in Urban Planning. *Vol. 12, 170 pp., United Nations Publications, ISBN: 9211200741, 2001*

[12] Vojenský topografický ústav: Letecký snímek, č. 548, č. 550, č. 552, č. 575, č. 577, č. 579, č. 580, č. 601, č. 603, č. 605, č. 606, č. 627, č. 629, č. 631, č. 632. *Dobruška, 1946*

[13] Český ústav zeměměřický a katastrální: Základní mapa ČR, 15-43-10. *Katastrální úřad, Opava, 2001*

[14] ČSN 72 1001 - Pomenovanie a opis hornín v inžinierskej geológii, *Validity: 1.8.1990*

Since 1.11.2004 replace: ČSN EN ISO 14689-1 (721005) - Geotechnický průzkum a zkoušení - Pojmenování a zatřiďování hornin - *Část 1: Pojmenování a popis, Validity: 1.11.2004*

ČSN EN ISO 14688-2 (721003) - Geotechnický průzkum a zkoušení - Pojmenování a zatřiďování zemin - *Část 2: Zásady pro zatřiďování, Validity: 1.4.2005*

[15] ČSN 73 1001 - Zakládání staveb. Základová půda pod plošnými základy, *Validity: 1.10.1988*

RESUMÉ

Jednou z nejdůležitějších charakteristik zemin a skalních hornin, která má dalekosáhle konsekvence s projektováním a realizací inženýrských děl je těžitelnost hornin. Její charakter má vliv na cenu realizace zemních prácí, technologií provedení, ale také vztah k celé řadě fyzikálně-mechanických vlastnosti a stabilitě stěn stavební jamy respektive zářezů liniových staveb apod. Cestou jak tento faktor nenechávat na náhodě, až při samotné realizaci stavby a v lepším případě na identifikaci při inženýrskogeologickém průzkumu, je jej implementovat již do zohledňovaných informací při územním plánování. Je důležité následně nezapomínat na potřebný a užitečný informační servis a poskytnout jej pro budoucí stavitele, investory o této limitující podmínce v rámci řízení na odborech zemního plánování a na stavebních úřadech. Příkladem způsobu použití je případová studie uvedená v předchozí kapitole s mapovým výstupem prezentujícím oblasti se stejnými třídami těžitelnosti, zobrazením zástavby a s potřebou si uvědomit oblasti s výskytem skalních hornin s vyššími třídami těžitelnosti vázanými v tomto konkrétním případě na inženýrskogeologický rajon flyšových hornin nerozlišených.

Výsledkem zhodnocení těžitelnosti na sledovaných územích je vymezení oblastí z hlediska vhodnější nebo obtížnější těžitelnosti a kvantifikace velikosti ploch jednotlivých rozmezí tříd těžitelnosti. Bylo zjištěno, že převahu na modelovém území má třída těžitelnosti 2-3 (70,2%), následují třídy 2-4 (18,5%) a 1-3 (8,9%). Můžeme konstatovat, že trendy výskytu zmíněných tříd podobné v rámci celého zájmového území, tak na zastavěné ploše v současnosti a také na nově zastavěné ploše. Celkově převládají vhodnější třídy těžitelnosti 1 až 4. Třída těžitelnosti 4-6 se na modelovém území nachází na omezené ploše, ale jejich lokalizace je podstatná. Pro tento účel byly zhotoveny přehledné mapy těžitelnosti (s překryvem se zástavbou, i s nově zastavěným územím).

Druhým hodnoceným geofaktorem byl charakter hornin předkvártérního podkladu a jeho hloubka., která je velmi důležitou pro zakládání budoucích staveb.

U řady staveb je potřeba založit stavbu až do úrovně předkvártérního podloží, zejména se jedná o případy náročnějších staveb, kdy se musí přenášet větší zatížení stavby do podloží, dále v případech kdy mocnost kvartérních pokryvů je malá a z hlediska hloubky založení nedostačující. Dalším důvodem bývá to, že kvartérní vrstvy nejsou dostatečně únosné pro přenos zatížení stavby.

Analýza dle typu předkvartérního pokryvu ukázala, že plošně největším typem (až ppolovina modelového území) v rámci celého modelového území je typ střídání soudržných a nesoudržných zemin s hloubkou podkladu 5-10 m (50,6% plochy). Střídaní skalních a poloskalních hornin v zájmové oblasti představuje 7,7%, přičemž nejrozsáhlejším je typ s hloubkou podkladu menší 5 m (7,5%).