

SUSTAINABLE STRUCTURAL DESIGN: ENERGY EFFICIENCY VS STRUCTURAL EFFICIENCY

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SCOPE OF PRESENTATION

- My presentation will focus on a rather forgotten aspect of Sustainability of Buildings .
- That is structural safety and integrity. Although it is an “essential requirement” it is rather not included in the current “literature” about sustainability.
- Sustainable Structural Design for new buildings means incorporation of environmental parameters from the early stage of design.
- For existing buildings it means that when renovation projects of a certain scale are undertaken, structural upgrade should be considered and funded jointly with functional and energy efficiency upgrade.
- New generation of Eurocodes will enlarge our understanding for sustainability.

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THERE IS NOTHING NEW IN WHAT I WILL SAY

Vitruvio,
De Architectura



SUSTAINABLE STRUCTURAL DESIGN

- The construction sector needs to develop a new way to conceive structures, aiming to achieve a competitive sustainable building market.
- In order to obtain this European objective, a new design methodology is needed, focusing on a multi-performance and life-cycle oriented approach.
- Sustainable Structural Design (SSD) methodology addresses the possibility to include environmental aspects from the very beginning of the project in structural design, so that proper decisions, with regard to design options, can be made in the most influential stages of design.
- The approach for sustainable structural design complies with the design rules and reliability provisions of the European standards for structural design (the Eurocodes), thus enabling harmonization between structural safety and sustainability in the design process, thus complying with the basic requirements for construction works of the Construction Products Regulation.

SUSTAINABLE CITIES

- The concepts of future urban planning will be based on new social, economic and technological ideals focused on improving the quality of life. To attain this main objective, architects and engineers must improve the quality of buildings and engineering works and establish new principles.
- The future of construction works will be closely governed by the sustainable development of urban and industrial areas and infrastructures, which results in modifications or substitutions or extensions of existing buildings and engineering works.

THE CONSTRUCTION PRODUCTS REGULATION

- In this new regulation, an additional basic requirement on sustainability was introduced
- *“The construction works must be designed, built and demolished in such a way that the use of natural resources is sustainable and in particular ensure the following:*
- *(a) reuse or recyclability of the construction works, their materials and parts after demolition;*
- *(b) durability of the construction works;*
- *(c) use of environmentally compatible raw and secondary materials in the construction works.”*

BASIC ASPECTS OF SSD

- **Design optimization:** The design of structures is made according to structural requirements prescribed by structural Eurocodes or other codes. Furthermore, design optimization should take into account the optimization of the building performance over the complete life cycle of the building, minimizing the need of maintenance and maximizing the recovery of materials in the end of life
- **Reduction of construction and demolition waste:** The waste produced during construction and demolition processes shall be reduced to a minimum and the residues that are unavoidable should be recycled or reused

BASIC ASPECTS OF SSD

- **Design for flexibility and adaptability:** Buildings have a long life span and thus, the eventual change of use or requirements should be considered in the design process
- **Durability of materials and components:** The durability of the materials should be taken into account to minimize maintenance needs and avoid the need for replacement
- **Robustness:** The ability of a structure to withstand unforeseen events, without being damaged to an extent disproportionate to the original cause

BASIC ASPECTS OF SSD

- **Resilience:** Similarly, the capacity of the structure to adapt to and easily recover from hazards, shocks or stresses without compromising long-term prospects
- **Design for deconstruction and disassembly:** The way the structure is demolished has extreme influence on the amount and quality of materials and/or structural components that can be further use in another structure.
- **Reuse and/or re-assembly of materials or structural components:** The further use of materials and/or structures should take into quality of the materials and an estimation of their remaining service life.

NEW GENERATION OF EUROCODES

- In May 2010 DG ENTR issued the Programming Mandate M/466 EN to CEN concerning the future work on the Structural Eurocodes. The purpose of the Mandate was to initiate the process of further evolution of the Eurocode system. M/466 requested CEN to provide a programme for standardization covering the following :
 - - Development of new standards or new parts of existing standards, e.g. a new construction material and corresponding design methods or a new calculation procedure;
 - - Incorporation of new performance requirements and design methods to achieve further harmonization of the implementation of the existing standards.

