ROYAL SWEDISH
GEOTECHNICAL INSTITUTE
PROCEEDINGS
No. 6

A NEW GEOTECHNICAL CLASSIFICATION SYSTEM

By

W. KJELLMAN, L. CADLING,
and N. FLODIN

STOCKHOLM 1953

ROYAL SWEDISH
GEOTECHNICAL INSTITUTE
PROCEEDINGS
No. 6

A NEW GEOTECHNICAL CLASSIFICATION SYSTEM

By

W. KJELLMAN, L. CADLING,
and N. FLODIN

STOCKHOLM 1953

Ivar Hæggströms

BOKTRYCKERI AB. STOCKHOLM 1953

522977

Contents

Preface

The main features of the new geotechnical classification system described in this report and of its application to geotechnical literature were outlined in 1944 by Mr Walter Kjellman, Head of the undersigned Institute. The principal sections of the system were drawn up during conferences with various members of the staff of the Institute. The system has then been completed and worked out in detail, while being used for classification of literature, by Mr Lyman Cadling and Mr Nils Flodin, Research Department Engineers.

The report was prepared by Mr Kjellman and Mr Cadling.

Stockholm, September, 1952

ROYAL SWEDISH GEOTECHNICAL INSTITUTE

§ 1. Importance of a Good Geotechnical Classification System.

The geotechnical literature is now rather comprehensive, and its annual increase is very great. Anyone working in the field of geotechnics[1]—whether in its practical application or in research—is frequently compelled to get hold of papers dealing with a particular subject. For this purpose he needs such a catalogue of the geotechnical literature that he can be sure of finding the right references—and of finding them quickly. Such a catalogue must be arranged on the basis of a good classification system.

A good classification system has also other fields of application. It can be used for dividing conferences, courses, and textbooks into sections, for planning research, for filing documents, etc.

§ 2. Earlier Geotechnical Classification Systems.

In 1944, when the Institute began to study the question of classifying geotechnical literature, mainly two geotechnical classification systems were in use, *viz.* the Universal Decimal Classification System (the UDC System) and the system used at the International Conference on Soil Mechanics and Foundation Engineering 1936 (the ICSM 1936 System).

§ 2 a. The UDC System.

The Universal Decimal Classification System derives its origin from U.S.A., where the first book on decimal classification was published in 1876. Since then the System has been enlarged and worked out in detail, and it is now very comprehensive. Current enlargements and modifications of the System are carried on under the direction of the Commission Internationale de la Classification Universelle in The Hague. What follows refers to the 1941 edition.

The UDC System includes all human knowledge. This huge subject is divided into ten sections, each of these into ten subsections, and so on. In some cases, the subdivision reaches as far as to the twelfth stage, so that the classification

[1] The term "geotechnics" is used in the Proceedings of the Institute instead of the cumbersome expression "soil mechanics and foundation engineering". The corresponding adjective is "geotechnical". A specialist in geotechnics is called here a "geotechnicist".

numbers of the last stage contain twelve digits. Beside these main numbers, many kinds of auxiliary signs are used in order to designate the subjects more exactly. Further, main numbers, with or without auxiliary signs, can be combined in different ways.

One disadvantage of the System, when used for a special branch only, is the fact that the classification numbers are unnecessarily bulky.

Another disadvantage—and a serious one—is that a thorough knowledge of the whole System is required, even when classifying a special branch only, and this knowledge is hardly possible to acquire without a rather comprehensive study of the System. Of course, classifiers and people concerned with library work can learn the System and use it in a right way, but others who cannot devote time to a comprehensive study of the System, can hardly nse it.

A science that is auxiliary to other sciences is especially difficult to classify by the UDC System, and is often classified in different ways by different scientists, each trying to incorporate it into his own science. For instance, the same geotechnical problem can be classified by altogether different numbers depending on the profession of the classifier and his attitude towards geotechnics. A slide in a river bank would probably be classified by a geologist under geology by the number 551.244 "Landslides", but by a geotechnicist under geotechnics by the number 624.131.54 "Stability of slopes". A slide in an earth dam would probably be classified by a dam specialist under dams by the number 627.891 "Dam failures", but by a geotechnicist under geotechnics by the same number as the slide in the river bank. This vagueness of the System is a grave disadvantage.

The principal section of geotechnics (624.131) does not seem to be quite adequate in itself. This is shown, for instance, by the fact that the Soil Mechanics and Foundations Committee of the Research Committee of the Institution of Civil Engineers, which is using the UDC System for a Bibliography on Soil Mechanics[1] has excluded some subsections, and has given to certain numbers interpretations different from those used in the UDC System. (By the way, even the adequacy of these modifications can be questioned.)

On account of the disadvantages mentioned above, the UDC System was rejected by the Institute.

§ 2 b. The ICSM 1936 System.

The papers submitted to the International Conference on Soil Mechanics and Foundation Engineering 1936 were divided into sections by means of a classification system made up especially for this purpose.

The System consists of the following 15 sections:

A Reports from Soil Mechanics Laboratories on Testing Apparatus, Technique of Testing, and Investigations in Progess

B Exploration of Soil Conditions and Sampling Operations

C Regional Soil Studies for Engineering Purposes

[1] Bibliography on Soil Mechanics. London 1950.

