



UNIVERSITY OF MINHO
DEPARTMENT OF CIVIL ENGINEERING



Escola de Engenharia
Universidade do Minho



Departamento de
Engenharia Civil

Design and constructions of long walls submitted to lateral loading: Case studies in Portugal. Technical and economical benefits

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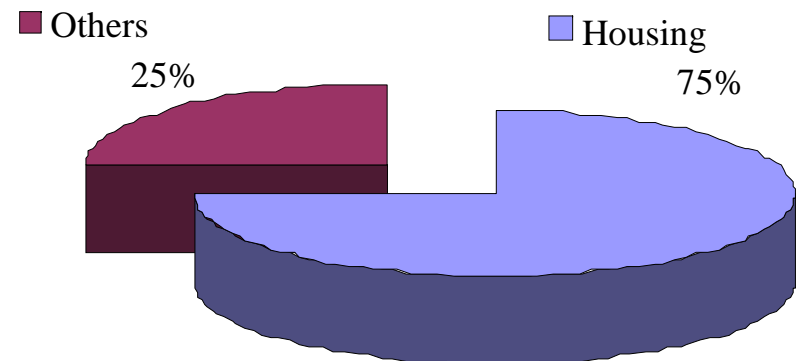
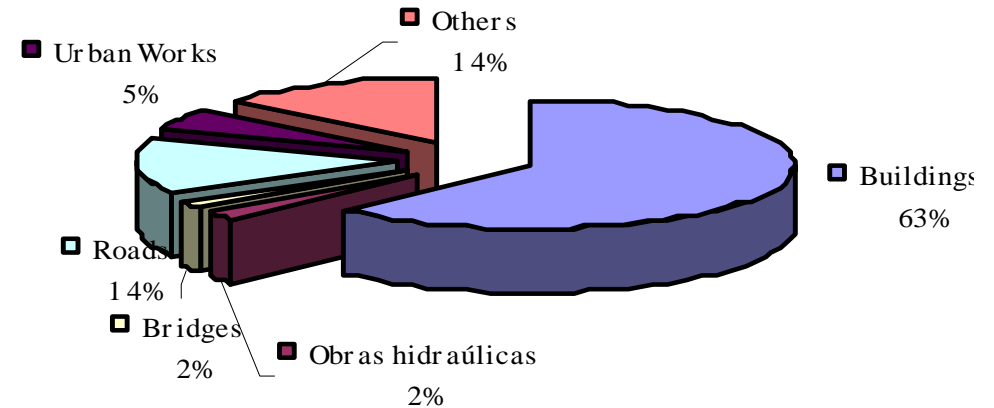




INTRODUCTION (I)

Construction Market in Portugal

- 7% of the GNP and 9% of the employment
- Masonry walls (non structural...) represent circa 12% to 17% of the total construction costs. This is the largest share, after the reinforced concrete structure

