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THE NEED FOR INTEGRATING STRUCTURAL / SEISMIC UPGRADE OF EXISTING BUILDINGS, WITH ENERGY EFFICIENCY IMPROVEMENTS

ECCE Position Paper 2020

The Need for Integrating Structural/Seismic Upgrade of Existing Buildings with Energy Efficiency Improvements

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A. EXECUTIVE SUMMARY

The majority of the existing building stock in most European countries built in the 80s, 70s or earlier lack of modern design standards including the requirements for seismic safety and energy efficiency. Thus, based on their date of construction, the vast majority are deficient both in terms of energy and seismic resistance. This creates the need for the society to take actions to keep and maintain the building stock in operational, reliable and resilient state in order to ensure primarily the safety of the users.

In Civil Engineering this ongoing process is achieved by updating the design codes to incorporate aspects studied after research laboratory work or identified through shortcomings in real hazard situations. In addition to safety, nowadays the comfort of the users is of prime importance. To satisfy the required comfort levels, the user should consume energy, in the form of heating, cooling etc. Therefore, this ongoing trend to satisfy these conditions, results in new buildings which are safer, more economic to operate and more sustainable **The Three S Approach, Safe - Sound - Sustainable (3S)**

However, the current building stock of Europe comprises of structures that have been designed and constructed over a long period of years, although for traditional masonry buildings this can be more than 100 years. A BPIE (Buildings Performance Institute Europe) survey [BPIE, 2011] revealed that a significant amount, over 40% of the existing building stock in EU is over 50 years old (only around 17% is constructed after 1991), i.e. exceeding firstly their design life, and secondly are constructed during a period that Seismic Knowledge and Standards were limited and Energy Performance Guidelines were non-existent. It is easily understood that for this "aging" group of existing buildings, key challenges lie ahead, regarding their structural safety, sustainability and energy performance. The structural performance of buildings is related to their stiffness and strength as well as their ability to undergo non-linear (ductile) deformations. The extent to which a building can resist loads depends mainly on the characteristics of its lateral load resisting system – LLRS (i.e. columns, beams and walls). Most existing buildings do not pose significant lateral resistance and require upgrading in order to increase the efficiency of one or more of the above. For EU countries in the south-eastern Europe, the structural performance and safety is intertwined with seismic vulnerability.

In the case of the aging existing buildings, the lack of consideration for the seismic effect means this building stock is more vulnerable to earthquakes. In addition, as it is exceeding its design life of 50 years, it means that along with strengthening interventions to improve the seismic performance, durability and structural assessments should also be carried-out to ensure functionality and thus safety and comfort for the users.

In addition to safety, in the last decade the importance on the energy front has been highlighted; increased energy consumption lead to adverse environmental impact (e.g. climate change). Therefore, for the building sector the energy efficiency term is introduced, which is highlighted by the Europe's aim to reduce by 2020 the Greenhouse emissions by 20% and achieve 20% energy savings [EPBD recast, 2010/31/EU]. The building sector accounts for large energy consumption in EU with the European households using nearly the 70% of the consumed energy in the form of electrical energy. A survey by BPIE (2011) on energy consumption revealed that the older building stock is the main contributor to this. This is expected as in the EU the main policy regarding the energy use in buildings is the Energy Performance of Buildings Directive (EPBD, 2002/91/EC) initially issued in 2002, and re issued in 2010. Therefore, it is evident that there is a big portion of the existing EU building stock that is under-designed, both regarding their seismic capacity and their energy performance, as it is well below the national minimum requirements set in the last fifteen years and therefore in need of structural and energy renovation to remain operational and safe.

To improve the seismic performance/capacity of existing buildings that have not been designed according to the earthquake standards of Eurocode EC8 (CEN2005), a variety of techniques based on the typology of the building and the level of the required strengthening are currently used. Regarding the energy performance level of buildings, it is influenced by a number of factors including the installed heating/cooling systems, the climatic conditions and the building envelope. The energy demand of buildings can be reduced by improving the insulation of the envelope, increasing the thermal capacity of the building and by using energy efficient systems in the building's operating processes e.g. heating [JRC 2012]. Therefore, any potential energy saving measures are inter-related with these factors with greatest focus on aging existing buildings which have the largest energy consumption due to insufficient insulation of the building.

Currently, from a sustainability perspective, emphasis is placed on developing an integrated structural and energy design methodology for new buildings that should be preferred over individual actions to ensure a Sustainable Structural Design (SSD). Such approaches like the SSD methodology will ensure that new buildings satisfy both structural safety and energy efficiency targets.

A building has to fulfill its own performance in usability, capacity, reliability, safety and comfort. In that context, designing a safe and sustainable construction **(The Three S Approach – 3S)** turns out to be a very complex issue, so a **holistic view is the key of Sustainable Structural Design (SSD)** in the construction sector. Furthermore, buildings should be designed and assessed in the light of time with a future in mind which can be predicted only in probabilistic terms, so an integral life-cycle approach is required. However, for existing buildings, especially of a certain construction age, the problem of seismic and energy inefficiency is of primary importance and a similar in concept approach is required to provide upgrading on both fronts. Only the last few years it is acknowledged that independent retrofit actions should be integrated to enhance the overall performance. It started with an effort to relate seismic efficiency with environmental benefits resulting from the mitigation of damage and/or demolition because of earthquakes. This is followed by a multidisciplinary approach to improve building's performance taking seismic and energy efficiency on equal consideration.

Our aim in this position paper was to review and examine the parameters involved in an integrated holistic approach in order to enhance the overall performance of existing buildings and provide solutions to close the gap, regarding the beneficial simultaneous refurbishment of the structural / seismic capacity and energy efficiency of existing buildings.

As a next step, the European Council of Civil Engineers aspires to continue their efforts in the future to ensure the sustainability of existing building stock in Europe. Building on the discussion in the following sections, the next goal will be drafting a proposal on a common European framework for assessment of the seismic vulnerability of existing buildings. A common method of evaluation of the seismic vulnerability of European buildings is of paramount importance for governmental authorities to quantify the required resources, plan investment schemes and define prioritisation strategies for seismic risk mitigation. Thus, a common European policy on seismic risk and risk mitigation can be established, ensuring the sustainability of the built environment and society through the continent with common resources and mechanisms.

1. INTRODUCTION, SCOPE AND OBJECTIVES

The European Union has established a legislative framework to boost the energy performance of its buildings. Buildings are the largest single energy consumer in Europe, responsible for approximately 40% of EU energy consumption and 36% of CO_2 emissions[1]. At present, about 35% of the EU's buildings are over 50 years old and almost 75% of the building stock is energy inefficient[2]. Many of these buildings are located in parts of south-eastern Europe which have high levels of seismic hazard. In these areas, energy inefficient buildings are also in need of seismic retrofit. Therefore, in those areas the retrofitting of buildings in order to improve energy performance should also include structural upgrading to increase resistance to seismic loading. An integrated approach to upgrading buildings is required so that they are made safe and sound in addition to sustainable. This Position Paper sets out the case for this integrated, holistic approach.

The primary EU Directive concerned with boosting the energy performance of buildings is the Energy Performance of Buildings Directive (EPBD)[3]. The EPBD, together with other Directives, promotes policies to achieve a highly energy efficient and decarbonised building stock by 2050. It recognises that the building sector has vast potential to contribute to a carbon-neutral and competitive economy. EU countries are required to formulate long-term renovation strategies which include an overview of the national building stock, policies and actions to stimulate cost-effective, deep renovation of buildings, policies and actions to target the worst-performing buildings, split-incentive dilemmas, market failures, energy poverty and public buildings, as well as an overview of national initiatives to promote smart technologies and skills and education in the construction and energy efficiency sectors. These national strategies are updated every three years. Construction is one of the most impactful industrial sectors because of the high consequences it generates for society, the environment and the economy. Indeed, building constructions involve social aspects such as safety and comfort, as well as economic aspects such as energy consumption and emissions.

The issue of seismic hazard and seismic risk is real for many countries and especially for policy-makers and citizens alike in south-eastern Europe. For example, in August 2016, an earthquake in Central Italy resulted in 299 deaths and left 4,500 people homeless. It is estimated from past events that approximately 20% of the building stock in areas affected by moderate to strong seismic events requires significant structural upgrading. The upgrading required typically involves improving the resistance of building to lateral loading, and work on columns, beams, floors and walls. Because of the intrusive nature of these works, elements of the building which influence its energy performance, such as cladding and insulation, usually have to be repaired once they are completed, if construction works are not carried out simultaneously.

It is therefore essential that an integrated approach to the retrofitting of buildings be taken, particularly in areas with high levels of seismic hazard. Thus, structural reinforcement and energy performance retrofit works need to be considered in a holistic way. This will improve cost-effectiveness and reduce the disturbance to residents and other building users. This approach aligns well with the objectives of the long-term renovation strategies. This approach should also be incorporated into the relevant national and European long-term renovation strategies. This will also result in a more resilient and sustainable building stock across Europe.

1. European Commission website, accessed 31 January 2020

2. Ibid.

3. 2018/844/EU, updated as part of the Clean energy for all Europeans package in 2018 and 2019.

There is a public need and obligation for engineers to design, construct and maintain building stock in operational and reliable condition, primarily in order to ensure the safety of the population and protect them from various hazards. In structural applications, this ongoing process is achieved by updating the design codes to incorporate state-of-the-art and innovative research results identified through advanced knowledge and experimental testing under real hazard situations. In addition to safety and protection, the soundness of buildings and user comfort is now of prime importance and a performance parameter. To satisfy the required performance levels, the user needs to consume energy in the form of heating, cooling, etc. Therefore, this ongoing trend to satisfy these conditions results in new buildings which are safer, sounder, more economic to operate and with increased sustainability for fulfilment of the 3S approach (Safe, Sound and Sustainable).

The scope of this position paper is to convince European Union Member States that the solution provided for both energy and structural deficiencies in most building stock should follow a holistic approach to address these issues simultaneously and link individual retrofit/upgrading activities within an integrated holistic procedure. The objective is to proceed and secure funding for the Structural and/or Seismic Upgrade of these buildings, alongside with grants given to upgrade the energy performance of buildings, under Directive 2010/31/EM of the European Parliament and of the Council of 19 May 2010.

Aside from increasing funding opportunities, the expected benefit is to raise awareness and demand for safe and structurally sound buildings among stakeholders, governments, owners and operators. It is also really important to improve knowledge and information regarding sustainable structural design and assessment and design for structural and/or seismic upgrading of existing buildings.

2. PROBLEM STATEMENT

Sustainable Structural Design (SSD) is a holistic view of engineering/structural design that combines the structural and environmental aspects of buildings and summarises them in a single parameter, provided in economic terms from the early stage of design. Current assessment methods evaluate buildings over their life cycle at a later design stage to provide comparable building solutions, while at this stage the information cannot be effectively used in the general design process. A more effective way of achieving building sustainability is to consider environmental and safety issues simultaneously in the early design stage, including the principles of durability, probabilistic reliability and structural safety. Since these parameters are mutually dependent, they need to be addressed simultaneously in very early stages.

For existing buildings, it is required that when renovation projects of a certain scale are undertaken, structural upgrading of the load resisting system should be considered and funded, jointly with energy efficiency upgrade works. It is well known that most existing ***European building stock*** is old and was built without modern provisions for earthquake resistance and energy efficiency, resulting in seismic vulnerability and low energy performance buildings. When they were designed and constructed, technical knowledge on durability, earthquake risk and seismic loads, analysis methods and modelling facilities, the impact of pollution on the ageing process of structures and most of all concrete quality was quite different.

In addition, as existing building stock is exceeding its design life of 50 years, it is anticipated that further retrofitting interventions to improve its performance under seismic loading, durability and energy efficiency upgrading to ensure functionality should also be carried out, thus enhancing safety, comfort, well-being and life quality, for both users and society.

To achieve a more sustainable building environment, engineers must be involved at every stage of the process and SSD must be their priority.

3. RETROFITTING MEASURES FOR BUILDING UPGRADE

The EU Commission introduced uniform Eurocodes in Europe, in particular Eurocode 8 (EN 1998-3) for earthquake assessment of existing buildings, to save lives and reduce losses from future earthquake events. Those codes represent the best available guidance on how to assess, design and construct retrofitting measures to limit seismic risk. The EN 1998-3, in its consolidated version since 2013, is the base code for the assessment and retrofitting of buildings and it (a) provides criteria for defining the seismic behaviour of already existing individual buildings, (b) describes the procedure for selecting the necessary rehabilitation measures, as well as (c) outlines procedures for the design of rehabilitation measures (e.g. concept definition, dimensioning and detailing of structural interventions and their connection to existing components, etc.).

Depending on the type and importance of the building, three damage limit states are defined in these Eurocodes (EN 1998) – near collapse (NC), significant damage (SD) and damage limitation (DL) – which are verified using displacement checks.

The following section aims to address the retrofitting measures and current state-of-the-art achievements in the upgrading of existing buildings, in order to avoid structural damages from future seismic events, especially when energy upgraded buildings are also structurally upgraded.

The following aspects should be considered with respect to structural upgrading:

- Any major local deficiencies identified should be adequately addressed.
- In the case of highly irregular buildings (both in terms of stiffness and excess strength distributions), their structural regularity should be improved as much as possible, both in the elevation and floor plan.
- The required characteristic values of regularity and load capacity (resistance) can be achieved either by changes in the strength and/or stiffness of the appropriate number of existing components, or by the introduction of new load-bearing components.
- If required, an increase of local ductility capacity should be ensured.
- The increase in strength during the intervention should not reduce existing global ductility.
- Special measures are needed for masonry structures. Brittle door lintels should be replaced, insufficient connections between ceilings and walls should be improved, and out-of-plane acting horizontal thrust against walls must be eliminated.

The intervention may be taken from the following list of indicative intervention strategies:

- local or general modification of damaged or undamaged components (renovation, reinforcement or complete replacement), considering their rigidity, strength and/or ductility;
- addition of new load-bearing components (e.g. of dressings or infill walls, chords of steel, wood or reinforced concrete in masonry structures, additions of shear walls in RC Structures, etc.);
- modification of the load-bearing system (elimination of some constructive joints; widening of joints; removal of vulnerable components; transfer to more regular and/or ductile arrangements);
- partial demolition of damaged areas;
- addition of a new support system that either partially or completely relieves seismic stress;
- possible conversion of existing non-load-bearing components into load-bearing components;
- introduction of passive protection devices either by means of dissipative bracing or vibration isolation;
- reduction of masses;
- restriction or rededication of the use of the building;
- introduction of a diaphragm.

