



• U • C •

University Tower Conservation and Restoration Works

PARIS
1866



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A close-up photograph of a clock face. The clock has a white dial with black Roman numerals. A green patina hand is visible, pointing towards the bottom right. The text "PARIS 1866" is printed on the dial. A red horizontal band is overlaid across the center of the image.

Goal

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A photograph of a stone bell tower, known as the University Tower, featuring a large bell in an arched opening and a statue on a roof finial. A semi-transparent blue band is overlaid across the middle of the image.

Passion

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Doubt

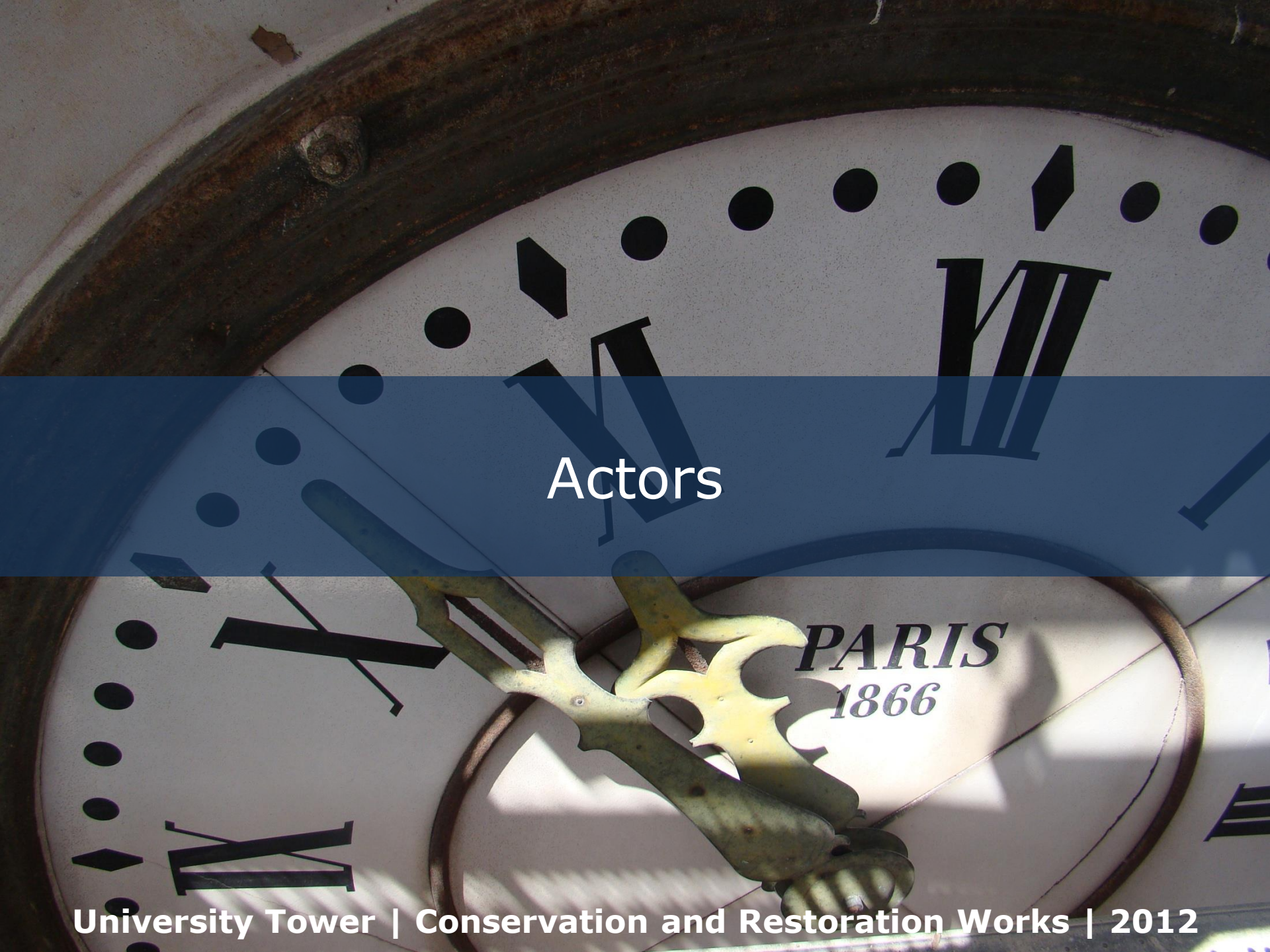


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Challenge

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A close-up photograph of a clock face. The clock has a white dial with black Roman numerals. A decorative, ornate hand is visible, pointing towards the bottom right. The text "PARIS 1866" is inscribed on the dial. A semi-transparent blue horizontal band is overlaid across the middle of the image.

Actors

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AUTHORS

CONSERVATION AND RESTORATION

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Victor Mestre

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Luís Ribeiro

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ARCHAEOLOGY

Sónia Filipe

ELECTRICITY

Fernando Martins

COORDINATION OF SAFETY SYSTEM

Luís Monsanto, Unipessoal, Lda

ARCHAEOLOGICAL MONITORING

DRYAS Arqueologia, Lda

CONTRACTOR

AOF

Augusto de Oliveira Ferreira & Cª Lda

TECHNICAL DIRECTOR

Filipe Oliveira Ferreira

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GCU | DGEEI | Manuel Ribeiro | Luís Ferreira Alves

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Luísa Beato | Nuno Campos

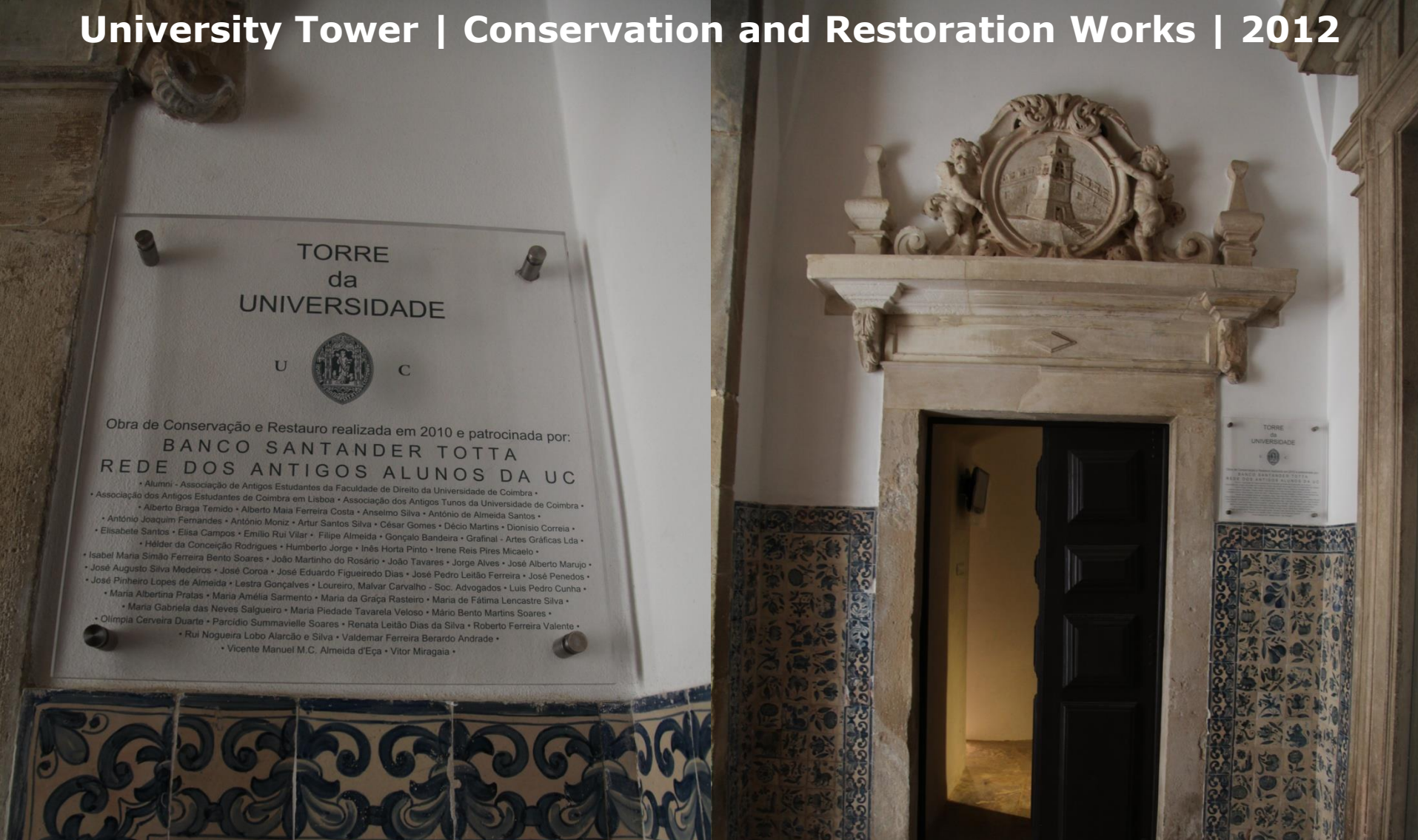
Milideias-comunicação visual, Lda

OTHER SUPPORT

DIIC | Science Museum

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Santander Totta

REDE
UC
REDE DE ANTIGOS ESTUDANTES
DA UNIVERSIDADE DE COIMBRA

A photograph of the University Tower, a historic building with a dark tiled roof and a clock tower. The clock tower is surrounded by scaffolding, indicating restoration work. A red semi-transparent banner is overlaid across the middle of the image. The word "Project" is written in white text on the banner. The sky is clear blue.

