Structural Analysis of Historic Construction – D'Ayala & Fodde (eds)

The PROHITECH research project

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ABSTRACT: The PROHITECH research project is framed within the INCO thematic areas, devoted to "Protection and conservation of cultural heritage" in the Mediterranean area. The main subject of the research is the seismic protection of historical and monumental buildings, and the main objective consists in developing sustainable methodologies for the use of Reversible Mixed Technologies (RMTs) in the seismic protection of the existing constructions. RMTs exploit the peculiarities of innovative materials and special devices, allowing ease of removal when necessary. Furthermore, an optimization of the global behaviour under seismic actions is achieved by the combined use of different materials and techniques. The endpoint of the research is a proposal of codification for the use of such technologies in the seismic protection of existing constructions.

1 INTRODUCTION

The Mediterranean and Balkan area is greatly exposed to seismic hazard. Consequently, its cultural heritage is strongly susceptible to undergo severe damage or even collapse due to earthquake. The constructions mostly exposed to seismic risk are the historical and monumental ones, since in many cases they are not endowed with basic anti-seismic features and/or no seismic retrofit has been applied to them. If the latest earthquakes occurred in this area are considered (Friuli-Italy, 1976; Vrancia-Romania, 1977; Campania and Basilicata-Italy, 1980; Spitak-Armenia, 1988; Banat-Romania, 1991; Erzincam-Turkey, 1992; Dniar-Turkey, 1995; Umbria-Italy, 1997; Adana-Turkey, 1998; Iznit and Duzce-Turkey, 1999; Athens-Greece, 1999; Afyon-Turkey, 2002; Bingol-Turkey, 2003; Bourmedes-Algeria, 2003; Al Hoceima-Morocco, 2004, to mention the most important, only), the extremely unsatisfactory degree of seismic protection is clearly apparent. Degradation in material quality, lack of appropriate maintenance and, above all, absence of elementary anti-seismic provisions are the clear reasons of the very large number of the collapses, particularly in old masonry structures, occurred during earthquakes.

The extreme seismic vulnerability of the historical constructions is confirmed by this evidence and, consequently, urgent strategies for the seismic protection of the cultural heritage are strongly required. Considering the construction as a system, the objective is improving its global performance, rather than providing solutions to specific structural or architectural problems, requiring the set-up of new technological systems. Moreover, the new intervention methods must be not only reliable and durable, but also, if required, easy to monitor and remove, the latter aspect corresponding to the widely shared policy of safeguarding existing buildings from inappropriate restoration interventions, with particular reference to historical and monumental constructions. At the same time, modern constructional systems have provided good seismic performances, strongly limiting damage and completely avoiding collapse. Consequently, a slow but continuous increasing in the sensitivity to the use of more advanced technologies in the earthquake protection policy has started. The excellent performances of innovative materials have been acknowledged and the potential advantages of using special techniques for seismic resistant structures has been recognized, in a step by step process. Although initially referred to new buildings, this trend represents an important study field in seismic rehabilitation of existing buildings, with particular interest for historical and monumental constructions (Mazzolani 2005a, b, c, 2006a, b, c, 2007a, b).

2 THE PARTNERSHIP

The scientific activity of PROHITECH project is subdivided into four parts, aiming at producing four main deliverables, to be developed since October 1, 2004 to September 30, 2008. The workplan is based on twelve scientific workpackages, plus three management workpackages. A number of sixteen scientific workpackage deliverables is foreseen. Sixteen academic institutions, coming from twelve Countries mostly belonging to the South European and Mediterranean area, are involved in the research programme (Fig. 1).

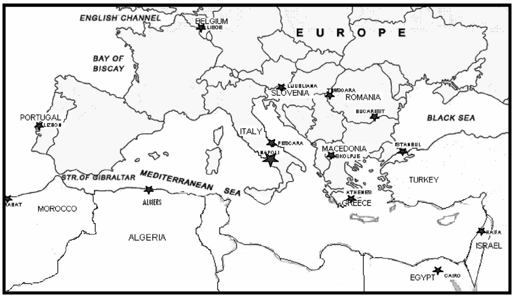

Figure 1. The PROHITECH partner countries.

