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Comparison of soil investigation codes and standards of the Russian Federation and Britain

Comparaison des codes et standardsrelatifs à l'étude des sols en Fédération de Russie et en Grande-Bretagne

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ABSTRACT
Russia has vast natural resources and is rapidly becoming open to world trade. Russian producers are increasingly being able to manufacture materials for export that are compliant with international codes and standards. However, the country maintains a well developed system of standards for work performed in Russia. This provides a challenge for international companies wishing to invest in Russia, but who are not familiar with the Russian design and construction systems. This paper compares the existing site investigations codes and standards with equivalent British Standards and considers the difficulties which may be encountered should the Russian design institutes integrate with the Europe and the European Norms

RÉSUMÉ
La Russie dispose de vastes ressources naturelles et s'ouvre rapidement au commerce international. Les producteurs russes sont de plus en plus capables de fabriquer des produits destinés à l'exportation qui sont en conformité avec les codes et standards internationaux. Toutefois, le pays conserve un système bien développé de standards s'appliquant au travail réalisé en Russie. Ceci constitue un défi pour les sociétés internationales désireuses d'investir en Russie, mais qui ne sont pas familiarisées avec les systèmes de conception et de construction russes. Ce document compare les codes et standards d'études de site existants avec leurs équivalents du British Standards et étudie les difficultés qui pourraient survenir si les instituts d'étude russes venaient à être intégrés à l'Europe et aux normes européennes.

1 INTRODUCTION

The authors' experience has been gained from executing several site investigations in the Russian Federation. Compliance with Russian codes and standards was necessary, but there was little available information on the investigation techniques and test methods used. To ensure that the data would be reliable and suitable for use by international designers care was taken to duplicate many activities, including the description of samples and performing laboratory testing. Where insitu testing was carried out, a review of test methods was undertaken to assess comparability between Russian and British standards. All work was closely supervised by experienced geotechnical engineers who were very familiar with the relevant British Standards and hence there was a high degree of confidence in the reliability of the data obtained. This has provided useful experience in many areas, two of which are discussed in this technical note. One aspect is a comparison between Russian and British investigation techniques, the other is an insight into Russian codes and standards and their implementation. An added complexity to undertaking work in Russia is that of obtaining unambiguous translations of formal documents.

2 CODES, STANDARDS AND REGULATIONS

The Russian codes and standards are generally based on three types of document: GOSTs, SNiPs and SPs. GOSTs are Interstate Standards, SNiPs are Construction Norms and Rules of the Russian Federation and SPs are Codes of Practice. These codes and standards are registered with the Ministry of Construction of the Russian Federation and are mandatory. The main codes and standards which apply to soil investigation are listed in the references. The British Standards Institute produces standards which are not mandatory under English law, but which are considered good practice. The two main British Standards which cover site investigation are listed in the reference section.

3 SCOPE OF INVESTIGATIONS

The main document for geotechnical investigations is SNiP 11-02-96, 'Engineering Investigations for Construction. Basic Provisions'. SNiP 11-02-96 provides the general principles and requirements for: a) Engineering-Geodetic surveys; b) Engineering-geological survey; c) Engineering-Hydrometeorological; d) Engineering-Environmental and e) Surveying of soils used as building materials. This paper focuses on engineering-geological surveys.

The section on Engineering-Geological surveying describes the processes that need to be carried out during the survey, including, gathering of previous data, initial desk top study, site investigations, laboratory results and reporting. All of these steps are described in detail in the standard and generally follow the basic principles of geotechnical investigation and reporting as provided in Section 1 Preliminary Considerations and Section 7 Reports and Interpretation of BS5930:1999.

Similar to BS5930 Section 7, SNiP 11-02-96 provides details on the textual and graphical content of the geotechnical report. The SNiP requires the following sections: Introduction; State of Knowledge of engineering-geological conditions; Physiographic and man-made conditions; Geological Structure; Hydrogeological conditions; Soil Properties; Specific Soils; Geological and engineering-geological processes; engineering geological zoning; conclusions and references. With regard to Specific Soils, this sections address processes including permafrost, swelling soils, saline environments, man-made ground. The requirements of BS and SNiP are comparable with regard to general principles and reporting.

