Journal of Mining and Metallurgy, 45 A (1) (2009) 1 - 12

Journal of
Mining and
Metallurgy

DEALING WITH THE CONDITIONS OF FUTURE BUILT-UP AREAS BY MEANS OF ANALYSING GEOBARRIERS OF ROCK WORKABILITY AND PREQUATERNARY BASE TYPE

Marian Marschalko# and Hynek Lahuta

VSB - Technical University Ostrava, Faculty of Mining and Geology,
17. listopadu, 708 33 Ostrava - Poruba, Czech Republic

(Received 5 January 2009; accepted 6 February 2009)

Abstract

The study deals with a significant current need to respect important natural geofactors of engineering-geological conditions in land-use planning and also to improve awareness of future developers at building offices by means of made map analyses. The tool that allows that is geographic information systems. The factors characterizing the geological environment are numerous while the study deals with two of them which are not currently taken into consideration in land-use planning. These are workability of rocks and Prequaternary bedrock. The research was carried out in the area numbered 3, which is one out of five realized model areas in the future. It is located in Ostrava, the third largest agglomeration in the north-west of the Czech Republic, which has been most affected by anthropogenic industrial and mining activities among the Czech cities as well as in the European scope. The area is defined by a map sheet 15-41-25 in the district of Slezská Ostrava (Koblov, Antošovice) and outside Ostrava it reaches to Šilheřovice, Vrbice and Pudlov.

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

1. Introduction

An up-to-date topic with which engineering geology can contribute to the requirements of practice and research, in particular the needs of land use planning [1, 2, 8, 10, 11, 12, 18, 20, 22], state administration, building offices, developers, etc. is an analysis of new possibilities of providing reference information on the engineering-geological conditions by means of geographic information systems. The study in the presented paper deals with an evaluation of two geofactors. They are the character of rocks workability and Prequaternary bedrock. Workability is a significant limiting factor, which affects the used technology and financial demands of earth work. Especially in case of demanding

Corresponding author: *marian.marschalko@vsb.cz*

constructions, the Prequaternary bedrock is a geological environment which will have to be interacted 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 of no.3, which is defined by topographical map in drawing scale 1:10 000 (topographic sheet No. 15-41-25). Namely they are Koblov, Antošovice, Šilheřovice, Vrbice and Pudlov. The mentioned methodology was applied in the interest area for the first time.

2. Evaluation of workability of rocks and pre-Quaternary bedrock

The first evaluated factor of the study is workability of rocks [5, 6, 7, 15, 17] the cognition of which in the studied area is important from various points of view, but especially in relation to *earth work* that deals with excavation of rocks, transport of the excavated material or loose fill, its dumping or possible compaction and other modifications connected with such earth work.

The closest characteristic to workability is *breaking characteristic of rocks.* It is resistance of the rock towards the action of a tool by means of which its parts are disconnected. It depends on the properties of the excavated rocks and rock massifs, parameters of the cutting machine and technical regime of its operation. Breaking characteristic of rocks can be expressed by the amount of work needed to loosen a volume unit of rocks. The own *workability of rocks* depends on the resistance which the rock puts up to loosening, but also other circumstances, such as clinging of the rocks to working tools, bulking of rocks and the resistance of rocks during their loading and unloading. The measure of workability of rocks is the amount of work needed to perform the activities mentioned above.

The evaluation of the workability of rocks makes part of engineering-geological survey and is grounded in the classification set by ČSN 73 3050 Standard *Earth Work*, according to which rocks are divided into 7 classes of workability of rocks, based on the difficulty of their loosening and extracting. By consent, the classes are labelled rock workability classes.

The rock workability classes may also be characterized by means of the rock breaking method, while the first class of loose rocks can be shovelled or loaded by a loading-machine but the last, seventh class concerns solid rocks that are difficult to break and must be blasted.

In the studied area it is not possible to carry out an analysis of workability of rocks for each unit of workability classes as there are engineering-geological zones for which typical rock workability classes are in a certain range (e.g. 1 to 3 or 2 to 4). Such as analysis has also its meaning as it distinguishes areas with more suitable or more difficult workability of rocks in terms of earth work.