MANDATE 515 DEC 2012

- The consideration of sustainability aspects in the construction sector jointly with considerable economic interests have been the main impulse to include the work item of assessment and retrofitting of existing structures in the Mandate M/515 with a high priority.
- The requirements in terms of structural safety are defined through the target value of reliability index, acceptable probability of failure or the acceptable level of risk.
- The standardization work programme of CEN/TC250 envisages that the new pre-normative documents will first be published as JRC Science and Policy Reports, before their publication as CEN Technical Specifications.

WHAT ABOUT EXISTING STRUCTURES?

- The vast majority of the existing European building stock has been built without modern provisions for earthquake resistance and energy efficiency, resulting in seismic vulnerable and low energy performance buildings.
- Europe's basic road infrastructure was built mainly between the years 1950-1980. It counts already 40-60 years of life. When designed and constructed technical knowledge was quite different as far as it concerns, durability matters, earthquake risk and seismic loads, analysis methods and modeling facilities, pollution impact on ageing process of structures and most of all poor quality of concrete and completely different, less heavy, traffic loads.

SUSTAINABLE STRUCTURAL UPGRADE

- These assets of European countries need urgent maintenance and retrofitting to keep their value and meet today's functional and safety standards.
- They need to be upgraded if Europe wants to maintain its productive and human respect standards.
- This represents a huge renovation and maintenance volume that Europe has to deal with during the next years.
- This has to be with a sustainable and innovative way.
- The application of advanced asset and risk management methodologies based on research is needed to further increase the efficiency of interventions.

DO WE HAVE RULES?

- STRUCTURAL REGULATIONS
- Eurocode 8 part 3 of EN1998 Assessment and retrofitting of buildings 2006
- National Codes, Regulations, Guidelines.
- Special provisions for Monuments.
- In most of European countries we have special rules for assessment and retrofitting of bridges, especially railway bridges.

DO WE HAVE PRIORITIES?

- There is no European strategy on upgrading common interest infrastructure.
- There is no European policy on upgrading the safety level of existing buildings.
- National strategies on the upgrade of buildings and infrastructure are based on the vulnerability evaluation of structures.
- An evaluation of the seismic risk of buildings is of paramount importance in order to quantify the required resources, to plan investments and to define prioritization strategies for the seismic risk mitigation.
- In most of the countries with high seismic risk we have national rules on the vulnerability evaluation of buildings and bridges.

THE ITALIAN CASE

- In 2014 a work group submitted to the Italian Minister a draft of the guidelines for a new seismic performance classification framework based on expected annual losses (EAL) which was the basis for the Seismic Risk Classification introduced in Italy in February 2017.
- The Classification has a structure similar to the Energy Performance Classification of Buildings and allows ranking the buildings in 7 classes (from A to G).
- To stimulate the adoption of risk mitigation measures, together with the Seismic Classification, the Italian government has introduced an interesting tax deduction scheme where the amount of deductible costs is based on the level of seismic risk reduction achieved through retrofitting works.

ECONOMIC ASPECT

- The need for investing on the upgrade of existing buildings and infrastructure is not only a humanistic duty. Respecting the value of life.
- Demolition and reconstruction programs are economically unaffordable.
- It is also of great economic importance. We have reliable data on the economic losses provoked by major earthquakes.
- Which is the daily cost of the Genoa bridge collapse?
- In a recent Congress on earthquakes in Greece was presented one research stating that a major seismic event in a city like Thessaloniki would have total losses of 20 Bn Euros.
- In a rather small earthquake in the island of Samos we had a total loss of 100 million Euros.

SAFETY MUST BE FIRST

- It is reasonable to state that in countries with high seismic risk it is economically foolish to invest on energy efficiency measures on unsafe buildings. We put a new skin on an old structure. Both will collapse in the first seismic event.
- As it is well known if buildings are cladded and insulated, then they may look new but their underlying structural issues remain, hidden, unseen and unassessed and may become life-threatening, especially in case of a major seismic event leading to a collapse.
- If that occurs, all EU money spent for energy Upgrades and refurbishment would be lost. However, the economic risk is redundant compared to the potential injury and loss of life.

WE NEED A NEW APPROACH

- We need a European policy on vulnerability assessment and retrofitting measures.
- A solution needs to be found so that funding can be given for work on structural assessment, strengthening and upgrade as well as energy efficiency work. Decision-makers need to comprehend the huge responsibility undertaken when ruling that energy efficiency measures only, would be funded by the EU. The new trend is smart financing for smart buildings. But, a building can only be called smart when it is safe and secure.

