GEOTECHNICAL SOIL PROPERTIES OF PODKRUŠNOHORSKÁ OVERBURDEN DUMP

GEOTECHNICKÉ VLASTNOSTI ZEMIN NA PODKRUŠNOHORSKÉ VÝSYPCE

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Abstract

Since the very beginning of its development the brown coal openwork in Sokolov area has been marked by lack of overburden dumps for piling up overburden materials.

Under these circumstances virtually all of these overburden dumps of operating opencast mines were fully or partially built up on a seam area and overlap part of coal reserves not being in the past designed for mining, or with awareness of necessary partial extraction in the future.

The overburden dump management works continually with tense balance of discharging areas, therefore it was always necessary to use the discharging areas to the maximum. Many measures were worked out for the purpose. We can say that without these measures we could not solve a whole series of complicated conditions of overburden dumps structure in this area and thus in some degree ensure reliability of dump capacities.

Abstrakt

Povrchové dobývání hnědého uhlí v sokolovském revíru je od samého počátku svého rozvoje poznamenáno nedostatkem výsypných prostorů pro ukládání skrývkových materiálů.

Za těchto okolností prakticky všechny výsypky lomových provozů zčásti nebo zcela byly budovány na slojovém území a překrývají části uhelných zásob v minulosti neuvažovaných k těžbě nebo s vědomím nutného částečného odtěžení v budoucnosti.

Výsypkové hospodářství pracuje prakticky neustále s napjatou bilancí výsypných prostorů, a proto bylo vždy nutno dbát na to, aby výsypný prostor byl využit maximálně. K tomu byla zpracována celá řada opatření. Je možno konstatovat, že bez těchto opatření by nebylo možno vyřešit celou řadu složitých podmínek stavby výsypek v revíru a do značné míry tak zajistit spolehlivost výsypkových kapacit revíru.

Keywords: overburden dump, geotechnics, soil, penetration, exploration well.

1 TERRAIN CHARACTERISTICS

The Podkrušnohorská overburden dump is located in a landscape area with excessive geomorphologic division at the boundary between the foothills of the Ore Mountains (Krušné hory) and the northern part of the Sokolovská basin. According to historical data the terrain of interest was originally created by a forest landscape area with variable representation of beech, oak and a distinct portion of coniferous, especially fir and pine tree. The landscape was originally dramatically broken and the division was preserved despite running mining activities - Podkrušnohorská overburden dump structure.

The terrain in question is situated to the north and northeast of the town of Sokolov among the villages Vintířov – Vřesová – Dolní Nivy – Boučí – Lomnice. The terrain affected by the activities at the Podkrušnohorská overburden dump spreads out on 8 cadastral areas in the district of Sokolov in the Karlovy Vary region. The total area of the terrain affected by mining activities amounts to 1,957.1 ha. The dump length in a west-east direction is 8.3 km and its width is 2.3 km. In total ca 886,000,000 m^3 of overburden soils have been piled-up at the dump.

The initial configuration of the terrain was situated in the southern part at spot height ca 460 - 480 metres above sea level and in the northern part ca 460 - 530 metres above sea level, the terrain sloped down from the north to the east and southwest under the general gradient not exceeding 2 degrees. Through the west part of the terrain Boučský and Hluboký brooks ran in widely open valley, which got narrower to a chine in the southern part. Between the western and eastern parts of the dump the Lomnický brook ran through in a shallow valley and the terrain had a pattern of elevation, which created good conditions for drainage. At the boundary between the middle and eastern parts of the dump the Lipnický brook ran through in the valley oriented N - S, which in the central part created depressions with an excess of surface and underground water. Through the east part of the terrain the Vintířovský brook ran in the valley oriented NW - SE. The east part of the original terrain was relatively flat with a plateau at the spot height ca 480 metres above sea level. In the eastern part the Lipnice opencast coal-mine was worked-out and its allotment was abandoned. The bottom of the former Lipnice opencast coal-mine and its W and N parts in general decline in a lateral direction N - S and in the southern and eastern parts under a general gradient N - N. In the southwest part of the present dump the Erika opencast coal-mine was worked-out. The opencast coal-mine bottom declines from the north and west to the south to the deepest point at the level of 429 metres above sea level, which was situated in the middle part of the opencast coal-mine. Both abandoned opencast coal-mines were filled up by older dumps. At present the backfilling at the entire dump was finished according to projects in force.

