A51 : MONESTIER DE CLERMONT VIADUCT

FOUNDATIONS OF MONESTIER VIADUCT

- Dominique Quivy — VINCI Construction France
- Laurent Bastard-Rosset — GTM TP Lyon
- Michel Londez — Independent expert Mécasol

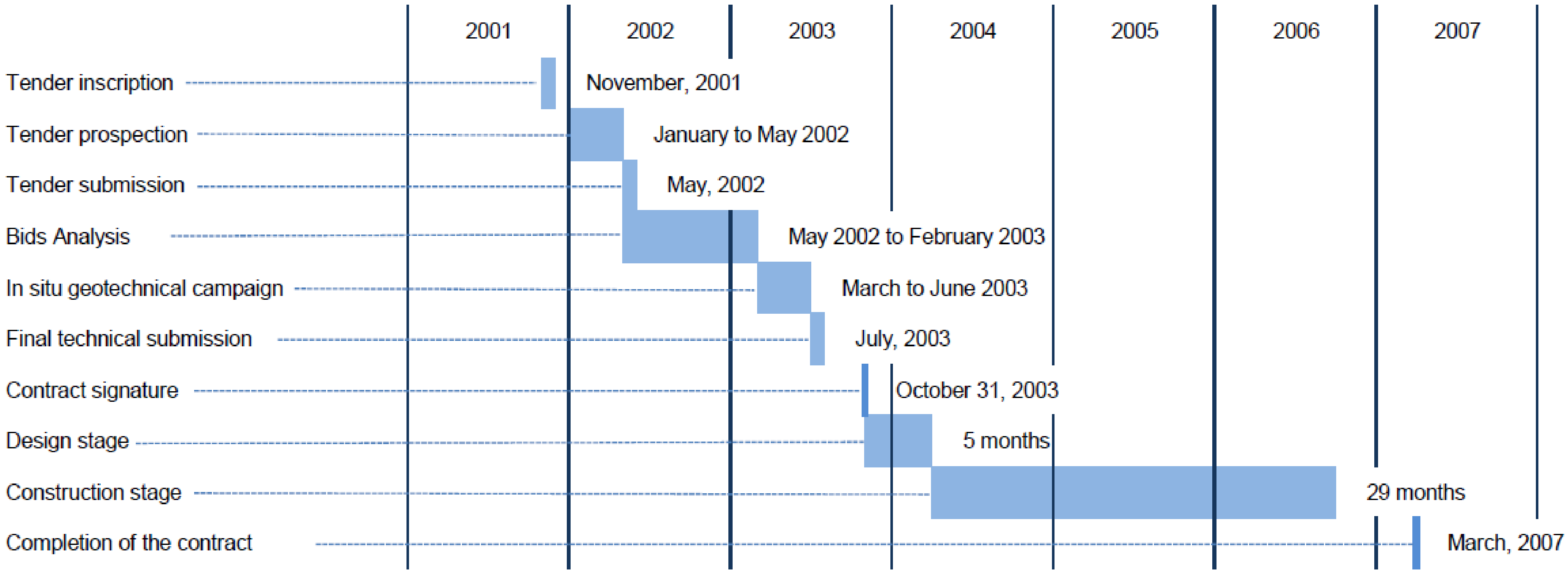
MONESTIER DE CLERMONT VIADUCT

PARTNERS

Contracting Authority	Les Autoroutes Rhône-Alpes
Design and built joint venture	GTM TP Lyon, mandatary
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

