

**COST C16**

**Improving the Quality of  
Existing Urban Building Envelopes**

**STRUCTURES**

Research in Architectural Engineering Series  
Volume 4  
ISSN 1873-6033

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**COST C16**

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**STRUCTURES**

edited by:  
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IOS Press

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ISBN 978-1-58603-736-9

Published by IOS Press under the imprint Delft University Press

Publisher

IOS Press BV

Nieuwe Hemweg 6b

1013 BG Amsterdam

The Netherlands

tel: +31-20-688 3355

fax: +31-20-687 0019

e-mail: [info@iospress.nl](mailto:info@iospress.nl)

[www.iospress.nl](http://www.iospress.nl)

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PRINTED IN THE NETHERLANDS

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## Preface

In front of you lies one of the four books produced within the scope of Action C16 “Improving the quality of existing urban building envelopes” which started as a COST UCE programme. The acronym ‘COST’ stands for European COoperation in the field of Scientific and Technical

research, and falls under the Urban Civil Engineering Technical Committee (UCE). The main characteristic of COST is a ‘bottom-up approach’. The idea and subject of a COST Action comes from the European scientists themselves. Participation is open to all COST countries but only those countries that wish to participate in an Action do so. As a precursor to advanced multidisciplinary research, COST has a very important role in building the European Research area (ERA), anticipating and complementing the activities of the Framework Programmes, acting as a bridge between the scientific communities of emerging countries, increasing the mobility of researchers across Europe and fostering the establishment of large Framework Programme projects in many key scientific domains. It covers both basic and applied or technological research and also addresses issues of a pre-normative nature or of societal importance. The organisation of COST reflects its inter-governmental nature. Key decisions are taken at Ministerial conferences and also delegated to the Committee of Senior Officials (CSO), which is charged with the oversight and strategic development of COST.

The COST Action C16 “Improving the quality of existing urban building envelopes” is directed to multi-storey residential blocks from the period after World War II, especially those built during the period when the need for housing in Europe was at its greatest. That is why the COST Action C16 focussed on the period 1950 to 1980. We found it necessary to propose this Action after the completion of Action C5 “Urban heritage/building maintenance”.

According to studies carried out by Action COST C-5, the estimated value of the European Urban Heritage amounts to about 40 trillion Euro (1998 prices) for the housing stock alone. The same research indicated the differences between the countries of the EU as well as what they have in common. The age profile of the building stock of a country like the Netherlands differs from that of the UK. Of interest too, are the costs of maintenance, renovation and refurbishment of the building stock. For the EU as a whole, this amount is about 1 trillion Euros per year (1998 prices). At the same time the three ‘Building Decay Surveys’ issued by the Federal Government of Germany that were based on systematic, scientific building research projects, indicated that 80% of all building decay is found in urban building envelopes (roof, walls, foundation).

There are elements in the building stock that are common to the countries in Europe. These include:

- Most of the buildings were completed after 1950. For a country like the Netherlands this means 75% of the existing buildings.
- The maintenance costs are mainly incurred in urban building envelopes,
- The renovation of buildings and reconstruction to provide an improved or different range of use will influence the building envelope,
- The quality of the building envelope very often fails to meet current demands and will certainly not meet future demands.

An important conclusion deriving from the points mentioned above is that however important maintenance may be, it does not lead to the desired improvement in the quality of urban building envelopes. Improvement of the quality of urban building envelopes must be the real task. Such improvement requires the development of new and suitable strategies for local authorities, housing corporations and owners and also architects and civil engineers.

Until now integrated engineering aspects have been disregarded in this process. In many European countries new technologies have been developed, but these have either not yet been translated into practice, or have been only locally used to achieve a higher quality in urban buildings. This results in a limited impact on urban environments. Therefore it is essential to bring all kinds of local solutions together, to learn from these and to find a more general approach that can be used for building systems. Often problems and their solutions are approached in isolation. The wish to improve the quality of an individual building envelope usually leads to a local, project-based solution. Solving the specific problems of this renovation-project becomes the sole target. To reach maximum value for money, it is essential to integrate all the factors influencing urban building envelopes and look at them in a broader scope.

As a result of changes in the composition of the population, society continuously changes with respect to various factors including age-structure, family composition and the availability of energy. Changes lead to situations that are reflected in the commissioning of buildings, which is gradually shifting from new construction to the reuse and renovation of existing buildings that often requires the modification of their facades.