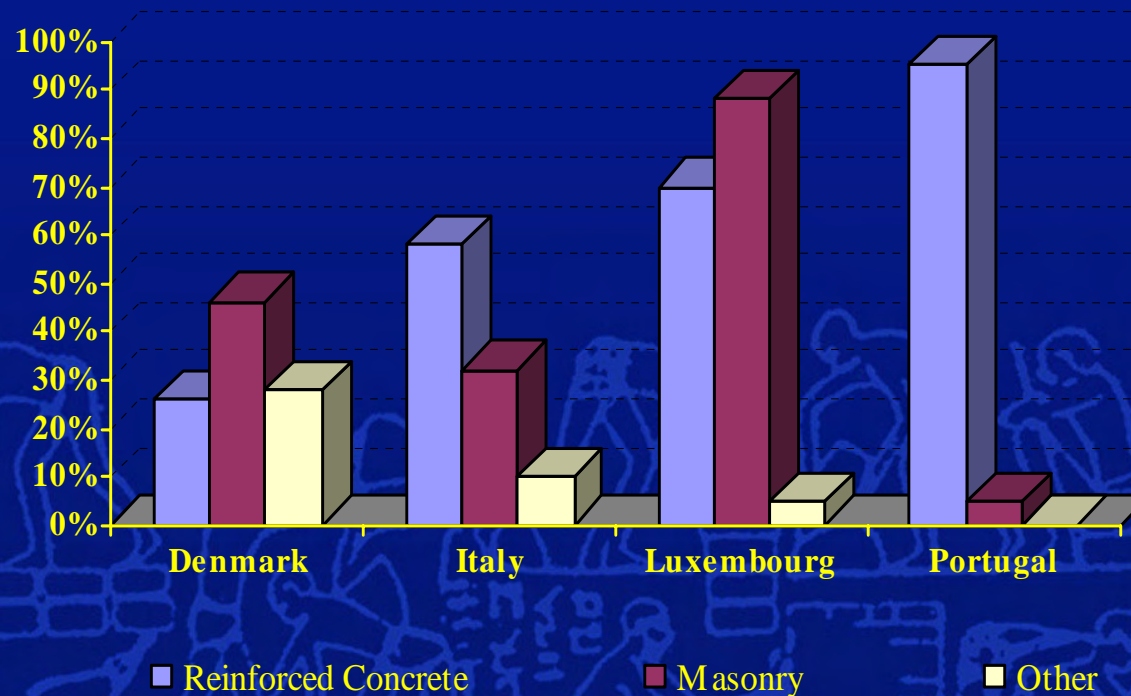


Weight of the different type of construction works and buildings



INTRODUCTION (II)

The “sole” structural solution for new buildings in Portugal is the framed concrete structure. It is hoped that the situation will change with the recent developments and investments from the industry.



Comparison of structural solutions in some European countries

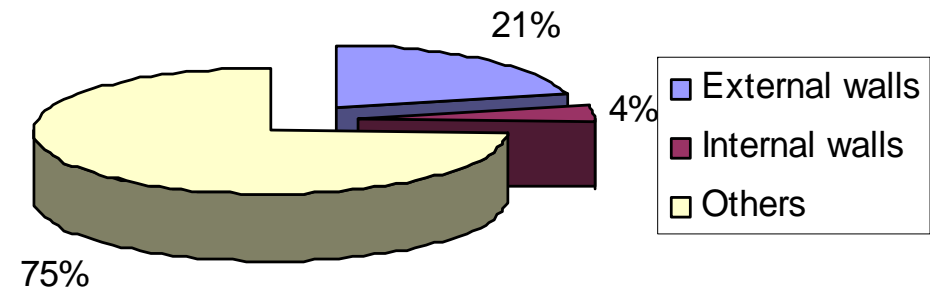


INTRODUCTION (III)

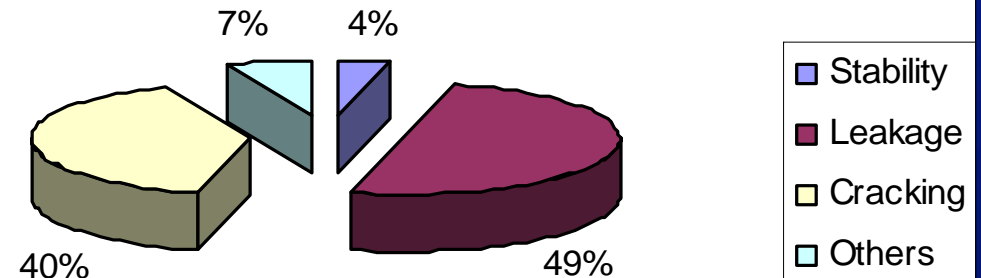
□ Construction Market in Portugal

- The masonry walls respond the several functional requirements, being their performance severely controlled by the quality of construction
- Damage in the masonry walls represents a normal pathology (therefore, unacceptable) in Portuguese construction

Damage in buildings



Damage in external walls



Importance of damage



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INTRODUCTION (IV)



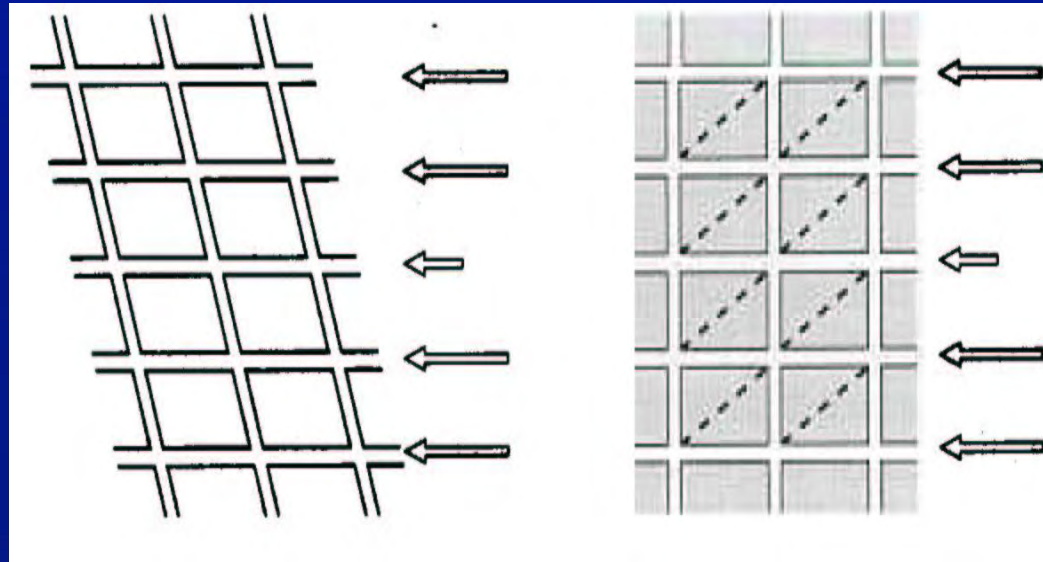
Excessively deformable slabs



Deficient interaction with the structure



INTRODUCTION (V)



