

TC 250 / SC 7 / EG 14: GROUND IMPROVEMENT

SCOPE OF WORK

To review existing ground improvement techniques and their design in order to find common principles and rules features for inclusion on Eurocode 7.

Name	Position*	Country
Cyril Plomteux	Member	France
Norbert Vogt	Member	Germany
Karsten Beckhaus	Member	Germany
Paolo Croce	Convenor	Italy
Alessandro Flora	Secretary	Italy
Beata Gajewska	Member	Poland
Jakub Saloni	Member	Poland
Colin Serridge	Member	UK
Robert Essler	Member	UK

PREVIOUS MEETINGS

Meeting no.	Date held/scheduled
1	Oct. 16th 2012: Face to Face - Brussels
2	February 28th 2013: Tele-meeting
3	May 15th 2013: Tele-meeting
4	June 24th 2013: Tele-meeting
5	October 7 th 2013: Tele-meeting
6	October 17th 2013: Face to Face - Vienna

COLLECTION OF INFORMATION ON G.I. TECHNIQUES

Technique	France	Germany	Italy	Poland	Romania	Turkey	U.K.
GROUTING (permeation, compaction, etc.)	X	X	X	X	X	X	X
JET GROUTING	X	X	X	X		X	X
DEEP MIXING	X	X	X	X			X
DEEP VIBRATION (Vibrated Stone - Sandy Columns)	X			X	X		X
DYNAMIC COMPACTION (Tamped Gravel - Sandy columns)	X			X			X
RIGID INCLUSIONS (VIBRATED)	X			X			
RIGID INCLUSIONS (BORED)	X			X			
BLASTING				X			
STABILIZATION with bindings (lime, cement, etc.) for earthworks	X	X	X	X		X	X
GROUND FREEZING	X		X				
VERTICAL DRAINAGE	X		X	X	X	X	X

FREQUENT USE OF GROUND IMPROVEMENT TECHNIQUES

COLLECTION OF INFORMATION ON G.I. TECHNIQUES

TECHNIQUE	Foundations	Retaining Structures	Embankments	Tunnels and Excavations	Dams and Reservoirs
GROUTING (permeation, compaction, etc.)	X			X	X
JET GROUTING	X	X		X	X
DEEP MIXING	X	X			
DEEP VIBRATION (Vibrated Stone - Sandy Columns)	X				
DYNAMIC COMPACTION (Tamped Gravel - Sandy columns)	X		X		
RIGID INCLUSIONS (VIBRATED)	X		X		
RIGID INCLUSIONS (BORED)	X		X		
BLASTING	X				
STABILIZATION with bindings (lime, cement, etc.) for earthworks			X		
GROUND FREEZING				X	
VERTICAL DRAINAGE	X		X		

MAIN APPLICATIONS OF GROUND IMPROVEMENT TECHNIQUES

COLLECTION OF INFORMATION ON G.I. TECHNIQUES

**NATIONAL DESIGN RULES
AND RECOMMENATIONS**



TECHNIQUE	CEN EXECUTION STANDARDS	NATIONAL RULES OR RECOMMENDATIONS
GROUTING (permeation, compaction, etc.)	EN 12715 (Grouting)	GERMANY*
JET GROUTING	EN 12716 (Jet Grouting)	GERMANY* ITALY**
DEEP MIXING	EN 14679 (Deep Mixing)	GERMANY*
DEEP VIBRATION (Vibrated Stone - Sandy Columns)	EN 14731 (Ground Treatment by Deep Vibration)	FRANCE**
DYNAMIC COMPACTION (Tamped Gravel - Sandy columns)		FRANCE**
RIGID INCLUSIONS (VIBRATED)		FRANCE**
RIGID INCLUSIONS (BORED)		FRANCE**
BLASTING		
STABILIZATION with bindings (lime, cement, etc.) for earthworks	EN 14227. (Hydraulically bound mixtures)	GERMANY**
GROUND FREEZING		
VERTICAL DRAINAGE	EN 15237 (Vertical Drainage)	

EXISTING STANDARDS, RULES, TECH. RECOMMENDATIONS
ON GROUND IMPROVEMENT TECHNIQUES.