The partner Countries are: Algeria (AL), Belgium (B), Egypt (EG), Macedonia (MK), Greece (GR), Israel (ISR), Italy (I), Morocco (M), Portugal (P), Romania (RO), Slovenia (SL), Turkey (TR).

In the following the partner institutions and the relative responsible persons are indicated. UNINA: University of Naples “Federico II”-Engineering Faculty (F.M. Mazzolani, project general coordinator); B: University of Liège (J. Jaspart); MK: University of Skopje (K. Gramatikov); GR: Technical University of Athens (I. Vayas); NA-ARC: University of Naples “Federico II”-Architecture Faculty (R. Landolfo); P: Technical University of Lisbon (L. Calado); ROPUT: Polytechnical University of Timisoara (D. Dubina); ROTUB: Technical University of Bucharest (D. Lungu); SL: University of Ljubljana (D. Beg); TR: Boğziçi University of Istanbul (G. Altay Askar); ISR: Technion Israel Institute of Technology, Haifa (A.V. Rutenberg); EG: Engineering Centre for Archeology and Environment, Faculty of Engineering, Cairo University (M. El Zahabi); M: Moroccan National Scientific and Technical Research Centre, Rabat (A. Iben Brahim); SUN: Second University of Naples (A. Mandara); AL: University of Science and Technology “H. Boumedien” of Algier, Civil Engineering Faculty (M. Chemrouk); UNICH: University of Chieti/Pescara (G. De Matteis, project technical coordinator).

3 THE BASIC ISSUES

Within the technical field of seismic rehabilitation, two aspects are receiving an increasing attention by engineers and researchers, namely:

- Preservation of Structural Integrity of existing buildings under severe/exceptional seismic actions;
- Improvement of building seismic performance by means of RMTs.

Both these aspects are closely interrelated each other, in the sense that the application of RMTs is, in some cases, the only tool to achieve a satisfying level of Structural Integrity under severe earthquake actions. The concept of Structural Integrity relies on the necessity to ensure seismic protection against collapse also in case of destroying events. In this view, it can be properly framed within the advanced concept of Performance Based Design (PBD). As well known, the PBD is a new way to approach the structural design against seismic actions, having the purpose to ensure a proper degree of structural reliability under any specified working conditions, including both serviceability and ultimate limit states.

Till now, the PBD has been applied to new structures only, which can be easily designed complying with relevant behavioural thresholds set by PBD it-self. No applications exist in the field of existing constructions, yet. In particular, neither criteria nor methodologies are available for achieving a satisfying design level against strong intensity earthquakes. This is indirectly confirmed by most of national seismic codifications, which, as a matter of fact, allow to avoid a rigorous seismic retrofit in case of historical constructions. This approach, of course, tends to preserve the monumental value of the construction, but at the same time is not adequate to protect against severe earthquakes. It is evident how this aspect deserves great attention not only in the perspective of saving human lives, but also at the light of preserving inestimable buildings from destruction. The use of innovative materials and Mixed Technologies is the most appropriate answer for ensuring an adequate performance, and hence the Structural Integrity, under strong seismic actions.

RMTs are based on the integration of structural members of different materials and/or construction methods into a single constructional organism. The basic feature of RMTs is that their application should be always completely recoverable, that is reversible, if required. This is considered as an essential design requirement in order to prevent historical and monumental buildings from unsuitable rehabilitation operations. The main aim of RMTs is the best exploitation of material and technology features, in order to optimize the structural behaviour under any condition, including very severe limit states produced by strong seismic actions. This practice, initially concerned with new technologically advanced buildings, is now being looked up with increasing interest also in the field of structural rehabilitation, due to the large possibilities of structural optimization and, hence, performance maximization, both achieved thanks to mixed technologies. In few words, the use of RMTs would involve the best exploitation of each material and/or technology used in the intervention, providing the best performance from both technical and economical point of view.