The new terrain configuration after the filling of the whole dump body is created by a new body of an elongated shape in a W - E direction of a total length ca 8.3 km and mean width 2.3 km with two peaks of elevation 600 m, between which a shallow saddle occurred in a S - N direction. From the peaks the dump terrain falls towards the south and southwest under a general gradient 1: 15 to 1: 17, to the southeast under a gradient 1 :13 up to 1: 15 and to the north 1 : 7 up to 1: 8. The individual dumping benches are sloped and ground-shaped to a required body form. [1]

As mentioned above the Podkrušnohorská dump was formed by connecting the Lipnice, Vintířovská, Pastviny, Týn and Boučí dumps. Nearly the entire dump excluding the middle part, where the Lipnice opencast coal-mine was located, and the southwest part, where the former Erika opencast coal-mine was situated with the lowest point in 429 metres above sea level, was strewn as an outer dump on a virgin soil to a maximum horizon height of 600 metres above seal level. It can be said the dump surface is broken similarly as the original terrain and after performing the area recultivation the dump will be integrated into the local natural and living environment as a cultural landscape area. [2]

2 PENETRATION MEASUREMENT RESULTS ASSESSMENT OF BP46 TO 462 AND BP 47 TO 472 PENETROMETERS – DETERMINATION OF SHEAR STRENGTH PROPERTIES OF STUDIED SOILS IN EFFECTIVE AND TOTAL RANGE OF FUNCTION

The point of interest of the presented paper is a strength evaluation of a set of 9 driving penetrometers, which were implemented within the years 1992 to 2007 in two identical points of the dump. The driving penetrometers were performed at the exterior Boučí dump being a part of the considerably space-extensive Podkrušnohorská dump (the dump involves discharge areas called Vintířov, Pastviny, Týn and Boučí). The backfill of the dump in the BP 46 and BP 47 penetrometer points is formed by clays occurred by discharging the worked-out claystones of cyprine strata from the roof of the Antonín coal seam.

Both driving penetrometers are situated in the assessed relief 5-5´ / X = 1 009 000, Y = 869 415; X = 1 008 000, Y = 867 540/. The fact that in this line the stability of the Boučí dump was reassessed, gave rise to the repeated penetration measurements in the BP 46 and 47 driving penetrometer points within the years 1992 to 1998. The measurement results were applied to stability calculations as input data.

2.1 Comparison of changes in the dump body in the years 1992-2007

During measurements tens of tables were obtained with hundreds of shear strength values. It is difficult to interpret such data quantity. Therefore, it is necessary to process the data in an acceptable way and acquire final values of shear strength, which characterize accordingly strength changes occurred in the dump body in the years 1992 to 2007. To compare the changes the tables *"Total penetrometer parameters after assessing by weighted mean"* were applied. The values for a so-called dump body were obtained via a weighted mean, when the weight was represented by thickness of single dump layers (see Tables 1 and 2). It concerns the total strength average of the dump body in a given tracking point and time excluding the contact area between the dump and the under bed which was assessed separately.

The dump division to the so-called dump body and the contact area between the dump and the under bed results from a long-lasting experience in tracking of dumps. At the dump base usually a contact between the dump and the under bed takes place, where a certain drop of strength parameters occurs. The existence of the

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contact may be put into direct connection with the water horizon occurring at the dump base. It can be said about the horizon at the dump base that depending on morphology of the original terrain it occurs virtually under the whole dump body. Its yield depends on the water quantity coming into the dump body and on efficiency of the drainage system. It concerns virtually a sole water horizon whose hydrological continuity can be proved in more area-extensive range of tracking.

