Bernard Feilden - Alessandro Alva

EARTHQUAKES AND HISTORIC BUILDINGS

Earthquakes cause immense damage to cultural property. In recent years the study of tectonics has shown that the earth's land masses are attached to plates, which move slowly over the earth's substrata of molten magma. Seismic zones, where earthquakes are frequent, occur from the release of great pressures gradually built up by the collision of two plates. Minor tremors can occur frequently; there are over two thousand such per year in Guatemala and these may well adversely effect the durability of historic buildings in seismic areas. At the moment the timing of earthquakes seems almost unpredictable, although due to increase in ground pressure it has been noticed that ground water levels rise in wells before an earthquake and animals show uneasiness. However, by the end of the century a warning of about one week may be possible. Study of past occurences show that a great deal of loss of life and damage to cultural property can be prevented if suitable measures are taken well in advance in seismic zones.

Seismic shocks arrive by direct primary waves, by secondary waves and surface ripples of Rayleigh waves.

Earthquakes or ground shaking causes dynamic movements in all three dimensions of a building: height, length and breadth. In considering historic buildings one must think dynamically and not in terms of normal statics; mass, velocity and energy input are related. Acceleration, velocity and amplitude of movements are all measurable. The ability of the historic building to absorb the energy input without damage is the question.

The energy release or magnitude of an earthquake is measured by seismographs or accelerometers on the Richter Scale, whilst the Modified Mercali Scale classifies their results. The Richter Scale as used by seismologists is logarithmic to the base of thirty two, increments of one unit representing thirty two times the energy release, so even an increment of 0.1

a considerable increase in energy with consequential damage where it is absorbed. The Modified Mercali Scale is subjective and related to the damage to existing buildings and installations, including all types of cultural property. The effect of the energy input of an earthquake depends primarily on the condition of the building, i.e. whether it has been well maintained, the quality of its workmanship and of previous earthquake repairs, its form and design, as well as local ground conditions and the direction and type of the seismic waves and the distance from the epicentre. It is not surprising therefore that with unfavourable ground conditions the 1977 Friuli earthquake of 6.4 Richter produced equally devastating results (Modified Mercali IX and X) as the 1976 Guatemala earthquake of 7.6 Richter, one of the most intense recorded, with over thirty two times the energy input of Friuli. The possibility of a series of earthquake shocks must also be borne in mind, for in Friuli the second major shock, following a whole series of minor tremors, caused great havoc to buildings already severly weakened [1].

The collapse of buildings is the primary cause of loss of life, so preventive measures to strengthen historic buildings will also save life and limb.

The secondary effects of earthquakes such as landslips, road fractures, bridge failures, floods and ground movement with changes of underground water levels and flow can be devastating. Their first effect is to disrupt communications and make rescue more difficult. In addition an earthquake site is generally held in a pall of dust.

A seismicity map of the world shows by far the greatest number of recorded events round the coast of the Pacific Ocean from New Zealand, Japan, Alaska, California to Central America and the Andean range of South America.

Tsunamis, or waves originating in earthquakes under the ocean are frequent and endanger coastal property and dwellings. Waves as high as 20 m have been recorded and each event consists of several waves. A warning centre has been established in Hawaii.

[1] Schwartzbaum, Silver, Grissom, « Earthquake Damage to Works of Art in the Friuli Region of Italy », JAIC 17 (1977): 9-16. Strongest Tremors of the 1976 Earthquakes in the Friuli Region, Italy.

Tremor or No.	Date	Richter Magnitude
2	6 May	6.0
42	9 May	5.8
54	11 May	4.8
188	11 Sept.	5.1
189	11 Sept.	5.5
222	15 Sept.	5.8
232	15 Sept.	6.0

A map giving seismic risks related to density of cultural property as proposed by ICOMOS will be most valuable in drawing attention to these hazards. Such a map should show geological fault lines in as great detail as possible.

