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The Role of the Government in the Field of Public Protection in the Prevention of Earthquake Disasters[1]

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Protecting human lives from devastating natural phenomena is among the most relevant goals of public protection at an international level. In this context, the Government has a huge responsibility in each country including the institutional framework of disaster management, knowledge transfer or legislation. The tendencies and consequences of recent natural disasters indicated that prevention has come to the fore globally. This approach is very important in earthquake prone areas as well. Generally, the most common measure after a devastating earthquake incident is the revision of seismic codes and declaring new design standards. On the other hand, strengthening existing building constructions is inevitable for the mitigation of damages and prevention. Italy is one of the European countries most affected by earthquakes. The lessons learned from Italian risk management strategies and retrofitting projects for unreinforced old masonry buildings can be useful for establishing national strategies and governmental measures within the framework of public protection.

Keywords: *public protection, prevention, collapse of buildings, role of government, preparedness, disaster relief programs*

Introduction

Generally speaking, the significance of previously threatening conventional military conflicts has been pushed into the background, and challenges originating from global terrorism and natural or civilizational hazards have come to the fore. The unpredictability and powerful effects of extreme natural phenomena have indicated that prevention and preparedness have become primary concerns in the modern approach of disaster management. In this context, there is an emphasis on public protection coordinated by the government.

Regarding Hungary, the deficiencies of research and development (R&D) and knowledge technology transfer appear in defence management as well. Besides technological innovation, the main possibilities for enhancing the effectiveness of public protection related to natural hazards are the involvement of citizens in the processes and the increase of participation in international R&D programs.

Thereby, based on the experiences and consequences of severe earthquake incidents and prevention efforts in Italy during recent years, this study discusses the possible methods for the mitigation of earthquake risk within the framework of public protection. The study

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furthermore makes a number of specific suggestions for the principals of governmental measures or programs, whereby the effectiveness of prevention can be enhanced.

General Interpretation of Public Protection

Theoretically, under the protection of civil inhabitants we can understand all efforts, methods, strategies and provisions, which aim to protect human life, material assets, essential, strategic, industrial, sanitary and cultural values or facilities in case of military conflicts or any kind of civilizational/natural disasters. The most important aspects of these provisions are to provide safety for the population in the affected areas and secure the functioning of vital facilities including basic supplies and important governmental organizations. In most cases the protection of civilian inhabitants is undertaken as part of a complex defence system by the mitigation of harmful effects, preparedness and minimizing casualties and injuries.

Based on the experiences of past natural and civilizational disasters, in most cases serious deficiencies and unpreparedness could be observed in the field of public protection, which is indeed highly dependent on the economic potential and social background of the affected countries or regions.

Speaking about the general interpretation of public protection, we need to discuss the main elements of it, including adequate reserving (propellant, food, drinking water and medicines), public preparedness, guidance, dissemination of information, crisis communication, alerting and emergency resource management (emergency protocols, logistics, personal protective equipment [PPE], etc.). [1] Regarding disaster management, those prevention measures that contribute to the increase of safety level of civil population and the defence capabilities of built environment, infrastructure and material or cultural values can also be classified as significant public protection provisions.

It could thus be argued that public protection is based on the active participation of population and central governing bodies during the period of preparedness and response as well.

Statutory Interpretation of Public Protection

Public protection is among the most important tasks within the framework of civil protection, thus the interpretation of the two concepts are closely related to each other. According to the explanatory notes of the Hungarian Disaster Protection Act, civil protection covers a society-wide concern, instrument and response system aiming to provide safety for the population in case of any disasters or armed conflicts. The system of public protection includes the provisions for public preparedness and the improvement of the conditions for survival, too. [2] Literally, civil protection is considered a responsibility of public society that aims to protect human life, to ensure the conditions for survival and to prepare people for emergency situations and their consequences. Dating from its formation, public protection—as an institutional framework—stands on two main pillars: the cooperation and work of state security bodies and the activities of civil defence organizations. Therefore, besides the official disaster management forces, charity and civil protection organizations, other state or municipal bodies and volunteer citizens assume an important role in this system. [3]