One or a combination of several of these intervention strategies can be selected. In all cases, the effect of these interventions on the building foundation and possible need to strengthen the existing foundation should be considered. With non-load-bearing structures, decisions concerning the rehabilitation or reinforcement of non-load-bearing structural elements must also be taken into account whenever, in addition to the functional requirements, the seismic behaviour of these elements may affect the lives of occupants or could affect the value of the goods stored in the building. In such cases, the total or partial failure of these components should be avoided through:

- suitable connections to load-bearing components;
- anchoring measures that are implemented to prevent the possible loss of parts of these components; and
- assessing whether the load-bearing capacity of non-structural elements is increased.

The possible effects of these provisions on the behaviour of load-bearing components should also be considered. To achieve structural upgrading, several materials and methods that can increase load-bearing capacity, stiffness, deformability and durability can be used, such as:

- **traditional** materials (steel, reinforced concrete), FRP (fibre-reinforced polymer);
- **new technologies** or **new inorganic composite materials and composition techniques**:

  - TRM (Textile Reinforced Mortar – a combination of inorganic binder with textile fibres – low cost and high temperature resistance),
  - ECC (Engineered Cementitious Composite – fibre cement mixes of low volume, high tensile strength, ductility and higher corrosion resistance, resistant to temperature and humidity conditions, suitable for repair and environmentally friendly),
  - UHPFRC (Ultra-High-Performance Fibre-Reinforced Concrete) with high compressive and tensile strength, low permeability and high ductility).

In addition to these considerations, which are related to structural upgrading, several methods and materials exist in the industry/market that can being used to achieve energy upgrading of the building, such as:

- **traditional** materials such as Mineral Wool, EPS, XPS, Cellulose, Cork, PUR;
- **newly developed thermal insulations**, such as:
- VIP (Vacum Insulation Panels),
- GFP (Gas filled Panels),
- Aerogels,
- PCM (Phase Change Materials).

For energy and construction renewal, these two groups can and should be combined in possible solutions, such as TRM + PUR, TRM + VIP, TRM + NIM, TRCM.

4. CODES AND POLICIES ON ENERGY AND SEISMIC UPGRADING-RECCOMENDATIONS FOR HOLISTIC APPROACH.

Current building stock comprises structures that have been designed and constructed over a period spanning some decades; for traditional masonry buildings, this may be 100 years or more. A BPIE (Buildings Performance Institute Europe) survey [BPIE, 2011] revealed that a significant portion (40%) of existing building stock in the EU is over 50 years old (only approx. 17% was constructed after 1991), i.e. it has first and foremost exceeded its design life and secondly was constructed during a period when seismic design codes and construction practices were very limited, and energy efficiency performance guidelines were non-existent. It is therefore clear that for this "ageing" group of existing buildings, key challenges lie ahead regarding primarily their structural safety, but also their sustainability and energy efficiency.

In order to assure sustainable development, there must be interactions among environmental, social and economic parameters. The construction sector contributes significantly to the three dimensions of sustainability. Indeed, according to the social dimension, people spend most of their time inside buildings, so a healthy and quality indoor environment has to be guaranteed. According to 2013 EU-28 data by Eurostat, the construction sector provides considerably to employment, accounting for 12.2 million people and 5.2% of total employees. Considering the economic dimension, the EU-28's construction sector was made up of more than 3.2 million enterprises in 2013 and generated EUR 487 billion of value added. Moreover, 2014 data by Eurostat reveal that an 11.4% share of the EU-28 population lived in households that spent 40% or more of their equalised disposable income on housing. Considering the environmental dimension, buildings are responsible for approximately 40% of total energy consumption and 36% of total greenhouse gases in Europe.

The structural performance of buildings is related to their stiffness, strength, robustness, as well as their ability to undergo non-linear (ductile) deformations. The extent to which a building can resist loads depends mainly on the characteristics of its structural resisting system (frame, wall, dual, etc.). Most existing buildings do not pose significant lateral resistance and require structural upgrading to increase the performance of their stiffness, strength, robustness or deformability.

In the case of EU countries located in the south-eastern part of Europe, e.g. Cyprus, Greece, Croatia, Albania, Bosnia, Montenegro, Serbia, Slovenia, Bulgaria, Turkey and Italy, structural performance and safety is intertwined with seismic vulnerability. Regardless of the structural material used to form the resisting system (reinforced concrete, masonry, steel and timber), the main criterion for withstanding earthquake loads is design adequacy. In the case of ageing buildings, a lack of consideration for seismic hazards resulted in a building stock with increased vulnerability to earthquakes. In addition, if the building is exceeding or approaching its design life of 50 years, this means that alongside strengthening interventions to improve seismic performance and durability, energy efficiency interventions should also be introduced to ensure functionality and thus safety, comfort and sustainability for users.

In addition to safety, the importance of energy efficiency in the last decade has been frequently highlighted. Increased energy consumption has an adverse environmental impact (e.g. climate change) and also leads to economic losses for communities. Therefore, an energy efficiency term for the building sector was introduced, which is underlined by Europe's aim to reduce greenhouse emissions by 20% by 2020 and achieve 20% energy savings [EPBD recast, 2010/31/EU]. The building sector accounts for a large share of energy consumption in the EU with European households using nearly 70% of energy consumed in the form of electricity. A survey by BPIE (2011) on energy consumption revealed that older building stock is the main contributor to this figure. This is expected as in the EU the main policy regarding energy use in buildings is the Energy Performance of Buildings Directive (EPBD, 2002/91/EC), initially issued in 2002 and re-issued in 2010.

Thus, part of the existing EU building stock is under-designed, both with respect to seismic capacity and energy efficiency performance, well below the national minimum requirements set in the last 15 years, and in need of renovation and retrofitting in order to remain operational and safe. If we consider the example of Cyprus, where the first seismic code was introduced in 1994 and the Energy directive in 2007, the existing building stock is categorised/defined as seismically vulnerable and/or energy insufficient based on their construction/built year relative to these two dates. Recent studies [Kyriakides et al. 2015] have shown that the majority (about 70%) of the existing building stock is approaching its life expectancy and lacks any seismic design. Subsequently, there is an immediate need to upgrade its performance to meet the demands of the design earthquake standards and its energy performance to satisfy the EPBD requirement.

To improve the seismic performance/capacity of existing buildings that were not designed according to the earthquake standards of Eurocode EC8 (CEN2005), a variety of techniques based on the typology of the building and the level of required strengthening are currently used for seismic retrofitting. For RC structures, seismic retrofit techniques are generally divided into local and global methods [JRC 2014a]. Local methods focus on improving the performance of particular structural elements and most commonly include strengthening of column-to-beam joints, column and beam jacketing and column and beam strengthening with advance materials such as fibre-reinforced polymers (FRP) or combined with new technology such as the textile reinforced mortar (TRM) technique in addition to traditional RC jacketing. These methods are used as part of major refurbishment of structures as they require partial demolition and reconstruction of the involved structural elements, which can also make them expensive. They tend to provide enhancement at the local level by increasing the rotational capacity of the elements or their shear capacity. On the other hand, global methods focus on enhancement of the structural system at the global level and tend to improve the overall behaviour of the structure, such as storey deformations and shear forces. The most conventional methods used in this category are the addition of shear walls, use of steel cross-bracings, base isolation and strengthening of infill masonry walls [FEMA 2006].

Among these techniques, strengthening of infill walls may well be the less intrusive option as it can be applied on exterior perimeter walls. The most common techniques applied use primarily a "jacketing" approach in the form of steel strip bracing, shotcreting (application of a thin concrete layer over the bricks), placing of prefabricated concrete panels using dowels over the wall and bonding of steel plates or FRP sheets onto the wall [JRC 2008]. An improved extension of the last method is the application of the TRM technique, which overcomes drawbacks of similar methods, i.e. fire resistance, additional weight, and durability issues as well as improves material bonding and compatibility [Triantafillou and Papanicolaou 2005]. The technique is based on a combination of textile with mortar, which is then applied in layers on brick walls. The textile comprises a yarn made grid, consisting of filament fibres, most commonly glass, carbon, aramid and basalt [Papanicolaou el al. 2011].

For masonry structures where seismic failure most frequently presents in out-of-plane failure, overturning of external walls and in-plane collapse of walls, seismic retrofit is achieved with various methods. Most commonly, a tie system is used around the building or in some cases internally to strengthen the walls; another possibility is the confinement of masonry walls at all corners using RC or reinforced masonry tie columns [JRC 2014]. A more efficient approach is the formation of floor and roof diaphragms [Senaldi et al., 2014]. Another option is e strengthening of walls, basically through a form of surface treatment with appropriate mixture overlays [Meireles & Bento, 2013]. This approach includes conventional methods such as ferrocement (several layers of hardware mesh of fine rods are covered with high-strength cement mortar) and shotcreting, where concrete is sprayed over reinforcing bars restrained on the masonry wall surface [ElGawdy et al. 2004]. Furthermore, as in RC structures, the TRM technique can be adjusted and used to strengthen stone masonry walls [San-Jose et al. 2008].

The energy performance level of buildings is influenced by a number of factors, including the type of heating/cooling system used, climatic conditions and the building envelope. The energy demand of buildings can be reduced by improving the insulation of the envelope, increasing the thermal capacity of the building and using energy efficient systems in the building's operating processes, e.g. heating [JRC 2012]. Therefore, any potential energy-saving measures are inter-related with these factors with the greatest focus on ageing buildings which have the largest energy consumption, mainly due to insufficient insulation.

Insulation of the envelope can be improved by reducing the energy loss from windows and doors, and by insulating the walls and the roof [IEA 2013]. With respect to insulation, the level of improvement depends on the thickness of the provided insulation and the properties of the insulating material, although thick insulating layers can be unfavourable due to space limitations, aesthetics and other technical constraints [JRC 2014a].

The selection of insulating materials has relied heavily on their thermal conductivity expressed through a low thermal transmittance U-value. On the other hand, heat storage materials are judged on their heat capacity. Based on that, commonly used materials include expanded polystyrene (EPS), extruded polystyrene (XPS), polyurethane and mineral wool. In addition, technological advances lead to the development and use of solutions like vacuum insulation panels, gas insulation panels, aerogels and phase change materials (PCM) [Jelle 2011]. PCM, in contrast to traditional insulation materials, can be incorporated into building components, e.g. it can be added to cementitious or lime mortar used as a coating layer, with the obvious benefit that the thickness of building components remains unaffected.

It can be concluded from the above that generally in the EU, a large part of the ageing building stock is in need of significant upgrading either because it has exceeded its design life, or it is not in line, or in many cases very far from current compulsory safety and energy guidelines/standards. Therefore, as is also acknowledged by the engineering research community (JRC 2014a), there is a need as well as a challenge to develop technology/procedures to upgrade/retrofit this building stock simultaneously in terms of safety and energy.

Currently, from a sustainability perspective, emphasis is placed on developing an integrated structural and energy design methodology for new buildings [Renos et. al. 2018] that should be preferred over individual actions. The focal point of the Sustainable Structural Design (SSD) methodology is a life-cycle approach, which integrates structural and environmental parameters. This will provide a holistic view of alternative constructive solutions using a performance-based approach where performance is judged not only by structural performance but also based on environmental parameters including energy efficiency [JRC 2014b & 2014c].

Approaches such as the SSD methodology will ensure that new buildings satisfy both structural safety and energy efficiency targets. However, for existing buildings, especially ageing ones, the problem of seismic and energy inefficiency is of primary importance and a similar conceptual approach is required to provide upgrading on both fronts. Only in the last few years has it been acknowledged that such independent retrofit actions should be integrated to enhance overall performance. It started with an effort to relate seismic efficiency with environmental benefits resulting from the mitigation of damage and/or demolition because of earthquakes. This was followed by a multidisciplinary approach to improve building performance, with equal consideration of seismic and energy efficiency. The result is a methodology based on cost-benefit analysis by calculating appropriate indicators that enable comparisons and different options of combined energy and seismic improvement scenarios [Calvi et al. 2016].

The latest development in this area proposes a specific new system, which combines TRM for strengthening with thermal insulating material in order to provide structural and energy retrofitting [Triantafillou et Al. 2017]. The system was used to upgrade masonry walls that were subsequently subjected to out-of-plane cyclic loading under different built configurations. The testing results showed that the strength and deformation capacity of specimens retrofitted with the new system was considerably improved compared to the one using only TRM.

The initial stage included identification of common elements to be upgraded, which meant that both energy and structural performance enhancement could be achieved by upgrading of the infill walls at the perimeter of the building. The integrated system is in a sense a single multi-layer system, in which each layer addresses a deficiency directly. At the same time, the indirect benefit of a designed layer on another deficiency must be quantified and incorporated in the system's effectiveness, e.g. an insulating material (polystyrene) used for energy upgrading may also improve durability. This first step, which investigates the contribution of the chosen insulating materials to the durability of a building, has delivered promising results but more testing needs to take place. A holistic solution for the simultaneous upgrade using TRM and traditional insulation as well as an innovative PCM layer to increase heat capacity is currently being examined using full-scale testing in the SupERB project, entitled a Novel integrated approach for seismic and energy upgrading of existing buildings, which was funded by the Research Promotion foundation of Cyprus. Testing for the holistic solution is taking place at the Large Structures laboratory of the Civil Engineering and Geomatics department at the Cyprus University of Technology. The proposed non-intrusive approach allows the continuation of normal use of the building during upgrading, hence avoiding the need for relocation of occupants.

It is becoming clear from observations after seismic events such as the one in L'Aquila, Italy (2009 earthquake) that there are significant advantages in adopting an integrated/holistic approach. In many cases, upgrading the energy efficiency of buildings without simultaneous strengthening for seismic loads results in the loss of an investment after an earthquake due to sudden collapse of the insulation systems connected at the building façade. This has a negative effect on the economy of households and countries, as well as on the safety of the population due to the sudden collapse of the insulation layer on the perimeter of a building or even the building itself. On the other hand, the simultaneous upgrading of existing buildings for structural performance and energy efficiency will contribute to the sustainability of the building stock and conservation of depleted raw materials.

5. CONCLUSIONS

Building retrofitting and enhancement interventions currently tend to focus on either energy efficiency or seismic resilience techniques. This position paper highlights the lack of consistent language and understanding across both fields, as well as the disconnection among stakeholders that arises from the development of seismic risk mitigation independently of sustainable development goals. Renovation, retrofit and refurbishment of existing buildings represent an opportunity to upgrade the structural and energy performance of commercial building assets for their ongoing life. Energy efficiency retrofits can reduce operational costs, particularly in older buildings, as well as help to attract tenants and gain a market edge, while structural retrofits can upgrade the lateral load resisting system of buildings and increase their average remaining life and thus, safety.

Although extensive know-how can be identified in both areas (i.e. structural and energy retrofitting), efforts for joint consideration presented in the literature are based on evaluating the environmental impacts of expected repairs due to seismic action over a period of time, neglecting the potential of energy efficiency enhancements and, more importantly, the possible benefits of an integrated investment strategy.