For more transparency visualization of the above mentioned comparison of measurement results from the years 1992 to 2007 has been performed using Excel graphs - see Figs. 1 and 2. [1] [3]

The acquired values of the strength parameters of dumped soils or let us say defined dependences of resistance and depth (i.e. trend lines) were plotted using lines. With an admissible simplification it can be said that the line inclination corresponds to the internal friction angle and the distance from the coordinate origin corresponds to cohesion. In such interpretation then the fact the trend lines are parallel proves equality of the internal friction angles; the same distance from the horizontal line (i.e. from the axis of elevation), or the same intersection on the axis *"Penetration resistance"* proves identical values of cohesion. Improvement of strength parameters of the dump backfill caused e.g. by an effect of primary consolidation will then reveals itself either by an increase of inclination of the trend line (Note: - untypical behaviour for a dump) or by an increase of the distance from the coordinate origin. In some case by both of them, however, improvement of these two strength parameters all at once is not typical for dumped soils. The dump backfill at the time after backfilling shows substantial lumpiness and behaves as so-called "false gravel", i.e. shows high values of internal friction angle and low values of cohesion. In the course of time a decrease of internal friction angle values should occur which is supposed to be compensated by a growth of cohesion values, i.e. trend lines should show a gradient reduction accompanied by shift of the lines farther from the coordinate origin. Such time-dependent change behaviour in distribution of strength parameters matches to theoretical presumptions on behaviour of the dump body. The measurement results from the driving penetrometers BP 47 (of the year 1992) and BP 471 (1998) exactly correspond to the hypotheses and prove the dumped soils really show a tendency to redistribute this way the distribution of strength parameters - see Fig. 2 [1] [2] [3]

In Fig.1 behaviour of strength changes of the dump body is captured in the point of penetrometers falling into the BP 46-462 measurement file. Just at the beginning it is necessary to say the measurement results from the year 1995 (BP 430) go beyond characteristic dump behaviour (it is interesting the same applies to the BP 440 penetrometer in the point of the BP 47 penetrometers), so the BP 430 and BP 440 penetrometers were finally excluded from the interpretation of penetration measurements.

Note: If the measurement at the BP 430 penetrometer was realized as the first, so it on the contrary would greatly fit into the behaviour framework typical for dump backfill - see so-called "false gravel" shortly after backfilling - high φ, low c, i.e. steep trend line intersecting the axis „*Penetration resistance*" near the coordinate origin.

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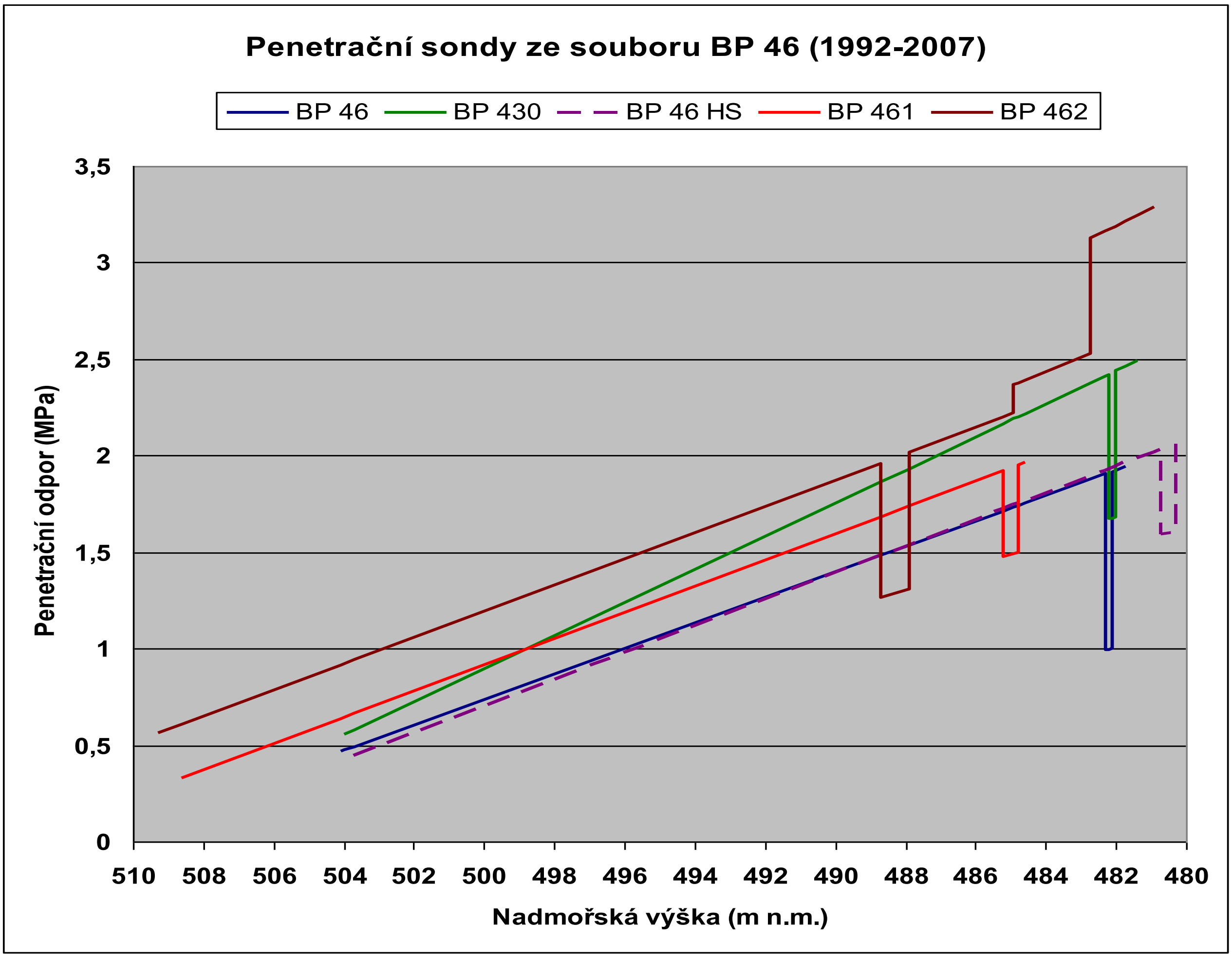