4 THE RESEARCH WORKPLAN

It is planned to achieve the above objectives through the creation of twelve scientific workpackages dealing

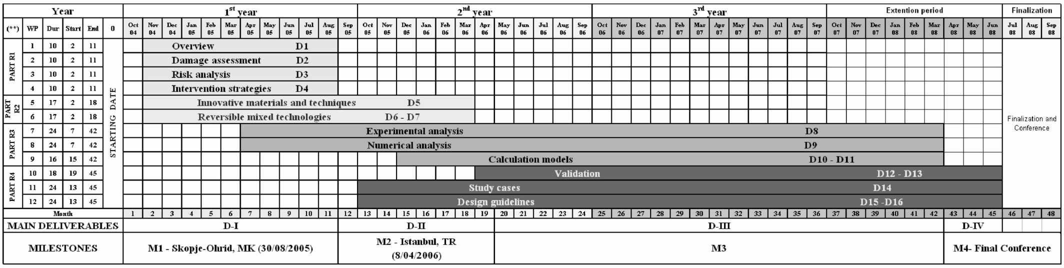

Figure 2. Workplan of the PROHITECH project.

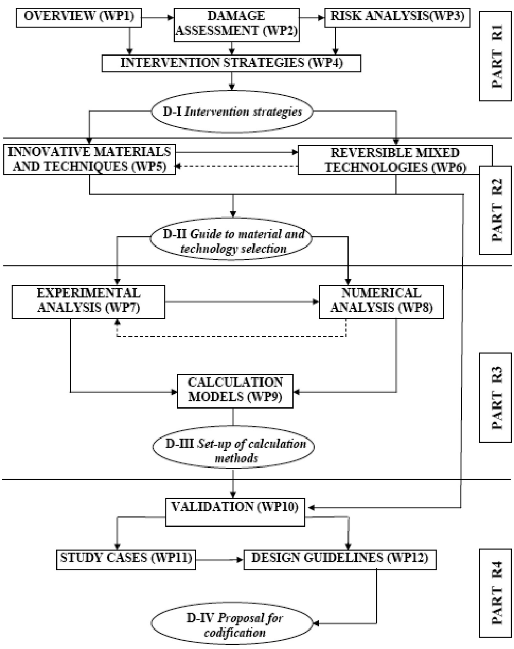

Figure 3. Interconnection among WPs, project deliverables and main deliverables.

with sixteen deliverables, which are aimed at the production of four main deliverables, representing the final output of the four parts which the research plan has been subdivided into. The final workplan is shown in Figure 2, whereas the interconnections among the WPs and the four Parts, leading to the achievement of the project goals, are shown in Figure 3. Details on the project workpackages can be found in Mazzolani (2005 a, b, c, 2006 a, b, 2007a).

5 MAIN OBTAINED RESULTS

5.1 *First main deliverable*

The first main deliverable is the synthesis of the results of the first year activity within the project part R1. Since this part represents a sort of state-of-the-art in the field of the intervention strategies for the protection of buildings, all partner Countries have provided their own contribution, leading to the definition of a common background, which represents the starting point for the development of the innovative contribution of the project (Mazzolani et al. 2005a).

The contents of the volume, composed of five chapters, essentially derive from the material collected within the first four workpackages. In particular, the contents of Chapters 1 and 3 are mainly based on the output of WP3, the contents of Chapter 2 synthesize the output of WP2, the contents of Chapter 4 derive from WP1 activity and the contents of Chapter 5 are based on WP4.

