

Architectural Heritage and Performance-Based Building Codes: Approaches and Experiences



Report of the IRCC Workshop
Madrid, Spain
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NOTICE

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Foreword

Architectural heritage buildings are an important symbol of a country's history and culture, and a great deal of effort is expended to preserve such buildings for the benefit of all. However, the process of achieving suitable levels of performance and safety, while maintaining the historical fabric and experience, can pose many challenges for regulators, designer and contractors, since any renovation or upgrade works have to preserve the inherited merits of the building while at the same time meeting the new and often higher levels of required performance.

This is especially challenging where buildings have legal protection under historical or heritage preservation acts, which may prevent alteration to the structure, building elements or finishes. The question becomes how to balance the heritage protection without preventing the performance upgrade of the buildings, which will also help to keep the buildings in good condition for many years to come.

In general, building codes and regulations are mostly conceived for application in new buildings, although they are also sometimes applied to existing buildings when they are subject to significant renovation or change in use.

The IRCC has carried out a survey to see how the issue of existing buildings and codes is been dealt with in several countries with performance-based building regulations. However, the IRCC survey did not take this particular case of historical buildings into account, so this workshop was convened to share international views and experiences for the case of existing buildings which are under protection for heritage reasons. Fire, one of the worst enemies of historic cultural heritage buildings, was a particular focus of the Workshop.

To launch the international discussion and debate on the issues, speakers from several countries gave their approaches and experiences, followed by a roundtable discussion. The aim was for IRCC members to leave the workshop with an increased understanding of the challenges and limitations of applying building codes to heritage buildings.

The Workshop presentations and discussions were necessarily wide-ranging, yet proved to be extremely insightful and beneficial to the IRCC members. Although it is impossible to capture the full extent of discussions and perspectives, the following provides a summary of some of the key issues that were discussed. As performance-based building regulations become more risk-informed in the future, the discussions and professional connections made at this workshop will help set the foundation for facilitating global cooperation and advancement in this area.

This international Workshop was organized by the Ministry of Housing¹ of the Government of Spain and the Inter-Jurisdictional Regulatory Collaboration Committee², IRCC, on the occasion of the second IRCC meeting in Madrid hosted by the Ministry of Housing from 10 to 12 November 2008.

The organization of the Workshop was under Brian J. Meacham, Chair of the IRCC, and Javier Serra, Deputy Director General for Innovation and Quality in Building of the Ministry of Housing, and member of the said Committee.

The Workshop was opened to national and international attendees, under request to the organizers.

Javier Serra

Editor

¹ Ministerio de Vivienda. Gobierno de España. (www.vivienda.es)

² Inter-Jurisdictional Regulatory Collaboration Committee, (<http://www.IRCCbuildingregulations.org/>)

Acknowledgments

The success of any workshop is due ultimately to the participants, and this workshop is no exception. The core of the workshop participants – the source of issues to be addressed and factors to be considered – were the members of the IRCC. As representatives of organizations responsible for the development and support of nationally-adopted building regulations in ten countries, the challenges you face and the experience you bring shaped the breadth and depth of discussion.

To help the IRCC expand their knowledge of heritage issues in regulation, consider new and different approaches to use of risk concepts in performance regulation, and learn from a broader cross-section of regulated areas, a small group of invited experts participated in the workshop, sharing their insights and experience, and making the workshop an incredibly valuable experience for all:

Ángel Arteaga, E. Torroja Institute, Spanish National Research Council (CSIC), Spain

Denis Bergeron, National Research Council, Canada

William Dodds, Building Standards Directorate for the Built Environment Scottish Government. Scotland. UK

Wataru Gojo, National Institute for Land and Infrastructure Management, Japan

José Luis González, School of Architecture of Barcelona, Polytechnic University of Catalonia, Spain

Mariana Llinares, E. Torroja Institute, Spanish National Research Council (CSIC), Spain

Agustín Mateo, AUIA Associated Architects and Engineers, Spain

Mario Muelas, AUIA Associated Architects and Engineers, Spain

Jesus de la Quintana, LABEIN Tecnalia, Spain

We sincerely thank each of you for your generosity in sharing your time, experience and expertise with the IRCC – your participation is deeply appreciated.

Finally, no workshop happens without planning, organization and administrative support. We extend our sincere appreciation to Javier Serra and the Spanish Ministry of Housing for their support.



Background and Introduction

Performance-, functional- or objective-based building regulatory systems are in use or under development in numerous countries world-wide. In some instances, such as in England and Wales, functional-based building regulations have been in use for more than 20 years, while in Canada, objective-based codes are just being promulgated. In New Zealand and Australia, major modifications are underway to the performance-based regulations, including a focus on better quantifying performance criteria, exploring different levels of performance which might be expected for different types of buildings, and investigating how risk might be used as a basis for establishing performance levels and criteria.

The fact that so many countries are developing and promulgating performance-, functional or objective-based codes, that the various countries can learn from one another and take advantage of joint research and learning opportunities, and can help transfer this knowledge to others are just some of the issues that led to the formation of the Inter-jurisdictional Regulatory Collaboration Committee (IRCC).

The IRCC, formed in 1996, is an unaffiliated committee of fourteen of the lead building regulatory agencies and organizations of thirteen countries (www.irccbldgbuildingregulations.org):

- Australian Building Codes Board (ABCB), Australia
- Austrian Institute of Construction Engineering (OIB), Austria
- Building and Construction Authority (BCA), Singapore
- China Academy of Building Research (CABR), China
- Department of Building and Housing (DBH), New Zealand
- Department for Communities and Local Government (DCLG), England and Wales
- Institute for Research in Construction, National Research Council (NRC), Canada
- International Code Council (ICC), USA
- Ministry of Housing (MOH), Spain
- Ministry of Land, Infrastructure, Transport and Tourism (MLIT), Japan
- National Board of Housing, Building and Planning, (Boverket), Sweden
- National Institute for Land and Infrastructure Management (NILIM), Japan
- National Office of Building Technology and Administration (NOBTA), Norway
- Scottish Government Directorate for the Built Environment (DBE), Scotland

Over the past ten years, the IRCC has developed guidelines for the introduction of performance-based building regulations (1998 - used by code developers in Spain, the USA and elsewhere in the drafting of their performance-based building codes), has held global summits on issues in performance-based building regulation (Washington, DC, 2003) and sustainability (Gold Coast, Australia, 2005), in addition to meeting at least twice annually to discuss issues and share experiences.

In those countries with a big historical and cultural architectural heritage the issue of how modern building codes have to be interpreted, applied or exempted when we plan works on them has become a new concern for concerned architects and building controllers. This workshop was organized to discuss how to balance the heritage protection without preventing the performance upgrade of the buildings, which will also help to keep the buildings in good condition for many years to come, and therefore to help IRCC members further explore these issues, and to learn from other regulated areas which have adopted performance concepts.

Invited Speakers

Angel Arteaga

Angel is a civil engineer, PhD, staff researcher of the CSIC in the 'EduardoTorroja' Institute (IETcc-CSIC). He has been member of the IETcc team preparing the Fire Safety Document of the Spanish Building Code and in the development of the European Structural Eurocodes as National Technical Contact in the Fire parts of the Eurocode 1 (Actions, EN 1991-1-2) and 2 (Concrete Structures, EN 1992-1-2) and member of project team preparing the part 1-7 Accidental Actions (En 1991-1-7). He works in the areas of Structural reliability, and risk analysis.

Denis Bergeron

Denis is an architect who started his professional career as a loss control expert in the property insurance industry. He joined the Canadian National Research Council (NRC) in 1990 as a fire safety expert in a team supporting the development of the National Building Code of Canada (NBC). Denis is currently the Director of Codes and Evaluation at the NRC's Institute for Research in Construction (IRC). His responsibilities include the development of the National Construction Codes of Canada and a national service for evaluation of innovative construction products and systems.

William Dodds

Bill is currently the Acting Head of Building Standards with the Scottish Governments. He is a Chartered Surveyor by profession and has been in the construction industry for over 30 years. Before joining the government two years ago, Bill was the Building Standards Manager for one of the largest local government building control offices in Scotland. He therefore has a good understanding of the regulatory making process as well as the practical difficulties of enforcing regulatory requirements.

Wataru Gojo,

Wataru is an architect who started his professional career in the Japanese Ministry of Construction. He also worked for the Ministry of Housing of Peru as well as for other institutions: Building Center of Japan, Building Research Institute in Japan. He joined the National Institute for Land and Infrastructure Management (NILIM) in 2001 as the Head of Standards and Accreditation System Div. Wataru is currently the Research Coordinator for Disaster Mitigation of Buildings, NILIM. He is also a member of IRCC, CIB TG37 (Performance-based Building Regulatory Systems), ISO TC59 SC15 (Performance Criteria for Single Family Attached and Detached Dwellings), Architectural Institute of Japan and Association of Urban Housing Sciences, Japan.

José Luis González

José Luis is an architect, PhD, who has specialized in structural and construction knowledge of historic buildings. He has been full Professor at the Polytechnic University of Catalonia, Barcelona, Spain since 1992. He was invited lecturer in several universities and courses. As an expert, he took part in the following restoration works: Pozzuoli Cathedral (2004), Colonia Güell Church in Santa Coloma de Cervelló (1988-2002), Casa de las Aguas in Barcelona (1987), Llopis House in Sitges (1985), Sant Pau Hospital in Barcelona (1981). He has also carried out different studies about construction and structural problems in historic buildings. He has written a number of books and articles in the field of restoration of architectural heritage.

Mariana Llinares

Mariana is an architect who has been a member of the IETcc team preparing the Fire Safety Document of the Spanish Building Code since the very beginning. She has participated in previous IRCC Workshops and in the european project: COST Action C-17: European Cooperation in the field of Scientific and Technical Research: Built Heritage. Fire Loss to Historic Buildings.

Mario Muelas and Agustín Mateo

Mario and Agustín are architects and members of AUIA (Associated Town Planning Architects and Engineers). They have specialized in restoration of historic buildings as well as in construction of sustainable dwelling houses. They have carried out a number of restoration projects for listed buildings. They therefore have a good understanding of practical difficulties of enforcing regulatory requirements in existing and listed buildings. Besides having a lot of their built work published, they have been awarded several architecture prizes.

Jesus de la Quintana

Jesus de la Quintana obtained his degree in engineering on 1993. He is the head of the Fire and Blast Safety Engineering Team of Tecnia, a private research centre in which 1.450 researchers work in R+D and market oriented projects. He has been involved in many projects related to fire and blast safety engineering, working in multiphysics, fluidynamics of the fire, advanced structural analysis, and advanced egress analysis. He has developed an on-site test verification for ventilation and smoke control in buildings and tunnels, and leads the corresponding patent. He has participated in the expert committee that worked in the Spanish Technical Building Code (C.T.E.), precisely in the fire safety part.

Workshop Program

09:00	Welcome and Introduction	Javier Serra Ministry of Housing, Spain
09:10	Fire Risk Assessment for Heritage Buildings	Mariana Llinares / Angel Arteaga , Torroja Institute, CSIC, Spain
09:30	Regulations on Cultural Heritage Rehabilitation: A Compromise between Two Different Cultural Times.	Mario Muelas and Agustin Mateo , AUIA, Spain
09:50	Proposal for a Spanish Guidelines on Application of the Building Code in Legally Protected Heritage Buildings	José González Moreno-Navarro , ETSAB, UPC, Spain
10:10	Case study: Performance fire risk assessment in the old Madrid Post Office retrofitting.	Jesus de la Quintana , LABEIN Tecnalia, Spain
10:25	Q&A Discussion	
10:35	Coffee break	
11:00	Application of building codes to existing buildings: outcome of the IRCC members survey and experiences in Canada¹	Denis Bergeron , NRC, Canada
11:20	Fire issues in historic buildings in Scotland	William Dodds , Building Standards Directorate for the Built Environment Scottish Government. Scotland. UK
11:40	Application of Building Regulations for Safety to Existing Heritage Buildings in Japan¹	Wataru Gojo , NILIM, Japan
12:00	Q&A Discussion	
12:30	Closing Statement	Brian J. Meacham , IRCC Chair. USA

Discussion, observations and summary

The audience was composed by more than 100 persons coming from public and private interested sectors, national, regional and local administrations, Architects associations, etc.

The organizers announced the intention to prepare a document that would gather all the material and conclusions from the Workshop. Brian Meacham and Javier Serra would be the editors. The workshop report would be prepared in electronic format. The Ministry of Housing will consider the possibility to prepare a bilingual hard print publication with the permission of IRCC.

The audience had a lively participation and made several suggestions. One of the proposals coming from Mr J. Monje was to prepare a multinational case study on heritage buildings aimed to show reasonable cases where codes would not be applicable.

One of the representatives from the Heritage Institute from the Spanish Ministry of Culture, (Carlos J. Cuenca) made stress on the importance of making differences between those interventions on highly legal protected buildings ("BIC: Bienes de Interés Cultural"), and those others aimed to 'restoration' with no change of use where the Code should not be applied. And a third case aimed to 'rehabilitation' where the methodology proposed by Prof. González would be suitable. The Ministry of Culture services offered their collaboration to make some progress in this respect.

Another audience intervention was on the need that professors and teachers in the Academia (mainly Schools of Architecture) make a reflection on how to address this issue in their studies plans and programs.

A representative from ARUP requested the need to have a clear system to get approvals on 'alternative solutions' as they are foreseen in the Spanish Code. Although there are a few cases in historic buildings in comparison with 'normal' buildings, they perceive some reluctance from municipal services when supervising the projects before granting the building permits. To them a good interpretation of the term 'equivalent' is the clue of this question.

A representative from the Heritage Commission of the Madrid City Council showed his worry on the safety issue concerning this kind of buildings. It is impossible to achieve a 100% of safety because as it is a probabilistic concept. That means that remaining risks have to be controlled in some way. Partial exemptions in some buildings have to be envisaged, documented and explicitly shown in buildings particularly when are publicly visited. I.e. load limit of floorings, etc.

A general conclusion from the workshop would be that in this kind of buildings a special treatment on the way codes are enforced should be considered. A case by case approach is very useful and providing guidance with best practices could help practitioners and administrations to act properly and preserve the heritage buildings in a compromise to keep them alive for future generations without losing its intrinsically historic values.



CODES FOR EXISTING BUILDINGS: DIFFERENT APPROACHES FOR DIFFERENT COUNTRIES

Denis Bergeron, MSFPE³, NRC, Canada



ABSTRACT

Although all IRCC⁴ member countries share a common interest in the development of performance approaches to building regulatory systems their discussions have normally been limited to codes and regulations for new construction. Many countries are however facing a major expansion of the construction activity from new construction to the renovation and transformation of existing buildings. IRCC member countries have undertaken work to better understand how different countries deal with regulations for the renovation or transformation of existing buildings.

This work began with the development of a survey with the aim of collecting key information that will subsequently be analysed and may lead to further study. The survey is addressing a number of key issues with respect to how countries deal with regulations for existing buildings:

- Are existing buildings covered by codes for new constructions?
- Is there a separate code for existing buildings?
- Do codes apply to all types of existing buildings?
- What are the triggering mechanisms for codes to apply to existing buildings?
- Do codes allow for relaxations or lower performance for existing buildings compared to codes for new construction?

³ D. Bergeron is Director, Codes and Evaluation, Institute for Research in Construction, National Research Council of Canada. The author acknowledges the participation of all IRCC members in this work with special thanks to Dr. Paul Stollard of the Scottish Building Standards Agency for his special contribution to this paper.

