

The Italian code of Geotechnical Engineering

R. JAPPELLI *, C. VALORE **

SUMMARY: Main documents on instructions and regulations in force in Italy in the field of Geotechnical Engineering are briefly presented. Detailed information on the main code edited in 1981 by the Ministry of Public Works of the Italian Government is given. Regulated by law are design, construction and control of foundations, retaining walls, earth embankments and fills, underground constructions, natural slopes and excavations, soil improvement methods, environmental geotechnics, including the effect of pumping from the subsoil.

For each type of construction, the provisions that must be complied with throughout the Italian territory, prescribe site and laboratory investigations, geotechnical computations, controls by testing and instrumentation, geotechnical reports, that should be included in design documentation. In some cases minimum recommended values of safety factors are specified. Observational approach is implicitly accepted.

The prescriptions are rather flexible in order to give the maximum responsibility to the designer in the assumption of fundamental hypotheses and correspondingly in the selection of computational methods.

Attention is repeatedly called on the necessity of extending investigations, computations and controls throughout the various phases of the work, taking into due account the effects of the possible differences between forecasts and actual observations.

On account of the great variety of geotechnical situations and of the properties of Italian soils and rocks the introduction of a rigid code does not seem appropriate.

1. Introduction

Rules, regulations and provisions in the field of Geotechnical Engineering are still rather limited in Italy and have not yet been edited into an organic single body. Furthermore, the documents are drawn up according to a variety of forms, depending on the purposes and the trends that have prevailed within each regulatory agency.

In spite of these limits and of many shortcomings, the Italian codes do touch upon various topics, some from a general standpoint and others in detail.

The provisions relating to almost all the topics are to be found in the documents listed in table I.

The annexe gives a list of the most important documents on codes, instructions or recommendations published in Italy by various public bodies or learned societies.

2. Sources of documents

The Italian National Research Council (C.N.R.) has been carrying out active work in the field of geotechnical codes since 1964, assigning to its standing consultative committees the task of laying down instructions [C.N.R. 1964-1978].

A.G.I. has sponsored comprehensive instruc-

tions with particular reference to nomenclature [A.G.I., 1963], geotechnical investigations [A.G.I., 1977] and piles [A.G.I., 1981].

The Ministry of Public Works has been active in the last two decades on the fundamental themes of geotechnics related to building construction. In 1967 the Ministry put forth a *Circular* whereby it gave its central and peripheral offices specific instructions about the design, construction and inspection of foundation works [LL.PP. CM. 1967]. The Circular, although frequently referred to by privates, strictly applies to public works. In 1974 the Ministry issued a *Decree* for disciplining activities in the building sector [LL.PP. DM. 1974]. Following this Decree, that among other branches of Civil Engineering considers Geotechnical Engineering as playing a central role, other codes referring to specific types of construction have been issued; amongst these a *Decree* deals exclusively with Geotechnical Engineering [LL.PP. DM., 1981]. This document is accompanied by instructions [LL.PP. CM, 1981] worked out by the Central Technical Service of the High Council of Public Works.

It should also be pointed out that some Italian Regions have already or are about to issue rules and instructions — regarding the territory and the protection of the natural environment — for various purposes, which come very close to Environmental Geotechnics.

A.G.I. has recently appointed a committee with the purpose of collecting and commenting the various regional regulations.

* Ruggiero JAPPELLI, Professor of Geotechnics, University of Palermo.

** Calogero VALORE, Researcher in Geotechnics, University of Palermo; Lecturer of Heart Retaining Structures, Calabria University.

TABLE I
TOPICS CONSIDERED IN ITALIAN CODES CONCERNING
GEOTECHNICAL ENGINEERING

<i>Government Bodies</i>			<i>Learned Societies</i>	
LL.PP. CM, 1967	INVESTIGATIONS FOUNDATIONS RETAINING WALLS UNDERGROUND CONSTRUCTIONS SLOPES AND EXCAVATIONS EARTH CONSTRUCTIONS ENVIRONMENTAL GEOTECHNICS		A.G.I., 1977 A.G.I., 1981	
LL.PP. DM, 1974 LL.PP. DM, 1981 LL.PP. CM, 1981				
	SPECIAL UNDERGROUND WORKS	A.G.I., 1975 A.I.C.A.P., 1983		
LL.PP. DM, 1982	EARTH DAMS			
LL.PP. DM, 1975	GEOTECHNICAL EARTHQUAKE ENGINEERING			
C.N.R., 1964-78	TESTING PROCEDURES NOMENCLATURE	A.G.I., 1963		
A.G.I. Italian National Society of Soil Mechanics and Foundation Engineering and for Rock Mechanics, Viale Regina Margherita, 183 - 00198 Roma		C.N.R. National Research Council, Piazzale A. Moro, 7 00185 Roma		
A.I.C.A.P. Italian Society for Prestressed Reinforced Concrete, Via G. Antonelli, 41 - 00197 Roma		LL.PP. Ministry of Public Works, Porta Pia, 00100 Roma		
		DM Decree, with a force of law		
		CM Circular letter, with instructions		

3. Authorities

As regards the soundness and authority of the various codes from a legal standpoint, it is worthwhile recalling that the provisions issued by the Ministry under the form of *Decree Laws*, marked LL.PP. DM in the Table, must be complied with throughout the Country by public agencies and by privates. The *Ministerial Circulars* marked LL.PP. CM, include instructions that are not strictly mandatory, to which authoritative reference can be made in the case of experts opinions on disputes.