In Chapter 1 (authors F.M. Mazzolani and G. De Matteis, the general and technical coordinators of the project, respectively) information on seismic hazard in the PROHITECH Euro-Mediterranean Countries is synthesized, including seismicity maps, main historical events, macroseismic intensity maps, seismic zonation maps and information on acceleration response spectra specific to different soil conditions. The study is organized by subregions and by Countries. Thus, three main subregions have been identified on the basis of the geographical proximity and common geodynamical environment of the considered Countries: a Western PROHITECH region, which includes Algeria, Morocco and Portugal; a Central PROHITECH region, in which Belgium, Greece, Italy, Macedonia, Romania, and Slovenia are grouped; an Eastern PROHITECH region, including Egypt, Israel and Turkey.

In Chapter 2 (authors G. Altay Askar, WP2 leader, and H. Luş) the damage assessment methodologies widespread in the PROHITECH Countries are illustrated. The chapter presents an overview of building typologies and construction practices, with some emphasis on the development of seismic design provisions, and it shows both quick and detailed damage assessment methods in use in various Countries. Furthermore, the damage patterns observed in previous earthquakes, the results of post-earthquake damage surveys, together with earthquake history and performance of some buildings representative of the cultural heritage of the Mediterranean area, are collected.

Chapter 3 (author A. Iben Brahim, WP3 leader), is devoted to the seismic vulnerability assessment of historical buildings in the PROHITECH Countries. In particular, the current approaches to damage assessment and the definition of the vulnerabilities of structural types are presented, together with the analysis of seismic risk related to the historical building heritage of the Mediterranean area, on the basis of the damage data reported in Chapter 2.

In Chapter 4 (authors A. Mandara, WP1 leader, and F.M. Mazzolani) the existing techniques used in the PROHITECH Countries for the protection of buildings against the seismic action, with reference to the different structural types, are described.

Finally, Chapter 5 (authors D. Lungu, WP4 leader, and C. Arion) illustrates the intervention strategies for seismic protection of buildings, with special attention towards both the technological and policy aspects of the problem.

5.2 *Project deliverables D1-to-D4*

Besides the main deliverable D-I, the output of Part R1 is completed by four project deliverables, as previously mentioned. Each project deliverable, whose contents come from the partner contributions, has been edited by the leader of the respective workpackage, and is made of two parts. The first part is the text of the deliverable, written by the WP leader on the basis of the partner contributions. The second part is an appendix collecting all the contribution documents written by the partners.

Project deliverable D1 (Mandara 2005) is an overview of the traditional technological systems used in the Euro-Mediterranean area for the rehabilitation of historical buildings. Project deliverable D2 (Altay Askar 2005) deals with the assessment of the seismic damage in historical constructions. Project deliverable D3 (Iben Brahim 2005) is focused on the risk and vulnerability assessment of the building historical heritage. Project deliverable D4 (Lungu 2005) deals with the intervention strategies for the seismic protection of historical buildings.

5.3 *Second main deliverable*

The main deliverable D-II deals with the elements required for a correct choice of both materials and technologies to be used in seismic rehabilitation (Mazzolani et al. 2006). It merges the outcome of the activity of WP5 (Innovative Materials and Techniques for Seismic Protection, leader L. Calado) and WP6 (Set-up of Advanced Reversible Mixed Technologies for Seismic Protection, leader D. Beg).

D-II is composed of four Chapters. Chapter 1 (authors F.M. Mazzolani and L. Calado) is an introduction to the RMTs, where the main aspects of seismic protection based on the use of special devices and systems are underlined. Moreover a general classification of the innovative devices for seismic protection is briefly presented.

The contents of Chapter 2 (authors L. Calado, J.M. Proença, P. Skuber and M. Esposto) mainly derive from the WP5 final report. Innovative materials are presented considering their basic principles, structural features, fields of application, experimental tests and numerical models, design criteria and codification issues, structural applications and economic aspects. The Chapter is concluded by a comparison and evaluation among the considered materials, based on the output of WP6 final report.

Chapter 3 (authors L. Calado, A. Panão and L. Pavlovčič) deals with the innovative devices which can be adopted for mixed reversible technologies. The structure of the Chapter is based on WP5 final report, while the contents come from both WP5 and WP6 final reports. Also in this case, every device is presented by considering the aspects mentioned in Chapter 2.