Unlike BS5930, SNiP 11-02-96 does not provide guidance on the scope and type of investigations for geotechnical investigations, but is limited to general principles and reporting. Details of the scope and types of investigations are provided in SP 11-105-97 which provides the regulatory requirements for extent of investigation, explorations depths, type of insitu testing and laboratory testing based on the category of structure, or fa-

cility. The category of structure, or facility is specified in GOST 27751-88 'Reliability of civil structures and bases. Basic provisions for design'. There are three Category Classes from Category I to III applicable to facilities and individual structures with Category I being the most critical, such as oil tanks with a capacity greater than 10,000m^3. In the Client's Technical Requirements for the investigation, a client may specify additional, or different types of investigations to supplement the mandatory scope defined in SP 11-105-97.

In general, the magnitude of the scope of investigations is similar to the guidance provided in Section 2 of BS5930, with two significant differences being that; 1) the Russian standards have a mandatory minimum level of investigation; 2) the Russian standards require geophysical investigations at all stages of investigation programs, whereas in BS5930 geophysical investigations are considered as a complementary tool available to the consultant.

4 SOIL AND (SOFT) ROCK DESCRIPTIONS

The classification of Soil and (Soft) Rock is described in BS5930, Section 6 "Description of Soil and Rock". Materials are described using the following standard headings;

1) Mass characteristics comprising state and structure
    a. Density/compactness/field strength
    b. Discontinuities
    c. Bedding
2) Material characteristics comprising nature and state
    a. Colour
    b. Composite soils types, particle grading and composition, shape and size
    c. Principal soil type, based on grading and plasticity shape.
3) Stratum Name; geological formation, age and type of deposit.

Tables 12 and 13 provide guidance for the description of the soils including a flow chart for the sequence of logging and aids for visual classification of soils in the field.

The philosophy of the British Standard system of logging is to provide detailed information on the physical, mechanical and geological condition of materials encountered, allowing an engineering geological model of the site under investigation to be developed. On occasion, these borehole records form the only information available of the conditions encountered during the investigation, however, this information can still be used where designers are familiar with "materials of similar age, origin or conditions based on the descriptions" (BS5930 – Section 6, 41.1). Based on this philosophy, BS5930 provides aids for the visual and tactile assessment of soils in the field for descriptions such as strength, plasticity, particle size. Normally, these properties are cross-referenced against the results of laboratory testing. In the absence of laboratory testing, the soil description can still provide useful information for design purposes.

In the Russian system, the classification of Soil and (Soft) Rock is included in GOST 25100-95, "Soils Classification". Translations of this standard often introduce terms which will be unfamiliar to geotechnical engineers outside of Russia. In this standard, materials are described using the following headings;

1) Class – by general nature of structure, eg rock (rigid structure), dispersible (with mechanical or water action), frozen.
2) Group – by nature of structure links, eg rock, semi-rock, cohesive, non-cohesive, icy.
3) Subgroup – by origin and condition of formation, eg Igneous, metamorphic, natural formations changed by physical, physical chemical, alluvial processes, man-made materials.
4) Type – by substance composition, eg ferrous, silicate, carbonate, organic and ice.
5) Kind – by name of soils including geological age eg, granites, basalt, sandstones, clay, silts, sand.
6) Sort – by quantitative determination (laboratory tests) eg strength, density, weathering, plasticity, particle size.

The examples given above are only a selection from the list provided in Table I, II and III of the standard.

It is common practice for Russian geologist and geotechnical engineers to omit engineering properties on borehole records without the aid of laboratory results. This may be due to the lack of tactile or visual aids for the description of soils in the Russian standard. The different soil and rock units are reduced into Engineering Geological Elements (EGE) based on material characteristics as well as strength and deformation properties. Determination of material properties by insitu and laboratory testing is discussed in subsequent sections of this paper. Borehole records mainly provide geological information with basic descriptions only including Subgroup, Type and Kind. The text of the report defines each EGE based on the laboratory data. In most cases, the EGE information is not added to the borehole records after the laboratory testing and hence, remain essentially as field logs.