The National Research Council (C.N.R.) stands as an authoritative source; under the current legislation the Ministry must obtain approval from C.N.R. before issuing any code whatever.

Although representing useful reference, the documents drawn up by the various learned societies do not have the force of law.

4. Topics

The topic of in situ investigations is dealt with extensively and organically in A.G.I., [1977] as recommendations. As to the laboratory tests, only concise instructions concerning the measurement of some physical characteristics of soils are available [C.N.R., 1964-78].

A.G.I. and other learned societies have pre-

pared recommendations on special underground work such as the use of shotcrete [A.G.I., 1975], and anchorages [A.I.C.A.P., 1981].

However, the relevant regulations on Geotechnical Engineering have been issued by the Ministry of Public Works under the form of Decrees (DM) and Circulars (CM). The main Decree [LL.PP. DM, 1981] deals with investigations to be carried out on soils, rocks, natural slope stability, general criteria and regulations for design, construction and inspection of foundations and retaining structures. This code refers to all civil engineering structures except dams and weirs for which separate legislation has been issued in the past and recently revised [LL.PP. DM, 1982].

The Decrees dealing with special structures such as bridges [LL.PP. DM., 1980] make reference to the main Geotechnical Code [LL.PP. DM, 1981] when foundations are involved.

Most of the Italian territory is seismically active; the design and building of structures in areas recognised as being seismic are regulated by an ad hoc *Decree* [LL.PP. DM, 1975].

5. The main geotechnical engineering code

The code [LL.PP. DM, 1981] concisely touches upon almost the whole field of Geotechnical Engineering.

The code deliberately does not adopt the approach of excessively standardizing investigation procedures and calculation methods, also on account of the difficulty of generalizing factors relating to the Italian physical environment, which is extraordinarily varied and complex. Therefore a distinction is made between general principles, that can be held valid anywhere and at any time, and the empirical knowledge, the validity of which is related to a certain moment and to a specific site: the former are dealt with by laws that all citizens must comply with throughout the country; the latter are circulated under the form of operational recommendations that must be periodically revised and updated.

After a series of general provisions, the subject matter is arranged according to the type of structure, namely foundations, retaining walls, earth embankments and fills, underground constructions, natural slopes and excavations; finally, some provisions regard environmental geotechnics, including effect of pumping from the subsoil, wastes, soil improvement, drains and filters.

Each chapter deals with the topic from four standpoints: *preliminary investigations, geotechnical calculations, construction problems, inspection and control.*

The subject matter is dealt with from a general and problematic standpoint; the provisions are relatively flexible, leaving the designer enough freedom to be able to plan and work out for himself the investigation and inspection programme, the geotechnical characterization of the subsoil, and to select the main hypotheses and geotechnical procedures.

As regards exploration, emphasis is placed on the close relationship between the investigation programme and geotechnical tests, and the design criteria and construction methods.

There is a fundamental rule stating that geotechnical design must always be founded on the mechanical characterization of the subsoil.

In this perspective, the designer is asked to formulate a clear working assumption, based on the data that are available at the design stage; the working assumption must be verified and eventually updated during construction operations by the designer and by the Engineer work director on behalf of the owner through a programme of geotechnical measurements and controls, that must however be envisaged in the design stage, and carried out accordingly with the appropriate frequency to

mark the eventual differences between forecasts and real developments and to compare predicted and measured performance. This design assumption must therefore be taken as a reference point which is to be used to assess and justify any variant that where to be made during construction for geotechnical reasons.

The application of these concepts, that are explicitly related to the process of « *permanent geotechnical design* » demands that the designer make clear reference to the construction and building procedures that are to be adopted.

Only for buildings of lesser importance is it permitted to omit the stability analysis of the soil-structure system and to judge on the basis of the documented performance of analogous structures on similar soils; it is up to the designer to decide whether it is necessary or not to carry out displacement calculations.

As to safety conditions the rules do point out the minimum global safety coefficient values to be adopted in some specified cases; however the designer is free to depart from such values, provided he may supply clear and written evidence in support of the different values he wishes to introduce.

6. Concluding remarks

To conclude this short overview, it must be recalled that the structure of the Italian geotechnical rules expressed in the provisions issued by the Ministry of Public Works, derives from the need to put forth a concise text which intends to be a rule of behaviour. The main objective is that of focussing on the stages of geotechnical design, and of drawing the attention of operators (owner, designer, experts, site superintendents, builders, inspectors) to the most important questions, principles and duties concerning investigations, calculations, construction procedure and inspection; at the same time however, the rules provide the designer and other operators with the necessary autonomy to depart from provisions in order to be able to better cope with and solve specific problems, provided the designer is able to supply the necessary rational documented justification and evidence.

With a view of coordination at an European level, the text, currently in force, is being revised and updated. A definition of the tasks of the various operators with regard to the geotechnical engineering aspects has been requested; an assessment of the design criteria for

the cases in which seismic problems are involved is under study; the necessity is felt of an approach to the foundation problems for old buildings and monuments; a standardization in testing procedures and in nomenclature is desirable.