Chapter 4 (authors D. Beg and G. De Matteis) is devoted to the seismic protection systems. Its con-tents come from WP6 final report and deal with the seismic protection systems for masonry buildings, reinforced concrete frames, brick or stone masonry structures, like towers, domes and vaults, and stone temples. At the end of the Chapter a general over-view on the seismic protection with active control system is presented.

5.4 *Project deliverables D5-to-D7*

The project deliverables D5, D6 and D7 are related to the activities developed within WP5 and WP6.

Project deliverable D5 (Calado 2006) is focused on innovative materials, including new metals and metal-based intervention techniques, in order to select suitable materials for creating both strengthening systems and special devices aimed at the optimization of the structural behaviour.

Project deliverables D6 and D7 (Beg 2006), as specific output of WP6, contemporary represent the complement and completion of the work performed in WP4 and WP5, by providing the information necessary to the proper use of innovative materials and mixed technologies in strengthening interventions, as well as the definition of special systems for seismic protection to be applied to existing buildings.

6 ACTIVITY IN PROGRESS

6.1 *General*

The activities actually in progress are those related to the project Parts R3 and R4 (WP7-to-WP12). Part R3, finalized to the set-up of adequate calculation methods for RMTs used in seismic protection, deals with the experimental and numerical analyses which represent

Figure 4. R.c. building for full scale tests in Naples (Italy).

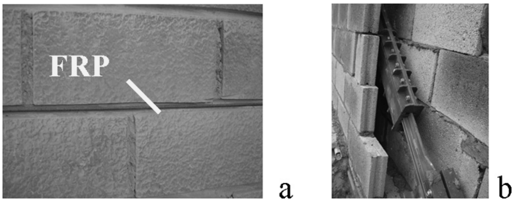

Figure 5. Interventions on the full scale r.c. building: (a) first repairing by FRPs; (b) second repairing by BRBs.

two fields strongly interconnected each other and undoubtedly fundamental for the project, they being expected to yield the necessary tools for performing practical design calculations. Part R4 is related to the validation of the innovative solutions and interventions, to the focus on ad-hoc selected study cases and to the development of adequate design guidelines.

6.2 *Part R3: Experimental and numerical research*

WP7 (Experimental analysis, leader K. Gramatikov, co-leader L. Taskov) is entirely devoted to the laboratory activity of PROHITECH, useful for giving an experimental contribution to the assessment and set-up of new mixed techniques for repairing and strengthening of historical buildings and monuments belonging to the Cultural Heritage of the Mediterranean basin. The experimental activity in progress is developed at five different levels: full scale building, large scale models, sub-systems, full devices, reduced scale devices.

The full scale cyclic tests have been performed on one r.c. building in the Bagnoli area in Naples (Fig. 4). This test represents a unique occasion of knowledge, since the studied building is not an "ad-hoc" built model, but it is a "real" construction, representative of a large part of the present building stock in many Countries during 20th Century.

The full scale building has been strongly damaged by applying a seismic input and then it has been repaired by means of FRP bars in the mortar joints of the external walls (Fig. 5a). Successively it has been damaged again, and an intervention by means of buckling restrained braces (BRBs) has been carried out (Fig. 5b).

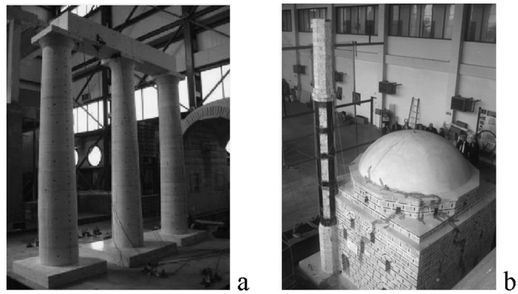

Figure 6. (a) Three-columns model of Greek temple; (b) Mustafa Pasha Mosque model during tests.