The particular tasks of civil protection were first internationally registered in the Geneva conventions in 1949. In Hungary, Act No. XXXVII. of 1996, concerning civil protection composed it first, and then the provisions were integrated into the Disaster Protection Act currently in force. The most relevant tasks of civil protection related to disaster management are the following: [2]

- public preparedness,
- operation and preparation of civil protection bodies,
- transmission of information,
- supply of personal protective equipment,
- maintaining protective structures like shelters or safe rooms,
- evacuation or resettlement of the affected population in case of emergency,
- food, water and medicine supply,
- reconnaissance of the affected area,
- rescue,
- risk and impact assessment,
- and emergency planning.

The methods of public protection can be divided into the following tasks: 1. personal protection, 2. collective protection. Personal protection implies the individual protection methods, for instance the application of respiratory or radiation protective equipment, while under collective protection we can mean the defence systems suitable for the protection of a large number of people by local or remote protection. Local protection covers sheltering in reclaimed areas or facilities, while remote protection aims at the removal or evacuation of citizens from the endangered territories.

In the European Union, the implementation of civil protection tasks and objectives operates under the EU Civil Protection Mechanism regulated by Decision No. 1313/2013/EU of the European Parliament and the Council. Similarly to the interpretation from Hungarian legislation, this international Mechanism aims to protect human life, property and environmental values or cultural heritage in case of natural or civilizational disasters or severe epidemics. In this case, the Mechanism also covers the preparedness and response activities in the framework of civil protection. The local authorities of the state counties play an important role in the implementation of the Mechanism. From 2013, when this legislation took effect (the Mechanism was originally established in 2001), the EU places a heavy emphasis on prevention and preparedness, thus among the task system of civil protection, risk assessment and emergency planning have emerged considerably. The European Commission provides guidance for planning, analysing and carrying out assessments. Besides prevention measures, the Mechanism is activated when international intervention or response is necessary or justified. Based on monitoring and early-warning information, the Emergency Response Coordination Centre is responsible for the coordination of operations, while by the European Emergency Response Capacity the participating countries can share and develop their capacities, forces and abilities under the aegis of the EU Civil Protection Mechanism. [4]

In the United States, the system of civil protection went through serious changes after the terrorist attacks in September 2011. The basis of the new concept was laid down in the Homeland Security Act of 2002, signed into law in November 2012. The system, controlled by the government, was composed of more than 180 federal agencies including the Federal

Emergency Management Agency (FEMA), formed in 1978, which is responsible for civil protection issues in case of disasters or emergencies. Basically, the main target fields of homeland security are emergency preparedness and response including emergency management and civil protection. In the framework of FEMA, the definition of civil defence originates from the Code of Federal Regulations issued in 1972, and defined as follows: "All activities and measures designed or undertaken for the following reasons: (a) to minimize the effects upon the civilian population caused by, or which would be caused by, an attack upon the United States or by a natural disaster; (b) to deal with the immediate emergency conditions which would be created by any such attack or natural disaster; and (c) to effectuate emergency repairs to, or the emergency restoration of, vital utilities and facilities destroyed or damaged by any such attack or natural disaster." [5] This interpretation put a great emphasis on recovery phase and restoration measures besides the emergency and prevention issues for protecting human life. It does not state that civil defence would be the responsibility of public society, civil defence is usually led by the government agencies and organizations. The meaning of civil protection in the US comes from the comprehensive interpretation of civil defence, but it has a greater emphasis on civil and social participation against the effects of military incidents or natural disaster. [6]

The Role of Prevention in Public Protection

As follows from the assessment of the explanations of public and civil protection, it is obvious that prevention and preparedness are the most important phases of emergency management. The following table (Table 1) summarizes those strategic-theoretical key factors that confirm the increasing role of preventive actions within the framework of disaster management, including the public protection efforts and programs.

This comparison also points out that within the increasing role of prevention merits derived from modernization and technological development are non-negligible. Furthermore, as a result of scientific research, which focus on risk analysis, risk management and precautionary provisions, advanced technological and strategic solutions are available to increase the efficiency of loss reduction.

Table 1. Comparison of prevention and response strategies.
(Edited by the author based on [7: Chapter 1 13].)