APPENDIX 1

A list of Italian instructions and regulations relevant to Geotechnical Engineering

A.G.I. (1963)	: Nomenclature and soil classification
A.G.I. (1975)	: Report on the use of shotcrete in Italy
A.G.I. (1977)	: Recommendations on the planning and conducting of geotechnical investigations
A.G.I. (1981)	: Recommendations for the design, construction and inspection of piles
A.I.C.A.P. (1983)	: Instructions on anchorages in soils and rocks - First draft
C.N.R. (1964-78)	: Testing procedures for the measurement of some physical characteristics of soils
LL.PP. DM. (1982)	: Regulations for design and construction of dams
LL.PP. CM. (1967)	: Instructions on foundations
LL.PP. DM. (1974)	: Provisions for buildings with specification for seismic areas
LL.PP. DM. (1975)	: Rules for buildings in seismic areas
LL.PP. DM. (1980)	: Rules for design, construction and inspection of bridges
LL.PP. DM. (1981)	: Geotechnical Engineering Code: Provisions
LL.PP. CM. (1981)	: Geotechnical Engineering Code: Instructions

APPENDIX 2

ITALIAN REPUBLIC MINISTRY OF PUBLIC WORKS

Technical provisions regarding soil and rock investigations, stability of slopes and artificial cuts, general criteria and regulations for planning, construction, inspection and control of earth retaining walls and of foundation structures.

Published in the GAZZETTA UFFICIALE DELLA REPUBBLICA ITALIANA. Supplemento Ordinario n° 37 - 7 Febbraio 1981

A. GENERAL PROVISIONS

A.1 Aim of the provisions

The provisions presented in this Code put forth the general criteria to be followed:

- in the design and conduction of tests on soils; the term soil is taken to include soil and rock in their natural site;
- in the design, construction and inspection of foundation structures, support structures, earth fill structures, underground works, artificial cuts, embankments, waste disposal, drainage and filtering facilities;
- in the study of the stability of natural slopes;

— in the feasibility studies of works extending out over large areas for which it is necessary to consider both geological and geotechnical problems;

— in the design and implementation of measures on ground such as soil reinforcement and the drainage of fluids.

The present regulations apply to all public and private works to be built on the territory of the Republic, as provided for by Section 1 of Act n° 64 of February 2, 1974. For special structures pursuant to sub-section (d) of section 1 of the above mentioned Act, the present regulations shall apply wholly, except as prescribed by the technical regulations referring to the individual special structures.

For areas classified as seismic the present provisions must be supplemented with those governing constructions in seismic areas, in pursuance of article 3 of the above-mentioned Act.

As regards the calculations and dimensioning of structures dealt with in the present code, construction materials, procedures and construction methods, reference is made to the specific regulations currently in force and in particular to the regulations issued for the application of Act n° 1086 of November 5, 1971, except otherwise provided for by the following sections.

A.2 General regulations

The design decisions must always be based on the geotechnical characterization of the subsoil obtained by means of surveys, investigations and tests.

The design calculations must include stability verifications. The choice of the safety coefficients must be motivated. If values other than those provided for by the present rules are adopted, they will have to be justified by a documented analysis.

The design shall also include an assessment of the expected displacements of the soil-structure system, as well as an evaluation of the admissibility of such displacements with regard to the safety and serviceability of the structure and of the neighbouring buildings.

The magnitude of the loads and of the actions to be considered in the geotechnical calculations shall be decided on the basis of an analysis which takes into account the probability and frequency of their duration, of the nature of the soils which constitute the subsoil as well as of the type of structure at hand.

Account shall be kept also of the surcharges acting directly on the ground surrounding the structure. Factors associated with construction operations shall be considered in the design.

During construction checks shall be carried out to ensure that the geotechnical characterization assumed at the design stage does respond to the actual conditions of the subsoil.

For structures considered small in relation to the global stability of the structure-soil complex, to rise in known areas, the geotechnical characterization of the subsoil can be attained by collecting information and data on which the design can be responsibly based.

In such a case the geotechnical stability calculations and the assessment of the displacements may be omitted, but the appropriateness of the adopted design decisions shall nevertheless be motivated in an ad hoc report.

A.3 Geotechnical and geological reports

The findings and the results of the surveys, of the investigations and of the geotechnical calculations, shall be presented in a geotechnical report, as an integral part of the design documents.

For the cases in which in pursuance to the present provisions a geological study is to be conducted, a geological report shall also have to be drawn up, and it shall accompany the design documentation.

A.4 Inspection

Inspections shall verify that the structures comply with the design forecasts and that the structure complies with the provisions laid down by the present code, keeping account of all the data collected during construction.

Further investigations and tests shall be carried out during inspection, as deemed necessary to verify that the structure is appropriate for its intended function.

B. GEOTECHNICAL INVESTIGATIONS

B.1 Aim of the provisions

The provisions laid down herewith regard the planning and carrying out of geotechnical investigations. Such investigations have the aim of collecting all the qualitative and quantitative data required for the design and for the control of the behaviour of the structure in its entirety and in relation to the soil.

B.2 Investigations during the design and construction stages

During the feasibility study stage a geologic and geotechnical investigation shall be carried out to evaluate the global stability of the area, before and after the construction of the structure, and to detect any problem depending on the nature and geotechnical characteristics of the soil in order to be able to select design solutions and related construction procedures.

For this stage use may be made of geological and geotechnical data inferred from the literature and from technical reports on other structures built in the same zone.

During the design stage the investigations shall be aimed at gaining in-depth knowledge about the qualitative and quantitative geotechnical characteristics of the subsoil so as to be able to compare possible solutions, choose the solution to be implemented and define the construction procedures.