This study demonstrates that a holistic view is the key to safety and sustainability in the construction sector. A framework for the use of Sustainable Structural Design (SSD) has been recorded as an integrated approach, able to include environmental performance in structural design.

The findings of this position paper highlight the fact that it is possible to directly compare energy efficiency and seismic resilience from a common point of view. In addition, it is verified that the benefit of a given intervention can only be maximised up to the point to which an additional investment does not result in increased performance. Thus, an integrated approach will always be advantageous with respect to investment in only Earthquake Resiliency or Energy Efficiency and requires devising an investment strategy in a way that simultaneously maximises "individual" benefits, and integrated results.

The need to embrace a new approach to design structures has been underlined in this position paper. Buildings are multi-dimensional systems and therefore, their assessment requires many parameters to be taken into account. To move towards sustainability and safety, a new integrated design approach is essential to enabling building assessment for a multi-performance perspective. **This approach is the 3S approach: Safe Sound and Sustainable.**

6. REFERENCES

1. BPIE, 2011, "Europe's buildings under the microscope – A country-by-country review of the energy performance of buildings", M. Economidou et al., Buildings Performance Institute Europe.
2. Calvi G.M., Sousa L. and Ruggeri C., 2016, "Energy efficiency and seismic resilience: a common approach", in: Multi-hazards approaches to civil infrastructure engineering CEN2005, Eurocode 8.
3. ElGawady M., Lestuzzi P. and Badou M., 2004, "A review of conventional seismic retrofitting techniques for URM", 13th International Brick and Block conference IB^{2}MaC, Amsterdam.
4. EPBD, 2002/91/EC.
5. FEMA, 2006, "Techniques for the Seismic Rehabilitation of Existing Buildings", Prepared by: Rutherford & Chekene (R & C) Consulting Engineers, Federal Emergency Management Agency, report 547.
6. IEA, 2013, "Technology Roadmap-Energy efficient building envelopes", International Energy Agency report.
7. Jelle B.P., 2011, "Traditional, state-of-the-art and future thermal building insulation materials and solutions – Properties, requirements and possibilities", Energy and Buildings, v43, pp. 2549-2563.
8. JRC, 2014a, "Technology options for earthquake resistant, eco-efficient buildings in Europe: Research needs", Marini A. Et al., Joint Research Centre report JRC87425 (EUR 26497 EN).
9. Renos A. Votsis, Elia A. Tantele, Nicholas Kyriakides, Andreas Christofe and Christis Z. Chrysostomou, 2018, "Framework for an integrated system for enhancing the energy efficiency and structural performance of buildings", Proc. SPIE 10773, Sixth International Conference on Remote Sensing and Geoinformation of the Environment (RSCy2018), 107731W (6 August 2018); doi: 10.1117/12.2501951.
10. JRC, 2014b, "Building Design for Safety and Sustainability", Tsimplokoukou K. Et al., Joint Research Centre report JRC93115 (EUR 27116 EN).
11. JRC, 2014c, "Seismic performance assessment addressing sustainability and energy efficiency", Romano E. et al., Joint Research Centre report JRC87423 (EUR 26432 EN).
12. JRC, 2008, "Seismic Retrofit of RC Frame Buildings with Masonry Infill Walls: Literature Review and Preliminary Case Study", Griffith M., Joint Research Centre report 44166 (EUR 23289 EN).

13. JRC, 2012, “Best Environmental Management Practice in the Building and Construction Sector”, Joint Research Centre Final Report, EMAS regulation Article 46.1.

14. Kyriakides N., Chrysostomou C.Z, Tantele E. and Votsis R.A., 2015, “Framework for the derivation of analytical fragility curves and life cycle cost analysis for non-seismically designed buildings”, Soil Dynamics and Earthquake Engineering, V78, pp. 116-126.

15. Meireles H. and Bento R., 2013, “Rehabilitation and strengthening of old masonry buildings”.

16. Papanicolaou C., Triantafillou T. and Lekka M., 2011, “Externally bonded grids as strengthening and seismic retrofitting materials of masonry panels”, Construction and Building Materials, V25, n2, pp.504-514.

17. San-Jose J.T., Garcia D., San-Mateos R. and Diez J., 2008, “Stone masonry walls: Strengthening with TRM”, in: Structural analysis of Historic construction, edited by D'Ayala & Fodde, Taylor and Francis Group, London.

18. Senaldi I., Magenes G., Penna A., Galasco A. and Rota M., 2014, “The Effect of Stiffened Floor and Roof Diaphragms on the Experimental Seismic Response of a Full-Scale Unreinforced Stone Masonry Building”, Journal of Earthquake Engineering, 18:3, 407-443.

19. Triantafillou T. and Papanicolaou C., 2005, “Textile Reinforced Mortars (TRM) versus Fiber Reinforced Polymers (FRP) as Strengthening Materials of Concrete Structures”, 7th International conference on Fiber Reinforced Polymers in RC structures, FRPRCS7, Kansas City, USA.

20. Triantafillou T.C., Karlos K., Kefalou K. and Argyropoulou E., 2017, “An innovative structural and energy retrofitting system for URM walls using textile reinforced mortars combined with thermal insulation; mechanical and fire behaviour”, Construction and Building Materials, v133, pp.1-13.

21. The EN Eurocodes, Joint research centre, European commission. Available at: http://eurocodes.jrc.ec.europa.eu/ [Accessed 14-Dec. 2017].

22. Directive 2010/31/EC – Energy performance of buildings, directive of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings (recast) European Parliament (2016) [Boosting Building Renovation: What potential and value for Europe?].

23. European Parliament - Boosting building renovation: what potential and value for Europe (2016) http://www.europarl.europa.eu/RegData/etudes/STUD/2016/587326/IPOL_STU%282016%29587326_EN.pdf, Accessed 14 December 2017.

24. L. Koutas, New techniques and materials for the seismic retrofitting of RC frames through infilled masonry: experimental and Analytical Study Ph.D. thesis – Civil Engineering Department, University of Patras, Patras, Greece (in Greek) (2015).

25. A. Pinto, H. Varum, J. Molina, Experimental assessment and retrofit of full-scale models of existing RC frames, 12th European conference on earthquake engineering (ECEE), London, United Kingdom (2002).

26. A. Belleri, A. Marini, Does seismic risk affect the environmental impact of existing buildings – Energy Build, 110 (2016), pp. 149-158.

27. T.C. Triantafillou, K. Karlos, K. Kefalou, E. Argyropoulou – An innovative structural and energy retrofitting system for URM walls using textile reinforced mortars combined with

thermal insulation: mechanical and fire behaviour, Constr Build Mater, vol. 133 (2017), pp. 1-13.

28. G.M. Calvi, L. Sousa, C. Ruggeri, Energy efficiency and seismic resilience: a common approach, P. Gardoni, J.M. La Fave **(Eds.), Multi-hazard approaches to civil infrastructure engineering, Springer International Publishing, Basel, Switzerland (2016),** pp. 165-208.
29. M.N. Fardis, T.B. Panagiotakos, Seismic design and response of bare and infilled reinforced concrete buildings – Part II: infilled structures, J. Earthquake Eng., 1 (3) (1997), pp. 473-503.
30. D. D'Ayala, A. Meslem, D. Vamvastikos, K. Porter, T. Rossetto, H. Crowley, V. SilvaGuidelines for analytical vulnerability assessment of low/mid-rise Buildings—Methodology, Vulnerability Global Component Project (2014), Available from:www.nexus.globalquakemodel.org/gem-vulnerability/posts/.
31. CEN European standard EN 1998–1: Eurocode 8: design of structures for earthquake resistance—part 1: general rules, seismic actions and rules for buildings, European Committee for Standardization, Brussels (2004).
32. BPIE (Building Performance Institute Europe), Europe's Buildings Under the Microscope (2011).
33. Directive 2010/31/EU of the European Parliament and of the Council, Energy Performance of Buildings (2010).
34. M. DE Vita, A. Manella, A. Sabino, A. Marchetti, Seismic Retrofit Measures of Masonry Walls of Historical Buildings, from an Energy Saving Perspective, Sustainability, 10(4). (2018).

7. ABBREVIATIONS

3S – Safe, Sound, Sustainable
BPIE - Buildings Performance Institute Europe
DL – Damage Limitations
EPBD - Energy Performance of Buildings Directive
EPS – Expanded Polystyrene
ECC – Engineered Cementitious Composite
GFP – Gas Filled Panels
LLLR – Lateral Load Resisting System
NC – Near Collapse
PCM – Phase Change Materials
PUR – Polyurethane
SSD - Sustainable Structural Design
SD – Significant Damage
TRM – Textile Reinforced Mortar
UHPFRC – Ultra-High-Performance Fibre-Reinforced Concrete
VIP – Vacuum Insulation Panels
XPS – Extruded polystyrene

B. APPENDICES

Ba. The 3S Approach Manifesto

The need for integrating Structural / Seismic Upgrade of Existing Buildings, with Energy Efficiency Improvements

The majority of the existing building stock in most European countries built in the 80s, 70s or earlier, lack modern design standards, including the requirements for seismic safety and energy efficiency. One of the most important Human rights is to possess **Safe, Sound and Sustainable buildings (3S).**

Thus, based on their date of construction, the vast majority of buildings are deficient both in terms of energy efficiency and seismic resistance. This creates the need for the society (public and engineers) to take actions to keep and maintain **the building stock in operational, reliable and resilient state, in order to ensure primarily the safety of the users.**

The extent to which a building can resist loads depends mainly on its columns, beams and walls, its load resisting system – LRS. Most existing buildings do not pose significant Lateral load Resistance and require upgrading to increase the efficiency of one or more of the above. In the case of aging existing buildings, **the lack of consideration for any dynamic effect means that the building stock is more vulnerable to earthquakes and other dynamic effects.**

In addition, as it is exceeding its design life of 50 years, it means that along with strengthening interventions to improve the building's seismic performance, **durability and structural assessments procedures to ensure functionality should also be carried-out, bringing safety and comfort for the users.**

In the last decade, **the importance on the energy front has been highlighted enough; increased energy consumption lead to adverse environmental impact** (e.g. climate change). Therefore, the building sector introduced the energy efficiency concept, highlighted by Europe's goal to reduce the Greenhouse gas emissions by 20% and achieve 20% energy savings by 2020. **The building sector accounts for large energy consumption in EU** with the European households consuming nearly the 70% of the energy demand in the form of electrical energy. **Unfortunately, the importance of safety has not been highlighted or considered likewise.**

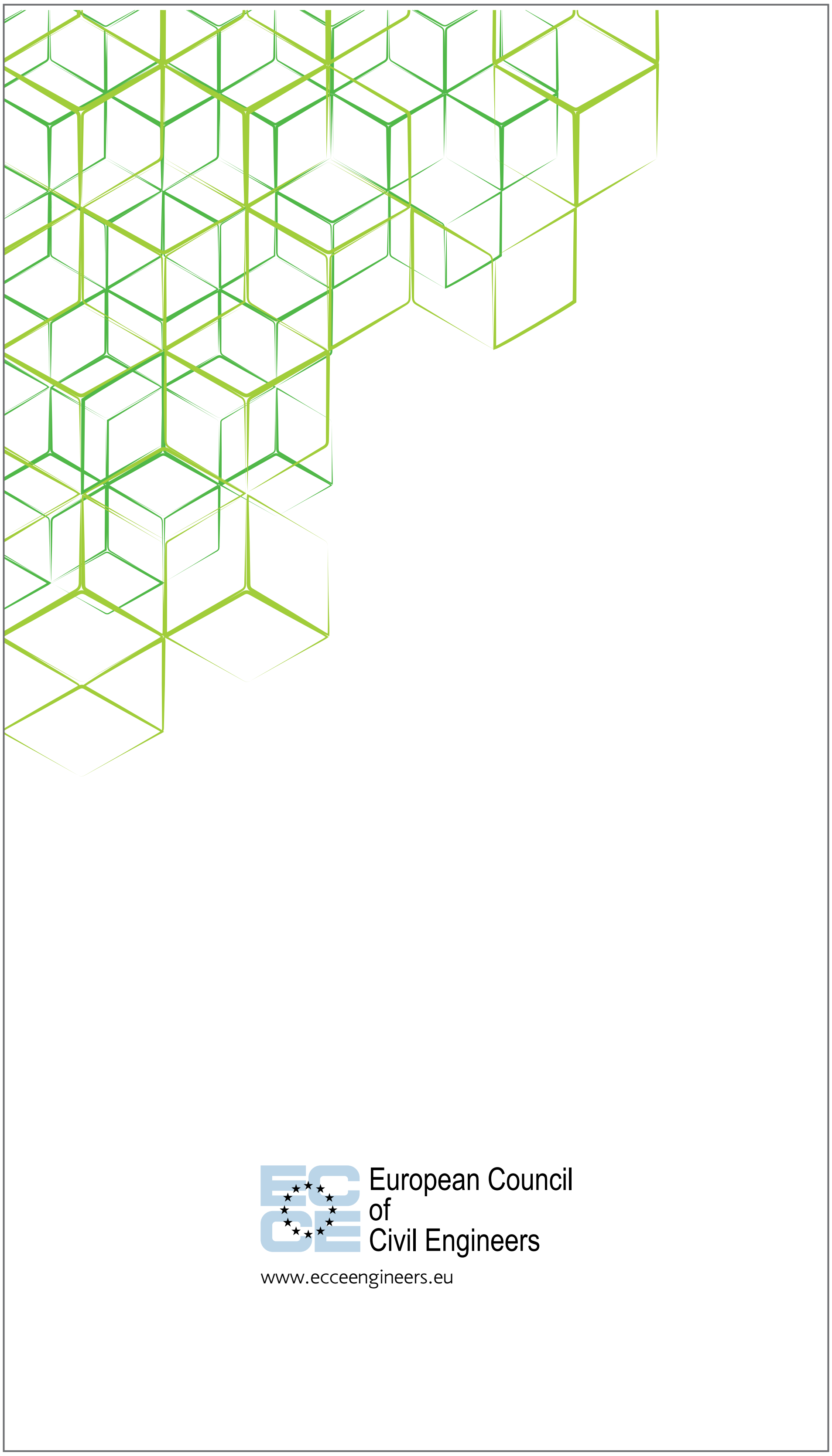
Currently, from a sustainability perspective, emphasis has been placed on developing an integrated structural and energy design methodology for new buildings to override individual actions to ensure a Sustainable Structural Design (SSD).

However, in older existing buildings, the issue of structural, seismic and energy inefficiency becomes of primary importance and a similar overarching concept approach is required to provide upgrading on both fronts and if possible, in an integrated common holistic approach.