Fig. 1 Driving penetrometrs from the BP 46 file

Penetrační sondy ze souboru BP 46 (1992-2007) - Driving penetrometers from the BP 46 file (1992-2007)
Penetrační odpor (MPa) - Penetration resistance (MPa)
Nadmořská výška (m n.m.) - Elevation (metres above sea level)

It is obvious from Fig. 1 the measurement results in the years 1992 and 1997 (see BP 46 and BP 46 HS penetrometers) do not differ from each other too much, only a dramatic resistance increase occurred (i.e. improvement of strength parameters) in the area of the contact between the dump and under bed. The body itself showed virtually no changes for the given period. The HP 46 HS penetrometer has been plotted as a dash line for the reason that otherwise both trend lines would virtually overlap in a certain depth interval.

After increasing the dump in the point of the BP 46 penetrometers by 4,9 m improvement of strength parameters (see the BP 461 penetrometer in Fig.1) occurred within the running process of primary consolidation. The internal friction angle values did not change (and there were no obvious reason for their increase, too), however, cohesion values showed a dramatic increase (see the shift from the coordinate origin). The dramatic improvement occurred especially within the landslip body itself; within the contact area between the dump and under bed virtually any changes occurred as compared to the year 1997, or more precisely very gentle improvement only.

The measurement results from the year 2007 (BP 462) show further improvement of strength conditions, i.e. an increase of cohesion values namely both for dump body and the contact area with the under bed. In 2007 even soils were captured in the area of the contact with the under bed, showing higher strength values than the dump body itself. Even the highest values of resistance were captured immediately in the area of the contact with the under bed - see the lately earmarked so-called area at the dump base. This improvement was measured by the driving penetrometer BP 462, however, it has to be said that so significant improvement at the dump base is not typical for dump bodies, it concerns rather a certain anomaly in improving strength conditions. [3]

In Fig.1 at the BP 462 penetrometer an anomalous layer at a depth h=20.6-21.4 m (488.7-487.9 metres above sea level) with parameters φ=5.9^{o}, c= 11.3 kPa was highlighted. This layer occurrence proves that although at an average total improvement of conditions occurred (both in the area of the dump body and in the area of the contact with under bed) points can appear at the dump body, where on the contrary deterioration of local conditions occurs.