GTM TP LYON

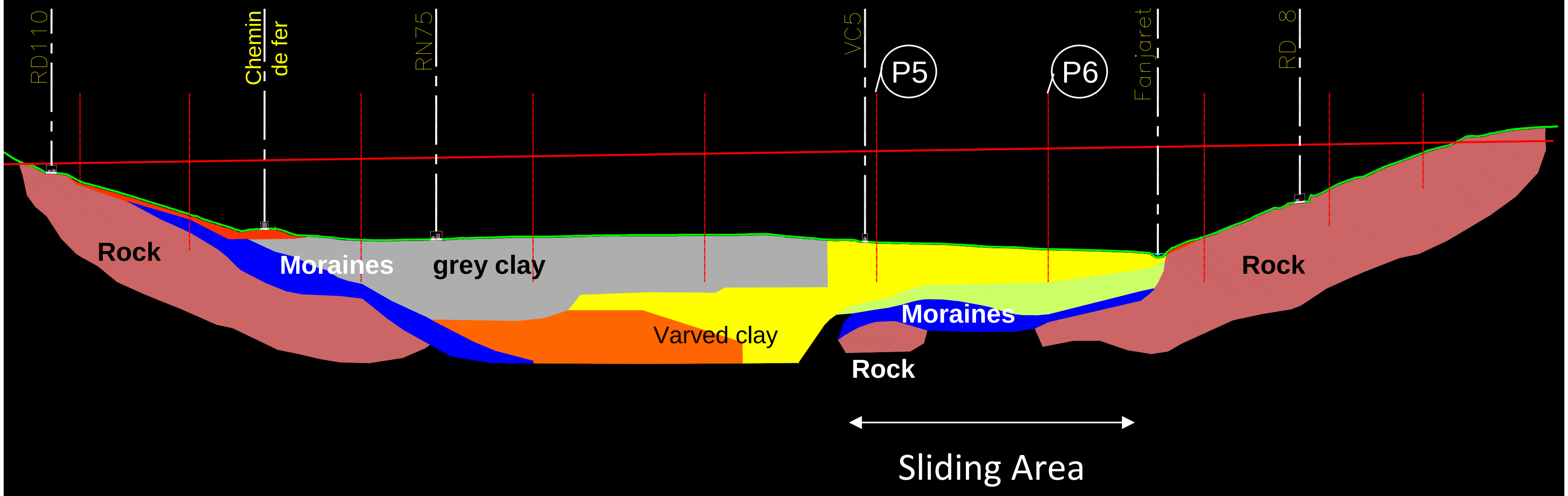
PLANNING



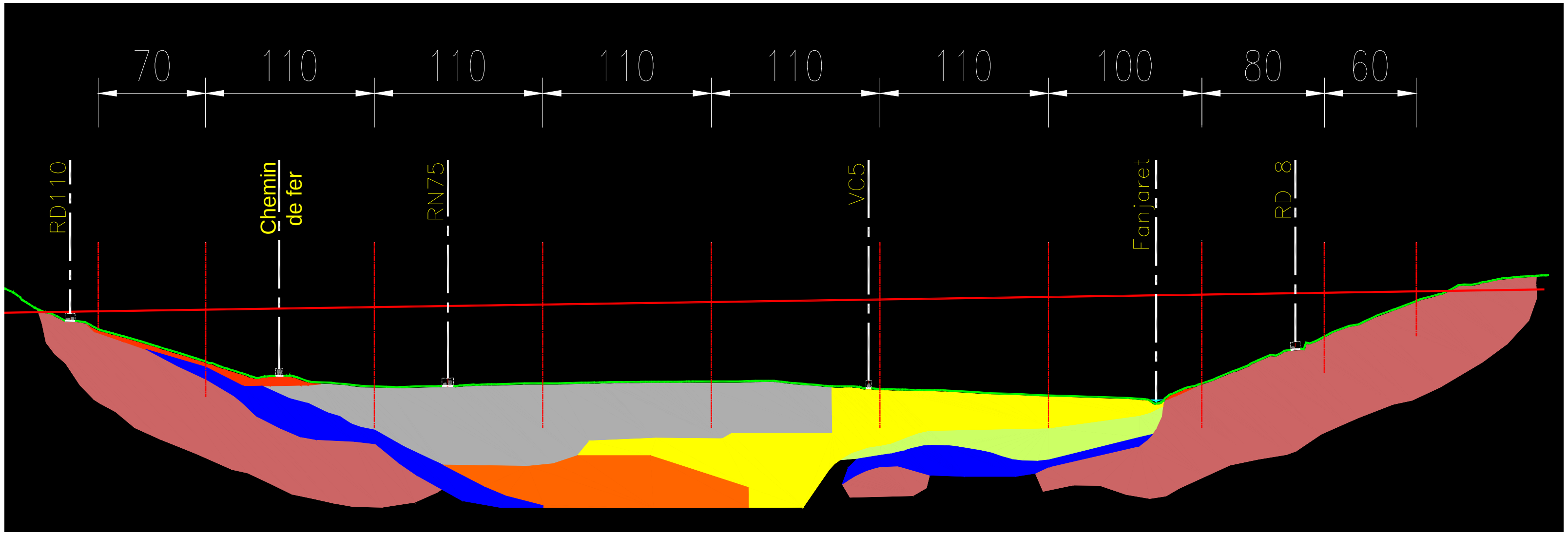
MONESTIER DE CLERMONT VIADUCT

GEOTECHNICAL ENVIRONMENT
Michel LONDEZ

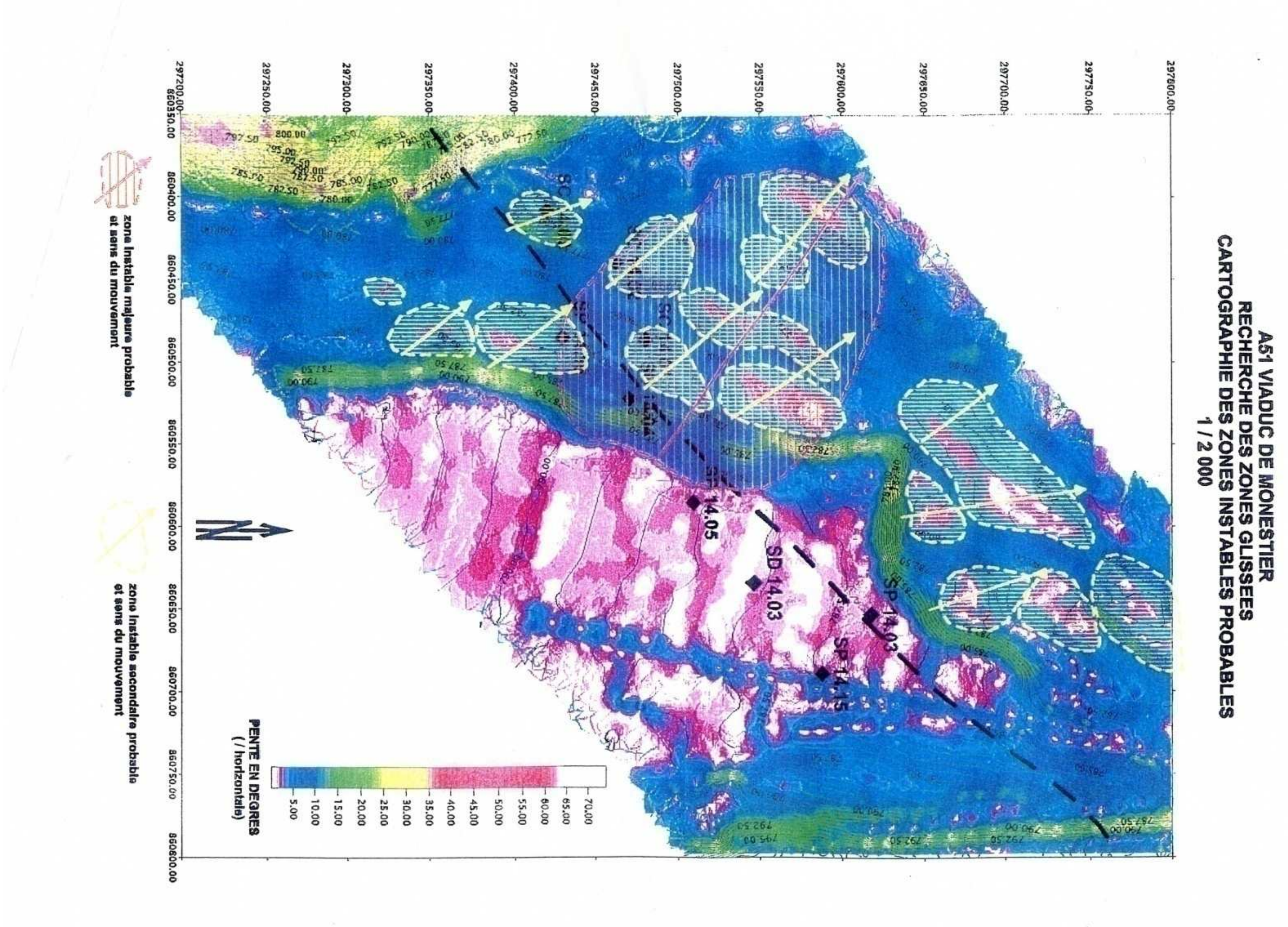
Geological Cross section



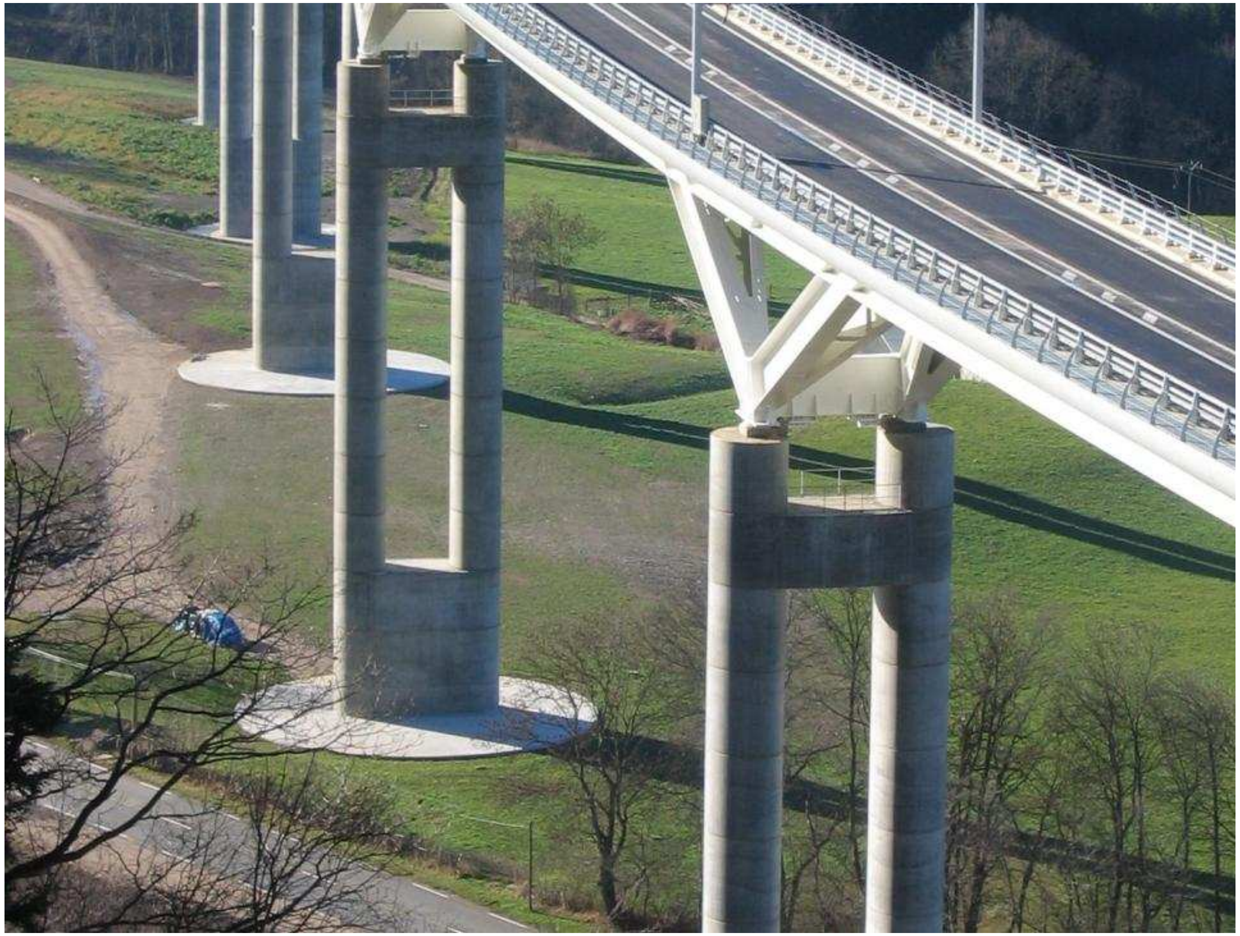
PIERS SETTING OUT



SLIDING ZONE



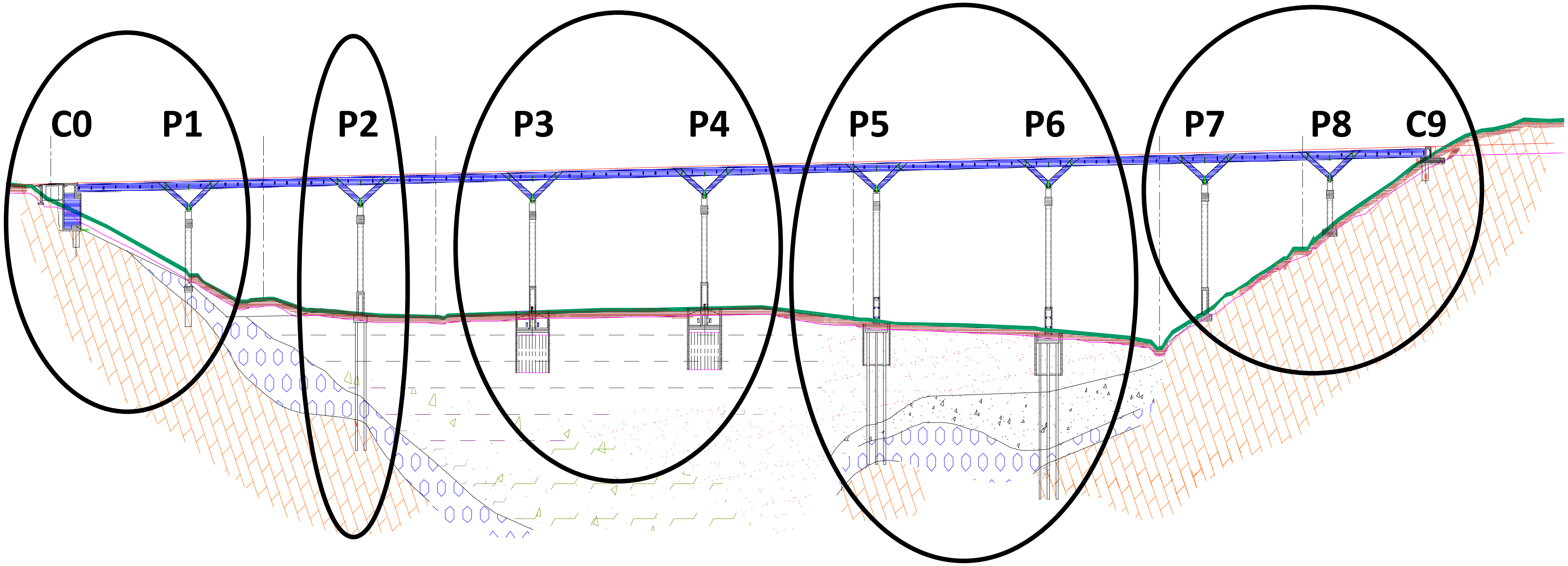