Project

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Knowledge

5m

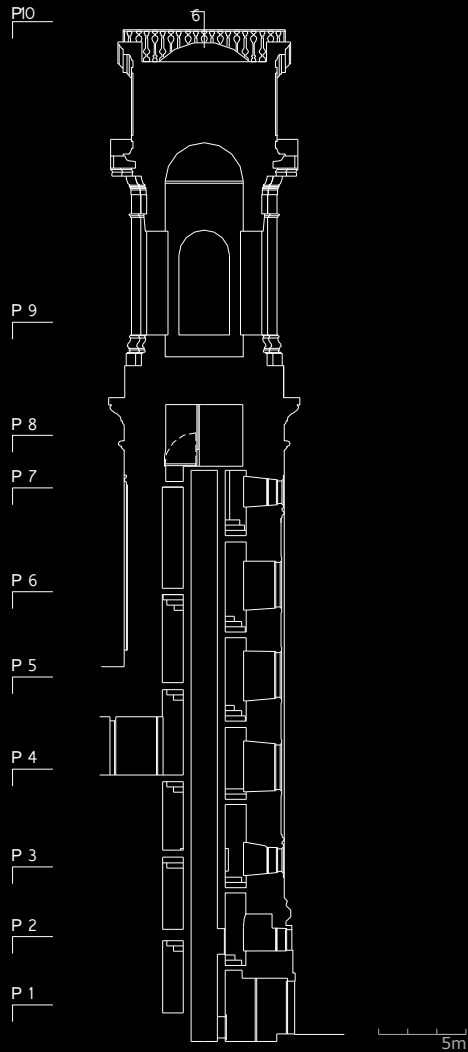
EAST ELEVATION

SOUTH ELEVATION

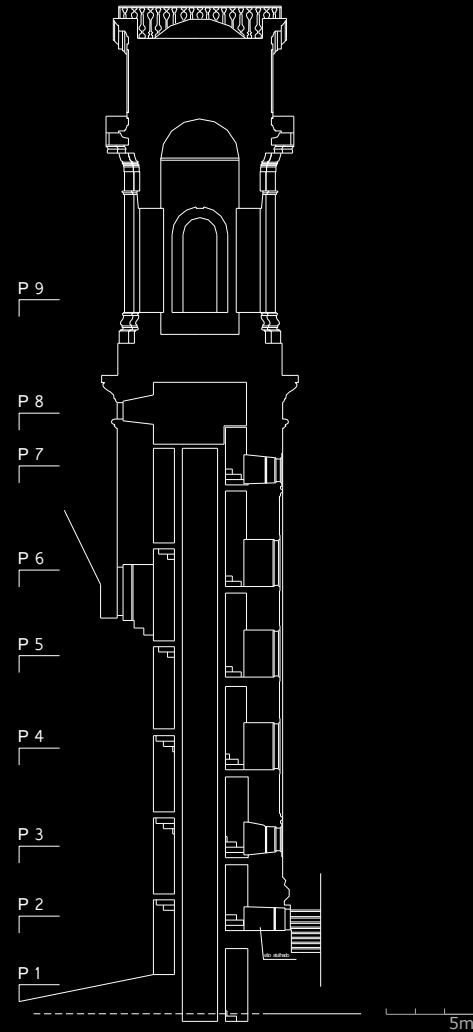
NORTH ELEVATION

WEST ELEVATION

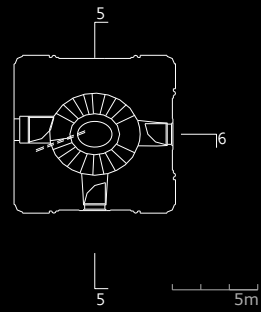
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SECTION 5



SECTION 6





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P10

P9

P8

P7

P6

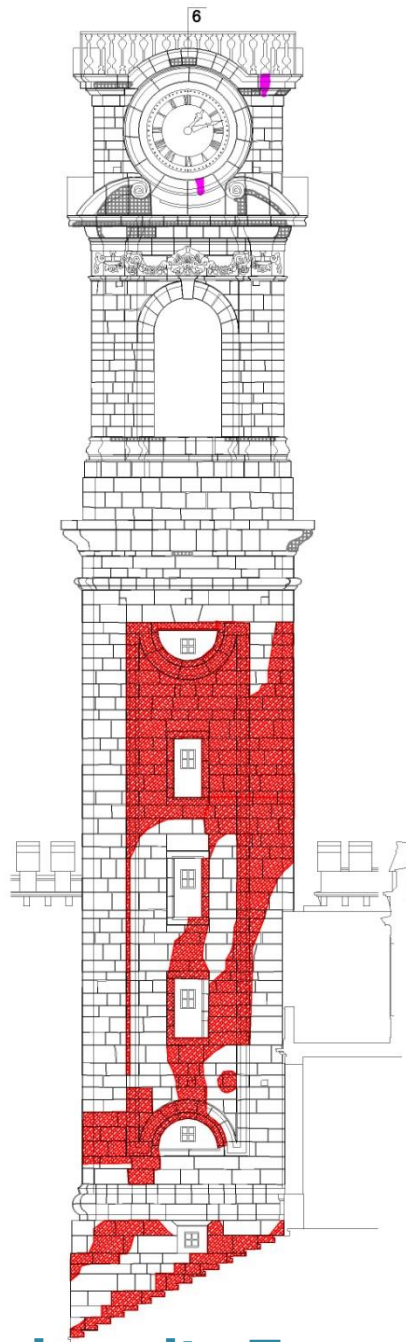
P5

P4

P3

P2

P1



P10

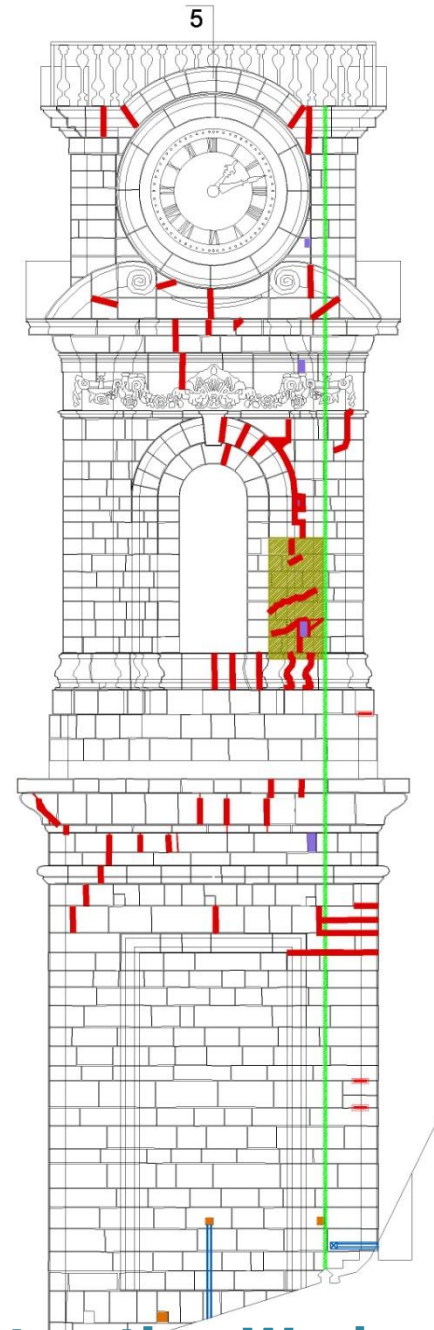
P9

P8

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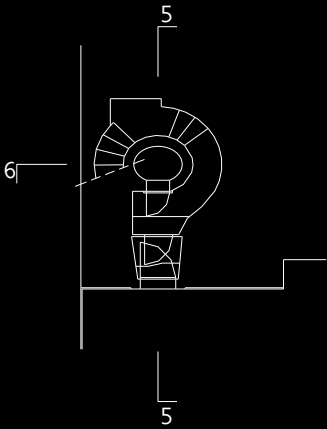
P6

P5

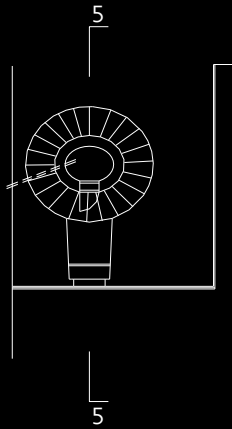


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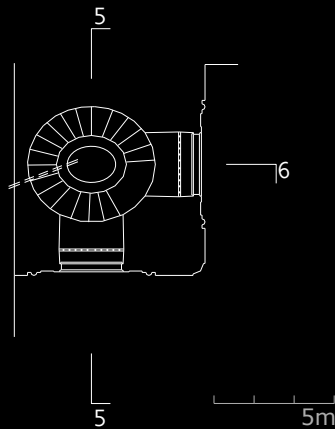
PLAN 1 (ENTRY)



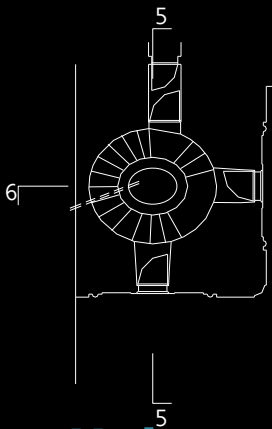
PLAN 2 (WICKET)