Masonry does not know that it is NOT load bearing



Thermal bridges



Unacceptable joints



INTRODUCTION (VI)



Unacceptable grooving



Stability risks



Expansion of bricks



Insufficient detailing



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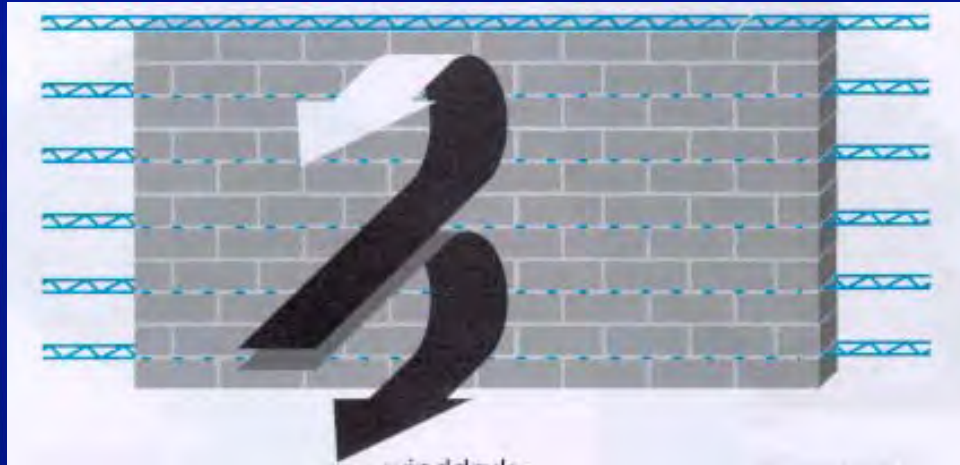
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CASE STUDIES USING BED JOINT REINFORCEMENT (APPLICATIONS)

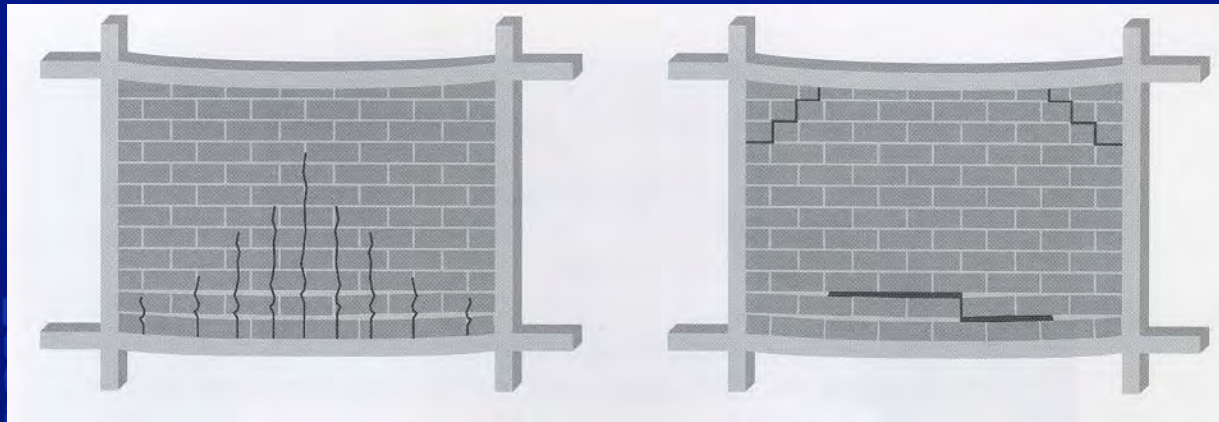




DESIGN



Horizontal Actions
(Wind and Earthquakes)