Response and recovery	**Prevention**
focus on specific, previous disaster events	based on vulnerability and risk factors, focus on future hazards
scenario is single event-based	scenario based on multiple risk factors
scope of activities covers the responses taken for a specific event	based on the constant monitoring and assessment of changing conditions
activities based on commands and control	roles depend on situations, opened for all range of participants
communication and relations follow the rule of hierarchy	changing, indirect communication and relations
mainly focus on predefined and planned practice	focus on coordinated practices, abilities and competences

Response and recovery	Prevention
short-term measures	medium- and long-term measures
using dynamically changing information	open and public source of information from updating and constantly changing diverse sources
specific source of information requiring authorization	information may change or differ according to different perspectives and points of view
in-out and vertical flow of information within controlled framework	diversified, lateral flow of information

In light of the above, it appears obvious that prevention measures constitute a more independent and opened system in time, hierarchy and possible scenarios. This enables the new technologies, scientific results and innovative approaches to be integrated.

The Role of Civil Protection in the Prevention of Earthquake Damage

In general, within the framework of public protection, civil protection tasks and objectives related to prevention are the following:

- public preparedness for the rules of conduct in emergency situations,
- creation and preparation of organizations dealing with public protection, and providing the necessary financial resources for their operation,
- dissemination of information, warning and alert,
- and emergency planning and management.

Regarding earthquake hazards it is important to clarify the devastating effects of seismic activities before the detailed discussion of civil protection activities. The primary—and in most cases the most devastating—impact of an earthquake is the destruction of buildings caused by the horizontal load generated by the shock waves. Secondary effects include tsunamis, landslides, fire or the outcome of the damage on critical infrastructures or public utility systems. We can mention a number of events, when secondary effects caused greater damage, but generally the most significant danger factor is ruin to building constructions, which usually results in buildings or bridges collapsing, roads cracking or serious structural damages on building constructions. All of these damages are direct consequences of the horizontal acceleration of seismic waves generating shear stress on load-bearing structures. Besides these physical loads, many examples can be mentioned, when building collapse occurred as the consequence of resonance. The building is exposed to the highest vibration load, when its natural frequency corresponds to the maximum vibration frequency of seismic waves thus generating high vibration amplitude and resolution. [8]

In light of the above, within the framework of civil protection the application of earthquake resistant building constructions and the implementation of state-supported projects or programs are the primary missions for preventing earthquake disasters and mitigating seismic risk. In addition to state engagement and coordination, the following actions can be mentioned in order to accomplish these goals:

Direct prevention efforts:

- using and developing earthquake resistant technologies and building materials, furthermore enhancing seismic resistance of vulnerable buildings,
- and developing and installing early warning and alert systems.

Indirect prevention efforts:

- improving the knowledge about local seismic hazard and risk,
- enhancing innovation and international partnership in the field of scientific research and experimental development,
- risk assessment (including risk analysis) and risk-based planning,
- and public preparedness.

It is important to note that the primary objective of the above-mentioned efforts is reducing human loss rather than economic losses. In the determination of measures for protecting human life, similarly to other natural threats, in case of earthquake events it is also an important aspect that earthquakes by themselves do not cause disasters. For severe damage and deaths, the seismic wave's effect on buildings or built infrastructure, furthermore occasionally secondary effects can be held responsible. From this point of view, the behaviour of masonry structures, seismic relief provisions and early-warning systems are key priorities for preventing earthquake damage and avoiding loss of human life. For the implementation of these objectives, state and government plays an important role besides the fact that successful prevention is based on society-wide involvement. In the following chapter I examine preventive measures (and their results and efficiency) taken within the framework of civil protection through major earthquake events in Italy from recent years.