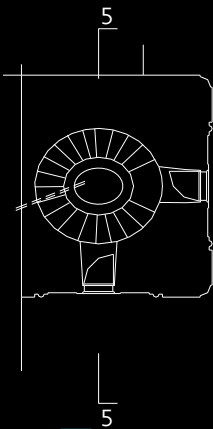
PLAN 3 (LARGE WINDOW)



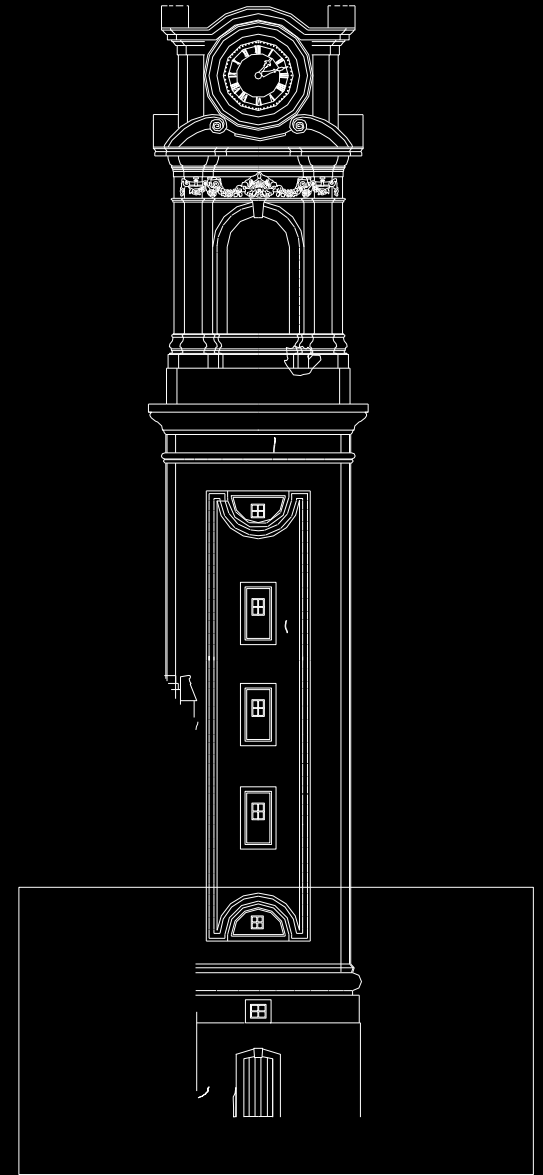
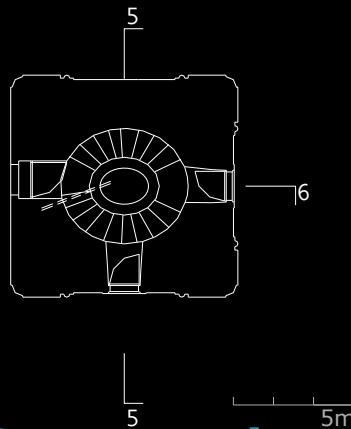
PLAN 4 (1ST DOOR)



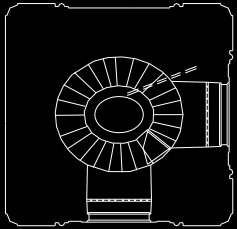
PLAN 5 (2ND DOOR)



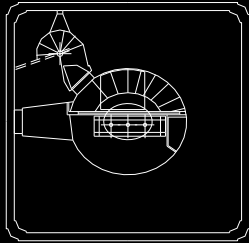
PLAN 6 (3RD DOOR)



PLAN 7 (2ND LARGE WINDOW)

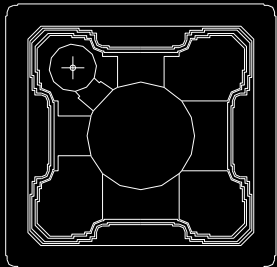


PLAN 8 (CLOCK)

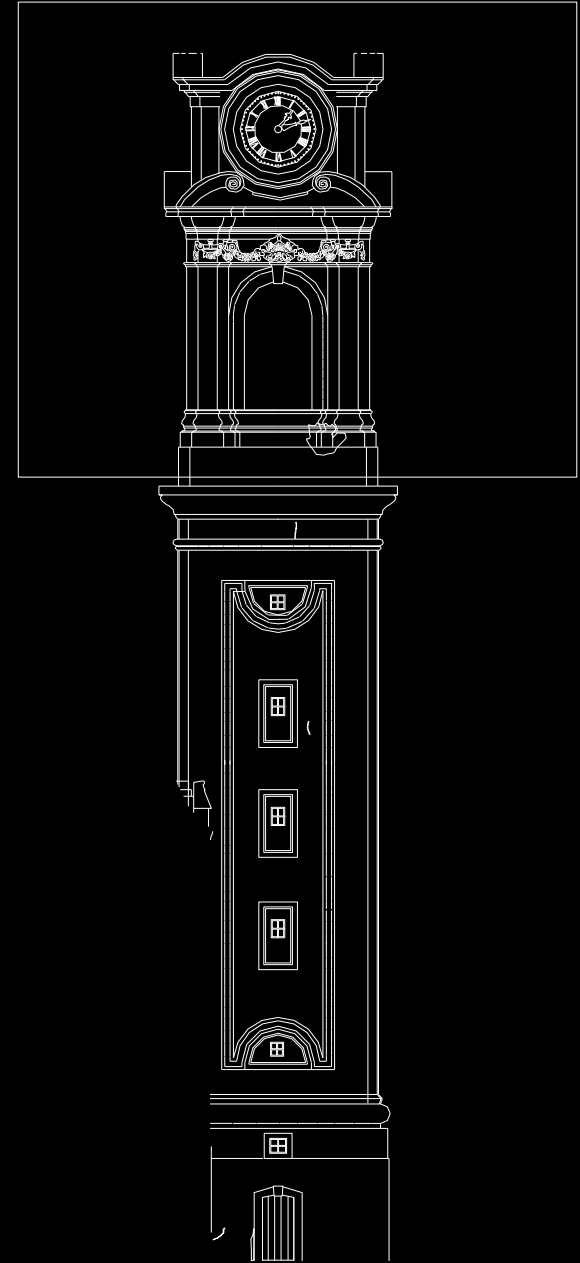
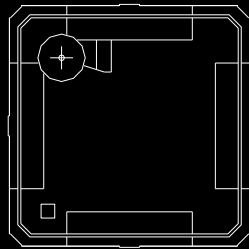


5m

PLAN 9 (BELLS)



ROOF PLAN





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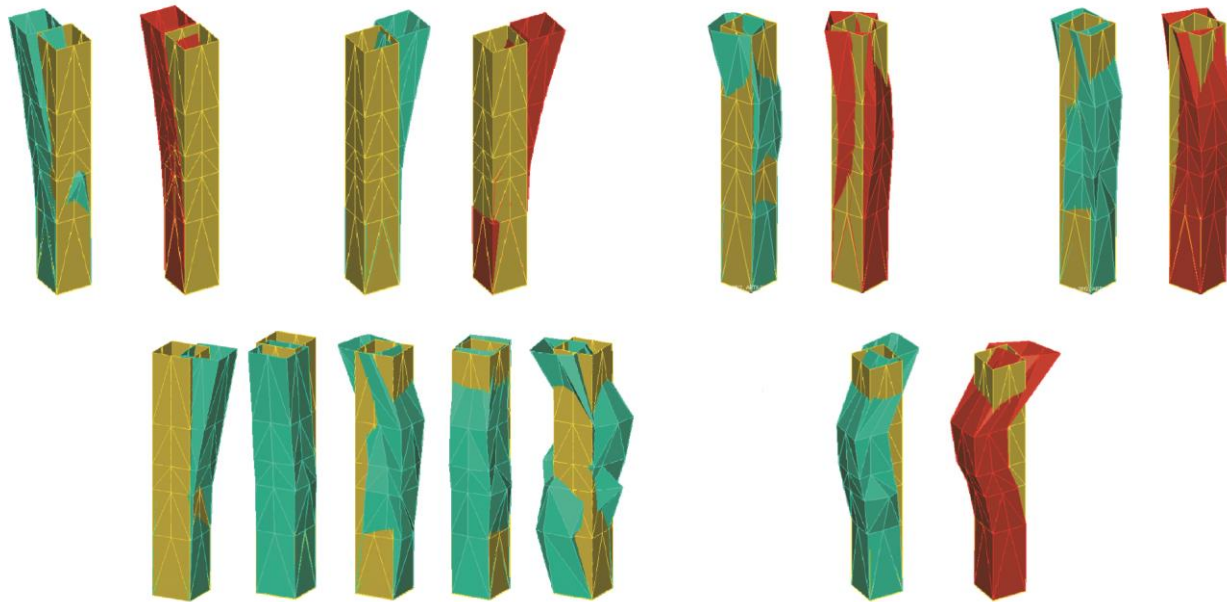


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The background of the slide is a close-up photograph of a stone wall. The stones are light-colored, possibly limestone or sandstone, with visible texture, including small pits and some staining. A dark blue, semi-transparent horizontal band runs across the middle of the image. The word "Research" is centered within this band in a white, sans-serif font.

Research

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MODAL IDENTIFICATION OF THE COIMBRA UNIVERSITY TOWER

ISISE
...
Department of Civil Engineering
...
University of Coimbra

Carlos Rebelo, Eduardo Júlio, Daniel Dias da Costa
presented at the:

UNICEP

JÚLIO, E., REBELO, C., DIAS-da-COSTA, D., *Structural Diagnosis of the Tower of the University of Coimbra by Modal Identification*, Elsevier, Engineering Structures 30 (12): 3468-3477 DEC 2008.