P3 & P4 FOUNDATIONS CONSTRUCTION
Laurent BASTARD-ROSSET



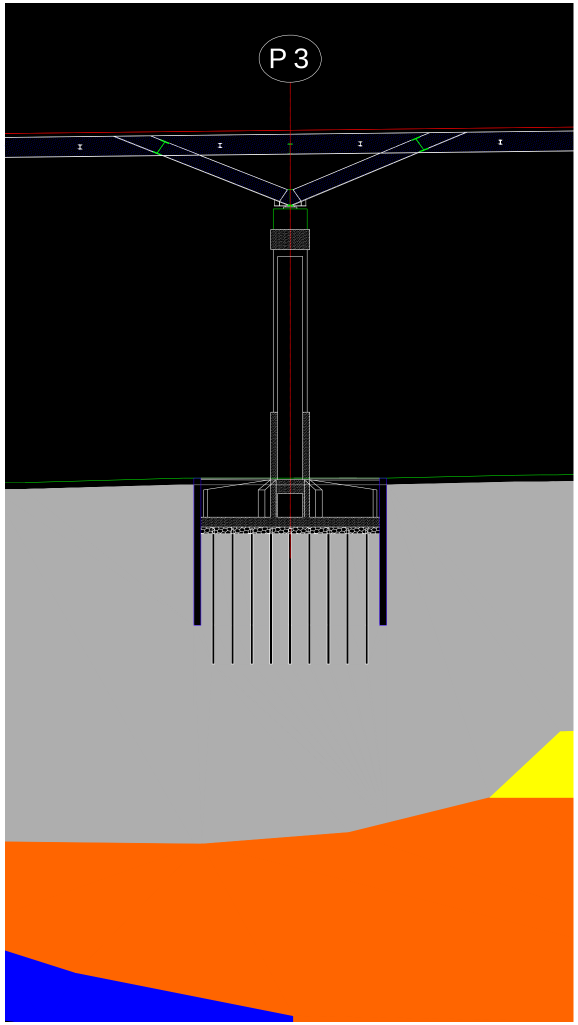
FOUNDATIONS

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**



P3 & P4 FOUNDATIONS

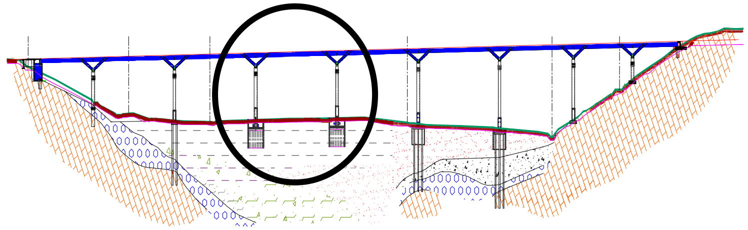


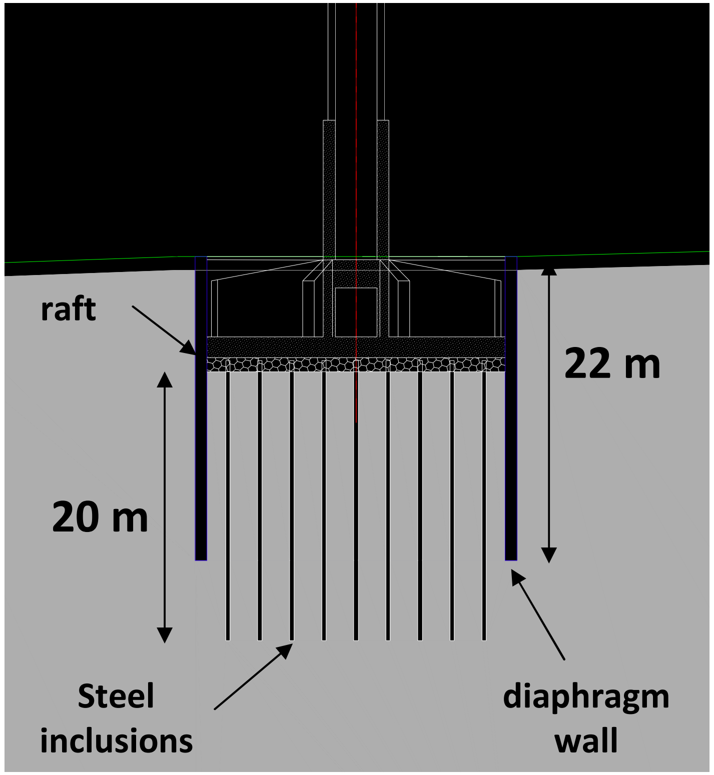
Bellow P3 and P4, varved clay which is water saturated, is present up to 80m deep.