D Soil Properties
E Stress Distribution in Soils
F Settlement of Structures
G Stability of Earth and Foundation Works and of Natural Slopes
H Bearing Capacity of Piles
I Pile Loading Tests
J Earth Pressure against Retaining Walls, Excavation Sheeting, Tunnel Linings, etc.
K Ground Water Movement and Seepage
L Soil Problems in Highway Engineering Including Frost Action in Soils
M Methods for Improving the Physical Properties of Soils for Engineering Purposes, Including Recent Developments in Constructing and Compacting Earth Fills
N Modern Methods of Design and Construction of Foundations
Z Miscellaneous

The System has no subsections, and seems also to have been built up without regard to future subdivision. Some sections should logically be subordinate to other sections instead of being parallel with them. (Section I, for instance, should logically be subordinate to Section H.) For this reason, the System is unsuitable as a basis for detailed classification. It seems not to have been used anywhere except at the 1936 Conference.

§ 2 c. The ICSM 1948 System.

The International Conference of 1948 adopted a classification system quite different from that of its predecessor. It consists of twelve principal sections, each divided into two to nine subsections. We confine ourselves here to a study of the principal sections, *viz:*

I Theories, Hypotheses, Considerations of a General Character
II Laboratory Investigations
III Field Investigations
IV Stability and Deformations of Earth Constructions
V Earth Pressure; Stability and Displacements of Retaining Constructions
VI Foundation Pressure and Settlements of Buildings on Footings and Rafts
VII Pile Foundations, Pile Loading Tests
VIII Problems of Road and Runway Constrnctions
IX Improvement of the Mechanical Properties of the Soil
X Groundwater Problems
XI Suggestions for International Collaboration, Exchange of Information
XII Subjects of a General Character

In this system several bases of division are used simultaneously. Sections I and IX represent one basis of division, namely the kind of geotechnical activities, Sections II and III embody a second basis of division, namely the place of the geotechnical activities, and Section X refers to a third basis of division, namely the kind of problem. Sections IV-VIII represent a combination of the third basis of division and a fourth basis of division, the kind of construction works. Sections XI and XII, finally, can hardly be referred to any basis of division, but form dumping-grounds for divers subjects of general nature.

The parallel use of various basis of division is illogical and rather confusing. Above all it seems unreasonable that all the theories and hypotheses for the various kinds of problems are collected (together with subjects of general character) in one section, whereas their applications are divided into a series of other sections according to the kind of problem and the kind of construction works.

For these reasons, the System was rejected by the Institute.

§ 3. The New Classification System (the SGI System).

§ 3 a. General Considerations.

To devise a classification system is to divide the subject into a number of principal sections, then to divide each principal section into a number of subsections, and so on. In each dividing operation only one basis of division should be used, if possible, in order that the system be logical. However, different bases of division may be used in different dividing operations, even if they are of the same order. It is essential for the value of the system that the most important basis of division be used primarily.

In the present case, the subject to be classified consists of all geotechnical knowledge. This knowledge refers to various kinds of geotechnical problems (stability, deformation, etc.), to various kinds of construction works (bridges, dams, etc.), to various kinds of soils (clay, sand, etc.), to various kinds of geotechnical activities (sampling, testing, computation, etc.), and to various places of geotechnical activities (field, laboratory, etc.). We have here already five different bases of division, which could be used in our classification system. There may be other bases of division, too, though less important.

The kind of problem was deemed to be the most important basis of division, and should, therefore, be applied primarily. Among the remaining possible bases of division mentioned above the kind of soil and the kind of geotechnical activities were deemed essential, and it was decided to take them into account in the subdivision or by means of auxiliary signs.

§ 3 b. Formation of Principal Sections.

In accordance with the considerations above, the kinds of geotechnical problems were enumerated as follows:

A Stability (Rupture) Problems
B Deformation Problems
C Ground Water (Seepage) Problems
D Vibration Problems
E Erosion Problems
F Frost Action Problems
G Quicksand Problems
H Shrinkage and Swelling Problems
I Other Problems

This division of geotechnical knowledge was made according to the gist of the phenomenon in question, regardless of the prevailing outer circumstances. Thus, for instance, the active and the passive earth pressure, the stability of slopes, and the bearing capacity of footings all belong in Section A, Stability Problems, whereas the earth pressure at rest and the settlements of foundations belong in Section B, Deformation Problems.

It was soon found, however, that the completely logical system thus arrived at would not be practical. Therefore, it was modified as follows.

Firstly, it was discovered that the above enumeration of problems covers the main part of geotechnics, namely soil mechanics, but not the remaining part, foundation engineering. Descriptions of methods of foundation and methods of improving the properties of soil cannot reasonably be classified according to the kind of problem. They were therefore collected in a new principal section called J, Improvement of Soils. Foundations.

Secondly, geotechnics contains many subjects of general character, which can hardly be attributed either to any particular problem, or to the new Section J. Snch subjects are, for instance, considerations of the importance, the history, the scope, and the subdivision of geotechnics, information on geotechnical institutions, societies, conferences, etc. These subjects were collected in another new section, called K, General.

Thirdly, there are a great many subjects which are common to all, or nearly all, the problems A—I. These subjects are structural characteristics and properties of various soils and their constituents, methods for their investigation, and also field investigations. It would be unreasonable to reiterate all these subjects under each problem A—I. Therefore, they were collected separately, and, as they constitute a considerable part of geotechnics, were divided into three new sections, namely L, Soil Science, M, Laboratory Investigations, and N, Field Investigations. (Though the subjects of Section M closely correspond to those of Section L, it was deemed appropriate to separate the former from the latter, as, among other things, it then becomes possible to use different degrees of subdivision in the two sections.)