MODAL IDENTIFICATION OF THE COIMBRA UNIVERSITY TOWER

Introduction

History

- The University of Coimbra was founded in 1290
- The Tower was erected between 1728 and 1733
- Located on the top of the highest hill of Coimbra
- Ex-libris of the university and of the city itself.



MODAL IDENTIFICATION OF THE COIMBRA UNIVERSITY TOWER

Introduction

History

- A proposal was submitted to include the cluster of buildings in UNESCO's World Heritage List
- The tower is part of that cluster of buildings dedicated to the production and dissemination of knowledge



MODAL IDENTIFICATION OF THE COIMBRA UNIVERSITY TOWER

Introduction

Motivation for this research study

- Recently, an inspection was undertaken to evaluate the state of conservation of the tower.
- Some anomalies, such as degradation of joints and cracked or missing stone blocks, were identified.



MODAL IDENTIFICATION OF THE COIMBRA UNIVERSITY TOWER

Introduction

Structural identification and FE model calibration

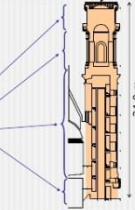
- Assess possible structural damages
- Safety concerning extreme (seismic, wind) events
- Possibility of opening the Tower for tourist visits.



MODAL IDENTIFICATION OF THE COIMBRA UNIVERSITY TOWER

Description of the Tower

- The tower has a rectangular plant and equal side views
- From top to bottom, the tower presents:
 - the terrace;
 - the zone of the clock;
 - the zone of the bells;
 - the main body;
 - the base with the entrance



MODAL IDENTIFICATION OF THE COIMBRA UNIVERSITY TOWER

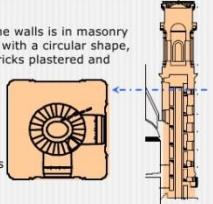
Description of the Tower

cross sections

The outer leaflet of the walls is in masonry and the inner leaflet, with a circular shape, is made of ceramic bricks plastered and whitewashed.

On the centre of the tower there is a wall also made of ceramic bricks

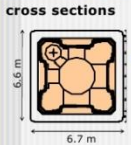
Connecting both walls, limestone steps form a spiral stairs leading to the last window.



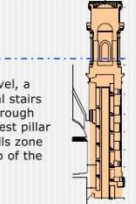
MODAL IDENTIFICATION OF THE COIMBRA UNIVERSITY TOWER

Description of the Tower

cross sections



At this level, a new spiral stairs begins through the Northwest pillar of the bells zone to the top of the tower.

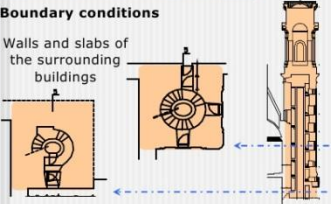


MODAL IDENTIFICATION OF THE COIMBRA UNIVERSITY TOWER

Description of the Tower

Boundary conditions

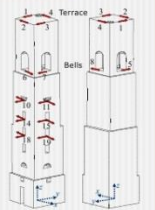
Walls and slabs of the surrounding buildings



MODAL IDENTIFICATION OF THE COIMBRA UNIVERSITY TOWER

Measurements

- 8-channel acquisition unit
- 20 degrees of freedom
- 14 locations conditioned by the accessibility from inside of the tower
- Four reference transducers at the terrace level
- Four setups:
 - bell level;
 - top semi-circular window;
 - third rectangular door;
 - second rectangular door.

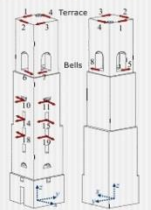


MODAL IDENTIFICATION OF THE COIMBRA UNIVERSITY TOWER

Measurements

Dynamic loading

- particularly windy day
- short periods of bell electromechanical operation
- some setups included bell swaying; those time periods were excluded from the analyzed time series
- There were two masts on the top of the tower
- an heavy mast introduced an almost harmonic signal in its first natural frequency (~1Hz)

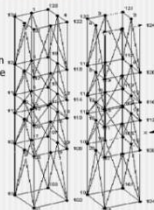


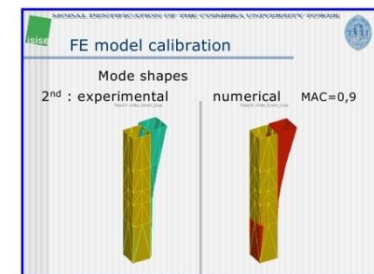
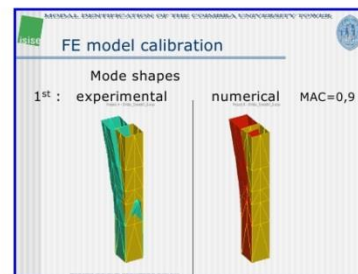
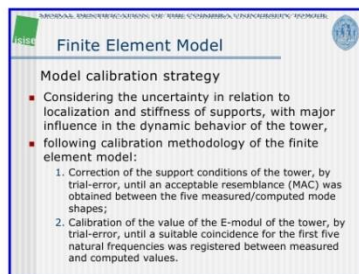
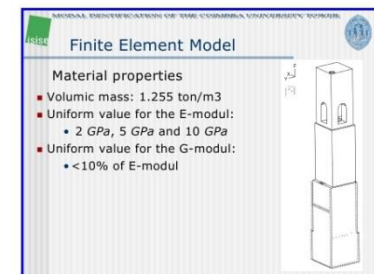
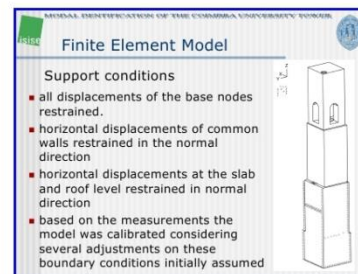
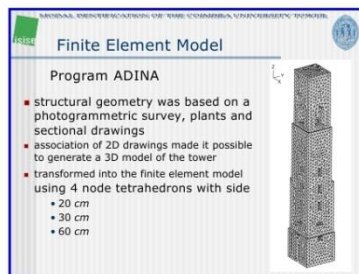
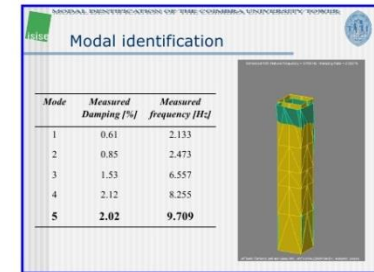
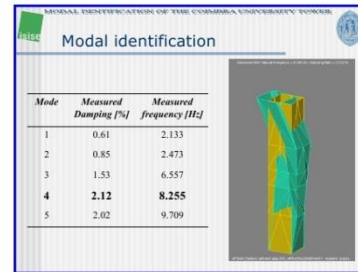
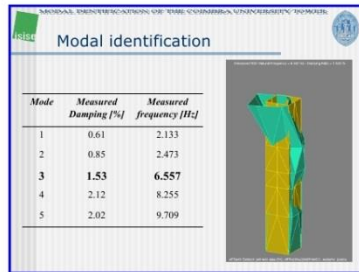
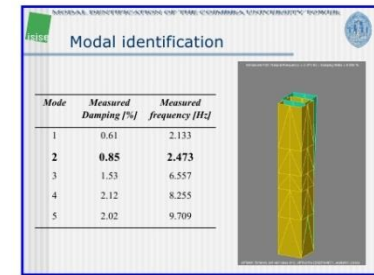
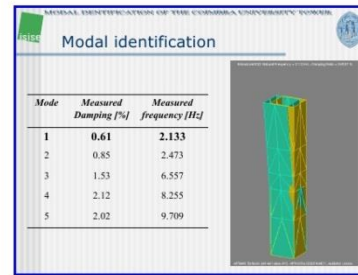
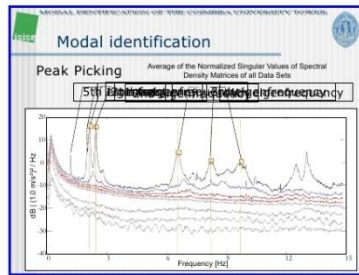
MODAL IDENTIFICATION OF THE COIMBRA UNIVERSITY TOWER

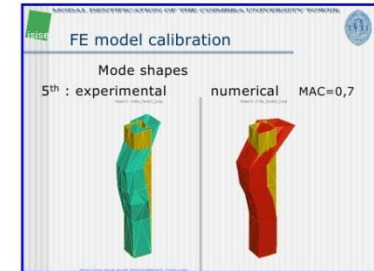
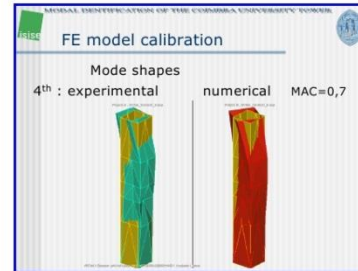
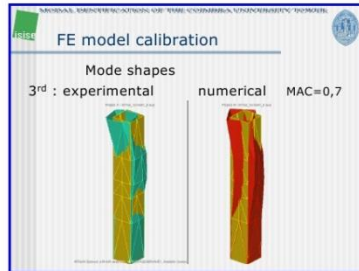
Modal identification

Analysis of the data

- decimation and low-pass filtering of the time series
- EFD - enhanced frequency domain decomposition - ARTeMIS software
- mesh used to visualize the mode shapes include 'slave' nodes







MODAL IDENTIFICATION OF THE COLOMBIA UNIVERSITY TOWER

FE model calibration

Uniform E-modul E=5.0GPa

Mode	Measured frequency [Hz]	Computed frequency [Hz]	Error %
1	2.133	2.152	-0.89
2	2.473	2.403	2.83
3	6.557	6.581	-0.37
4	8.255	8.160	1.15
5	9.709	9.583	1.30

MODAL IDENTIFICATION OF THE COLOMBIA UNIVERSITY TOWER

Conclusions

- Despite the lack of knowledge concerning the support conditions and the mechanical characteristics of materials, the results allow the conclusion that **the numerical model satisfactorily reproduces the dynamic response of the tower.**

MODAL IDENTIFICATION OF THE COLOMBIA UNIVERSITY TOWER

Conclusions

- Furthermore, it can be stated that, from this analysis, **there is not any evidence that the structural integrity of the tower is compromised.** In fact, if inadmissibly lower values had been obtained for the Young's modulus and/or shear modulus or if a different level of accuracy had been registered for one or more modal frequencies, one could have concluded that the integrity of the tower might be affected.