⁴ Inter-jurisdictional Regulatory Collaboration Committee is a collaborative of countries engaged in discussions, work and exchange on building regulatory policy issues with focus on the use of the performance concept. It currently consists of 11 countries and welcomes interest from other countries. Current IRCC member countries are Australia, Austria, Canada, China, England and Wales, Japan, New Zealand, Norway, Scotland, Spain, United States. For more information see <http://www.irccbuildingregulations.org/>

- Is the performance-based or prescriptive approach used for existing buildings?
- What level of government is responsible for regulating existing buildings?

Preliminary analysis of the survey results seem to indicate a considerable variety of approaches for regulating existing buildings ranging from strict application of codes for new construction to explicit relaxations and lower performance expectations regarding the renovation or transformation of existing buildings. This survey was developed early in 2007 and IRCC work was still underway at the time of submitting this paper.

This paper will report on work undertaken by IRCC to better understand regulations for existing buildings in various countries and the use of the performance-based approach in these regulations.

PERFORMANCE BASED BUILDING REGULATORY SYSTEMS

Building regulatory systems around the world are going through dramatic change in response to changing stakeholder needs and political environments. The common element resulting from the changes however is the introduction of greater flexibility for the building code users. This is achieved through the explicit statement of the objectives or goals of the regulations and an increased use of performance-based requirements. This characteristic of these new building regulatory systems is an important feature for those wanting to encourage innovation and the advancement of new technologies. All IRCC members share this common goal and use this collaborative to develop a greater understanding of their different regulatory environments and promote basic principles that they can share and adapt for use in their respective jurisdictions.

Priority Issues and Drivers for Building Regulations

Building regulations have traditionally been well established in most countries to mitigate certain risks for which there is a broad consensus that regulation is the preferred mechanism. The most widely recognized risk-based building regulation issues are those of safety (against fire, structural failure, accidents in the use of a building, etc.) and health (indoor air quality, hygiene, etc.). In most countries it is also agreed that building regulations play an important role in protecting the community from catastrophic losses with requirements to mitigate losses resulting from fire conflagrations and natural hazards such as earthquakes and hurricanes.

Recent years have seen the emergence of new political and social pressures on building regulations to address issues associated to raising expectations for the protection of human rights and of our global environment. These emerging regulatory issues have been recognized in most countries as being those of accessibility to buildings for persons with physical disabilities and those related to the conservation of non-renewable resources such as energy and water. Broader sustainability and climate change issues are also being considered in many countries. Unlike the more traditional risk-based health and safety issues, these emerging regulatory issues are associated to new social aspirations. They do not aim at mitigating losses or harm from certain hazards but rather aim at providing a certain level of social dignity or sustainability for issues of concern to a growing number of people.

Decision to regulate certain aspects of building construction is generally the result of a series of steps that form part of the normal policy development process in most countries. This process aims at limiting to a strict minimum the burden of building regulations and to make use to the greatest extent possible of other available mechanisms. Such mechanisms vary considerably from one country to another but generally include the use of promotion tools, incentive programs, consumer education, market forces, etc. In recent years however many countries have seen rapidly changing priorities at the political level, characterized by a sense of urgency to act in areas such as climate change, which lead to pressures for the development of new building regulatory instruments.

Shared Technical Principles

The IRCC members recognized that a number of technical principles have been commonly adopted as the fundamental basis of their building regulatory systems.

Traditionally building regulations were set by prescriptive specifications (a door must be a certain width; a wall must have a certain thickness). The key distinguishing factor of the IRCC is the commitment by members to develop regulations for new buildings that are based on functional or performance requirements. Instead of stating what must be built, requirements are given in the form of what function the building must fulfill (functional) or what the building must achieve (performance). While it would be highly desirable that such functional or performance requirements be expressed in quantitative terms and be verifiable by approved methods the reality is that in most countries the functional or performance requirements are expressed in qualitative terms essentially because of the unavailability of sufficient knowledge to determine in measurable terms their performance level.

As the building regulations must be legally enforceable it is quite reasonable, and probably essential, that they be supplemented by guidance that outlines how compliance can be achieved. Such guidance might be performance or prescriptive based and have some form of legal status. However in most IRCC member countries it is only guidance and there is allowance for flexibility in showing compliance with building regulations.

Another point of common recognition is that building regulations shall constitute a minimum level of functionality or performance below which it shall not be possible to build. As such building regulations shall not represent levels to which the industry, society or the general public aspire. It follows that building regulations are concerned only with those issues for which there is a need to regulate for reasons of health, safety or other widely supported social or economic goals (accessibility; resource conservation). It is recognized that issues of appearance and taste are not appropriate for building regulations and are better addressed by planning measures or the market forces.

Diverse Legal Practices

The IRCC members however recognize that the legal, political, social and economic environments may vary considerably from one country to another and that the technical principles adopted as the basis for building regulation systems have been adapted for use in their respective countries.

In most countries responsibilities for setting regulations and for their implementation involve many actors from the central and regional levels. Models vary but there is generally an effort to increase uniformity of regulations within a country through a centrally developed set of regulations, while allowing flexibility in the enforcement and compliance mechanisms at the regional or local level.

Verification of compliance with building regulations can be achieved in a number of different ways. It can be through public bodies, private companies licensed by the government or by recognized professional institutions. It may also be an assessment of the design or of the competence of the builders and may be performed before the work starts, during construction or before occupation of the building. The common principle however is a legal requirement for independent verification of compliance in some form and at some stage.

Although building regulations cover new buildings there is an application to existing buildings in most IRCC member countries. The application of building regulations to existing buildings varies considerably between countries and is the object of this paper.

BUILDING REGULATIONS FOR EXISTING BUILDINGS

In most countries new construction accounts for a very small fraction of the total building inventory. For some building regulatory issues of key importance there is a need to have a more rapid impact on the performance and quality of the entire building stock, which results in the application of building regulations to existing buildings. We have seen earlier that it is very difficult to develop a common approach to building regulations for new buildings because of different legal practices in various countries. In regulating existing buildings this is further complicated by the huge differences between countries with respect to the age and condition of the existing building stock and also with respect to the cultural and social environment. For example there may be substantial differences between countries on the notion of the rights of a homeowner and regarding societal preferences for preservation as opposed to replacement of old buildings.

The work done by IRCC to better understand these differences and how each country sets its own framework for regulating existing buildings is the result of a survey and discussions on the responses received from eight countries. The questionnaire addressed several aspects of building regulations for existing buildings and the responses revealed that on some aspects the differences between countries - and sometimes within the same country – are such that it is very difficult to report on common principles or practices that are shared by most countries. This paper does therefore concentrates on those aspects of the survey where there appears to be a more common approach among IRCC members.

IRCC Questionnaire on Building Regulations for Existing Buildings

1. Do the building codes or regulations for new buildings also apply to existing buildings?
 - a. Under what conditions? E.g. major renovation, change of use or occupancy, etc.
 - b. What relaxations or alternative measures are used for the application of building codes or regulations for new buildings to existing buildings?
 - c. Is the performance (safety, health, energy, etc.) required of existing buildings similar or less than that for new buildings?
2. Does your country have building codes or regulations that specifically apply to existing buildings? In other words, do you have separate codes or regulations for existing buildings?
3. What triggers the application of codes or regulations to existing buildings? E.g.
 - a. Retroactive date,
 - b. Type of building (e.g. high rise) or occupancy (e.g. hospitals),
 - c. Inspection that identifies unsafe or unhealthy conditions,
4. Regarding the types of existing buildings (e.g. high rise) and occupancies (e.g. hospitals) covered by codes or regulations:
 - a. Could you specify what types of buildings or occupancies are covered by codes or regulations for existing buildings and under what circumstances?
 - b. Do codes or regulations for existing buildings have different provisions depending on the type of building or occupancy? E.g.
 - i. Different provisions for commercial vs. residential occupancies;
 - ii. Different provisions for owners/occupiers of residential buildings vs. provisions for landlords of residential “rental” buildings – occupied by others;
5. Do codes or regulations for existing buildings:
 - a. Address all aspects that are covered in building regulations for new buildings (safety, health, energy, etc.)? If not could you specify what aspects are covered and under what circumstances.
 - b. Require the same level of performance as the codes or regulations for new buildings?
6. What approach is used in codes or regulations for existing buildings? E.g.
 - a. Essentially prescriptive measures,
 - b. Risk based analysis,
 - c. Performance based methods,
7. What levels of government (national/federal, provincial/state, local/municipal) are responsible for the regulation of existing buildings?
 - a. Development and adoption of codes and regulations,
 - b. Enforcement,

Trigger Mechanisms

In most IRCC countries the building regulations for new buildings also apply to existing buildings when there is a major renovation or alteration, an addition or extension of the building and also when there is a change of use of the building (for example the conversion of a building from a commercial to a residential use). This would normally be associated to a requirement to obtain a building or occupancy permit from the local authority. At this point many factors may be considered to determine what portions of the existing building shall be upgraded to comply with current regulations for new buildings. Such factors may include: the size of the building extension and how it is separated from the existing building; the size, condition and use of the existing building; the type of use affected by a conversion, etc. In some countries a renovation, extension or change of use of a portion of an existing building will require the entire building to be upgraded while in other countries only the portion of the building affected by this transformation will be covered by current regulations for new buildings and the rest of the building would not need to be upgraded. In at least one country the required upgrading as result of a building renovation or extension will be limited to certain aspects such as safety from fire and access and facilities for people with disabilities. A change of use may however be a key factor and a conversion to residential units would automatically require the upgrading of the entire building.

In some countries requirements for licensing of certain types of premises (residences for elderly people, liquor permits, large assembly halls, etc.) also constitute triggers for compliance to building regulations, which in most cases will require upgrading of key safety and health aspects of the building.

Some countries have developed separate codes or regulations for existing buildings and the survey results indicate that they may differ substantially from one country to another. In many countries fire safety regulations administered by the fire authorities are in place and apply to the ongoing maintenance and use of existing buildings. These regulations would typically focus on key fire safety aspects of buildings, which may include automatic alarms and fire suppression systems, means of egress, occupant load, fire separation and fire resistance of key building elements, etc. For specific fire hazards these regulations could require upgrading of fire protection measures. In at least one jurisdiction a requirement for mandatory fire risk assessment of all workplaces may lead to the upgrading of certain features of an existing building. In other countries however codes or regulations for existing buildings cover much broader aspects of buildings than fire and may include, for certain types of premises, requirement related to hygiene, indoor air quality, etc. In some countries such broad application of regulations for existing buildings would cause application and verification problems because, unlike fire regulations, the verification regime in place does not offer the framework and expertise necessary to verify compliance for non-fire safety related issues.

Mandatory upgrading regulations have been adopted in some countries to force the immediate upgrading of existing buildings with respect to certain regulatory goals or issues. These regulations may not be tied to any building work or transformation and are generally administered using an upgrading schedule determined by factors such as age and condition of the building, size and use, etc. Several countries have been using this mechanism to force the upgrading of buildings to provide access and facilities for people with disabilities. More recently this mechanism is being considered or used in a growing number of countries for achieving performance targets in the areas of energy and water conservation and other sustainability related goals. In earthquake prone countries this mechanism is also used to require the upgrading of the seismic resistance characteristics of certain types of buildings when it is determined that their current performance level is below an established minimum threshold. Some jurisdictions also use this mandatory upgrading mechanism to mandate the installation of automatic sprinklers in certain types of buildings.

Through mandatory periodic inspections of certain aspects of existing buildings some countries use a different mechanism to mandate the correction of dangerous and unhealthy conditions and the upgrade of related building components. This mechanism is typically used in critical safety areas through the mandatory inspection of electrical and gas installations, elevators and lifts, pressure vessels and boilers, etc. In one country this mechanism is applied to broader issues and includes the mandatory inspection of buildings for structural sufficiency, general condition and maintenance of the building envelope (for example the water tightness of facades, roof, basements), etc. Upgrading may

be required as result of these mandatory inspections and some governments offer financial assistance to the building owner to facilitate application of the regulation.

In addition to regulatory instruments most countries will also use a broad variety of voluntary compliance measures. They essentially aim at encouraging building owners to maintain their buildings in good condition and to voluntarily upgrade certain key building features to help the government achieve their performance targets. Depending on the country this approach can take the form of promoting building upgrades through the development and dissemination of guidelines and education material on issues as diversified as energy conservation, seismic resistance, safety, etc. In at least one country, governments offer financial assistance to building owners to improve the earthquake resistance of existing buildings.

Levels of Performance

Recognizing that it is often impossible to directly apply to an existing building requirements intended for new construction all countries will allow flexibility in the choice of solutions to achieve the building regulatory goals. Where the survey indicates differences between countries is with respect to the performance level of the solutions for existing buildings compared to the requirements for new buildings.

With exception of two countries all respondents reported that there is a clear provision in the building regulations that the performance expected from upgrading of existing buildings does not necessarily need to be equivalent to that for new construction. In other words the performance level required of existing building upgrades may be less than that for new construction work. These decisions as to what constitutes an acceptable level of performance are often made at local or regional government level. Some countries have developed sets of prescriptive requirements for existing buildings to express what constitutes an acceptable level of performance. In other jurisdictions where a functional or performance based approach is well established for new construction there may be allowance for use of risk assessment and similar decision-making tools to determine the acceptable level of performance of solutions for existing buildings.

At least two jurisdictions have indicated that only certain key aspects of existing buildings – generally those directly impacting occupant safety and health – would require to be upgraded to current standards for new construction and that for the other building components the building regulations in place at time of building construction would be used to govern upgrading work. In at least one country regulations for existing buildings have allowances for relaxations of the schedule of work, meaning that corrective work may be phased over a longer period of time than what would be expected for new construction.

Two countries where the functional or performance approach is well established have responded that the level of performance of existing building upgrades is equivalent to that of new construction work. Such building regulatory frameworks offer opportunity for alternative solutions to be proposed, provided it can be demonstrated that they provide an equivalent level of performance.

CONCLUSIONS

Building regulations have traditionally been developed to apply to new construction. As a growing percentage of the construction activity is with the renovation, transformation, extension and upgrading of existing buildings more countries are engaged in developing regulatory tools for existing buildings. An important aspect of regulation for existing buildings is the determination of the performance level required from building upgrades.

In many countries this is achieved by comparing existing building upgrades to the performance levels required for new construction. A fundamental difficulty encountered is the unavailability of sufficient knowledge to express the performance target of building regulations in quantified measurable terms that can be verified. Developing tools and methods to help develop these performance parameters is essential to the success of this approach.

In other countries the regulations make allowance for risk-based approaches for determining what constitutes an acceptable level of performance. With the rapid expansion of the scope of regulations

from the traditional fire and safety issues to emerging social objectives such as accessibility and resource conservation new decision-making tools need to be developed to support this approach.