Deformation of the
supporting elements

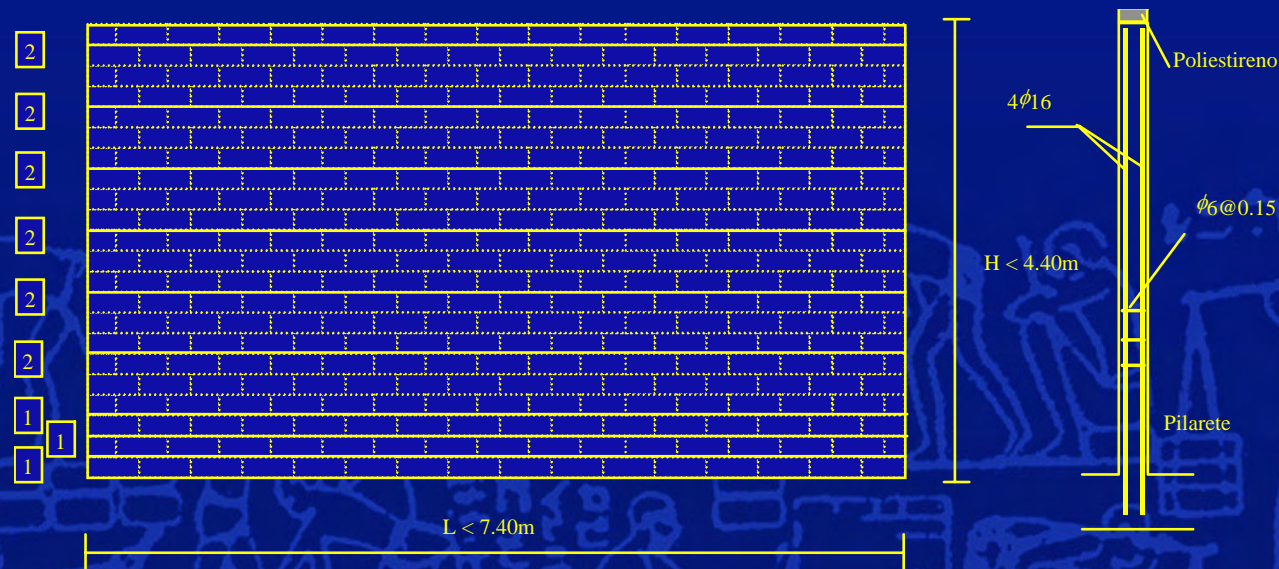




LISBOA (New Stadium for Sporting)

□ Problem and Solution

- Masonry infill walls (non-structural) with large dimensions
- Usage of bed joint reinforcement to resist out-of-plane bending and crack control
- More efficient and cost competitive solution, with respect to the traditional solution with reinforced concrete elements



Panels of 7-9 m x 4.4 m, with
vertical concrete elements
MURFOR each 2 or 3 courses



LISBOA (New Stadium for Sporting)