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 & P4 FOUNDATIONS





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

P3 & P4 : DIAPHRAGM WALLS GROUND EXTRACTION

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 : STATE OF THE FOUNDATION JUST BEFORE GRAVEL IS LAY DOWN

P3 & P4 : GRAVEL LAYER AND PIEZOMETER IN PLACE

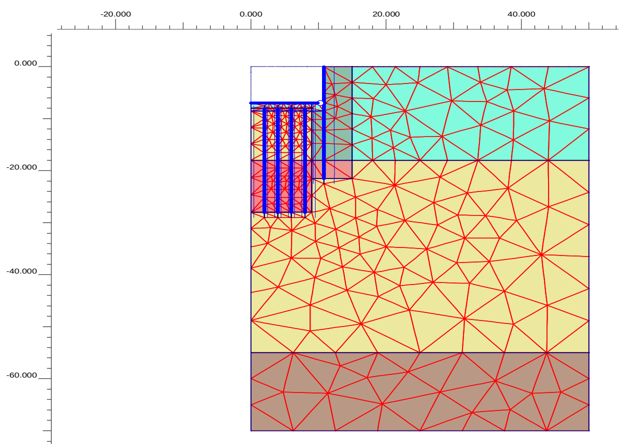
P3 & P4 : REINFORCEMENT OF CONCRETE SLAS

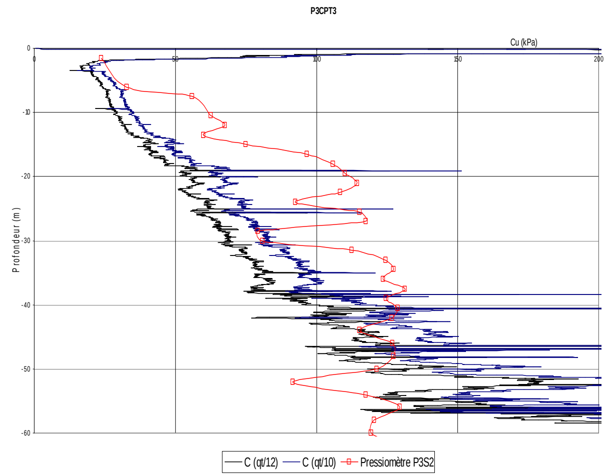
GTM TP LYON

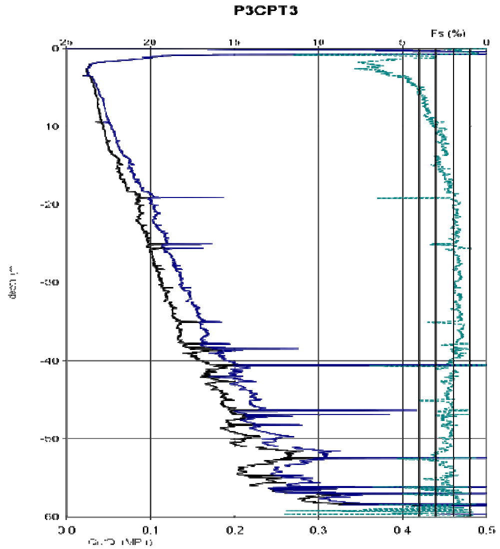
P3 & P4 : STIFFENING STRUCTURE WALLS

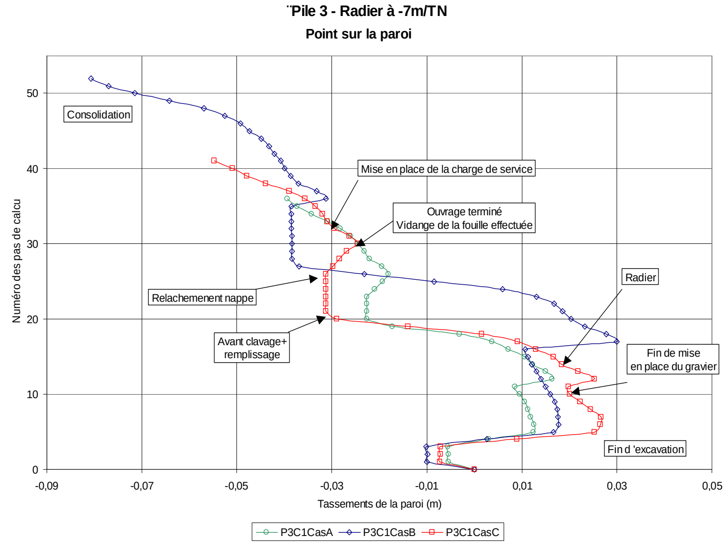
P3 & P4 : GENERAL VIEW

SETTLEMENTS CALCULATIONS
Michel LONDEZ









- **P3 to P6**
  - Core borings,
  - CPTU 65 m deep
  - Pressiometric tests
  - Cross hole
  - Pumping test
  - Inclinometres
  - Laboratory tests

MAIN RESULTS

- **Accross the valley:**

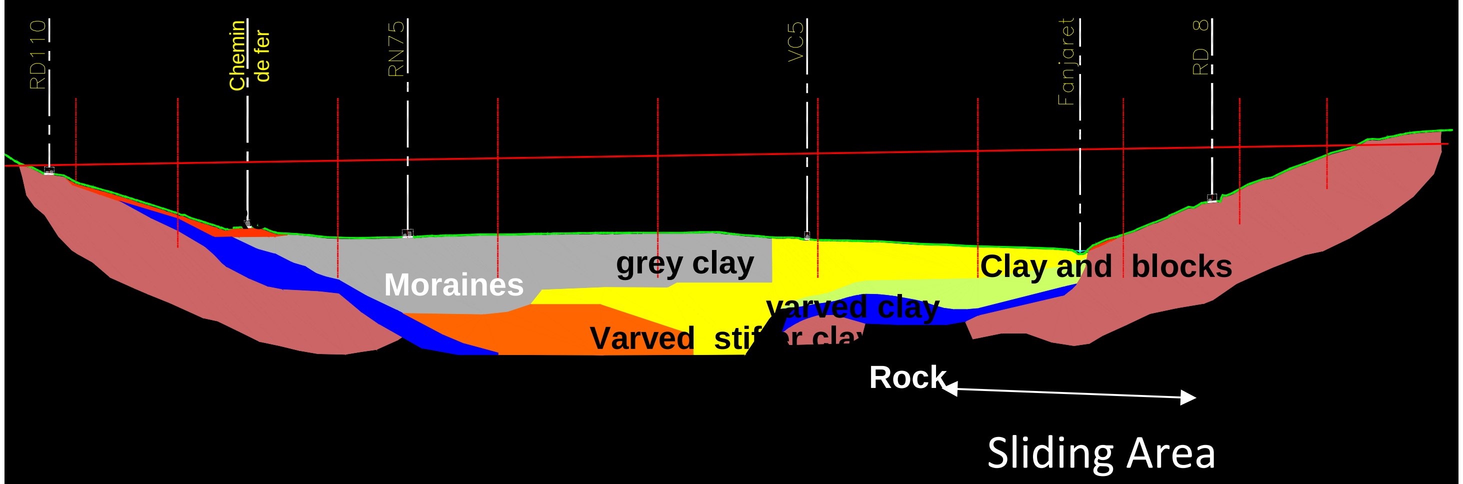
- **South west area:**
  - **Rock at 50 m.**
  - **Fluvio-glacial permeable till between 40 à 50 m**
  - **Gravelly clays below soft and remolded clays**

- **Centre and north of the valley:**
  - **Deepening of rock (P2)**
  - **Argiles homogeneous clays at the surface, varved below**