Dowrick in his most useful book " Earthquake Resistant Design " [2] lists those countries with a low, medium or high risk, the latter being Afghanistan, Albania, Argentina, Burma, Chile, China (in parts), Colombia, Costa Rica, Cyprus, Dominican Republic, Ecuador, Greece, Guatemala, Honduras, India (in parts), Indonesia (in parts), Iran, Iraq, Italy, Japan, Mexico, Nepal, New Guinea, New Zealand, Nicaragua, Panama, Peru, Philippines, Taiwan, U.S.A. (high in parts), U.S.S.R. (high in parts). The few countries considered by Dowrick to have above average codes are India, Japan, Spain and U.S.S.R. and he states all could benefit from major improvements. The art of seismology, being in its infancy, is based upon gross simplifications, using nominal horizontal loadings or base shear solely for the purpose of design of new buildings. It is the considered opinion of experts that such codes do not apply to historic buildings. It must be stressed that no historic building should be condemned to destruction or loss of beneficial use because it does not or cannot comply with the current official code, which in any case is suspect. Many factors outside the code must be taken into consideration, as well as the basic data of the ground movement seismic spectrum, which can be predicted by a seismologist for a given site.

The seismic spectrum for any particular site will take local soil types and conditions into account, such as soft soil, for sensitive clays lose their strength under dynamic loading, the slope of sedimentary soils, the existence of any bedding planes and their angle of slope, horizontal changes in soil types, the depth of soil over bedrock and the topography of bedrock including ridges and deposited soils. Water content and the level of the water table is also important for with a water table less than about 8 m depth there is a danger of soil liquefaction in an earthquake. Dowrick gives advice on the best field and laboratory tests in Tables 3.1 and 3.2, page 50.

Each historic building is a case for individual study involving a meticulous inspection of the fabric. A study of its previous repair history and preventive maintenance are the first steps, followed by such strengthening against dynamic forces as is practicable and economic in conjunction with

[2] D. J. Dowrick, « Earthquake Resistant Design ». A Manual for Engineers and Architects, John Wiley & Sons, TA 658.44.D67 624 76-26171, ISBN 0 471 99433.2.

its overall conservation plan, which gives a reasonable approach to prolonging its life and reducing the earthquake hazard to its occupants.

Examination of earthquake damage shows that the direction of the waves has a considerable effect on the resistance of the building. The following is an imagined scenario of earthquake damage. First roof tiles begin to slip and fall and weak timber joints break. The roof timbers batter the walls. Then cracks form at the corners in walls and where stresses concentrate around door and window openings and in vaults and arches. The centre portion of an arch or vault may slip downwards, wedging and battering the structure apart. The roof falls in and portions of vaults and domes fall. Columns vibrate and crack and batter each other. Pinnacles and towers rotate, shift and fall down causing damage and façades split apart. The structure disintegrates into large lumps if well built and rubble if badly built. With simple vernacular buildings the front walls fall out into it can be deduced that square, circular and octagonal buildings have resistant forms; rectangles, particularly if long may have differential behaviour at opposite ends, whilst projecting wings and features produce weaknesses. It is quite common to see buttresses sheared off walls.

The basic causes of damage are relative ground displacement and ground acceleration. The factors affecting the seismic performance of a historic building are its mass, stiffness, period of vibration, damping or ability to absorb energy, resonance, stability, structural geometry, continuity in structural mass and resistance. Historic buildings lack toughness and flexibility, qualities which can be designed into new buildings. The compatibility of various structural elements and redundancy or ability to find alternative structural actions in the earthquake emergency are important considerations.

Last but not least is the general condition of the structure — has it been well maintained and carefully repaired in the past. Earthquakes seek out the hidden weaknesses in a building, so are often blamed for what was a faulty repair, bad workmanship or lack of preventive maintenance.

Structural performance of historic buildings in earthquakes

Having examined the risk to the historic building we can now consider its resistance in general terms and available methods of improving this resistance. The resistance depends upon the form of the structure, the strength and workmanship of its construction and its materials and its dynamic performance. Simple and symmetrical forms are best, not too elongated and with uniform and continuous distribution of strength.

Besides the effect of the direction of the shock wave, the predominant frequency of these waves and the natural frequency of the building and ground are vital questions. The stiffness of the building in relation to the properties of the subsoil should be assessed by a seismic engineer. The whole building may vibrate in a certain frequency due to its form and stiffness and if there is a dynamic resonance the structural damage will be much greater. Battering by different elements may accidentally increase this resonance or decrease it. It has been observed that a masonry building can survive a few shocks of great intensity, but that vibration of long duration is damaging.