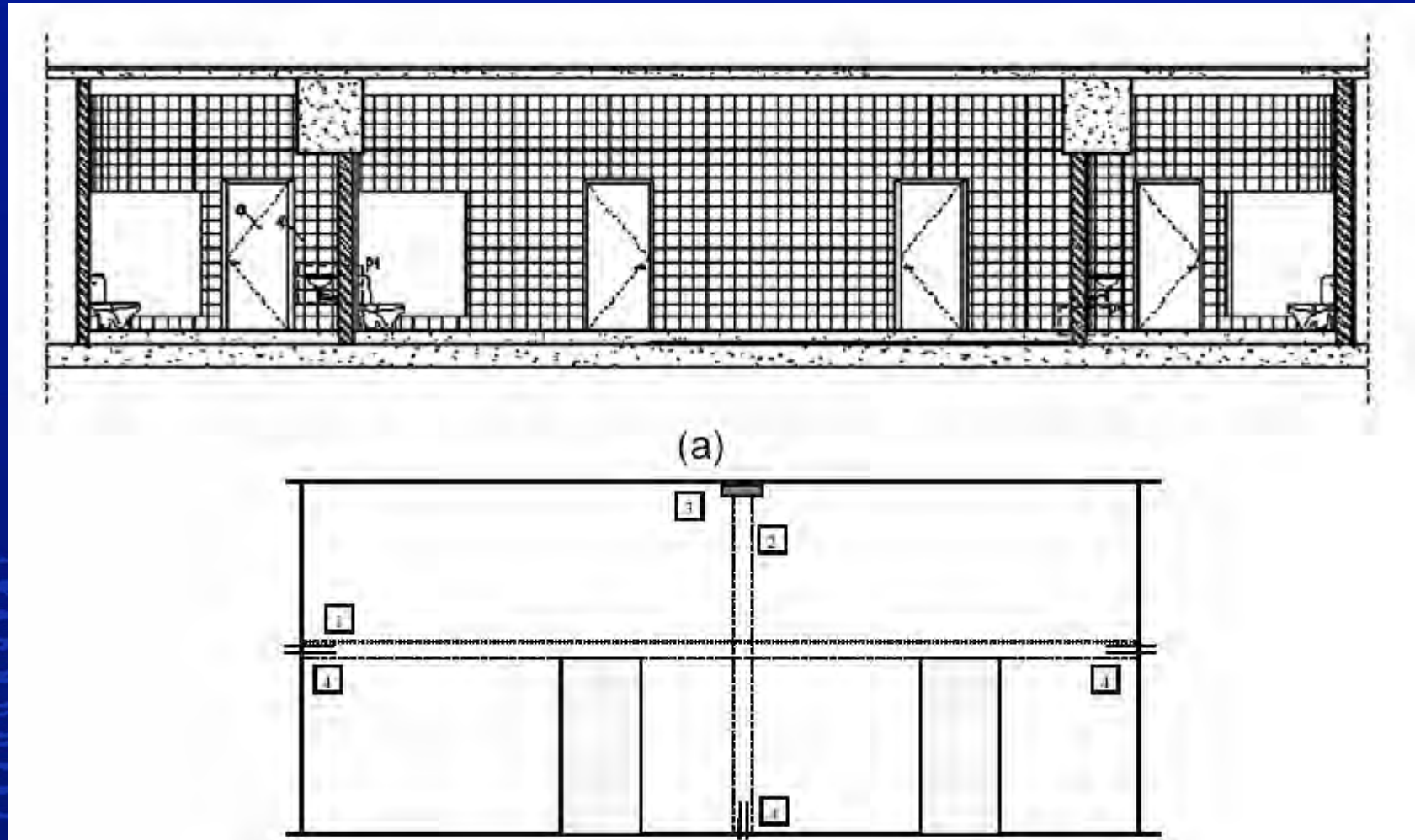
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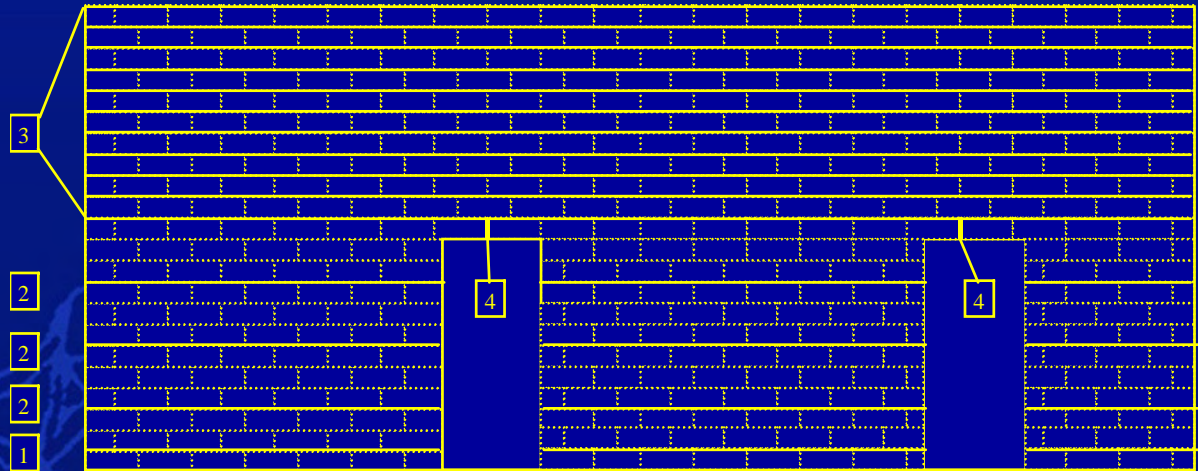
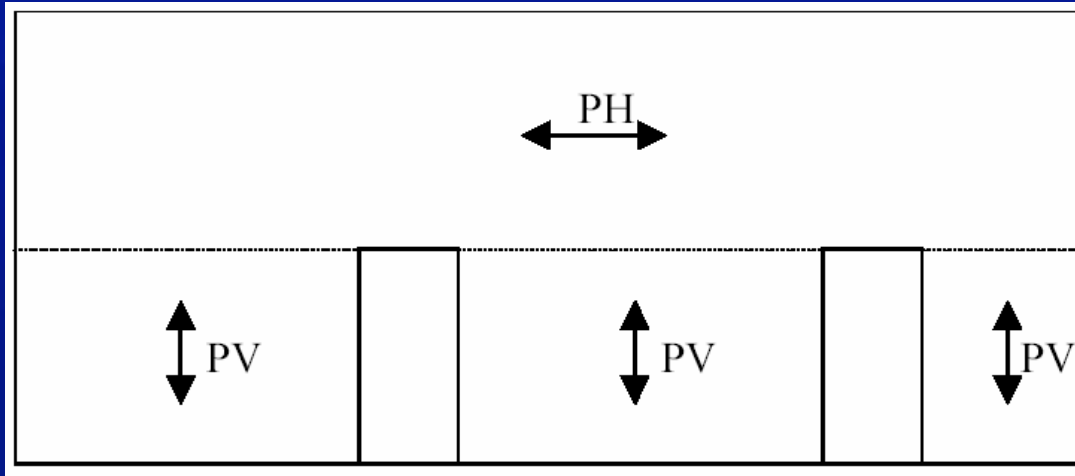
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Proposed original solution

