A51 : MONESTIER DE CLERMONT VIADUCT

FOUNDATIONS OF MONESTIER VIADUCT

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- Contracting Authority: Les Autoroutes Rhône-Alpes
- Design and built joint venture: GTM TP Lyon, mandatory
- MECASOL: Geotechnical engineering
- VINCI Construction B.E.T.: Civil engineering design office
- STRATES: Architect: Jean-Vincent Berlottier
- PAYSAGE PLUS: Landscape painter
- BAUDIN-CHATEAUNEUF: Structural steel Construction
MONESTIER DE CLERMONT VIADUCT

GEOTECHNICAL ENVIRONMENT
Michel LONDEZ
PIERS SETTING OUT

MONESTIER DE CLERMONT VIADUCT
Five different types of foundations:

- C0 & P1: Large pits (4 m diameter)
- P2: Concrete piles (1,5 m diameter)
- P3 & P4: Semi-deep Foundations
- P5 & P6: Piles inside circular diaphragm wall
- P7, P8 & C9: Spread footing
Bellow P3 and P4, varved clay which is water saturated, is present up to 80m deep.

Ground is therefore not stiff enough to carry heavy loads.

The design of the foundations is quite unusual: the principle consists in taking off a quantity of clay equivalent to the load brought by the pier itself (weights of the foundation + pier + deck).
P3 FOUNDATION INCLUDES:
- a diaphragm wall (20m diameter and 22m deep).
- 20m long steel profiles (HEA 300) driven into clay.
- a 1,50m thick concrete slab, poured above a 1,00m thick gravel layer.
- 80cm thick concrete walls stiffening the structure and allowing transfer of pier load to the diaphragm wall and concrete slab.
- The inside volume (1700m3) remains empty except during construction of the pier when it is filled with water.
P3 & P4 : DIAPHRAGM WALLS GROUND EXTRACTION

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P3 & P4: DIAPHRAGM WALLS GROUND EXTRACTION

MONESTIER DE CLERMONT VIADUCT
P3 & P4 : DIAPHRAGM WALLS REINFORCEMENT AND CONCRETE
P3 & P4: STEEL PROFILES DRIVEN INTO CLAY (STAGE 1)
P3 & P4 : CLAY EXCAVATION INSIDE DIAPHRAGM WALLS
FINAL PREPARATION OF THE GROUND BEFORE GRAVEL LAYING OPERATIONS AND CUTTING BACK OF STEEL PROFILES
P3 & P4: GRAVEL LAYER AND PIEZOMETER IN PLACE

12.10.2004 08:49
P3 & P4: REINFORCEMENT OF CONCRETE SLAS
P3 & P4 : STIFFENING STRUCTURE WALLS
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P3 & P4 : GENERAL VIEW
- P3 to P6
  - Core borings,
  - CPTU 65 m deep
  - Pressiometric tests
  - Cross hole
  - Pumping test
  - Inclinometres
  - Laboratory tests
Main results

- Across the valley:

- South west area:
  - Rock at 50 m.
  - Fluvio-glacial permeable till between 40 à 50 m
  - Gravelly clays below soft and remolded clays

- Centre and north of the valley:
  - Deepening of rock (P2)
  - Argiles homogeneous clays at the surface, varved below
The foundations of P3 and P4 include:

- A cylindrical skirt made of diaphragm wall, 20m diameter and 22 to 26 m deep.
- A 1,50m thick concrete slab
- Steel inclusions (HEA 300), down to 20m below the slab,
- Stiffening walls 80cm thick to transfer the shaft efforts to the slab and the diaphragm walls

An inner volume of 1700m$^3$ above the slab remains empty.
### Strength

<table>
<thead>
<tr>
<th>Volumetric mass (KN/M³)</th>
<th>$C'$ (KN/M²)</th>
<th>$\varphi'$ (°)</th>
<th>OCR</th>
<th>Depth (m)</th>
<th>Type of soil</th>
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</thead>
<tbody>
<tr>
<td>18.5</td>
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<td>24</td>
<td>$\sigma'_0 + 50$ KN/M²</td>
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<td>Upper clay</td>
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<tr>
<td>18.5</td>
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<td>24</td>
<td>$\sigma'_0$</td>
<td>18 – 37/55</td>
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<tr>
<td>18.5</td>
<td>10</td>
<td>30</td>
<td>$1.2 \sigma'_0$</td>
<td>37/55 - 80</td>
<td>Lower clay</td>
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</table>
## Deformation

<table>
<thead>
<tr>
<th>CASE A</th>
<th>CASE B</th>
<th>CASE C</th>
<th>Soil</th>
</tr>
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<tbody>
<tr>
<td></td>
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<tr>
<td>Triaxial Interpretation</td>
<td>Oedometric Interpretation</td>
<td>Oedometric method</td>
<td>Soils</td>
</tr>
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<td>$E_{50\text{ref}}$ (kN/m²)</td>
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</table>

**Upper clay**

**Medium clay**

**Lower clay**

**Soil**
• Excavation of a mass of soil close to the estimated load brought by the pier
• Inclusions to control the soil relaxation, reduce the recompression settlement
• Maximum loads during construction (pre-loading with water)
• After final bearings installation, settlements calculations under final loads and surcharges, consolidation.
• Acceptable differential settlements between piers: 6 cm.
### Design loads

**Settlements in mm**

<table>
<thead>
<tr>
<th>Calculation Cases</th>
<th>Soil parameters</th>
<th>Raft construction</th>
<th>Loads without Superstructures + water</th>
<th>Total + service loads + Consolidation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>P3</td>
<td>P4</td>
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<td><strong>A</strong></td>
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OBSERVATIONS DURING CONSTRUCTION

P3 settlements and loads versus time

- **P3 total loads (t)**
- **P3 net loads (t)**
- **P3 Settlement (mm)**

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P4 Settlements and loads versus time

- P4 total loads
- P4 net loads (t)
- P4 settlement (mm)
• For P3, settlements during construction were close or slightly higher than those estimated with the triaxial interpretation (case A).

• Needs for settlements reductions have been estimated necessary.

• Adaptations of the design have been done:
  - Preload with water, removed when superstructures have been completed.
  - Deck level set out 20 mm above designed level to increase the acceptable differential settlements to 80 mm instead of 60 mm initially considered in the design.

• For P4, the settlements are much lower due to the longer length of the diaphragm wall skirt.
P3 et P4 Settlements versus time.

- Settle (mm)
- Days

Lines:
- P3 settle
- P4 settle
- End of construction
Comparison between estimations and observations

Settlements in mm

<table>
<thead>
<tr>
<th></th>
<th>End of construction</th>
<th>In service</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>P3</td>
<td>P4</td>
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<tr>
<td>Estimations</td>
<td>33 to 62</td>
<td>37 to 56</td>
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<tr>
<td>Observations</td>
<td>37</td>
<td>19</td>
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</tbody>
</table>

• * End of consolidation~ 80 years
• ** After ~4 years: Consolidation not completed
• **To be compared to 80 mm acceptable differential settlements