For earth structures the investigations shall also include location and exploration of sources for construction materials and the study of their properties.

The investigations, the studies, and the surveys shall be completed in due time for the preparation of the design, except for further developments in relation to needs arising during the construction stage.

For smaller structures in already known areas, the investigations and surveys may be restricted to the collection of information and data previously obtained, on which the design may be responsibly built.

The validity of the design assumptions shall have to be cross-checked during construction taking into consideration, besides the data gathered during the design stage, also the data obtained through measurements and observations during construction; if necessary, the structure should be modified according to the conditions encountered.

B.3 Scope of the investigation

The geotechnical study shall be extended to that part of the subsoil that either directly or indirectly will be influenced by the construction and that will influence the behaviour of the structure itself (significant volume).

The scope of the investigation shall therefore be commensurate to the size, type, structural features and importance of the structure to be built, to the complexity of the subsoil and to the state of geotechnical knowledge of the area under examination.

B.4 Investigation tools

The investigation programme shall be worked out on the basis of the expected features of the subsoil and keeping account of the problems under examination.

The geotechnical investigations comprehend:

- a) borings and excavations;
- b) sampling;
- c) identification and location of the watertable and measurements of the relevant underground water circulation characteristics;
- d) in situ and laboratory tests for determining the properties of the soils;
- e) geophysical investigations, if necessary.

The investigation tools shall be chosen each time in relation to the soils constituting the subsoil, the purposes and features of the structure.

The investigation programmes shall be sufficiently flexible so as to allow any changes ensuing from the knowledge accrued during the exploration work.

C. FOUNDATIONS

C.1 Aim of the provisions

The present regulations refer to the foundations of any type of structure.

As regards the calculation of the elements which make up the foundation, the materials used, the building procedures and methods, the specific regulations currently in force shall apply.

The provisions under chapter II of Act n° 64 of February 2, 1974 shall be complied with for the foundations of structures rising in seismic areas.

C.2 Design criteria

The foundations should be designed together with the superstructure; construction methods should be specified.

Any foundation structure must satisfy the following requirements:

- the stress state induced in the soil must be compatible with the strength characteristics of the soil, in the initial situation at the beginning and also in those that may presumably develop subsequently;
- the displacements of the foundation structures must be such as not to jeopardize the equilibrium conditions and the serviceability of the superstructure.

Due account must be kept of the influence that the building at hand may have on the foundations and on structures existing in its surroundings.

The design must include:

- investigations, surveys, studies to identify and evaluate the factors that may affect the behaviour of the foundations;
- choice of the type of foundation;
- verification of the stability of soil-foundation system;
- prediction of the settlements and of their progress with time;
- choice of construction procedures;
- proportioning and safety verifications of foundation structures.

C.3 Provisions for the investigations

The surveys and investigations — to be conducted in compliance with the provisions in section B — are aimed at ascertaining the constitution of the subsoil and the presence of ground water either with free surfaces or artesian, and at determining or enabling the assessment of the physico-mechanical properties of the soils.

The exploration depth, to be computed from the lowest elevation of the foundation structure, is to be decided and justified each case at a time according to the shape, size, and structural features of the building, to the value of the loads to be transmitted to the foundation soils, to the characteristics of the foundation soils and to the morphology of the area surrounding the building.

Special investigations are to be carried out in areas where motivated geological, historical and mining evidence point to the existence of underground cavities.

C.4 Direct Foundations

C.4.1. Design Criteria

The founding level must be located beneath the top layer, and also beneath the layer of soil affected by frost and by significant seasonal variations in water content. Choices based on different criteria shall be adequately justified.

The foundation shall be directly protected or placed at such a depth as to be protected against superficial soil erosion processes.

Verifications should prove that the behaviour of the foundation as a whole and of each of its individual components is compatible with the safety and serviceability of the superstructure.

To this end the limit load (bearing capacity) of the foundation-soil system, and the settlements, both for each individual component of the foundation and for the structure as a whole, shall be determined.

For cases in which the type and size of the foundation can be inferred from a long-standing and satisfactory local practice, the choices must be documented and justified on the basis of a global judgement with explicit reference to the geotechnical conditions of the subsoil.

C.4.2. Limit load and admissible load of the foundation-soil system

The limit load of the foundation-soil system shall be calculated on the basis of the geotechnical characteristics of the subsoil and of the geometry of the foundation.

In the calculations account must also be kept of possible changes in the characteristics of the soil and in the state of the site that may be brought about by the construction.

If the structure is to rise on or in the vicinity of a natural or artificial slope, the overall stability of the slope must be ascertained in compliance with provisions of section G, keeping moreover account of the forces imposed on the slope by the foundation.

The admissible load must be selected as a fraction of the limit load.

The safety coefficient shall not be lower than 3, unless the features of the structure, especially accurate investigations, homogeneity and uniform behaviour of the soil, thorough knowledge of actions on the structure and the adoption of calculation methods that accurately model the physical situation, make it possible to adopt lower values.

C.4.3 Settlements

Absolute and differential settlements and their progress with time shall be compatible with the admissible state of stress and serviceability of the structure.

The prediction of settlements shall be based on calculations referring to the geotechnical conditions of the subsoil; loads and surcharges should be appropriately evaluated.

The prediction may be restricted to a global judgement if a long-standing and satisfactory local practice provides the grounds for an assessment of the behaviour of the soil-structure system.

