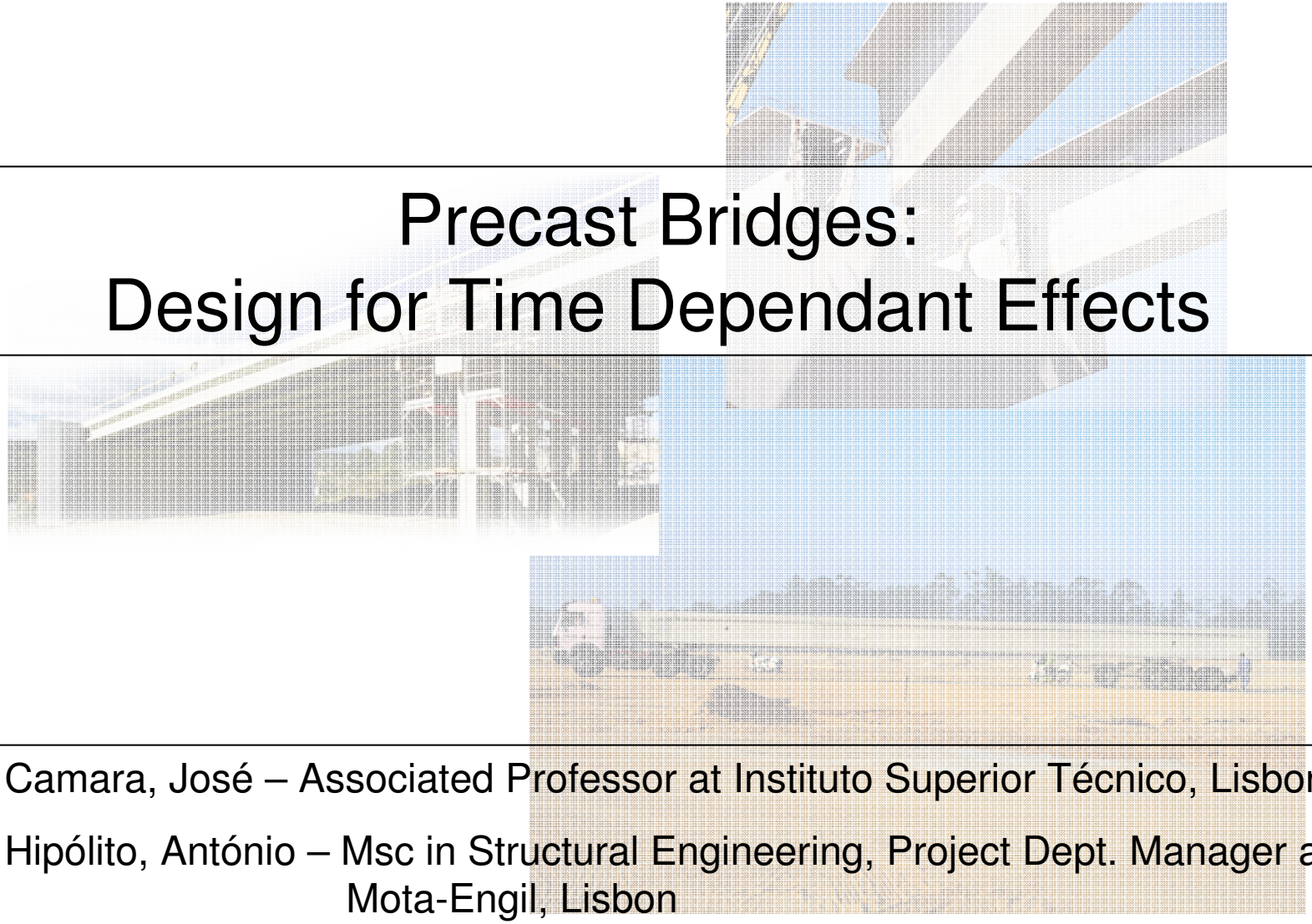
INSTITUTO SUPERIOR TÉCNICO

MOTA-ENGIL



# Precast Bridges: Design for Time Dependant Effects



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# Objectives

1. Present a mathematical tool to take into account time effects in a simply and rational way

2. Study the influence of prestress layout on structural behaviour and economy

3. Study the influence of construction procedure on the prestress value

# 1. Mathematical Tool

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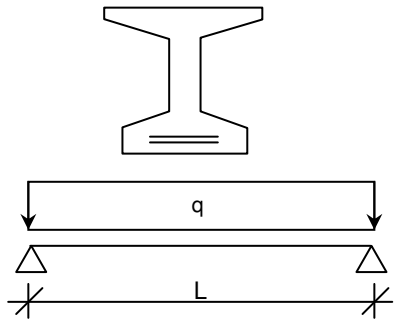
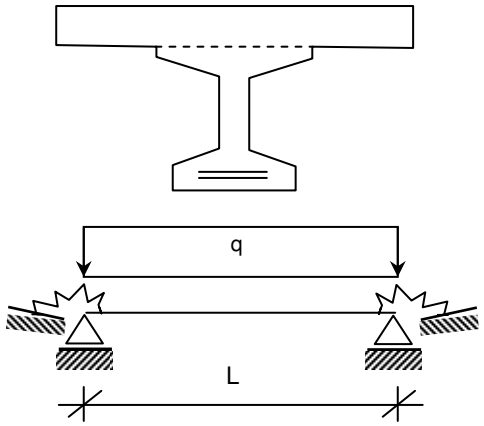
## Basis

### Structural System 1




### Structural System 2




## Long Time Analysis

**Usual Formula**

$$S_\infty = S_1 + \frac{\varphi}{1+\chi\varphi}(S_2 - S_1)$$