The new trend nowdays is...
smart financing for smart buildings.
But a building can only be called smart...
once it fulfills the **3S** approach
"safe, sound and sustainable".

So, as ECCE we declare year 2020 as...
The Year of the **3S** Approach

ECCE Moto for 2020


European Council of Civil Engineers
www.ecceengineers.eu

Bb. Seismic Risk Chart

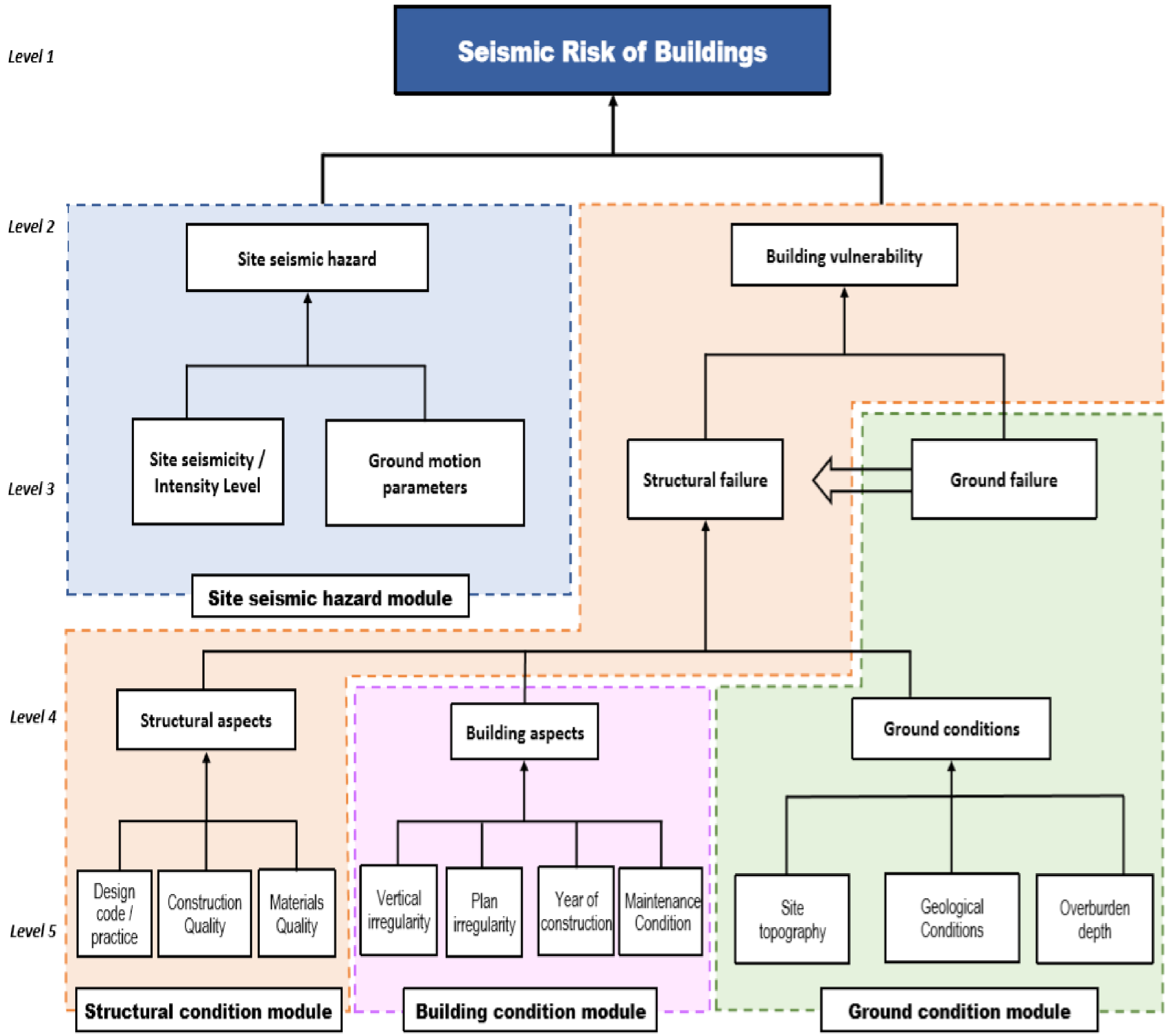


Figure1 – Hierarchical Earthquake Risk Assessment of Buildings (Platonas Stylianou 2020)

Bc. Material Gathered

(QUESTIONNAIRE FROM VARIOUS COUNTRIES)

CYPRUS - 1

QUESTIONNAIRE

“The need for integrating Structural / Seismic Upgrade of Existing Buildings, with Energy Efficiency Improvements”

Name and Surname: Dr Nicholas Kyriakides (Cyprus University of Technology)
Email: nicholas.kyriakides@cut.ac.cy

QUESTIONS

I. General

1. Does your Country suffer from earthquake or other dynamic loading problem or other combination of dynamic loadings and if yes approximately how frequently –Please attach historical records, if possible.

☒ Yes ☐ No

Cyprus lies in a region of moderate seismicity. Significant earthquakes (with magnitude ≥4 Richter) occur very often, approximately 3-5 per year. Major earthquakes (with magnitude ≥5 Richter) occur regularly, approximately 1 every 3 years. An earthquake of »6.5 occurs approximately every 40 years.

2. When was the last major / serious earthquake or other dynamic event that took place in your Country that affected the stability of buildings and civil works? What was the intensity?

The major earthquakes of the last 20 years that affected the stability of buildings and civil works are shown in the table below.

Date	Location	Magnitude	MMI	Deaths	Injuries
1896-06-29	Limassol				
1953-09-10	Paphos	6.5 M_s	X	40	100
1995-02-23	Paphos	5.9 M_w	VII	2	5
1996-10-09	Limassol	6.8 M_w	VII	2	20
1999-08-11	Yerasa	5.6 M_w	VII		15

3. Were the affected buildings or civil works repaired?

Do you know what was the amount of money needed in order to repair the above?

☒ Yes ☐ No

The most disastrous recent earthquake was the 1996 Limassol earthquake. Very strong earthquake in the southwest of Cyprus. It caused panic in the districts of Paphos, Lemesos, Lefkosia, Larnaca and Ammochostos. Two people lost their lives and 20 were lightly injured. There were damage reports from especially Pafos and Lemesos. The reported data were taken from the Rehabilitation and Reconstruction Services, Town Planning Department of the Ministry of Interior and they were evaluated by the Geological Survey department. The total cost for restoration reached the amound of 6.5 million Euros. In 1995, a destructive earthquake in the district of Pafos caused the death of 2 people. Several houses collapsed in the villages of Pano Arodes and Miliou. Some damage was caused to buildings in the villages of Peristerona, Steni, Gialia, Argaka, Pomos, Pyrgos, Lefka, Neo Chorio Akama, Latsi and Poli Chrysochous. The total cost of restoration provided by the Rehabilitation and Reconstruction Services was close to 7 million Euros. In 1999 a Strong earthquake with epicenter near Gerasa village in Lemesos, strongly felt across the entire island. It caused damage to buildings in Lemesos and the north part of the district. Forty people were lightly injured mainly because of panic. A large number of aftershocks continued for months.

4. Please briefly explain what damages it caused (with regard to buildings, roads, bridges, etc.)

Both the 1995 and 1996 earthquakes have caused severe structural damages to a few buildings (10-20) with 3-5 storeys, moderate damage to approximately 100 low rise RC and masonry buildings and slight damage to a few hundred low rise.

5. Where there any fatalities or serious injuries?

☒ Yes ☐ No

There were 2 fatalities both during the 1995 and 1996 earthquakes and 20 to 40 injuries respectively

6. What was the time needed in order to fix the damages and to reinstate smoothly operation?

A few months

7. Are you aware of any special measures or others means applied, to mitigate/prepare for these events in your Country?

☒ Yes ☐ No

- Eurocodes 8-1 and 8-3 for the seismic design of new buildings and assessment and retrofitting of existing ones.
- Informative material and Educational Programs addressed to many target groups (teachers, students, volunteers, people with disabilities, tourists) for self- protecting measures.
- Guidelines and Procedures for earthquake disaster management by Civil Defense (Emergency Plan Egelados).
- Educational seminars for pre-earthquake inspection/assessment of existing buildings addressed to engineers.
- Operational exercises for seismic disaster management by the Civil Defense.

II. State regulations/legislations and concrete experiences.

8. Is there a legal or technical guide/regulation on Energy Efficiency Upgrading of existing buildings in your Country?

☒ Yes ☐ No

The last revised edition of the Building Energy Efficiency Regulation was put into force in 2017 (Government Gazette 2367/B/12-7-2017)

9. Are there any legal or technical regulations/codes related to Seismic or Structural strengthening or upgrades in your Country?

☒ Yes ☐ No

In 2011 the Eurocodes have been enforced as obligatory for the assessment and retrofitting of existing structures

10. Are the Eurocodes applied for seismic assessments and seismic/structural strengthening of existing buildings in your country?

☒ Yes ☐ No

The implementation and use of Eurocodes become mandatory in 2011

11. Are there incentives provided by the government, to individuals, for structural upgrades / renovations / seismic upgrades in your Country?

☒ Yes ☐ No

12. Have you received any training related to seismic and energy efficiency upgrading?

☒ Yes ☐ No

Most engineers in Cyprus have the opportunity to attend seminars, conferences and training programs relevant to the above issues.

Additionally, the energy efficiency assessment is carried out by engineers, certified energy inspectors.

13. Have you participated in a workshop/conference on the above topics?

☒ Yes ☐ No

The last related Conferences was hosted in Greece:

The 16th European Conference on Earthquake Engineering "Recent Advances in Earthquake Engineering in Europe", Thessaloniki, 2018.

III. From practice

14. What are the most common building categories in your Country, regarding existing buildings built before 2000 and how many storeys are they?

According to the database kept in Earthquake Planning and Protection Organization (E.P.P.O.), the building categories/types are:

- Reinforced concrete structures
- Masonry structures
- Steel structures

15. What is the most widely used construction material for those buildings?

Concrete is by far the most widely used construction material (approximately 70%)

16. What is the common technique/material used for energy efficiency upgrading of existing buildings?

Thermal rigid insulation, thermal insulating plaster, renovation of thermal mechanical equipment.

17. What are the most widely used techniques/applications for seismic strengthening of existing buildings?

<u>Concrete structures:</u>

Construction of concrete jackets (shotcrete or cast concrete)
Construction of new lateral shear walls
Addition of bonded steel laminates
Addition of FRP fabrics

<u>Masonry structures:</u>

Rigid diaphragm adding
Infusion of grouting
Shotcrete jacket
Metal ties and fastenings
New plastering

18. Do you have unmaintained, deteriorated or abandoned buildings that suffer structural deficiencies/ material degradation in your Country?

☒ Yes ☐ No

CYPRUS – 2

QUESTIONNAIRE

"The need for integrating Structural / Seismic Upgrade of Existing Buildings, with Energy Efficiency Improvements"

Name and Surname: Loucas Hadjinicolas
Email: lhadjinicolas@limda.moi.gov.cy

QUESTIONS

I. General

1. Does your Country suffer from earthquake or other dynamic loading problem or other combination of dynamic loadings and if yes approximately how frequently –Please attach historical records, if possible.

☒ Yes ☐ No

The last Earthquake with important damages was in 1999. Also another Earthquake was held in 1995 with 2 human losses.

2. When was the last major / serious earthquake or other dynamic event that took place in your Country that affected the stability of buildings and civil works? What was the intensity?

The last Earthquake with important damages was in 1999 in Limassol (magnitude 5.6)

3. Were the affected buildings or civil works repaired?

Do you know what was the amount of money needed in order to repair the above?

☒ Yes ☐ No

They were repaired but we do not have information about the cost to repair them.

4. Please briefly explain what damages it caused (with regard to buildings, roads, bridges, etc.)

Collapse of 2-3 old masonry buildings in 1995 Earthquake in Paphos. Damages on old concrete buildings.

5. Where there any fatalities or serious injuries?

☒ Yes ☐ No

2 human losses in 1995 Earthquake in Paphos after the collapse of a masonry building roof.

6. What was the time needed in order to fix the damages and to reinstate smoothly operation?

2 years. The time needed in order to fix the damages depends from the type of the damages. Sometimes a building permission is required.

7. Are you aware of any special measures or others means applied, to mitigate/prepare for these events in your Country?

☒ Yes ☐ No

- Cyprus Earthquake Designing Code since 1994.
- Eurocodes since 2012.

II. State regulations/legislations and concrete experiences.

8. Is there a legal or technical guide/regulation on Energy Efficiency Upgrading of existing buildings in your Country?

☒ Yes ☐ No

There is a technical guide on Energy Efficiency Upgrading of existing building in Cyprus, but is not mandatory the Energy Efficiency Upgrading of existing building in our Country.

9. Are there any legal or technical regulations/codes related to Seismic or Structural strengthening or upgrades in your Country?

☒ Yes ☐ No

The Eurocode 8 – Part 3 is applied in Cyprus, but the seismic strengthening of existing buildings is not mandatory in our Country.

10. Are the Eurocodes applied for seismic assessments and seismic/structural strengthening of existing buildings in your country?

☒ Yes ☐ No

The Eurocode 8 – Part 3 is applied in our Country.

11. Are there incentives provided by the government, to individuals, for structural upgrades / renovations / seismic upgrades in your Country?

☒ Yes ☐ No

12. Have you received any training related to seismic and energy efficiency upgrading?

☒ Yes ☐ No

I have received several training programs related to seismic and energy efficiency upgrading.

13. Have you participated in a workshop/conference on the above topics?

☒ Yes ☐ No

I was participated in several seminars/conferences about these topics.

III. From practice

14. What are the most common building categories in your Country, regarding existing buildings built before 2000 and how many storeys are they?

Most existing buildings were made from reinforced concrete. Most of them have 2-3 storeys.

15. What is the most widely used construction material for those buildings?

Reinforced concrete

16. What is the common technique/material used for energy efficiency upgrading of existing buildings?

Fixation of thermal insulation panels are glued to existing concrete members and walls.

17. What are the most widely used techniques/applications for seismic strengthening of existing buildings?

There are several techniques which are used to strengthen reinforced concrete buildings in our country. The most widely used technique is reinforced concrete jacketing.

18. Do you have unmaintained, deteriorated or abandoned buildings that suffer structural deficiencies/ material degradation in your Country?

GREECE

QUESTIONNAIRE

"The need for integrating Structural / Seismic Upgrade of Existing Buildings, with Energy Efficiency Improvements"

Name and Surname: Dionyssia Panagiotopoulou MSc Civil Engineer, E.P.P.O.,
Katerina Tarnava MSc Civil Engineer, E.P.P.O.,
Gabriela Zagora MSc Civil Engineer, E.P.P.O.
Email: info@oasp.gr

QUESTIONS

I. General

1. Does your Country suffer from earthquake or other dynamic loading problem or other combination of dynamic loadings and if yes approximately how frequently –Please attach historical records, if possible.