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FIRE ISSUES IN HISTORIC BUILDINGS IN SCOTLAND

**William Dodds, Building Standards Directorate for the Built Environment Scottish Government.
Scotland, UK.**



Fire Protection in Heritage Buildings

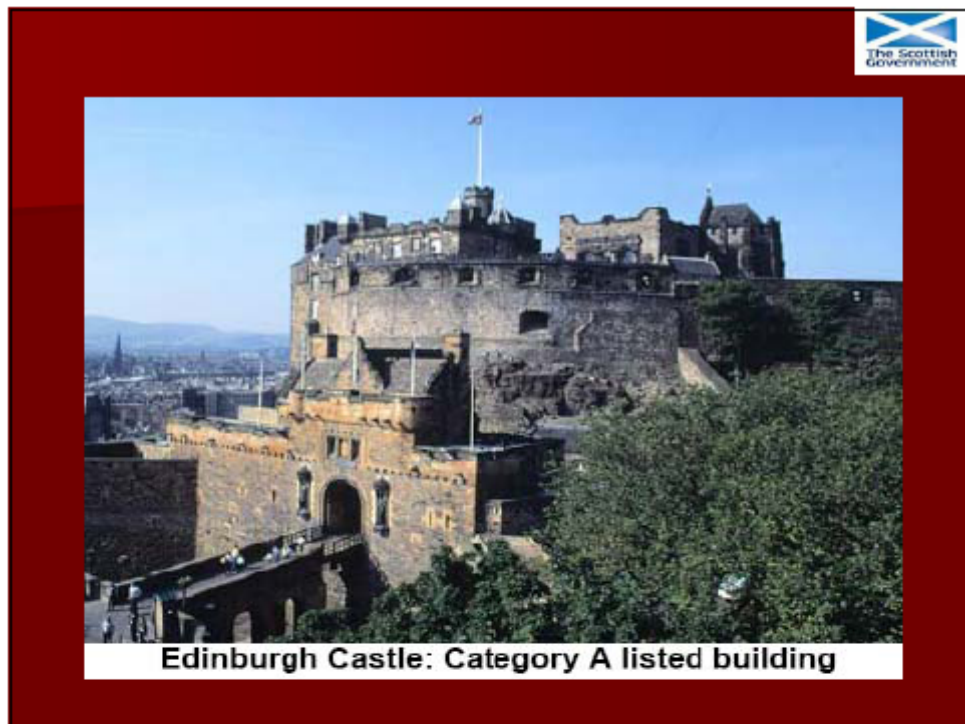


- Historic buildings were generally constructed without regard to fire risk and were constructed without the levels of fire resistance now required for new construction
- For example, deliberate compartmentation to confine the outbreak of fire or adequate consideration of escape routes were not features of their design.
- The buildings themselves therefore create fire safety problems where the presence of certain features actually assists the rapid spread of fire.

Building Regulations



- Old Building Control System had prescriptive standards
- New Building Standards System in 2005 introduced functional standards
- New regulations are significant because, together with the supporting Technical Handbooks they allow judgement to be made on how successfully a historic building can be converted to meet the requirements of the functional standards.



Fire Protection in Heritage Buildings



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Building Regulations

- The guidance offered by the Technical Handbooks with respect to fire standards is designed essentially for new build
- Strict application of the guidance has the potential, when applied to historic buildings, to cause significant loss of historic fabric and character.
- However, safety of life in a fire situation is paramount, which is reflected in the design of the standards



Fire Protection in Heritage Buildings

- To further complicate the issue, most historic buildings will have undergone alterations and changes throughout their life
- Features such as ducts, chases, ventilation shafts, and chimneys may have been built over and forgotten. They thus provide an easy route for fire and smoke to spread throughout the building.

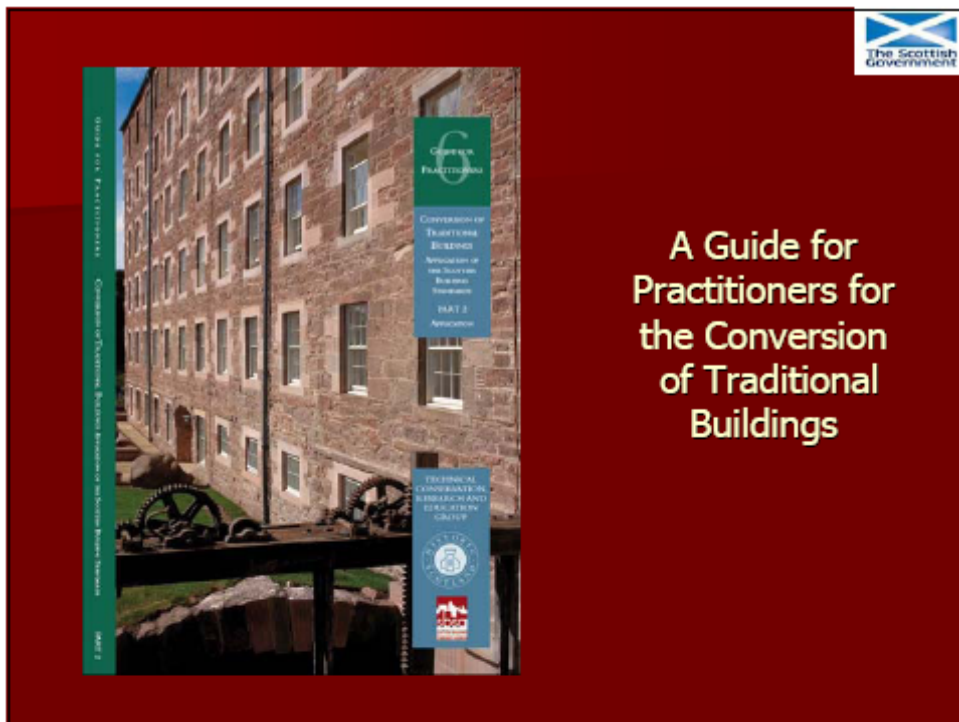
Fire Protection in Heritage Buildings



- Most historic buildings will contain undivided roof voids and hidden voids where a fire can smoulder unseen and break out at a point remote from the seat of the fire.
- Interconnected voids are a major hazard that must be accurately identified during the initial building surveys.

Fire Spread in roof voids

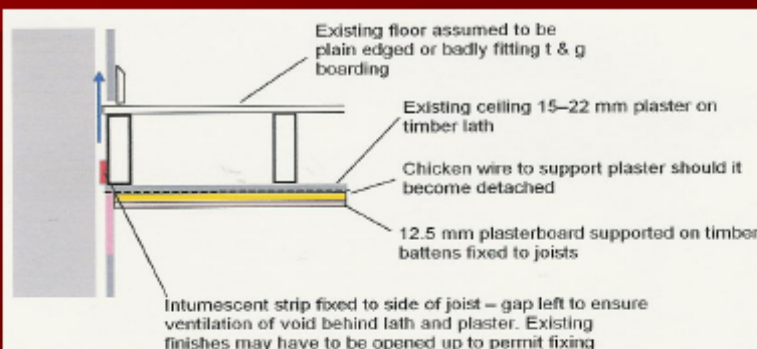




Fire Protection in Heritage Buildings

- The guide for practitioners is specifically concerned with the with the conversion of Scotland's traditionally constructed built heritage.
- Its primary aim is to assist in the finding of sensitive and applicable solutions to the conversion and reuse of Scotland's built heritage

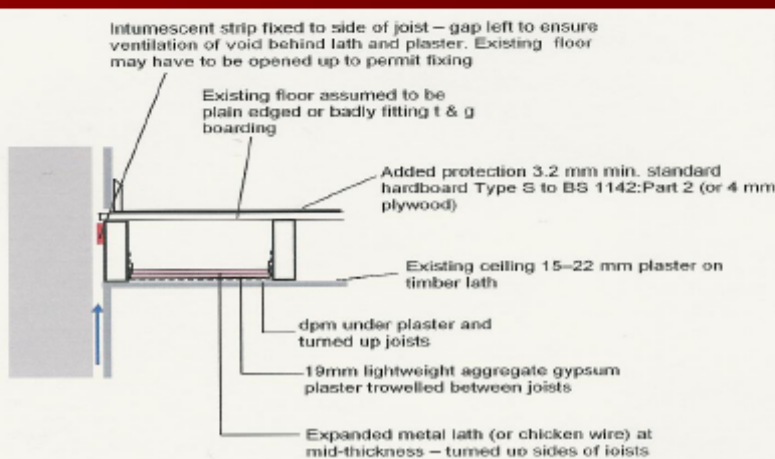
Fire Protection added to underside of existing ceiling 30 minutes



(a) Fire protection added to underside of existing ceiling: half-hour protection

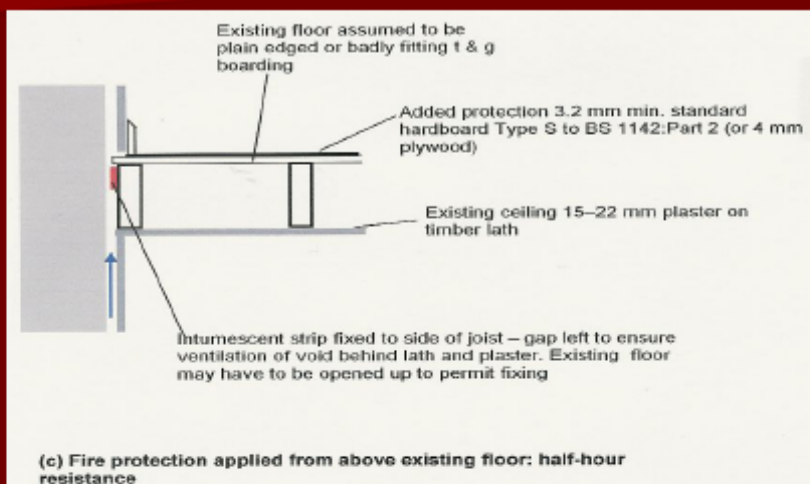
Note: for one-hour protection battens and plasterboard substituted by 13 mm lightweight plaster on metal lathing.

Fire Protection applied from above existing floor 60 minutes

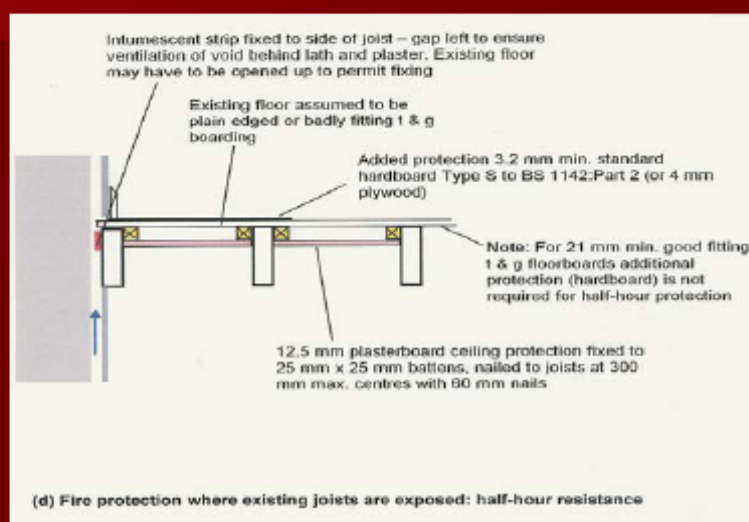


(b) Fire protection applied from above existing floor: one-hour resistance

Fire Protection applied from above existing floor 30 minutes



Fire Protection where existing joists are exposed 30 minutes



Fire risk from stored materials in roof void (lack of management)



Colgarth Castle remote rural location
difficulty of access and time for fire service
to attend protected with sprinklers.



**Colgarth Castle protected by sprinklers
decorated to be unobtrusive and blend in
with the building**



**Historic ceiling has fire resistance
improved with intumescent paper**



Duff House has a range of Fire Protection measures



Structural support for this stair would be difficult to determine using current design criteria, however protection can be provided using active fire protection measures.



Discreet sprinkler head. Integration with existing architectural features can assist to blend in modern fittings with their surroundings



Sidewall sprinkler head above a cornice. Minimally sized fittings can be visually unobtrusive



Smoke detector located discreetly to match the colour and cornicing in an ornate ceiling



Former Victorian Railway Station





Former Church Hall



Door upgraded to provide fire protection by inserting intumescent sealing strip.



Discreet installation of Emergency lighting in existing historic light fitting



Fire Protection in Heritage Buildings



Fire Protection in Heritage Buildings



Drummond Place, Edinburgh (Photo: I Macneil)

Future Development



A Practitioners Guide To Fire Protection and Fire Safety Management

- Designed to consolidate guidance from other guidance documents.
- Designed to support (Practitioners Guide Conversion of Traditional Buildings)

Fire Protection in Heritage Buildings



Fyvie Castle. Turriff. Aberdeenshire

APPLICATION OF BUILDING REGULATIONS FOR SAFETY TO EXISTING HERITAGE BUILDINGS IN JAPAN: A STUDY INTO BUILDINGS IN A GRAY AREA BETWEEN “EXISTING UNCONFORMABLE STRUCTURES” AND “CULTURAL PROPERTIES”

Masao KUROKI¹, Nihon Sekkei, INC., Japan

Wataru GOJO¹, NILIM, Japan



INTRODUCTION

Article 3 of the Building Standards Law of Japan (BSL) stipulates exceptional handling for existing buildings that are cultural properties. In particular, concerning buildings such as Important Cultural Properties (ICPs), all the provisions of the BSL including those related to safety are excluded from the scope of application. It can be conjectured that this is because the above provisions in Article 3 were intended to be applied, at the time of establishment of the BSL, to those which are intuitively unfit for the retroactive application of the BSL in 1950, such as old wooden shrines and temples. Nevertheless, there have been some cases in recent years that can be considered to be beyond the scope of the intention at that time, such as large urban buildings in the early stage of modern architecture designated as ICPs².

In addition, the scope of buildings that are said to be worthy of preservation has now come to include even buildings that were built after World War II³. Historic buildings as cultural properties do not belong to rare exceptions, and it can be thought that now is the time for us to understand that a certain proportion of existing buildings will be treated as cultural properties in due course.

¹ This paper was originally written by Masao Kuroki in Japanese for “the symposium on building control for existing building stock” held in September 2008 by Research Committee on Building Legislation of the Architectural Institute of Japan and edited and translated into English for IRCC Heritage Building Workshop by Wataru Gojo (AIJ Committee member).

² Mitsui Main Building (1929), Meiji Life Insurance Building (1934), etc.

³ the National Museum of Western Art (1959)

While cultural properties have become familiar to people, the time has come in which familiar objects are becoming cultural properties⁴. This paper summarizes how the BSL and other regulations are applied to the buildings that are cultural properties in Japan, and outlines an example of preservation work of a modern building designated as ICP.



Mitsui Main Building



Meiji Life Insurance Building



1. CURRENT BUILDING REGULATIONS IN JAPAN FOR CULTURAL PROPERTIES

1.1 Number of cultural properties that are buildings (as of Jan. 1, 2008; source: website of the Agency for Cultural Affairs)

National Treasures:	213 (257 buildings)
Important Cultural Properties (ICPs)	2,328 (4,210 buildings)
Registered Cultural Properties (RCPs):	6,616 (number of buildings NA)

→ *The number of RCP is increasing at a rate of several hundred cases per year. The number would be more if those designated by local governments were included.*

1.2 Definition of Cultural Properties under the Cultural Properties Protection Law

Article 2 (Definition of Cultural Properties)

1. In this law, “cultural properties” means those listed hereunder.

- (1) Buildings, paintings, sculptures, handicrafts, handwritings, books, ancient documents, and other tangible cultural products that are of high historic or artistic value to Japan (including the lands or other articles that are unified with the foregoing products and constitute their value) as well as archeological specimens and other historical materials that are of high academic value (hereinafter called “tangible cultural properties”)

Article 27 (Designation of Important Cultural Properties)

1. The Minister of Education, Culture, Sports, Science and Technology shall designate tangible cultural properties that are important as Important Cultural Properties.
2. The Minister of Education, Culture, Sports, Science and Technology shall designate Important Cultural Properties that are of high value from a standpoint of world culture and are matchless treasures of the people as National Treasures.

→ *Definitions of ICP and National Treasure*

⁴ Cases of 100 works designated by Documentation and Conservation of Buildings, Sites and Neighbourhoods of the Modern Movement (docomomo100) as well as other cultural properties designated by local governments, etc.

Article 57 (Registration of Tangible Cultural Properties)

1. The Minister of Education, Culture, Sports, Science and Technology shall register the tangible cultural properties (excluding Important Cultural Properties) which are deemed to especially require measures for preservation and utilization in light of their value as cultural properties, in the original register for cultural properties.

