SC7/WG1/TG3 Rock Mechanics:
Overview and Assessment on future Works

Ground Models in Eurocode 7-1

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Requirements for the Works on EC 7:

- Clarification
- Simplification
- Ease of Use
Simple Projects: Simple Ground Model

Structure not sensitive against settlements, loads remain low

\[ F_{\text{Horizontal}} \]
\[ F_{\text{Vertikal}} \]

Sandstone
Strength = xx Mpa
E-Modulus = xx Mpa
(values derived from investigation results or possibly from experience, too)
## Geotechnical properties

Site investigation, field and lab test results

<table>
<thead>
<tr>
<th>Rock Type</th>
<th>Description</th>
<th>Orientation of Discontinuities</th>
<th>Rock Strength</th>
<th>E-Moduls</th>
<th>Hydraulic conductivity</th>
<th>Etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Type of Rock, strata, layering, thickness of layers, minerals, filling of joints, etc.</td>
<td>Angle and dip of joints and layers</td>
<td>[MPa]</td>
<td>[MPa]</td>
<td>[m/s]</td>
<td>Range of values</td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>D</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>
Filstal Bridge: Semi-integral Bridge Highspeed Railway Line Stuttgart - Munich

- Foundations: Combined Pile-Raft-Foundations
- Underground: Limestone rock masses, partly clayey, weathered, karst
Filstal Bridge

Results Ground Investigations

Filstalbrücke Rechtes Gleis: Stuttgart-Ulm

Achse 30
Filstal Bridge

Results Ground Investigations

- Quarternary Sediments (qu)
- Rock Masses White Jurassic Limestone (ox1)
- Rock Masses Brown Jurassic Limestone (cl + bt, bj)
- Inhomogeneous weathering, fragmented
- Main Filstal fault (red)
  → influenced range about 70 m
  → fractured rock mass
Filstal Bridge: Ground Model Axis 30
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Specific requirements for rock mechanics

- Geometrical data due to discontinuities (joints) have to be respected, variations may be favorable or unfavorable.
- Restrictions for ground investigations and lab tests due to extension of representative volumes and samples
- Joints, zones of weakness, inhomogeneities: uncertainties about strength parameters
- Supervision on site, monitoring: very important, verification of the ground model!
Proposal Project Team PT 2: Assessment of Complexity of Ground Conditions

<table>
<thead>
<tr>
<th>Table 1 Example guideline for assessing complexity of ground conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>simple</strong></td>
</tr>
<tr>
<td>Presence of</td>
</tr>
<tr>
<td>• uniform ground conditions</td>
</tr>
<tr>
<td>• isolated direct foundations are systematically applied in the zone</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

- natural and / or man-made cavities (e.g. Karst)
- high (>3 m) thickness of made ground
- sliding ground
- sloping ground (above 15°)
- high geometric variability (e.g. residual granitic profiles)
Proposal Project Team PT 2:  
Level of Understanding of the Ground Model

Table 2  Confidence of the ground model – related to complexity of ground conditions and amount of investigation.

<table>
<thead>
<tr>
<th>Amount of ground investigation</th>
<th>complexity of ground conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Qualitative ground investigation or past experience (GIL1)</td>
<td>simple</td>
</tr>
<tr>
<td></td>
<td>UL2 – medium understanding</td>
</tr>
<tr>
<td>Normal extent and quality (e.g. EN 1997-2) (GIL2)</td>
<td>simple</td>
</tr>
<tr>
<td></td>
<td>UL3 – high understanding</td>
</tr>
<tr>
<td>Thorough ground investigation. Advanced field and lab testing (GIL3)</td>
<td>simple</td>
</tr>
<tr>
<td></td>
<td>Not recommended (not economical)</td>
</tr>
</tbody>
</table>
Complexity of the Ground Conditions: Some Remarks

- Complexity of Ground Conditions depends on the structure going to be founded in the specific soil:

- \( \Rightarrow \) simple ground can become a complex ground and vica-versa
  maybe complex for flat footing and simple for deep foundation

- Table 2: Complex Ground Conditions – through ground investigations with advanced field and lab testing:
  not suited to enable the geotechnical engineer ot have a high understanding of the ground conditions?

  design for complex ground conditions possible with medium level of understanding?
Possible influences on the Level of Understanding

- Range and quality of ground investigations
- Personal experience
- Personal abilities
- Quality management
- Supervision
- Etc.

Specific Criteria and requirements for the extent of ground investigations are necessary!

-> May not be left to personal judgement.
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- **Safety Concept:**
  - Factors of Safety should not be a matter of judgement within estimating the accuracy of the ground model
    -> who decides on the level of understanding?
  - Consulting Engineer with „high oder medium level of understanding“ -> may cause different factors of safety
  - Is this a practicable and suitable way? Clients, consultants, etc. are usually acting not only with respect to technical requirements but also regarding economic interests!
Safety Concept: Actual Discussions

- Partial Factors not constant
- May change depending on personal evaluation and assessment of engineers, e.g. the "level of understanding"
- Should Partial Factors become "floating values"?
Results Ground Investigations

- Section 1: White Jurassic Limestone (ox2), slightly weathered and fractured
- Section 2: fault zone, highly fractured rock mass, clayey material
- Section 3: White Jurassic Limestone (ox2), weathered, highly desintegrated due to near-surface loosening (orthogonal jointing)
Filstal Bridge: Complex Ground Model Axis 10

includes layering and orthogonal jointing

Section 1

Section 2

Section 3
Should clauses like this be a part of a code, esp. EC 7?
Geotechnical Categories

- Used and defined in current EC 7
- Concept is established
- Leads to requirements for soil investigations and basics for the ground model
- Are depending on the complexity of the soil and the construction

Replacing them by new concepts?
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General Concluding Remarks:

• Keep or make EC 7 as simple and short as possible.

• Avoid clauses and rules what are more suitable for a textbook and not appropriate for a code.