☒ Yes ☐ No

The seismicity of Greece is the highest in Europe and the 6th globally. Significant earthquakes (with magnitude ≥4 Richter) occur very often, approximately 110 per year. Major earthquakes (with magnitude ≥5 Richter) occur regularly, approximately 11 per year. Please see attached files "Events4_5Greece.docx" and "Events5Greece.docx" with historical records for the last decade, according to the Institute of Geodynamics of Greece.

1. When was the last major / serious earthquake or other dynamic event that took place in your Country that affected the stability of buildings and civil works? What was the intensity?

The major earthquakes of the last 20 years that affected the stability of buildings and civil works are shown in the table below.

Location	Date	Magnitude	Intencity	Pick ground Acceleration (g)
Athens	07-09-1999	5.9	IX	0.30
Lefkada	14-08-2003	6.2	VIII	0.42
Andravida	08-06-2008	6.5	VIII	0.19
Kefalonia	26-01-2014	5.8	VI	0.38
Lesvos	12-06-2017	6.1	IX	0.20

3. Were the affected buildings or civil works repaired?

Do you know what was the amount of money needed in order to repair the above?

☒ Yes ☐ No

The most disastrous earthquake was the Athens' earthquake in 1999. The vast majority of the damaged buildings have been repaired. The total cost of public expenses and fundings exceeded the amount of 1 billion Euros, in 1999 values. For repairs and reconstructions for the structural damages the amount was up to 450 million Euros. Private spending is difficult to estimate but it must have been more than twice the public.

4. Please briefly explain what damages it caused (with regard to buildings, roads, bridges, etc.)

As long as the Athens' earthquake is considered, the results of the post-earthquake inspections have shown that out of 60,812 inspected buildings (residential, commercial and industrial establishments), 17,965 were marked as "GREEN" (suitable to use), 38,165 were marked as "YELLOW" (temporarily not suitable to use) and 4,682 were marked as "RED" (dangerous to use).

The results of the post-earthquake inspections (where available) for the most destructive earthquakes of the last 20 years, are listed in the table below.

<table>
<tr><th>Location</th><th>Date</th><th>Magnitude</th><th>Damages</th></tr>
<tr><td>Athens</td><td>07-09-1999</td><td>5.9</td><td><table>
<tr><td rowspan="4">inspections</td><td>GREEN</td><td>17,965</td><td>29%</td><td>suitable to use</td></tr>
<tr><td>YELLOW</td><td>38,165</td><td>63%</td><td>temporarily not suitable to use</td></tr>
<tr><td>RED</td><td>4,682</td><td>8%</td><td>dangerous to use</td></tr>
<tr><td>Σ</td><td>60,812</td><td></td><td></td></tr>
</table></td></tr>
<tr><td>Lefkada</td><td>14-08-2003</td><td>6.2</td><td>Many buildings were severely damaged, problems to the road network due to landslides and rockfalls, damages to the port.</td></tr>
<tr><td>Andravida</td><td>08-06-2008</td><td>6.5</td><td><table>
<tr><td rowspan="4">inspections</td><td>GREEN</td><td>2,141</td><td>22%</td><td>suitable to use</td></tr>
<tr><td>YELLOW</td><td>5,630</td><td>58%</td><td>temporarily not suitable to use</td></tr>
<tr><td>RED</td><td>1,874</td><td>19%</td><td>dangerous to use</td></tr>
<tr><td>Σ</td><td>9,645</td><td></td><td></td></tr>
</table>Problems to the road and railroad network, liquefaction, landslides and rockfalls.</td></tr>
<tr><td>Kefalonia</td><td>26-01-2014</td><td>5.8</td><td><table>
<tr><td rowspan="4">inspections</td><td>GREEN</td><td>1,280</td><td>46%</td><td>suitable to use</td></tr>
<tr><td>YELLOW</td><td>1,321</td><td>47%</td><td>temporarily not suitable to use</td></tr>
<tr><td>RED</td><td>203</td><td>7%</td><td>dangerous to use</td></tr>
<tr><td>Σ</td><td>2,804</td><td></td><td></td></tr>
</table>Problems to the road network due to landslides, damages to the port.</td></tr>
<tr><td>Lesvos</td><td>12-06-2017</td><td>6.1</td><td>The majority of masonry buildings in Vrisa, collapsed, problems to the road network due to landslides.</td></tr>
</table>

Additionally, in every earthquake many historical buildings, monuments and structures of cultural value are damaged or even collapsed.

5. Where there any fatalities or serious injuries?

☒ Yes ☐ No

The fatalities and serious injuries of the most destructive earthquakes of the last 20 years are listed in the table below.

Location	Date	Magnitude	Fatalities/ Injuries
Athens	07-09-1999	5.9	143/>700
Lefkada	14-08-2003	6.2	- / 50
Andravida	08-06-2008	6.5	2/200
Kefalonia	26-01-2014	5.8	-
Lesvos	12-06-2017	6.1	1

6.What was the time needed in order to fix the damages and to reinstate smoothly operation?

The reinstating time varies depending on the extent of the affected area, the nature of the damages and the economic and legal terms applied on each seismic event.

In Athens, 1999, two years after the earthquake, nearly 78% of the repairable buildings were restored.

In Andravida, 2008, 2 years after the event, about 37% of the approved repairs and reconstructions were completed.

7. Are you aware of any special measures or others means applied, to mitigate/prepare for these events in your Country?

☒ Yes ☐ No

- Greek Code for Interventions for existing Reinforced Concrete buildings (KAN.EPE.).
- Informative material and Educational Programs addressed to many target groups (teachers, students, volunteers, people with disabilities, tourists) for self- protecting measures.
- Guidelines and Procedures for earthquake disaster management (Emergency Plans).
- Technical handbooks and guidelines.
- Educational seminars for pre-earthquake inspection/assessment of existing buildings addressed to engineers.
- Operational exercises for seismic disaster management.

II. State regulations/legislations and concrete experiences.

8. Is there a legal or technical guide/regulation on Energy Efficiency Upgrading of existing buildings in your Country?

☒ Yes ☐ No

The last revised edition of the Building Energy Efficiency Regulation was put into force in 2017 (Governement Gazette 2367/B/12-7-2017)

9.Are there any legal or technical regulations/codes related to Seismic or Structural strengthening or upgrades in your Country?

☒ Yes ☐ No

In 2012 was put into force the Greek Code for Interventions for existing Reinforced Concrete buildings (KAN.EPE., Gov. Gaz. 42/B/20-1-2012, 2nd Revision Gov. Gaz. 2984/B/30-8-2017).
The Greek Code for Interventions for existing Masonry buildings is expected to be implemented soon. Find the English version of KANEPE (1st revision) in the link below:
http://ecpfe.oasp.gr/sites/default/files/files/%CE%9A%CE%91%CE%9D%CE%95%CE%A0%CE%95_EN2013_FINAL(1).pdf

10. Are the Eurocodes applied for seismic assessments and seismic/structural strengthening of existing buildings in your country?

☒ Yes ☐ No

The implementation and use of Eurocodes combined with the corresponding National Codes began in 2014 (Gov.Gaz. 1457/B/5-6-2014).

11. Are there incentives provided by the government, to individuals, for structural upgrades / renovations / seismic upgrades in your Country?

☒ Yes ☐ No

12. Have you received any training related to seismic and energy efficiency upgrading?

☒ Yes ☐ No

Most engineers in Greece have the opportunity to attend seminars, conferences and training programs relevant to the above issues.
Additionally the energy efficiency assessment is carried out by engineers, certified energy inspectors.

13. Have you participated in a workshop/conference on the above topics?

☒ Yes ☐ No

The last related Conferences hosted in Greece were:
The 16th European Conference on Earthquake Engineering "Recent Advances in Earthquake Engineering in Europe", Thessaloniki, 2018.
The 5th International Conference on Civil Protection & New Technologies, "Safe Kozani 2018", Kozani.

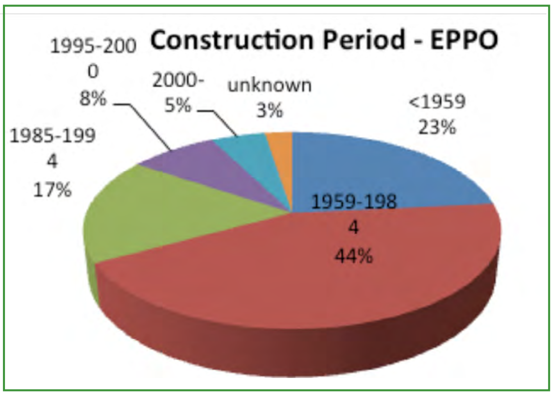
III. From practice

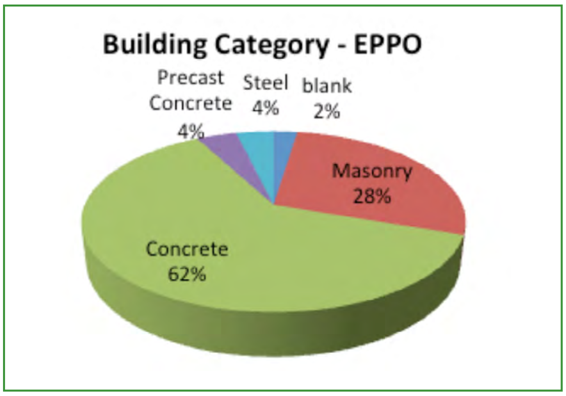
14. What are the most common building categories in your Country, regarding existing buildings built before 2000 and how many storeys are they?

According to the database kept in Earthquake Planning and Protection Organization (E.P.P.O.), the building categories/types are:

- Reinforced concrete structures
- Precast concrete structures
- Masonry structures
- Steel structures

The distribution of buildings of Public Use according to the construction period and the building category/type is presented on the graphs below.

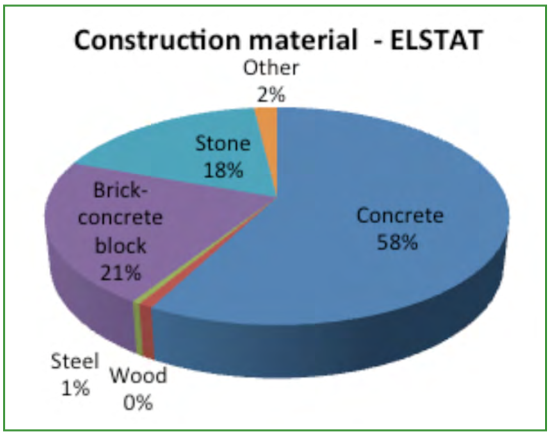


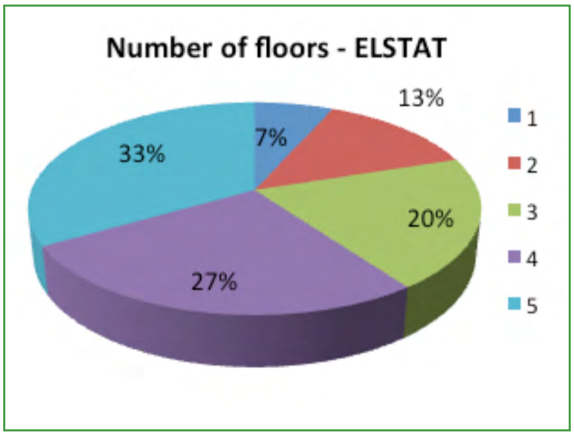


15. What is the most widely used construction material for those buildings?

The distribution of all buildings in Greece according to the construction material and the number of floors, in accordance with the 2011 Population – Housing Census of Hellenic Statistical Authority (ELSTAT), is presented in the table and graphs below.

Number of floors	Basic construction material						Number of buildings
	Concrete	Steel	Wood	Brick–concrete block	Stone	Other	
1	867,528	31,793	16,722	709,035	424,022	66,532	2,115,632
2	910,029	2,406	2,928	157,274	282,701	10,185	1,365,523
3	320,776	409	291	15,281	15,037	470	352,264
4	237,693	194	27	3	1,484	75	239,476
›5	32,670	66	0	0	5	1	32,742
Sum	2,368,696	34,868	19,968	881,593	723,249	77,263	4,105,637





16. What is the common technique/material used for energy efficiency upgrading of existing buildings?

Thermal insulation, renovation of thermal mechanical equipment.

17. What are the most widely used techniques/applications for seismic strengthening of existing buildings?

Concrete structures:
Construction of concrete jackets (shotcrete or cast concrete)
Construction of new lateral shear walls
Addition of bonded steel laminates
Addition of FRP fabrics

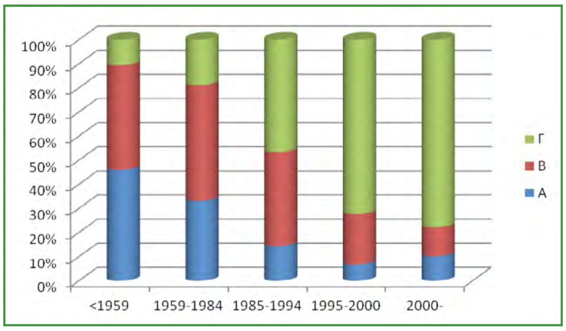
Masonry structures:
Rigid diaphragm adding
Infusion of grouting
Shotcrete jacket
Metal ties and fastenings
New plastering

18. Do you have unmaintained, deteriorated or abandoned buildings that suffer structural deficiencies/ material degradation ın your Country?

☒ Yes ☐ No

Deterioration of structures constitutes a vulnerability factor and leads to unsufficient seismic behaviour. The distribution of buildings according to their seismic vulnerability and the construction period, in accordance with the results of 1st Degree Pre-earthquake Assessment of public use buildings (administered by E.P.P.O.) is shown in the graph below.

A: corresponds to buildings with the higher seismic vulnerability.