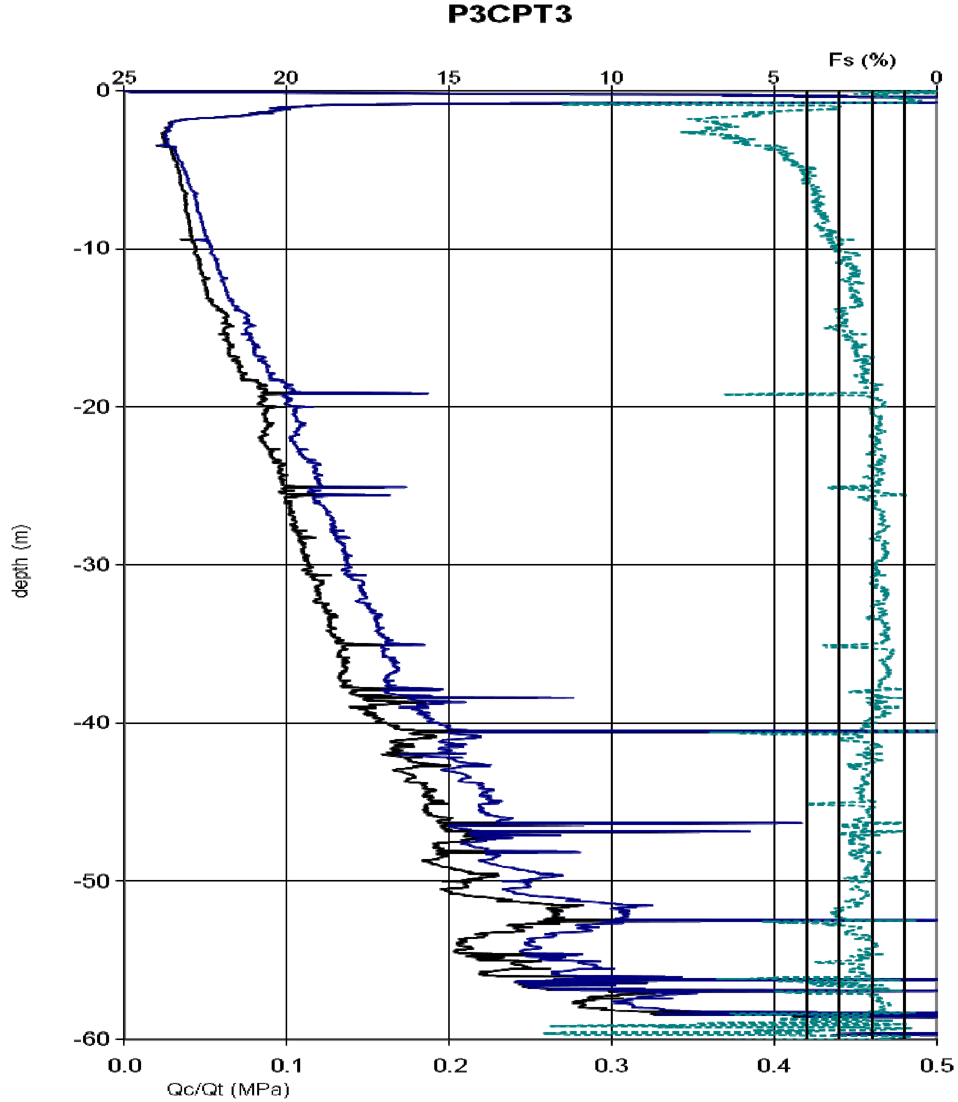
GEOLOGICAL PROFILE

GTM TP LYON

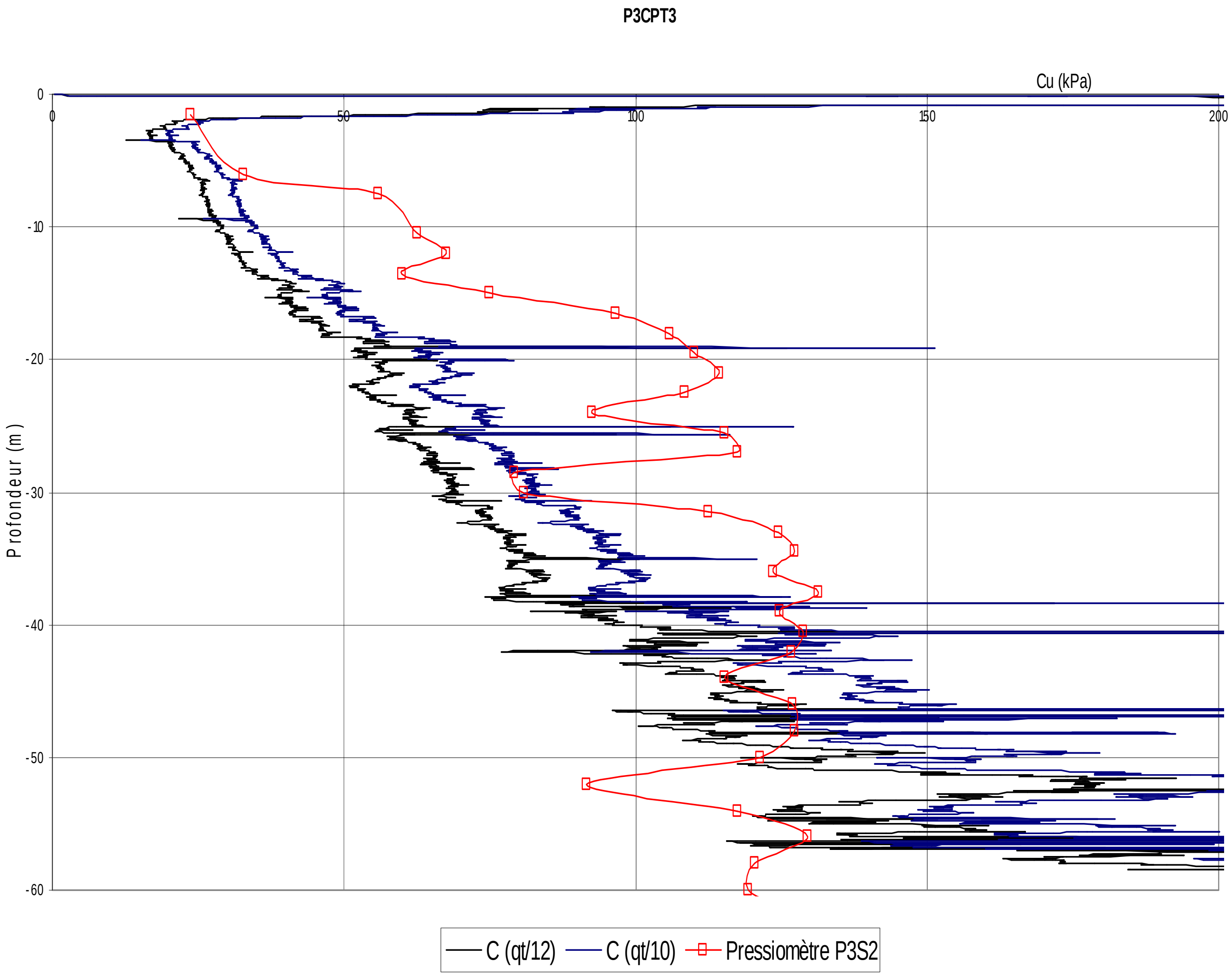
Geological Cross section



PENETRATION TEST FOR P3

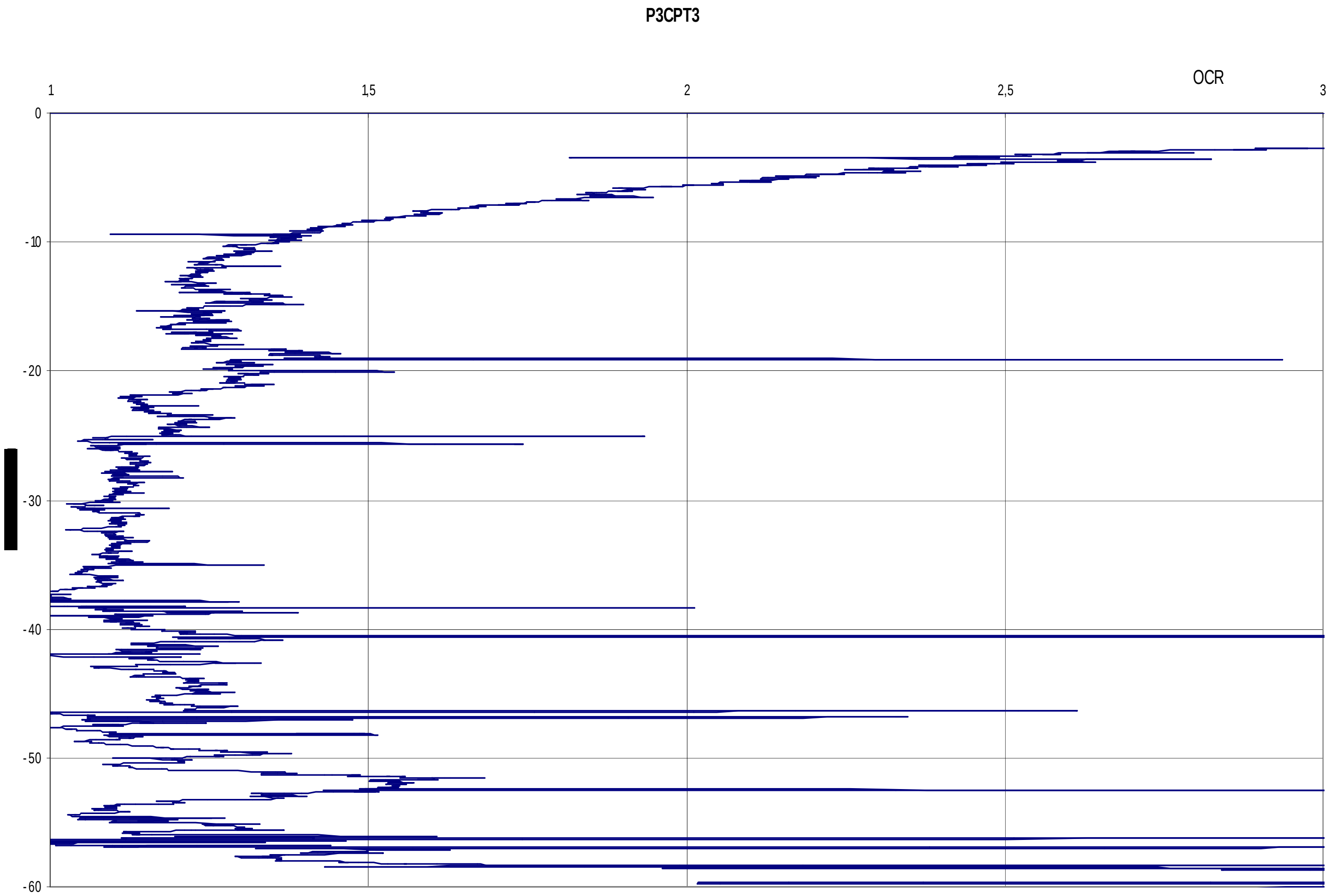


CU (KPA) FROM CPTU AND PRESSURMETRES

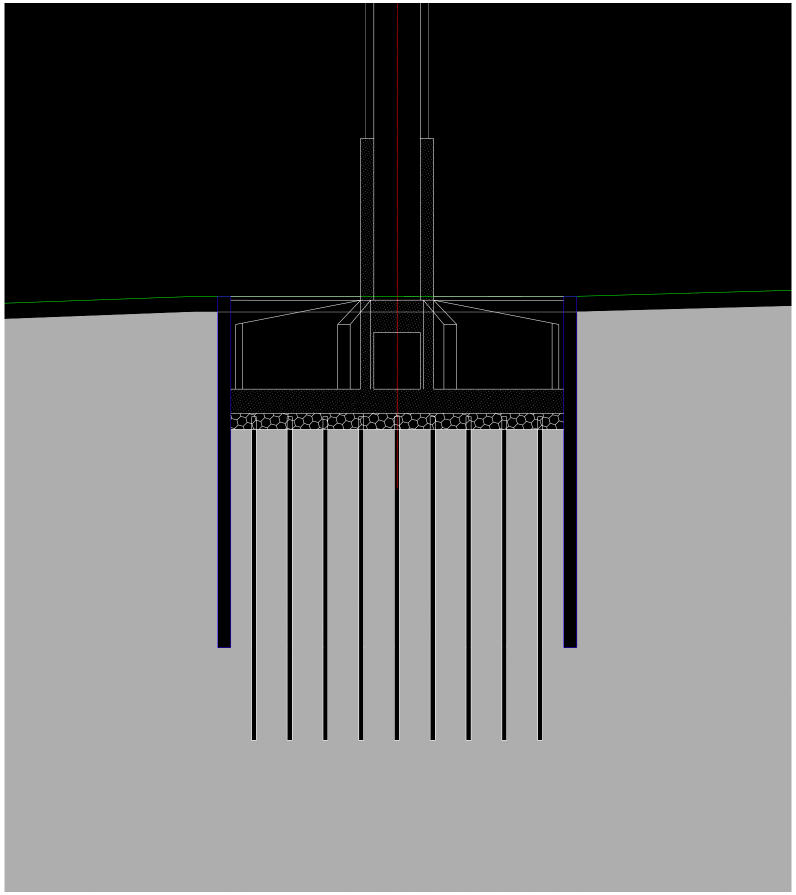


GTM TP LYON

OCR FOR P3



FOUNDATION OF BEARINGS P3 & P4



The foundations of P3 and P4 include :