→ *Definition of RCP*

→ *Newly added in 1996 to complement the conventional system for cultural properties*

1.3 Provisions for Cultural Properties under the BSL

Article 3 (Exemption from Application)

1. The provisions of this Law or those of orders or ordinances based thereon shall not apply to buildings coming under any of the following items:

- (1) Buildings designated or provisionally designated as National Treasures, Important Cultural Properties, Important Tangible Folk-custom Cultural Properties, Natural Monuments in Special Historical Places and Popular Scenic Spots, or Natural Monuments in Historical Places and Popular Scenic Spots under the Cultural Properties Protection Law.
- (2) Buildings recognized as Important Works of Art, etc. under the provisions of the old Law concerning Preservation of Important Art Objects

→ *Unconditionally out of the scope of application*

- (3) Buildings for which measures have been taken to restrict their alteration from their present condition and to preserve them under the ordinances based on the provisions of Article 182 paragraph 2 of the Cultural Properties Protection Law or other ordinances (hereinafter referred to as "preserved buildings"), if the Designated Administrative Agency designates as such with the consent of the Building Review Council.

→ *Out of the scope of application as a result of designation by an ordinance and consent by the Building Review Council*

- (4) Buildings reproducing the original form of buildings which were formerly such buildings mentioned in (1) or (2) or preserved buildings, if the Designated Administrative Agency concludes that such reproduction is indispensable with the consent of the Building Review Council.

→ *Out of the scope of application based on consent by the Building Review Council*

Article 85-2 for "Buildings Important for Landscape"

Whole or part of the provisions of Articles 21 through 25, Article 28, Article 43, Article 44, Article 47, Article 52, Article 53, Article 54 through Article 56-2, Article 58, Articles 61 through 64, Article 67-2 paragraphs 1 and 5 through 7 and Article 68 paragraphs 1 and 2 may be relaxed as prescribed in ordinances of the municipal government upon obtaining the approval of the Minister of Land, Infrastructure and Transport.

Article 85-3 for buildings in "Traditional Building Preservation Zones"

Whole or part of the provisions of Articles 21 through 25, Article 28, Article 43, Article 44, Article 52, Article 53, Article 55, Article 56, Articles 61 through 64 and Article 67-2 paragraph 1 may be relaxed as prescribed in ordinances of the municipal government upon obtaining the approval of the Minister of Land, Infrastructure and Transport.

→ *Relaxation of restrictions on existing cultural buildings other than that under Article 3*

→ *In the above two articles, the provisions of Article 20 for structural safety and Articles 35 and 36 for fire safety are not regarded as objects of relaxation.*

2. SAFETY MEASURES FOR DESIGNATED CULTURAL PROPERTIES

To ensure the safety of buildings that are cultural properties (ICPs and "traditional buildings in Traditional Building Preservation Zones"), the Agency for Cultural Affairs has issued guidelines and notices. In any of such documents, an integrated approach for human safety and the protection of value as cultural properties are considered.

2.1 Safety in case of Earthquake

“Guidelines concerning the Safety of Buildings That Are Cultural Properties, etc. in an Earthquake” (Notice of the Cultural Properties Protection Department Manager of the Agency for Cultural Affairs dated January 17, 1996)

Main points of the guidelines are as follows:

- Structures should be reinforced as a general rule (as long as their value is not impaired).
- Measures for controlling human damage should be taken, under inevitable circumstances, by means of restricted access, etc.
- Daily maintenance is indispensable.
- Buildings in “Traditional Building Preservation Zones”, should be reinforced based on the preservation plan of each zone. Technical reference should be made to “Detailed Seismic Evaluation and Retrofit of Wooden Houses” (compiled under the supervision of MLIT⁵/1995).

Partial citation of the above guidelines:

1. General remarks

1-1 Basic principles concerning the safety of buildings that are cultural properties, etc. in case of earthquake

Buildings that are ICP and traditional buildings in Traditional Building Preservation Zones (hereinafter called the “buildings that are cultural properties, etc.”) have various aspects in which design-related, technology-related, historical, and academic value are recognized, and it is difficult to proceed with repairs based on uniform standards. However, some of the buildings that are cultural properties, etc. have problems in terms of anti-seismic performance in regards to difficulties in maintenance, repairs at regular intervals, geographical conditions, methods of use, etc., and it is required that safety should be ensured against earthquakes.

Due to the foregoing, it is required that structural reinforcement, etc. should be carried out as long as practicably possible, and, at the same time, “soft” measures should also be taken. Note that this policy is intended to present principles for ensuring safety, and it is planned that specific methods of reinforcement and items, standards, etc. for structural evaluation will separately be described in technical guidelines.

In ensuring the safety of buildings that are cultural properties, etc. at the time of an earthquake, its target shall be set not to have a serious influence on human lives even in a strong earthquake, and as a general rule, reinforcement works shall be carried out whenever necessary reinforcement is possible as long as the value of the buildings that are cultural properties, etc. will not be impaired, and safety shall be provided by imposing restrictions on access under inevitable circumstances such as those in which major value as cultural properties will be lost as a result of reinforcement.

In addition, in order to ensure the safety of buildings that are cultural properties, etc. at the time of an earthquake, aside from repair work for improvement in anti-seismic performance, maintenance as well as improvements in the methods of use, improvements in the environment of the surrounding areas, expansion of disaster prevention facilities, etc. are also effective, and, therefore, efforts need to be made to take the aforesaid measures as well.

Although these measures are to be taken by owners, persons in charge of management, managing bodies (hereinafter called the “owners, etc.”) as the main entity, it is desirable that specialty matters, such as the assumption of damage resulting from an earthquake, the preparation of a plan for dealing with such damage, and the investigation of necessity, etc. of fundamental large-scale repair, should be addressed by referring to opinions raised by building experts. These matters need to be implemented promptly, but if they would impose great burden on the owners, etc., reinforcement shall be postponed until the occasion of fundamental large-scale repair and, for the time being, taking measures such as clearly indicating danger, in place of imposing restrictions on access, etc., shall be deemed to be acceptable.

2.2 Fire Safety

Measures by strengthening maintenance with emphasis on fire prevention are encouraged by “Fire Prevention for Buildings That Are Cultural Properties and Daily Maintenance of Fire Prevention

⁵ The Ministry of Land, Infrastructure, Transport and Tourism

Facilities" (notice dated January 24, 1986 issued by the director of the Building Division of the Cultural Properties Protection Department of the Agency for Cultural Affairs) .

Main points of the notice are as follows:

- Emphasis should be placed on accidental fires as well as incendiary fires, thereby encouraging implementation of maintenance based on the idea that both fire prevention and crime prevention are of great importance.
- Daily maintenance and monitoring, maintenance of fire prevention facilities, strengthening of patrols, etc. are indispensable. Restriction on access should be an option provided that measures through maintenance cannot be fully effective.

2.3 Measures under the Fire Service Law

There is an exemption system for the application of equipment installation requirements based on the provision of Article 32 of the Fire Service Law Enforcement Order, and there have been many cases in which such exemption was actually applied under the system. In these cases, as substitute measures for the normal installation of firefighting equipment, the preparation of a firefighting plan according to the scale of cultural properties, their geographical conditions and composition of personnel, as well as the improvement and strengthening of fire prevention systems of self-defensive firefighting organizations, etc., are encouraged though there may be difference in individual cases.

The provision of Article 32 of the Fire Service Law Enforcement Order is as follows:

Chapter 2 Firefighting equipment, etc.

Section 3 Technical standards on installation and maintenance

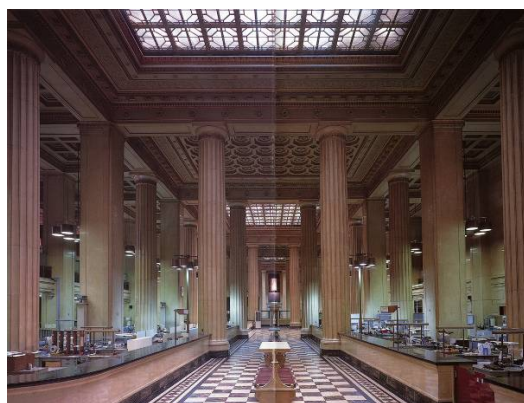
Article 32 The provisions in this section shall not be applicable provided that, judging from the situation of the location, structure or equipment of the objects of fire prevention, the fire inspector or the chief of the department in the jurisdiction deems that, in regards to firefighting equipment, etc., there is substantially small danger of occurrence or catching of a fire and any damage due to an accident such as a fire can be kept to a minimum, without conforming to the standards on firefighting equipment, etc. under the provisions of this section.

3. ACTUAL EXAMPLE

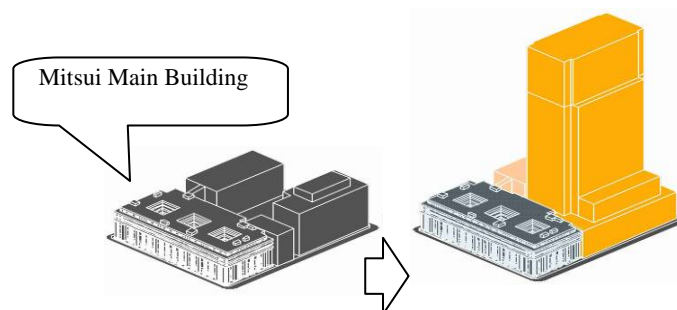
In the preservation work of the Mitsui Main Building, earthquake resistant and disaster prevention measures were taken as follows. The building was an ICP, constructed in 1929 with total floor area of 32,340 m² and height of 31m. A new high-rise building was added to the preserved part of the old building.



Mitsui Main Building



Bank Hall



3.1 Application of the BSL

Regarding the unconformable BSL provisions in the existing portion of cultural properties, although it was to be excluded from the scope of application under Article 3 Paragraph 1 of the BSL, check and verification with the current regulations were carried out to secure safety, and measures were taken as much as practically possible.

Major items of non-conformance to the BSL (as of 2002) were as follows:

- Structural safety (steel frame and concrete structure that was not covered by the current regulations)
- Fire compartment (no vertical compartment around a well-style hall)
- Fire compartment (in some part the area of separated sections exceeded the limit)
- Width of the stairs (in some part the width was less than the requirements)
- Evacuation distance (in some part the distance exceeded required the limit)
- Smoke exhaust equipment (not installed)
- Restrictions on interior surface (some habitable rooms had wooden interior surface)

Measures taken for the above items were as follows:

- Regarding the structural safety, verification was done based on the standard of the Law for Promotion of Seismic Retrofit of Buildings, and safety was confirmed. A conclusion was obtained that no structural reinforcement was required concerning the major structural parts.
- Regarding fire safety, verification was done based on the Safe Evacuation Verification Method under current BSL (verification method for evacuation safety from habitable rooms and of whole floor) and measures were taken where application was practically possible, and consideration was made for the protection of value as a cultural property.
- The door of habitable rooms were repaired to meet the requirements of BSL for the Specified Opening Protective Assembly. Based on this, verification of evacuation safety was done, and it was confirmed that the requirements of the performance criteria under the current BSL were satisfied except for some portions.
- However, the parts that had high value as cultural properties and did not satisfy the current BSL requirements even when the performance provisions were applied, such as the bank hall on the first floor, the interior surface of executive rooms, etc., were preserved as they were.

3.2 Application of the Fire Service Law

Based on Article 32 of the Fire Service Law Enforcement Order, the “portion that constituted the value of cultural properties” was judged to be exceptional and exemption from the obligations for installing firefighting equipment was applied. In the bank hall and other internal space that had been designated as an ICP, the installation requirements of automatic fire alarm equipment, emergency announcing equipment, guiding lamps, and sprinklers were relaxed. The function of sprinklers was to be substituted by the installation of extension hoses from existing indoor hydrants (which existed already since the time of original construction) and the addition of fire extinguishers. The water pipe equipment was not installed for the reason that it would greatly affect the outer wall that was a portion designated as an ICP, and the existing “common hydrants” (hydrants to be used commonly by buildings in the street) were to be used as the substitute for it.

3.3 Measures taken for other portions than the above

Concerning requirements other than those on structural safety and disaster prevention, measures were taken only for items for which (physically and culturally) they were practically allowable.

For portions for which there were requirements that were very difficult to conform to from a physical viewpoint and there were no alternative solutions by performance criteria, such as the minimum height of overhead and pit depth of an elevator, were left as they were.

The case showed that, if unconformable buildings were checked by the BSL and related regulations in detail, there would appear many items for which retroactive application would not be practical. Examples of such requirements are: accessibility related matters, materials and products standards, equipment and machinery requirements, etc.

4. CONCLUSION AND PROPOSALS

4.1 Regulations concerning safety measures for cultural properties

- In the BSL of Japan, obligations for retroactive application are imposed on existing buildings on the occasions of extension work and other triggers by providing standards of a certain level, but all the obligations are not applied for designated cultural properties such as ICPs.
- In the case of buildings out of the scope of application of the BSL, such as ICPs, it is recommended that integrated approach of both soft safety measures (maintenance, operation, etc.) and hard ones (design, construction, equipment installation, etc.) should be taken. Nevertheless it has not been clearly defined as to what order of priority should be taken in response to both aspects of human safety and the protection of cultural properties.

4.2 Relationships between cultural properties and other existing buildings

- Current regulations including the BSL treat buildings that are cultural properties as special and exceptional cases, but, in the future, cases may also appear in which it is inappropriate to handle such buildings in such a manner.
- There might possibly be cases in which it is more appropriate to understand that buildings that are cultural properties are not special but should be considered as of an extended nature of ordinary existing buildings. Conversely, some of ordinary existing buildings might possibly be a future cultural property that should be handled more flexibly.

4.3 Problems for the future

- Existing buildings have high individuality, and it is inappropriate to apply uniform prescriptive provisions to all the existing buildings. In addition, they should be handled flexibly to a certain extent in the application of performance-based requirements as well.
- In specific cases, there may be some existing buildings for which there is no choice but to take measures that may impair cultural value, or to demolish them, due to the difficulty to conform to detailed prescriptive requirements, that are not for human safety and other essential performance.

4.4 Proposals

In the present system, in principle, all the existing unconformable buildings are simply divided into two, i.e. "ordinary existing buildings" and "cultural properties out of the scope of application." In the Cultural Properties Protection Law, "Registered Cultural Properties" are already stipulated as of an intermediate nature between ICPs and ordinary existing buildings. Possibility of similar handling of existing buildings in the BSL should be considered.

Proposal 1. To promote utilization of Article 3 Paragraph 1 Subparagraph 3 of the BSL

It should be considered to establish an intermediate category between the "ICPs, etc." that are out of the scope of application of the BSL and the existing ordinary unconformable buildings, which should be called "buildings that are semi-cultural properties" or "historic existing buildings," to specify existing buildings having high historic and cultural value. Then, for such buildings, intermediate and flexible retroactive application of BSL requirements with well-balanced emphasis on safety and preservation should be considered through utilization of the consent given by the Building Review Council stipulated in Article 3 Paragraph 1 Subparagraph 3 of the BSL.

Proposal 2. To increase flexibility in exemption of retroactive application of BSL

At the time of considering intermediate category buildings as mentioned above, it should also be considered to limit the provisions to be applied to these buildings to key important requirements. For example, to prepare the list of provisions for essential performance including human safety to be retroactively applied rather than the list of those of exemptions would be effective to avoid forcing those buildings to conform to detailed requirements that are difficult to apply and not necessarily essential.

PROPOSAL FOR SPANISH GUIDELINES* ON APPLICATION OF THE BUILDING CODE TO LEGALLY PROTECTED HERITAGE BUILDINGS

José Luis González Moreno-Navarro, UPC, Spain



1. INTRODUCTION

The protection of the historical heritage in Spain is regulated by Article 46 de of the Constitution, from which diverse laws of the Autonomous Regions and the Spanish Historical Heritage Act are derived.