MODAL IDENTIFICATION OF THE COLOMBIA UNIVERSITY TOWER

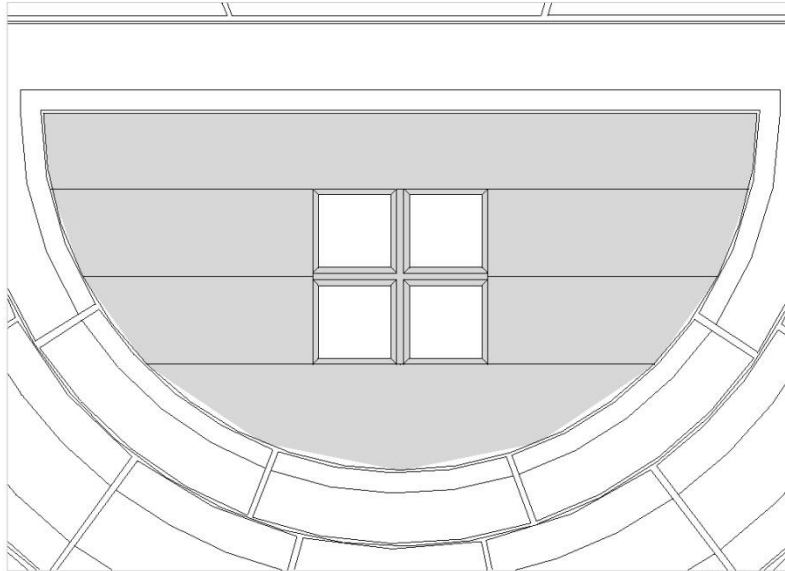
Conclusions

- Further investigations were also proposed to the owner:
 - Geometric survey of elements common to the tower and adjacent buildings, including connections;
 - Soundings to characterize the materials and their state of conservation of both exterior and interior walls of the tower, especially in the bells zone;
 - In situ and laboratorial testing for mechanical characterization of the structural materials of the tower;

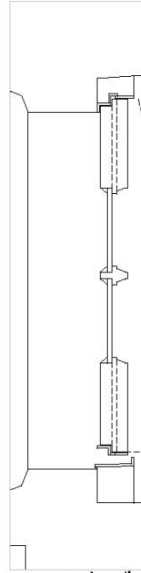
A 3D architectural rendering of the University Tower, showing the restoration work. The image is split horizontally: the top half shows the interior of the tower's upper section with a green-painted balcony and a central vertical shaft, while the bottom half shows the exterior of the tower with a large clock face. The text "Art | Reason" is overlaid in the center.

Art | Reason

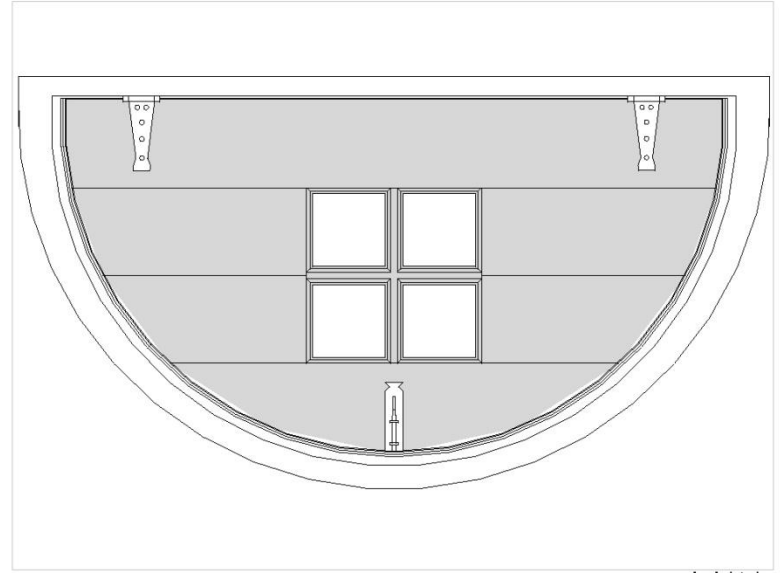
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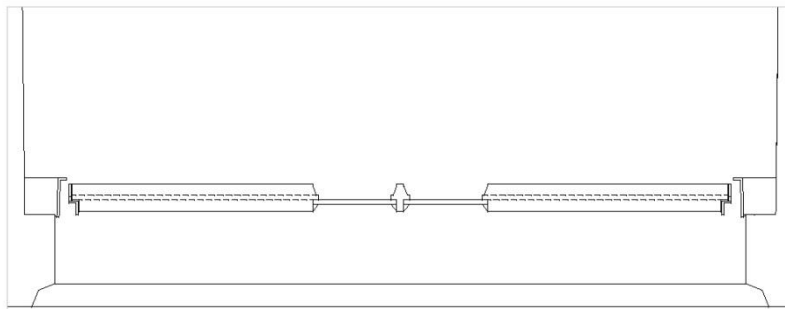
alçado exterior



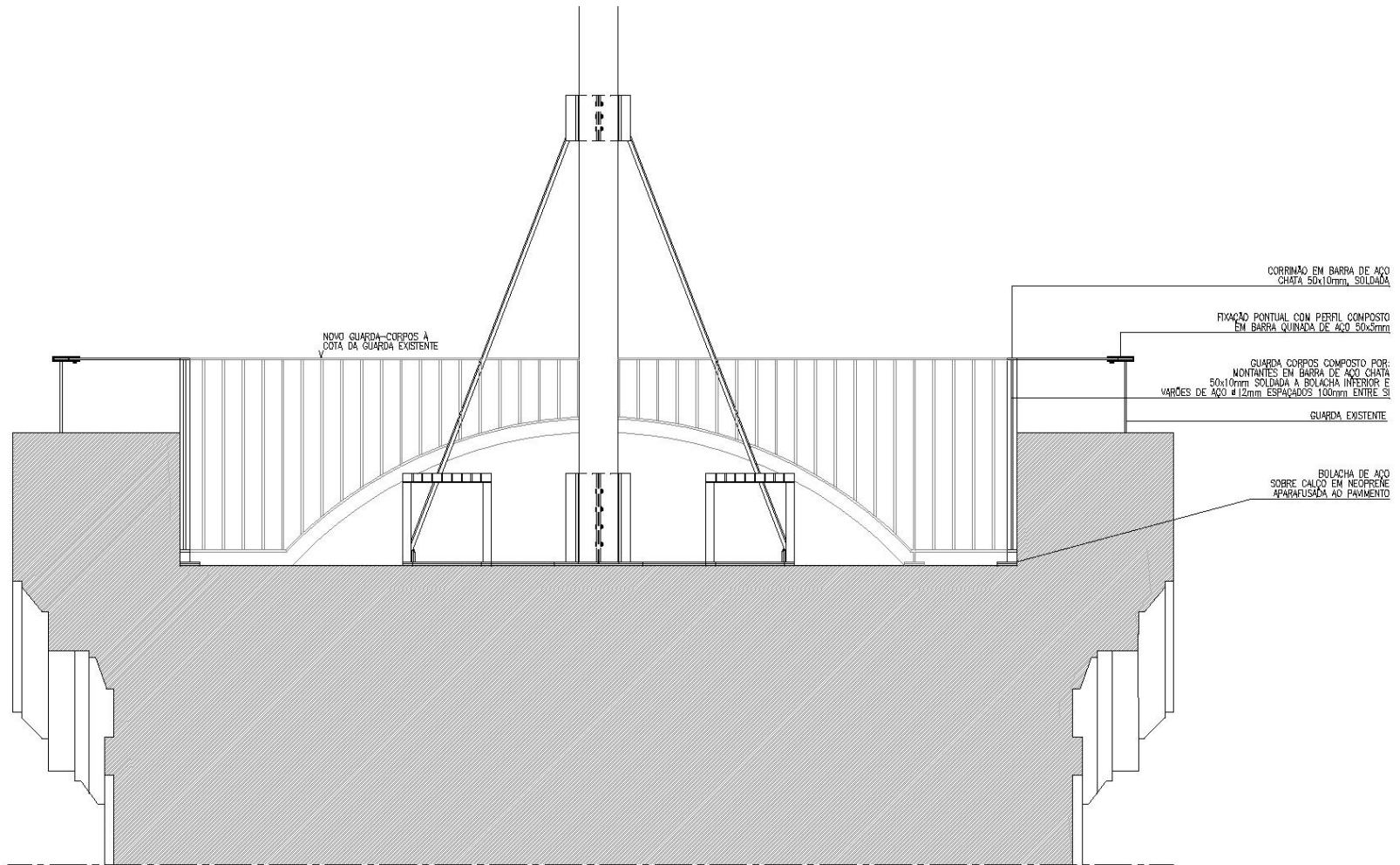
corte vertical



alçado interior



corte horizontal





NO ALTO

Getting close

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Educational Building Site



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NO ALTO DA TORRE



Estar no alto da Torre e olhar sobre a cidade de Coimbra e sobre o Rio Mondego faz parte do imaginário de universitários e visitantes mas poucos têm tido, até hoje, a possibilidade de o concretizar. A Torre "mirante" possibilita a leitura superior sobre o conjunto arquitetónico que forma a Universidade e uma vista global da cidade, enquanto urbanidade coerente, integrando as sucessivas adições ao longo de séculos, e ainda de toda a envolvente paisagística. A Torre se identifica com os edifícios históricos mais representativos de Coimbra e se revê, através deles, a evolução da cidade. Subir à Torre da Universidade tem, também, um sentido de conquista e de sucesso, reforçado pela dificuldade da tarefa, que exige determinação, controlo e esforço físico considerável. A intervenção prevista para a Torre propicia um novo ciclo na sua existência, ampliando a sua função e potenciando o interesse na visita ao Paço das Escolas.