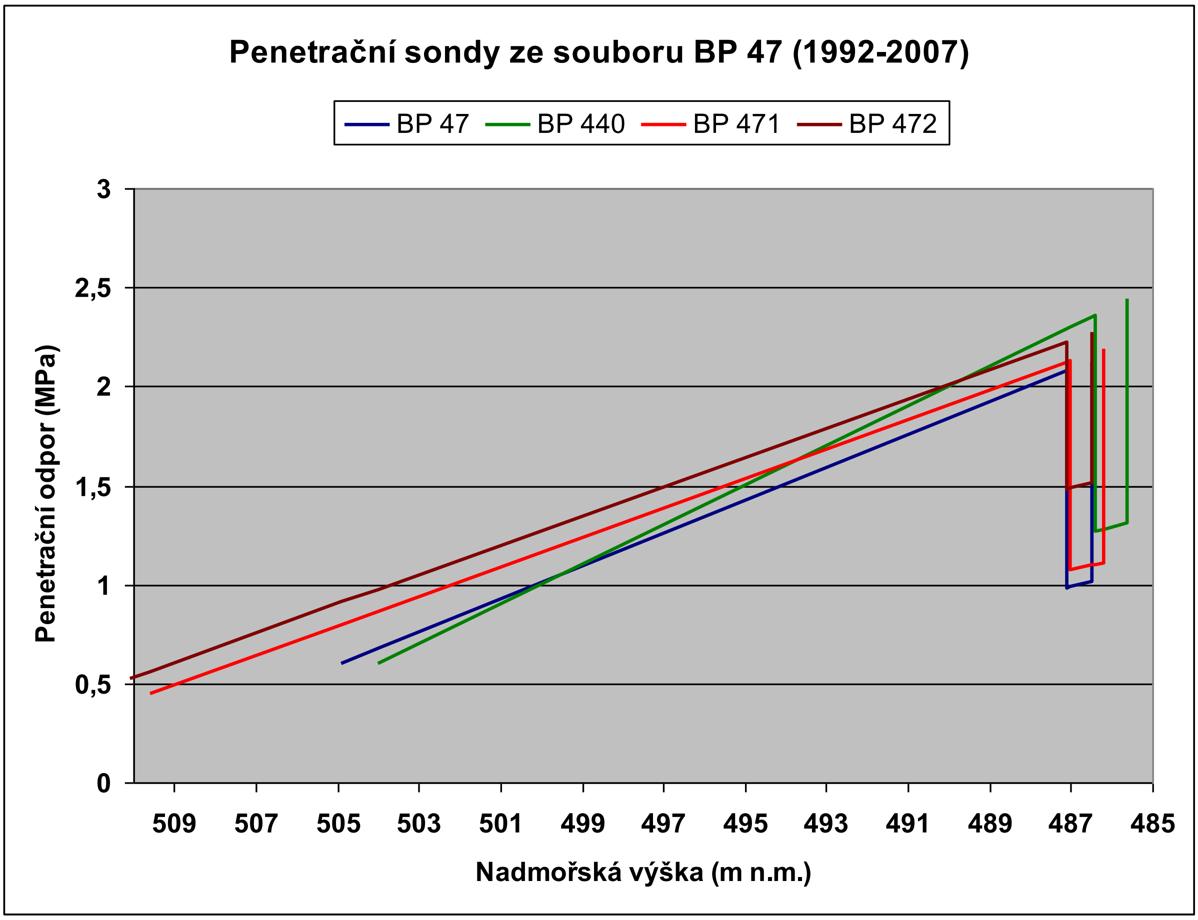

Fig. 2 Driving penetrometers from the BP 47 file
Penetrační sondy ze souboru BP 47 (1992-2007) - Driving penetrometers from the BP 47 file (1992-2007)
Penetrační odpor (MPa) - Penetration resistance (MPa)
Nadmořská výška (m n.m.) - Elevation (metres above sea level)

