Diversity of Characteristics of Sandy Soils in Relation to Foundation Engineering

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Abstract. Subsoil sandy soils is very variable environment. This environment is dependent on many factors. The bearing capacity and settlement are important and critical parameters in the case of assessing soil as foundation soil. The publication focuses on the bearing capacity value of the table bearing capacity which the assessment of foundation soil without expensive field testing and their evaluation possible. However, this only applies to buildings in the 1st geotechnical category. The nature of the various classes of sandy soils is defined on the basis of the indicative value of bearing capacity. Values of bearing capacity within individual classes are mainly influenced by grain size.

1. Introduction
Sandy soils represent a class of non-cohesive soils along the gravel. This is a group with a grain size of 0.06 to 2 mm. It can be divided this group of sandy soils into five classes S1 to S5 from the purposes of building foundations. Suitability of sandy soils as foundation soil depends on many factors. It is vital to assess the resistance of a settlement in the case of foundations. The most important properties are defined in the standard CSN 73 1001 Foundation of structures, Subsoil under shallow foundations, which affect the soil in terms of its capacity. Foundation soil belonging to 1st geotechnical category is assessed based on the quantification of the parameters specified in the standard.

The geotechnical category according to CSN 73 1001 includes only a small and simple structure with negligible risk. Basic requirements for assessing the design of the building foundation will be fulfilled according to experience and geotechnical survey. The publication is aimed at bearing capacity of sandy soils.

2. Characteristics of bearing capacity of sandy soils
Sandy soils represent a group of non-cohesive soils. Bearing capacity of these soils is very variable. Approximate values of bearing capacity are determined based on the CSN 73 1001 and valid until...
1 meter a depth of foundation. For more complex structures and greater depth of the building foundation is necessary to test in situ. On the basis of these values can be quantified behaviour of sandy soils. This allows you to understand the changes in value of bearing capacity within individual classes S1 to S5. These changes are dependent on the physical and mechanical properties of the sand and the environment in which the soil is stored. It uses the effective shear strength characteristics to determine the bearing capacity of sandy soils. This means effective cohesion and the effective angle of internal friction. Bearing capacity of sandy soils is also subject to publication available in [1, 2, 3] and in [4, 5].

In connection with the table calculation values reported below in the graph (Figure 1) (Figure 2) it should be mentioned that it is the value related to a depth of max. 1 meter. The values of bearing capacity are markedly dependent also on the width of the foundations which are reported as 0.5; 1; 3 and 6 meters. From this graph in Figure 1 indicate that the maximum value the table design bearing capacity reaches 800 kPa. Generally, the best values have the sands at the base width of 3 meters. From the above-mentioned maximum value of 800 kPa (100%) for the group S1 (SW) well-grained sand, the value drops to 225 kPa (28.1%) in group S5 (SC), clayey sand. It is such a difference of 575 kPa (about 72%). Wherein the values decrease regularly about 200 kPa (25%) among the various classes of S1 (SW) to the S3 (S-F). Between S3 (S-F) and S4 (SM) is already a difference of only 100 kPa (12.5%) and between class S4 (SM) and S5 (SC) it is an only 75 kPa (9.4%). It can therefore say that in the case of the width of the base of 3 m are the best values of bearing capacity in a range of classes S1 to S5 and at the same time there is the greatest difference in the individual classes.

![Figure 1](image.png)

**Figure 1.** The average value of bearing capacity $R_d$ [in kPa] of sandy soils at depth of foundation 1.0 meter, for the width of foundation 6, 3, 1, 0.5 m according to [6]

In the second place, from the viewpoint of the highest bearing capacity values, it is the width of the base 6 meters. Values are significantly lower than in the previous case, the width of the base. For class S1 (SW), which shows the highest values for all of the widths of the base, reaches 600 kPa (75%), it is about 200 kPa (25%) less than the width of the base of 3 m. The lowest value reaches 175 kPa (21.9%) for class S5 (SC). Overall, this represents a difference of 425 kPa (53.1%). Jump between classes is not as pronounced as in the previous case for the width of the base of 3 m. Among the S1 class (SW) and class S2 (SP) is a difference of 100 kPa (12.5%), while the S2 class (SP) and the class S3 (S-F) difference increases to 175 kPa (21.9%). However, among the class S3 (S-F) and class S4 (SM), the difference decreases markedly to 75 kPa (9.3%), which also holds between class S4 (SM) and the class S5 (SC).