Standing at the top of the tower and getting upon the city of Coimbra and the Mondego River is part of the imaginary of university students and visitors alike. But for few have had the possibility of doing so. The Tower "look-out" offers an extraordinary time of architectural and landscape observation and panoramic perspective of the city's urban environment, covering successive additions over the centuries, as well as the surrounding landscape. Being seen from the most representative historic buildings of Coimbra, and through them, the evolution of the city. Climbing to the top of the Tower also affords a sense of achievement and success, reinforced by the difficulty of the task, requiring determination, control and considerable physical effort. The intervention planned for the tower will give it a new cycle of existence, broadening its function and potentiating the interest in the visit to the Paço das Escolas.

EMPREITADA DE CONSERVAÇÃO
E RESTAURO DA TORRE
DA UNIVERSIDADE DE COIMBRA
CONSERVATION AND RESTORATION
OF THE UNIVERSITY TOWER

CONTEXTO HISTÓRICO E ARTÍSTICO
ARTISTIC AND HISTORICAL CONTEXT

A Universidade de Coimbra, que comemora 750 anos, constitui um dos patrimónios mais importantes do actual Paço das Escolas, na Alta da Cidade, no século XVI. A Torre da Universidade, apesar de ser um dos edifícios mais antigos do século XVIII, é o único que sobreviveu ao século XX, mantendo a sua estrutura original e a sua função de observação e de vista panorâmica da cidade. A Torre "mirante" possibilita a leitura superior sobre o conjunto arquitetónico que forma a Universidade e uma vista global da cidade, enquanto urbanidade coerente, integrando as sucessivas adições ao longo de séculos, e ainda de toda a envolvente paisagística. A Torre se identifica com os edifícios históricos mais representativos de Coimbra e se revê, através deles, a evolução da cidade. Subir à Torre da Universidade tem, também, um sentido de conquista e de sucesso, reforçado pela dificuldade da tarefa, que exige determinação, controlo e esforço físico considerável. A intervenção prevista para a Torre propicia um novo ciclo na sua existência, ampliando a sua função e potenciando o interesse na visita ao Paço das Escolas.



2 NO ALTO DA TORRE DEGRAU A DEGRAU

REAValiação DO ESTADO DE CONSERVAÇÃO

CHECKING OUT THE CONSERVATION STATE

A Torre está construída em cascalho branco da zona de Colúmbia, encontrando-se em condições de conservação, apesar de apresentar diversos problemas. Já previamente identificados. A falta de intervenção, e o abandono da superfície pétrea era muito heterogênea devido a diversos factores: colonização biológica (mossagranismos, fungos e líquenes, plantas e crustáceos negros), manchas de oxidação de elementos metálicos e a presença de estruturas naturais, típicas do encaixeamento das rochas calcárias.

The tower is built of white limestone from the region of Colúmbia, and is in reasonable condition, in spite of several anomalies already known in previous inspections. Before this intervention the stone consisted of quite heterogeneous as a result of different factors: the biological colonization (mossagranism, fungi and lichens, plants and crustaceans), black stains, oxidative oxidation of metal elements and natural structures typical of the fitting of limestone.

FACTORES DE LUGAR
A Torre está construída em cascalho branco da zona de Colúmbia, encontrando-se em condições de conservação, apesar de apresentar diversos problemas. Já previamente identificados. A falta de intervenção, e o abandono da superfície pétrea era muito heterogênea devido a diversos factores: colonização biológica (mossagranismos, fungos e líquenes, plantas e crustáceos negros), manchas de oxidação de elementos metálicos e a presença de estruturas naturais, típicas do encaixeamento das rochas calcárias.

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3 NO ALTO DA TORRE DEGRAU A DEGRAU

LIMPEZA DA SUPERFÍCIE PÉTREA

ORGANIZAÇÃO, ESTALEIRO E SEGURANÇA

O trabalho de conservação e restauro da superfície pétrea foi iniciado pela remoção dos agentes biológicos que colonizavam toda a área de espaço exterior.

Os estudos de carácter realísticos na fase de projecto foram analisados e concluídos-se a metodologia mais eficaz, que visasse a garantir uma leitura homogênea e que não removesse a patina natural desta peça arquitectónica. A Torre apresentava, essencialmente, líquenes, fungos, algas e vegetação superior, esta homogeneizada no fim do ciclo dos trabalhos de conservação.

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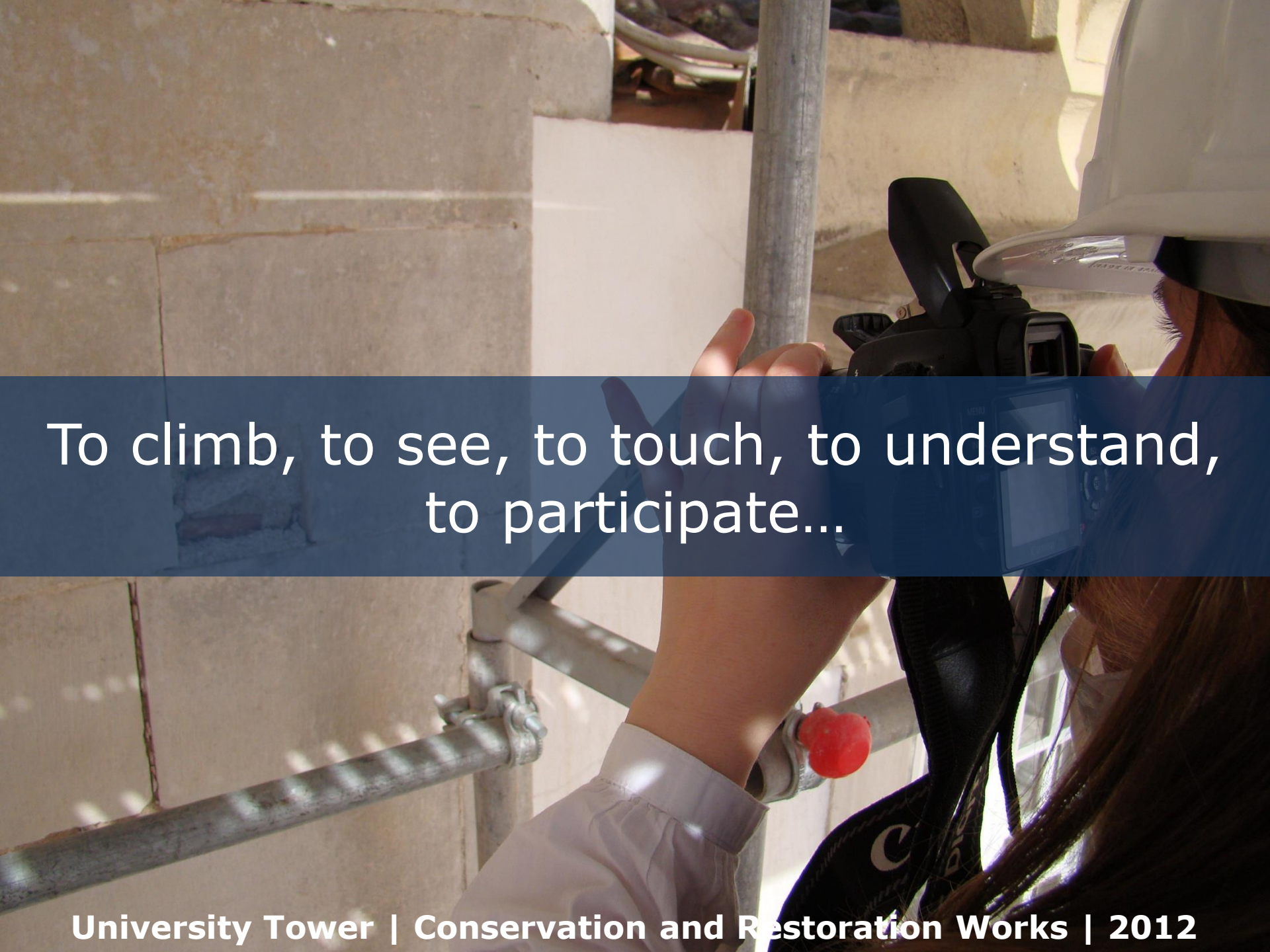
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As imagens mostram as diferentes fases do trabalho de conservação e restauro da superfície pétrea da Torre. Desde a limpeza inicial até à aplicação dos materiais de conservação.



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To climb, to see, to touch, to understand,
to participate...