Figure 7. Steel-wood-concrete composite floor system: (a) push-out tests (Naples); (b) beam tests (Lisbon).

The programme of large scale tests on shaking table comprehends the models of a Gothic Abbey (Fossanova, Italy), of an Ancient Greek Temple, of the Byzantine St. Nikola Church (Psacha, Kriva Palanka, Macedonia) and of Mustafa Pasha Mosque (Skopje, Macedonia).

Two three-columns models of a Greek temple (Fig. 6a) have been tested in Athens (Greece), where the mechanical properties of marble have been experimentally determined too. The Mustafa Pasha Mosque model (Fig. 6b) has been tested at the IZIIS Laboratory in Skopje, Macedonia (Krstevska et al. 2007, 2008), where the Gothic Abbey and the Byzantine Church models will be also tested.

Tests on sub-systems are related to both full scale and reduced scale specimens.

Full scale tests involve innovative steel-wood-concrete composite structures and timber frames retrofitted by shear panels and/or dissipative beam-to-column connections. The experimental campaign on steel-wood-concrete composite structures, set-up and designed at the University of Naples "Federico II" (Italy), has been performed in Lisbon (Portugal) and in Naples (Italy). Monotonic push-out tests for studying the connections behaviour and both mono-tonic and cyclic tests on composite beam and floor system (Fig. 7) have been carried out.

The set-up of metal panels, useful for retrofitting interventions, has been already experienced on a full scale r.c. building in Naples (Fig. 8a). Furthermore,

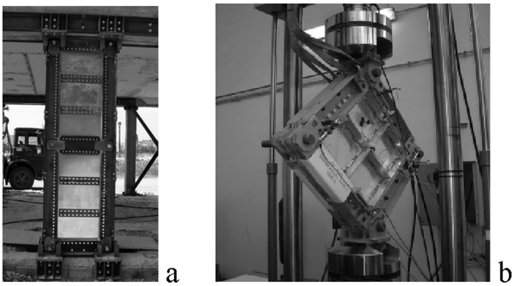

Figure 8. (a) Metal shear panel experienced on full scale r.c. building; (b) tests on bracing type aluminium shear panels.

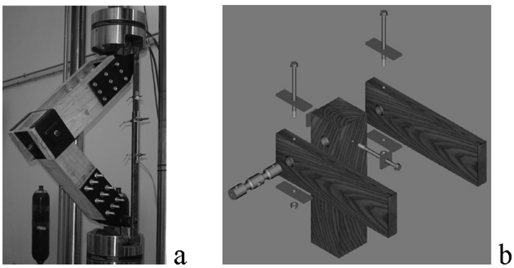

Figure 9. Dissipative beam-to-column wooden connection: (a) experimental tests; (b) component parts of the connection.

an experimental campaign on bracing type pure aluminium shear panels (Fig. 8b) is currently ongoing in Naples.

Experimental studies on timber frames retrofitting have been carried out in Naples (Italy) and in Istanbul (Turkey). The behaviour of a dissipative connection of a beam-to-column wooden joint has been evaluated by means of "ad hoc" tests (Fig. 9).

Reduced scale tests on masonry walls retrofitted by steel/aluminium plates or by a steel wire mesh have been carried out in Timisoara (Romania). The behaviour of r.c. panels is experimentally analysed in Bucharest (Romania). Testing on buckling and bending behaviour of iron/steel elements reinforced by FRP is in progress in Liège (Belgium).

Finally, tests on DC 90 dampers and on titanium clamps have been carried out in Ljubljana (Slovenia), while tests on magneto-rheological devices are going on in Aversa (Italy).

WP8 (Numerical analysis, leader R. Landolfo) is aimed at the set-up of numerical models for describing the behaviour of both structural materials and special devices on the basis of experimental tests. Numerical procedures are then applied to the seismic analysis of upgraded constructions in order to investigate the influence of main variables by means of parametric dynamic analyses. The first part of work within WP8 has dealt with a series of preliminary numerical studies

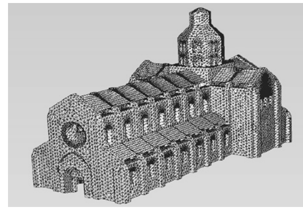

Figure 10. FEM model of Fossanova Gothic Abbey.