It was discovered that within the *whole interest area* the rocks with workability class 2-3 take up (Fig. 1) a substantial part (78.6%). The most dominant landscape element in this workability class is fields and meadows (45.9%), followed by forests (39.8%) and built-up area (8.2%). The next more extensive part (16.6%) is taken up by rocks with workability class 3-4. The dominant landscape element of this class is forests (42.4%), water areas (32.9%) and fields and meadows (22%). The built-up area covers only 2.5% of the rock workability class area. The rock workability class 1-3 covers an area of 3.1% of the interest area, while the dominant elements are built-up area (39.3%) and fields and meadows (39.2). The rock workability class 2-4 (0.2%) appears scarcely in the interest area while 55.5% of this area is covered by fields and meadows. The workability of rocks in the landscape elements, apart from built-up area, was studied due to future expansion of the built-up area into those areas.

The workability class 1 is formed by fine soils of 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 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 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 are partially mouldered to moulder. The soils are again of 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.

Even more significant are rocks with higher rock workability classes represented in the interest area ranging from 4 to 6, while their representation in the interest area is small (1.4% of the area). Their localization is vital for the purposes of land-use planning and implementation of future structures due to more difficult breaking characteristic of rocks. They are found in the zone of undiscriminated flysch sediments. In this rock workability class fields and meadows dominate (85.9%); the built-up area takes up only 9.7% of the area.

The relation of rock workability classes to the required types of mechanization to break the rocks subject to ČSN 73 3050 Standard must be understood according to current possibilities. As currently there are machines which are able to extract rocks of workability classes 1-4 directly without prior loosening. Solid rocks of classes 5 to 7 still must be loosened before own excavation by digging, breaking or blasting, while rocks of classes 5 to 6 can be loosened and excavated by current high-performance heavy excavators due to their digging power. Apart from controlled blasting, rocks of workability classes 5-7 can be loosened also by hydraulic wrecking hammers.

If we evaluate the rock workability analysis on the *present built-up area* it is apparent that (Fig. 2) the most built upon rock workability class is class 2-3, which concerns more than three quarters of the built-up area (78.1%). This area had suitable characteristics for easy execution of excavation work. The rock workability class 1-3 concerns 14.8% of the present built-up area, class 3-4 relates to 5% and rock workability class 4-6 is characteristic for only 1.7% of the built-up area.

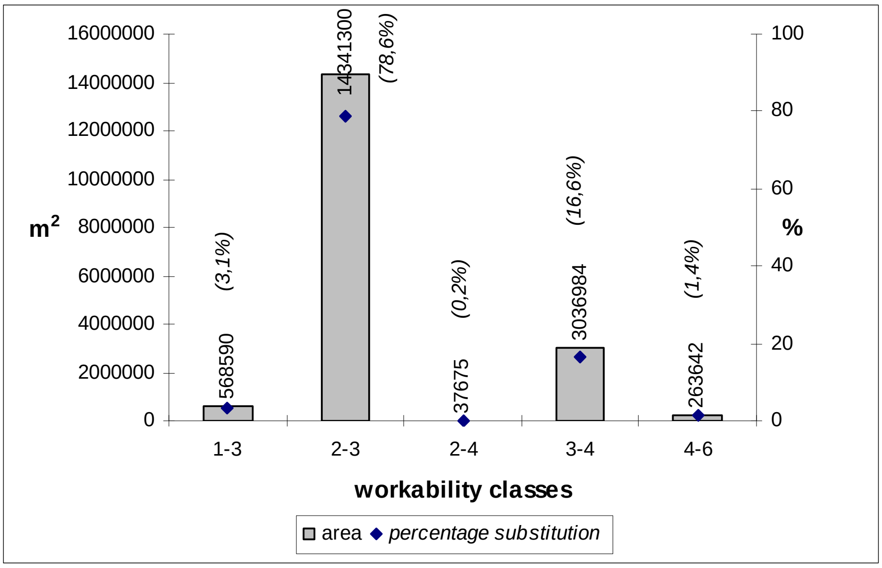

Figure 1. Areal and percentage representation of the workability classes within the whole interest area