Article 39 of the Spanish Act (and the equivalent articles of the Autonomous Regions) establishes in its Point 2 that the actions on immovable properties shall be addressed to their conservation, consolidation and rehabilitation. The diversity of meanings of these three terms within the sphere of the architectural heritage is well known. Despite this, none of these acts, which were published in the 1980s, offers any more than a scant detail of the development of these three possible tasks.

The new legislative approaches, which seek to correct these deficiencies, bring together in the brief space of a few articles the doctrines set out in the international documents which have been agreed over the course of the last two decades, on these three concepts and others, such as restoration, integrity, authenticity, etc.

Article 20.3 of the new Act on the Historical Heritage of Andalusia from 2007, which is representative of this new generation of laws, offers the key to everything in a few words:

“The materials used in conservation, restoration and conversion (rehabilitation) shall be compatible with those of the respective property. Reversibility criteria shall be followed in their choice, and they shall offer sufficiently verified behaviours and results. The building methods and the materials to be used shall be compatible with the constructive tradition of the property.”

In all probability, the ongoing revision of the rest of the laws of the Autonomous Communities or the State will follow a similar path, since this is the international attitude.

At the same time, this same legislative corpus also imposes the protection of movable properties. Indeed, it is quite common for a protected building to contain in its interior movable properties of cultural interest which form part of its own history. Therefore, obviously enough, the conservation, restoration and conversion (rehabilitation) actions shall not only protect the building itself but all the movable properties which may be sheltered in its interior as well.

Moreover, likewise derived from the Constitution, the protection of the rights of users of new buildings, or existing converted or renovated, relating to the safety and habitability, is also specified in the Act on the Planning and Development of Building (LOE) in 1999, and the Technical Building Code (CTE) in 2007

It is easy to verify that there are significant contradictions between the legislative ensembles (heritage and building): the LOE and the CTE only contemplate in their details newly-constructed works and current building techniques, and their main objective is to provide assurances of safety and habitability for the users of the buildings, without hardly contemplating the protection of movable or immovable properties.

2. THE USUAL TYPE OF WORKS ON THE PROTECTED BUILDING

Before continuing it would be appropriate to explain what type of works are usually carried out on protected buildings.

Such works are the result of two main causes: a) the repair of pathological conditions, lesions, degradations, etc., and b) a structural or functional adaptation, according to the planned use of the building. Indeed, a combination of both causes is common in historical buildings.

Pathological conditions

The works to be carried out have the aim of repairing, as far as possible, lesions or deficiencies, which may be of two types:

- a) structural faults, cracks, detachments, leaning, collapse, etc., or
- b) moisture/damp

Generally speaking, in any specific case, no sure knowledge exists of the causes of the problem or of the type of works required to correct it.

The deficiencies with respect to fire safety, safety of use, the rest of the health-related habitability aspects (HS) and especially HS3, or the problems with respect to noise do not generate lesions or degradations.

Structural or functional adaptation

Works are required for one or more of the following reasons:

- 1) The preventive inspection of the building. Before carrying out the inspection, there is no knowledge of the possible deficiencies and much less of the works to be performed.
- 2) An increase in the users' safety or habitability requirements. The reasons for this may lie in one or more of the five standards or there may be some other type of reason, such as an improvement of accessibility.
- 3) Partial or total change of use of the building. The works to be carried out may be known, but not their effect on the building in relation to the five standards.
- 4) The opening of a historical building to the public for visits. This poses a large number of questions, mainly from the standpoint of structural, fire-related or use-related safety. There is no sure knowledge of either the existing deficiencies or the works to be carried out.

3. THE TECHNICAL BUILDING CODE (CTE) AND THE PROTECTED BUILDING

Let us take a brief look at the relationship which the legislation has established between the CTE and the architectural heritage by means of a quick glance at the key articles involved.

Article 2. Scope of application states that the “CTE shall be applied to the newly-built construction works” and likewise to “the works of expansion, modification, reform or rehabilitation which are carried out on existing buildings”, as long as such application is compatible with “the nature of the intervention and, as the case may be, with the degree of protection which the affected buildings may enjoy. The possible incompatibility of application shall be justified in the project and, as the case may be, it shall be compensated by alternative measures which are technically and economically viable.”

A key issue is what is meant by an “alternative measure”. Let us look at its definition.

Article 5. General terms of compliance with the CTE states that “In order to justify that a building fulfils the basic standards which are established in the CTE, one may choose:

- a) to adopt technical solutions based on the Basic Documents (DBs), or
- b) to adopt alternative solutions, which are understood to be those which diverge wholly or partly from the DBs. The project designer or the works manager may, under their responsibility and with the promoter's prior consent, adopt alternative solutions, as long as they justify documentarily that the projected building fulfils the basic standards of the CTE because their performance is at least equivalent to that which would be obtained by application of the DBs.”

Before continuing, it would be well to clarify what a DB is. *Article 3. Content of the CTE* defines it as a Basic Document which contains:

- “a) the description of the basic standards and their quantification,
- b) some procedures of which the use proves the fulfilment of said basic standards”.

The various DBs devoted to the standards of safety [structural safety (SE) as opposed to Fire Safety (SI) or Safety of Use (SU)] or to the standards of habitability [energy saving-related habitability (HE), health-related habitability (HS), noise-related habitability (HR) form the main part of the Code].

In the document from November 2006 (referenced at the end of this paper), it may be seen that the Code, through its DBs, does not provide ways of solving the problems posed by its application to the works on existing buildings, except in one case: Annex D of the DB on Structural Safety. The text of this annex can provide certain directions and ideas.

4. THE “ANNEX D” OF THE CTE-DB (Basic Document) ON “STRUCTURAL SAFETY”

It is of great interest to point out what this annex states in its point *D.1.2. Prior considerations*:

“The direct use of the rules and regulations stated in this CTE is not appropriate in the structural assessment of existing buildings which have been constructed on the basis of earlier rules, for the following reasons:”

The most important of these reasons should be highlighted here:

“The current rules are usually based on standards which are different from and generally stricter than those which were in force at the time when the building was designed, for which reason many existing buildings would be classified as unreliable if they were to be assessed according to the current rules.”

This is an idea which has been known for a long time to all the restoration professionals, an idea which appears in writing here in a document of compulsory observance for the first time. Obviously enough, it is applicable to the rest of the standards on safety or habitability.

However, the methods proposed in Annex D are only valid for buildings constructed in the 20th Century and not for those built before.

Nevertheless, the articles of Annex D demonstrate a key fact: in order to be able to consider the application of the Code to an existing building, it is indispensable to possess a very thorough knowledge of the building.

The need for such knowledge increases when it must be demonstrated that the solutions or procedures proposed by the Technical Code are incompatible, and even more when it comes to proposing alternative solutions.

The process of applying the CTE shall begin, therefore, with the indispensable assessment or knowledge of the existing building from all standpoints affected by the Code.

5. THE FEASIBILITY OF EQUIVALENT ALTERNATIVE SOLUTIONS

Upon considering a public or private development on a protected building according to some of the foregoing types of works on the basis, of course, of a thorough knowledge of the building, is it possible for there to exist alternative solutions which will allow “the projected building to fulfil the basic standards of the CTE so that its performance will be at least equivalent to what would be obtained by applying the DBs”?

If the historical building is not to be protected, all types of solutions are possible. Nevertheless, according to general experience and the studies which have been conducted (the document from December 2007 referenced at the end of this paper), whenever the objective of protecting the building is a priority, it will not be possible by any means to achieve 100% compliance with the Technical Code.

Accordingly, it is necessary to accept the fact that in the case of a protected building, it is impossible to comply with the totality of the Code in most cases, and provide the necessary legal coverage.

This raises two immediate issues. On the one hand, the circumstance of not being able to comply with the Code in its totality does not mean that partial compliance is impossible. Accordingly, the entire effort of analysing the building, acquiring a thorough knowledge of it and developing alternative solutions and applying them to the project and the work shall be addressed to achieving the maximum compliance. Since this compliance will never be complete, however, it is necessary to determine the consequences a lack of total compliance will have on the pertinent legal responsibilities and on the use of the various parts or ensemble of the building. There will be limitations of use which will form an integral part of the process.

It would appear necessary to provide an informative action for the general public through the Ministry of Housing and, naturally enough, through the Ministry of Culture in order to highlight the fact that a protected building cannot be expected, in addition to being a cultural property, to fulfil all the standards of new buildings, which lack precisely this cultural benefit.

In accordance with all this, it is necessary to develop a document establishing the procedure to adapt the compliance with the CTE to the works on protected buildings. This document has been called the “Guide to Application of the CTE to Protected Buildings” (GACTEP).

6. BASIC CONTENT OF THE GACTEP

As already indicated, it is the result of work (November 2008) promoted by the Higher Council of Architects referenced at the end of this paper.

The Guide is structured in three parts:

The first part contains the rules and general terms of application.

The second part is formed by the so-called Assessment Guides (GEs) for protected buildings.

The third part comprises the Feasibility Study Guides (GVs).

The building assessment has a twofold objective:

- a) to inform on the degree of compliance of the building in its present condition with the standards posed by the CTE, and

- b) to foresee and appraise, depending on its planned use, the real feasibility of adapting the building, by means of restoration or rehabilitation works, to the standards of the CTE without detriment to the preservation of protected values or elements.

In the almost absolute majority of all cases, the degree of compliance of the building in its present condition with the CTE will be minimal and it will therefore be necessary to proceed, within the frame of the restoration or rehabilitation works, to its strengthening, repair, adaptation or accommodation according to the criteria established in the GVs. According to the envisaged use of the building, these actions will be more or less complex.

The feasibility study shall resolve the pertinent deficiencies or incompatibilities on the basis of the criteria provided by the GVs. In the event of scant compliance, the feasibility study will allow solutions to be found which will increase performance to the maximum without affecting the protected aspects. In the case of total non-compliance, it shall state the alternative solutions or measures which will allow the limitations of use to be reduced.

7. LIMITATIONS OF USE AS A RESULT OF NON-COMPLIANCE OF THE CTE

In protected buildings there may be activities which are not found in the classifications stated in the CTE. In such event, a specific study shall be carried out on the risk associated with such particular activities in the Building Assessment and in the Feasibility Study, based on the risk assessment factors and criteria stated in Article 2, Point 7 of the CTE, notably including the following:

User characteristics; number of persons commonly occupying, visiting, using or working in the building; vulnerability or need for special protection by reason of such persons' age or disability; familiarity with the building and its means of evacuation, and protection level of the building.

If the Feasibility Study were to conclude that there exists an activity with a risk which cannot be avoided or reduced (such as the ascension of a bell-tower) it will be stated in the Project document called "Limitations of use" and in the section of the documentation on the work called "Confirmation of the Limitations of Use".

Both in the project stage and on completion of the work, the promoter shall be informed of the limitations of use. In turn, the promoter shall report the limitations of use to the persons in charge of the management of the building's use so that they may ensure compliance with such limitations.

8. ASSESSMENT AND FEASIBILITY STUDY PROCESS

The assessment shall be in three stages:

Stage 1:

- a) Compilation of data, especially on the history of the building and its surroundings
- b) Initial inspection of the building and its surroundings

Stage 2:

- a) Evaluation of possible effects of envisaged new uses
- b) Formulation of hypotheses of the causes of the pathological conditions and determination of tests, etc. for the verification of such causes
- c) Update all information depending on possible effects and hypotheses
- d) Definition of verifications, tests, etc.

Stage 3:

- a) The carrying out of verifications, tests, etc.
- b) If there are no pathological conditions, an Initial Opinion-Report shall be prepared on the compliance with SE SI SU HS HR. If pathological conditions are indeed observed, confirmation

shall be provided of the respective hypotheses (if they are not confirmed, the process returns to Stage 2).

The Feasibility Study comprises two stages:

Stage 4:

- a) Initial proposal of repair of lesions, or initial approach to the solutions for the structural or functional accommodation of the building.
- b) Verification of incompatibilities with the CTE and, as the case may be, determination of alternative solutions or measures.

The overall path from Stages 1 to 4 is reversible. If no possible alternative solution is found, it is necessary to go back and re-begin the process in order to continue studying the building.

Stage 5:

Development of a feasible definitive proposal on the repair of the visible lesions, or development of feasible alternative solutions, allowing work to begin on the development of the project.

ASSESSMENT						
REASONS FOR THE INTERVENTION	Without change of use			With change of use		
	Pathological conditions		Compulsory or preventive inspection	Functional improvements	Public tourism – cultural visits	New programme
	SE	HS1		Definition of the specific requirements of the improvements or new programmes		
INITIAL DEFINITION OF REQUIREMENTS						
STAGES 1	Compilation of maximum documentation					
	Initial inspection of the building and its surroundings					
	level of activity					
2	Hypothesis of the causes		Evaluation of possible effects of envisaged new uses			
	Update all information depending on possible effects and hypotheses (Surveys, elevations, trial excavations, test bore, etc.)					
	Definition of verifications, tests, etc.					
3	<div>↕</div> The carrying out of verifications, tests, etc.					
	Diagnosis-Opinion		Initial Opinion-Report on compliance with SE SI SU HS HR (if pathologies are detected, follow Column 1)			
<div>↓</div> <div>↑</div> FEASIBILITY STUDY						
4	Proposals on repairs		Specific proposals on improvements and programmes			
	<div>↕</div> <div>↕</div> <div>Verification of incompatibilities for reasons of protection of the building with DB of SE SI SU HS HR and appraisal of possible <u>solutions</u></div>					
5	Feasible proposal on repair SE or HS1		If appropriate, proposal on feasible repair	Proposal on improvements with proven feasibility	Feasible proposal on public visits	Feasible proposal on restricted public visits
	proposal on new programme / proven feasibility					
DEVELOPMENT OF THE BASIC PROJECT AND EXECUTION						

9. PROJECT DOCUMENTATION

In addition to all the terms established in Article 6 of the CTE, the following documents shall be developed and contained in the project:

- a) The document entitled “Building Assessment”, which shall be prepared according to the criteria established in the GEs.
- b) The “Feasibility Study” document shall resolve the respective deficiencies or incompatibilities by means of the criteria provided in the Documents for the Feasibility Study. In the event of scant compliance, it shall allow solutions to be found which will increase the performance to the maximum without affecting the protected aspects. In the event of total non-compliance, this document shall state the alternative or compensatory measures or solutions which will allow the reduction of the limitations of use. The Feasibility Study shall be prepared according to the criteria established in the GVs.

In order to be able to develop the basic project, it will be necessary to have carried out the Prior Assessment and the Feasibility Study.

- c) The basic project shall define the general characteristics of the restoration or rehabilitation work and its final performance by means of the adoption and justification of specific solutions defined in accordance with the criteria of the DVs and, as the case may be, with the Catalogue of Solutions, taking into consideration the assessment which has been previously carried out.
- d) The “Provisional Limitations of Use” document, in which the consequences, on the use of the building, of the deficiencies in strict compliance with the CTE which are defined in the Feasibility Study shall be specified.

10. COMPLETION DOCUMENTS AND USE OF THE BUILDING

The restoration, conversion (rehabilitation) or repair works on the building shall be carried out in accordance with the project. However, the access to areas of which it has not been possible to obtain an exact knowledge in the assessment stage may require modifications of the project. In such event, the modifications shall be decided by the works manager with the promoter's prior consent.

The “Confirmation of Limitations of Use” document shall specify the limitations on the use of the building due to deficiencies in the strict compliance with the CTE which were initially defined in the Project, and the verification, extension or reduction of such limitations as a result of the solutions finally adopted in the works.

The building and its facilities shall be used appropriately in accordance with the instructions of the “Confirmation of Limitations of Use” document, refraining from making any use which is incompatible with the envisaged use.