Historic buildings are generally stiff, even if made of timber, and the bonding together of all elements is most important. In a severe earthquake badly bonded elements act like battering rams oscillating in different modes. As historic buildings are stiff they are generally considered safer if they are on 'long period sites', i.e. resting on soft soils of some depth. The exceptions are tall towers, spires and minarets which are flexible and more affected by the longwaves which can reach up to 1000 km from an epicentre. Architectural elements such as asymetrical towers should be completely separated from the main structure by a gap of 100 m, if possible, to avoid battering.

Prevention of earthquake damage can only be practiced within the context of the past history of the conservation of the building. In seismic zones the strengthening of valuable cultural property should be included in the general programme of preventive maintenance, as and when made economically possible in conjunction with other major building repairs such as renewal of roofs or strengthening walls and foundations.

Methods of strengthening historic buildings

Of structural materials timber is considered the most earthquake resistant, provided its joints are sound and it is not attacked by insects and fungi, but unfortunately it is vulnerable to fires which follow earthquakes. However, its shock resistance is high. In the middle grades of resistance are in situ reinforced concrete, steel, prestressed concrete followed by primitive reinforced masonry. It is interesting to note that the Nabataeans reinforced the masonry of their principal temple in Petra, Jordan, now called the Qasr el Bint, with longitudinal timbers which were effective in preventing the collapse of its walls but not the roof.

Unfortunately, apart from those with timber framing, most historic buildings come in these lowest grades of resistance, being stiff structures made of brittle material. Mercali quite rightly lays great emphasis on the quality of the workmanship of the original building and we must add the way subsequent repairs have been done. The damping effect of the structure is increased by the use of lime mortars (and avoidance of Portland Cement).

Mercali has indicated that good workmanship is a vital factor in the earthquake performance of masonry buildings, which he puts into four categories:

(Masonry A, B, C and D as used in the Modified Mercali Scale given on page 2)

Masonry A - Good workmanship, mortar, and design; reinforced, especially laterally, and bound together by using steel, concrete, etc.; designed to resist lateral forces.

Masonry B - Good workmanship and mortar; reinforced, but not designed in detail to resist lateral forces.

Masonry C - Ordinary workmanship and mortar; no extreme weaknesses like failing to tie in at corners, but neither reinforced nor designed against horizontal forces.

Masonry D - Weak materials, such as adobe; poor mortar; low standards of workmanship; weak horizontally.

Perhaps he is unduly critical of adobe, which if mixed with long straw or tough grasses can achieve remarkably high tensile strength and toughness, but the mud mortar between the blocks may be the weakest element.

The condition of the mortar is as important, or possibly more so, than the quality of the original workmanship, for over the centuries lime mortar can deteriorate and become denatured. Repointing grouting and replacement of defective mortar are the practicable remedies, but in extreme cases reconstruction may be the only remedy.

Examination of earthquake damage shows that binding of walls together at the corners is vital, together with tying floors and roofs to walls. The insertion of tensile reinforcement with some degree of prestressing and bonding together of elements gives the masonry of historic buildings greater earthquake resistance. Experiments have shown that adobe, or mud brick, with diagonal prestressed cables anchored top and bottom has much greater resistance to dynamic forces. In existing adobe buildings reinforcement in the form of diagonal galvanized steel wires might be added under the layer of mud plaster that is normally renewed and anchored to flat slabs of reinforced concrete at the top and bottom.

For simple two storey masonry houses built with lime mortar, Kolaric [3] recommends reinforcement in both directions with 16 mm steel ties fixed to the floor joists and anchored with 15 x 15 plates, 5 mm thick, which are recessed into the external walls and then covered with plaster. Similar strengthening should be done at roof level where the anchoring of wall plates and tying of roof timbers together should be given special attention, as earthquake damage often starts at this point: the falling of heavy roof tiles and collapse of roof and floor timbers are perhaps one of the major causes of loss of life, generally preceding or promoting the collapse of walls. The roof structure should incorporate diagonal ties, which can be used to strut gable walls.