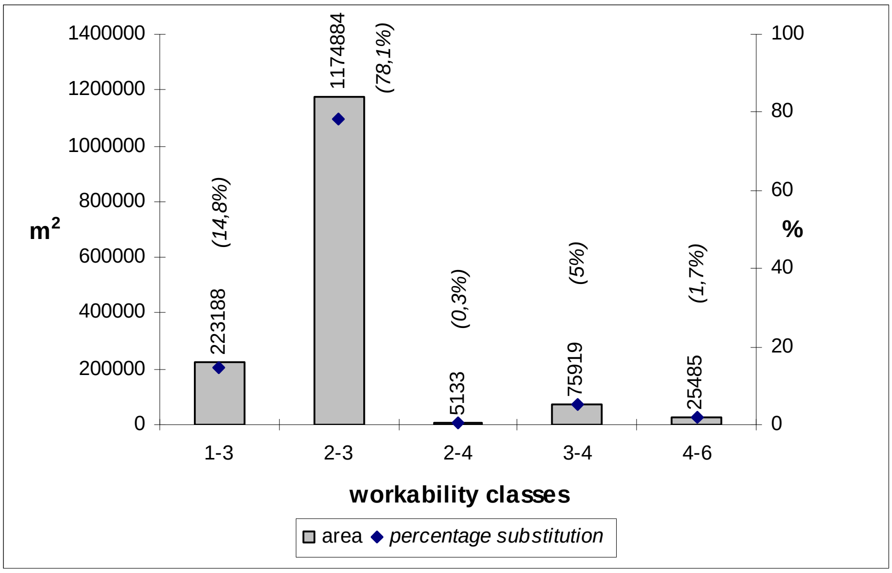

Figure 2. Areal and percentage representation of the workability classes within the current built-up area

The rock workability analyses results within newly built-up area since 1946 to date show similar trends to the previous studies (Fig. 3, 4). In the newly built-up areas rock workability classes 2-3 (89.1%) dominate, followed by classes 3-4 with 6.5% and the smallest is the class 4-6 with 2,1 %.

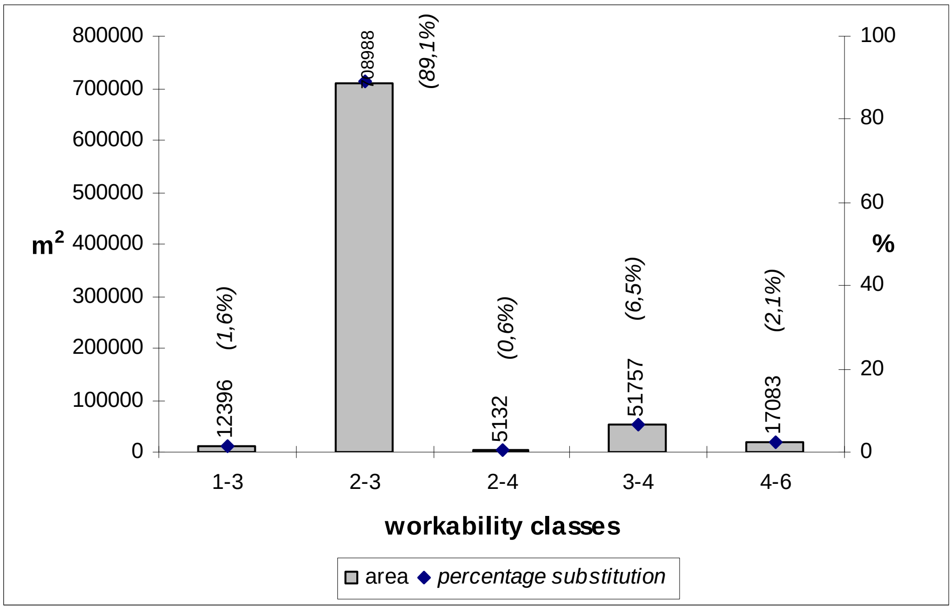

Figure 3. Areal and percentage representation of the workability classes within the newly built-up area (1946 – present*)*

The second part of the study focused on the examination of the type of *Prequaternary bedrock rocks* [3, 4, 9, 13, 14, 15, 16, 19, 21] *and its depth in the inte-rest area*. Prequaternary bedrock is a geological environment which will have to be interacted with and must be taken into account during selecting engineering foundation. There-fore, its cognition is important, limiting information when selecting the method of the implementation of future foundation engineering as well as for certain other ways to make use of landscape. For example, its character affects the hydro-geological conditions and those influence the utilization of landscape in relation to the ground water source requirements, the character of aquifers with free surfaces, etc.