Sources – Bibliography

Institute of Geodynamics www.gein.noa.gr
European-Mediterranean Seismological Centre (EMSC) www.emsc-csem.org
Gis Hellenic Accelerograms Database – GHEAD – E.P.P.O.
www.oasp.gr, http://195.251.49.25/map/
"One year after the earthquake of September 7, 1999". E.P.P.O. Athens 2000 www.oasp.gr
"Two years after the earthquake. Hope is born again". E.P.P.O. Athens 2001 www.oasp.gr
1st Degree Pre-earthquake Inspection of public use buildings. E.P.P.O.'s Methodology and Database www.oasp.gr
Zagora G., 2018. "Post Earthquake Procedures: Comparison of the 2008 (Greece) and the 2009 (Italy) Seismic Events". 16th European Conference on Earthquake Engineering, Thessaloniki 2018.
Oikonomou A.D. et al., 2018. "A Comparative Analysis of Prevention, Response and Recovery Procedures of Thessaloniki (1978) and Kefalonia (2014) Earthquakes". 16th European Conference on Earthquake Engineering, Thessaloniki 2018.
Panagiotopoulou D., Tarnava K., Zagora G., 2018. "First Degree Pre – Earthquake Inspection: E.P.P.O.'s Training Program for Engineers". 5th International Conference on Civil Protection & New Technologies, "Safe Kozani 2018", Kozani.
Stylianides K. et al., 2016. "1st Degree Pre-earthquake Inspection of public use buildings". 3rd International Conference on Civil Protection & New Technologies, "Safe Evros 2016".

MALTA

QUESTIONNAIRE

"The need for integrating Structural / Seismic Upgrade of Existing Buildings, with Energy Efficiency Improvements"

Name and Surname: Jeanette Mireille Muñoz Abela obo Kamra Tal-Periti, MALTA
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QUESTIONS

I. General

1. Does your Country suffer from earthquake or other dynamic loading problem or other combination of dynamic loadings and if yes approximately how frequently –Please attach historical records, if possible.

☒ Yes ☐ No

Occurrence for low grade tremors (less than 3 Richter) is common and occurs around 2 to 3 times a year. Significant earthquakes (greater than 5.5 Richter) are very infrequent and occur every 150 years.

2. When was the last major / serious earthquake or other dynamic event that took place in your Country that affected the stability of buildings and civil works? What was the intensity?

Last major earthquake was in 1693; 6.3 Richter.

3. Were the affected buildings or civil works repaired?

Do you know what was the amount of money needed in order to repair the above?

☒ Yes ☐ No

Important buildings such as churches and palazzos are noted to have been affected. There is not much historical data for smaller/domestic buildings.
The amount of funds required to repair is hard to access but would run into the tens of millions of Euros in today's currency.

4. Please briefly explain what damages it caused (with regard to buildings, roads, bridges, etc.)

Effected buildings were mainly church dome; e.g. Mdina Cathedral Dome collapsed and was never re-built. The Bishop ordered a flat roof to be built in its place which was then painted to achieve a trompe l'oeil effect. No roads or bridges were affected.

5. Where there any fatalities or serious injuries?

☒ Yes ☐ No

None recorded in Malta. However, since the epicenter was in Messina, there were several fatalities in Sicily.

6. What was the time needed in order to fix the damages and to reinstate smoothly operation?

There is insufficient historical record about post-earthquake repair works.

7. Are you aware of any special measures or others means applied, to mitigate/prepare for these events in your Country?

☒ Yes ☐ No

In view of the infrequent nature of earthquakes, there appears to be a false sense of security among the local population that the Maltese Islands are immune to a seismic event. Hence, if any, seismic resistant measures are applied.

II. State regulations/legislations and concrete experiences.

8. Is there a legal or technical guide/regulation on Energy Efficiency Upgrading of existing buildings in your Country?

☒ Yes ☐ No

Legal Notice 376 of 2012 Energy Performance of Buildings Regulations, 2012Legal Notice 47 of 2018 Energy Performance of Buildings Regulations, 2018

The energy performance certificate (EPC) is however only a statement of rating since no target efficient rating is mandatory to date.

An EPC is mandatory during the selling or renting or building a property; both residential and commercial.

9. Are there any legal or technical regulations/codes related to Seismic or Structural strengthening or upgrades in your Country?

☒ Yes ☐ No

There are no official mandatory regulations/codes, however since Malta is an EU member state, EC8 applies for all EU funded public procurement projects.

EC8 part 3 deals with retrofitting and therefore to be used on existing buildings, but this is seldom used.

10. Are the Eurocodes applied for seismic assessments and seismic/structural strengthening of existing buildings in your country?

☒ Yes ☐ No

In the past decade, EC8 has been applied mainly for important buildings; example, hospitals, airport terminals and high-rise buildings. However, its use is not wide spread for structure of other uses.

11. Are there incentives provided by the government, to individuals, for structural upgrades / renovations / seismic upgrades in your Country?

☒ Yes ☐ No

12. Have you received any training related to seismic and energy efficiency upgrading?

☒ Yes ☐ No

Several engineers in Malta are trained in the use of EC* and some are also certified assessors of the Energy Performance Certificate.

13. Have you participated in a workshop/conference on the above topics?

☒ Yes ☐ No

Two conferences have been hosted recently on earthquakes:

July 2015 Georisks in the Mediterranean and their mitigation (this was focused on seismology rather than by seismic engineering)

September 2018 European Seismic Committee was held in Malta

III. From practice

14. What are the most common building categories in your Country, regarding existing buildings built before 2000 and how many storeys are they?

Most structures in Malta are used as apartment blocks or offices. These are typically maximum 10 storeys high.

15. What is the most widely used construction material for those buildings?

The vast majority of the buildings in Malta built prior to 2000 are load-bearing unreinforced masonry construction with concrete slabs; generally with a soft-storey basement. There are also a number of reinforced concrete and steel frame buildings. One 25 storey tower was built of reinforced concrete. There are no reinforced masonry buildings in Malta.

16. What is the common technique/material used for energy efficiency upgrading of existing buildings?

Thermal insulation in the form of expanded polystyrene and gypsum boarding.

17. What are the most widely used techniques/applications for seismic strengthening of existing buildings?

Insertion of steel frames and bracing. Carbon fibre wrapping has also been used, but this does not withstand impact, and attention needs to take due to the brittle nature of this material.

18. Do you have unmaintained, deteriorated or abandoned buildings that suffer structural deficiencies/ material degradation in your Country?

☒ Yes ☐ No

There are several deteriorated structures mainly due to water ingress and humidity that eventually end up being abandoned.

Around 15-20% of the building stock is vacant property.

SLOVENIA

QUESTIONNAIRE

"The need for integrating Structural / Seismic Upgrade of Existing Buildings, with Energy Efficiency Improvements"

Name and Surname: Branko Zadnik
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QUESTIONS

I. General

1. Does your Country suffer from earthquake or other dynamic loading problem or other combination of dynamic loadings and if yes approximately how frequently –Please attach historical records, if possible.

☒ Yes ☐ No

If yes give details.

There is well organized system of monitoring of seismicity in Slovenia by Slovenian Environment Agency (ARSO - http://www.arso.gov.si/en)

historical known strong earthquakes in Slovenia happened in years: 1348, 1511, 1895, 1917, 1956, 1963, 1974, 1976, 1977, 1982, 1995, 1998, 2004.

2. When was the last major / serious earthquake or other dynamic event that took place in your Country that affected the stability of buildings and civil works? What was the intensity?

July 2004, magnitude 4,9 according to EMS *(European Macroseismic Scale)*

3. Were the affected buildings or civil works repaired?

Do you know what was the amount of money needed in order to repair the above?

☒ Yes ☐ No

If yes give details.

Yes , 90% of affected buildings and civil works were repaired

4. Please briefly explain what damages it caused (with regard to buildings, roads, bridges, etc.)

Collapse of older masonry buildings, landslides and consequently influences on roads,

5. Where there any fatalities or serious injuries?

☒ Yes ☐ No

If yes give data.
1 death, 7 injuries

6. What was the time needed in order to fix the damages and to reinstate smoothly operation?

14 days evaluation of injuries

2 years rehabilitation of damaged buildings

7. Are you aware of any special measures or others means applied, to mitigate/prepare for these events in your Country?

☒ Yes ☐ No

If yes give details.

Education of population through activity of ARSO and Administration of the Republic of Slovenia for Civil Protection and Disaster Relief (ACPDR) (http://www.sos112.si/eng/)

II. State regulations/legislations and concrete experiences.

8. Is there a legal or technical guide/regulation on Energy Efficiency Upgrading of existing buildings in your Country?

☒ Yes ☐ No

If yes give details (attach as well the Regulation or legislation).

Energy Act (EZ-1); (http://www.pisrs.si/Pis.web/pregledPredpisa?id=ZAKO6665)

Building Act (Ul. RS, št. 61/17 in 72/17 – popr)
(http://www.pisrs.si/Pis.webpregledPredpisa?id=ZAKO7108)

9. Are there any legal or technical regulations/codes related to Seismic or Structural strengthening or upgrades in your Country?

☒ Yes ☐ No

If yes give details (please also attach the Regulation or legislation).

Building Act (Ul. RS, št. 61/17 in 72/17 – popr) (http://www.pisrs.si/Pis.web/pregledPredpisa?id=ZAKO7108

10. Are the Eurocodes applied for seismic assessments and seismic/structural strengthening of existing buildings in your country?

☒ Yes ☐ No

If yes give details
Building Act (Ul. RS, št. 61/17 in 72/17 – popr) (http://www.pisrs.si/Pis.web/pregledPredpisa?id=ZAKO7108

11. Are there incentives provided by the government, to individuals, for structural upgrades / renovations / seismic upgrades in your Country?

☒ Yes ☐ No

If yes give details.

After the earthquake (2004) technical guidelines where prepared for reconstruction of damaged buildings, unfortunately there do not exists legislation which would obliged the investors to make the seismic strengthening of the old buildings in case of normal reconstruction.

12. Have you received any training related to seismic and energy efficiency upgrading?

☒ Yes ☐ No

If yes give details.

Idea of seismic and energy upgrading is a topical subject at meetings, congresses and symposiums of different Slovenian professional societies.

13. Have you participated in a workshop/conference on the above topics?

☒ Yes ☐ No

If yes give details

III. From practice

14. What are the most common building categories in your Country, regarding existing buildings built before 2000 and how many storeys are they?

masonry buildings up to 5 floors
reinforced concrete buildings up to 90 m

15. What is the most widely used construction material for those buildings?

brick products reinforced concrete

16. What is the common technique/material used for energy efficiency upgrading of existing buildings?

thermal insulation panels are glued and further fixed to a wall.

wooden roof structure is isolated by the combination of the rigid and flexible thermal insulation elements, depends on the structure.

17. What are the most widely used techniques/applications for seismic strengthening of existing buildings?

Depending on the structural design of the building, for the brick buildings horizontal and vertical seismic ties.

18. Do you have unmaintained, deteriorated or abandoned buildings that suffer structural deficiencies/material degradation in your Country?

☒ Yes ☐ No

If yes can you please give us numbers or percentage with regard to the total?

there is no official information

BULGARIA

QUESTIONNAIRE

"The need for integrating Structural / Seismic Upgrade of Existing Buildings, with Energy Efficiency Improvements"

Name and Surname: Dimitar Natchev, UCEB, Bulgaria
Email: bg_ecce@uceb.eu

QUESTIONS

I. General

1. Does your Country suffer from earthquake or other dynamic loading problem or other combination of dynamic loadings and if yes approximately how frequently –Please attach historical records, if possible.

☒ Yes ☐ No

If yes give details.

According to the Bulgarian construction legislation, Bulgaria is an earthquake area.

2. When was the last major / serious earthquake or other dynamic event that took place in your Country that affected the stability of buildings and civil works? What was the intensity?

On 22nd of May 2012 an earthquake with magnitude Ms=5.8 occurred in the town of Pernik about 20 km SW from the capital Sofia causing moderate damages in a wide area including the main city.

3. Were the affected buildings or civil works repaired?

Do you know what was the amount of money needed in order to repair the above?

☒ Yes ☐ No

If yes give details.

There is no precise data on state aid and personal involvement

4. Please briefly explain what damages it caused (with regard to buildings, roads, bridges, etc.)

The building stock is affected-residential buildings, houses not secured for seismic resistance

5. Where there any fatalities or serious injuries?

☒ Yes ☐ No

If yes give data.
Moderate damages, without human sacrifices

6. What was the time needed in order to fix the damages and to reinstate smoothly operation?

Two months to fix the damages, two years to repair

7. Are you aware of any special measures or others means applied, to mitigate/prepare for these events in your Country?

☒ Yes ☐ No

If yes give details.

Earthquake Emergency Action Plan is prepared for some regions in Bulgaria

II. State regulations/legislations and concrete experiences.

8. Is there a legal or technical guide/regulation on Energy Efficiency Upgrading of existing buildings in your Country?

☒ Yes ☐ No

If yes give details (attach as well the Regulation or legislation).

In your Country we have a full set of laws and Ordinances on Energy Efficiency Upgrading of existing buildings

9. Are there any legal or technical regulations/codes related to Seismic or Structural strengthening or upgrades in your Country?

☒ Yes ☐ No

If yes give details (please also attach the Regulation or legislation).

The national construction legislation regulates the Repair and Strengthening of existing buildings.

10. Are the Eurocodes applied for seismic assessments and seismic/structural strengthening of existing buildings in your country?

☒ Yes ☐ No

If yes give details

The Eurocodes ape applied for seismic assessments and seismic/structural strengthening of existing buildings in parallel with the national norms.

11. Are there incentives provided by the government, to individuals, for structural upgrades / renovations / seismic upgrades in your Country?

☒ Yes ☐ No

The legislation is restrictive – obliges the clients to strengthen the building structure when structural modifications of existing building is envisaged.

12. Have you received any training related to seismic and energy efficiency upgrading?

☒ Yes ☐ No

If yes give details.

CPD training on Repair, Restoration and & Strengthening of buildings and energy efficiency

13. Have you participated in a workshop/conference on the above topics?

☒ Yes ☐ No

If yes give details.

Participation in National and International Workshops and Conferences

III. From practice

14. What are the most common building categories in your Country, regarding existing buildings built before 2000 and how many storeys are they?

The buildings in Bulgaria are categorized by structural type

15. What is the most widely used construction material for those buildings?

Reinforced concrete and brick masonry

16. What is the common technique/material used for energy efficiency upgrading of existing buildings?

Application of modern thermal insulation materials on the building envelope

17. What are the most widely used techniques/applications for seismic strengthening of existing buildings?

Strengthening with reinforced concrete structures and steel structures

18. Do you have unmaintained, deteriorated or abandoned buildings that suffer structural deficiencies/material degradation in your Country?

☒ Yes ☐ No

If yes can you please give us numbers or percentage with regard to the total?

No data available

POLAND

QUESTIONNAIRE

"The need for integrating Structural / Seismic Upgrade of Existing Buildings, with Energy Efficiency Improvements"

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QUESTIONS

I. General

1. Does your Country suffer from earthquake or other dynamic loading problem or other combination of dynamic loadings and if yes approximately how frequently –Please attach historical records, if possible.

☒ Yes ☐ No

Seismic earthquakes are in Poland very rarely. In upper Silesia, the mining region, we can register few because of rockburst in coal mines. This year it happened 3 times.