Even when buildings may still be functionally satisfactory, there may be external factors, such as the dullness of the image that they summon up or their poor technical quality, that require that attention should be paid to the shell of the building. There are many reasons why buildings may no longer be adequate. Failure to satisfy current demands may be expressed in lack of occupancy and further deterioration of the neighbourhood. This establishes a vicious circle, which can and must be broken. All too quickly discussions turn to demolition and new development, without prior investigation of the reasons for the situation. From an economic point of view, renovation and the reuse of buildings, which takes into consideration the technical and spatial functions and also the urban and architectural aspects, often appears to provide a better solution.

The aim of the COST Action C16 is to improve techniques and methods used to adapt the envelopes of buildings constructed during the second half of the 20th century in the COST countries. These 'non-traditional buildings' were constructed from in situ poured concrete systems, large scale prefabricated systems and/or small concrete/mixed elements although in some countries brick or stone was still used. The demand for housing in the post-war period necessitated the rapid production of large numbers of dwellings. Qualitative aspects were less important. Furthermore dwellings of the types constructed at that time no longer fulfil contemporary or anticipated future demands for housing, with the possible exception only of those built during the last 5 years.

At this stage, it must be noted that two other ongoing Actions in the field of Urban Civil Engineering, also address issues related to buildings: COST Action C12 on "Improving buildings' structural quality by new technologies"; and COST Action C13 on "Glass and interactive building envelopes".

The Technical Committee on Urban Civil Engineering considers that in addition to the tasks directly connected to the main objective of their Action, participants in the COST Action on "Improving the quality of existing urban building envelopes" should establish and maintain close contacts with the two above mentioned Actions. This will foster co-operation with these Actions and avoid potential overlaps.

About one year after the start of COST Action C16, it was put on a hold for more than 8 months, to permit the 'renaissance' of the COST programmes, while in the meantime COST C12 had almost ended and it was considered that the C13 Action had only a slight connection

with the targets of COST C16. The CSO therefore agreed with the request of the Management Committee that the end of this Action should also be postponed by 8 months so that it would still last for the planned duration of four years.

## SCIENTIFIC PROGRAMME

To date problems relating “Urban Building Envelopes” and their solutions are approached in isolation. The original design planners, architects and engineers work together to realise a building according to the current state of knowledge, but this co-operation longer exists during the life-cycle of the building.

For far too long prolongation of the occupation by the use of maintenance was sole aim. If improvement did become an option only a few aspects were considered. At present the current state of knowledge is usually local, being concentrated in some of the housing co-operations, architectural and engineering companies. However much has been done to spread this information in order to initiate discussion about when and how existing buildings with their envelopes can be improved to fit them for the future.

The COST mechanism will foster international concentration on the integrated problems related to non-traditional dwellings. It will create a direction for improvement of urban building envelopes and also illustrate the state of the art in the various countries concerned.. What has already been learned in one country can now easily be shared or can be translated to fit the needs of other countries. His will make the implementation of new practices much easier.

The World Wide Web will be used to bring all the information on the major non-traditional housing systems in Europe together as well as the various techniques for the improvement of urban building envelopes. We are happy to announce that for the first time since the establishment COST, it has become possible not only to publish books but to place the information on the World Wide Web. See [www.costc16.org](http://www.costc16.org). High schools and universities interested in the subject of the renovation of existing buildings can now have east access to this knowledge.

This study was based on the following scientific programme:

- Description and analysis of the types of system related to the factors influencing urban building envelopes;
- Analysis and comparison of the legislation and technical regulations relating to renovation in European countries;
- Analysis of how urban building envelopes have been changed to date in relation to relevant factors;
- A survey of existing engineering techniques that can be used, modified or developed to reach this goal;
- A synthesis of possible global approaches leading to guidelines on how to reach maximum value for money in relation to the desired quality and working conditions in the urban environment and also how this approach can be reached for other types of buildings.

## THE SCHEME OF THE APPROACH OF ACTION C16

The original idea given in the technical annex of the Action was to start with a preliminary approach lasting six months. After that, three working groups would be set up on the themes of: the current envelopes, the needs and the techniques. A period of three years was allocated for this. The last six months of this period would have been used to integrate the result of the working groups and to prepare the final international symposium.

As stated above, one year after the start of the Action C16, together with other Actions, was placed on hold, because of the reorganisation of the COST organisation to create an umbrella organisation. At the beginning of 2004, on the basis of the contract between the European Science Foundation and the European Commission for the Support of COST, this reorganisation started with the establishment of the fully operative COST office in Brussels.