Another example is physical-mechanical properties of the Prequater-nary bedrock and their referentiallity to the workability of rocks affecting earth work as well as the stability of vertical building walls. Thus, the reference information on its character would much help potential developers, investors and designers. It would be convenient if the information became part of land-use planning documents.

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 above the mentioned combination of the second and third categories, the result of which is depth over 5 m.

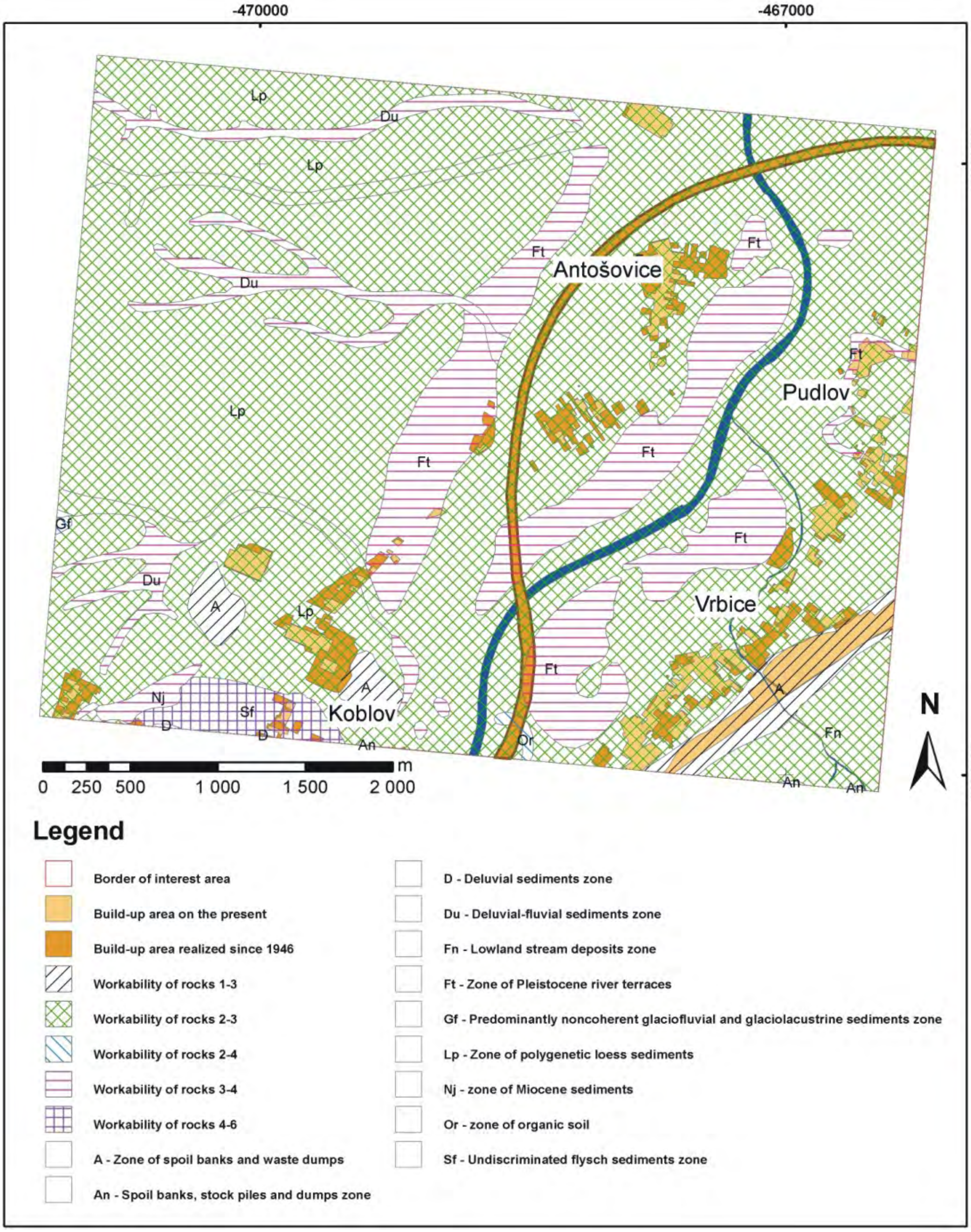

Figure 4. Workability classes on the built-up area

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).