Fourthly, it became evident that Section A, Stability Problems, would be excessively large compared with the other sections. Therefore, the active and the passive earth pressure problems, which form a well-defined group holding a prominent position in the history of geotechnics, were moved from Section A into a new Section O. As it is often difficult to know whether the earth pressure under consideration has reached its limiting value (the active or passive pressure) or holds an intermediate value (depending on the deformation conditions), the earth pressure problems in Section B, Deformation Problems, were removed from it, and were also inserted into the new Section O, which will therefore include all earth pressure problems.

Fifthly, it appeared that each of the Sections D—I would be very small compared with each of the other sections. It was also desired that the sections be not more than 10 in number, so that, together with their subsections, they could form a decimal classification system. For these two reasons, the Sections D—H were incorporated into Section I.

After these changes had been made, the headings of the sections were modified accordingly. The sections were also rearranged into a better sequence, and were labelled with the figures 0—9. Thus, the list of principal sections assumed the following appearence:

0 General
1 Soil Science
2 Laboratory Investigations
3 Field Investigations
4 Earth Pressure Problems
5 Stability Problems
6 Deformation Problems
7 Ground Water Problems
8 Special Problems
9 Improvement of Soils. Foundations

The signification of these headings, *i.e.* the contents of the various principal sections, is clear from their subdivision as seen in the Appendix, which shows the whole system.

Unfortunately, the definite list of the principal sections is not logical, since all sections do not refer to the same basis of division. Indeed, only Sections 5—8 and partly Section 4 do refer to the primary basis of division, the kind of problem. This may seem a poor result, but, as has been seen above, each particular divergence from the original strictly logical system was enforced by practical reasons. Anyhow, the new system seems to be more logical and more fit for use than the three earlier systems described in § 2.

§ 3 c. Subsections.

When dividing the principal sections into subsections, various bases of division have been used. The principal Section 0 (General), for instance, constitutes an enumeration of subjects only. In the principal Section 3 (Field Investigations)

the subdivision is based on the completeness of the investigations, beginning with the simplest investigations (31 Inspection of Site) and ending in the most thorough ones (33/37 Investigations Involving Penetration into Ground). In other principal sections the most general subjects are placed first, and are followed by more and more specialized items.

In most sections the first subsection (Subsection 0) is used for subjects of general character, Subsection 8, for subjects collected from the other subsections, and Subsection 9, for miscellaneous.

The subdivision of some sections (for instance, Section 1, 2, and 3) is partly very detailed, and is surely too detailed for many classification purposes. However, those who prefer a rough classification can of course omit some subsections and/or some auxiliary signs, and can make use of sections suitable for their particular needs only.

§ 3 d. Combination of Main Numbers.

The numbers representing the principal sections, their subsections, etc., are called main numbers.

Sometimes the subject can be classified more precisely by combining two main numbers. This is done by means of : (colon). For instance, 021 represents the history of geotechnics in general, whereas 021:41/44 designates the history of the problem of earth pressure against walls.

The main numbers which can be combined in this way with other main numbers are marked out by notes in the System (see the Appendix).

§ 3 e. Auxiliary Signs.

Two important bases of division, namely the kind of soil and the kind of geotechnical activities, were not taken into account in the main numbers. In order to make use of them, so that the subject be classified more precisely, we have introduced them by means of so-called auxiliary signs.

The auxiliary signs expressing the kind of soil are figures added to the main numbers but separated from them by ′ (accent). Four such figures are used, corresponding to the following rough classification of the soils:

1 cohesive soils
2 noncohesive soils
3 peat
9 other masses

The main numbers to which these auxiliary signs can be added are marked by a full line in the System (see the Appendix).

The auxiliary signs expressing the kind of geotechnical activities are letters which are placed directly after all numbers. Five such letters are used indicating:

a general
b computations
c model tests
d observations on site
e remedial measures

The main numbers to which these auxiliary signs can be added are marked by a dash line in the System (see the Appendix).

The application of auxiliary signs is exemplified below:

52 = Stability of slopes
52'2 = Stability of slopes; noncohesive soils
52'2b = Stability of slopes; noncohesive soils; computations

82 = Frost problems
82d = Frost problems; observations on site
82de = Frost problems; observations on site and remedial measures

§ 4. Present Application of the SGI System.

The main application of the SGI System at the Institute is the classification of geotechnical literature. This work began in 1946. The literature catalogues being compiled are intended to cover all geotechnical literature in the Germanic and Romanic languages, in the first place the Scandinavian, English, German, and French languages. Up to now about 3 000 papers are registered in the catalogues.

An author catalogue and a subject catalogue are made up. Each of them consists of cards of the internationally accepted size, 75 × 125 mm, typographically arranged in accordance with prevalent library rules.

In the author catalogue, each book or paper has one card. Such a card referring to a paper is shown in Fig. 1. The card carries at the top the author's name followed below by the heading of the paper and the name of the publicatiou in which the paper is to be found. The classification numbers are given in the middle of the card, and an abbreviation of the name of a library from which the paper can be borrowed is indicated in the bottom left-hand corner. The cards are arranged in the catalogue in alphabetical order according to the name of the author or, if the book or paper is anonymous, in general according to the first word of its heading.