This delay caused to loss of some momentum. A second problem that had to be solved was that the members of C16 came from a variety disciplines and included structural engineers, architects and physicians. Although an interdisciplinary approach is one of the targets of a COST Action, this did give rise to problems in the working group on techniques. For example bearing structures demand a different specialisation from that required for secondary elements, such as facades and roofs. The management committee was wise in its decision to split the Techniques Working Group into a working group on structures and a working group on facades and roofs.

## THE METHODOLOGY

The methodology used for the work of the four working groups of the Action C16 “Improving the quality of existing urban building envelopes” differs.

The first book entitled ‘The state of the art’ is divided into two parts. The first part comprises a survey on the housing stock for each country. It contains data related to the building period, main typology and technologies. In the second part the topics covered describe the quality of the housing stock. The ‘state of the art’ depends on the time at which a survey takes place. That is why we consider it an advantage to also publish the two keynote lectures in this first book. These describe approaches to the modification of the multi storey family stock that is currently under investigation.

In the second book, ‘The needs’, the method used to obtain precise information was to develop a table that includes the needs, solutions and priorities for each country. It is evident that these needs and priorities will differ greatly from country to country, as illustrated for example by comparing Sweden to Malta. To determine these aspects, criteria such as land use, architectural aspects and building physics are used, as well as aspects relating to finance and management.

In the third book, ‘Structures’, a framework for possible solutions has been set up. It contains 20 case studies in which changes in bearing structures to fit for future purposes was the goal. Examples include descriptions of how to build extra floors onto existing buildings for both financial reasons and also to make the installation of elevators more profitable.. Another example illustrates the need for greater flexibility, and shows how a part of the bearing structure can be changed to provide this.

In the fourth book, ‘Facades and roofs’, which is based on the results of the working groups’ ‘The state of the art’ and ‘Needs’, two documents have been developed, ‘Technical Improvement of housing Envelopes’ and ‘Country Criteria in the form of a matrix’. Relations between the most frequently used refurbishing solutions and their impact on sustainability have been worked out in depth. Sustainability is described in a set of performances such as, technical, economic, functional/social and environmental. Case studies illustrate these theories.

Together these books provide much information and can help countries and people to learn from each other. It is my wish that that you will all profit from their content.

Leo G.W. Verhoef (Chairman COST Action C16)

April 2007

# Techniques for Adaptation of the Structures of a Multi-storey Family House in Florence

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**ABSTRACT:** This paper presents the structural adaptation of the residential buildings “Le Navi” in Florence. As well as tackling the typological, architectural and environmental obsolescence of the multi-storey blocks, the refurbishment programme also achieved compliance with current national seismic regulations. The intervention on the structures involved above all the introduction of tension rods for wind bracing, that improve and reinforce the structure in relation to seismic events.

## 1 GENERAL DESCRIPTION OF THE CASE STUDY

The “Le Piagge” District in the Municipality of Florence is the location of a residential complex, called “Le Navi” as it is shaped like a ship, built at the end of the 70s for renting to low-income users (Fig. 1).



Figure 1. Urban district Le Piagge, Florence

This project was carried out with the support of the recent Italian law on urban renewal called “Contratti di quartiere” (“Neighbourhood Contracts”, Ministerial Decree 22.10.1997), which mainly focuses on the regeneration of town districts severely affected by social, economic and physical decay. It points out the fundamental role of the rehabilitation of existing housing estates, rather than that of overall renewal. The renewal plan was carried out using public funding from three different programmes: the “Neighbourhood Contracts”, the “Urban Recovery Pro-

gramme”, and the “Experimental Building Programme”, the co-ordination of which involved significant efforts in terms of engineering. These programmes are aimed at the urban and environmental recovery of the whole district. They contribute to the social and economic development of the area through the direct involvement of users in the development of the programme.

The intervention was particularly devised to solve four main factors of building deterioration:

- The inadequacy of residential typologies in relation to the distribution of families and the needs expressed by users;
- The overall presence of severe building pathologies due to the use of unsuitable/poor-quality materials and construction technologies;
- The poor quality and/or poor performance of building services in relation to the distribution of the buildings (the “central atrium” type with duplex housing on two sides inevitably leads to a negative effect on the internal quality of the units. These negative effects involve air flow, lack of transverse ventilation, presence of humidity in the rooms, etc.)
- The lack of solutions that could give the various parts of the site an architectural identity and reduce the alienating character caused by the repetitiveness and anonymity of the buildings.