The persons in charge of the management of the building's use will be responsible for informing the users of the risks which they take if they make any use which contravenes what is stated in the “Confirmation of Limitations of Use” document.

Studies on which this paper is based:

- 1) Commissions from the Higher Council of Architects' Associations of Spain to the Polytechnic University of Catalonia (UPC)

November 2006

El nuevo Código Técnico de la Edificación y la Restauración Arquitectónica. Primera fase: estado de la cuestión. (The New Technical Building Code and Architectural Restoration: Current Status of the Issue)

Working team: José Luis González, Albert Casals, Javier Sanz, architect-professors at the UPC, and José Luis Pérez López of “Pérez López Abogados Asociados S.L.”

November 2008

Aplicación del CTE a las obras de Restauración Arquitectónica. (Application of the CTE to Architectural Restoration Works)

Working team: José Luis González, architect; Albert Casals, architect; Soledad García-Morales, architect; Alicia Dotor, architect; Belén Onecha, architect; Santiago Rovira, industrial engineer; Pere Roca, civil engineer; Francisco Arriaga, architect.

2) Commission to the UPC from the Territorial Action and Planning Area of the Directorate-General of the Cultural Heritage, attached to the Department of Culture and Communication Media of the Autonomous Government of Catalonia.

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FIRE RISK ASSESSMENT FOR HERITAGE BUILDINGS**Mariana Llinares Cervera, Ángel Arteaga Iriarte, IETcc-CSIC, Spain****1 INTRODUCTION**

Two essential qualities are added to the purely material value of heritage buildings: they are unique and irreplaceable. These characteristics bring about the need for their protection to be considered in a particular manner, since they are essential for understanding our history.

In Spain, buildings pertaining to our Historical Heritage enter within the scope of a specific regulation, basically contained in the Law 16/1985 of 25th June on the Spanish Historical Heritage, which refer to them as: “the main witnesses of the historic contribution of Spaniards to the universal civilisation and of their contemporary creative capacity”.

On the other hand, regional governments have their own democratically elected parliaments, form their own cabinets and legislate and execute policies in certain areas such as heritage protection. Their legislation is applied to all the Properties of Cultural Interest under their authority except to those pertaining to the State, the National Heritage (Monarchy) and the Church.

The aim of these laws is to guarantee the preservation of the Spanish Historical Heritage and to allow the access to these Properties and their enjoyment to the greatest possible number of citizens. The laws establish different levels of protection and indicate in which cases the need for an administrative authorisation exists in order to carry out works that affect the maintenance of the urban and architectural structure of the building, as well as of the general characteristics of its surroundings. No reference is made, though, to specific measures that should be adopted, such as for example those required for fire protection.

It is common for these buildings to be destined at present to uses not originally foreseen. Also, the current demands for these new uses are more exacting and the obligation arises thereof to take into consideration new risks that may imply the need for rehabilitation or restoration works that in their turn call for the adaptation of the legislation in force that refers to security and habitability standards.

To allow the public to use these buildings implies their being able to do so safely. Moreover, the impact inflicted upon the building materials, structure and spaces must be the least possible and the actions undertaken, as reversible as possible. The ideal solution is that which preserves both the character and the historical materials while it provides the building with the greatest possible security level at a reasonable cost.

Fire may be the greatest risk of all threatening these buildings. It combines the possibility of loss of human life as well as of part or even the whole of the historic structure and/or its contents due to a fire. Such material loss is definitive and irreparable, making cultural consequences derived therefrom quite considerable.

The initial construction, as well as repairs carried out throughout the life of a heritage building usually include characteristics that can contribute to a quick fire development and propagation, such as the use of combustible materials (e.g. wood) in walls, floors or structures, or the presence of cavities that communicate different spaces or even lead to the exterior of the building.

So far, most codes and standards, both in Spain and in many other countries, do not take fire protection of existing buildings specifically into account, not even those of historic value. Rather, they establish measures for the protection of new buildings which mostly affect design characteristics.

Generally speaking, existing buildings usually present more problems where regulations or standards compliance is concerned than new ones, due to the fact that it is not possible to introduce significant modifications in their design. Historic buildings in particular have even greater limitations due to their specific construction characteristics, besides other less tangible aspects, such as their value.

In the case of Spain, the Technical Building Code in its Part I has a performance approach which allows the use of alternative methods or solutions as far as it can be assured that they present the same security level as that provided by the accepted methods established in Part II. Yet, no guidelines are given about the way of adopting adequate measures, nor quantitative limits are established in the basic requirements. This makes the application of this performance approach quite complex, since it becomes necessary to make a quantitative evaluation of the fire risk. Accepted quantitative limits must be established, and they may in most cases be lower than those derived from the prescriptive solutions (taken from earlier codes), which are usually quite conservative.

The relevant objectives to be taken into account when thinking of fire protection in heritage buildings are the following:

- protection of human lives;
- protection of the building structure and contents;
- preservation of the value of the building;
- protection of the building environment.

In European countries in general the problem of heritage loss due to fire is being dealt with for a relatively short time now. The following are two examples: the European project FIRE TECH [1], whose aim is to evaluate the fire risk to the European heritage and to propose methods to quantify it and the COST Action (inter-government framework for the co-ordination of national research at the European level) C17 "Built Heritage. Fire Loss to Historic Buildings" [2], in which we have participated, and among whose objectives were the definition of the level of fire loss to historic buildings in Europe as well as the promotion of preventive measures.

2 RISK MANAGEMENT

In the Spanish Technical Building Code, accepted solutions established in its Part II aimed at fire protection, are not backed up by a solid scientific basis, as is the case of those affecting other installations of a building or the structure analysis. This is the reason why it is not always possible to quantify the safety level achieved by their application. Therefore, it is not easy to establish a system of equivalents between different alternatives so that these may be used to reach the same safety level, which would be desirable in the case of historic buildings.

To adequately protect a particular building against fire it is not enough to accumulate measures without evaluating their risk reduction effect. The application of risk analysis methods can reduce the costs of the systems, provide a greater safety level, and improve the building functional qualities. In order to achieve this, a performance based code should quantify the safety level that society or an individual is ready to accept as sufficient, in other words, the risk level they would be capable of taking on.

It is impossible to totally eliminate the presence of all risk: there will always remain a certain residual level that must be lower than the level considered acceptable. The establishment of this "maximum acceptable risk" is one of the essential problems. Although there are no unique criteria for establishing it, there are guidelines that at least allow estimations to be performed of what an acceptable level could be.

On the other hand, rational bases for risk assessment are perfectly established, given the experience in their application in other fields in which decision making is required based on uncertain knowledge: economy, engineering, politics, etc., even the fight against terrorism [3]. However, the practical application still presents problems generally due to lack of data.

The word "risk" is used in everyday language, as well as in the technical one in several fields, with different meanings: it may refer to the probability or frequency with which an event occurs, or to the importance of the undesirable consequences it causes as well. In risk analysis the term is always used implying both aspects (the probability of an event occurring and the consequences it may have). Thus, risk is expressed as the product of the probability or frequency of the occurrence of a particular event and the magnitude of the consequences in case it occurs (mathematic expectation of the possible consequences).

$$R = P \times C$$

Probability can be defined as the degree of certainty for an event to occur during a determined period of time. In principle, these probabilities should be objective, evaluated from theoretical considerations and/or registered occurrence frequencies, either in the form of: point estimates, confidence intervals or by complete statistical characterization (their function of distribution, its parameters and correlations).

These values should ideally be based on the greatest possible number of data, but unfortunately, there are almost no databases with reliable and numerous registers. This makes it necessary to resort to subjective opinions of experts that replace or complement the said values.

Another aspect that makes risk analysis difficult is that consequences are generally not one-dimensional. Rather, they must be expressed as a damage vector in terms which are not homogenous: loss of life, injuries, material loss, environmental damage, inconvenience to the users, etc. taking into account both immediate consequences as those that appear later in the course of time.

To reduce the damage to a single dimension (monetary terms may be the option) is not easy and is controversial, but it becomes necessary if we finally intend to reach a rational sorting of all alternatives.

3 STATISTICAL DATA ANALYSIS

Statistical definition of the available data is an essential tool for any engineering work and this is even more certain in the field of Fire Engineering, in which due to its complexity, recent date and the lack of data, it becomes necessary to take advantage of the few existing data.

With regard to fire statistics data, the very first problem we can find has to do with something that may seem trivial: the definition of the concept "fire". Thus, a "fire" is usually considered to be that which calls for an intervention of firefighters.

This definition, necessary for data comparison, is not related exclusively with the proportions the fire reaches. In some cultures or at some social levels, building residents themselves may extinguish fires that in other places would require the presence of firefighters. Moreover, it is well known that a considerable number of calls basically turn out to be false alarms that should be separated from these data.

Another more appropriate definition of the concept “fire”, if there are data to back it up, would be the one used by Fontana et al. [4] in their statistical studies based on the claims to insurance companies for damages caused by fire.

All these conditions, mentioned explicitly or imaginable from the source of data, must be taken into account in order to carry out a reliable analysis, when no uniform criterion exists for sample extraction.

The ever-growing interest in data acquisition allows us to predict that there will be soon more information available and less uncertainties, which will be useful for decision making to achieve a greater fire protection of buildings.

Spain is one of the countries with the greatest delay in the collection of statistical data related to fires. Up to date, this information has been gathered individually by each Fire Extinction Service according different criteria.

The fact that these services are transferred to Autonomous Regions or to greater City Councils makes a unified approach more difficult. Until now, the only data gathered were the firefighters' Reports, collected in paper format, which are difficult to handle and easy to get lost. Some firefighters' services have performed statistical studies with their own data, but these are always very short temporal series and have a limited value.

The Civil Protection Service is currently working on a standardized document for a future unification and computerization of data related to fires (except forest fires) in different Autonomous Regions (not all). This, however, is a long-term project and will not be available for quite a long time. The objective is to incorporate the obtained computer processed data into the General Statistics Plan of the Ministry of the Interior in order to disseminate them, perform their follow-up, evaluate them and, if necessary, use them to propose future revisions of fire regulations.

4 FIRE RISK ANALYSIS METHODS

There are many methods of performing a fire risk analysis and each one of them uses different assessment procedures. The use of different parameters in different methods depends on the objective of the analysis or on the evaluation criteria of the author. However, there are certain general guidelines to be followed:

- a) identify the possible causes of fire;
- b) quantify the probabilities and the consequences;
- c) identify the options of control;
- d) quantify the impact of these options;
- e) select the adequate protection.

One possible classification of the existing risk analysis methods may be the following:

- qualitative methods:
The simplest approach to risk analysis consists of subjective evaluations, based on experts' opinions. The expressions used in the evaluation of these methods are: excellent, good, fair, bad, very bad; high, medium, low; as safe as...

The main problem of qualitative methods is that they do not reflect on an absolute scale the degree of seriousness a possible risk may reach if different risk sources or alternative solutions are compared. Therefore, they are not very useful when rational decisions are to be taken.

However, these should be used as the first step in a quantitative risk analysis method.

- semi-quantitative methods:
Risk assessment using this type of methods, essentially heuristic, makes it necessary to consider all the building characteristics, as well as all the factors which could start a fire (either positively or negatively). Grades defined by numeric values are then assigned to these factors and later combined arithmetically with different weights in order to assign a global index for a

particular solution. This will allow a compared evaluation between different solutions and their assessment relative to an established acceptable risk level.

For each different type of building, the choice of its relevant characteristics and the rest of variables to be taken into account, as well as the different degrees and weighting assigned to them must be done by a group of experts, preferably using decision making methods.

- quantitative methods:

These methods are the most complex ones and at the same time those that offer the greatest amount of information about fire risk in a building. The numeric results are obtained applying explicit hypotheses, data and mathematic relations.

The obtained data may seem very precise but they are not always totally objective, given the fact that it is necessary to make estimates and simplifications as well as to make decisions that lead to a certain degree of uncertainty. Many times the obtained results are equivalent to those that could have been obtained using a semi-quantitative method, although with a much greater effort.

Quantitative methods should be used to calibrate semi-quantitative methods.

Any of these fire risk analysis methods may be used with two different objectives: either not surpassing the accepted risk limits or deciding between different alternative measures.

In dealing with Heritage buildings, the convenience of using risk management is evident, but at the same time difficulties due to the lack of data and the unique character of the buildings make its thorough application (quantitative methods) complex and expensive, therefore making sense only in case of relevant buildings.

5 CONCLUSIONS

The tendency to give building codes a performance approach should facilitate the application of semi-quantitative methods to easily reach equivalent solutions (in terms of security or risk level) in existing buildings comparable to those for new buildings, while taking into account both property and people protection.

These methods are particularly interesting for historic buildings which may not require a quantitative analysis method due to their importance or volume. An acceptable security level may be achieved by evaluating the cost-benefit ratio of preventive (to limit the probability for a fire to occur) and protective measures (to limit the magnitude of losses and damage).

Once established the formulation of one specific typology, their use could be quite simple, even for the building conservators themselves, when they are to make objective decisions for their protection.

On the other hand the use of semi-quantitative methods still requires further research, mainly due to the lack of data.

Parameters used in existing methods in other countries are not always valid for all types of buildings. Most of these methods can only be applied to a certain type of buildings (e.g. buildings for industrial use, churches...) and are closely related with the type of construction of the said countries.

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STANDARDS FOR THE REHABILITATION OF THE ARCHITECTURAL HERITAGE: A COMPROMISE BETWEEN TWO DIFFERENT CULTURAL ERAS.

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ARCHITECTURAL HERITAGE: YESTERDAY AND TODAY

The essential aim of any rehabilitation process in a deteriorated historic building is to ensure its place in the usable heritage of present-day society.

This ambition, prompted by a desire for the building to remain a backdrop for life, for it to continue to be architecture and not merely an object to look at, raises the key contradictions that must be addressed in the rehabilitation process: the conflicts between the cultural paradigms that shaped the building in its time and the expectations of the society that will be using it today.

While most historic buildings were designed to last, have a certain air of eternity and can accommodate a wide variety of functions, present-day architecture is largely characterised by the existence of an expiration and/or obsolescence date built in from the very design stage, and by the attempt to create buildings that fit their intended purpose like a glove. Differences in concepts such as privacy, safety and comfort from one century to another must also be factored into the equation of these fundamental contradictions.

NATURE AND AIMS OF REHABILITATION

Most of Spain's historic buildings have undergone a number of changes at different times in their lives. These modifications are not from a single period; rather, every architectural intervention that has taken place in the course of their history overlays the previous ones. This adaptability to a variety of eras is one of the attributes that has enabled them to survive to the present and makes them good candidates for rehabilitation.

The aim of the rehabilitation process, therefore, is not to bring the building back to a specific era in its history by restoring the design corresponding to that particular moment, but to make the building's current stage a part of that history.

It is not a question of creating a new building on the plot of the existing one, nor of simply restoring its appearance or structure. The key to successful rehabilitation is ensuring that the building is coherent with both its own past and with its intended use in its new life.

Under this approach, the first task is to identify the basic features that characterise the building, i.e., that have been maintained despite any circumstantial changes that it may have undergone over time. These functional, spatial, formal and construction values must be retained and become the focus of the final design after the architectural work is performed.

The second step, diametrically opposed to the first, is to analyse the elements that must be introduced so that the building can be used today. The essential parameters of these elements, which refer to their functionality, comfort and safety, are laid down in the applicable legislation.

Achieving a balance between these two opposite premises would counter two misguided attitudes: on the one hand, the indiscriminate application of current regulations, standards and codes to historic buildings with utter disregard for their most singular features, one of whose extreme consequences is the hollowing out of buildings in which the preserved façade “masks” a modern structure; and on the other, the ultra-conservationist tack that would condemn buildings to certain ruin by rejecting the changes needed for their present day use.