The measurement results at the penetrometers from the BP 47-440-471-472 file show analogous nature of behaviour as the results from the BP 46-430-46HS-461-462 penetrometers. It can just be stated that in general "they match better" than the results from the BP 46 penetrometers. Besides the above anticipated an "exemplary" decrease of internal friction angle values compensated by an increase of cohesion values at the BP 47 and 471 penetrometers, in the contact area with the under bed no oscillation of the range of such contact occurrence in a certain deep range occurs as it is so at the penetrometers of the BP 46 file. At the panetrometers of the BP 47 file the measurement results in the contact area between the dump and under bed overlap (see Fig. 2), so the dump area managed to be captured virtually permanently in the same depth. Further then it is necessary to state the measurement results in the contact area with the under bed are at the BP 472 penetrometer (the year 2007) considerably more normal than it was at the BP 462 penetrometer (the year 2007), for although even at the BP 472 penetrometer in the contact area with the under bed significant improvement of strength conditions at the base of the dump appeared, so the part of the dump still keeps to be its the weakest part as for strength, which exactly matches to the findings on behaviour of the dump body acquired on a long-term basis. [4]

The measurement results from the year 1995 surpass again a typical dump behaviour and are hardly interpretable - see so-called "false gravel" shortly after backfilling (high φ, low c), which do not match the fact that during the first measurement in the year 1992 the dump backfill did not show this nature of distribution of the strength parameters.

The results from the year 1998 (BP 471), or let us say, the trend line for the dump body shows a slight decrease of the internal friction angle being compensated by an increase of cohesion values, which exactly matches to a typical change process in distribution of the dump strength parameters. As compared to the year 1992 improvement of conditions was recorded not only for the dump body, but for the contact area between the dump and the under bed, too (though it concerns a slight improvement only) - see Fig. 2. The same is true even for measurements of the year 2007 (BP 472), when an increase of cohesion values was captured both for the dump body and the contact area with the under bed, where a highly perceptible increase of cohesion values, or if you like an increase of penetration resistance values was captured. [5]

As compared to the BP 461 and BP 462 penetrometers the increase of cohesion for the dump body in the points of the BP 471 and BP 472 penetrometers is slightly lesser. However, here this fact the BP 472 penetrometer is situated in a considerable distance from the other penetrometers could negatively reveal itself, so in case of this penetrometer the “same” dump point was not exactly compared.