Many of the interventions involve both the structure and the envelope, and are aimed at the typological, technological and structural rehabilitation of two of these three identical buildings, each with 140 living units. Redevelopment of the overall site area, of about 55,000 square metres, is also planned. The project includes the creation of a public garden of high environmental quality with forest areas and small hills to break up the flatness of the landscape and create more interesting pedestrian and cycling areas.

## 2 PROBLEMS CONCERNING THE STRUCTURE

### 2.1 *Type of structures (referred to the aspect analysed)*

The structure of the buildings is formed of parallel reinforced concrete walls cast in situ at a modular distance of 6.8 m, thus forming a structural frame which strip windows and prefabricated panels and floors are inserted into. Consequently, the type of dwelling is characterized by the repetition of a module corresponding to the constant distance between the structural walls. (Fig 2-3)



Figure 2-3. The structure formed by parallel concrete walls is visible in the modularity of the façade

### 2.2 *Problems*

Structural problems particularly concern the inadequacy of the structure for seismic loads. The structure showed a widespread presence of defects resulting from the deterioration of the materials and the unsuitably rigid construction technologies used. Furthermore, as regards the enve-

loping there are a lot of problems which are strictly related to the structure of the building and the interventions required, such as the lack of insulation of façades and roofs, the decay caused by pelting rain and the action of mould, and the lack of liveable areas and small balconies. (Fig. 4-5)



Figure 4-5. Decay of the façades due to atmospheric agents

### 2.3 Strategy for improvements

This project provides an answer for structural, architectural and technological problems by concentrating efforts on four main tasks:

- Modifying the distribution of residential types and optimizing the planning of the units with the aim of making them respond to the needs expressed by users;
- Highlighting the maintenance, renovation and replacement interventions necessary to eliminate the effects and causes of the decay, to comply with standards and, more generally, to improve living conditions;
- Improving structural performance;
- Introducing, as far as restoration of the façades is concerned, architectural elements that can reinforce the architectural identity of the two buildings. Diversification of the façade solutions will create a less alienating and more familiar urban landscape.

Furthermore, the aim is to improve the living quality of the units by looking at the architectural elements and the aspects that guarantee building hygiene. In particular, the living quality of the connecting spaces between the two buildings has been enhanced by the addition of courtyards in the middle of the horizontal circulation of the units. The courtyards interrupt the internal walking path, thus providing natural light and air circulation for the buildings. As well as improving the environmental quality of these spaces, such a solution significantly reduces the negative effects of the presence of long, dark corridors. The refurbishment strategies, which include both structure and envelope, were aimed at developing the following objectives:

- Compliance with seismic regulations;
- Complete renovation of the façades with the overlap of a thermal insulation layer (external thermal insulation coating);
- Replacement of external windows and doors to improve their thermal insulation properties (this also contributes to enriching and bringing character to the external façades);
- Complete replacement of the balustrades of the existing balconies with diversified solutions including: galvanized steel balustrades with a solid lower part, and balustrades in a light, transparent material;
- Creating new balconies overhanging the level of the duplex units with galvanized steel balustrades and coloured safety glass;
- Finishing the balconies at the top two levels with a galvanized steel grill and added balustrades. The balustrades are made from coloured safety glass and galvanized steel grill panels;

- Partial enclosure of the balconies near the new heating units (boilers) with galvanized steel panels (inserted using the “dry method” in accordance with prefabrication techniques);
- Addition of internal courtyards that interrupt the long (internal) layout corridors and allow natural light and air flow (improvement of environmental conditions).
- Compliance with current standards regarding hygiene (sanitary facilities) and utilities (electrical systems);
- Setting up a powered ventilation and recirculation system for improved air displacement in the single-sided units.

#### 2.4 Actions

The main actions involving structural interventions can be listed as:

- Reinforcement of the concrete structure via a hardening intervention with the introduction of tension rods for wind bracing between all structural modules;
- Addition of new balconies made from a 3 m overhanging concrete slab, galvanized steel and coloured safety glass.

The guidelines for design management particularly focussed on avoiding large-scale, intrusive or destructive interventions on existing structures, and also included:

- a careful and detailed reconnaissance of the existing structures, their layout, nature and primitive character;
- identification of technical resources and strengths, and their disposition.