By way of example, there follows a description of the same strata using both the Russian and British systems:

Russian; Crumbly soil with loamy filler up to 40%, dense, low to high saturation, eluvial, Quaternary Age

British; Firm to stiff, moist, grey silty CLAY with gravel (Residual soil of Bykovskoye Formation).

The majority of the engineering interpretation under the Russian system is based on statistical analysis of the laboratory results and this commonly gives rise to a multitude of EGEs within a site. In comparison, the BS system typically results in fewer units based on the geological strata and the main physical and engineering differences within each one. For example, a site which was investigated following both the Russian and British systems resulted in thirty five strata and six strata respectively. Whilst a broad correlation could be developed between the Russian EGEs and BS Units a direct conversion from one system to another is generally not possible due to the apparent inconsistent manner of the delineation of the EGEs. To develop an engineering geological model of the site adopting the Russian system would have been relatively complex, whereas the six strata delineated under the British system proved adequate for design and construction purposes. As can be seen above, the two logging systems are not comparable, however, the dual logging exercise ensured a high degree of confidence in the reliability of the data obtained and simplified and optimised the design process.

5 INSITU TESTS

The Russian code SP 11-105-97 provides the requirements of the various insitu tests that are specified in Russian standards. The main insitu tests identified are: static soundings; dynamic soundings; and stamp tests (plate load test). Geophysical testing is included in SP 11-105-97, but not covered in this paper. For reference SP 11-105-97 provides 19 different geophysical techniques that can be used for various site conditions. As well as insitu tests, SP 11-105-97 provides guidance on the types of drilling method to be used for various ground conditions. Basic drilling techniques are mentioned including core drilling, cable tool percussion, augering and vibrohammer. The availability and quality of drilling and insitu testing equipment across Russia varies significantly. Typically, the only coring equipment found in remote locations in Russia include single barrels. Double core barrels in Russia generally refer to a single core barrel with casing.

5.1 *Static soundings*

The basis of the static sounding is similar to the Cone Penetration Test (CPT). The principles of the CPT in Russia (GOST 19912-2001) are comparable to those of the British Standard (BS1377-1990 Part 9) test and data from the Russian CPT equipment can, on occasion, be directly related to results from tests carried out in accordance with the British Standard. The Russian standard SP 11-105-97 provides normative physical and mechanical properties based on the results of the static sounding including density, elastic modulus, angle of internal friction. However, equipment is commonly mechanical and hence penetration rates can vary widely and readings are typically manual not electrical. In addition, friction reducers for rods are uncommon which can effect results of deeper investigations. The results of the soundings and their interpretation should be treated with caution and based only upon detailed knowledge of the equipment used and preferably in conjunction with results from other exploratory techniques.

5.2 *Dynamic soundings*

Russian dynamic soundings (GOST 19912-2001) are similar to the British Standard Dynamic Probe Test (BS1377-1990 Part 9) in terms of procedure and reporting. Difference between the standards relate to the apparatus. The Russian standard has light (mass 30kg, drop 40cm), medium (mass 60kg, drop 80cm), and heavy (mass 120kg, drop 100cm) types of testing whilst BS has heavy (mass 50kg, drop 50cm) and super heavy (mass 63.5kg, drop 75cm). The Russian standard use the same 74mm dia, 60≥ cone for all forms of tests, whilst BS uses a 43.7mm dia, 90≥ cone for heavy testing and a 50.5mm dia, 90≥ cone for super heavy. Conversions between the hammer energy and surface area of cone will be required to convert between the codes. In Russia, the Standard Penetration Test (SPT) is not a standard tests, but trip hammers meeting BS standards can generally be locally fabricated and SPT's can be performed with suitable guidance from experienced personnel to obtain good quality SPT data.

5.3 *Stamp test*

The Russian Stamp Test, GOST 20276-99, is equivalent to a British Standard Plate Load Test (BS1377-1990 Part 9). The apparatus for tests carried out at surface are similar to that described in the British Standard and evaluation of the results are comparable. Hence, the results from Russian tests can be regarded as equivalent to those obtained from testing in accordance with British Standards. However, caution should be given to tests conducted in boreholes as hole cleaning tools are not available to prepare the test surface which will affect the repeatability and reliability of the results. The Russian standard also provides for the deformation/ strength testing to be undertaken using a 27.7cm dia screw auger.

