

TC250/SC7 - EG14 – Ground Improvement

DRAFT INTERIM REPORT

July 28th 2014

Foreword

In the **current EN 1997**, the clauses of interest for EG14 are listed in **section 5.5: “Ground Improvement and Reinforcement”**. It is a very short section that does not provide any useful information and should be entirely rewritten, by making **two new chapters** respectively on **“Ground Improvement”** and on **“Ground Reinforcement”**.

The **Evolution Group EG 14** has thus prepared a **first draft of the forthcoming chapter on Ground Improvement**, which is provided in the following pages. The tentative list of such chapter is as follows:

- 1. General**
- 2. Classification of Actions**
- 3. Actions and Design Situations**
- 4. Design Methods and Design Considerations**
- 5. Monitoring and Control**

Chapters 1 and 4 have been already developed to some extent. In particular, Chapter 1 may include the following paragraphs:

- Scope
- Normative References
- Terms and Definitions

Chapter 4 may include the following paragraphs:

- General
- Ultimate Limit State Design
- Serviceability Limit State Design
- Structural Design

The other chapters have not been considered in detail yet.

It is pointed out that Ground Improvement can be used for nearly all geotechnical applications such as:

- Foundations
- Retaining structures
- Slopes, cuttings and embankments
- Water control

It will be thus particularly important to cross-check the chapter on Ground Improvement with all the other chapters of the Eurocode.

1. General

1.1. Scope

This chapter covers Ground Improvement for the following geotechnical applications:

- Foundations
- Retaining structures
- Slopes, cuttings and embankments
- Water control

Elements created by means of G.I. techniques which are physically connected to any structure shall be designed according to the relevant sections of EC7 (e.g. pile foundation / retaining structure), considering the specific design rules provided in the structural design sub-section 4.4.

1.2. Normative References

Execution standards for ground improvement processes are produced by CEN TC 288 “EXECUTION OF SPECIAL GEOTECHNICAL WORKS”. At present, the available execution standards are:

- EN12715 : Grouting
- EN 14679 : Deep Mixing
- EN14731 : Ground Treatment by Deep Vibration
- EN 12716 : 2001 Jet Grouting

1.3. Terms and definitions

- Ground Improvement is defined as: “the modification of ground properties obtained by binding and/or densifying the ground and/or creating inclusions in the ground”.
- An Inclusion is any discrete element created in the ground, physically disconnected from any structure, provided with prescribed geometry and mechanical properties.
- A Rigid Inclusion is defined as an inclusion made of material significantly stiffer than the surrounding soil and having measurable unconfined compressive strength.
- Discrete G.I. is defined as a G.I. where inclusions which are created in the ground remain separated from the surrounding ground.
- Diffused G.I. is defined as a G.I. where the ground can be modelled as a homogeneous material to be described by a single set of parameters.
- Load transfer platform is defined as a stratum interplaced between the discrete G.I. and the structure, to provide load transfer and/or to modify its distribution as required for the design.

2. Classification of Actions

(needs to be cross-checked with the other chapters of the Eurocode)

3. Actions and Design situations

(needs to be cross-checked with the other chapters of the Eurocode)

4. Design methods and design considerations

4.1. General

The design of ground improvement can be done with two alternative methods:

- Design of Diffused Ground Improvement. This design method is applicable when the mechanical behaviour of the improved ground can be conveniently modelled by conventional soil or rock models. In order to follow this method, the designer should evaluate the change of ground properties (i.e. cohesion, friction angle, etc.) and should consequently define the “Improved Characteristic Values” for the material properties. In such case, design rules for foundations, retaining structures, embankments, slopes etc. are applied according to the relevant sections of the Eurocode. The Improved Characteristic Values are evaluated using empirical methods, comparable experience or analytical/numerical modelling.
- Design of Discrete Ground Improvement. This design method can be applied when ground improvement relies on inclusions. The overall performance of the improved ground is calculated by considering separately the characteristics of the inclusions, the soil/rock and their interaction. In such case, design rules for foundations, retaining structures, embankments, slopes etc. are applied according to the relevant sections of the Eurocode 7, with additional considerations and rules given in following sub-sections. The addition of a load transfer platform may be required.

4.2. Ultimate Limit State Design

The verification of the ultimate limit state shall follow the rules of the specific application of ground improvement (foundation, retaining structure, embankment, etc.) according to the relevant sections of EC7.

For discrete G.I. design method the internal limit state of the inclusions shall be verified.

4.3. Serviceability Limit State Design

The verification of the serviceability limit state shall follow the rules of the specific application of ground improvement (foundation, retaining structure, embankment, etc.) according to the relevant sections of EC7.

For discrete G.I. design method special consideration shall be given to the evaluation of the load distribution between the soil and the inclusions.

4.4. Structural Design

4.4.1 General requirements

Design parameters may be derived from preliminary trials according to the relevant execution standards.

4.4.2 Geometrical dimensions

- Variability of dimensions considering the G.I. technique
- Characteristic dimensions
- Relevant position including tolerances

4.4.3 Characteristic effects of actions

- Stresses derived from load distribution calculations
- Eccentricity of loads
- Allowable cracking

4.4.4 Strength and deformability

- Unconfined compressive strength
- Tensile strength
- Shear strength
- Bond strength
- Partial safety factors, related to G.I. technique
- Stiffness parameters

4.4.5 Verification of internal capacity

- STR1: stress strength
- STR2: buckling resp. rules on the slenderness considering removed confinement of the inclusion

- Local GEO: check the bearing capacity of a single inclusion belonging to the improved ground (the failure of a single inclusion element does not necessarily imply a failure of the discrete G.I. in total, which may imply a lower safety factor for a single inclusion)
- Global GEO is covered by relevant sections, taking into account the inclusions
- Creep to be considered in special circumstances

4.4.6 Durability and environmental requirements

- Consider long-term stability of the G.I.
- Consider components in the soil or ground water affecting the mechanical properties of G.I. with time
- Consider the effects on the ground water regime
- Consider any polluting effect on the ground and ground water

5. Monitoring and control

The effects of ground improvement techniques should be verified by monitoring, with reference to the design assumptions.