Factors which influence the behaviour of the entire structure were identified and evaluated in accordance with the terms established by the regulations in force, in particular:

- L. 2/2/1974, no. 64
- L. 26/4/1976, no. 176
- L. 25/11/1982, no. 1684
- D.M.LL.PP. 14/2/1992
- D.M.LL.PP. 16/1/1996
- Circ.Min.LL.PP.10/4/1997, no.65/AA.GG.
- CNR 10011/88

The occasion of the functional and structural refurbishment of the two buildings, divided into two identical units both in terms of geometric shape and design solutions, provides the opportunity for the seismic adaptation of the existing structures, to develop comparison models and therefore to test solutions and devices related to connections. Through the use of a mathematical model, more proposals have been made for possible interventions highlighting successes and/or failures, which will be illustrated in section 3. (Fig. 6,7).

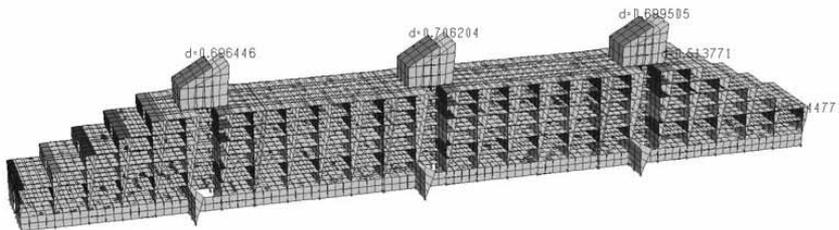


Figure 6 Dynamic deformations. Longitudinal seismic effects

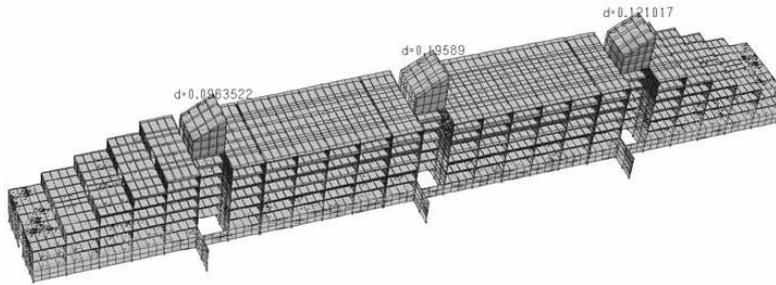


Figure 7 Dynamic deformations. Transverse seismic effects

## 2.5 Description of works and critical evaluation

### 2.5.1 Structural upgrading

After checking the different configurations caused by seismic action, it was decided to use a cell by cell hardening intervention between each structural module, which also included the addition of wind bracing tension rods to improve and reinforce the structure in relation to the seismic event. The elements forming the new structure are:

- Steel diagonals: Fe430B steel profiles, tubular section,  $\varnothing$  101.6 mm, thickness 5.6 mm, painted with rust inhibitor, joined to metal plates;
- Metal plates for anchoring the hardening diagonals: thickness 20 mm, dimensions 220x800 mm, directly fixed and glued to the structure at each floor;
- Flexural connections of the joint made from steel bars Fe B44 K (Fig. 7-9), thickness 16 mm, dimensions 150 mm. These are inserted into 60/50 holes at the bottom of the structural walls, protected by plastic membranes and filled with expansive mortar EMACO 2000 kg/m<sup>2</sup> concrete.