$$\Delta\varphi'_1 = \varphi'_1\,(t_\infty, t_0) - \varphi'_1\,(t_1, t_0)$$

$$[1+(\chi\varphi')_1]_{ef} = [1+(\chi\varphi')_1]\frac{E_{1,t0}}{E_{1,t1}}$$

**Proposed Formula**

| | |
|---|---|
| Efforts | $M_\infty = \overline{M_1} + \frac{\Delta\varphi'_1}{[1+(\chi\varphi')_1]_{ef}}\left(\overline{M_2} - \overline{M_1}\right)$ |
| Stresses | $\sigma_\infty = \overline{\sigma_{1,i}} + \frac{\Delta\varphi'_1}{[1+(\chi\varphi')_1]_{ef}}\left(\overline{\sigma_{2,i}} - \overline{\sigma_{1,i}}\right)$ |
| Curvatures | $\left(\frac{1}{R}\right)_\infty = \left(1+\varphi'_{1,0}\right)\cdot\overline{\left(\frac{1}{R}\right)_1} + \Delta\varphi'_1\cdot\overline{\left(\frac{1}{R}\right)_2}$ |
| Deformations | $\delta_\infty = \left(1+\varphi'_{1,0}\right)\cdot\overline{\delta_1} + \Delta\varphi'_1\cdot\overline{\delta_2}$ |