The Experiences of Earthquakes in Italy: August 2016 Central Italy Earthquake

According to earthquake statistics, the 2016-year data sheets compared to the previous 16 years (from 2000 to 2015) show that the number of seismic incidents between the strength of M 6–6.9 and M 7–7.9[3] did not increase significantly in the year 2016. [9] However, some really devastating earthquakes hit our planet during this year, from which one of the most severe events was the Central Italy earthquake in August, with a total number of 300 casualties. It is important to note that due to the tectonic conditions Italy is among the most seismically active countries in Europe. The epicentre of the deadly Italian earthquake was approximately 40 km away from L'Aquila, where a previous notorious earthquake devastated the city in 2010, causing hundreds of casualties and serious destruction. This central area of Italy is said to be seismically vulnerable by the typical geological composition and tectonic processes driven by the movement of the Adriatic micro plate and the collision zone of Eurasian and African plates. The epicentre of August 24, 2016 earthquake was close to the town of Accumoli in the Lazio region in the central Apennines. The IX degree intensity scale[4] seismic event caused enormous destruction in Italian towns like Amatrice, Accumoli, Pescara del Tronto, Saletta or San Lorenzo a Flaviano.

3 On Richter Magnitude scale including 9 degrees of amount of maximum energy released.

4 Mercalli intensity scale is a seismic scale used for measuring the intensity of an earthquake including 12 degrees of intensity.

The total number of casualties was close to three hundred, furthermore, approximately four hundred persons were injured as a result of ground shake and building collapse. The most important geophysical features of this event were the following: [10]

– Mw (moment magnitude): 6.2;
– Hypocentre depth: 8 km.

These data indicate a fast course seismic phenomenon with strong ground shaking followed by many significant aftershocks. These features and strength were more than enough to cause serious destruction on mostly historical and other masonry buildings. Furthermore, many bridges, roads and other infrastructural facilities were damaged, which were enhanced by the numerous aftershocks during the following days. The narrow streets of historical towns were devastated by a huge amount of debris making the work of rescue forces more complicated. [10] It is known that according to seismic activity this territory is classified as first category in Italian seismic hazard maps. The high level of risk is in close connection with the great number of vulnerable buildings, which can be found in local towns. Similarly, to the application of the international Eurocode 8 seismic building code in Hungary, the design criteria for buildings in Italy is based on probabilistic seismic maps in order to mitigate earthquake damage. [11]

Prevention and Mitigation Measures

Generally speaking the precautionary actions of a country or a region are relevantly determined by the experiences of previous disaster events. Regarding the prevention strategies and seismic risk mitigation measures in Italy, the first big steps were taken after the consequences of some devastating seismic events from the 1980s and 1990s, but the earthquakes that occurred in 2003 and 2009, and caused major damage were the first significant milestones of mitigation efforts in Italy's modern history. After the 2009 L'Aquila earthquake, about one billion Euros were invested by the Italian Government to enhance the level of preparedness and seismic risk reduction. The main priorities of these interventions and provisions were as follows: [12]

– Improvement of knowledge including scientific assessment of seismic phenomena, seismic hazard mapping, risk assessment and earthquake engineering.
– Mitigation of exposure and vulnerability, like developing seismic codes and emergency planning.
– Reduction of harmful effects by improving the civil protection and emergency plans, developing early warning and alarm systems and public preparedness.

This event led the civil protection authorities to reconsider the future prevention and preparedness measures. Experiences gained from last years' earthquakes in Italy indicated that the solution for the mitigation of earthquake risk is reinforcing buildings and developing emergency management within the framework of preparedness. With regard to disaster hazard, the biggest problem in Italy is the prevalent culture of building construction due to the fact that seismic performance of ancient masonry buildings is very poor and the structural modification of these buildings would be an extremely high expenditure.

Following these above-mentioned principles, the basic objectives of the earthquake related regulations after the 2009 L'Aquila earthquake were to allocate enough financial resources and to implement new technical standards. During the previous decades, within the framework of “improving of knowledge,” a few investigations and assessments took place in order to collect information about the condition of Italian buildings, their vulnerability and function, furthermore national ordinance was proclaimed for the evaluation of seismic behaviour, resilience and level of safety of different constructions. These measures are inevitable for planning, establishing priorities and creating strategies. In regard to the high seismic risk and vulnerability of Central Italy, within the framework of civil protection, some precautions were implemented in order to protect human life and mitigate potential losses.