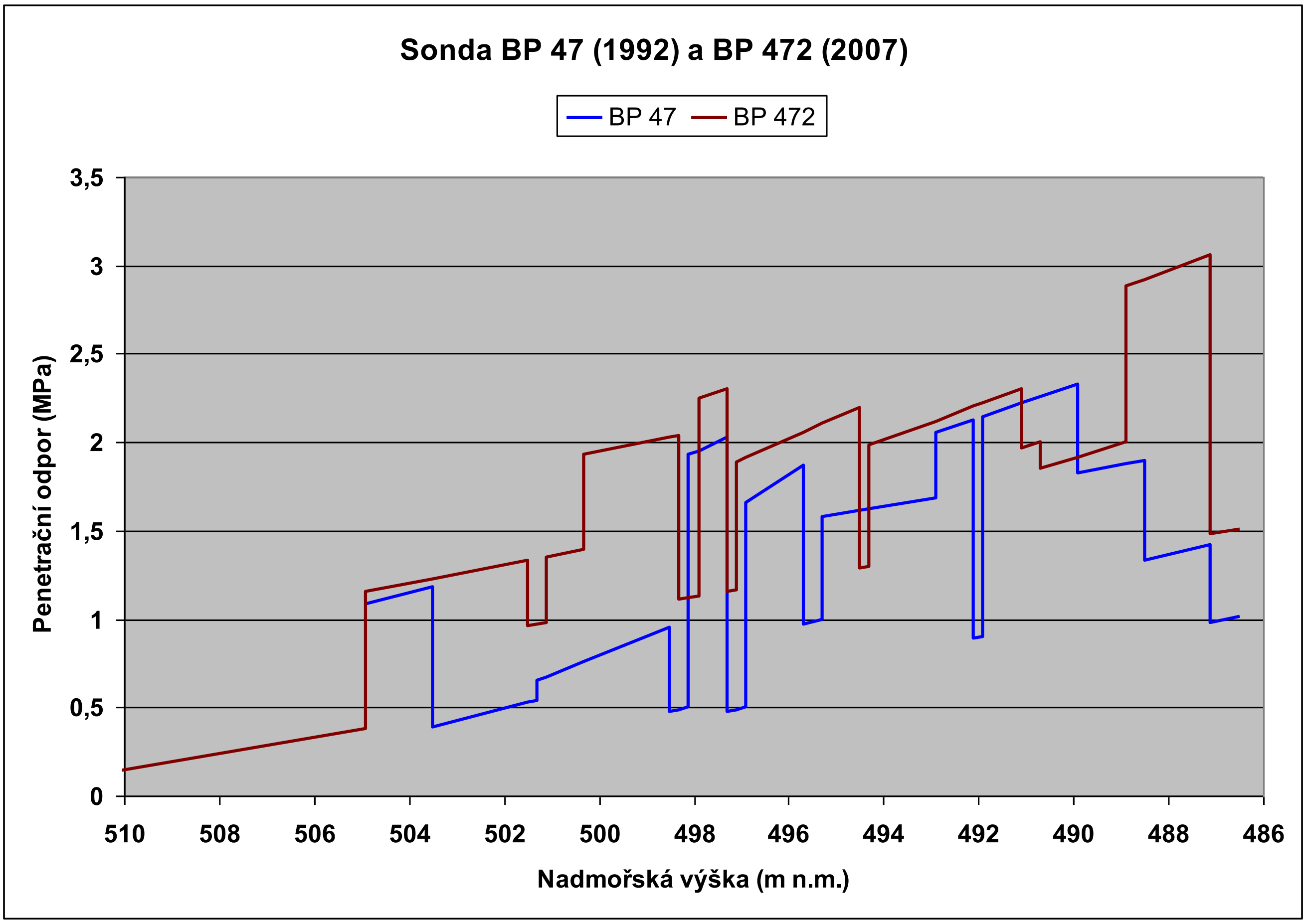

Fig. 3 Comparison of driving penetrometrs
Sonda BP 47 (1992) a BP 472 (2007) - BP 47 (1992) and BP 472 (2007) Driving Penetrometers
Penetrační odpor (MPa) - Penetration resistance (MPa)
Nadmořská výška (m n.m.) - Elevation (metres above sea level)

In Fig. 3 there are plotted the trend lines of all geotechnical layers which the dump was divided to at the BP 47 (the year 1992) and BP 472 (the year 2007) penetrometers. [1] [3]

In conclusion of this analysis the acquired shear strength parameters of the penetrometers from the year 1992 to 2007 are summarized to two below stated tables to be able to compare the measurement results quickly.

Tab. 1 Shear strength parameters of the BP 46 - 462 penetrometers

Year/ penetrometer		Shear strength parameters		
1992 **BP 46**	**Dump body**	**8,1°**	**17,1 kPa**	**16,9 kN.m^{-3}**
	Contact with under bed	**4,6°**	**5,8 kPa**	**16,9 kN.m^{-3}**
1995 **BP 430**	**Dump body**	**10,2°**	**19,1 kPa**	**17,7 kN.m^{-3}**
	Contact with under bed	**6,3°**	**17,4 kPa**	**17,6 kN.m^{-3}**
1997 **BP 46 HS**	**Dump body**	**8,2°**	**16,4 kPa**	**17,5 kN.m^{-3}**
	Contact with under bed	**6,1°**	**15,5 kPa**	**17,5 kN.m^{-3}**
1998 **BP 461**	**Dump body**	**8,0°**	**24,5 kPa**	**17,5 kN.m^{-3}**
	Contact with under bed	**6,1°**	**19,8 kPa**	**17,5 kN.m^{-3}**
2007 **BP 462**	**Dump body**	**7,5°**	**35,4 kPa**	**18,6 kN.m^{-3}**
	Contact with under bed	**8,4°**	**34,8 kPa**	**18,6 kN.m^{-3}**