# 2.1. Case Study: Base solution

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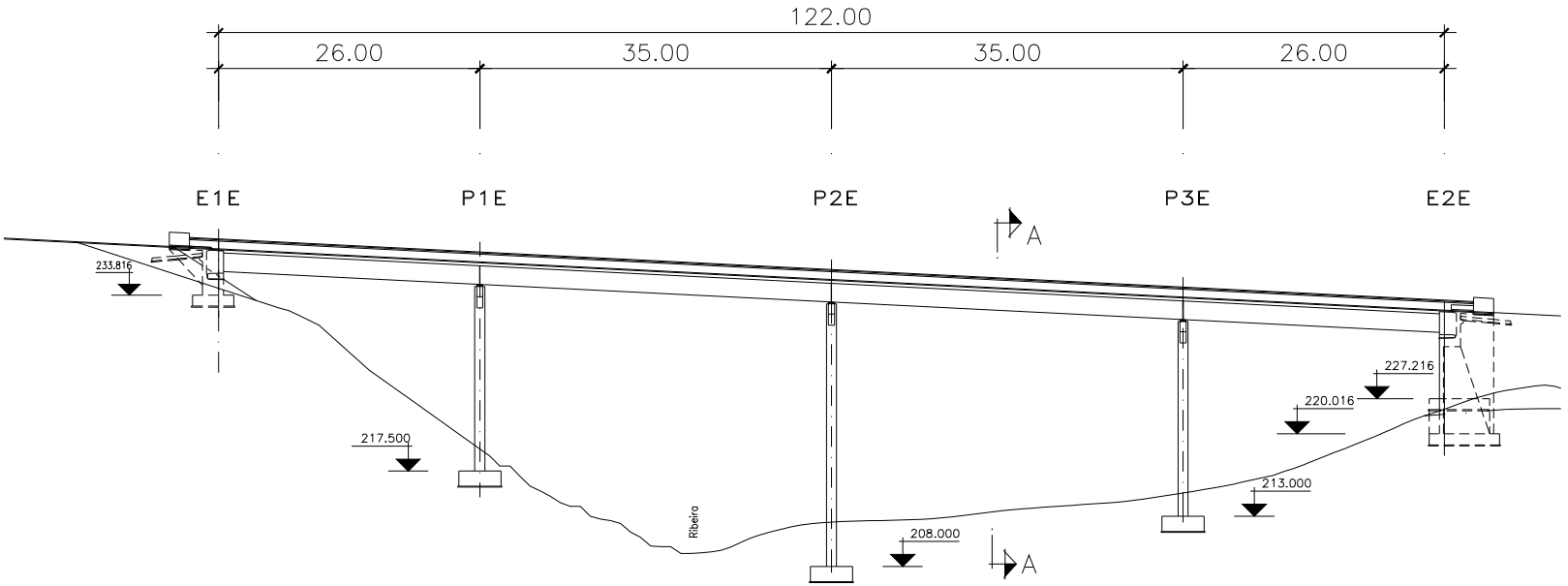
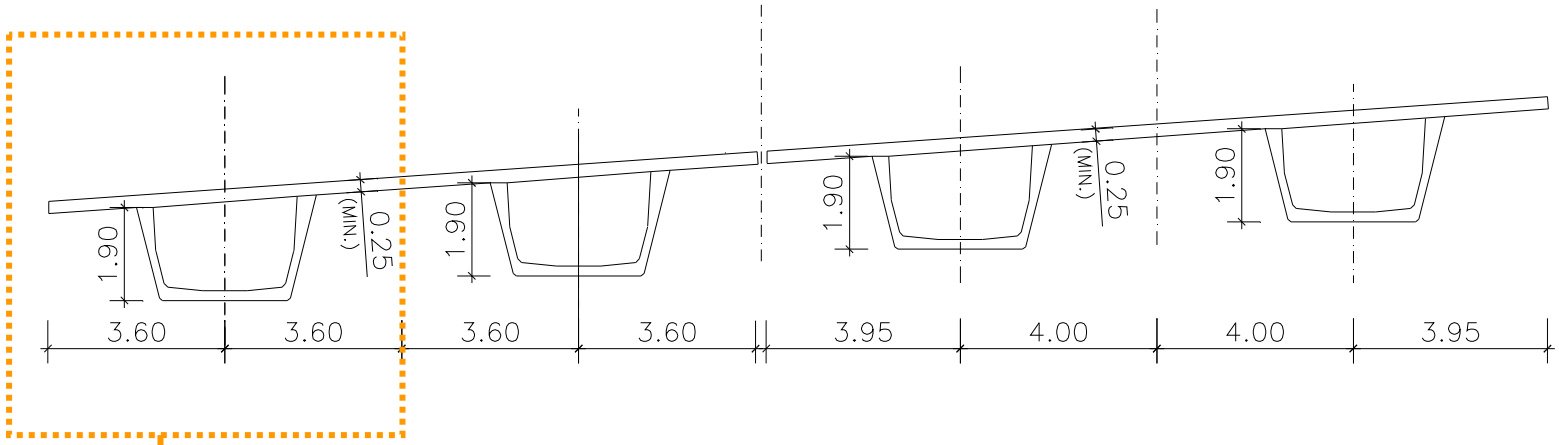
Longitudinal Geometry