Post-earthquake investigations included major focus on the damage of school buildings, because the local school in Amatrice suffered serious damage and collapsed in 2016, despite being a newly built building constructed in 2012. The same situation happened with the school of S. Giuliano after a devastating earthquake struck in 2002. The experience with regard to the poor seismic performance of school buildings in Italy led the government to establish a retrofitting program for improving the seismic resilience of schools in high-risk seismic zones in Italy. The Government provided the funds in several phases in order to retrofit the endangered school buildings from 2003. Within the framework of National Seismic Prevention Program, the Amatrice earthquake was preceded by great efforts and enormous investment for improving the seismic safety of school buildings and other important public facilities. On the other hand, previous Italian earthquake disasters pointed out that the damage and collapse of privately-owned dwelling buildings are responsible for most of the casualties, thus it has become evident that despite public facilities private dwellings need to be retrofitted, too, by encouraging private owners to strengthen their homes. Therefore, the National Seismic Prevention Program was extended to strategically important buildings and facilities, furthermore the necessity of retrofitting or reconstructing existing private buildings was realized. [12]

One of the first and most important steps of the Italian National Seismic Prevention Program was the selection of public and private buildings to be retrofitted by new technologies. After the devastating Central Italy earthquake in 2002, participating public buildings were selected by their location, function and a seismic safety revision, which was carried out to evaluate the level of vulnerability. The governmental contribution and subsidy for strengthening private dwellings were different, since these efforts focused on incitement rather than total financial contribution. The selection of participating private dwellings was more complicated than public buildings due to the fact that the vast majority of privately owned buildings did not dispose of risk analysis or safety assessment. The first filter criteria was hazard classification, while the second was the features of the building, including location, age, technology of construction or number of people exposed. A great number of domestic masonry buildings required local strengthening besides the general, regulated seismic upgrading interventions in order to increase the constructions’ seismic safety level. According to State legislation, applying comprehensive seismic upgrading, an increase of minimum 20% of safety level had to be reached per construction during the safety verification. Local strengthening or interventions intend to retrofit single structural elements or particular parts of the building constructions to prevent fractures and dislocations and out-of-plane loads in local structural elements without the modification of basic structural features, because in most cases these anomalies are responsible for the collapse of buildings. on the other hand, the former seismic incidents clearly indicated that without strengthening measures falling insulation, chimneys, cantilevers, parapet walls, external supporting walls or other roof structural elements can cause fatalities and severe injuries. These local interventions did not imply the complex evaluation of the seismic behaviour of the entire construction; the only parts which had to be tested were the resilience, shear and ductility of the retrofitted structural element such as beams, columns, and joints of other load-bearing elements.

As the result of the State's prevention program, a good example for the implementation of successful earthquake resistant design is the small Italian town called Norcia located only 17 km away from the epicentre of the August 2016 earthquake. Not a single dead or injured person was registered, furthermore only a few buildings were damaged during the devastating seismic event. The reason is quite simple and in close connection with the national seismic prevention program, as many buildings had been reinforced after powerful earthquake events hit the territory in the previous decades. However, despite precautionary measures two months after the August 24th, 2016 incident, a devastating earthquake with the strength of M 6.6 destroyed the ancient stone masonry basilica of St. Benedict in Norcia. [13]

As the consequence of former earthquake incidents, within the framework of Italian national retrofitting program local strengthening has been widely used on unreinforced masonry in private and public buildings, which fulfils determined and specific conditions through the solutions discussed in the following chapter. [12]

Strengthening Old, Unreinforced Masonry Buildings

In view of the foregoing, it has been established that Italy is among those countries presenting significant historical values, where the high degree of seismic risk is the consequence of the fact that the substantial proportion of buildings were constructed more than a century ago including mostly unreinforced masonry buildings. Despite being part of cultural heritage, a great number of people live in these houses as their homes. Due to the old technology of construction and usage of locally available materials, these buildings are disposed to seismic damage even during a moderate earthquake. Each construction has special, unknown characteristics. Furthermore, strong deficiencies are present in the education and professional practice concerning old masonry constructions, because recent studies and projects focus on modern steel and concrete structures. [14] In these historical towns or cities, reducing the vulnerability of old masonry buildings to seismic impacts is among the most important measures of public protection in which the State plays a very important role from legislation to operational inventions. The objectives in retrofitting old heritage masonry buildings are complex, since through local strengthening the result is supposed to withstand seismic impacts (or reduce vulnerability) and need to preserve the values of cultural heritage at the same time. Furthermore, providing the conditions of adequate maintenance is also an inevitable task for long term solutions, moreover Italian examples also proved that poor maintenance is itself sufficient for building collapses during earthquakes. [14]

