Deliverable 6.3

Prototype walls design, detailing and construction

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WORKPACKAGE 6: Demonstration of constructability

Leader: ANDIL

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1 INTRODUCTION

1.1 DESCRIPTION AND OBJECTIVES OF THE WORK PACKAGE

This Work Package is fundamental for the consolidation of the project output as it encompasses the final assessment and demonstration of the proposed technologies. It provides also the practical material to draft guidelines for the construction in real conditions and more accurate information on cost estimation of the proposed solutions, which is essential for both end-users and SMEs.

The leader of this task is a SME-AG (ANDIL) given that it is of prior importance that SMEs’ stakes are fully incorporate in the main results of the project.

The main aims of WP6 are:

- to address the construction requirements in a real case application of the technology;
- to design and build prototype walls;
- to assess the execution of the prototype walls with on-site testing;
- to develop procedures for quality control;
- to assist the drafting of practical guidelines.

The main tasks in which the work package is organised are:

- the construction of prototypes;
- the assessment of technical and economic feasibility;
- the in-situ testing of prototypes.

1.2 OBJECTIVES AND STRUCTURE OF THE DELIVERABLE

Demonstration of wall design, detail and construction in practical cases was done using calibrated models and experimental results. All prototype walls were designed and built under the technical and scientific assistance of RTD-Performers (D6.3).

The actual erection of real walls allows assessing the specific problems connected with this kind of structure, which are of a higher degree of complexity than those examined so far, since they involve real site construction.

Output obtained from real construction will be used to update the production time in order to have a more effective cost estimation of each solution. This will also allow further comparison with competing technologies (Task 6.2) as well as product optimisation, and will moreover be used to prepare final WP3 reports and guidelines foreseen in Task 7.2.

Proper case studies, adopting the newly defined construction technology, were found in the various Countries involved in the research (D6.2).

Deliverable 6.3 presents the prototype walls design, detailing and construction subdivided by Countries, as different solutions arose from the project.
2 PROTOTYPE WALLS DESIGN, DETAILING AND CONSTRUCTION

2.1 PROTOTYPE WALLS BY ANDIL/UNIPD

Within the project UNIPD devised an innovative infill system with insertion of deformable joints inside the masonry (see WP3). The proposed solution is designed both to significantly reduce the damage to the wall panel due to the deformations imposed by the frame during an earthquake and to improve the global response of the concrete structure.

The synergy between ANDIL and the University of Padova has led to the construction of wall prototypes representative of the system (patent submitted by ANDIL). The National Final of Ediltrophy 2015 competition (annual competition organized by Formedil) was chosen to carry out this part of demonstration activities within the INSYSME project for the reasons already described in D6.2.

The competition aims to promote the activity of schools for building construction workers. Nine senior teams composed by two people each (plus teacher/instructor) participated to the National Competition. The teams came from all over Italy, after passing a pre-selection.

Ediltrophy Final was held during the annual SAIE edition in Bologna, on October 17th. SAIE is the main Italian commercial fair in the construction sector and one of the main in Europe. The competition consisted in the realisation of a portion of DRES system, built on a reinforced concrete frame section. The outer part of the wall was coated with prefabricated panels made of concrete and clay, suspended and hooked to a system of profiles and metal guides, with an interspace of ventilation (ventilated façade). The maximum allowed length of the competition was 5 hours.

2.1.1 Wall design

The mock-up design is described in detail by next drawings.

Figure 2.1. Size and shape of the used RC frame section. Made available for each competitor group at start (designed by Arch. Lianaj Gazmend).
Prototype walls design, detailing and construction

D6.3
2.1.2 Wall detailing

As in real construction infill walls are often cover either by plaster, thermal insulation coating, or external façade elements, it was decided to apply a prefabricated brick wall veneer system, in order design the details corresponding to the application of an external element, that take into account the horizontal sliding movements of the back infill wall.

For this reason, considering that most often façade elements lean on a principal system of long vertical supporting elements (that hinder horizontal movement to occur), a system based on shorter elements (fixed to the masonry) was designed and produced. A second series of elements attached to the façade panel was connected.
The vertical and horizontal perforated profiles had to be fixed paying attention to adjust the height, the position and the expected distance from the wall. Tolerance laying allowed (distance between wall panels and blocks) was ± 1 cm.
The panel and masonry veneer façade weigh was 10.5 kg each. Therefore, they had first to be attached to the supporting structure with care and then adjusted (with the adjustment screws located over the hooks), so as to distribute the weight on all four support points.

![Diagram of panel and masonry](image)

**Figure 2.8.** Details of coating panels (designed by Arch. Llanaj Gazmend).

The vertical rubber joint to be positioned between the pillar and the masonry was provided in two parts. The smaller one (8 cm) had to be laid down, while the other piece had to be tied vertically to the pillar during the construction using wire. If the width of the strip exceeds the thickness of the wall (30 cm), the exceeding part protrudes toward the ventilated façade while inside will lay in line with the pillar and the wall itself.