C.4.4 Structural components of the foundation

For checking the strength of each structural component of a foundation account shall be kept of the reactions of the soil, of any thrusts caused by water and of the influence of any surcharges applied directly to the soil.

The combination of the abovementioned loads and actions that induces the worst state of stress on each

foundation component should be considered in verifications.

In the assessment of the state of stress of the structural components of the foundations account shall be kept of the interaction between soil-foundation system and the superstructure.

C.4.5 Foundation Excavations

Excavations for reaching the founding level shall be carried out keeping account of provisions under subsections A2 and D2 and under section G.

The foundation soil shall not be subjected to remoulding and deterioration before building the structure. Any flowing or stagnating waters shall be removed from the site of the excavations.

The founding plane of foundation structural components shall be made regular and protected with lean concrete.

If the excavations are carried out in permeable soils below the watertable provisions under section L shall be complied with.

C.5 Pile Foundations

C.5.1 Design Criteria

The design of a pile foundation requires sizing of the piling and of the respective capping and connecting elements; this includes the selection of the type of pile and of its mode of construction and the study of the behaviour of the pile-soil system.

The limit load of the single pile and of the pile group as well as the admissibility of settlements of the piling shall be determined taking account of the characteristics of the superstructure, in compliance with provisions under subsection A2.

Any variations of the soil characteristics and the influence that the construction of the piling may have on buildings existing in the surrounding area, shall be assessed.

If geotechnical conditions leading to negative skin-friction do exist, account shall be kept of the effects of the latter when choosing the type of pile, its sizing and verifications.

C.5.2 Specific Investigations

Investigations shall be performed in compliance with section B and they shall also aim at ascertaining the feasibility of the type of pile in relation to the characteristics of the soil and water in the subsoil.

The depth to be reached by the investigations is to be computed starting from the lower end of the pile.

C.5.3 Limit and admissible loads of single pile

One or a combination of the following procedures shall be used in determining the limit load of the pile-soil system:

- a) analytical methods for the evaluation of the resistance at the tip and along the shaft;
- b) correlations based on results of in situ tests;
- c) direct tests on test piles (see subsection C.5.5);
- d) analysis of the behaviour of the piles during driving.

The choice of the calculation procedure shall be motivated.

In assessing the axial load on single piles, account shall not be kept of the contribution afforded by the connecting structures resting on the ground.

Direct testing by means of pile loading tests on piles or groups of piles shall in any case be carried out for large structures, but also when, due to the nature of the subsoil, the findings of the investigations do not provide grounds for expressing reliable judgements as to the behaviour of the pile.

The value of the safety coefficient shall not be lower

than 2.5. Calculation of pile bearing capacity should take account of any horizontal actions.

C.5.4 Admissible load of the pile group

The calculation of the admissible load of the pile group shall be carried out on the basis of the admissible load on each single pile and of the influence of the geometry of the pile group, of the pile type and of the subsoil properties.

The admissible load of the pile group shall be established taking also account of the absolute or differential settlements compatible with the safety and serviceability of the building and of the neighbouring buildings.

C.5.5 Loading tests

The design tests for determining the limit load of single piles pursuant to subsection C.5.3 shall be repeated until the values of the axial load reach the point of failure of the pile-soil system or in any case they shall be such as to provide significant settlement-load and settlement-time diagrams.

For inspection testing purposes of a pile group the load to be reached should be at least 1.5 times the admissible load of the single pile as assessed in pursuance with subsection C.5.3.

The number of piles to be subjected to the loading test shall be decided according to the importance of the structure and to the degree of homogeneity of the subsoil. For large structures this number shall be at least equal to 2 percent of the total number of piles, with a minimum of two.

For prefabricated and driven piles the percentage of piles to be subjected to inspection testing may be reduced to 1 percent, two remaining the minimum.

D. RETAINING STRUCTURES

D.1 Aim of the provisions

The provisions laid down herewith apply to retaining walls, diaphragm walls, sheet pilings and shorings of excavations.

D.2 Design Criteria

The behaviour of the support structures, taken as structure-soil system, must be examined keeping account of the following factors:

- a) physico-mechanical characteristics and sequence of the foundation soils and of any fill materials involved by the works;
- b) watertable(s);
- c) profile of the surface topography before and after construction;
- d) surrounding buildings;
- e) strength and deformability characteristics of the structure;
- f) drainage and measures to control discharge of surface and underground waters;
- g) construction and back-filling procedures.

The stability of the support structures and of the structure-soil system shall be checked. Verifications must be carried out with reference to conditions corresponding to the various construction stages, and at the end of construction, keeping account of the possible variations in the underground water level.

When water seepage takes place in the ground affected by the works, verification with regard to piping shall be carried out.

In the case of structures rising on slopes or near to slopes the stability of the latter shall also be checked in pursuance with provisions under section G.

The design shall also provide for the sizing of the drainage and water discharge systems, keeping account

also of provisions under section N and with the restrictions laid down in section L.

For braced excavations the stability against bottom heave should also be checked.

D.3 Specific Investigations

As to the general investigation criteria reference is to be made to section B.

The significant volume mentioned under subsection B3 shall contain all possible slip surfaces relevant to the global stability of the structure and of the surrounding soil. In particular, in soils in which seepage takes place such volume shall include zones where piping may occur.

D.4 Verifications of Retaining Walls on Shallow Foundations

D.4.1 Actions on the retaining wall

Actions due to the soil, water surcharges and the weight of the wall shall be calculated and combined so as to consider, in turn, the severest conditions for the verifications as mentioned in the following subsections.