*National Standard on Design

** Recommended practice on design, execution and quality control

PRESENT STATE OF EUROCODE 7

(1) investigations

(2) design factors

(3) control

5.5 Ground improvement and reinforcement

(1)P A geotechnical investigation of the initial ground conditions shall be carried out before any ground improvement or reinforcement method is chosen or used.

(2)P The ground improvement method for a particular situation shall be designed taking into account the following factors where appropriate:

- thickness and properties of the ground or fill material;
- magnitude of water pressure in the various strata;
- nature, size and position of the structure to be supported by the ground;
- prevention of damage to adjacent structures or services;
- if the ground improvement is temporary or permanent;
- in terms of anticipated deformations, the relationship between the ground improvement method and the construction sequence;
- the effects on the environment including pollution by toxic substances or changes in ground-water level;
- the long-term deterioration of materials.

(3)P The effectiveness of the ground improvement shall be checked against the acceptance criteria by determining the induced changes in the appropriate ground properties.

EG14 SUGGESTIONS

5.5 Ground improvement and reinforcement



Two separate sections respectively for:

- Ground Improvement
- Ground Reinforcement (Reinforced Ground Structures)

Tentative Definition of GROUND IMPROVEMENT:

“A change of ground properties obtained by binding and/or densifying the ground and/or by installing rigid inclusions.”

CLAUSE 1

(1) investigations

(1)P A geotechnical investigation of the initial ground conditions shall be carried out before any ground improvement or reinforcement method is chosen or used.

Specify: “investigations should cover the specific needs of the G.I. technique”

CLAUSE 2

(2) factors to be accounted for

(2)P The ground improvement method for a particular situation shall be designed taking into account the following factors where appropriate:

- thickness and properties of the ground or fill material;
- magnitude of water pressure in the various strata;
- nature, size and position of the structure to be supported by the ground;
- prevention of damage to adjacent structures or services;
- if the ground improvement is temporary or permanent;
- in terms of anticipated deformations, the relationship between the ground improvement method and the construction sequence;
- the effects on the environment including pollution by toxic substances or changes in ground-water level;
- the long-term deterioration of materials.

- **Clause 2 is quite generic.**
- **However, it could be maintained with minor changes.**