- a cylindral skirt made of diaphragm wall, 20m diameter and 22 to 26 m deep.

- A 1,50m thick concrete slab

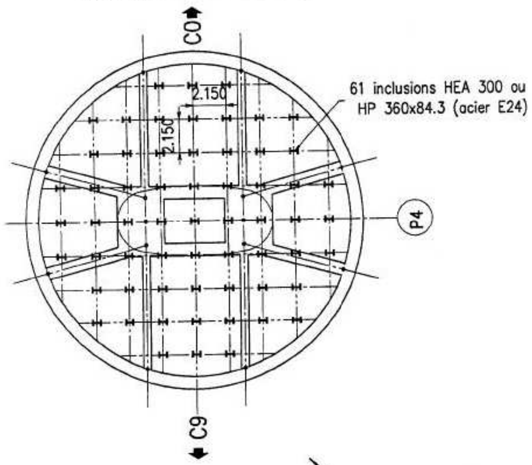
- Steel inclusions (HEA 300), down to 20m below the slab,

- Stiffening walls 80cm thick to tranfert the shaft efforts to the slab and the diaphragm walls

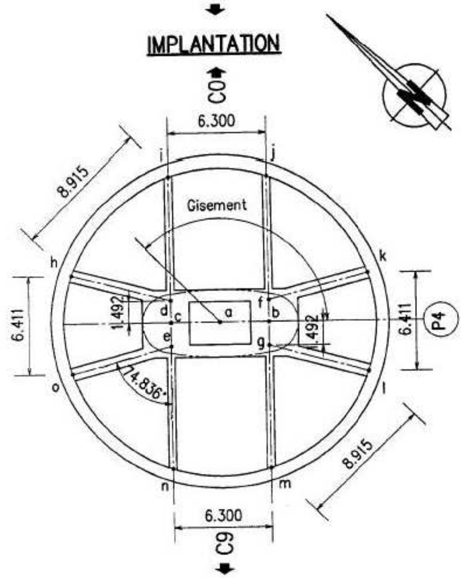
An inner volume of 1700m^3 above the slab remains empty.