A ring beam of reinforced concrete under the wall plate is an obvious improvement to the earthquake resistance of a masonry building; such a ring beam should be extended downwards with embedded columns and tied across the vaults and extended around the base of domes as has been done to reinforce the Church of La Merced in Guatemala Antiqua. Similar reinforcement has been placed in the adobe built chapel of the Convento di San Bernardo in Cusco, the columns having been inserted into vertical shafts in the centre of the wall. The mix of the reinforced concrete should have strength characteristics close to that of the masonry, so should consist of weak aggregates and mixes.

Considerable strengthening of masonry buildings can be obtained by grouting procedures of all types using hydraulic limes as described in "Conservation of Historic Buildings", Chapter 20. In special cases the use of expensive polyester and expoxy resin grouts will be more than justified. Such grouts can be used following the normal injections, thus exploiting their penetrating power to fill fissures and fine cracks and avoiding the necessity of filling large voids with costly material. They are specially valuable as the increase the tensile strength of masonry and consolidate friable lime mortar, which weakness was reported to be one of the principal reasons for the collapse of many historic buildings in the Montenegro earthquake of April 1979. Rough masonry walls that are plastered can be strengthened in the way suggested for mud brick or by applying wire netting onto both faces and tying the faces together at about 1 metre centres, then replastering.

Plaster or wattle and daub panels in timber constructions can be strengthened with galvanized expanded metal reinforcement applied to both sides and, if possible, nailed to the framing timbers if they are not exposed and such panels can also be consolidated by grouting. Cross walls and partitions must be securely attached to the main walls. Lintels over doors and windows should extend at least 40 cm beyond the opening to give extra protection. If doors and windows are so placed as to cause a weakness in a

[3] M. Kolaric, Unpublished paper given at ICCROM in September 1977.

wall, long reinforced concrete ties may have to be inserted in a concealed way, so as to disperse the concentration of dynamic stress which occurs at their corners.

Tall chimneys present a hazard as they will have a different mode of vibration from the main building and are liable to collapse first, so causing damage and perhaps weakening a vital part of the structure. They should be strengthened if possible by vertical drilling and insertion of prestressed ties, or if in poor condition, by being rebuilt inserting vertical reinforcement anchored securely to the mass of the wall below.

As earthquake shocks are transmitted to the building through its foundations both by vertical movement and acceleration and horizontal, the horizontal shear forces will have to be resisted. If the foundations fail the results will be totally disasterous, so foundations should always be investigated. If the watertable is high the danger of soil liquefaction is much greater, so the possibility of natural drainage should be looked into when making the investigation.

If a building rests on sloping strata or variegated soils, i.e. peat and clay, special measures will be necessary, such as piling to support the building all on the same strata which must be sound and not liable to liquefaction when an earthquake occurs. The pilecaps must be linked with horizontal beams and secured to the existing structure carefully. In other cases it may be sufficient to unify the foundations with ground beams around the perimeter. Care must be taken to avoid a new design that has the same natural frequency as the soil.

In seismic zones archaeological sites will need special conservative action after having been excavated, unless after recording they are back-filled with earth. Archeological monuments consisting of stone facing with earth fill are particularly vulnerable if the jointing of the stone is in poor condition. Indeed, many archaeological sites were reduced to mere rubble in the 1976 Guatemala earthquake, because they were exposed to risks that had not existed previously before being dug. Some taking down and consolidation by rebuilding may be necessary, in which case photogrammetric records and numbering of stones on an elevational grid, as done at Macchu Picchu, Peru, will be necessary.

To prevent mechanical plant from sliding, overturning and jamming during an earthquake from 20 - 40 mm tolerances may be necessary. There must be flexibility in connections with pipes and wires and their fixings must be strong enough to withstand three dimensional movements. Electric mercury switches are dangerous, because vibration may activate them and heating boilers with firebrick linings are also liable to damage. Water and

electric supplies to hospitals and fire fighting services need special protection and should be examined by specialists. Also sculpture and landscape ornaments will need special fixings to prevent them being thrown about during an earthquake.