CLAUSE 3

(3) control

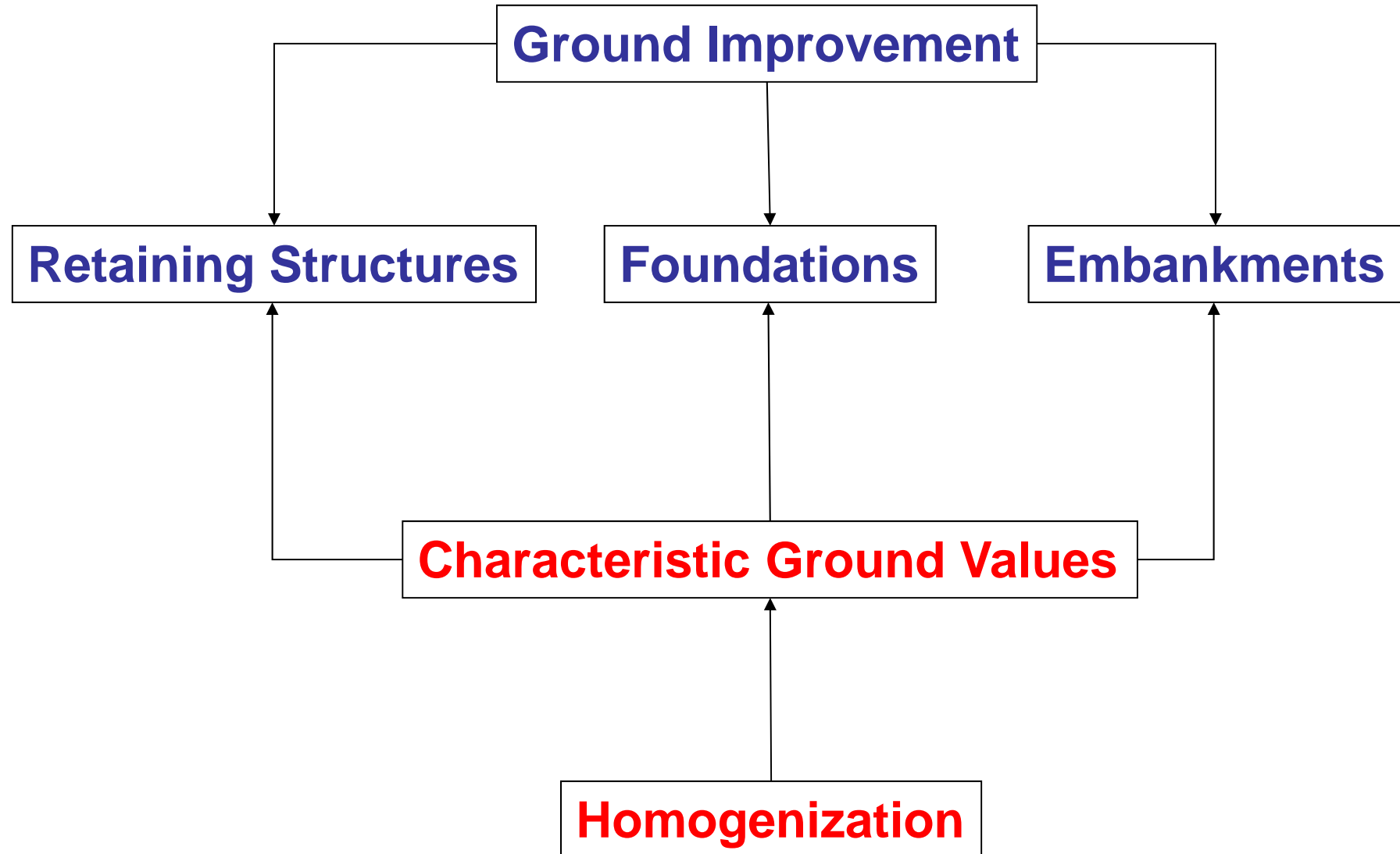
(3)P The effectiveness of the ground improvement shall be checked against the acceptance criteria by determining the induced changes in the appropriate ground properties.

- **Clause 3 does not consider design principles or methods.**
- **It seems to address construction control.**
- **It should be either removed or clarified.**
- **Suggestion: “checked to fulfill the design requirements/specifications”.**

NEW CLAUSES

2 POSSIBLE DESIGN METHODS FOR G.I.

First Design Method: “Homogenization”. This first approach could be used when the mechanical behaviour of the improved ground can be conveniently modelled by conventional soil (or rock) models (e.g. Mohr-Coulomb failure criterion). In order to follow such approach, the designer should evaluate the change of ground properties (i.e. cohesion, friction angle, etc.) and should consequently define some “Improved Characteristic Values” for the material properties. In principle, once this task is accomplished, conventional calculation methods could then be used for any kind of problem (foundations, retaining structures, embankments) without special requirements. However, the evaluation of such “improved characteristic values” may not be an easy task. With such regard, a close connection with EG 11 (Characterization) should be pursued.



DESIGN METHODS FOR G.I.

Second Design Method: “Structural Element”. This second approach could be implemented for those techniques which are able to create an element of very stiff material provided with (sufficiently) Well Defined Geometry and Mechanical Properties. The latter can usually be defined by uniaxial strength and elastic modulus. Typical techniques falling in this second approach would be Jet Grouting and Deep Mixing. However such design approach may need specific design rules, for the relevant geotechnical constructions (i.e. Foundations, Retaining Structures). For this purpose, it is important to keep in touch with EG7 (Pile Design).