The results imply that the largest type within the whole interest area (Fig. 5, 8) is the type of alternation of cohesive and cohesionless soils with the Prequaternary bedrock depth of 5-10 m (45.4% of the area), followed by the identical type with depth over 10 m (40.2%). The same types with the overburden depth over and below 5m take up a minute area there. A relatively large area in comparison with the other interest areas is taken up by the type of alternation of solid rock and semirock with the bedrock depth below 5m (14.2%), with depth 5-10m only 0.04% of the interest area.

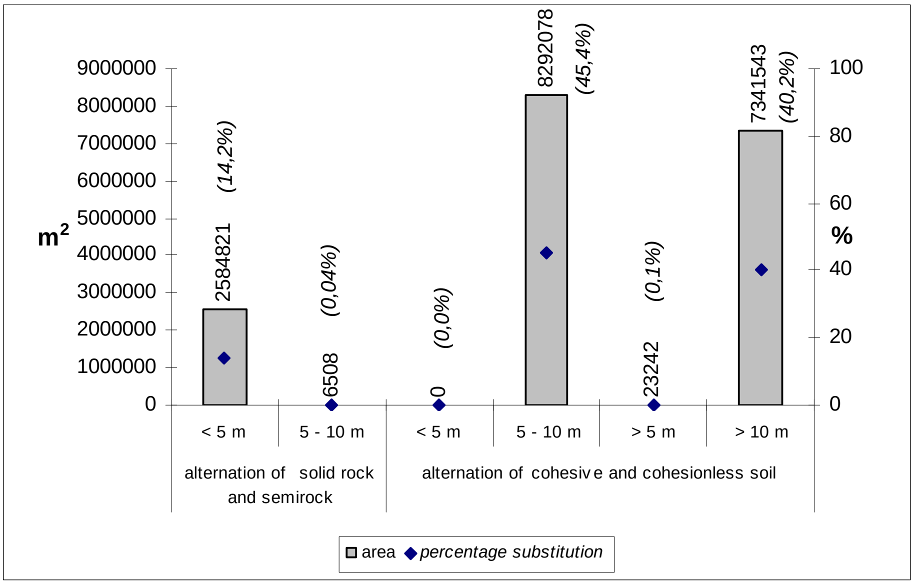

Figure 5. Areal and percentage representation of the types of pre-Quaternary bedrock rock within the whole interest area

The following *analysis of this geofactor with regard to the present built-up area* showed (Fig. 6,8) that the most built-up area lies on the type of alternation of cohesive and cohesionless soils with the bedrock depth 5-10 m (78.8% of the built-up area), followed by the identical type with the depth over 10 m (14.2%). The type of alternation of solid rock and semirock is again covered by more built-up area than in other interest areas; it is the type with overall bedrock depth over 10 m (6.7%).

The last carried out *analysis on the newly built-up area since 1946 to date* showed an identical trend to the previous analysis (Fig. 7, 8).

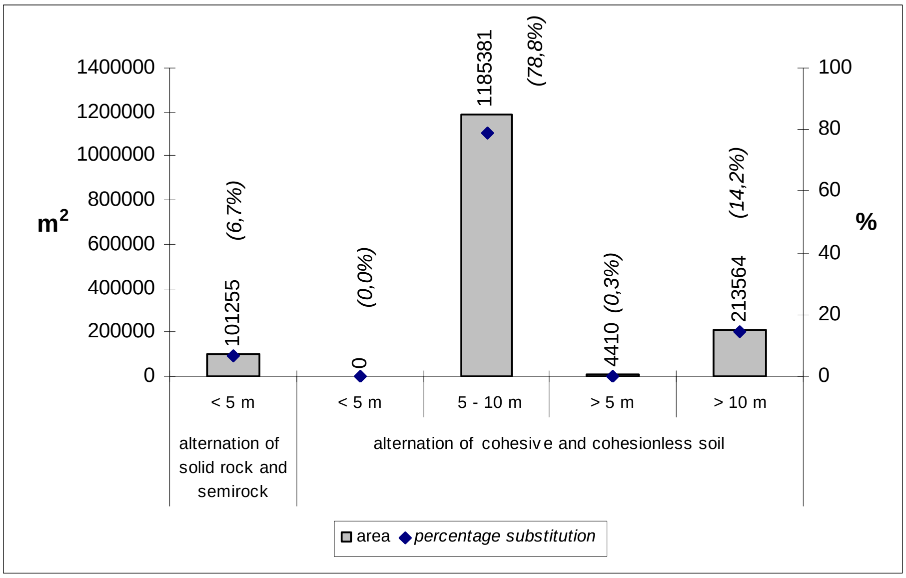

Figure 6. Areal and percentage representation of the types of pre-Quaternary bedrock rock and soils within the current built-up area