The Russian insitu testing methods are broadly similar to those described in the British Standards and thereby providing a good equivalency between the two system of standards.

6 LABORATORY TESTS

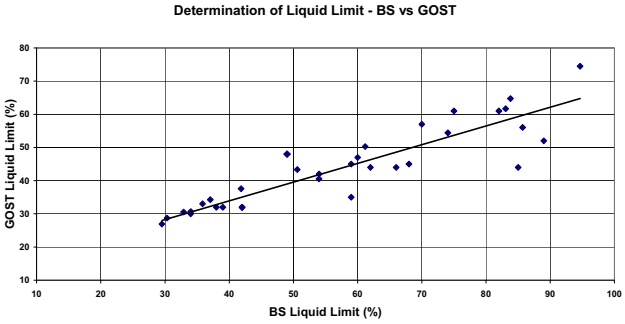
The British Standard for performing tests on soils is BS1377:1999 'Methods of test for Soil for civil engineering purposes', which is divided into nine parts covering various laboratory and insitu tests. Under the Russian system, there is an individual GOST for each laboratory test method. The references to this paper provide a list of selected GOSTs for soil testing. This technical note refers only to those tests with which direct experience has been gained.

6.1 *Classification tests*

The Russian standards for the determination of moisture content, organic content, bulk density and particle density are all similar to those in the British Standards. The tests involve weight and volume measurements and oven drying. It is considered that the results can be regarded as equivalent to the British Standard.

The determination of the Plastic Limit of cohesive soils in accordance with the GOST 5180 standard is in general accordance with BS1377 and the result can be considered as equivalent. The Russian method of determining the Liquid Limit of soils uses a hand-held cone method, whilst the British test adopts the cone penetrometer method of testing. The cone penetrometer provides higher repeatability as it reduces operator error. Experience of testing using both standards on the same soil samples has shown that the result between the two standards are not equivalent and that a correction is required to convert between the two sets of results. A selection of test results obtained from the two standards is plotted on Figure 1 and a suggested correlation is also indicated. As can be seen the Liquid Limits are quite similar for values of about 30%, but for higher Liquid Limits, those determined by the Russian test method are lower than those determined by the British test method.

Figure 1. Comparison of Liquid Limits derived using BS and GOST



The particle size distribution test method for soils by sieve and pipette analysis for the GOST 12536-79 and BS 1377 is basically similar. The main difference between the Russian and British particle size distribution tests is that the Russian sieves are constructed with circular holes whilst the British holes are square. The standard sieve sizes also differ slightly to those of the British Standard, but once the particle size distribution curve is plotted the results are comparable for the purposes of classification and for the use of empirical formulas that rely on particle size analysis.

6.2 *Deformation testing*

One dimensional consolidation tests, oedometer tests, are performed in Russia. The main differences between the Russian test method, GOST 12248-96, and the British, BS1377, are: 1) the Russian specimens are larger; 2) the Russian test is carried out without inundation, whereas the BS test is fully submerged; 3) consolidation pressure stages differ slightly and 4) the Russian testing method does not require measurement of settlement over time during each loading or unloading cycle. Whilst a value of m_v (magnitude of settlement) can be determined from the Russian oedometer test, it is generally not possible to determine c_v (rate of settlement). However, Russian soil testing laboratories have, upon request, deviated from the standard Russian test method and have measured settlement over time to provide an estimate of c_v values.

6.3 *Strength tests*

The direct shear tests as carried out according to Russian GOST 12248-96 and British BS1377 are similar in that a vertical normal force is applied to the sample and the sample is sheared horizontally along a predetermined plane. The notable differences between the tests procedures are: 1) the Russian test apparatus is cylindrical with a diameter of 71.5mm and a height of 35mm, compared to the British standard box with an area of 60x60mm^2 and a height of 40mm; 2) the Russian test is not inundated; 3) the Russian standard allows for either a strain, or stress controlled test. Russian soil testing laboratories generally do not have the equipment to conduct strain controlled tests and therefore typically stress controlled tests are performed. In this stress controlled test method a load is applied and on cessation of movement, the displacement is measured. The load is increased and the process is repeated until failure of the sample. The British test method shears the sample at a constant rate and the applied load recorded. The strain rate is limited to allow the sample to remain drained.