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To go further

Filipe Pimentel



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A photograph of a worker in a white hard hat and yellow gloves using a blue hose to clean a stone wall. The worker is wearing a white long-sleeved shirt and dark pants. The background is a large, textured stone wall with visible joints and some staining. A red horizontal band is overlaid across the middle of the image.

Intervention

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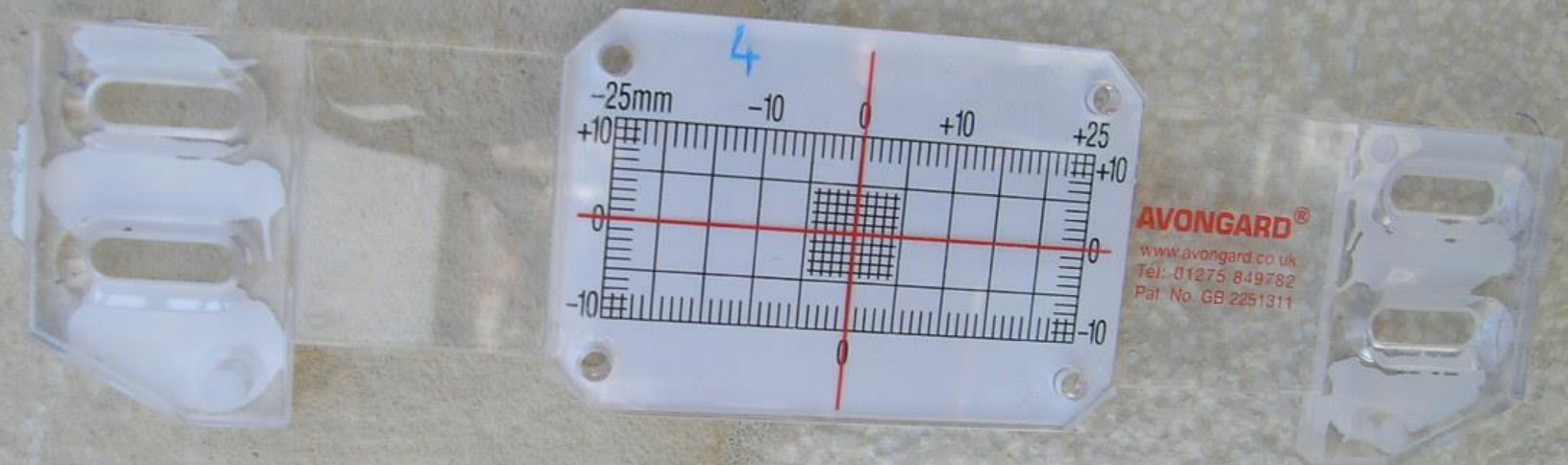


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The image is a composite of two photographs. The top half shows the University Tower, a tall, narrow stone structure, completely encased in a complex network of metal scaffolding. A large white sheet is draped over the right side of the tower. The bottom half shows a courtyard of the University of Coimbra, featuring a two-story building with a series of arches on the ground floor and a balcony with a decorative wrought-iron railing on the upper floor. A set of stairs leads up to the balcony. A red semi-transparent banner is overlaid across the middle of the image, containing the text 'Present | Futur'.

Present | Futur

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A low-angle photograph of the University Tower, a tall, light-colored stone structure with a clock face and a bell. The tower is set against a blue sky with scattered white clouds. The image is framed by a dark blue border. A semi-transparent dark blue horizontal band across the middle of the image contains the text "To enjoy".

To enjoy

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To care

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Best before the...