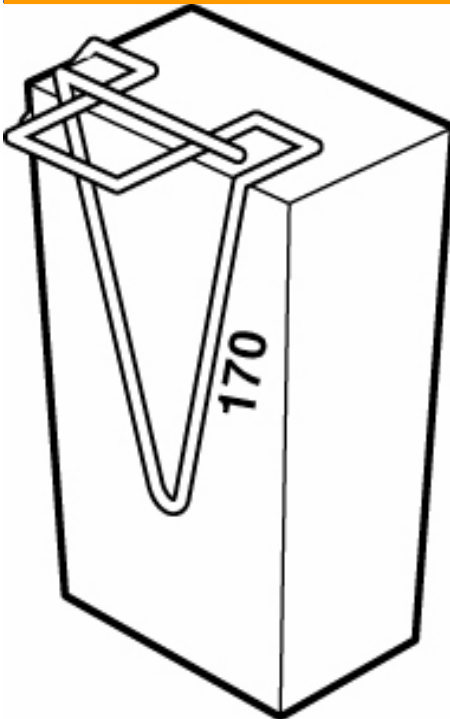


LISBOA (New Stadium for Sporting)



Panel of 10.4 m x 4.4 m
MURFOR each 3 courses (base)
MURFOR in all courses (top)

Adopted alternative solution



LISBOA (New Stadium for Benfica)



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BRAGA (New Municipal Stadium)



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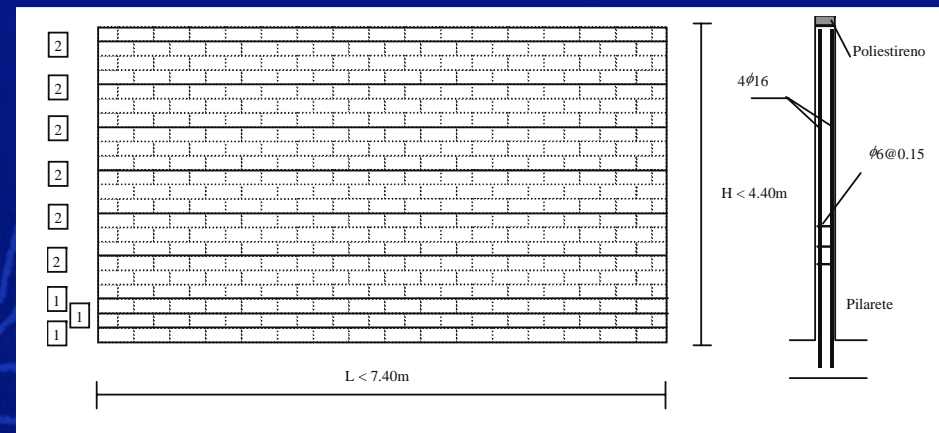
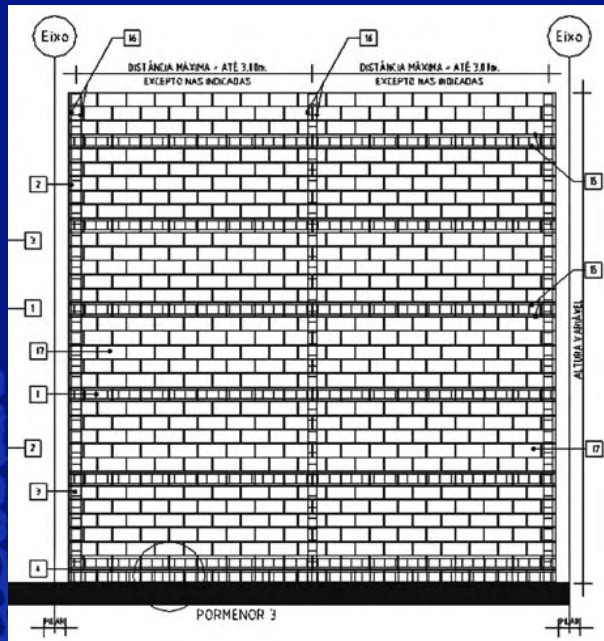




LISBOA (Odivelas Parque)

□ Cost Analysis

- Masonry panels (non-structural) with generalized spans of 12 m (up to 16 m) and heights of 6.0 m (up to 8.0 m)
- Usage of bed joint reinforcement to resist out-of-plane bending and for crack control