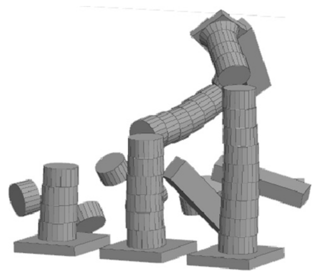

Figure 11. FEM model of an ancient Greek temple.

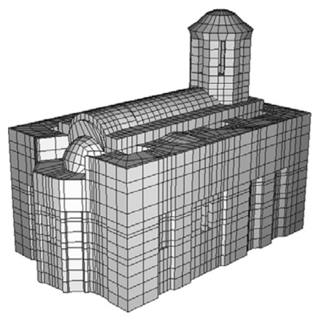

Figure 12. FEM model of St. Nikola Church.

concerning a benchmark activity, by which the partners have created a sort of collective background in the field of numerical analyses. The second part of WP8 activity has concerned the pre-analyses of some of the experimental tests planned within the project. Figure 10 shows the FEM model of the Gothic Abbey in Fossanova, whereas Figure 11 shows the collapse mode given by the numerical model of the Greek temple subassemblage. The FEM model of St. Nikola Church is plotted in Figure 12, whereas Figure 13 represents the vibration modes of the FEM model of the Mustafa Pasha Mosque (Landolfo et al. 2007), used to predict the behaviour of the large scale model and to design the consolidation system.

On the bases of the experimental and numerical analyses, the calculation methods for reversible mixed technologies used in seismic protection will be set-up within the WP9.

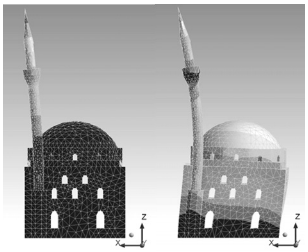

Figure 13. FEM model of Mustafa Pasha Mosque.

The results of Part R3 will compose the third main deliverable, which will be organized in three main parts: (1) Experimental activity (referring to the different types of experiments); (2) Numerical activity (dealing with the simulation of experimental tests by numerical models and comparisons of results); (3) Calculation models (referred to the identification of simplified models to be used as design tools in structural restoration).

The output of WP7 and WP8 will be collected in D8 and D9 project deliverables, respectively. The output of WP9 will lead to two project deliverables: D10, dealing with analytical models for special materials and devices for the seismic structural control, and D11, dealing with simplified models for the seismic analysis of historical constructions.

6.3 *Part R4: Set-up of codification rules*

The activity related to Part R4 will be completed at the end of the project. The results of the work performed during the whole project period will be finalized to codification proposals. Contemporary, the selected innovative materials and techniques, the developed reversible mixed technologies, together with the calculation methods, will be subjected to extensive validation studies. The data obtained by WP5 and WP6 will be analysed and compared with traditional materials and technologies. Firstly, a cost-to-benefit evaluation will be performed to outline the scope and the effectiveness of new materials and/or technologies. As a second step, the performance of the proposed solutions will be assessed in terms of strength, including low-cycle fatigue resistance, ductility and dissipation capacity compared with conventional solutions. The results from the experimental (WP7) and numerical (WP8) analyses will be extensively used. Special conclusions will be drawn on the applicability of different innovative solutions depending on the specific conditions and design requirements.

Special attention will be paid to the validation of the proposed calculation models on the basis of experimental and numerical results, so as to prove their reliability in the perspective of their inclusion in the Design Guidelines (WP12). For the specific case of monumental constructions, a feasibility study will be performed to assess the applicability of various innovative solutions to different types of buildings. Together with the considerations based on the structural performance, additional architectural and historical–cultural aspects will be accounted for in the context of the possible interventions.