# 2.1. Case Study: Base Solution

Transversal Geometry




Beam selected for the study

# 2.1. Case Study: Base Solution

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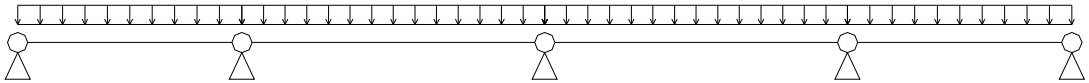
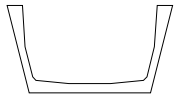
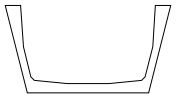
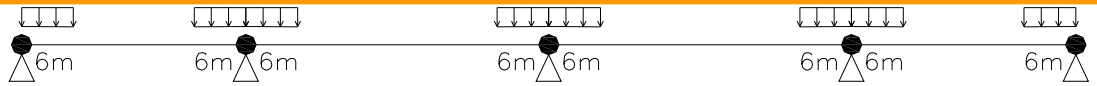
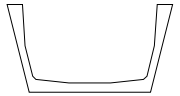
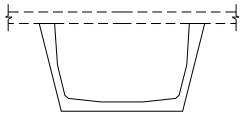
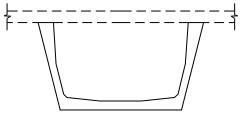
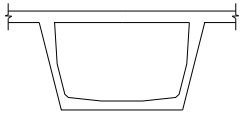
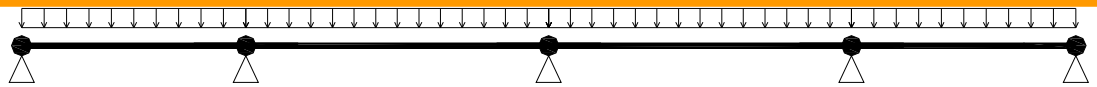
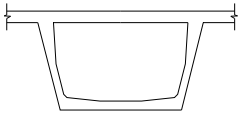
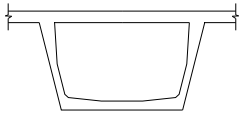
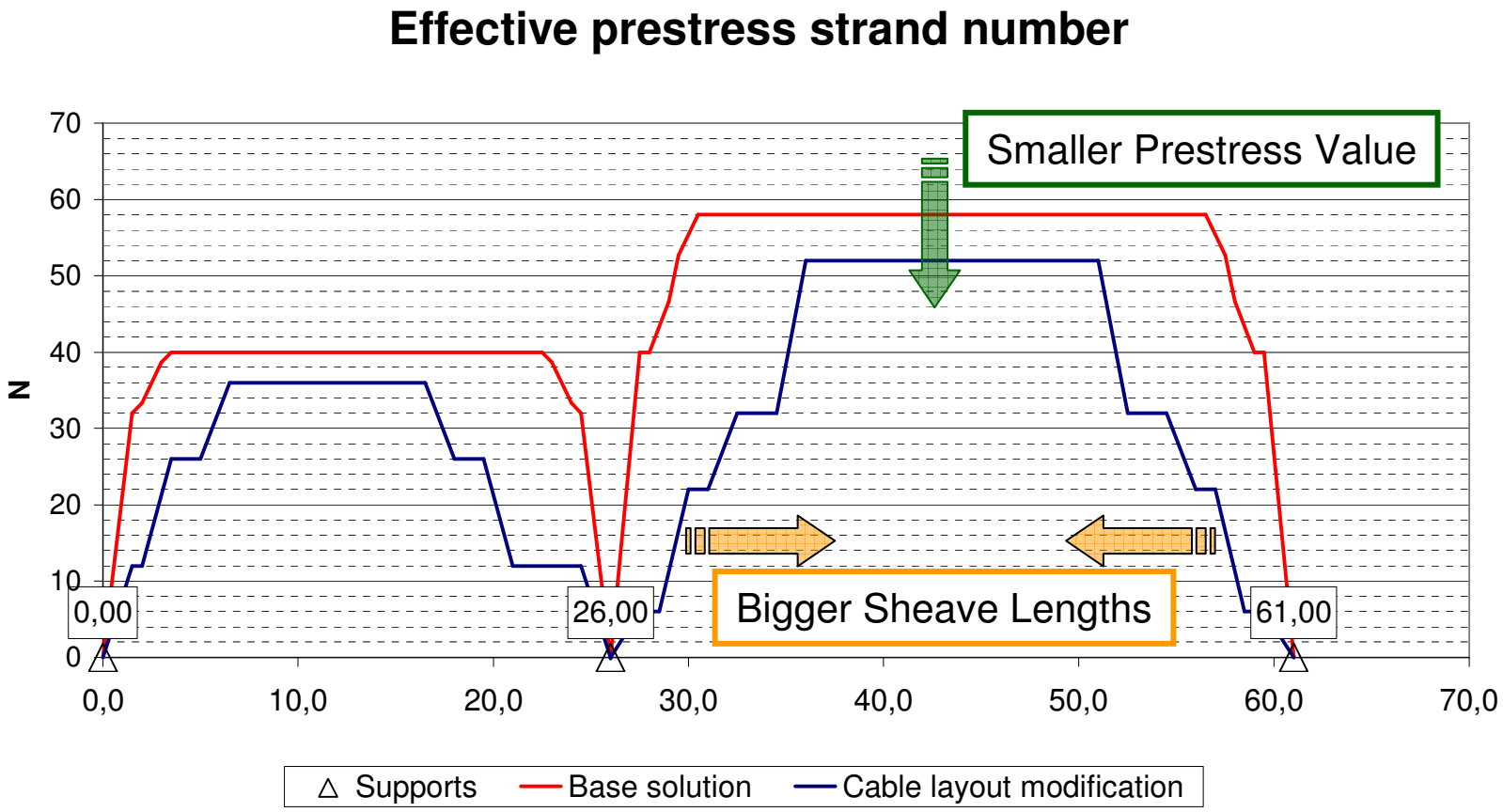
## Construction Procedure