For foundation width of the 1 meter, values of bearing capacity are much worse, but only for certain classes. The highest value achieved again class S1 (SW) that is 500 kPa (62.5%), which represents about
300 kPa less than the width of the base of 3 m. The lowest value is 175 kPa at class S5 (SC) which is identical to the value for the width of the base 6 meters. The difference values between the highest and the lowest value is substantially less than in the previous two cases, it is a 325 kPa (40.6%). Differences within individual classes as well decrease. Among the S1 class (SW) and class S2 (SP) is 150 kPa (18.7%). Among the class S2 (SP) and the class S3 (S-F), the difference is reduced to 75 kPa (9.4%). The difference of 50 kPa (6.3%) is between classes S3 (S-F) and S4 (SM) as well as between classes S4 (SM) and S5 (SC).

Last quoted width of the base of the table design bearing capacity is 0.5 meters. Tabulated values of bearing capacity are the lowest in its entirety classes at this width. The highest value is 300 kPa (37.5%) in the S1 class (SW). The lowest value is then about 175 kPa lower. It is 125 kPa (15.6%) for class S5 (SC). The value decreases gradually from class S1 to class S5, wherein the values fall regularly between classes about 50 kPa (6.3%). The exception is 25 kPa (3.1%) between classes S2 (SP) and S3 (S-F).

![Figure 2.](image)

The average value of bearing capacity $R_d$ (in percentage) of sandy soils for depth of foundation 1.0 meter, for the width of foundation 6, 3, 1, 0.5 m according to [6]

The class S1 (SW) well-graded sand reaches its highest value, which includes grains throughout the defined period for sands, it is 2 to 0.06 mm. This is seen as regards the difference of value of bearing capacity in the individual classes. Simultaneously it is the class with the greatest variability in the values as regards dependence on the width of the base. This is the difference up to 500 kPa (62.5%) among the width of foundation from 3 m and 0.5 m. The smallest differences are in the case of class S5 (SC) clayey sand. Thus, in the class with the smallest values of bearing capacity. Low values of bearing capacity are given by the admixture of finer-grained cohesive fraction of the silt and clay. The difference between the highest and lowest value represents 100 kPa (12.5%). Although the width of base plays difference within the individual classes, the value is identical for the width of the base 6m and 1 m in the case of the last class S5 clayey sand.

Bearing capacity of sandy soils is subject to very substantially representation of fine-grained ingredients, among other things. We differentiate between three main groups according to the content of fine-grained ingredients, as shown in Figure 3. This is a group containing 0-5% fine-grained component, which represents the most favourable condition in terms of bearing capacity. This includes well-graded sand and poorly-graded sand. Among other things, sort out grains of sand also plays an
important role. This means that the sand with grains of the same size throughout the range from 0.06 to 2 mm, thus heterogeneous sand has much better properties than poorly graded sand.

![Diagram of sandy soils classes]

**Figure 3.** Distribution of sandy soils classes according to [6]

The second group includes soil containing fine-grained component ranges from 5 to 15%. It is a sand with an admixture of fine-grained soil. The values of the bearing capacity are significantly lower than in the first set due to an increase in fine-grained component. They are also significantly better than in the third group. It comprises soil containing fine-grained component in the range of 15-35%. This includes clayey sand and silty sand. From the viewpoint of bearing capacity clayey sand, it has significantly poorer properties than silty sand. Overall, the last class represents a group with the least bearing capacity in the context of sandy soils. A number of authors analysed the bearing capacity of sandy soils in specific cases [7, 8, 9] or in [10, 11].

3. Conclusions

Introduced study represents a group of sandy soils in terms of building foundations. On the basis of tabulated data of bearing capacity, it is obvious that values are very different depending on the content of fine-grained fraction and the width of the foundation. Sandy soils of (SW) well-graded sand at the dimension of a width of three meters, the highest levels in terms of bearing capacity. It is up to 800 kPa, which in our case was given as 100%. The width of the base of 3 meters have proven the most optimal in relation to the bearing capacity, which represented the highest values of in each of the classes S1 to S5 in comparison with other mentioned widths of foundations of buildings. It was 0.5 m, 1 m and 6 m. The lowest values are found at the base of width of 0.5 m in a range of all classes S1 to S5. The difference in class S1 is compared to of the base of width of 3 m the value of 500 kPa, which is 62.5%. The class S5 (SC) clayey sand has the lowest values of bearing capacity under all compared widths of foundations, which represents the highest value of 225 kPa while the lowest values of 125 kPa. This is a difference of 100 kPa, which represents 12.5%.

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