RESEARCH BY MEMBER STATES AND JRC

- A lot of scientific research has been done during the last years on seismic hazard assessment, seismic vulnerability of structures, assessment and retrofitting existing structures, sustainability of structural design etc.
- This research by National scientific units and by the European Joint Research Center is a significant database to serve on the effort for a common European approach on vulnerability assessment and retrofitting methods.
- With this common language joint seismic and energy efficiency upgrade under a common sustainability frame, funding will be possible.

SOME PUBLICATIONS BY JRC



JRC SCIENCE AND POLICY REPORTS

Building Design for Safety and Sustainability

Kostas Tsimpanogiannis
Marco Liguori
Paolo Negro

2014



JRC SCIENTIFIC AND POLICY REPORTS

Seismic performance assessment addressing sustainability and energy efficiency

Elvira Romano
Paolo Negro
Fabio Taucer

2014



JRC SCIENCE AND POLICY REPORT

New European Technical Rules for the Assessment and Retrofitting of Existing Structures

Policy Framework
Existing Regulations and Standards
Prospect for CEN Guidance

Support to the implementation, harmonization and further development of the Eurocodes

AUTHORS

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EDITORS

Silvia Dinova, Artur Pinto, Paul Luechinger, Steve Denton

2015



JRC SCIENTIFIC AND POLICY REPORTS

Technology options for earthquake resistant, eco-efficient buildings in Europe: Research needs

Alessandra Marini, Chiara Passoni, Paolo Riva
(University of Bergamo)

Paolo Negro, Elvira Romano, Fabio Taucer
(Joint Research Centre)

2014



TRANSPORT INFRASTRUCTURE

- The 2008 financial crisis had an impact on the way EU Member States deal with the maintenance of transport infrastructure. Most of the States looked at the infrastructure maintenance budgets as a potential source of budget savings. The result has been a varying state of transport infrastructure maintenance spending across Europe but in general we have a clear lack of investments.
- Recent accidents showed that this can be dangerous for human lives and economically catastrophic.
- As this infrastructure is rapidly ageing Europe has to face a big problem of sustainable retrofitting of infrastructure.

INFRASTRUCTURE

- Common interest infrastructure retrofitting programs should be based on common principles of assessment and repair and strengthening.
- Although structural science has been evolving last years mainly in the area of existing structures we have a lot to do so that existing National rules converge to a European standard.
- Furthermore, the application of advanced asset and risk management methodologies based on big data, the wide use of sensors and infrastructure simulation can lead to a tailor-made maintenance program while research progress aim to further reduce the spending need.
- Within this context it is important to explore what the role of the EU can be in order to support a good infrastructure quality.

ECCE WORKING TEAM

- ECCE tries to raise Awareness for the problem of safety of the existing building and infrastructure stock. Safety is one of the six essential requirements mentioned in the Eurocodes, the most important one, and no sustainable approach can forget this.
- Decision-makers need to comprehend the huge responsibility undertaken when ruling that energy efficiency measures only, would be funded by the EU. The new trend is smart financing for smart buildings. But, a building can only be called smart once it is safe and secure.
- ECCE has created a working team to elaborate on all these ideas.

SOME FIRST MEASURES

- EU has to encourage the new approach, making some simple additions to legal texts to allow to grant funding for the Structural and / or Seismic Upgrade of the buildings, before, or at least together with, the grants given for the upgrade of the energy performance of buildings, under Directive 2010/31/EM, of the European Parliament and of the Council of 19th of May 2010.
- The starting point for legally binding rules on the structural upgrade in case of major renovation projects should be state/government owned buildings and buildings of high importance (as categorized in the Eurocodes) as well as buildings that gather many people.

SEISMIC PERFORMANCE CLASSIFICATION

- ECCE will contribute to the effort of defining a common method for the Seismic Classification of Buildings. This could be combined with the electronic identity of structures, provided in many countries, and could be similar to the Energy Performance Classification of Buildings and become the basis for the Seismic Risk Classification.
- Finally financial measures should be taken, similar to those that promote energy efficiency upgrading, based on the minimization of expected annual losses (EAL), which is the economic justification for this prevention strategy.

**SMART BUILDINGS ARE SAFE AND
SECURE BUILDINGS**

THANK YOU