As I mentioned, the seismic behaviour of unreinforced masonry buildings (URM buildings from now on) significantly differs from other traditional concrete or light steel frame structures depending on the age, condition and building material. Based on the experiences of building damages due to Italian and other European earthquakes, the typical seismic damages of URM buildings are the following:

- huge and deep cracks on vertical building structures by lateral loads and torsion stresses,
- fractures and extensive detachments along connections by horizontal shear loads, [15]

- fall of big structural elements (external cladding, wall parts, parapet walls, facade, arch keystones or chimneys, etc.),
- collapse of unconnected intersecting walls exposed to out-of-plane bending,
- failure of walls due to excessive surface of wall openings,
- collapse of load bearing horizontal structures as the consequence of low lateral strength and excessive in-plane loads. [16]

Similarly to exposure and vulnerability, strengthening methods also differ from recently applied, prevalent constructions, since the vast majority of research focus on new seismic resistant technologies and strengthening methods on existing modern buildings in spite of the fact that the ratio of old URM constructions in European urban areas is considerably high. The traditional technique for retrofitting URM buildings is the application of recently used repair materials which act more favourable behaviour against seismic forces. This method needs to ensure the physical cohesion of the original and newly built materials to prevent cracks and dispatches between them. In most cases, modern techniques are more effectively implemented by the usage of steel, carbon, fiberglass or concrete strengthening elements or energy dissipating structures and devices. The latter—for instance base isolation—in most cases is not feasible in existing building constructions or requires overly expensive and significant volume of interventions. The basic principal of strengthening interventions is to increase the load carrying capacity of the connections of structural elements, which can be implemented by bracing and anchoring. [14] On the other hand, another important objective is to create the conditions for the 3-dimensional motion of the structural elements by the interventions. The successful implementation of local strengthening on URM buildings by modern techniques, above all, makes it necessary to carry out thorough analysis and assessment of each URM structures. In view of these principals, implementing retrofitting projects for URM buildings through risk management strategies requires the following main steps:

1. Identification of the level of seismic risk and the evaluation of seismic activity and hazard.
2. Ensure financial funds or support private owners in seismic retrofitting.
3. Evaluation of construction including limit thresholds, seismic performance related to properties like ductility, dissipation or flexibility, material composition, quality and state of integrity. Besides the necessity of detailed description about the URM construction, diagnosis of sensitivity and behaviour for seismic loads is also reasonable. [17] Material assessment requires laboratory testing, while the evaluation of safety is based on numerical modelling and qualitative methods. [14]
4. Testing and modelling of local strengthening or retrofitting techniques in order to identify the most effective feasible method.
5. Implementation of strengthening interventions.
6. Results should be incorporated into technical specifications, regulations and risk management strategies considering the fact that effectiveness can only be tested during seismic events. Furthermore, the final step shall extend to providing handbooks and guidelines for private owners and professionals about retrofitting projects. [14]

The specific conditions mentioned above differ in case of unreinforced masonry buildings and reinforced concrete or steel structures depending on age, size, layout, condition, previous damage, structural modifications, foundation or the compressive stress that can be measured in vertical structural elements.

Solutions for Retrofitting URM Buildings

As this study mentioned before, one of the most critical weak points of URM constructions is the structural connection, thus strengthening joints was an important goal in Italian and other retrofitting strategies. Regarding the Italian State programs and legislation, the most widespread technical solutions for improving structural connections to contribute to monolithic response of URM buildings to seismic impacts are the following.