Preventive action before an earthquake

In high risk zones at least, there should be some preventive action before a possible earthquake. We have dealt with some structural possibilities of strengthening historic buildings. Fire fighting precautions rate highly also; public safety is the main concern of earthquake measures followed by minimizing the cost of any incidents. During the incident falling walls and roofs and glass breakage are the worst hazards, where possible laminated glass should be used, especially in public buildings and museums. In addition to listing and marking all cultural property it should be fully recorded using photogrammetry where appropriate, priority being given to property of high value in a high risk zone. Full documentation of all cultural property makes action after the emergency more certain and efficient and has proved most valuable in the Montenegro earthquake of April 15.
Emergency plans should be worked out in advance between the military and the civil authorities with the advice of conservators of cultural property. A depot or store for emergency conservation supplies should be created. Regular inspections at 5 year intervals will provide the basis for preventive maintenance, thereby reducing risks to life and property. In seismic zones museums, as the repositories of cultural property, should have a high priority for strenghtening measures, especially as their conservation laboratories will be needed after a disaster.

If the building collapses around the occupants there should be a chance of rescue. Public safety is increased if there is preparedness for a disaster. Each house should have a safe place specially strengthened which can be reached quickly. Here there should be a container of water, emergency food, a torch and battery operated radio.

At the town and regional planning levels risks should be evaluated and minimized by forethought. The whole town of Huarez Ancash in Peru with inhabitants was submerged by a landslide of mud precipitated by a massive avalanche; with 80,000 casualties this was a disaster as terrible as Pompeii or Herculanum. In Guatemala City, the fourth used as a capital site due to seismic events, modern buildings were built across geological fault lines. This should not have been permitted and all main services in zones with severe seismic risks should run parallel to the faults.

After an earthquake

After a disaster there is a great human shock. It is not this paper's role to amplify or describe this. Part of the unrecorded shock syndrome, however, is to assist in the destruction of what is left, arson is common and wanted destruction of historic buildings that could have been saved is surprisingly frequent, although prior documentation could have prevented this. The confusion of the event compounds these additional dangers to cultural property. Some conservation organizations have attached Army officers whose duty is to organize security and fire fighting measures. Earthquake protection could easily be added to these duties in seismic zones. Such officers could liaise effectively with the rescue organization, which is generally in the hands of the military with field engineering units at their command.

Quick inspection of the damage is essential. Dangerous elements must be made safe. What can be saved should be shored and strutted to prevent collapse should there be further tremors as often happens. An international colour code is necessary. The following is suggested:

Red: demolish
Yellow: shore up and save
Blue: safe.

Architects with sound engineering judgment and wide cultural knowledge are necessary for this work. Also military engineers should receive special training for earthquake duties. Particular emphasis must be given to strutting and shoring techniques and structural first aid in earthquake situations. Often there is external difficulty and danger in making an inspection, in such situations a mobile photogrammetric unit would be of immense assistance, as it could take measurements and produce drawings without risk. However, although technically possible, such equipment has yet to be developed.

Of course, the main effort must go into rescue, evacuation of casualties and providing temporary accommodation, but sufficient manpower and resources should also be given to emergency measures to save cultural property. The safety of working conditions will need constant monitoring. Helmets and dust masks should always be worn. If markets or cold stores are left too long, severe health hazards arise due to decomposition of perishable matter. Rats and other vermin increase and make the difficult work of cleaning much worse, so much so that gas masks and protective clothing become necessary. A similar but even more unpleasant risk occurs

when it is the local custom to bury the dead in tombs above ground, for these disintegrate and scatter their decaying contents.

It is essential that an expert in architectural conservation is present to advise the military commander and has authority to prevent unnecessary demolition of cultural property and unthinking removal of archaeological material. He must have the authority and means to make safe historic buildings by temporary strengthening and shoring. Adjustable screwed steel acrow struts together with salvaged timber are invaluable for quick work. Temporary roofing materials are urgently needed together with polythene sheets to protect valuable objects which cannot be moved. Works of art such as frescoes that are part of a historic building should be urgently protected against the elements and made structurally secure. Archaeologists and art historians should be invited to inspect the ruins when they are safe, as many important discoveries can be made in their fields of activity. It may be decided to leave some buildings as ruins to act as a memorial of the earthquake and a reminder that precautions are desirable.