HISTORIC HERITAGE, CURRENT STANDARDS: CONTRADICTIONARY TERMS

The successful rehabilitation of a historic building hinges on many factors, most of which are incumbent upon the developer of the project or the author of the design. They include the compatibility of the building's features with its new use, an in-depth study of its history, the correct identification of the attributes to be preserved and coherence with the forms of expression characterising different historical periods. Irrespective of all other considerations, however, the one factor that enables a building to be legally reincorporated into society's usable heritage and makes its “resurrection” possible is its compliance with statutory standards and codes.

Taken as a whole, such legislation clearly reflects the functional, construction and preventive standards that society requires of a building at any given time. Its constant re-adaptation stands as proof of the ongoing changes in social attitudes toward the subjects covered by these codes and regulations.

To some extent, they mirror or represent the challenges and fears of the community in which the building is situated, and their impact on the field of architecture is such that their strict and continuous application has given rise to most of the types of structures that comprise Spain's building stock and shape its cities.

Regardless of the existence of differences of opinion around any given “rule”, the social standards as a whole that make up this body of regulations should logically be one of the determinants of the final design of a building constructed in the period when these standards are in force.

But what are the consequences of attempting to strictly apply this legislation to a building designed to other standards, erected by a society where comfort, safety and functionality were defined in terms clearly different from today's?

The design of a historic building can simply not be re-shaped to make it fit the parameters established by today's standards if the features that made it a candidate for rehabilitation are to be preserved.

The brevity of this communication precludes a detailed analysis of the impact that strict compliance with regulations regarding compartmentation for fire prevention, new accessibility requirements or the changing specifications on protective elements may have on the space, functionality, volume or design of specific parts of a historic building.

Rather, this point will be illustrated with an example, focusing on a key element in the definition of the function, space and form of historic buildings: stairways. Their position in the building, role in the functional scheme, dimensions and design are essential to the interpretation of the whole. However, most stairways do not meet the requirements laid down in current fire protection provisions on escape routes, step dimensions, sectional layout or railings and protections. If the regulations were strictly applied to such members, their design would have to be changed and they would have closed off in a separate area and fitted with air-tight vestibules. Otherwise, a new circulation core would have to be built that would meet all of the legal requirements, thus relegating this essential architectural element to a merely decorative role.

This action may save the stairway “sculpture”, but would substantially alter the entire architectural structure of the building.

Efforts to adapt general standards to the specific characteristics of historic heritage buildings are presently being made, of course. This seminar is a clear example of the sensitivity to the consequences for such buildings of the indiscriminate application of today’s codes and regulations. That same concern underlies the greater flexibility shown in everyday practice, as evidenced by the existence of explanations in the text of the standards themselves or the leniency practised by some officials when supervising designs and construction.

However, this system, whose purpose is merely to mitigate the most obvious negative effects of specific regulations on a localised, occasional basis, not only fails to solve the problem. In fact it often leads to solutions that are counterproductive to the building as a whole, causing far more harm than would have been done by strictly complying with the standards for that particular element in the first place.

If current regulations and codes are only partially adapted to historic buildings and are limited to an individual analysis of the impact that each of their provisions would have on the construction element or part of the building to which it specifically refers, the end result may be an interesting museum of culturally significant pieces in a building divested of its personality, disconnected from its own past and imperfectly complying with standards completely foreign to it.

The relics of past eras that have survived in a run-down historic building, as any building requiring rehabilitation is, are usually strewn throughout and blemished by time or inappropriate renovations. The rehabilitator’s main task is to formulate a coherent discourse that relates the building to its own history, based on these remnants and on the requirements for the building’s new use.

This coherence cannot be maintained if that discourse is altered by varying the proportions, design and dimensions of the elements concerned.

The only way to achieve compatibility between the two eras, the past and the present, to formalise the modern stage of a historic building, is to consider it as a whole, study its history, delimit its key attributes and analyse what changes are necessary to make it usable in the present time.

Taking those fundamentals as a point of departure, a proposal can be put forward that is coherent with both the character and future use of the building, in the full awareness that certain aspects of the historic building will necessarily be forfeited and not all of the standards required for new construction will be met. The building will have been saved, however, and the architectural know-how it embodies will form part of today’s built heritage.

REACHING A COMPROMISE IN THE APPLICATION OF CURRENT REGULATIONS TO HISTORIC BUILDINGS

As a possible solution for the application of regulations and codes, a “standards impact” study could be conducted at the design level, similar to the environmental impact assessment conducted when work is performed in a landscape of particular natural value. This study would analyse the building as a whole and the consequences for its integrity of strict compliance with the regulations.

In this study, which could be a chapter in the design specifications, the essential features of the building and the effect that the strict application of the regulations would have on them would be

analysed. The consequences of non-compliance with these standards would also be assessed, and any necessary alternative measures proposed.

The respective authorities would then focus on this study as the basis for their supervisory activities, making any necessary corrections relevant to the specific proposal submitted and the underlying reasons.

An approach of this type, which seeks alternative solutions to the immediate, piecemeal application of the regulations, will require a different attitude on the part of both the designer and of the person who must evaluate the design, which would encompass such issues such as listed below.

- The consideration of the problem that a certain standard is intended to solve, over and above the exact wording that this standard may have at a given time (in other words, an emphasis on the spirit rather than the letter of the standard).
- The assessment of the characteristics, behaviour and adaptability of historic architectural features (such as cloisters, passageways and construction methods), rather than the mere pursuit of a resemblance to elements in modern architecture (courtyards or corridors, for instance) and application of the respective standards on the grounds of such similarity.
- The establishment of a system of values in which the spatial, functional and formal attributes of a historic building are factored into the evaluation of the proposal and given the same weight as the dimensional, preventive or comfort specifications contained in the standards to be applied.

The foregoing is merely the sketch for a new approach to the application of today's standards to a historic building or ensemble.

However, beyond the specific form that this change in approach may take, the key issue is that the main aim of any rehabilitation project, reaching a suitable balance between preservation of the historic cultural values of a building and its adaptation for present day use, can only be achieved by considering the building as a whole when applying the existing legislation.

FIRE SAFETY OF A NINETEENTH CENTURY CAST-IRON STRUCTURE THROUGH A COMPUTATIONAL FLUID DYNAMICS´ BASED ANALYSIS OF A WATER MIST FIRE SUPPRESSION SYSTEM

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INTRODUCTION AND GENERAL APPROACH

An iconic historic building nestled in the very heart of Spanish capital, Madrid, in the “Cibeles” square, was seriously compromised by the strict requirements of fire safety regulations.

The building, a 250,000 m² and seven floors high, is being renewed to house the Spanish capital town hall. A nineteenth century cast-iron riveted structure, sometimes massive, sometimes in delicate trusses, was in the way to disappear under a thick sturdy layer of intumescent protection. The requirement was generally ninety minutes resistance to ISO fire, being one hundred and twenty minutes in some zones of the building located under the ground line.



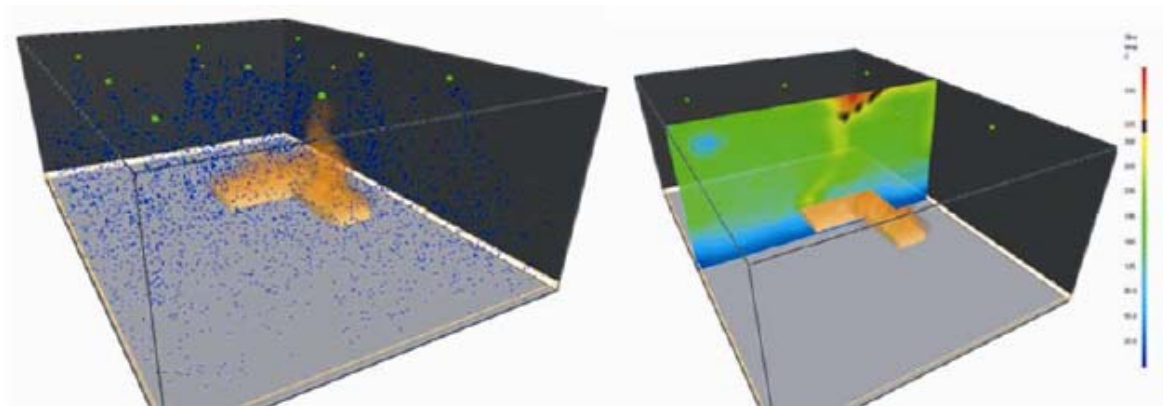
Labein-Tecnalia was asked to do a complete “research meets practice” work identifying, defining and validating an alternative integrated solution based on a water based fire suppression system.

The necessary water supply and the material losses in case of FIRE conditioned the preliminary designs, so a water mist system was selected to increase the effectiveness of the water as a suppression agent with the small droplet sizes and very high working pressures that characterized this sort of technology, thus obtaining the pursued benefit of a water supply reduction.

The integration of water mist effects in the thermodynamics of a fire was a non-sufficiently explored issue, so an innovative research project was on the way combining experimental tests and numerical simulations.

Therefore, the project required a basic stage, based on real large-scale tests, where fire load was modelled and the interactions between fire and extinguishing system was properly characterized. Temperature profiles were accurately adjusted to test measurements.

Complex numerical models were built to reproduce the real thermal interactions measured in the tests, and were extrapolated in the real geometry of the studied building.



Firstly, a risk analysis of the whole building was made, in which four FIRE design scenarios were identified as the most extremely dangerous because of their high impact on the structural stability and people's safety.

The scope of the project consisted of the analysis of the structural stability of three fire scenarios situated on ground level, and the advanced egress analysis of a fourth scenario, located in an underground zone in which an added difficulty arises because smoke evacuation was highly limited. The height of these rooms were 5,9 meters and 3,9 meters, respectively.

To avoid any kind of intumescent protection in the cast iron structure, the water mist system was designed to extinguish the fire, being critically important the way the system was activated, the building was divided into several detection zones, with independent circuits for the water mist system.

The optical smoke detection sensitivity was fixed into two different levels (3%/m and 10%/m of extinction coefficient), configuring a prealarm and alarm stage based protocol in case of fire.

This protocol was included in the Computational Fluid Dynamics (CFD) numerical model, to take into account the real behaviour of the safety measures installed in the building in view of a fire emergency.

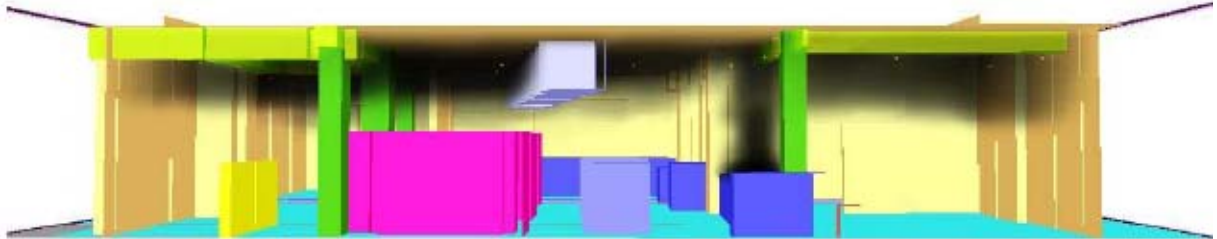


Figure: CFD smoke movement.

By means of the fluid dynamic analysis, lots of results related to FIRE situation were got, such as: temperature maps, radiative and convective boundaries, visibility maps, heat fluxes, smoke transport or concentrations of dangerous substances. Some of these magnitudes have been used in structural analysis and others in advanced egress analysis.

In that way, the most important results of CFD numerical model for the second fire scenario were the following ones, corresponding to a fire initiated on an office desk.

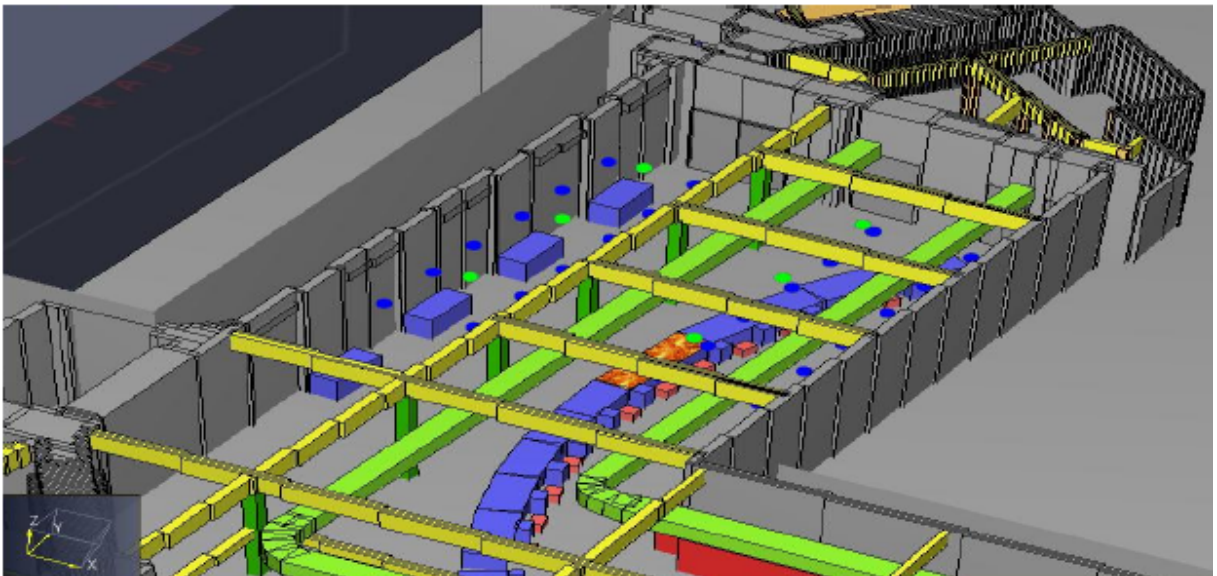


Figure: CFD model of the second scenario.

SMOKE MOVEMENT

As the graphic below shows, the smoke was detected rapidly so prealarm was activated, and after the second alarm plus one minute delay, the water mist system started off. So the extinguishing system action will begin 99 seconds after the fire had begun.

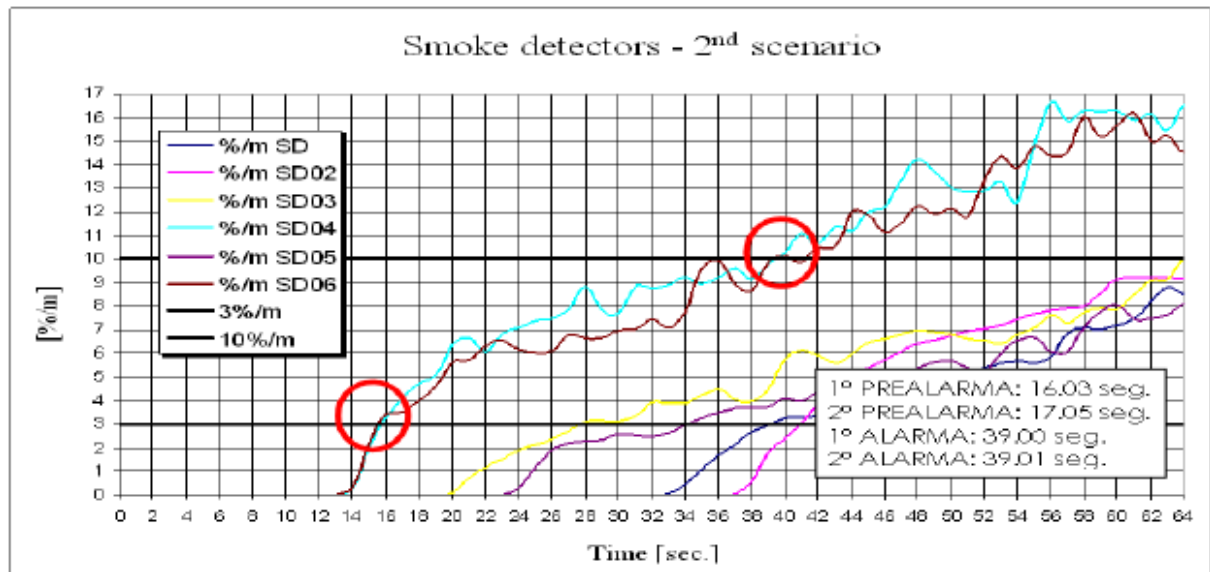


Figure: Results of smoke detection.