Tie-Rods

It is vital that an important factor of modern seismic-resistant building techniques is transferring horizontal loads into the walls placed in the direction of seismic waves and then to the basement through the structural elements provided with adequate, stiffened connections. On the other hand, another essential aspect of local strengthening is providing three-dimensional, unified movement of structural elements without separation and crack in connections, which makes the masonry building more resistant to out-of-plane effects of seismic waves.

Using metallic tie-rods fixed along the longitudinal and lateral masonry building elements (Figure 1) is among the most favourable solutions to meet the above-mentioned requirements. in most cases the tie-rods are installed in the interior of floor levels and anchored by bearing plates on the surface of exterior walls. Another way for strengthening the wall connections with tie-rods is installing circumferential tie-rods on the exterior surface of the walls. The tie-rods are usually made of stainless steel, composite material or fibre reinforced polymer. [18]

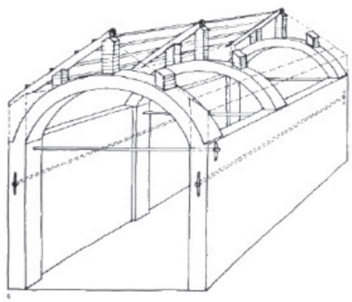

Figure 1. Implementing structural connections by metallic tie-rods. [18]

Steel Ties

Using horizontal steel ties for local seismic strengthening contributes for the prevention of out-of-plane failure of walls by fixing floor joist to external walls. (Figure 2) This solution increases the flexural strength of the building and helps the construction's three-dimensional movement during seismic shock, thus avoiding collapse and the separation of load-bearing elements from each other. In addition, as the steel ties fixing the outer leaf to the robust wall structure are anchored from the external walls. This technology prevents the peeling and falling of the outer layer cavity wall. Steel ties were effectively applied for example in Italian and New Zealand retrofitting programs, too. [19] This solution is sometimes implemented by the disconnection and reconnection of adjacent structural elements. Using steel ties has a particularly favourable result on stone masonry buildings. [18]

Figure 2. Using steel ties for increasing flexural strength and reinforcing outer structural elements. [19]

Ring Beams

Another effective solution for improving wall to wall and wall to roof connections is the installation of ring beams made of reinforced masonry, steel or reinforced concrete. A reinforced masonry ring beam is implemented by steel reinforcement in cement mortar connected to the existing wall. (Figure 3) This method is usually applied on good quality masonry material, like brick. As an alternate solution, using steel ring beams is the simple local strengthening method for wall to roof connections, like wood to masonry. Installing steel truss or steel plates connected with bars and rods through the walls are wide dispersive solutions for steel ring beams. Drilled or grouted reinforced steel bars furthermore ensure fix connections of steel ring beams in case of installing them on both sides at the top of the wall. Another effective solution of ring beams for masonry constructions is the reinforced concrete ring beam connected to the existing wall by grouted or drilled ring bars. This reinforcement is primarily useful to avoid the excessive increase of tangential loads between the ring beam and the wall.

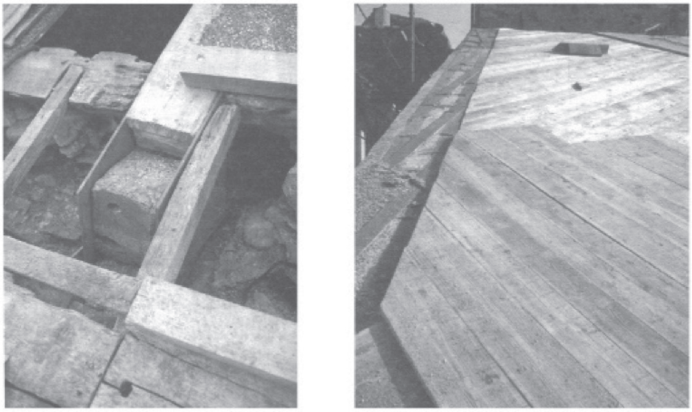

Figure 3. Strengthening the connections with steel ring beams between the wood roof element and the walls. [18]

Carbon Fibre Reinforced Polymer (CFRP) Wrapping

This solution is used for reinforcing rigid concrete or masonry columns and beam-column joints by wrapping around or covering them with fibre layers. The most important features and functions of this technology are ductility, high deformation and shear capacity, good corrosion resistance in order to improve the loading resistance of beam-column connections and prevent fracture and failure in axial compression inside the load bearing columns. [20]

The Implementation of Public Protection and Safety Programs to Prevent Earthquake Disasters

In the implementation of earthquake precautionary and preparedness measures, the role of the State covers the following three principal tasks:

- the determination of types of measures and the establishment of regulatory and operational conditions (seismic codes, construction standards, maintenance);
- the recognition and determination of priorities in the affected territories;
- and providing resources and financial funds.

