A VIEW ON SOME SOFT ROCK EXPERIENCES IN BELGIUM*

QUELQUES CAS DE TRAVAUX SUR ROCHES MEUBLES EN BELGIQUE

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Abstract

Works carried out in the gently rugged southern part of Belgium have dealt, in several sites with soft rocks engineering problems, specially in matter of foundations and tunneling. The paper shortly reports some relevant cases which have led to important in situ and laboratory investigations to assess mechanical properties and behaviour models to input in design calculations.

Résumé

Lors des travaux de génie civil réalisés dans le sud de la Belgique – une zone géographique caractérisée par des ondulations et plissements du terrain – on a rencontré à plusieurs endroits des problèmes de roches meubles notamment lors de l'exécution de travaux de fondations ou de creusement de tunnels. La communication ci-après fait état de quelques cas importants qui ont nécessité des recherches approfondies in situ et en laboratoire pour la détermination des propriétés mécaniques et des modèles de comportement à prendre en considération dans les calculs.

Introduction

A large part of the soft rock research and foundation engineering experience in Belgium, comes from works carried out in sites located in the Sambre and the Meuse river valleys as well as in the Ardennes plateaus in the southern part of the country (fig. 1). From a geological point of view, the relevant bibliography reports that most of the foundation problems arise in soft rock layers, belonging mainly to the Ordovician, Silurian, Devonian and Carboniferous periods of the middle and upper Palaeozoic era, as well as in those belonging to the Cretaceous period of the upper Mesozoic era.

Palaeozoic soft rocks

Important applied investigations have been done upon the weathered fractured Silurian shales and/or phyllites. The Silurian rock ($) spreads from the south central (Brabant area) to the southern regions (Condroz area, fig. 1). They have been submitted to important tectonic effects which gave overturned folds and overthrusts. At a regional scale, they show a quite regular schistosity which general slope is bearing to the north (Robaszynski and Dupuis, 1983).

The assessment of the deformation response of the upper layers of Silurian shales is the aim of a research undertaken for the construction of a nuclear power plant at the site of Tihange, on the right bank of the Meuse river, downstream the city of Namur (point 1 fig. 1). The bedrock, overlapped by alluvial sand-gravel deposits up to 11 m thick (Nuyens and Huergo, 1981), exhibits tectonic complex forms such as saddle folds, dislocations, dip slips, and other geologic structural disturbances which are often so severely weathered that soft fissile shales, have locally changed into clay or weak amorphous claystone (Huergo, 1983).

Many troubles arise with this kind of rocks, specially when they have to be manipulated to assess their mechanical properties. Available samples for laboratory are not easily obtained and when so, considerable disturbances are unavoidable so that the values of the experimental parameters are largely below the actual ones. Fig. 2 shows load-unload cyclic test envelopes

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* Belgian report to the ISSMFE technical committee T.C.22 on soft rocks and indurated soils
  Rapport de la Belgique au comité technique T.C.22 sur les roches meubles et les sols indurés
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Fig. 1: Palaeozoic and Mesozoic bedrock areas in southern Belgium (after the Belgian Geological Service).

Table 1

<table>
<thead>
<tr>
<th>Depth z (m)</th>
<th>Dip (°)</th>
<th>E (0.5σc) (MPa)</th>
<th>ν</th>
<th>σc (MPa)</th>
<th>σf (MPa)</th>
<th>σt (MPa)</th>
<th>σd (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20.7</td>
<td>78</td>
<td>126.7</td>
<td>0.29</td>
<td>1.8</td>
<td>1.4</td>
<td>0.24</td>
<td>0.43</td>
</tr>
<tr>
<td>29.4</td>
<td>59</td>
<td>743.2</td>
<td>0.19</td>
<td>3.9</td>
<td>2.9</td>
<td>0.54</td>
<td>0.96</td>
</tr>
<tr>
<td>33.5</td>
<td>90</td>
<td>538.4</td>
<td>0.13</td>
<td>6.9</td>
<td>5.9</td>
<td>0.84</td>
<td>1.51</td>
</tr>
<tr>
<td>33.1</td>
<td>38</td>
<td>165.7</td>
<td>0.38</td>
<td>4.7</td>
<td>3.9</td>
<td>0.64</td>
<td>1.18</td>
</tr>
<tr>
<td>35.2</td>
<td>65</td>
<td>396.0</td>
<td>0.29</td>
<td>4.0</td>
<td>3.4</td>
<td>0.55</td>
<td>0.96</td>
</tr>
<tr>
<td>36.6</td>
<td>89</td>
<td>595.4</td>
<td>0.25</td>
<td>8.8</td>
<td>6.9</td>
<td>2.0</td>
<td>3.71</td>
</tr>
</tbody>
</table>

E: Young modulus  
ν: Poisson modulus  
σc: Uniaxial unconfined strength  
σf: Uniaxial tensile strength  
σd: Shear strength

Table 1 resumes laboratory results showing the influence of the weathering or the tectonical disturbances of the encountered strata.

Owing to the experimental difficulties, most of the practical values of the parameters to be put into the calculations have been determined from in-situ Menard pressuremeter tests. This method proves to be the most suited to assess mechanical properties of the soft rock (so soft that somewhere the use and the interpretation of CPT cone penetration are suitable, cf. Nuyens and Huergo). Indeed, measurement techniques such as load cells, jacks or dilatometers, have shown to be ineffective because borehole disturbances induce local failure or stress concentrations (this is often the case with the dilatometer contact for different shales. Curve A2911 shows typical stress-strain behaviour of shallow soft shale. This diagram may be compared to the other envelopes corresponding to the more compact deep shales.