Within WP10, the validation criteria for restoration interventions are synthesized in the project deliverable D12, while project deliverable D13 deals with the performance assessment of the new technologies, which are compared to the traditional ones.

The knowledge gained within the project will be conveniently applied to some selected study cases (WP11), consisting in historical buildings belonging to the heritage of Mediterranean Countries, in order to perform feasibility analyses of seismic protection interventions by means of RMTs. The selected study cases are indicated hereafter. The *Mustafa Pasha Mosque of Skopje* and the *St. Nikola Church in Psacha*, both in Macedonia, as well as the *Gothic Abbey in Fossanova* (Italy) and the *Greek Temple in Athens*, correspond to the project large scale models (WP7). The *Royal Palace of Naples* and the *Gallery "Umberto I"*, both in Naples (Italy), are characterized by wooden and iron structures, respectively. The *Koletti building in Athens* (Greece) is the only r.c. structure considered, while the *Beylerbeyi Palace in Istanbul* (Turkey) is interesting for studying the interaction between timber and masonry elements. The *Medina of Salé* in Morocco has been also selected for considering the complex behaviour of undiversified building blocks.

The design of relevant application solutions based on RMTs is also foreseen together with the critical evaluation of collected examples of real restoration cases, belonging to the current experience in each partner Country. This activity is framed in WP11, leading to the preparation of the corresponding project deliverable (D14). The interconnection between the study cases and the development of design guidelines (WP12) is evident, since the first step can be considered as a benchmark for the set-up of the codification rules. As a result of the WP12 activity, two project deliverables will be realized: a proposal of codification rules for the design of seismic protection interventions by using RMTs (D15); a manual for the actual implementation of the procedures proposed and developed within the project (D16).

The final document of the whole project will comprise the fourth main deliverable, downstream of the fourth year activity, containing a set of recommendations elaborated on the basis of all collected data and results. The proposal will comply with the most up-to-dated codification issues in the field of seismic design, say the Performance Based Design, and will share the same global layout, language and philosophy as Structural Eurocodes issued by CEN.

7 EXPECTED RESULTS

The PROHITECH project is an important opportunity to develop knowledge and technology in the field of the seismic protection of the Euro-Mediterranean cultural heritage (Mazzolani 2007a, b). The innovative character of the technical solutions proposed for seismic retrofitting is mainly based on the concept of RMTs. The main expected results of the research activity are the following.

The basis for the assessment of an up-to-dated state-of-the-art concerning advanced systems of seismic protection of existing constructions will be set-up, in harmony with the specific demand of all Euro-Mediterranean Countries for a more comprehensive framing of anti-seismic rehabilitation.

Both conscience and knowledge about "new" materials and technologies as a suitable alternative to "traditional" solutions will increase, since the last ones are proved to be often inadequate to provide a satisfying seismic performance, in particular when applied to historical and monumental constructions.

The adoption of materials and systems which are reversible, recyclable, environmentally friendly, and economically sustainable will be supported. The present degree of knowledge on the application of these materials and systems is not particularly advanced, neither codified in any form, hence it is expected that the research activity carried out within PROHI-TECH project will yield significant innovation in seismic protection practice.

New and up-to-dated information on the problem of seismic protection will be disseminated, thanks to the participation of acknowledged institutions, belonging to both Europe and Mediterranean basin, all of them widely experienced in the field of seismic design and with an ongoing significant research activity in such area.

Young engineers and architects, as well as researchers involved in seismic design, will have the opportunity for a qualified training and research activity, aimed at an enrichment of existing skills in the field of structural engineering.

Design and constructional rules for interventions based on advanced and innovative technologies will be set-up. This is expected to recall to a greater interest of both construction industry and practicing engineers, so as to have a remarkable impact on the current anti-seismic rehabilitation practice.

Information on the ongoing activity is available in the web site www.prohitech.unina.it.

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