Tab. 2 Shear strength parameters of the BP 47 - 472 penetrometers

Year/ penetrometer		Shear strength parameters		
1992 **BP 47**	**Dump body**	**10,4°**	**20,5 kPa**	**16,9 kN.m^{-3}**
	Contact with under bed	*5,8°*	*4,2 kPa*	*17,0 kN.m^{-3}*
1995 **BP 440**	**Dump body**	**12,7°**	**19,5 kPa**	**16,8 kN.m^{-3}**
	Contact with under bed	*6,5°*	*10,7 kPa*	*17,0 kN.m^{-3}*
1998 **BP 471**	**Dump body**	**9,0°**	**28,5 kPa**	**17,3 kN.m^{-3}**
	Contact with under bed	*4,7°*	*14,3 kPa*	*17,3 kN.m^{-3}*
2007 **BP 472**	**Dump body**	**8,8°**	**32,5 kPa**	**17,5 kN.m^{-3}**
	Contact with under bed	*6,3°*	*19,8 kPa*	*17,5 kN.m^{-3}*

3 CONCLUSIONS

It is obvious from a visual comparison that although in general distinct improvement of strength conditions occurred (see the increases in penetration resistance values for most of the layers of the BP 472 penetrometer), locally points appear in the dump body, where on the contrary for the period of the years 1992 to

2007 a local deterioration of conditions occurred (see Fig. 3) - positions in the depth intervals h=15.6-15.8 m (494.5-494.3 metres above seal level) and h=19.0-20.2 m (491.1-489.9 metres above seal level). In these points restraint of groundwater flow and its local accumulation could occur after additional load of the dump (shrinking of pores could appear as a result of an increase of dump thickness). Just like the layer in the depth h=20.6-21.4 m in Fig. 1, these positions of a local drop of resistance values prove that although at average total improvement of conditions occurred (namely in the area of the contact with the under bed), so at the dump body points could appear, where on the contrary a permanent deterioration of local conditions occurs.

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REFERENCES

[1] MANN, J., DYKAST, I., *Stabilitní posouzení výsypného prostoru Lomnice - Boučí*. Most : 1992. VUHU a.s. Zpráva 278/1992.

[2] DYKAST. I., *Stabilitní posouzení Podkrušnohorské výsypky*, Most: 1996. VUHU a.s. Zpráva 180/1996.

[3] ŠIPEK, M.. *Vyhodnocení penetračních sond BP46 a BP47, stanovení smykových, pevnostních vlastností zkoušených zemin, v efektivním a totálním oboru hodnot.* Sokolov: 2007.

[4] MIKOLÁŠ, M., *Problems of dumping areas of open pit mines within the Sokolov brown coal territory*. Gliwice: 2007. Kvartalnik gornictvo i geologia zeszyt 3.

[5] MIKOLÁŠ, M., FRAUS, F., KRET, J., *Stability of dump under the Krušné hory mountains*, Tilmisoara: 2007. Journal of engineering tome V (2007) University Politechnice Tilmisoara

RESUMÉ

Při vizuálním porovnání je zřejmé, že i když celkově došlo ke zřetelnému zlepšení pevnostních poměrů (viz. nárůsty hodnot penetračních odporů u většiny vrstev sondy BP 472), tak se ve výsypkovém tělese objevují lokálně místa, kde za období let 1992 až 2007 došlo naopak k lokálnímu zhoršení poměrů – viz. na obr. 3 - polohy v hloubkovém intervalu h=15.6-15.8 m (494.5-494.3 m n.m.) a h=19.0-20.2 m (491.1-489.9 m n.m.). V těchto místech mohlo dojít při přitížení výsypky ke znemožnění proudění podzemní vody a k jejímu lokálnímu nahromadění (mohlo dojít ke sevření pórů v důsledku navýšení mocnosti výsypky). Stejně jako na obr. 1 vrstva v hloubce h=20.6-21.4 m dokazují tyto polohy lokálního poklesu hodnot odporu, že i když došlo v průměru k celkovému zlepšení poměrů (a to jak v oblasti tělesa výsypky, tak v oblasti kontaktu s podložím), tak se výsypkovém tělese mohou objevovat místa, kde naopak dochází zřejmě k trvalému lokálnímu zhoršování poměrů.