Horizontal elements: 4.0 euros / m²
Vertical elements: 1.6 euros / m²
Special shaped blocks: 2.0 euros / m²

Bed joint reinforcement: 2.8 euros / m²
Gain in workmanship: -6.9 euros / m²
COST: -234.000 euros
(in 20.000 m²)



Conclusions and remedial actions

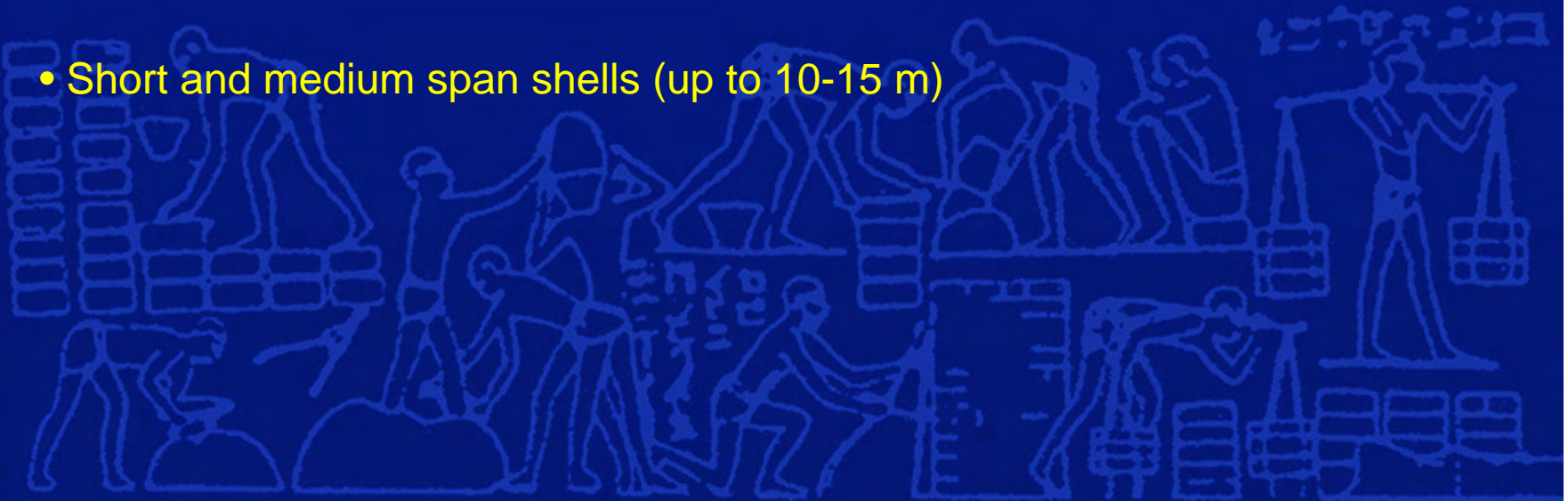
- ❑ Cracking of non-loadbearing walls is a major defect of the building industry. Bed joint reinforcement is a possible solution for this problem.
- ❑ The usage of bed joint reinforcement can also allow building large size non-loadbearing walls, with better performance and lower cost.
- ❑ Innovative case studies are presented and discussed.
- ❑ According to the new European seismic regulations, non-structural masonry infills should be taken into account in the seismic analysis. The adverse effects of irregularity must be considered and collapse must be avoided, Bed joint reinforcement or other similar solutions should be adopted in areas of high seismicity.



A NEW STRUCTURAL PRODUCT (I)

□ Development of industrialised reinforced masonry solutions for medium span shells

- Four European countries (Germany, Italy, Portugal and Spain)
- Project CRAFT / European Community (11 / 2001 to 07/ 2004)
- Facing ceramic bricks
- Short and medium span shells (up to 10-15 m)