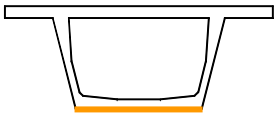
| Longitudinal structural system | Span section | Support section |
|---|---|---|
|  discontinuous structural system<br>**Phase 1: Positioning of the prefabricated beams and phase 2: Execution of the beams connection giving continuity to the system.** |  |  |
|   continuous structural system<br>**Phase 3: Concreting of the top slab for 6.0m to each side of the supports** |  |  |
|   continuous structural system<br>**Phase 4: Execution of the remaining slab deck** |  |  |
|  continuous structural system<br>**Phase 5: Finalising the bridge deck (non structural elements).** |  |  |

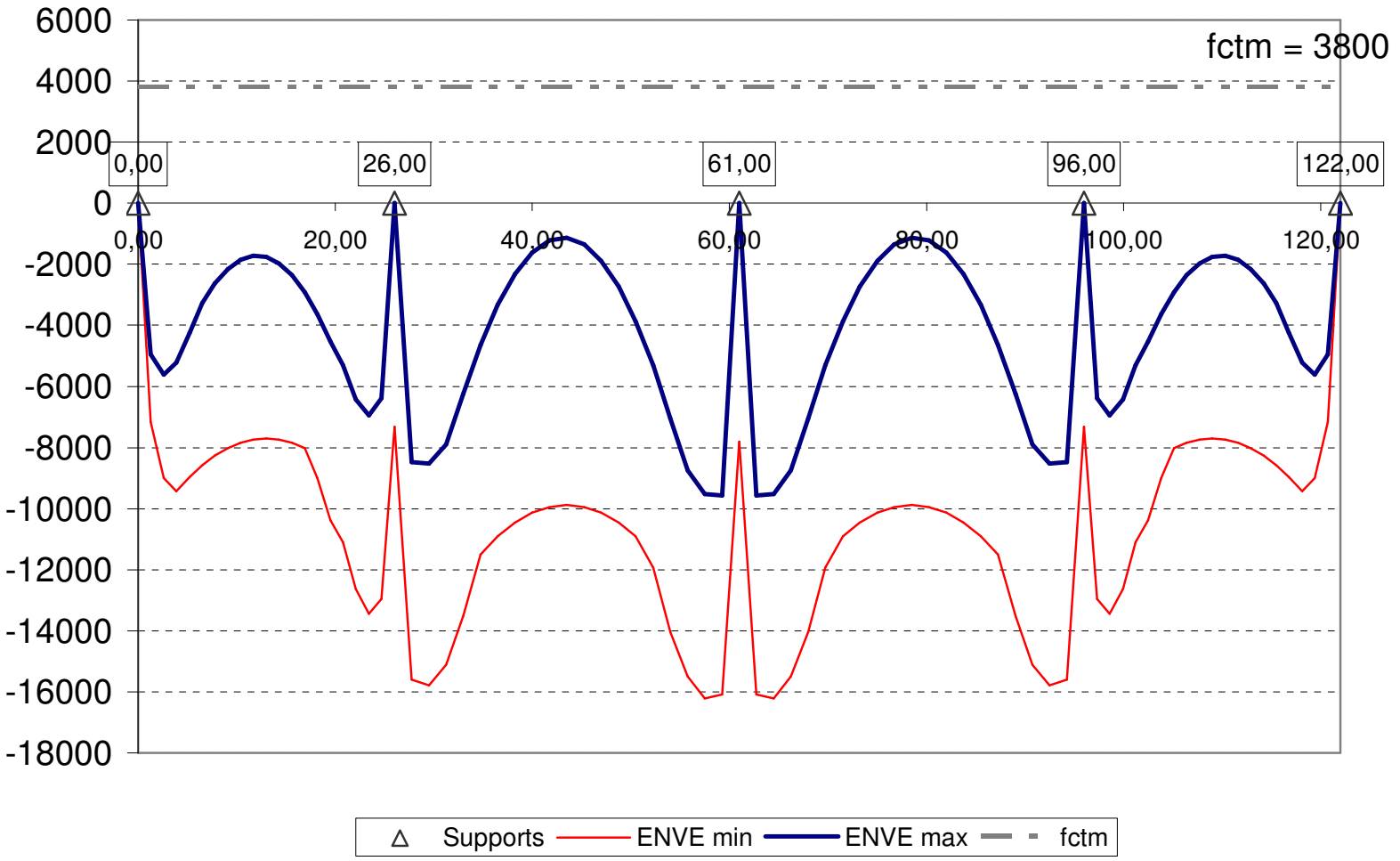
# 2.2. Cable Layout Study



# 2.2. Cable Layout Study

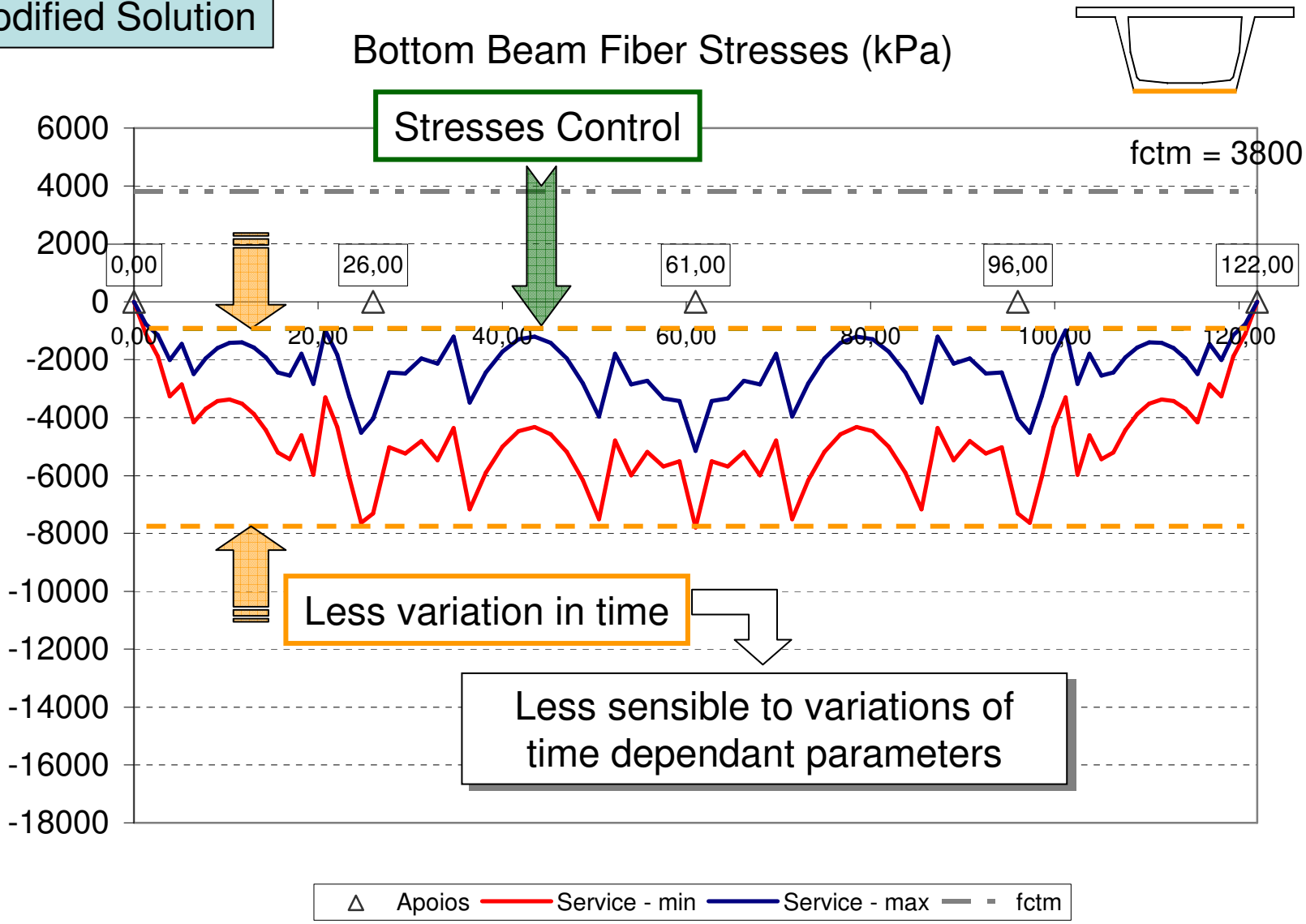
Base Solution





# 2.2. Cable Layout Study

Modified Solution



# 2.3. Construction Procedure Study

## Case C

- Position of the pre-slabs, 0.10m thick, while in a simple supported system
- Complementary concrete as in the base solution