Figure 8 Wind bracing tension rod scheme

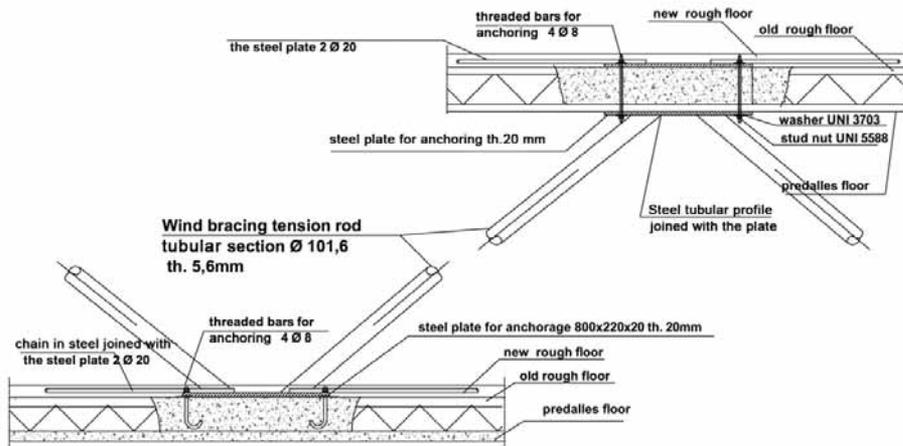


Figure 9 Detail of the wind bracing tension rods. Longitudinal section

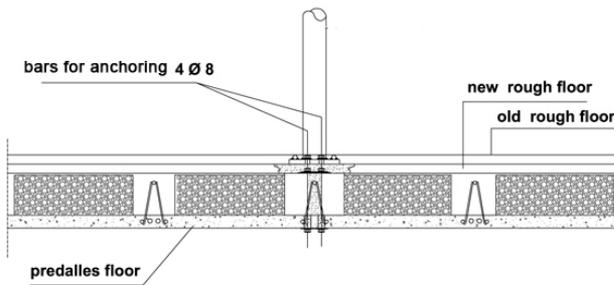


Figure 10 Detail of the wind bracing tension rod. Cross-section

The distribution of the strengthening profiles was, of course, carried out in relation to the distributional and functional requirements of the building in its final prospective study, but also in such a way as to control the increases in stress in a compatible way, specifically and locally reconsidered in the structures already in place (Fig. 11-16).

Because of the remarkable monolithic nature of the structure, it was also difficult to design accurate means for noise insulation. For this reason, the use of specific technical solutions in the structural joints that can help in the interruption of various kinds of vibration waves was tested.

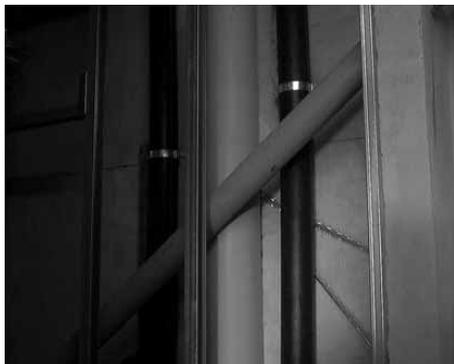


Figure 11 Hardening near the installations



Figure 12 The cavities near the new structures



Figure 13 Welding between tubular profiles



Figure 14 Top steel plate for anchoring



Figure 15 Bottom steel plate for anchoring



Figure 16 Anchoring operations to the existing floor

The main interventions for interrupting vibration waves were the following:

- Use of an adhesive polymer film at the interface between existing floor and the new rough floor (including one vertical strip at the position of the vertical panels) to interrupt the material continuity of the elastic medium, with a view to improving vibration insulation while still maintaining the expected mechanical efficiency of the structural reinforcement;
- Use of reinforced neoprene cushions alongside the anchoring plates for the wind bracing profiles in order to increase knowledge of and obtain quantitative comparisons for the effects of introducing structural reinforcements (concrete reinforcing, steel diagonals) on the sensitivity of the material and continuity connections in the structure for noise transmission. Particular attention was also paid to noise produced by the system networks concentrated in the cavities beside the new structures.

The mathematic model used allows new intervention solutions to be proposed, highlighting successful results and/or failures. It was decided to give less importance to the stair units as the quality of their foundations, being clearly in a condition of weakness, did not match their strength and aseismic capacity. Generalised cell by cell reinforcement was used to unload the units, rebalancing their role and function (these units were not conceived of, designed and/or constructed as priority earthquake defences). Within this framework, the structural and heat-proof joints (except those on the top floors) were removed, eliminating the differences in resources and rigidity and producing a sort of “uniform strength”.

The structure is affected by a variety of smaller interventions at a local level caused by the new distributions. These do not, however, alter general performance expectations. Rather they confirm the regularity and symmetry, contributing to achieving predictable behaviour without any unusual escapes or unexpected stress “peaks”.

### *2.5.2 Upgrading façades and adding balconies.*

Interventions for refurbishment of the facades included the following actions:

- Removal of the existing windows, changing type, geometry and distribution of the openings, assembly of new aluminium window frames;
- Creation of an external thermal insulation system (ETICS) and, in the structural walls, creation of a cavity for the insertion of the pipes for the new boilers;
- Removal of all of the parapets of the balconies and their replacement with new parapets in concrete and galvanized steel;
- Creation, on the second floor, of new balconies with a concrete slab overhanging by approximately 3 metres and parapets made from galvanized steel and coloured safety glass;
- Creation at the position of the balconies on the top floor of a galvanized steel structure which vertical and horizontal opaque grill panels and coloured safety glass panels as parapets are inserted into;
- Creation on the top balconies of horizontal grill elements in galvanized steel with functions of solar shading.