In the subject catalogue, each book or paper has one card for each subject that it deals with. Such a card is shown in Fig. 2.[1] The head of the card

[1] This card is one of those two subject catalogue cards which correspond to the author catalogue card shown in Fig. 1.

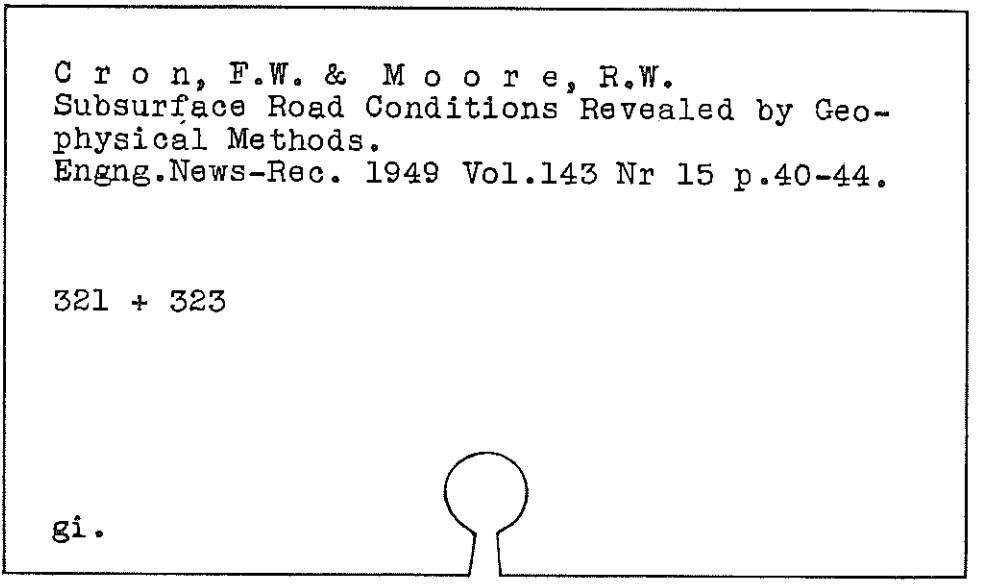

Fig. 1. Author catalogue card.

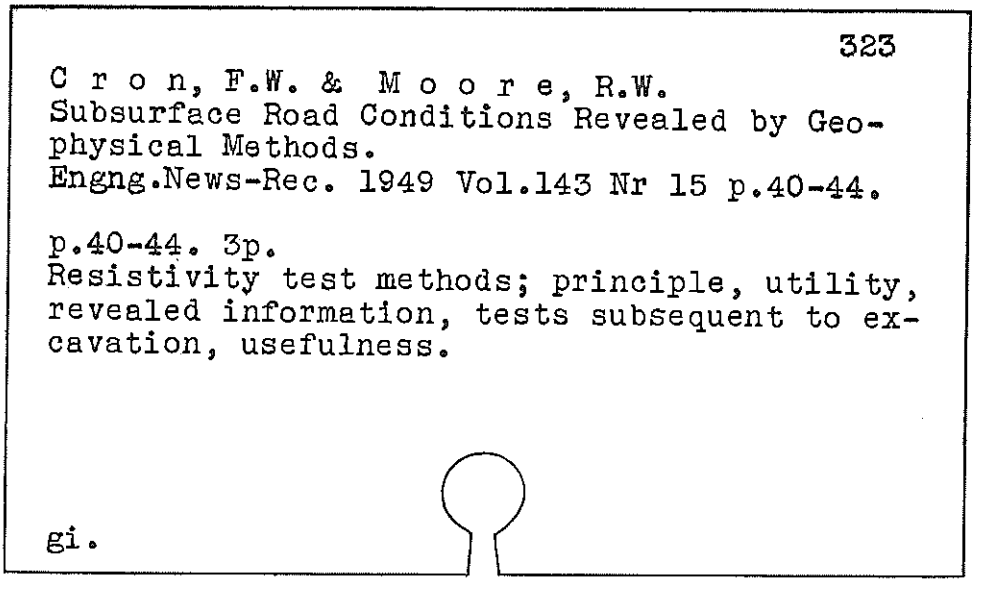

Fig. 2. Subject catalogue card.

(i.e. the author's name, the heading of the paper, and the name of the publication) is identical with the head of the corresponding card in the author catalogue. The classification number is written in the top right-hand corner. The pages of the paper dealing with the subject defined by the classification number and their total number are indicated under the head. Then follows a short account of the pages in question. The library notation is in the bottom left-hand corner of the card. The cards are arranged in the catalogue in order of subjects according to the classification system.

The classification carried out by the Institute is more detailed than is usual. Thus, a work dealing with several subjects is classified by a series of classification numbers (not only by the classification number of its heading), as shown by the following examples.

The paper represented by the cards in Figs. 1 and 2 and entitled "Subsurface Road Conditions Revealed by Geophysical Methods" (Engng. News-Rec. 1949 Vol. 143 Nr 15 p. 40—44) is classified not by the number 32, "Remote measurement of soil conditions" (Geophysical explorations), but by the numbers 321, "Seismic methods", and 323, "Electrical methods", *i.e.* by the details dealt with in the paper.