13

FEB

2011

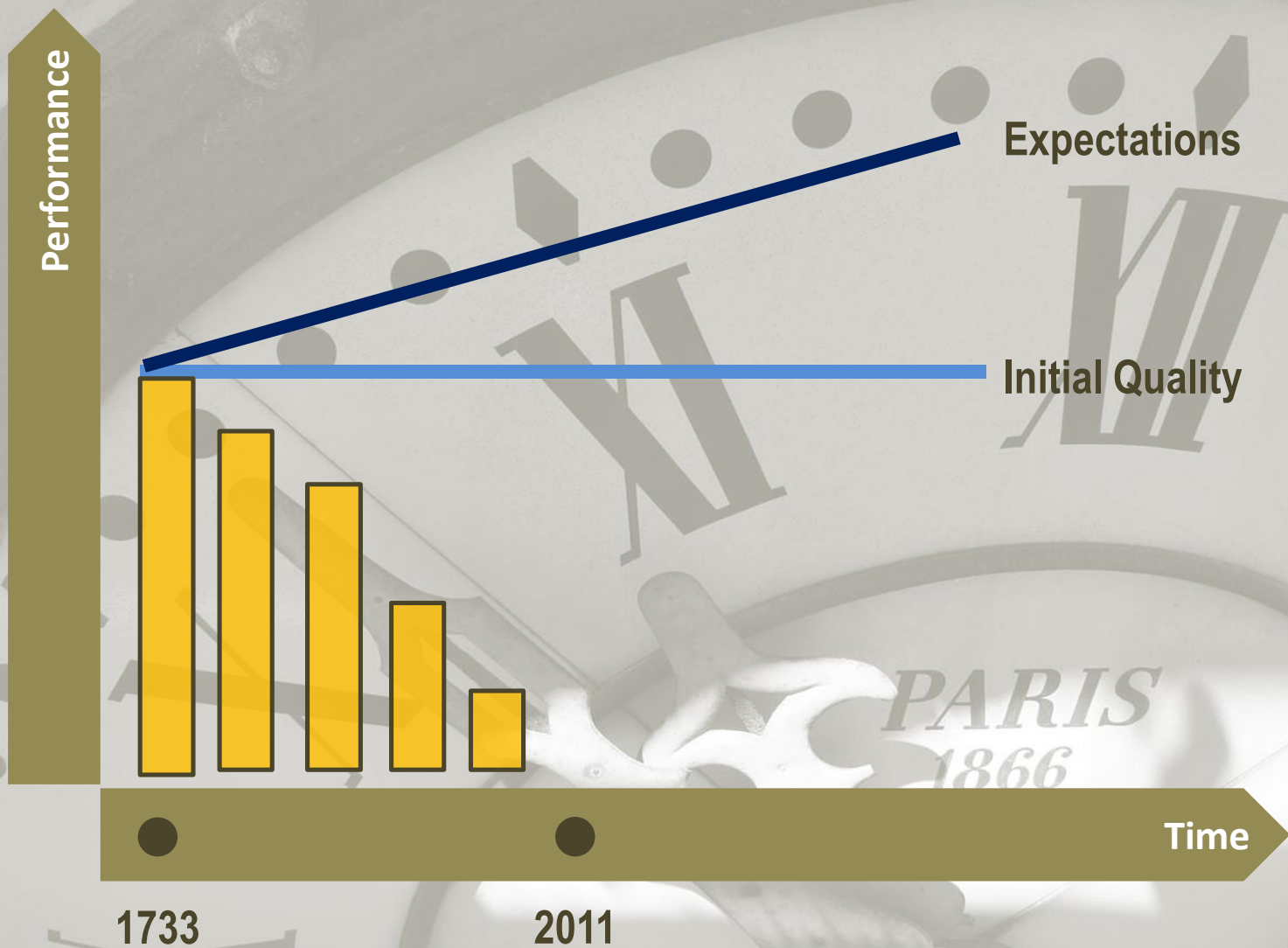
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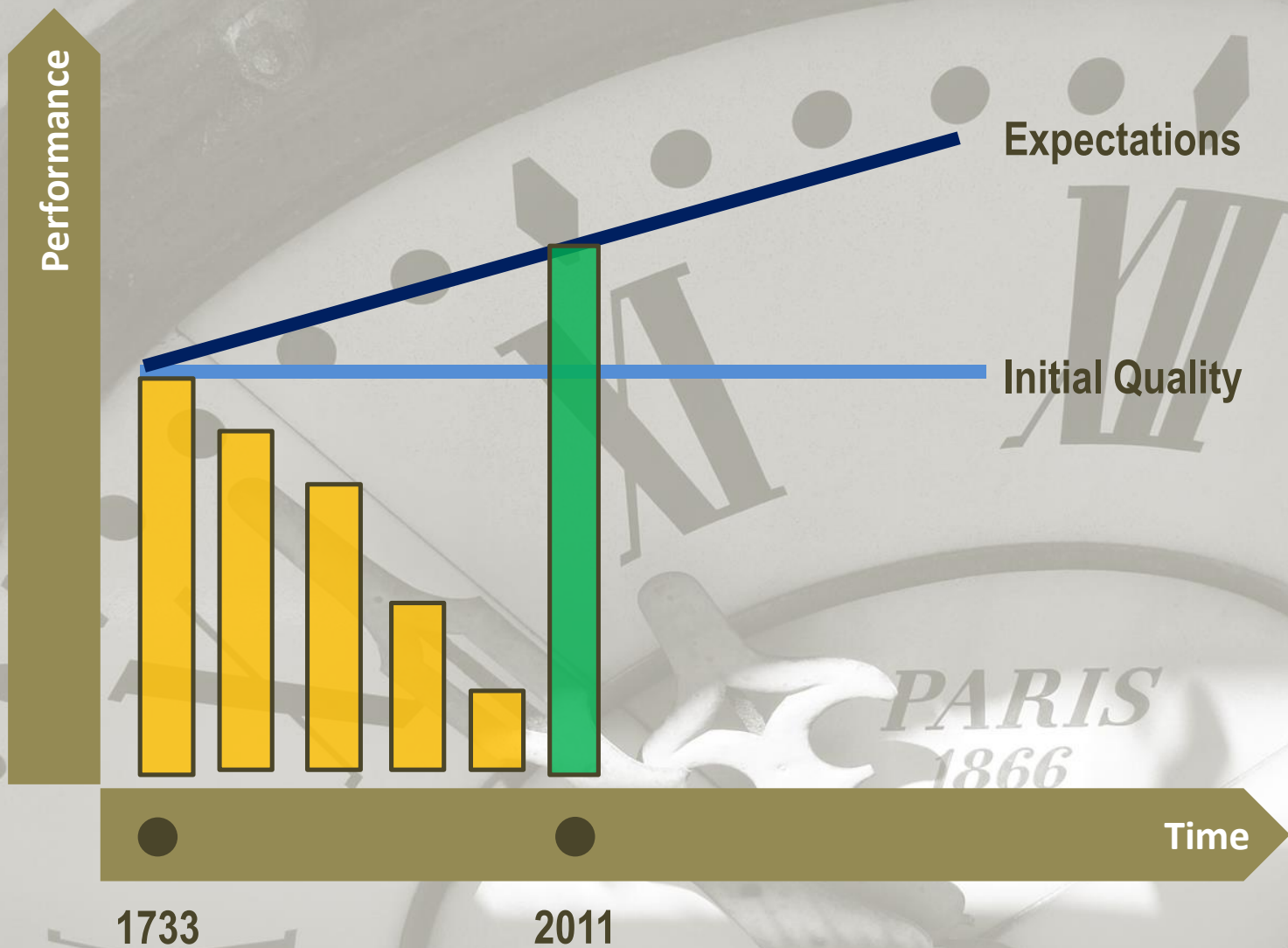
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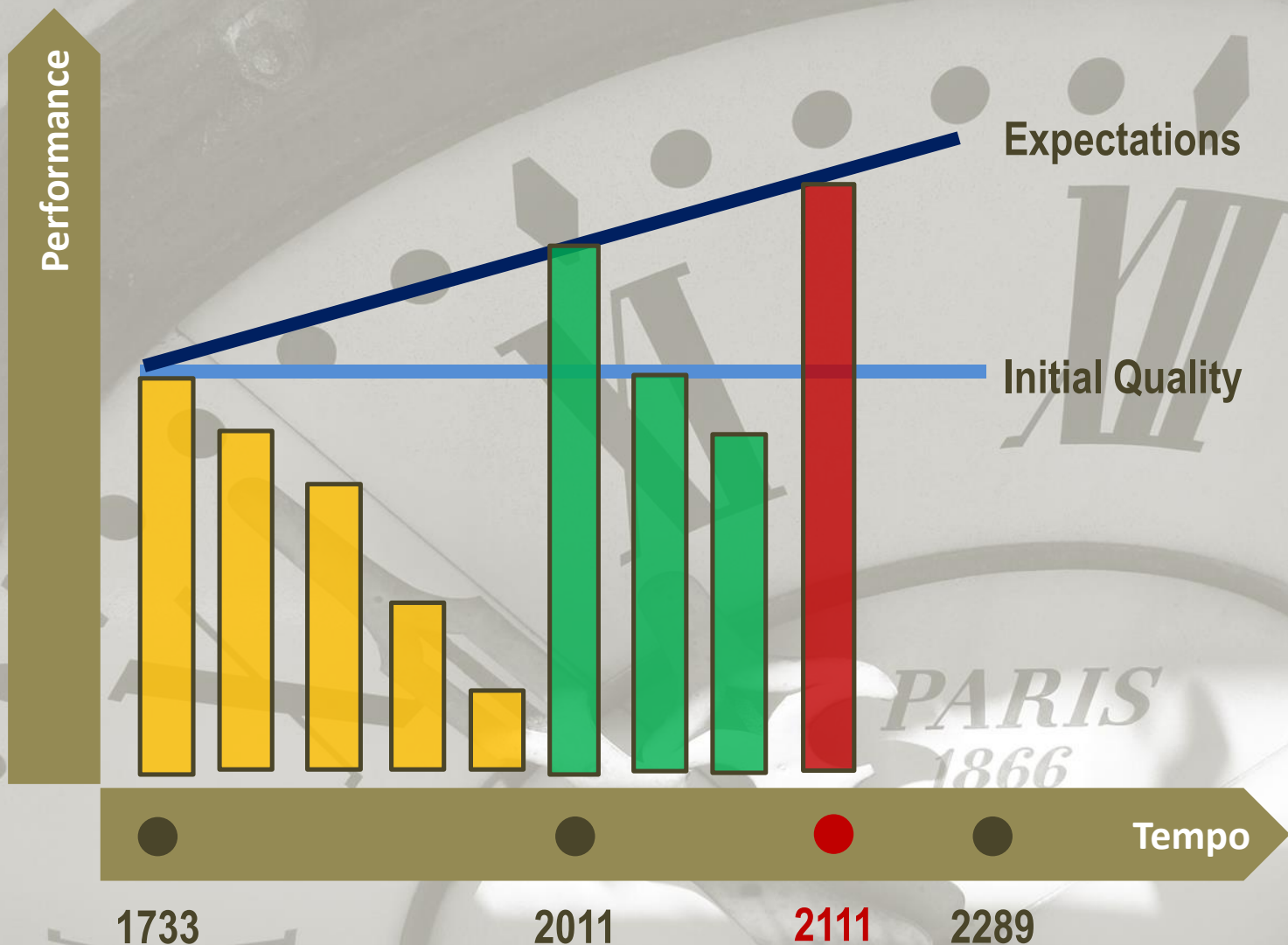
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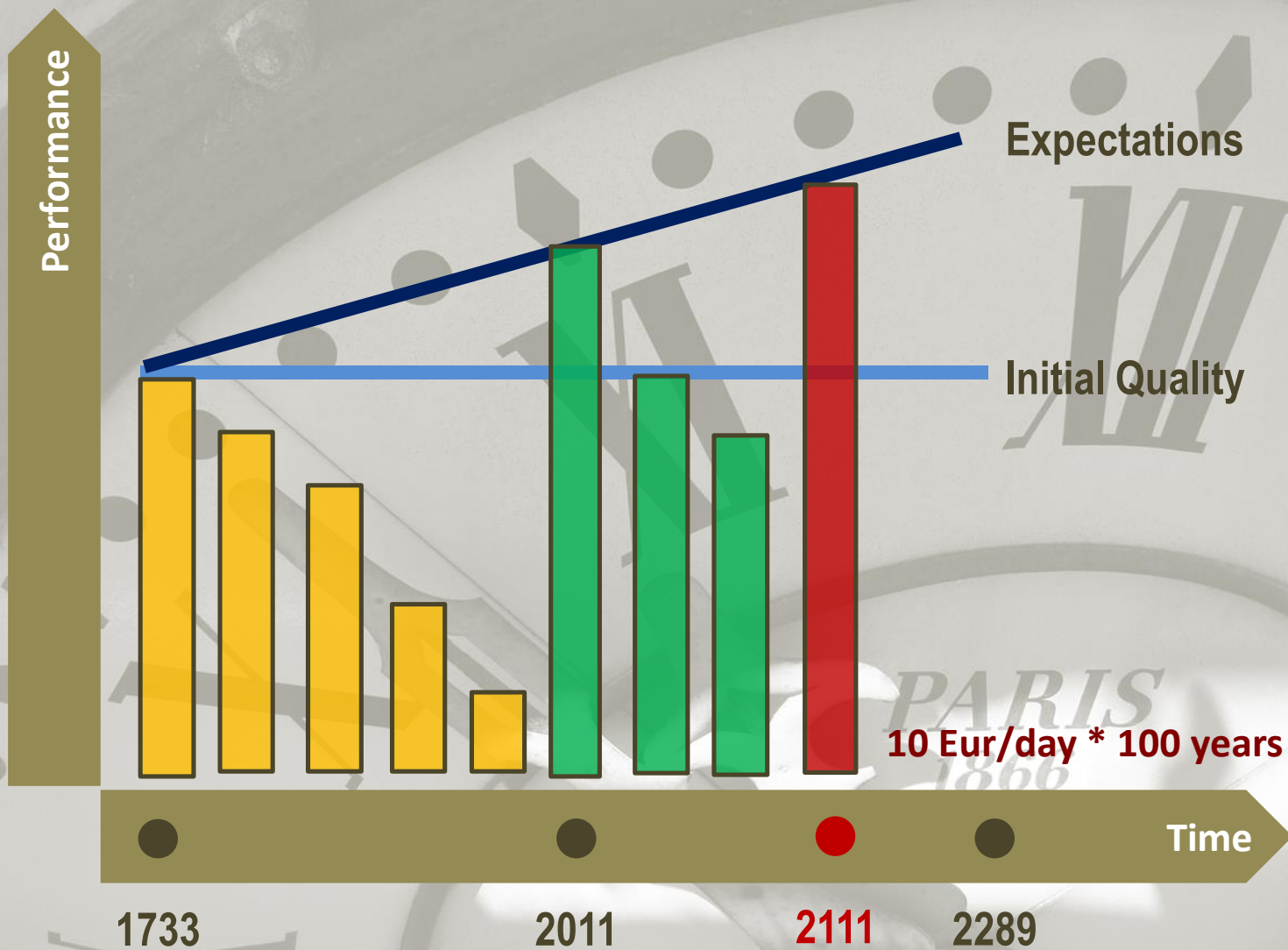
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To climb...

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PARIS
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