### 3 TECHNICAL DATA SHEET

The structure was checked through the assessment of loads and overloads in compliance with Ministerial Decree 16 January 1996 and using the following seismic parameters:

Table 1. Seismic parameters used.

Seismic coefficient	9
Seismic protection coefficient	1
Foundation coefficient	1
Coefficient of response	1
Coefficient of structure	1.4

The calculation of loads and overloads for verification was in compliance with the aforementioned Ministerial Decree 16 January 2006, particularly considering:

- Living volume: accidental overload equal to  $200 \text{ kg/m}^2$  with inertial rate of 0.33.
- Balconies: accidental overload equal to  $400 \text{ kg/m}^2$  with inertial rate of 0.33.
- Roof: accidental overload caused by snow with inertial rate of 0.33 equal to:

$$\begin{aligned}
 q_s &= \mu_1 q_{sk} & \text{where:} \\
 q_{sk} &= 115 & \text{kg/m}^2 \text{ (zone II, to } s < 200 \text{ above sea level)} \\
 \mu_1 &= 0,8 & \text{(stratum angle } < 30^\circ \text{)?} \\
 q_s &= 92 \sim 100 & \text{kg/m}^2
 \end{aligned}$$

The model for analysing the entire building was created by modelling all of the reinforced concrete walls using shell elements with a thickness of 18 cm.

The need to model the bracing system prevented the use of a rigid floor outline. The problem was resolved by modelling several floor levels with shell elements with a thickness of 28 cm having no density in order not to load the bracing elements that would only be activated following a seismic load. In fact, these elements are installed by connecting the various already deformed floors. The floor load is thus transferred onto the main walls (and on the beams of the corridor) as a distributed load in accordance with the calculations given below.

The procedure involves dynamic analysis in two distinct stages: the first calculates the frequencies of the vibration itself, the second calculates shifts and stresses resulting from the response spectrum assigned in input. From the point of view of processing time, the stage of frequency calculations is more burdensome: this stage was kept separate, however, to the stage of calculating the spectral response and is always launched first. There are two specific printing phases for these results, one which involves the oscillation frequencies only and a second which also highlights eigenvectors. Thus, once the frequencies have been identified, if the system to be resolved does not change, the user can then proceed with spectral analysis only.

In the spectral analysis, the program (MASTER SAP) uses the response spectrum assigned in input, as set out by the regulations. For the global directions X and Y the spectrum decreases for periods of more than 0.8 seconds. The spectrum in the global direction Z, if present, is unitary. The amplitude of the spectrums of responses is determined by the seismic parameters foreseen by regulations and assigned in input by the user.

The procedure initially calculates the modal participation coefficients for each direction and frequency of the seismic event. These coefficients can be seen as the dynamic contribution of each mode of vibration in the assigned directions. It will therefore be possible to see which direction each individual mode of vibration has predominant effects in.

Subsequently, the shifts and stresses for each dynamic direction activated are calculated for each mode of vibration. The overall effect, caused by the individual modes of vibration, is calculated for every dynamic direction by means of the square root of the sum of the squares of the individual effects. A specific printing stage is foreseen for these results.

The last processing involves calculation of the total effects, obtained by taking into consideration all of the dynamic directions applied. These results (envelope) can be obtained, at the user's discretion, in three separate ways, including those suggested by Italian regulations and by the Eurocode 8.

#### 4 CONCLUSIONS

The urban refurbishment of the district "Le Piagge" can be considered as one of the most representative interventions in terms of improvement of architectural, technological and structural performance. The final design, involves an overall investment of 17 million Euros, with a net building cost of 13.5 million Euros, 3.2 of which were spent on the building envelope. The purpose of the work is to obtain 312 newly refurbished units by improving the quality of the 280 existing ones and designing 32 additional ones of a smaller size. Hence, the cost of each unit is about 43,500.00 Euros, 10,300.00 Euros of which were spent on the building envelope. The sum of all the unit areas is 25,600 square metres.

The cost forecast is therefore 530 Euros per square metre, 125 Euros of which were spent on the building envelope.

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