The aspect of the smoke layer, before and after water mist system activation, is represented in next figure. This image shows a vertical section of the building, and it could be noticed how the falling water droplets cooled the smoke making it go down destroying stratification, just only in the zone where the system had been activated, maintaining smoke stratified in other areas.

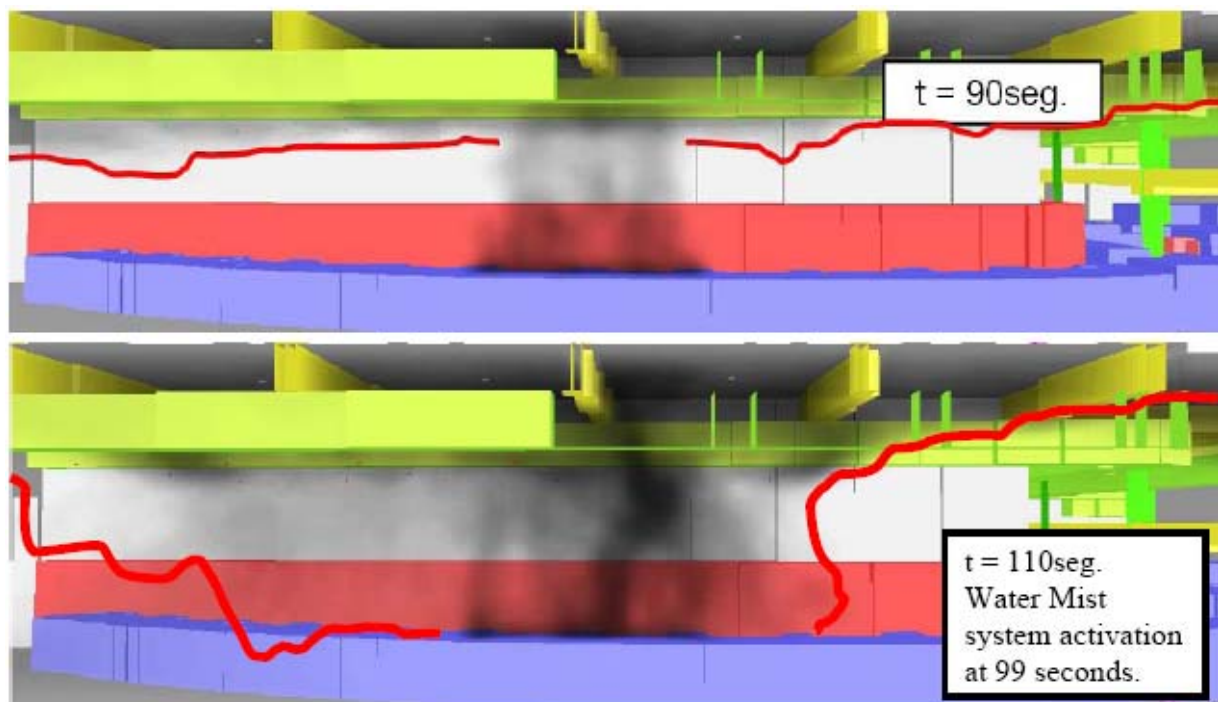


Figure: Smoke transport, after and before of the water mist activation.

THERMAL ACTION AND OTHER EFFECTS

The maximum temperature around the structure was also calculated, this maximum peak happens an instant before the extinguishing system starts. In this scenario, total heat flux was calculated for the forthcoming structural analysis in order to take into account the convective and radiative heat transfer, the estimated value was 2, 74 KW/m².

Regarding people's safety, concentrations of substances from the combustion and visibility level had been calculated for the fourth scenario, where low ceiling of the enclosure and limited ventilation made environment hazardous for tenability conditions.

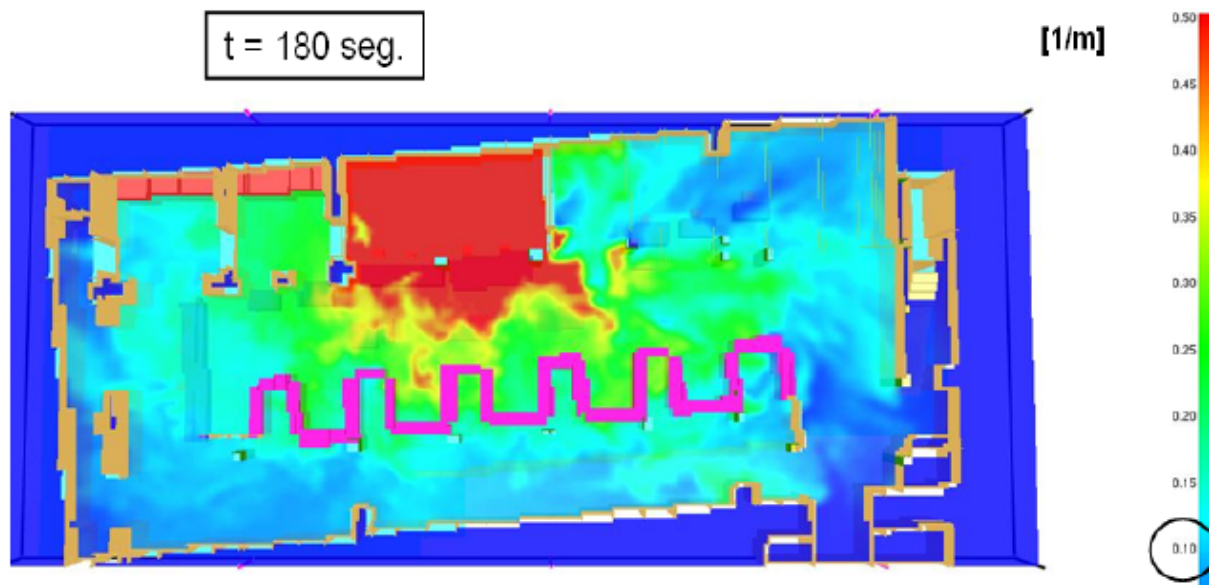


Figure 5: visibility, calculated for the fourth fire scenario.

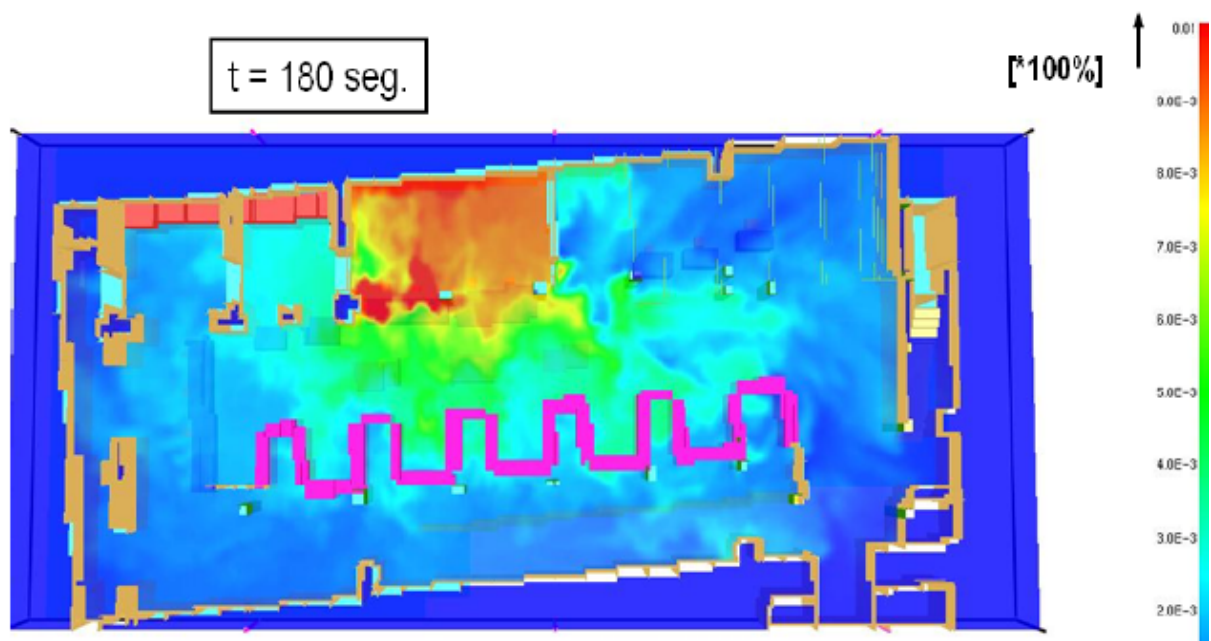


Figure: CO2, calculated for the fourth fire scenario.

STRUCTURAL ANALYSIS

After determining the thermal effects of the fire, the next stage of the project was to know the behaviour of different structural elements, such as beams, truss structures and columns. In the structural analysis, all cross-sections of columns and beams of the structure were characterized making different assumptions to take into account the particularities of these old cast iron elements, and through a finite element method, the evolution of the temperature inside the structural elements

was calculated. Then a mechanical resistance analysis has been made, including the previous temperature evolution and the material properties' losses.

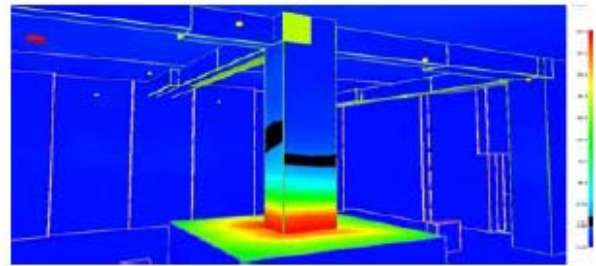


Figure: Heat flux over a column, localised fire.

With a structural study of isolated elements and sub-structures in case of an ISO fire, the critical temperatures and failure modes of elements had been calculated. Moreover, the displacements produced by temperature and mechanical loads had been also calculated. As an example, in the next figure the mechanical behaviour of truss structure is shown.

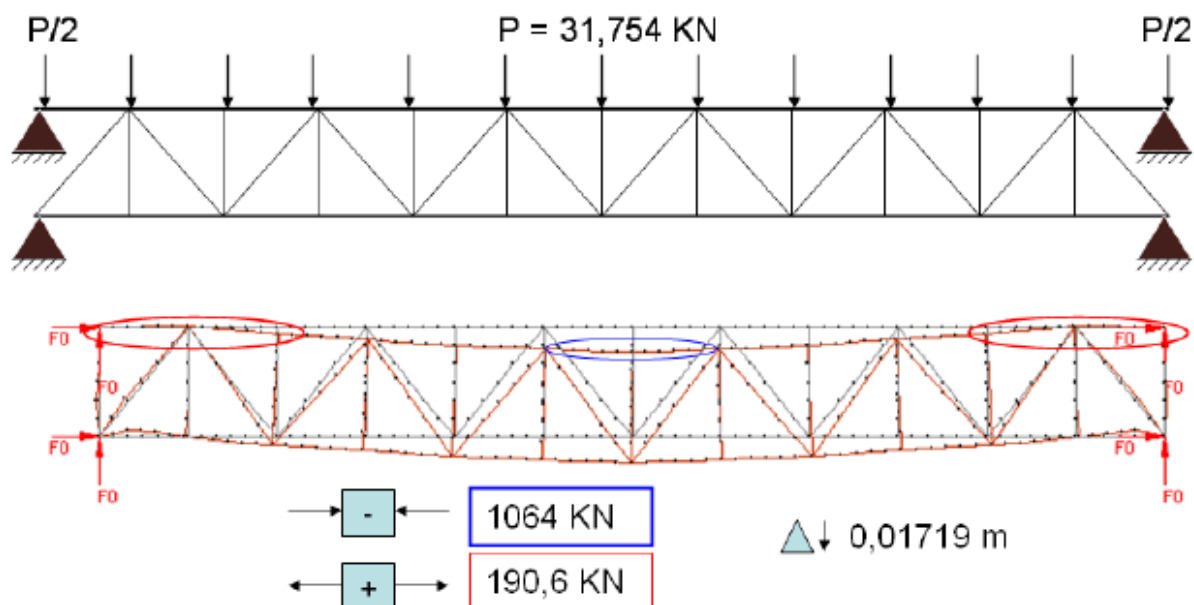


Figure: Mechanical behaviour of truss structure with heat flux interaction.

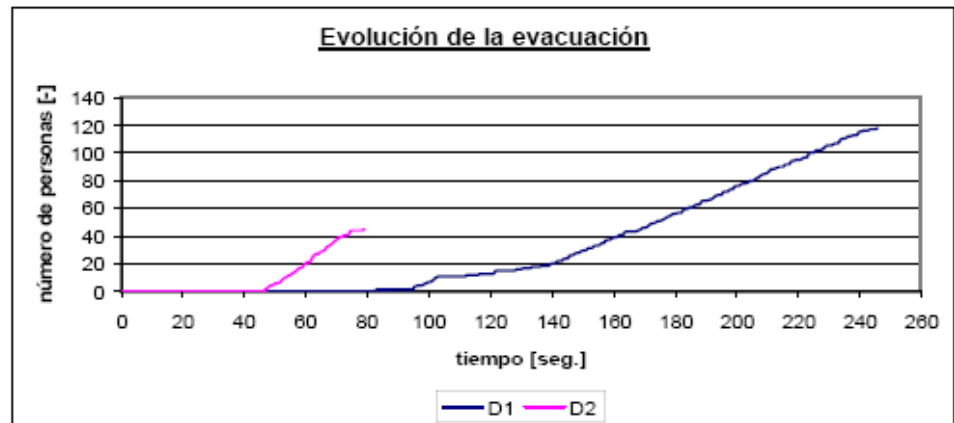
The same procedure had been repeated in all fire scenarios, leading us to determine in which structural elements passive protection must be added.

ADVANCED EVACUATION ANALYSIS

Finally the work has been completed with the study of advanced egress analysis for the most critical fire scenario. As it is said before, the results obtained in the fluid dynamic analysis were incorporated in it.

First of all population was estimated inside the office distinguishing general public from workers who know the geometry and exits available in the building. In the same way, physiological and psychological features were defined for each person, taking into account the age and the genus. Among these characteristics, the following ones deserve an emphasis: height, weight, breadth capacity, orientation, extreme behaviour, impatience... In this analysis, specific features and protocols of emergency plan were included, such as visual signals and emergency paths.

Figure: People evacuation through two different exits.



Another important aspect was the width of the emergency exits and hallways, which produced holdups in some occasions while occupants' capacities were reduced, because of fire conditions. Nevertheless, these situations did not put anyone at risk. Only in this way, it could be possible to notice how the people evacuate the building through emergency exits even if any queue was produced.



Figure: advanced egress analysis of the most critical scenario.

CONCLUSIÓN

As a conclusion it can be told that the safety level achieved by the proposed water mist system in case of fire was validated and verified for people safety and structural stability, fulfilling the objectives settled by the regulation through a performance based approach.



Figure: Building structure final aspect without any additional protection.

Thus the majority of this cast-iron structure does not require any additional protection, demonstrating that heritage can survive to fire scenarios without jeopardizing its beauty and splendour.