Assumptions concerning calculation of earth pressures on the wall shall be justified with due consideration of the expected displacements and of the function of the wall. Specifically, the active thrust may be adopted if this latter is compatible with the possible displacements of the wall.

As to the verification mentioned in subsection D.4.2, in the calculations account is not to be kept of the contribution of the resistance offered by the soil in front of the wall; in specific cases, to be justified on the basis of the mechanical characteristics of the soils and of the methods used to construct the wall, account may be kept of the soil resistance but only up to values not exceeding 50 percent of the passive thrust.

D.4.2 Verification against wall-sliding

For safety against the sliding of the wall along the foundation plane, the ratio of the sum of the resisting forces along the slip direction to the sum of the components along the same direction of the driving forces shall not be lower than 1.3.

D.4.3 Verification against wall-overturning

The resultant of the weight of the structure plus the forces acting permanently plus actions of long duration shall not fall outside the middle one-third of the base.

The ratio between the moment of the stabilizing forces to that of the overturning forces both computed with respect to the front edge of the base shall be greater than 1.5.

D.4.4 Verification against ultimate bearing capacity failure of soil-wall system

These analyses must be carried out in compliance with provisions laid down under section C, keeping account of the inclination and eccentricity of the resultant of the forces transmitted to the foundation soil. The safety coefficient shall not be lower than 2.

D.4.5 General stability verification

These analyses regard the stability of the soil mass on which the wall insists against deep sliding processes.

The safety coefficient shall not be lower than 1.3.

D.5 Construction procedures

A drainage system should be installed behind the support wall that must be capable of guaranteeing in time an adequate discharge of rain and of ground water. The drainage system shall be sized according to provisions of section N.

The wall shall be interrupted by transverse joints, extending down to the foundations, when the length of

the structure or the nature of the soil requires this measure.

For the cases where backfilling is required, the provisions under subsection E.3 shall be complied with.

Compaction of the backfill, if necessary, shall be carried out in compliance with provisions under section E.

E. EARTH-FILL STRUCTURES

E.1 Aim of the provisions

The regulations presented here apply to structures made of earth materials and to backfills.

Levelling up works and waste disposal facilities are dealt with under section I.

Earth dams are the subject of special technical provisions.

E.2 Investigations on soils and on construction materials

Investigations shall be planned and carried out in pursuance with provisions under section B.

In the design it is important to consider globally the structure-subsoil system. To this end the stratigraphic profile of subsoil, the physico-mechanical characteristics of the foundation soils and the characteristics of the ground water, if any, should be ascertained.

The design shall envisage the selection of construction materials; this shall be done keeping account of the natural resources of the area, within the constraints imposed by the legislation in force.

To this end, if quarries are to be opened for providing the materials, geological and geotechnical investigations are to be performed to ascertain the availability of appropriate materials and the feasibility of carrying out the works.

The chosen materials shall be subjected to laboratory tests for geotechnical classification purposes and to determine their characteristics in relation to compaction and, if necessary, to their mechanical properties and their permeability.

E.3 Design Criteria

The structure shall be designed keeping account of its functional requirements and of the characteristics of the foundation soils. The sources of the materials and their availability shall also be indicated.

The stability of the structure-foundation soil system shall be indicated with reference to conditions corresponding to the various construction stages, at completion of the structure and during operation, assuming values of the physico-mechanical characteristics as determined by means of investigations pursuant to subsection E.2. As regards embankments the safety coefficient shall not be lower than 1.3. As to earth dams the regulations laid down in the technical code on dams shall apply.

The settlements due to the deformations of the foundation soils and of the materials of which the structure is made must be compatible with the functionality and the safety of the structure itself.

The impact that the structure being designed may have on other existing structures must be ascertained and any measures to be taken in order to restrict its unfavourable effects should be specified.

In the case of structures rising on slopes, the influence of the actual construction operations on the general stability conditions of the slope shall be examined. The analysis shall be performed pursuant to subsection G.2.

The design of structures that may be considered small with regard to their size and function, may be based on prudent appraised values of physico-mechanical characteristics of the material used and of the foundation soil.

The design shall also consider all the measures required for protecting the structure from weathering agents.

E.4 Placement of materials

The materials of which the structure is formed up shall be placed in lifts and compacted. To this regard provisions must be given in the design for placement procedures; controls to be carried out during construction and the acceptance limits should also be stated in design documents.

Placement without compaction is permitted, besides in the case of backfills, also for rockfill structures and for underwater structures, whatever the material used, but with due consideration of the importance of the structure.

Account shall be kept of the placement procedure in the design, both when defining the typical cross-section of the structure, and when evaluating the physico-mechanical properties of the materials.

F. UNDERGROUND CONSTRUCTIONS

F.1 Objective of the Regulations

The regulations presented in this section shall apply to structures that are wholly immersed in the subsoil and that are built by means of underground excavations.

F.2 Specific Investigations

The geological and geotechnical investigations for selection, location and layout of the structure and for collecting the data to be used for the geotechnical calculations shall be planned and carried out according to the criteria laid down in sections A and B.