Another paper entitled "Foundations for the Aggersund bridge, Denmark" (Proc. 2. Internat. Conf. Soil Mech. a. Found. Engng. 1948 Vol. 4 p. 107—122) is classified by the numbers 562'1d "Bearing capacity of single piles; cohesive soils; observations on site", and 632bd "Consolidation settlements; computations and observations on site". These two subjects can hardly be inferred from the heading.

Such a detailed classification involves, of course, a huge amount of work. It is to be emphasized that this work requires geotechnical training, and therefore cannot be done by a librarian; it must be performed by a geotechnicist. We have undertaken this heavy toil in view of the following important advantages which the Institute and its clients derive from the detailed literature catalogue.

Nearly always when literature references are searched for, only references to a certain limited subject are wanted. The main advantage of a detailed literature catalogue is that it can immediately produce these references without mixing them with irrelevant references.

If, for instance, somebody is doing research on the earth pressure at rest, our detailed literature catalogue at once provides references to all the classified literature on this specific topic. From an ordinary literature catalogue of a general technical library he can get hundreds of references to literature on the wide field of earth pressure in general, but this material is practically useless to him.

It should also be pointed out that the detailed classification, which implies a careful study of the whole contents, gives a much more reliable idea of the paper in question than the classification done in the public libraries, which is normally based merely on the heading of the paper. Experience shows that the heading often gives a poor or even misleading notion of the real contents.

§ 5. Concluding Remarks.

The purpose of this report is to show how our Institute has built up a new and detailed geotechnical classification system, and how we apply it to geotechnical literature. The System is not claimed to be the ideal one; it can surely be criticized. It is made up on the basis of Swedish conceptions of geotechnics, and the problems dominating in Sweden have been given dominating space in the System. This may not fully agree with foreign needs. However, it is hoped that this report will open an international discussion on the geotechnical classification problem, which certainly is very important.

The report may also be regarded as a contribution to the discussion of the problem how to master the rising flood of technical literature. In our opinion, for which reasons were given above, a good solution cannot be reached by librarians and by means of a universal classification system. The right way is specialization. Engineering comprises perhaps 100 special branches, and each of them should solve its own literature problem by means of its own classification system.

§ 6. Summary.

A good geotechnical classification system is of great importance, above all for the classification of geotechnical literature. Three classification systems have hitherto been used in geotechnics; all have deficiencies and inconveniencies.

A new, detailed geotechnical classification system is presented. It is constructed according to the decimal principle, and to some extent with the UDC System as a pattern. Its present application to classification of geotechnical literature is described.

APPENDIX

The SGI Geotechnical Classification System

X Geotechnics

Principal sections

0 General
1 Soil science
2 Laboratory investigations
3 Field investigations
4 Earth pressure problems
5 Stability problems
6 Deformation problems
7 Ground water problems
8 Special problems
9 Improvement of soils. Foundations

Complete system

Auxiliary signs

The following two kinds of general auxiliary signs are used in connection with the main numbers marked by a full line and a dash line in the margin, respectively:

Auxiliary signs for kinds of soil
To be added directly to the main numbers and separated from them by ' (accent).

1 cohesive soils
2 noncohesive soils
3 peat
9 other masses

Auxiliary signs for kinds of activities
To be placed directly after all numbers.

a general (not used in connection with the main numbers »general»)
b computations
c model tests
d observations on site
e remedial measures

Special auxiliary signs are used in some sections. They are separated from the main numbers by - (hyphen). The signs are explained at the beginning of the sections in question.

0 General

00 Significance, extent, and subdivision of geotechnics. Geotechnics in relation to other sciences

01 Nomenclature

02 History. Personal history

021 History

Subdivision by means of colon. For instance, 021:41/44 "History of earth pressure against walls"

022 Personal history

03 Institutions, firms (activities, organization, buildings, lay-out, equipment, etc.)

04 Societies, committees, conferences, meetings, discourses, exhibitions, etc.

05 Education

06 Publications (bibliographies etc.)

Subdivision by means of colon, For instance, 06:251 "Bibliography on determination of shear strength"

07 Standards

Subdivision by means of colon. For instance, 07:561/563 "Standards concerning bearing capacity of piles"

09 Other general subjects

1 Soil Science

"Geotechnical Soil Science"

Investigations of soil properties, see 2 and 3

10 General
General description of various soils

11 Origin and occurrence of soils and other geological subjects of geotechnical importance
Regional soil conditions, see 18

12 Classification and identification of soils
Atterberg limits, characteristics of different soils

13 Structural characteristics of soils (composition, density, structure, etc.)

130 General

131 Soil aggregate
Structural characteristics of soil constituents, see 132/139

131.0 General

131.1 Composition and density
Grain size distribution, see 132.1

131.10 General

131.11 Water content

131.12 Organic matter content

131.15 Unit weight

131.16 Porosity. Void ratio

131.17 Relative density
Compactibility, see 173

131.19 Miscellaneous

131.2 Structure

131.9 Miscellaneous

132 Mineral constituents

132.0 General

132.1 Grain size distribution, grain size and shape

132.2 Composition and structure

132.3 Density (specific gravity)

132.9 Miscellaneous

133 Organic matter

134 Pore water (incl. dissolved materials)
Acidity, pH value

135 Decomposition products (undissolved)

139 Miscellaneous

14 Physico-chemical fundamentals for the engineering behaviour of soils
Colloidal and electrokinetic properties and phenomena