Steel profiles setting out

Maillage des inclusions



IMPLANTATION



PARAMETRES OF CALCULATIONS

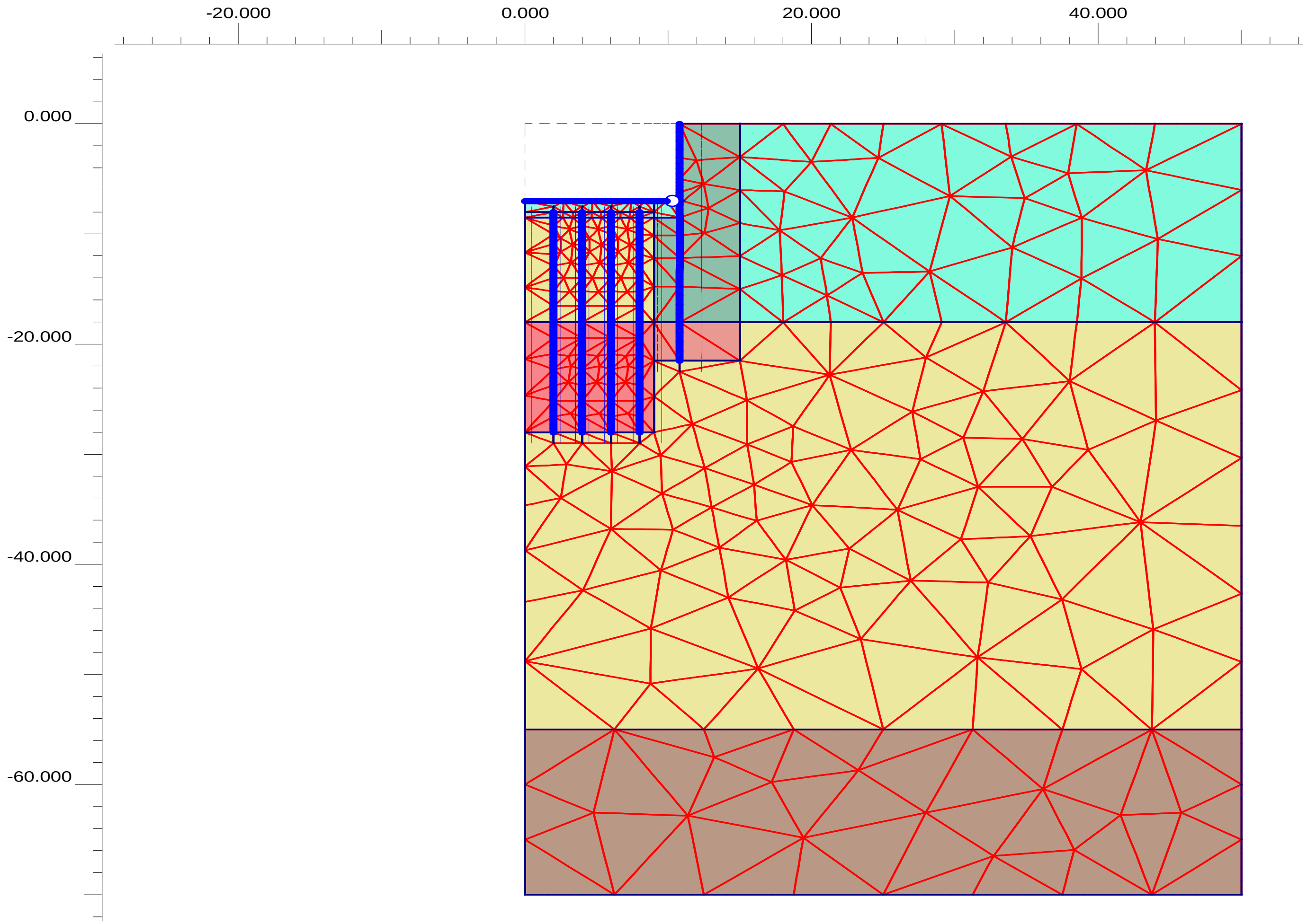
Strength

Volumetric mass(KN/M³)	C′ (KN/M²)	φ′(°)	OCR	Depth (m)	Type of soil
18.5	5	24	σ'_0+50 KN/M²	0 - 18	Upper clay
18.5	0	24	σ'_0	18 – 37/55	Medium clay
18.5	10	30	1.2 σ'_0	37/55 - 80	Lower clay

Deformation

CASE A		CASE B		CASE C		
Triaxial Interpretation		Oedometric Interpretation		Oedometric method		Soil
E_{50}réf (kN/m²)	E_{oed}réf (kN/m²)	E_{50}réf (kN/m²)	E_{oed}réf (kN/m²)	Cc/1+e	Cg/1+e	
7500	6000	3150	2500	0.12	0.024	Upper clay
7500	6000	3150	2500	0.12	0.024	Medium clay
7500	6000	7500	6000	Hardening Model		Lower Clay

CALCULATION MODEL



SEQUENCES OF CALCULATIONS

- 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

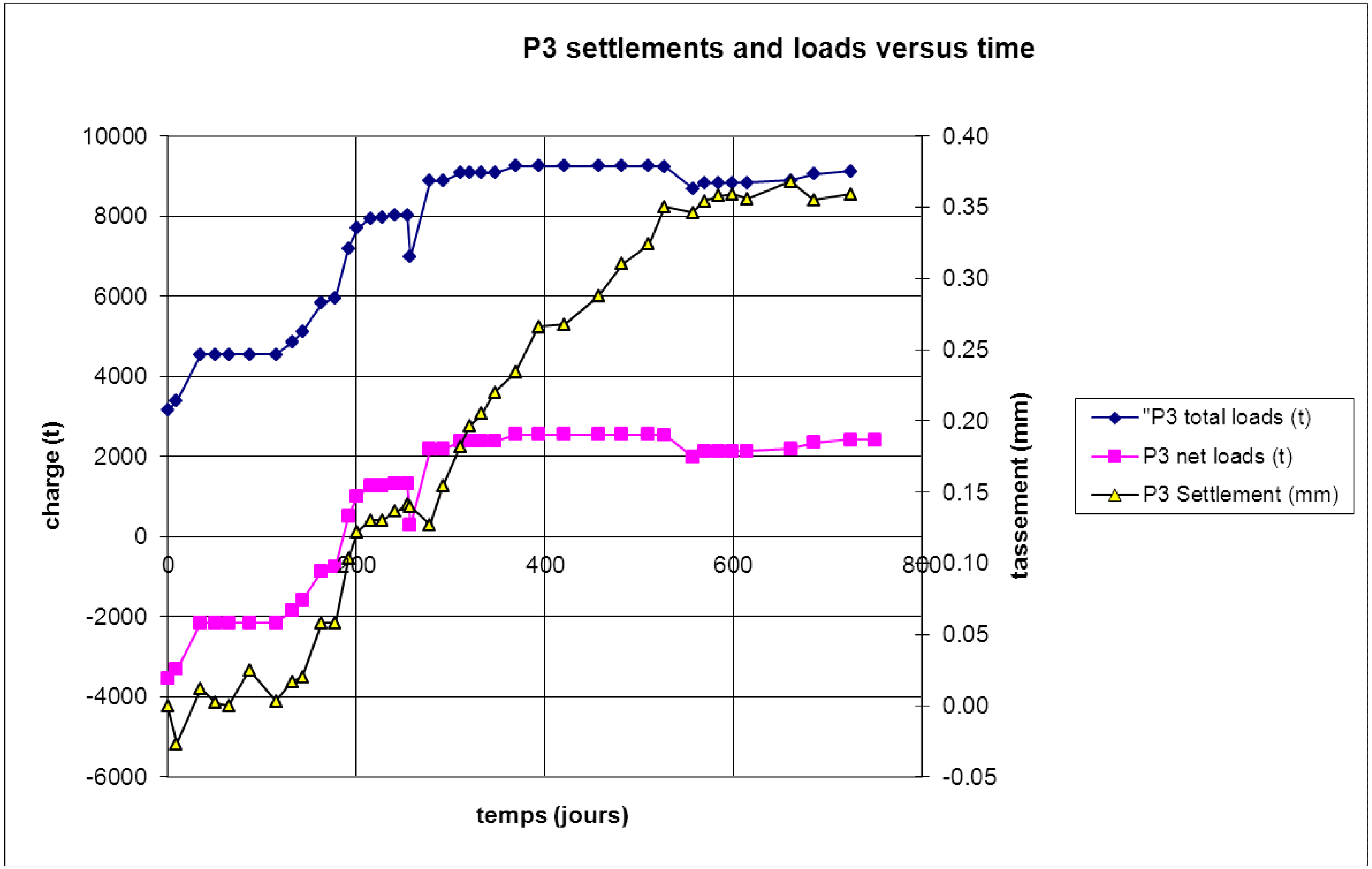
Settlements in mm

Calculation Cases	Soil parametres	Raft construction		Loads without Superstructures + water		Total + service loads + Consolidation	
		P3	P4	P3	P4	P3	P4
A	Triaxial interpretation	5	6	33	35	21	21
B	Triaxial interpretation*0.42	7	6	62	56	50	38
C	Oedometric model	7	7	50	44	30	35