The most built up type since 1946 has been the type of alternation of cohesive and cohesionless soils with bedrock depth 5-10 m (74.3%), the same type with bedrock depth over 10m covers 16.5% of the newly built-up area and the type of alternation of solid rock and semirock covers 8.6%.

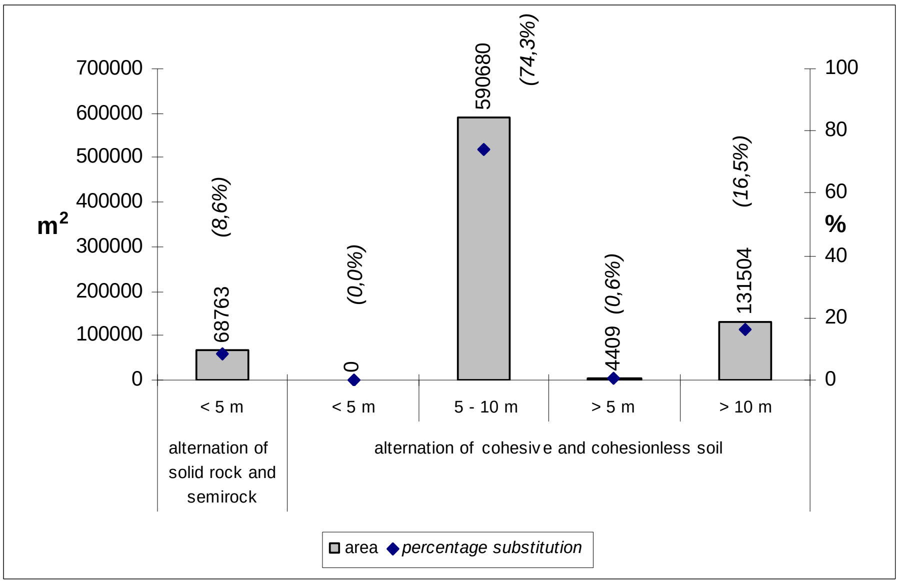

Figure 7. Areal and percentage representation of the types of pre-Quaternary bedrock rock and soils within the newly built-up area (1946 – present)