For accurate execution, it was necessary to carefully juxtapose coating panels during the installation and to pay attention to the right/left sides before attaching the hooks. In order to avoid breakage of the panel, it is necessary not to over-tighten the screws when fixing them.
Figure 2.9. Mounting sequence of steel frame (designed by Arch. Llanaj Gazmend).

Figure 2.10. Laying prescription of deformable bed joints (designed by Arch. Llanaj Gazmend).
Tongue and groove vertical joints are mortarless. Laying bed joints, take care to hold the two blocks to keep out the mortar between them.

Figure 2.11. Laying prescription (designed by Arch. Llanaj Gazmend).

Figure 2.12. Detail of deformable joint (designed by Arch. Llanaj Gazmend).
Figure 2.13. Perspective view of mock-up (designed by Arch. Llanaj Gazmend).
2.1.3 Wall construction

The following pictures present a sequence of the construction phases above explained, as they were tested before the Ediltrophy event, at Formedil premises in Bologna.

The National final of Ediltrophy 2015 was held during the annual SAIE edition in Bologna, on October 17th. SAIE is the main Italian commercial fair in the construction sector and one of the main in Europe. The competition consisted in the realisation of a portion of DRES system, built on a reinforced concrete frame section, similar to those shown below and built as reference trials before the competition (from Figure 2.14 to Figure 2.20). At the end of this sub-section, Figure 2.21 and Figure 2.22 present the walls built during Ediltrophy competition.

Figure 2.14. The RC frame section base of the mock-up.

Figure 2.15. Front view of mock-up.
Figure 2.16. Back view of mock-up.

Figure 2.17. Laying of horizontal rubber joints.

Figure 2.18. The brackets set up.
Figure 2.19. The profiles set up: vertical (left) and horizontal (right).

Figure 2.20. Prefabricated panel back (left) and prefabricated panel set up (right).
Figure 2.21. Front view of mock-ups at SAIE during Ediltrophy competition.

Figure 2.22. Back view of mock-ups at SAIE during Ediltrophy competition.
2.2 PROTOTYPE WALLS BY APICER/CTCV/UMINHO

University of Minho developed a system called Térmico System, which aims both to reduce the damage of the wall panel due to the deformations imposed on it from the frame during an earthquake and to improve the global response the concrete structure (see WP3).

The partnership among APICER, CTCV and University of Minho has led to the exhibition of wall prototype of Térmico system, in Tektónica 2016, between 4 and 7 of May, at FIL – International Fair of Lisbon.

This application has been chosen as case study for the following reasons: (1) the high visibility of Tektónica fair at national and international level, (2) the great opportunity to show this new system to all stakeholders in the construction sector, and (3) an exceptional opportunity to exchange views with the building professionals and to increase the impact of the research.

Tektónica, now at its 18th edition, is the largest fair in the construction sector in Portugal. The fair usually is attended by different players of the construction sector from Spain, France, Belgium, UK, Italy, Morocco, Algeria, Tunisia, Colombia, Angola, Mozambique, Cape Verde, Canada, USA, Cameroon, Costa Rica, Saudi Arabia and United Arab Emirates.

Universities, research centres, start-up companies have in TEKTÓNICA an opportunity to demonstrate how cutting-edge knowledge can be transformed into new business opportunities.

2.2.1 Wall design

The prototype wall showed at the exposition is part of an infill built in an RC frame similar to the one used for the experimental campaign (similar concrete and reinforcements), see Figure 2.23.

Due to transportation and space exhibition restrictions at Tektónica fair, it was decided to use the dimensions of a specimen as shown in Figure 2.23. In this way, it could be easily placed in the space allocated to APICER in the exhibition area. The complete geometric characteristics of the specimen are described in detail in Figure 2.23 and Figure 2.24.

![Figure 2.23. Front view of prototype.](image)

![Figure 2.24. View from above of prototype](image)
2.2.2 Wall detailing

The details of the specimen are presented in Figure 2.25. All auxiliary components were considered in the construction of the small wall.

![Wall prototype detailing diagram]

Figure 2.25. Wall prototype detailing

2.2.3 Wall construction

The specimen was constructed at University of Minho and then transported to Lisbon, where the Tektónica fair took place. Some photos are added to this report to illustrate the exposition of the specimen.
Figure 2.26. INSYSME project at APICER and CTCV booth in Tektónica fair.

Figure 2.27. Wall prototype in Tektónica fair
Figure 2.28. Wall prototype in Tektónica fair (back view)

Figure 2.29. Wall prototype in Tektónica fair (back view and reinforcements)
Figure 2.30. Wall prototype in Tektónica fair (details of reinforcement and connectors)

Figure 2.31. Wall prototype in Tektónica fair (front view)