140 General

141 Adsorption of polar and non-polar molecules
Hydration, heat of wetting

142 Ion adsorption
Binding capacity, exchange reactions

143 Stability of suspensions
Peptization, coagulation
Cf 381

144 Electrokinetics
See also 175

144.0 General

144.1 Electrical double layer. Surface potentials

144.2 Electrophoresis. Electro-osmosis
Cf 912

144.3 Streaming potential

144.9 Miscellaneous

149 Miscellaneous

15 Behaviour of soils subjected to shear. Shear strength. Consistency

150 General

151 Relation between shearing stress and strain. Shear strength

152 Consistency
Atterberg limits, see 12

158 Thixotropy

159 Miscellaneous

16 Relation between normal stress and strain

160 General

161/163 Deformations dependent on time

161 General

162 Deformations accompanied by squeezing out (or suction) of water
Consolidation

163 Other deformations dependent on time

166 Deformations not dependent on time

17 Other soil properties

171 Permeability

172 Capillarity

173 Compactibility

174 Thermal properties

175 Electrical properties
See also 144

179 Miscellaneous

18 Regional soil conditions
This number can be combined with UDC general auxiliary numbers of place, for instance, 18 (62) "Soil conditions in Egypt"

19 Miscellaneous

2 Laboraty Investigations. Investigation of Soil Samples

Model tests, see problems 4/99

20 General
Lay-out of laboratory, equipment, storage of samples

21 Geological investigations (of geotechnical importance)

22 Classification and identification tests
Atterberg limits tests

23 Investigation of structural characteristics of soils (composition, density, structure, etc.)

230 General

231 Investigation of soil aggregate
Investigation of soil constituents, see 232/239

231.0 General

231.1 Composition and density investigations
Determination of grain size distribution, see 232.1

231.10 General

231.11 Determination of water content

231.12 Determination of organic matter content

231.15 Determination of unit weight

231.16 Determination of porosity or void ratio

231.17 Determination of relative density
Compaction tests, see 273

231.19 Miscellaneous

231.2 Structure investigations

231.9 Miscellaneons

232 Investigation of mineral constituents

232.0 General

232.1 Determination of grain size distribution (mechanical analysis), grain size and shape

232.10 General

232.11 Sieve analysis

232.12 Sedimentation analysis (in gravitational or centrifugal field)

232.13 Elutriation analysis (with water, air, etc.)

232.14 Microscopic investigations

232.19 Miscellaneous

232.2 Composition and structure investigations of mineral grains

232.20 General

232.21 Thermal methods

232.210 General
232.211 Differential thermal analysis
232.212 Weight loss analysis
232.213 Dilatation analysis
232.219 Miscellaneous
232.22 Microscopic investigations
232.23 X-ray analysis
232.24 Chemical analysis
232.29 Miscellaneous
232.3 Determination of density of mineral grains
232.9 Miscellaneous
233 Investigation of organic matter
234 Investigation of pore water (incl. dissolved materials)
235 Investigation of decomposition products (undissolved)
239 Miscellaneous

24 Investigations concerning the physico-chemical fundamentals for the engineering behaviour of soils
Colloidal and electrokinetic investigations

240 General
241 Investigations of molecular adsorption
Determination of hygroscopicity
242 Investigations of ionic adsorption
243 Investigations of stability of suspensions
Cf 381
244 Electrokinetic investigations
244.0 General
244.1 Investigations of electric double layer
244.2 Electrophoretic and electro-osmotic measurements
Cf 275 and 912
244.3 Measurement of streaming potential
244.9 Miscellaneous
249 Miscellaneous

25 Investigations of the behaviour of soils subjected to shear. Determination of shear strength and consistency

250 General
251 Investigations of the relation between shearing stress and strain. Determination of shear strength
251.0 General
251.1/251.7 Direct methods
251.1 General
251.2 Box-shear tests
251.3 Unconfined compression tests
251.4 Triaxial tests

251.5 Rotation-shear tests
Ring-shear tests, laboratory vane tests

251.7 Other direct methods

251.8 Indirect methods
Cone tests

252 Determination of consistency
Determination of Atterberg limits, see 22

258 Thixotropic investigations

259 Miscellaneous

26 Investigations of the relation between normal stress and strain

260 General

261 One-axial tests
Unconfined compression tests, see 251.3

261.0 General

261.1 Oedometer tests

261.2 Ring-consolidometer tests (with or without measurements of lateral pressure and lateral expansion)

261.9 Miscellaneous

263 Triaxial tests

269 Miscellaneous

27 Investigation of other soil properties

270 General

271 Determination of permeability

271.0 General

271.1 Constant-head tests

271.2 Falling-head tests

271.9 Miscellaneous

272 Determination of capillarity

273 Determination of compactibility

274 Investigation of thermal properties

275 Investigation of electrical properties
Electro-osmosis, see 244.2

279 Miscellaneous

29 Miscellaneous

3 Field Investigations

Special field investigations, such as model tests, measurement of earth pressure and settlements, see problems 4/99. Investigation of soil samples, see 2