Whilst the circular shape and size of the Russian testing apparatus is unlikely to have a significant impact on the results, the unsaturated nature of the sample and the shearing procedure of the Russian test complicates the interpretation of the results as it is unclear whether the parameters measured are representative of undrained or drained conditions. Whilst the results of the Russian test will provide engineering parameters, caution is required in deriving design parameters.

Triaxial testing is undertaken in accordance with Russian GOST 12248-96 and is similar with the BS1377 method of triaxial testing. The authors' experience of inspecting triaxial cells in Russian laboratories has shown that the cells set-up is very similar to that of the British Standard and therefore the results from the GOST standard can be regarded as equivalent to those gained under British Standard. The GOST standard allows for both undrained and drained conditions and the measurement of pore water pressure measurement. Whilst a technical standard and laboratory equipment to undertake triaxial testing are available in Russian Laboratories, it is the authors' experience that supervision of triaxial testing is recommended to assess the competency of the laboratory staff and the validity of the results.

6.4 *Compaction testing*

The Russian and British test methods for the determination of maximum dry density are similar and are based on the compaction of layers of soil within a mould at various moisture contents to enable a compaction curve for the material to be plotted. The standard mass of the rammer described in Russian standards is 2.5kg. The main difference between the British and Russian test methods is the definition of oversized particle. In the Russian test method, all material in excess of 10mm is removed, whilst in the British test method, all material greater than 20mm is removed. Both the British and Russian Standards have equations for the determination of maximum dry density taking into account the percentage of material that is oversized.

The British and Russian test methods for the determination of insitu density are very similar with methods for both sand and water replacement as well as nuclear density measurements being described. However, nuclear density devices are scarce and it is very difficult to transport these devices within Russia and almost impossible to import them.

There is no Russian standard for the California Bearing Ratio (CBR) test for pavements and there is no available alternative.

7 CONCLUSION

A summary of the assessed reliability of comparison between the British and Russian standards is provided below. Low means caution should be taken when comparing the data and additional information on the material is required; Medium means some interpretation is required to provide an equivalence to western standards; and High means a direct comparison is possible.

Table 1: Summary of comparison of British and Russian Standards

Type of Test	Assessed Reliability		
	Low	Med	High
Field Logging	■		
Laboratory Test			
Moisture Content			■
Plastic Limit			■
Liquid Limit		■	
Bulk Density			■
Specific Gravity			■
Organic Content			■
Particle Size Distribution		■	
Consolidation	■		
Consolidated Drained Shear	■		
Triaxial Tests			■
Compaction		■	
In-situ Test			
SPT		■	
Plate Loading Test		■	
CPT	■		

The key to a successful investigation conducted in Russia is experienced supervision of site and laboratory activities and also an experienced and competent translator is invaluable.

REFERENCES

British Standards Institution, "Methods for tests of Soils for civil engineering purposes", BS1377-1990

British Standards Institution, "Code of Practice for Site Investigations" BS5930:1999

GOST 5180-84 "Soils. Methods of laboratory determination of physical properties".

GOST 12071-84 "Soils. Sampling, packing, transporting and storing of samples".

GOST 12248-96 "Soils. Method of laboratory determination of strength and deformability".

GOST 12536-79 "Soils. Method of laboratory determination of granulometric (grain) and micro-aggregative composition".

GOST 19912-2001 "Soils. Field methods by static and dynamic soundings".

GOST 20276-99 "Soils. "Soils. Field methods for determining the strength and strain characteristics"".

GOST 20522-96 "Soils. Method of statistical processing of test results".

GOST 22733-77 "Soils. Method of laboratory determination of maximum density".

GOST 25100-95 "Soils. Classification"

GOST 27751-88 "Reliability of civil structures and bases. Basic provisions for design".

SNiP 11-02-96 "Engineering Investigations for Construction. Basic Provisions".

SP 11-105-97 "Engineering Geological Site Investigations for Construction"