In practice, the determination of types of measures covers the technologies and precautionary interventions, which are necessary to enhance the level of safety. Furthermore, threat assessment, previous earthquake incidents and other seismic events and prevention efforts that took place in the surrounding areas have a major role to play in this context. Regarding the fact that in most cases planned interventions concern the private property of the population, in effective prevention programs the involvement of residents and private owners is essential. in this context, incitement, financial support, comprehensive preparedness and dissemination of information about risk, possibilities and future steps are among the most important governmental issues.

Another important aspect is the selection of target areas and priorities in the light of risk and vulnerability within the framework of public protection. Regarding the assessments and evaluations of old towns and cities like Budapest in Hungary or many others in Italy, the main reason for vulnerability originates from the deteriorating condition of old masonry buildings, unfavourable subsoil conditions, high degree of built-up space and high density of population in central urban areas. The best way for the identification of priorities is risk mapping, which concerns seismic zone maps based on peak horizontal acceleration values and details about building constructions exposed to seismic hazard. Besides the target fields of the prevention interventions, this type of digital mapping system facilitates the operational decision-making processes, defence planning and the implementation of rescue actions. The use of a spatial information system shall provide accurate data about the number of residents, the function of buildings, technologies of construction and previous strengthening or structural modifications about each building in a designated settlement, part of a city or a specific planning area. This type of seismic risk mapping furthermore contributes to the preparation of seismic codes for existing URM constructions including multi-storey dwelling-houses and cultural heritage buildings.

In order to ensure the conditions of the above-mentioned provisions on State level, in close relationship with governmental innovational strategies, defence management should comprise a flexible institution system and "innovation-friendly" legislation, furthermore these provisions and objectives should be built into policy strategies. Within the framework of defence management, the infrastructure or technologies should be built on innovative services in which international knowledge transfer, local territorial features and needs are taken into account.

Regarding the constant flow and extension of knowledge, another aspect for developing preparedness and the level of efficiency of prevention both in Italy and Hungary is the necessity of guidelines and handbooks for the inhabitants and professionals as well. This approach is particularly due within engineering education, since courses and forms of training related to architecture mainly deal with modern steel and reinforced concrete structures and the lack of knowledge related to specific innovative anti-seismic technologies and historical URM constructions results in a large gap in sufficient expertise and the understanding of seismic performance of historic and old masonry constructions. [21]

Summary

Regarding earthquakes as the result of natural geophysical processes, the cause of their formation cannot be influenced by human factors; therefore, risk must be taken into account. However, through adequate public protection programs and interventions implemented by the Government, seismic risk can be significantly decreased.

There is a close connection between the tectonic processes formed in the territory of Italy and the Pannonian basin even if the central region of Italy is exposed to higher seismic hazard, which can be considered significant at a European level as well.

Analysing the seismic vulnerability and post-earthquake risk mitigation strategies and efforts, it has been established that the main reason for vulnerability in old historical towns and urban areas originated from the high proportion of existing unreinforced masonry buildings. This indicates the necessity of retrofitting programs, local strengthening and adequate maintenance of these buildings in order to fulfil the most basic requirement of public protection, which is considered the protection of human life. In this context, following the provisions and retrofitting programs implemented in Italy, the consequences can be built into governmental defence and prevention programs, national legislation and innovational strategies. In addition, this study makes a number of suggestions for criteria, aspects and development opportunities, which contribute to decision-making and prioritization of interventions. In close correlation with these measures, the involvement, participation and preparation of residents, furthermore enhancing the knowledge about existing URM constructions should be treated as an important factor as well.

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