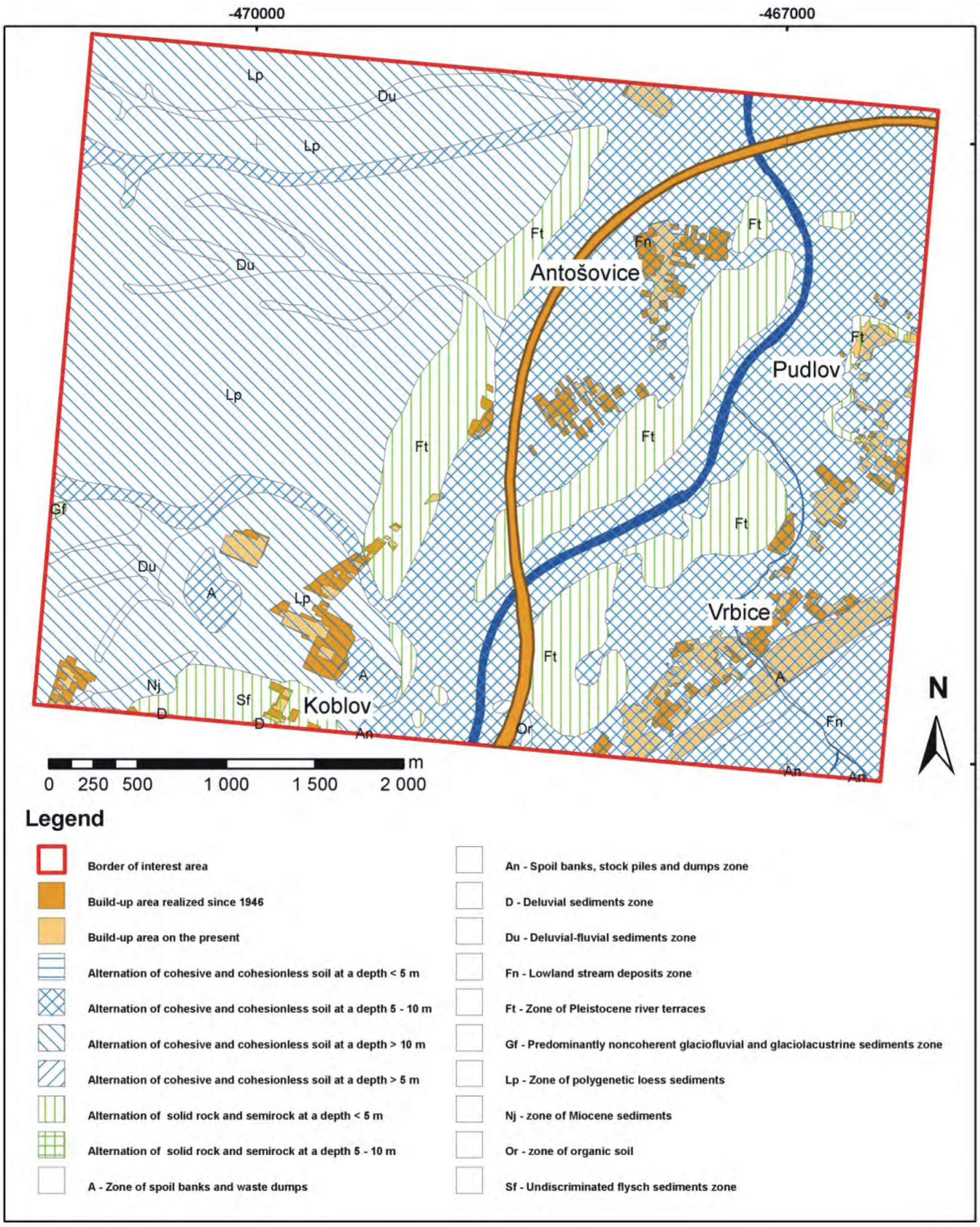

Figure 8. Type of pre-Quaternary bedrock on the built-up area

3. Conclusion

Identification and determination of *workability of rocks* is one of the most important tasks of engineering-geological survey for different construction types (road works, building foundations, tunnels, underground services, sewage systems, etc.). The extent of this property primarily depends on the type of construction, geological and geomorphological conditions of the interest locality. Apart others, the determination of workability class are important for the preparation of technological method of earthwork, time plan and financial budget for the implementation of a construction project. The workability of rocks depends on the resistance which the rock puts up to loosening, and other circumstances such as tackiness of the rocks on the working tools, bulking of rocks and resistance of rocks during their loading and tipping.

Carrying out the analysis of the workability of rocks was outlined on the basis of rock workability class ranges (e.g. workability of rocks 1-3). It was discovered that the dominant rock workability class, not only within the whole interest area but also in relation to the present built-up area and the so-called newly built-up area since 1946, is the rock workability class 2-3. The rock workability classes 1-3 and 3-4 are represented much less. This means that overall, more suitable rock workability classes 1 to 4 prevail (99.6%).

The workability class 4-6 is limited in the interest area, but due to financial reasons and intensity of labour (e.g. during general site excavation) their localization is important (similarly as in the case of zones). For this purpose detailed maps of workability of rocks have been prepared.

Another analyzed characteristic was the type of rocks of pre-Quaternary bedrock and their depth. This characteristic is very important for foundation engineering. With 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 Quaternary cover is small and in terms of foundation the depth is insufficient. Another reason is the fact when Quaternary layers are not sufficiently bearing for the construction load transfer. An appreciable reason is an increasing need in founding more demanding structures, underground constructions (e.g. collectors, garages) in bigger depths and thus the depth and character of the pre-Quaternary bedrock must be identified. This necessity is most vital in the city centres, in particular.