F.3 Design

F.3.1 Design Criteria

In the design of underground structures the following shall be specified and adequately justified:

a) the choice of the location and of the layout of the structure according to the geological, hydrogeological and geomorphological characteristics of the area, the geotechnical properties of the soils, the position and characteristics of existing structures;

b) the excavation methods, the provisional works, the measures required for draining, if necessary, or for collecting underground waters and any special procedure for the temporary or permanent improvement of the ground;

c) the effects of the excavations and of dewatering on the stability of the structures rising in the area affected by the excavations, and identification of possible corrective measures to be adopted, if it is the case;

d) prediction of possible presence of toxic or explosive gases, underground circulating waters, of the geotechnical conditions of the subsoil and of the ventilation required during construction and during operation;

e) definition of the geometric and structural features of the structure;

f) the instrumentation and control programme to monitor the behaviour of the structures and of the soil during the construction and, if necessary, during operation.

In the project the hypotheses assumed in order to evaluate the stress components induced in the soil around the structure must be clearly stated as well as the implications of the approximations that may therefrom ensue.

F.3.2 Excavation Methods

Excavation methods must be selected keeping account of the geotechnical properties of the soils that are to be excavated and of the presence of ground water and of other structures if any.

The excavated material must be placed in areas that are to be indicated in the project, keeping account of the provisions under section I.

F.3.3 Verification of the lining

The assumptions on which the verifications of the lining are based must be compatible with the method and the construction sequence.

The project shall keep account of the presence of other surface or underground structures and, if necessary, constraints on future building activity in the zone surrounding the work at hand must be put forth.

F.4 Control of the Structure

The design choice shall be controlled on the basis of observations and of experimental data collected during the construction. The observations shall be carried on during the operation stage for a certain time interval to be decided and pointed out in the design documents.

G. STABILITY OF NATURAL SLOPES AND OF ARTIFICIAL CUTS

G.1 Objective of the Regulations

The present regulations apply to:

- a) natural slopes which are the seat of landslides;
- b) natural slopes where any type of structure is to be built;
- c) slopes whose stability is relevant to the safety of existing structures;
- d) artificial cuts.

G.2 Natural Slopes

G.2.1 Stability Analyses

Evaluation of stability conditions shall include calculations for determining the safety degree of the slope, both in its natural situation and after any foreseeable modification to its configuration.

The calculations shall be based on geological and geotechnical data acquired by means of specific investigations.

G.2.2 Specific Investigations

Surveys and investigations shall be carried out pursuant to provisions of section B and according to the following criteria:

- a) the topographic features of the slope shall be defined through a plano-altimetric survey at adequate scale and extended to a sufficiently large area;
- b) the geologic study shall specify the nature of the soils, their tectonic and structural arrangement, their geomorphological characteristics and their expected evolution;
- c) the geotechnical investigations shall specify the physico-mechanical characteristics of the soils, pore water pressures within the slope and within discontinuities, the displacements of points located at the surface or inside the slope.

The depth and extent of the investigations shall be decided in relation to the geometry of the slope, to the results of the surveys indicated in a) and b), to the probable position of any slip surface.

In the case of unstable slopes the investigations shall permit also the definition of the geometric and kinematic characteristics of the sliding mass.

G.2.3 Stability Calculations

The choice of the calculation method for the evaluation of the stability conditions shall be accomplished keeping account of the location and shape of the foreseeable slip surfaces, of the structural pattern, as well as of the mechanical characteristics of the soil.

As regards unstable slopes, the methods to be adopted are those — where applicable — which allow the verification to be carried out by taking into account the sliding surface located by means of the investigations.

In other cases a range of possible slip surfaces suffi-

cient for identifying the safety coefficient with acceptable approximation, should be examined.

When it is not possible to easily determine the neutral pressures, the verification calculations must assume the most unfavourable conditions that can be reasonably anticipated.

G.2.4 Stabilization Measures

The design of stabilization measures of a slope must be accompanied by stability calculations developed in compliance with the previous sub-section. The plan for controlling the effectiveness of the adopted measures must be an integral part of the design documentation.

G.3 Excavation Faces

G.3.1 Specific Investigations

Specific investigations are those indicated under sub-section G.2.2. Only parts of the above mentioned investigations may be carried out and their extent be decided upon according to the local situation, the depth, the width, the purpose and the time interval during which the excavation remains open.

G.3.2 Design Criteria and Stability Calculations

The slope shall be configurated so as to present an appropriate safety margin against instability to be evaluated by means of the calculation methods indicated under G.2.3.

In the case of uniform and homogeneous soils and when neutral pressures are known with a good degree of reliability, the safety coefficient shall not be lower than 1.3.

In other conditions the safety coefficient value to be adopted shall be chosen for each case, keeping account mainly of the structural complexity of the subsoil and of the neutral pressures.

Account shall be kept of existing buildings and of surcharges in the vicinity of the edges of the excavation.

In the design any influence of the excavation on the hydraulic conditions of the area involved shall be examined.

H. GEOTECHNICAL FEASIBILITY OF CONSTRUCTIONS COVERING LARGE AREAS

H.1 Objective of the Regulations

The present regulations include the geotechnical criteria to be adopted in the elaboration of urban plans and in the design of groups of buildings covering large surfaces and which can bring about appreciable changes in the conditions of the subsoil, namely:

- a) new urban or industrial settlements;
- b) restructuring of existing settlements, including those to be subjected to stabilization measures or to be relocated elsewhere according to Act n° 445 of 9 July 1908, and subsequent modifications and integrations;
- c) water supply and sewage systems and networks of any type;
- d) roads, railways, waterways;
- e) harbours;
- f) airports;
- g) artificial water reservoirs and diversion canals from water courses;
- h) facilities and plants for dewatering and for the extraction of gas from the ground.