30 General

301 Extent of investigations

302 Recording results of investigations

31 Inspection of site (incl. aerial photography and airphoto examination)

310 General

311 Geotechnical inspection

312 Geological inspection

313 Biological inspection

317 Aerial inspection

319 Miscellaneous

32 Remote measurement of soil conditions

Geophysical explorations

320 General

321 Seismic methods

322 Continuous vibration methods

323 Electrical methods

329 Miscellaneous

33/37 Investigations involving penetration into ground

33 General

34 Sinking of holes

Special auxiliary signs. Separated from the main numbers by - (hyphen)

1/3 Stabilization of the hole

1 With casing

2 With drilling fluid

3 By other methods

5/6 Fetching up of loosed material

5 By washing

6 By mechanical means

340 General

341 Displacement of the material

342 Crushing of the material

Percussion drilling

343 Cutting loose the material

Rotary drilling, digging

344 Washing loose the material
Jetting
349 Miscellaneous

35 Measurements directly in ground

350 General
351 Mechanical methods
Soundings
Loading tests, see 51
Measurements concerning water in the ground, see 358
351.0 General
351.1 Axial[1] movement of measuring tool
Penetration tests
351.2 Tangential[1] movement of measuring tool
Vane tests
351.3 Radial[1] movement of measuring tool
351.9 Miscellaneous
358 Measurements concerning water in the ground
358.0 General
358.1 Ground water table
358.2 Pore pressure
358.9 Miscellaneous
359 Miscellaneous

36 Sampling and handling of samples

360 General
361 Non-representative samples (with regard to composition and structure)
Wet samples
362 Disturbed samples (with regard to structure)
362.0 General
362.1 Axial[1] entering of sample
Posthole augers, helical augers
362.2 Radial[1] entering of sample
Slit tube samplers
362.9 Miscellaneous
363 Undisturbed samples

Special auxiliary signs. Separated from the main numbers by - (hyphen)
1/5 Methods for preventing disturbance and loss of sample
1 Cutting sample free from subsoil
2 Break of vacuum below sample
3 Producing vacuum above sample
4 Mechanical retaining of sample
Core retainers
5 Other methods for preventing disturbance and loss of sample
8 Shallow sampling
9 Taking of long cores

[1] In relation to the hole.

363.0 General
Disturbances of soil during sampling, requirements for good samplers, area ratio

363.1 Sampling without continuously controlled recovery ratio
Samplers with free piston, open samplers, samplers with retracted piston

363.2 Sampling with continuously controlled recovery ratio
Samplers with stationary piston

363.9 Miscellaneous

366 Handling of soil samples
Handling of samples in the laboratory, see 20

366.0 General

366.1 Preservation

366.2 Storage and transport

366.9 Miscellaneous

367 Water samples

369 Miscellaneous

37 Other investigations involving penetration into ground

38 Auxiliaries for field investigations

380 General

381 Drilling fluids
Cf 143 and 243

382 Appliances for driving and withdrawal

383 Special auxiliaries for investigations (borings) through water
Rafts, platforms

384 Conveying equipment

389 Miscellaneous

39 Miscellaneous

4 Earth Pressure Problems

40 General

41/44 Earth pressure against walls and similar structures

41 General

42 Limit pressure

420 General

421 Active earth pressure

422 Passive earth pressure

43 Earth pressure at rest and after movement not large enough to cause limit pressure

44 Other problems of earth pressure against walls and similar structures

45 Silo pressure

46 Earth pressure on tunnels, underground conduits, and similar structures

48 Apparatuses and methods for measurement of earth pressure

49 Miscellaneous

5 Stability Problems (Bearing Capacity of Soils, Stability of Slopes, Bearing Capacity of Piles, etc.)

Earth pressure problems, see 4

50 General

501 Factor of safety in stability problems in general

51 Bearing capacity of soils (horizontal or nearly horizontal ground loaded by shallow or deep footings, embankments, etc.)

52 Stability of slopes (natural slopes, cuttings, embankments, earth dams, etc.)

Stability of slopes acted upon by seepage forces, see 722

53 Slip in the contact surface between structure and soil

56 Stability of piles (incl. related deformation problems)

560 General

561/563 Bearing capacity of piles

561 General

562 Single piles

563 Pile groups

565 Lateral stability of piles

569 Miscellaneous

58 Local and progressive shear failures

Subdivision by means of colon. For instance, 58:52'1b "Computations regarding progressive failure of slopes in cohesive soils"

59 Miscellaneous

6 Deformation Problems (Stress Distribution, Settlements, etc.)

Earth pressure problems, see 4. Deformation problems in connection with piles, see 5

60 General

61 Stress distribution

Earth pressure measurements, see 48
Pore pressure measurements, see 358.2

610 General

611 Contact stresses between soil and loaded areas, footings, etc.

612 Stress distribution in subsoil (also in slopes, earth dams, etc.)

Stress distribution around piles, see 56

619 Miscellaneous

62/64 Settlements (and swelling) due to variations of load

Settlements due to lowering of the ground water table
Settlements due to special causes (vibrations, frost action, etc.), see 8

62 General

63 Settlements due to compression of soil (incl. consolidation)

630 General

631/633 Settlements dependent on time

631 General

632 Settlements accompanied by squeezing out of water

Consolidation

633 Other settlements dependent on time

636 Settlements not dependent on time

64 Settlements due to deformation of soil (at constant or nearly constant volume)

Settlements due to lateral displacement of soil
Problems in connection with local and progressive failures, see 58

68 Apparatuses and methods for measurement of deformations

69 Miscellaneous

7 Ground Water Problems

Consolidation, see 632. Frost action in soils, see 82. Measurements concerning water in the ground, see 358

70 General

71 Ground water seepage

Special methods for dewatering and improvement of soils, see 91

710 General

711 Natural seepage

712/716 Seepage in connection with construction works, drains, etc.