It was found out that in the interest area there are two basic types of Prequaternary bedrock, alternation of cohesive and cohesionless soils and alternation of solid rock and semirocks. Those types were further classified according to the depth of the Prequaternary bedrock. The analysis according to the type of the Prequaternary bedrock showed that the largest type in the interest area was the type of alternation of cohesive and cohesionless soils (85.7%), namely with the bedrock depth ranging from 5 to 10 m (45.4%) and over 10 m (40.2%). The alternation of solid rock and semirocks covers an extensive area when compared with other researched areas (14.2%), while the dominant type was with bedrock depth below 5 m.

4. Acknowledgement

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

5. References

1. Bell, F. G., Geological Hazards, Publisher Spon Press (UK), ISBN 0419169709. (1998). p. 608.
2. Čabalová, D., Baliak, F., Kopecký, M., (1999), Geology, Script STU (in Czech), Publish STU, Bratislava.
3. Czech Institute of Surveying, (2001), Mapping and Cadastre: The location map, 15-41-25 (in Czech), Cadastral Office, Opava.
4. Chlupáč, I. et al., Geological history of the Czech Republic. 1st edition Praha: Academia (in Czech), ISBN 80-200-0914-0, (2002), p. 436.
5. ČSN 73 1001 - Foundation engineering, (1998), Underlying ground under bare basics Validity: 1/10/1988
6. ČSN EN ISO 14688-2 (721003), (2005), Geotechnical investigation and testing - The description and classification of soil - Part 2: Principles of classification (in Czech), Validity: 1.4.2005
7. ČSN EN ISO 14689-1 (721005), (2004), Geotechnical investigation and testing - The description and classification of rocks - Part 1: The name and description (in Czech), Validity: 1/11/2004
8. Doornkamp, J. C., Lee, E. M., Geology and land use planning, St Helens, Merseyside, Summary report Rendel Geotechnics, Birmingham, (1992), p. 64.
9. Dopita, M. et al., (1997), Geology of the Czech part of the Upper Silesian Basin (in Czech), Ministry of Environment, Prague.
10. 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, Hardcover, ISBN: 3-540-21075-X, (2004), p. 803.
11. Hrašna M., Adamcová R., (1993), Site suitability of the pre landfills waste 1:50000 (in Czech), MoE SR, Bratislava Geofond.
12. IAEG, Engineering geological and environmental maps and plans. 6th Intern. Congress, Amsterdam, Vol. 1, (1990), pp. 23-281.
13. Macoun, J. et al., Quaternary Silesian and Moravian Gate (in Czech), Central Geological Survey, Prague, (1965), p. 420.
14. Macoun, J., et al., (1989), Geological map of Czechoslovakia (inCzech), Nov 15-43 Ostrava, 1:50000, Central Geological Survey, Kolín.
15. Marschalko, M., Lahuta, H., Juriš, P., Analysis of Workability of Rocks and Type of PreQuarternary Bedrock in the Selected Part of the Ostrava Conurbation by Means of Geographic Information System. Acta Montanistica Slovaca,

číslo 2, Ročník 13, Košice, Slovakia, (2008), pp. 195-203.
16. Matula, M., Pašek, J.,, Regional engineering Geology of Czecho-slovakia (in Czech), Alfa, Bratislava, (1986), p. 295,
17. Motlík, M., Hofmanová, A., ČSN 73 3050 Earthworks. Replaces CSN 73 3050 from 21.8.1963, effective from 1.9.1987 (in Czech), Publishing ÚNM, (1987), p. 36.
18. Petro, L., Frankovsk, J., Matys, M., Wagner, P., et al., Engineering Geology of Geotechnick glossary (in Czech), State Geological Survey of Dionysus Štúra, Bratislava (2008), p. 465.
19. Sloboda, J., et al., (1990), Sloboda, J., et al., Map of engineer-geological region CR, Nov 15-43 Ostrava, 1:50000, (in Czech), Central Geological Survey, Kolín.
20. United Nation, Integrating Geology in Urban Planning, United Nations Publications, Vol. 12, ISBN: 9211200741, (2001), p. 170.
21. Topography Military Institute, (1946), Aerial View, No. 548, No. 550, No. 552, No. 575, No. 577, No. 579, No. 580, No. 601, No. 603, No. 605, No. 606 , No. 627, No. 629, No. 631, No. 632 (in Czech), Dobruška.
22. Willey, E. C., Urban geology of the Toowoomba conurbation, SE Queensland, Australia. Quaternary International, Volume 103, Issue 1, (2003), pp. 57-74.