The conservator must also have authority to organize transport of all movable works of art and other cultural property to safe storage outside the earthquake zone. First aid can be given to frescoes by the application of surgical gauze using Paraloid B 72 as adhesive; similar treatment can be prescribed by a trained conservator for other materials. First aid to art objects will often be necessary and all organic material will need to be fumigated before storage in the depository. After fumigation, consolidation and reassembly will follow. A conservation laboratory with plenty of space, but simple equipment is an essential provision after an earthquake.

To avoid confusion a central control point must be established where all conservation volunteers can report, in order to ensure that their efforts are not frustrated. ICCROM can assist by coordinating international conservation aid as was done in the case of the Friuli earthquake and the Florence flood.

Repairs after the emergency

After the first phase there comes a long climb back to normality, which may last several years.

The quantum of the damage must be assessed, which means detailed inspection of all cultural property and grading of damage. The Jugoslav system used in the Montenegro earthquake has three main categories with subdivisions as follows:

USUABLE - Green:

- Grade 1 - slight superficial damage virtually intact
- Grade 2 - superficial damage non structural
- Grade 3 - superficial and slight structural damage

TEMPORARILY UNUSUABLE - Orange:

- Grade 1 - structural damage, e.g. roofing and ceilings
- Grade 2 - serious structural damage to walls, etc.

UNUSUABLE - Red:

- Grade 1 - severe structural damage, unsafe but capable of repair
- Grade 2 - partial collapse, e.g. roofs and floors
- Grade 3 - total collapse, requiring reconstruction of walls, etc.

The colours in outline or cross hatching or double cross hatching for the respective grades are superimposed on a large scale map, thus giving a global view of the problem.

A disaster also presents opportunities to correct defects either in town planning or historic structures. The recommendations with regard to prior strengthening should be incorporated in the repair programme as precautions against the next earthquake. At town planning level it may be the policy to up-grade dwellings or even change uses. The opportunity can also be taken to underground unsightly electrical wiring, especially if new trenches have to be dug for drainage.

A multi-disciplinary team will have to be assembled and this should consist of conservation architects, specialist engineers, archeologists, historians, urban planners, art historians and conservator restorers.

NOTE: Schools of architecture in seismic zones should be ready to send student volunteers to form a cultural property protection force, with tents and feeding arrangements.

NOM: BERNARD FEILDEN ET ALESSANDRO ALVA - ICCROM - Italie.

THEME: STRUCTURES

TITRE: MOUVEMENTS TELLURIQUES ET EDIFICES HISTORIQUES.

RESUME:

Les réglements gouvernementaux sont inappropriés quant à la consolidation des monuments historiques, alors qu'ils sont conçus pour les constructions nouvelles. Les monuments historiques ont souvent survécu à plusieurs tremblements de terre qui interviennent entre 50 et 100 ans dans plusieurs régions.

Les auteurs cherchent à éveiller l'attention des architectes non spécialisés en ingéniérie quant aux problèmes des édifices historiques situés dans des zones de séisme. Ils examinent la séquence typique de l'effondrement et révisent les méthodes permettant de renforcer les édifices historiques.

Ils soulignent l'importance d'une action préventive pour laquelle il est bon d'assurer une collaboration entre les autorités militaires et les personnes chargées de la préservation, afin d'entretenir les édifices historiques par le renforcement de façon à protéger la vie des occupants et des constructions de valeur.

Les inspections ont prouvé qu'un monument historique bien entretenu offre une résistance surprenante aux mouvements telluriques.

NAME: BERNARD FEILDEN AND ALESSANDRO ALVA - ICCROM, Italy.

SUBJECT: STRUCTURES

TITLE: EARTHQUAKES AND HISTORIC BUILDINGS.

SUMMARY:

Govermental regulations are inadequate to deal with the strengthening of historic buildings as these are prepared for new construction. Historic buildings have often survived several earthquakes which come at intervals of between 50 and 100 years in many regions.

This paper aims at making architects without specialised knowledge of engineering aware of the problems of historic buildings in earthquake zones. The typical sequence of collapse is examined and methods of strengthening historic buildings are reviewed.