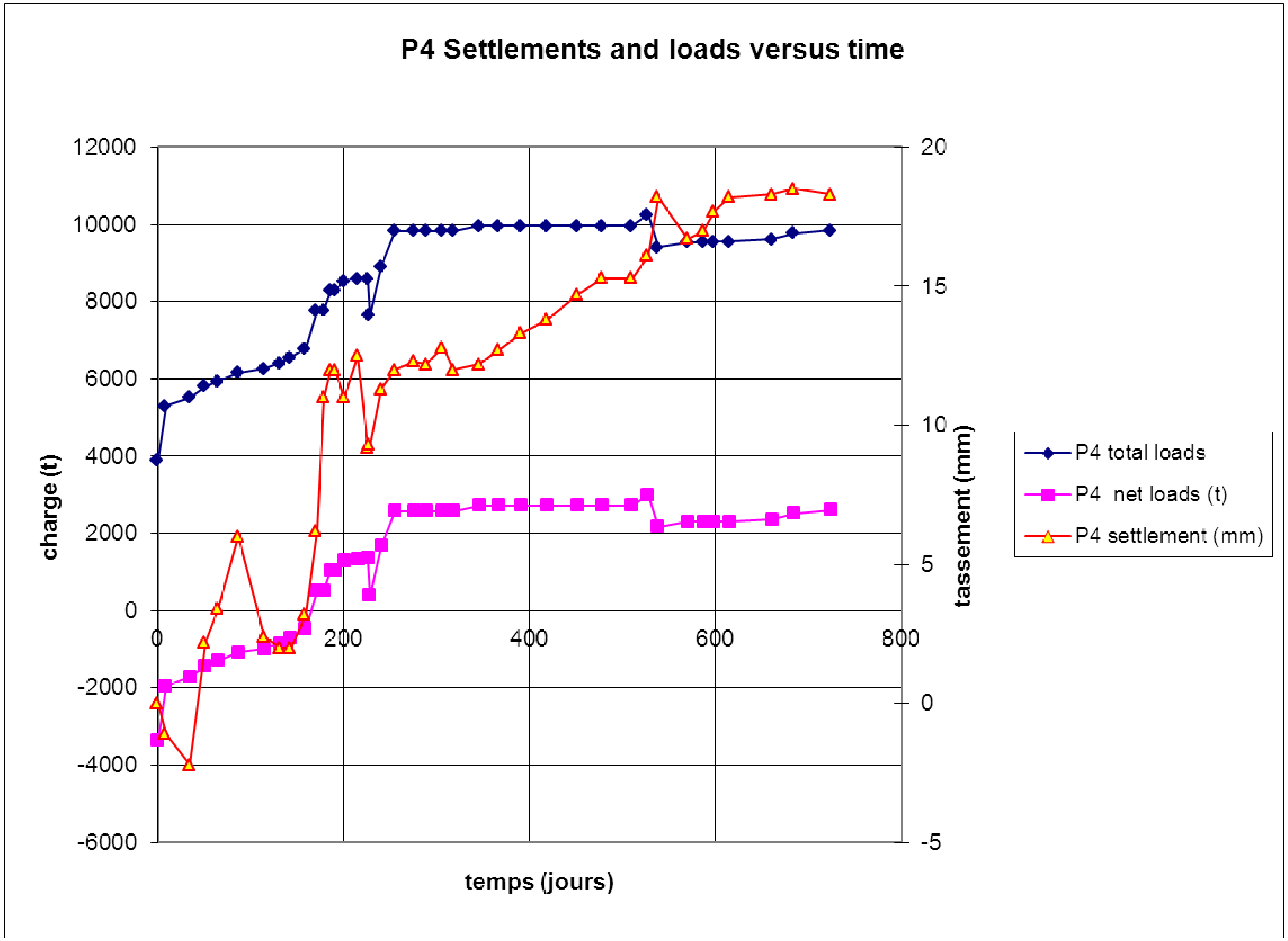
Deformation

CASE A		CASE B		CASE C		
Triaxial Interpretation		Oedometric Interpretation		Oedometric method		Soil
E_{50}réf (kN/m²)	E_{oed}réf (kN/m²)	E_{50}réf (kN/m²)	E_{oed}réf (kN/m²)	Cc/1+e	Cg/1+ e	
7500	6000	3150	2500	0.12	0.024	Upper clay
7500	6000	3150	2500	0.12	0.024	Medium clay
7500	6000	7500	6000	Hardening Model		Lower Clay

OBSERVATIONS DURING CONSTRUCTION



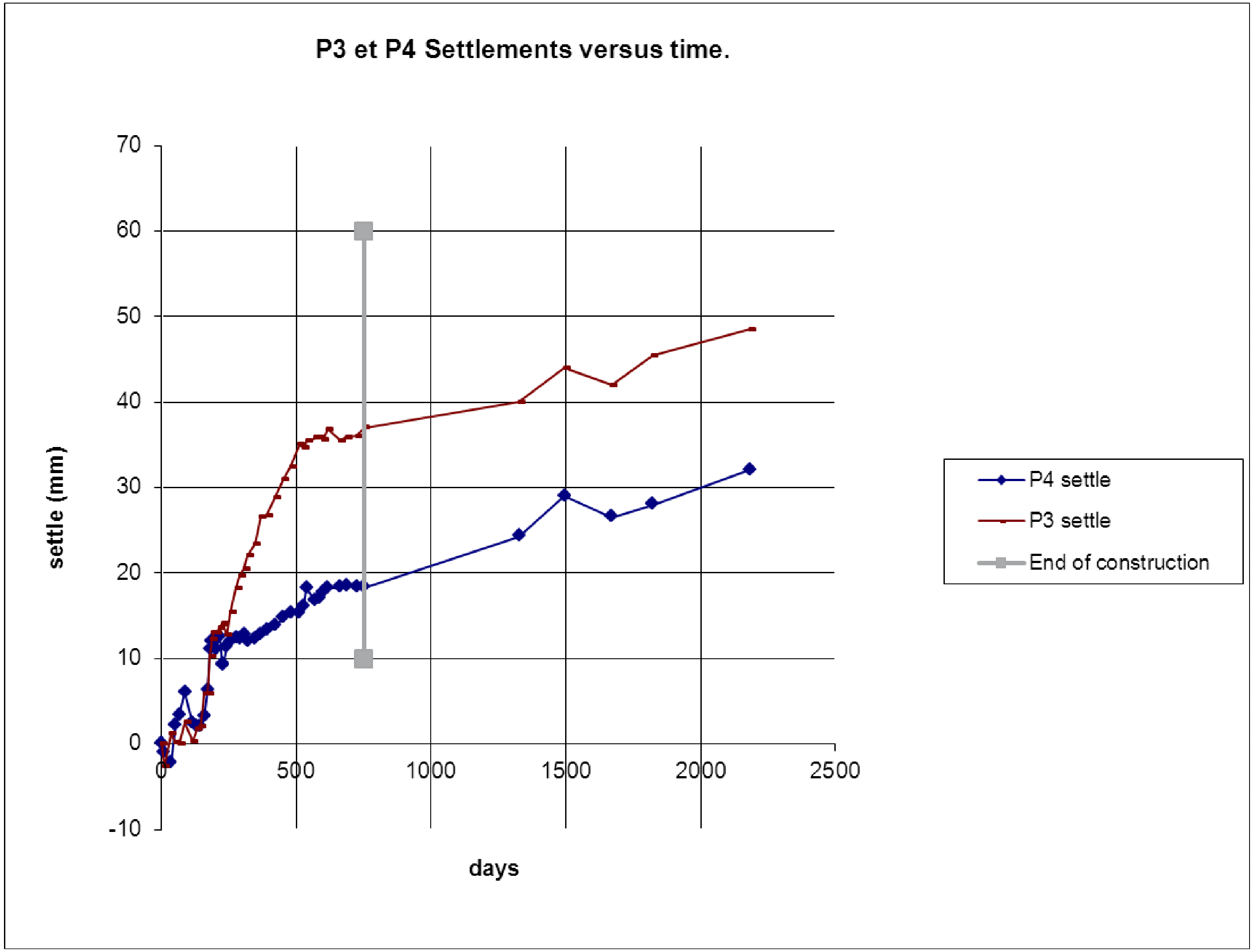
OBSERVATIONS DURING CONSTRUCTION



COMMENTS

- For P3, settlements during construction were close or slightly higher than those estimated with the triaxial interpretation (case A)
- Needs for setlements 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 differencial settlements to 80 mm instead of 60 mm initialy considered in the design.
- For P4, the setlements are much lower due to the longer length of the diaphragm wall skirt.

SETTLEMENTS VERSUS TIME



GTM TP LYON

Comparison between estimations and observations

Settlements in mm

	End of construction		In service	
	P3	P4	P3	P4
Estimations	33 to 62	37 to 56	21*	21*
Observations	37	19	11.5**	13.5**

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

VINCI CONSTRUCTION FRANCE