H.2 Specific Investigations

Geological studies and geotechnical characterization must be extended to the area that may be influenced by works to be carried out.

In particular, the investigations must aim at ascertaining the stability conditions of slopes, keeping also ac-

count of any possible harmful effects that the structure to be built may induce.

Furthermore, subsidence phenomena produced by changes caused to the regime of surface and underground waters, and by the removal or filling of earth materials must be taken into consideration.

H.3 Feasibility study

Before designing the individual structures — for which specific regulations hold, — it is necessary to verify and document in a technical report the feasibility of the whole project from the geological and geotechnical standpoints, and if necessary, identify the limits imposed on the design by the characteristics of the subsoil.

I. WASTE DISPOSAL FACILITIES AND LEVELLING AND FILLING UP WORKS

The present rules apply to the accumulation of any type of earth material.

In compliance with town planning schemes and with the legislation in force regarding the protection of water courses, protection of the environment and of public hygiene, the choice of areas to be used for dumping or filling purposes is to be made on the basis of geological and geotechnical studies.

Dumps and fills must be built on the basis of a project that sets their size and the mode of construction, that states the measures to be taken in order that its stability conditions be maintained in time, keeping account also of future uses of the area, that examines the stability of the foundation soil-structure system, with special attention to slope stability, and that considers the impact of the structure on surrounding buildings.

The hydraulic investigations of the area to be used for dumps and fills shall envisage all the necessary facilities for collecting and canalizing surface and deep waters, and also any water drained from the body of the dump.

L. UNDERGROUND WATER PUMPING OPERATIONS

The present regulation applies to the structures and facilities involved in the pumping of water from underground.

In designing water extraction works it must be verified that any surface settlements that may ensue are compatible with the stability and serviceability of the structures existing in the area involved.

The design must also provide for the means and modalities of extraction so as to avoid that the water which is extracted carries out any soil or its finer particles.

M. SOIL IMPROVEMENT

The present regulation applies to improvement measures adopted, for soil and rock, with the aim of permanently or temporarily modifying their mechanical characteristics by means of technological procedures of any kind.

The design of improvement works shall include:

a) analysis of the conditions requiring the measure in relation to the structures to be built and to the objectives to be achieved;

b) acquisition of specific geotechnical and geological data, required by the design, by means of in situ and laboratory tests;

c) final plan of improvement works and of construction procedures;

d) specifications for verifying whether or not the design predictions are fulfilled by means of tests carried out during the progress of the works, and in situ control.

N. DRAINS AND FILTERS

The present regulations apply to structures consisting of one or more layers of sandy-gravelly materials or of synthetic materials, built with the aim of controlling seepage and the neutral pressures in the subsoil inside earth fill structures and along the contact surface between soil and structure.

Design of drains and filters shall provide for the selection of the materials keeping account of the purposes to be met for ensuring functionality of the filters and of the characteristics of the soils with which they come into contact.

SOMMARIO

Normativa italiana di Ingegneria Geotecnica

Le questioni relative a norme e regolamenti nell'Ingegneria Geotecnica hanno acquistato importanza crescente. L'attenzione degli operatori e degli enti pubblici interessati all'utilizzazione e alla gestione del territorio è stimolata da un lato dallo sviluppo delle discipline che fanno capo all'Ingegneria Geotecnica, e dall'altro dalla coscienza — che negli ultimi anni si è andata progressivamente formando anche al di fuori della comunità geotecnica — che non si può utilizzare in modo razionale il territorio, senza una approfondita conoscenza dei caratteri fisico-meccanici di quest'ultimo.

Fra le varie iniziative riguardanti la normativa, spicca la proposta di approntare un codice modello, la cui redazione è promossa dalla Comunità Europea ed affidata alla Società Internazionale di Meccanica dei Terreni e Tecnica delle Fondazioni.

La normativa geotecnica italiana è costituita essenzialmente dal Decreto Ministeriale 21-1-1981, riguardante fondazioni, opere di sostegno, costruzioni di materiali sciolti, costruzioni in sotterraneo, pendii naturali e fronti di scavo, discariche, colmate e problemi geotecnici relativi alle grandi aree.

Il testo della norma si colloca in una posizione equilibrata e per alcuni aspetti avanzata rispetto alle normative vigenti negli altri paesi europei. Si ritiene quindi non inutile presentare la normativa italiana in lingua inglese per favorirne la diffusione tra i colleghi stranieri.

Nella presente nota, dopo un cenno all'attività normativa, che è stata svolta in Italia nel campo dell'Ingegneria Geotecnica, si pongono in risalto gli aspetti principali considerati nel citato Decreto.

Per ciascun tipo di costruzione le disposizioni riguardano sotto l'aspetto geotecnico le indagini preliminari, i calcoli, le questioni costruttive, i controlli. Si richiama l'attenzione sulla necessità di estendere le indagini, i calcoli ed i controlli alle varie fasi del lavoro, e di tener conto degli scostamenti fra le previsioni e la realtà. Le disposizioni sono relativamente flessibili, in modo da consentire ai vari operatori responsabili decisioni autonome e motivate in dipendenza dei risultati delle osservazioni e dei controlli.

In Appendice si riporta la traduzione integrale in lingua inglese del testo del Decreto.