## Case D

- Slab deck totally built on a simple supported system

☝ Both cases with increased sheave lengths

# 2.4. Results

| Long Term Prestress | | |
|---|---|---|
| | P [kN] | $P/P_B$ |
| A | 8950 | 111.5% |
| B | 8030 | 100.0% |
| C | 8950 | 111.5% |
| D | 10800 | 134.5% |

A: Base solution
B: Base solution + increased sheaves
C: Increased sheaves + precast slabs over simply supported system
D: Increased sheaves + slab deck over simply supported system

# Conclusions

- The mathematical tool presented, gives a very rational and feasible procedure for structural behaviour evaluation
- Careful design of cable layout, particularly sheave lengths, can grant better structural behaviour and economy
- Construction procedure can influence significantly the prestress values
- For the type of structures studied, beam continuity during construction, is favourable for the prestress value

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Thank you for your time

# 1. Mathematical Tool

## Basis of Formulation

- Aging Coefficient Method: $E_{c,adj} = \frac{E_c}{1+\chi\varphi}$
- Known simplified formula: $S_\infty = S_1 + \frac{\varphi}{1+\chi\varphi}(S_2 - S_1)$

## Proposed Formula

| | |
|---|---|
| Efforts | $M_\infty = \overline{M_1} + \frac{\Delta\varphi_1'}{[1+(\chi\varphi')_1]_{ef}}\left(\overline{M_2} - \overline{M_1}\right)$ |
| Stresses | $\sigma_\infty = \overline{\sigma_{1,i}} + \frac{\Delta\varphi_1'}{[1+(\chi\varphi')_1]_{ef}}\left(\overline{\sigma_{2,i}} - \overline{\sigma_{1,i}}\right)$ |
| Curvatures | $\left(\frac{1}{R}\right)_\infty = \left(1+\varphi_{1,0}'\right)\cdot\overline{\left(\frac{1}{R}\right)_1} + \Delta\varphi_1'\cdot\overline{\left(\frac{1}{R}\right)_2}$ |
| Deformations | $\delta_\infty = \left(1+\varphi_{1,0}'\right)\cdot\overline{\delta_1} + \Delta\varphi_1'\cdot\overline{\delta_2}$ |

Scales creep's influence

$$[1+(\chi\varphi')_1]_{ef} = [1+(\chi\varphi')_1]\frac{E_{1,t0}}{E_{1,t1}}$$

$$k_{hom} = \frac{E_{c,t1,aj}}{E_{1,t1,aj}}$$