712 General

713 Seepage to wells, excavations, drains, etc.

Seepage in connection with sheet pilings, see 714

714 Seepage in connection with dams, sheet pilings, etc.

716 Other seepage problems in connection with construction works

719 Miscellaneous

72 Stability of earth acted upon by seepage forces

720 General

721 Piping due to heave

722 Stability of slopes acted upon by seepage forces

729 Miscellaneous

73 Ground water erosion

Erosion problems in general, see 810

74 Corrosion due to ground water

79 Miscellaneous

8 Special Problems

80 Vibration problems
Subdivision by means of colon. For instance, 80:52c "Model tests regarding the effect of vibrations on the stability of slopes"

81 Erosion problems
Ground water erosion, see 73

810 General

811 Scour

812 Wind erosion

819 Miscellaneous

82 Frost and heat problems

83 Quicksand problems
Stability of earth acted upon by seepage forces, see 72

84 Shrinkage and swelling (due to desiccation and sorption, respectively)

85 Handling of soils (excavation, transport, etc.)

86 Rock pressure and other problems related to rock

87 Special problems closely related to special construction works, to town planning, etc. (also summaries of general problems related to a special subject)

870/877 Problems in connection with construction works

870 General

871 Houses

872 Roads and airfields

872.1 Pavements
Cf 95

873 Railways

874 Bridges

875 Hydraulic works

875.0 General

875.1 Dams and levees

875.2 Quays

875.3 Canals

875.9 Miscellaneous

876 Tunnels and underground conduits

877 Other construction works (retaining walls, poles, etc.)

878 Problems in connection with town planning

879 Miscellaneous

89 Miscellaneous

9 Improvement (Strengthening, Compaction) of Soils. Foundations

90/97 Improvement of soils
Methods of increasing bearing capacity of piles, se 982.5
Displacement of soil, see 983

90 General

91 Dewatering by various methods
Drainage by pumping in wells and sumps, see 713. Natural flow to drains, etc., ditto

910 General

911 Consolidation of soil by applying a load (embankment or vacuum) without drainage or in combination with drainage

911.0 General

911.1 Without special drains

911.2 With sand drains

911.3 With cardboard drains

911.4 With filter wells

911.9 Miscellaneous

912 Electro-osmosis
Cf 144.2 and 244.2

913 Application of heat. Ventilation

917 Planting of grasses, shrubs, etc.

919 Miscellaneous

92 Compaction
Compaction in connection with stabilization, see 95

920 General

921 Rolling

922 Tamping

923 Vibrating

924 Blasting

925 Piling

926 Ponding

929 Miscellaneous

93 Artificial cementing (*in situ*)
Injection processes
Freezing, see 94
Stabilization, see 95

930 General

931 Cement grouts

932 Bituminous emulsions
933 Clay grouts
934 Soluble silicate solutions
935 Asphalt grouts
939 Miscellaneous

94 Freezing
940 General
941 Liquid refrigerant
942 Gaseous refrigerant
943 Solid refrigerant

95 Stabilization (by mixing with other soils, cement, bitumen, etc.)
Cf 872.1
950 General
951 Correction of grading
952 Addition of cement
953 Addition of a bituminous stabilizer
959 Miscellaneous

96 Ion exchange. Electrochemical hardening

97 Other methods for improvement of soils

98 Foundations
980 General
981 Spread foundations. Pier foundations
982 Pile foundations
Stability of piles, see 56
982.0 General
982.1 Pile types
982.2 Location of piles (spacing, inclination, etc.)
982.3 Installation of piles (driving, preboring, etc.)
982.4 Bond, connection to pile cap, anchorage, etc.
982.5 Methods of increasing bearing capacity of piles
982.9 Miscellaneous
983 Displacement of soil
989 Miscellaneous

99

LIST OF PUBLICATIONS FROM THE ROYAL SWEDISH GEOTECHNICAL INSTITUTE

Proceedings

No. 1. Soil Sampler with Metal Foils. Device for Taking Undisturbed Samples of Very Great Length. *W. Kjellman, T. Kallstenius,* and *O. Wager* 1950

2. The Vane Borer. An Apparatus for Determining the Shear Strength of Clay Soils Directly in the Ground. *Lyman Cadling* and *Sten Odenstad* 1950

3. Device and Procedure for Loading Tests on Piles. *W. Kjellman* and *Y. Liljedahl* 1951

4. The Landslide at Sköttorp on the Lidan River, February 2, 1946. *Sten Odenstad* 1951

5. The Landslide at Surte on the Göta River, September 29, 1950. *Bernt Jakobson* 1952

6. A New Geotechnical Classification System. *W. Kjellman, L. Cadling,* and *N. Flodin* 1953

Meddelanden

Nr 1. Kortfattat kompendium i geoteknik 1946 1946

2. Redogörelse för Statens geotekniska instituts verksamhet under åren 1944—1948 1949

3. »Bra borrat — bättre byggt». Meddelande utgivet till institutets deltagande i utställningen »Bygg bättre», Nordisk Byggnadsdag V 1950