2. When was the last major / serious earthquake or other dynamic event that took place in your Country that affected the stability of buildings and civil works? What was the intensity?

It was 10 December 2017 in Olza, near Wodzislaw Slaski. Magnitude 3,4. No affected the buildings stability, and civil works

3. Were the affected buildings or civil works repaired?

Do you know what was the amount of money needed in order to repair the above?

☒ Yes ☐ No

If yes give details.

4. Please briefly explain what damages it caused (with regard to buildings, roads, bridges, etc.)

Buildings, depends of force, specially the old buildings are seriously damage. Some of them need to be destroyed as the are not able to reside in. For infrastructure there are not serious damages.

5. Where there any fatalities or serious injuries?

Because of rockburst one miner died in 2012 and two died in 2015,

☒ Yes ☐ No

6. What was the time needed in order to fix the damages and to reinstate smoothly operation?

First decision to protect people was done immediately, maximum in hours. Reinstate operation as soon as possible, Action is provided continuously.

7. Are you aware of any special measures or others means applied, to mitigate/prepare for these events in your Country?

☒ Yes ☐ No

II. State regulations/legislations and concrete experiences.

8. Is there a legal or technical guide/regulation on Energy Efficiency Upgrading of existing buildings in your Country?

☒ Yes ☐ No

If yes give details (attach as well the Regulation or legislation).
Preparation of such regulation are always in progress. Some technical organization gives guides to follow best solutions on energy efficiency and energy saving.

9. Are there any legal or technical regulations/codes related to Seismic or Structural strengthening or upgrades in your Country?

☒ Yes ☐ No

10. Are the Eurocodes applied for seismic assessments and seismic/structural strengthening of existing buildings in your country?

☒ Yes ☐ No

11. Are there incentives provided by the government, to individuals, for structural upgrades / renovations / seismic upgrades in your Country?

☒ Yes ☐ No

12. Have you received any training related to seismic and energy efficiency upgrading?

☒ Yes ☐ No

13. Have you participated in a workshop/conference on the above topics?

☒ Yes ☐ No

If yes give details.
We participated in conferences organized in Poland by local and international organizations. During such conferences generally the workshops were provided.

III. From practice

14. What are the most common building categories in your Country, regarding existing buildings built before 2000 and how many storeys are they?

Offices, hotels, residential and commerce. Up to 15 storeys.

15. What is the most widely used construction material for those buildings?

Reinforced concrete and steel construction.

16. What is the common technique/material used for energy efficiency upgrading of existing buildings?

Substitute windows for new made with better thermal coefficient. Changing lights source for LED. Correct warming system of external walls.

17. What are the most widely used techniques/applications for seismic strengthening of existing buildings?

Have no data.

18. Do you have unmaintained, deteriorated or abandoned buildings that suffer structural deficiencies/ material degradation in your Country?

☒ Yes ☐ No

If yes can you please give us numbers or percentage with regard to the total?
Have no data.

RUSSIA

QUESTIONNAIRE

"The need for integrating Structural / Seismic Upgrade of Existing Buildings, with Energy Efficiency Improvements"

Name and Surname: Russian Society of Civil Engineers – Moscow Department (RSCE-MD)
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QUESTIONS

I. General

1. Does your Country suffer from earthquake or other dynamic loading problem or other combination of dynamic loadings and if yes approximately how frequently –Please attach historical records, if possible.

☒ Yes ☐ No

On the territory of Russia earthquakes usually take place in mountain regions, in tectonic plates collide places: the Caucasus, Altai, the Western and Eastern Siberia, Kamchatka. The majority of the earthquakes in Russia happen in Kamchatka and Kurile islands which quite often leads to tsunami. In 1952 the earthquake in the Pacific Ocean at the vicinity of Kamchatka coast line resulted in tsunami which destroyed town of Severo-Kurilsk – that earthquake is considered to be the most devastating on the number of victims.

Earthquake in Russia	The Richter scale, points
Kamchatka in 1924 and 1952	From 7,8 upto 9
Saint Petersburg in 1940 and 1977	From 2,1 upto 3
Moscow in 1986 and 1990	From 2 upto 3
Kuril islands in 1963	8,5
Dagestan in 1970	6,7
Sakhalin island in 1995	7,6
Altai in 2003	7,3
Saint Petersburg in 2004	2
Kuril islands in 2006	8
Kamchatka in 2006	7,6
Chechnja in 2008	5,8
Baikal lake in 2008	6,3
Kemerovo region in 2013	5,6

2. When was the last major / serious earthquake or other dynamic event that took place in your Country that affected the stability of buildings and civil works? What was the intensity?

The latest major earthquake took place in Kemerovo region on June 19, 2013 with 5,3 – 5,6 points on the Richter scale. At the epicenter the intensity reached 7 points. That earthquake is considered to be the most severe for the last 100 years.

3. Were the affected buildings or civil works repaired?

Do you know what was the amount of money needed in order to repair the above?

☒ Yes ☐ No

The results of that earthquake: about 5 thousand buildings suffered, more than 350 of them were demolished. The total damage was estimated about 40,5 million euro.

4. Please briefly explain what damages it caused (with regard to buildings, roads, bridges, etc.)

After the earthquake the railway station in Belovo and some other public buildings were demolished. The earthquake affected more than 5 thousand buildings; more than 350 of them were completely demolished.

5. Where there any fatalities or serious injuries?

☒ Yes ☐ No

6. What was the time needed in order to fix the damages and to reinstate smoothly operation?

It took 5 years to eliminate the damage of buildings and infrastructure and restore normal functioning.

7. Are you aware of any special measures or others means applied, to mitigate/prepare for these events in your Country?

☒ Yes ☐ No

In order to be ready for such accidents and minimize the consequences of them there are 446 seismic station on the territory of Russia, which register seismic activity and more likely can determine the earthquake center, its power, distance to it and event time. The stations conduct operational data processing, notification of the governmental bodies in order to inform of the possible danger and population evacuation.

The second major measure is the enforcement of the designed buildings and engineering construction in seismic active regions of Russia. Earthquake engineering requires more finance expenditure. From technical point of view it is more rational to choose areas of rock formation, use additional measures, increase strength and rigidity of the bearing structure.

II. State regulations/legislations and concrete experiences.

8. Is there a legal or technical guide/regulation on Energy Efficiency Upgrading of existing buildings in your Country?

☒ Yes ☐ No

The energy efficiency becomes the state priority. For the first time that task was formulated and legislated by the federal law No 28-FL “On efficiency” on April 3, 1966. In 2003 the President of Russia signed the Decree “Certain measures on increase of energy and ecological efficiency of the Russian economy”. In 2009 a new legislation in energy saving FL No 261 “On energy saving and increase of energy efficiency and amendments to the RF legislation” was approved.

In the same 2009 the Governmental Decree No 1830 was adopted “On approval of measures’ plan on energy saving and increase of energy efficiency in the Russian Federation directed on implementation of FL No 261 “On energy saving...”, the main issues of which were:

- Modernization of energy supply systems (use technology of pipe laying in FPI).
- Thermal isolation of buildings (external isolations of building walls and slabs; thermal isolation of attic space, technical floors and basements; restoration of inter-panel hermetic seams with elastic filler; more effective technologies of window and door aperture).

- ❑ Energy saving technologies inside the buildings (use of radiators with maximum efficiency of convectional heat exchange; implementation of newest, energy saving lighting fixtures).
- ❑ Consumption accounting of the resources (use of counters of energy consumption with day/night tariff; counters of hot/cold water consumption in buildings, annual increase of energy consumption rates).

9. Are there any legal or technical regulations/codes related to Seismic or Structural strengthening or upgrades in your Country?

☒ Yes ☐ No

The major earthquakes which occurred in seismic dangerous regions of Russia and more detailed analysis of their aftermaths showed the necessity of new approaches (Kamchatka, Sakhalin, the Northern Caucasus, Krasnodar, etc.) The need for mass increase of seismic resistance of buildings already erected and those under construction was of high importance. For usage by design and construction organizations in projects of high seismic resistance of existing buildings and their implementation in regions with seismic activity of 7,8 and 9 points the norms and regulations (series 0.00 – 2.96c) "Increase of seismic resistance of buildings" were worked out.

- ❑ Strengthening of stone and brick buildings:
  - Structuring of concrete coating at one or both sides;
  - Structuring of metal and reinforced concrete cages.
- ❑ Strengthening of facades,
- ❑ Strengthening of separating walls with metal cages,
- ❑ Transformation of brick partition into stiffness diaphragm,
- ❑ Strengthening of frame buildings:
  - Per elements strengthening of bearing structure;
  - Strengthening of building in general.
  - Antiseismic belts.

10. Are the Eurocodes applied for seismic assessments and seismic/structural strengthening of existing buildings in your country?

It is known that 40 per cent of Russian territory covers seismic dangerous zones. The analysis has shown that costs of design and construction in seismic dangerous regions in calculations on European code EN 1998 are higher in comparison with calculations according to Russian norms SNiP II-7-81 "Construction in seismic regions". As a result of requirements comparison it was found out that the discrepancy of values of calculated seismic load according to Russian and European norms comprises 1,4.

The seismic zoning schemes of the territory of the Russian Federation according to SNiP II-7-81 "Construction in seismic regions" reflect 10 %, 5 % and 1 % probability of increase with 50 years of intensity of seismic impact and correspond to the frequency of occurrence of seismic shocks. While in European code EN 1998 there is only one scheme used and it corresponds to the average frequency of seismic shocks once in 500 years.

The comparable analysis shows that there is a major methodic and terminological differences between the Russian and European norms, as well as differences in requirements to construction materials which is determined by various climates and operating conditions.

11. Are there incentives provided by the government, to individuals, for structural upgrades / renovations / seismic upgrades in your Country?

☒ Yes ☐ No

12. Have you received any training related to seismic and energy efficiency upgrading?

☒ Yes ☐ No

13. Have you participated in a workshop/conference on the above topics?

☒ Yes ☐ No

III. From practice

14. What are the most common building categories in your Country, regarding existing buildings built before 2000 and how many storeys are they?

Categories of buildings in Russia exist only on explosion and fire safety. The seismicity is estimated in jurisdiction of the building. According to SNiP II-7-81 the calculated seismic intensity is determined on one of the third schemes (schemes OCP-97) A, B and C depending on the jurisdiction of the building.
A – All buildings, not included into B and C.
B – Schools, hospitals, theatres, buildings with huge people gathering.
C – Very important buildings (atomic electric stations).
The seismicity of construction site can be upgraded or reduced depending on category of ground seismic characteristics (I, II, III) on 1 point at scale MSK-64.
Till year 2000 mostly 2 - 16 storied buildings were built in Russia.

15. What is the most widely used construction material for those buildings?

The most widely spread materials for construction of buildings and facilities in Russia nowadays are commodity concrete and reinforcement. They are used for prefabricated reinforced concrete constructions as well as for monolithic construction. Depending on conditions sometimes brick is used.

16. What is the common technique/material used for energy efficiency upgrading of existing buildings?

To increase energy efficiency of the existing buildings capital renovation is performed, in particular thermal insulation of buildings' facades using such materials as thermoisol and foam polystyrene.

17. What are the most widely used techniques/applications for seismic strengthening of existing buildings?

Increase of load bearing capacity at expense of strengthening of building framework.

18. Do you have unmaintained, deteriorated or abandoned buildings that suffer structural deficiencies/ material degradation in your Country?

☒ Yes ☐ No

No data at our disposal.

SERBIA

QUESTIONNAIRE

"The need for integrating Structural / Seismic Upgrade of Existing Buildings, with Energy Efficiency Improvements"

Name: Serbian Chamber of Engineers
Email: info@ingkomora.rs

QUESTIONS

I. General

1. Does your Country suffer from earthquake or other dynamic loading problem or other combination of dynamic loadings and if yes approximately how frequently –Please attach historical records, if possible.

☒ Yes ☐ No

In the last 100 years, there have been ten earthquakes in the territory of Serbia of magnitude greater than 5 degrees Richter scale. In the last century, earth often shaken in the spring and autumn, and none of those earthquakes was in winter.

In Kopaonik, in Brus in 1978, a quake of 5.7 degrees per Rihter occurred.

From 1998 to 2008, there were more earthquakes across the country.

On April 30, 1999, around 12,000 buildings were damaged in a devastating earthquake in the area of the Municipality of Mionica.

On July 1, 1999, a five-degree earthquake strucked the area of Trstenik.

On February 21, 2001, the earthquake of 4.6 magnitude of the Richter scale strucked the central part of Serbia.

November 28, 2001, a four-level earthquake in the Merkali scale was recorded in the Prokuplje region, 170 kilometers south of Belgrade.

May 25, 2002 earthquake measuring 4.5 degrees Richter scale was registered in the Veliko Gradiste-Golubac region.

April 24, 2002 The earthquake of 5.1 magnitude in Rihter with the epicenter in the Binačka Morava valley, between Gnjilane and Presevo, was felt in the wider southern Balkan region.

July 8, 2002 Earthquake of a small intensity of 3.7 degrees Richter scale strucked the area of Raska.

On August 2, 2002, a 4-degree earthquake Rihter scale was felt in Belgrade and the central part of Serbia. Epicenter was in Golubac and Veliko Gradiste.

July 27, 2003 the earthquake of the 3.2-degree Richter scale was registered in the Kopaonik area.

On May 15, 2004, the earthquake measuring 3.7 degrees by Rihter strucked the Vranje area. In September of that year, the new earthquake of a lower intensity of 3.2 degrees Richter scale again hit the areas of Vranje, Bujanovac, Trgovište and Presevo.

On November 21, 2005, the earthquake measuring 3.9 degrees by Rihter strucked Kopaonik.

March 22, 2006 The Earthquake of 4.5 degrees Richter scale was registered in the Mionica region.

On May 11, 2006, a 4.3 magnitude earthquake in Rihter with a epicenter on the slopes of Malena, was felt in Valjevo, Belgrade and other parts of Serbia.

June 28, 2006 The earthquake of the 3.2-degree Richter scale was felt around Golubac.

On November 21, 2006, earthquake of the 4.8-degree Rihter scale, strucked the area of Paracin.

On April 8, 2007, a 3.2-degree Richter scale strucked the area southwest of Kraljevo.

February 15, 2008 the epicenter of earthquake have been in the region of Cacak, a 4.5-point magnitude according Rihter, has been felt in most parts of Serbia.

Earthquake in Kraljevo occured in November in 2010.

2. When was the last major / serious earthquake or other dynamic event that took place in your Country that affected the stability of buildings and civil works? What was the intensity?

The earthquake at Kraljevo had an intensity of about 5-6 degrees according to Rihter scale, corresponding to an acceleration of seismic waves of 250-500 mm / s. For the conditions in Serbia and the Balkans, such an earthquake is considered very strong. The earthquake of this magnitude occurs in the territory of Serbia with a frequency of about 10 years. Serbia is located in the northern peripheral area of the Mediterranean, which belongs to seismically more active areas.