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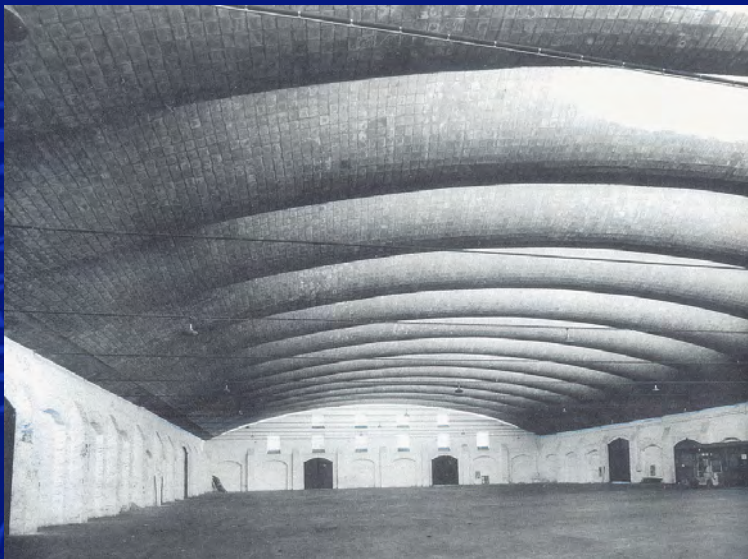
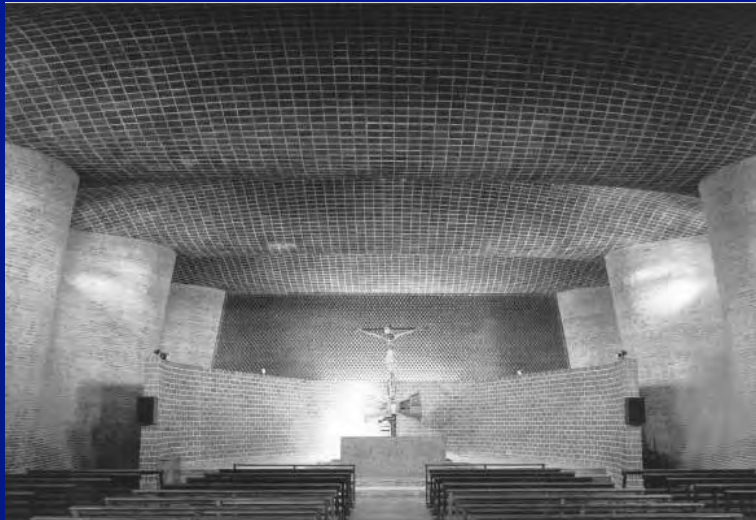


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A NEW STRUCTURAL PRODUCT (II)



Inspiration in Eladio Dieste's work (1917-2000)



A NEW STRUCTURAL PRODUCT (III)



Partial prefabrication (UPC, Spain)



Full prefabrication (UM, Portugal)



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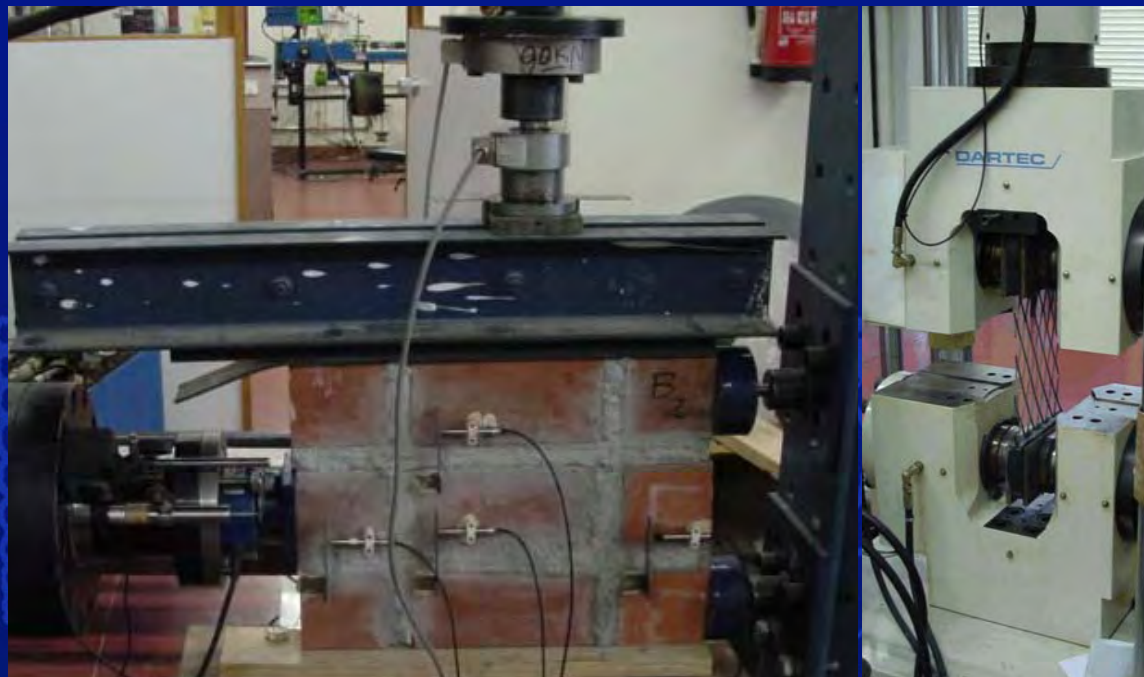


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A NEW STRUCTURAL PRODUCT (III)



R&D program



A NEW STRUCTURAL PRODUCT (IV)



Results