The importance of preventive action before an earthquake. Liaison between military and preservation authorities should be promoted. The importance of regular maintenance of historic buildings linked with strengthening measures is emphasised as this will save both the lifes of occupants and historic buildings. Inspections have shown that well maintained historic buildings are surprinsingly earthquake resitant.

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TEMA: ESTRUCTURAS

TITULO: MOVIMENTOS TELURICOS Y EDIFICIOS HISTORICOS.

SUMARIO:

Los reglamentos gubernamentales son inadecuados para los problemas de reforzamiento de edificios históricos, por la sencilla razón de que fueron concebidos para construcciones nuevas. Los edificios históricos han, a menudo, soportado varios terremotos a intervalos que varían entre 50 y 100 años, en muchas regiones de la tierra.

Esta ponencia trata de llamar la atención de los arquitectos, sin un conocimiento especializado de ingeniería, sobre los problemas de edificios históricos en zonas sísmicas. La secuencia típica de colapso es examinada, haciendo una revisión de los métodos para reforzar los edificios históricos.

Se menciona la importancia de una acción preventiva antes de un terremoto. Debe promoverse la colaboración entre autoridades militares y autoridades de preservación. Se enfatiza la importancia del mantenimiento de edificios históricos en relación con las medidas de reforzamiento, para salvar tanto las vidas de los ocupantes como las construcciones valiosas. Las inspecciones han mostrado que un monumento histórico bien mantenido, es sorprendentemente resistente a los movimientos telúricos.

Имена : Филдэн Бернард и Алра Алесандро

Предмет : СТРУКТУРЫ

Название : ЗЕМЛЕТРЯСЕНИИ И ИСТОРИЧЕСКИИ ПОСТРОЙКИ

Краткое Описание :

Государственное законодательство недостаточно сильно, чтобы подействовать на укрепление исторических построек, благодаря тому, что они относятся только к новым постройкам. Историческия постройки очень часто смогли пережить несколько землетрясений которые случаются в интервалах от 50 до 100 лет во многих местностях.

Цель настоящего сообщения это ознакомить архитекторов не имеющих специализированного знания в инжинерном деле с проблемами исторических построек в зонах подверженных землетрясениям. Изучают типичные ритмы колляпсиса и пересматривают методы подпорки исторических строений.

Важность предохранительных действий до землетрясения и связь между военными и охраняющими властями должна быть усиленна. Важность регулярного поддержания исторических построек, вместе с методами для усиления подчеркнута в настоящем докладе, ибо оно способно спасти жизнь живущих в них как и самые исторические здания. Инспекции показали, что хорошо поддержанныя исторические постройки имеют изумительное сопротивление против землетрясений.

NOME: BERNARD FEILDEN E ALESSANDRO ALVA - ICCROM, - Italia.

TEMA: STRUTTURE

TITOLO: TERREMOTI ED EDIFICI STORICI.

SOMMARIO:

Le norme governative che regolano il consolidamento degli edifici sono spesso inadeguate poiché la maggior parte di esse è preparata per gli edifici moderni.

Gli edifici storici sono spesso sopravvissuti ai diversi terremoti succedutisi ad intervalli di 50 e 100 anni in molte regioni.

Questo saggio tende a rendere consapevoli gli architetti sprovvisti di una conoscenza specializzata dell'Ingegneria, dei problemi riguardanti gli edifici storici situati nelle zone soggette ai terremoti.

Vi si esamina la sequenza caratteristica dei crolli ed i vari metodi di consolidamento degli edifici storici. Vi si accentua l'importanza dell'azione preventiva prima di un terremoto, la quale dovrebbe essere promossa e portata a termine dalle autorità militari in collaborazione con le autorità preposte alla conservazione.

Viene, inoltre, enfatizzata l'importanza del regolare mantenimento degli edifici storici e delle misure di consolidamento appropriate poiché esse salverebbero sia le vite degli occupanti che gli edifici storici stessi.

Le ispezioni hanno più volte dimostrato che gli edifici storici ben tenuti sono sorprendentemente resistenti ai terremoti.