The earthquake at Kraljevo occurred on November 3, 2010.

3. Were the affected buildings or civil works repaired?

Do you know what was the amount of money needed in order to repair the above?

☒ Yes ☐ No

Within one year after the earthquake, the Government of the Republic of Serbia secured 2.3 billion dinars, 462 prefabricated houses were built, 13 thousand households were reconstructed, and 8.500 apartments. Approximately 10% of funds for the renovation of these facilities were provided by various donors, private and public companies, associations, embassies.

4. Please briefly explain what damages it caused (with regard to buildings, roads, bridges, etc.)

The Crisis Staff Commission in Kraljevo estimated that more than 12,000 objects were more or less damaged from the earthquake.

5. Where there any fatalities or serious injuries?

☒ Yes ☐ No

Two people were killed, while around 200 citizens were injured.

6. What was the time needed in order to fix the damages and to reinstate smoothly operation?

For example, after the earthquake in Kraljevo, it took 11 months to build 463 new prefabricated houses and 1500 families whose homes were severely damaged, received financial assistance and material to repair themselves.

7. Are you aware of any special measures or others means applied, to mitigate/prepare for these events in your Country?

☒ Yes ☐ No

Within the City Administration, the Department of Civil Affairs works in finding a state-level solution in the field of preventive actions to address the causes of potential emergencies.

II. State regulations/legislations and concrete experiences.

8. Is there a legal or technical guide/regulation on Energy Efficiency Upgrading of existing buildings in your Country?

☒ Yes ☐ No

For all buildings for which a building permit is issued, including renovation, reconstruction, The Law on Planning and Construction is applied, as well as the Rule book on the energy efficiency of buildings related to the reconstruction of existing buildings.

(Official Gazette of the Republic of Serbia No. 72/2009 / 2009-Correction, 64/2010 - Constitutional Court Decision, 24 / 2011,121 / 2012,42 / 2013-Constitutional Court Decision, 50/2013-Constitutional Court Decision, 98/2013 - the Constitutional Court's decision, 132 / 2014,145 / 2014 and 83/2018).

9. Are there any legal or technical regulations/codes related to Seismic or Structural strengthening or upgrades in your Country?

☒ Yes ☐ No

Rule book of the SFRJ of 1978. regulating seismic strengthening in the Republic of Serbia.

Rule book on technical norms for the construction of high-rise buildings in seismic areas(Official Gazette of SFRJ No.31/1981-844,49/1982-1249,29/1983-869,21/1988-614,52/1990-1729).

Rule book on technical norms for rehabilitation, reinforcement and reconstruction of buildings of high-rise earthquake-damaged buildings and for the reconstruction and revitalization of buildings, Official Gazette of SFRJ No. 52/85.

The preliminary map of the seismic reionization of the territory of the Republic of Serbia contains the following basic geodynamic models: A, B, C, D, E, S1 and S2. The models were determined on the basis of data from geological, hydrogeological and engineering-geological features of the terrain, using existing seismic parameters data.

10. Are the Eurocodes applied for seismic assessments and seismic/structural strengthening of existing buildings in your country?

☒ Yes ☐ No

Seismics - SRPS EN 1998

- SRPS EN 1998-1: General rules, seismic actions and rules
- for buildings;
- SRPS EN 1998-2: Bridges;
- SRPS EN 1998-3: Assessment of condition and reinforcement of buildings;
- Eurocode 8: Design of structures for earthquake resistance

11. Are there incentives provided by the government, to individuals, for structural upgrades / renovations / seismic upgrades in your Country?

☒ Yes ☐ No

The incentives are intended for the construction of facilities and procurement of equipment to increase the capacity of existing production, increase productivity and quality, procure equipment for production needs, increase export opportunities and expand the market for sales or improve market positioning.

12. Have you received any training related to seismic and energy efficiency upgrading?

☒ Yes ☐ No

Serbian Chamber of Engineers organizes professional training through the National and European Training Program, Permanent Education, from 1.1.2015.

13. Have you participated in a workshop/conference on the above topics?

☒ Yes ☐ No

The Serbian Chamber of engineers in cooperation with the Association of structural Engineers of Serbia, participated in many conferences and workshops.
One of them is WG meetings and workshop 30.3.-1.4.2016. Belgrade, Serbia.

III. From practice

14. What are the most common building categories in your Country, regarding existing buildings built before 2000 and how many storeys are they?

Masonry, Concrete (most common is 6-10 storeys), Steel structure, Brick (most common is to 6 storey);

15. What is the most widely used construction material for those buildings?

- ❑ Concrete;
- ❑ Steel;
- ❑ Brick and wood;

16. What is the common technique/material used for energy efficiency upgrading of existing buildings?

- ❑ Isolation materials (stiropor, neopor)
- ❑ Styrofoam, other insulation materials
- ❑ High efficiency windows (PVC);

17. What are the most widely used techniques/applications for seismic strengthening of existing buildings?

- ❑ -For masonry structures, strengthening by dampers and concrete walls;
- ❑ -Horizontal and vertical bolts, reinforcement of the foundation.

18. Do you have unmaintained, deteriorated or abandoned buildings that suffer structural deficiencies/ material degradation in your Country?

☒ Yes ☐ No

All of them have been repaired.

GERMANY

QUESTIONNAIRE

“The need for integrating Structural / Seismic Upgrade of Existing Buildings, with Energy Efficiency Improvements”

Name and Surname: The Institute of German Engineers e.V. - ZDI
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QUESTIONS

I. General

1. Does your Country suffer from earthquake or other dynamic loading problem or other combination of dynamic loadings and if yes approximately how frequently –Please attach historical records, if possible.

☒ Yes ☐ No

Selection of significant earthquakes in Germany and immediate surroundings

Location (Federal State)	Year	Maximum Intensity (EMS-98)	Magnitudes Ml	Magnitudes Mw	Dead persons, damaged buildings, costs of repair*
Albstadt (BW)	1911	VIII	6,1	5,7	6250; damaged buildings 0.75 Mio RM
Bad Saulgau (BW)	1835	VII - VIII	5,8	5,4	
Albstadt (BW)	1943	VII	5,6	5,3	
Euskirchen (NRW)	1951	VII - VIII	5,7	5,1	
Albstadt (BW)	1978	VII - VIII	5,7	5,2	6850 damaged buildings; 275 Mio DM
Liège (in the east of Belgium)	1983	VII	5,0	4,6	2 dead persons, 26 injured, hundreds of damaged buildings, 100 Mio DM
Roermond (NL)/ Heinsberg (NRW)	1992	VII	5,9	5,3	1 dead person, 25 injured, 7200 damaged buildings, 290 Mio DM
Rambervillers (Northwestern France, Vosges)	2003	VI – VII	5,9	4,8	10.5 Mio €
Waldkirch/ Kandelwald (BW)	2004	VI	5,4	4,6	ca. 3 Mio €

* Loss amount in respective currency of the time and not adjusted for inflation

Earthquakes with a moment magnitude of 4.5 have a mean return period (RP) of 10 years and those of Mw>=5.5 a RP of about 100 years.

2. When was the last major / serious earthquake or other dynamic event that took place in your Country that affected the stability of buildings and civil works? What was the intensity?

See above

3. Were the affected buildings or civil works repaired?

Do you know what was the amount of money needed in order to repair the above?

☒ Yes ☐ No

See above under #1.

4. Please briefly explain what damages it caused (with regard to buildings, roads, bridges, etc.)

Mostly fissures in walls, parts of walls fell out

☒ Yes ☐ No

See above under #1

6. What was the time needed in order to fix the damages and to reinstate smoothly operation?

7. Are you aware of any special measures or others means applied, to mitigate/prepare for these events in your Country?

☒ Yes ☐ No

II. State regulations/legislations and concrete experiences.

8. Is there a legal or technical guide/regulation on Energy Efficiency Upgrading of existing buildings in your Country?

☒ Yes ☐ No

9. Are there any legal or technical regulations/codes related to Seismic or Structural strengthening or upgrades in your Country?

☒ Yes ☐ No

Eurocodes with their National Annexes

10. Are the Eurocodes applied for seismic assessments and seismic/structural strengthening of existing buildings in your country?

☒ Yes ☐ No

11. Are there incentives provided by the government, to individuals, for structural upgrades / renovations / seismic upgrades in your Country?

☒ Yes ☐ No

12. Have you received any training related to seismic and energy efficiency upgrading?

☒ Yes ☐ No

13. Have you participated in a workshop/conference on the above topics?

☒ Yes ☐ No

III. From practice

14. What are the most common building categories in your Country, regarding existing buildings built before 2000 and how many storeys are they?

15. What is the most widely used construction material for those buildings?

16. What is the common technique/material used for energy efficiency upgrading of existing buildings?**1**

17. What are the most widely used techniques/applications for seismic strengthening of existing buildings?

18. Do you have unmaintained, deteriorated or abandoned buildings that suffer structural deficiencies/ material degradation in your Country?

☒ Yes ☐ No

PORTUGAL

QUESTIONNAIRE

"The need for integrating Structural / Seismic Upgrade of Existing Buildings, with Energy Efficiency Improvements"

Name and Surname: Fernando de Almeida Santos
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QUESTIONS

I. General

1. Does your Country suffer from earthquake or other dynamic loading problem or other combination of dynamic loadings and if yes approximately how frequently –Please attach historical records, if possible.

☒ Yes ☐ No

If yes give details.

Last significant earthquake happened in Azores (1998) with an intensity of 5.9 in the Richter scale and before that, a major earthquake occurred in Azores (1980) with an intensity of up to VIII in the MM scale and 7.2 in the Richter scale. In 1969, an earthquake with an MM intensity of IV and up to VII (7.5 in the Richter scale) affected mostly the southwest region of continental territory. The most severe earthquake recorded so far was in 1755 and devastated Lisbon, with an intensity of up to X in the MM scale in the south and southwest coast. These earthquakes were originated in the contact of the earth's tectonic plates, at the sea, and therefore were not originated by local seismicity. On the other hand, in 1909, in the central southwest, the Benavente earthquake, originated at a local fault, had an MM intensity of up to IX in its vicinity.

2. When was the last major / serious earthquake or other dynamic event that took place in your Country that affected the stability of buildings and civil works? What was the intensity?

Last major earthquake happened in Azores (1st January 1980) with an intensity of up to VIII in the MM scale and 7.2 in the Richter scale. Its epicenter was located at the sea (coordinates 38º 42.0′ N 27º 42.0′ W), close to the islands of Terceira, São Jorge and Graciosa.

3. Were the affected buildings or civil works repaired?

Do you know what was the amount of money needed in order to repair the above?

☒ Yes ☐ No

If yes give details.

Many buildings collapsed and therefore new ones were built. Most of those that were damaged were repaired.

4. Please briefly explain what damages it caused (with regard to buildings, roads, bridges, etc.)

More than 12 000 infrastructures were destroyed or seriously affected. 57% of all housing buildings were affected, 1/5th of these collapsed and 10100 were damaged. It is important to stress that most of the collapsed buildings were old masonry buildings, without any structural design to cope with seismic actions. Modern buildings suffered minor damages.

5. Where there any fatalities or serious injuries?

☒ Yes ☐ No

If yes give data.

73 fatalities and about 400 injured

6. What was the time needed in order to fix the damages and to reinstate smoothly operation?

Temporary houses were built immediately, but reconstruction of definitive buildings lasted for years.

7. Are you aware of any special measures or others means applied, to mitigate/prepare for these events in your Country?

Yes ☐ No

If yes give details.

A large network of seismographic stations were built since then (19 in the Azores alone), to monitor seismic activity. Besides, since this event, all new buildings in Azores had to cope with the so-called preservation rules that were guidelines related to its structural performance under seismic loading. Furthermore, at a national level, a new seismic code was introduced in 1983.

II. State regulations/legislations and concrete experiences.

8. Is there a legal or technical guide/regulation on Energy Efficiency Upgrading of existing buildings in your Country?

☒ Yes ☐ No

If yes give details (attach as well the Regulation or legislation).

Yes. There is a variety of legislation requiring public and private buildings to comply with energy efficiency rules (Decreto-Lei n.º 118/2013, Lei n.º 52/2018, Decreto-Lei n.º 68-A/2015,)

9. Are there any legal or technical regulations/codes related to Seismic or Structural strengthening or upgrades in your Country?

☒ Yes ☐ No

10. Are the Eurocodes applied for seismic assessments and seismic/structural strengthening of existing buildings in your country?

☒ Yes ☐ No

if yes give details

The national codes or Eurocodes have to be used for the design of all new buildings, and this includes seismic design. Has far as seismic assessments and seismic/structural strengthening of existing buildings is concerned, the Eurocode 8 and/or related references have to be used, in the lack of specific national legal guidance.

11. Are there incentives provided by the government, to individuals, for structural upgrades / renovations / seismic upgrades in your Country?

☒ Yes ☐ No

If yes give details.

12. Have you received any training related to seismic and energy efficiency upgrading?

☒ Yes ☐ No

IIf yes give details.

Throughout their life, engineers receive complementary training in these areas

13. Have you participated in a workshop/conference on the above topics?

☒ Yes ☐ No

If yes give details.

The Portuguese Society of Seismic Engineering, based at LNEC, Lisbon, organizes each year a conference on seismic design and behavior of all kinds of structures, besides other workshops focusing on seismic related issues.

III. From practice

14. What are the most common building categories in your Country, regarding existing buildings built before 2000 and how many storeys are they?

Most buildings in historical areas of cities are built in masonry and not height than 3 storeys, dominantly. However, most buildings dated from after the 40's began to have reinforced concrete elements, and after the 60's most buildings have a seismic resistant structure, the vast majority in reinforced concrete. This is a direct consequence of a national code for seismic design in 1958 (RSCCS). After 1985, with the introduction of a new seismic code (RSA-1983), the seismic design of buildings is much more demanding and reliable. Their height generally does not exceed 12 storeys.

15. What is the most widely used construction material for those buildings?

Reinforced concrete, mostly not prestressed. Use of prefabrication is sparse, except for slabs.

16. What is the common technique/material used for energy efficiency upgrading of existing buildings?

EPS and ETICS systems.

We also use systems incorporating cork - product of great national production

17. What are the most widely used techniques/applications for seismic strengthening of existing buildings?

FRP's, steel structures and the addition of reinforced concrete elements.

18. Do you have unmaintained, deteriorated or abandoned buildings that suffer structural deficiencies/ material degradation in your Country?

☒ Yes ☐ No

If yes can you please give us numbers or percentage with regard to the total?

We have no such official value.

We believe that 20% of the urban park is degraded

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