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Editorial: Reflections on the 14 World Conference on Earthquake Engineering

Along with about 3000 other participants I have just attended the World Conference on Earthquake Engineering. Held in Beijing, it was a conference huge in scale. At times up to 24 parallel oral presentations sessions were being held concurrently, as well as several hundred posters on display. Given the large amount of material presented it is impossible for one person to attempt a balanced summary. I will just mention several aspects arising from my attendance at sessions of most immediate relevance to developing countries.

First, mention should be made of the Confined Masonry Initiative. Broadly promoted under the umbrella of the World Housing Encyclopedia, an international group of practitioners are promoting confined masonry as an alternative to reinforced concrete frames with masonry infills. These frame and infill structures have not behaved well in past damaging quakes. This is hardly surprising when you consider that the frames are designed as 'open frames' but are then infilled. If the ground floor is left open it invites a dangerous soft-storey mechanism. The infill masonry walls, whose presence is usually ignored by structural engineers, completely dominate structural behaviour. By contrast, confined masonry buildings where columns and beams need only resist axial rather than bending actions, perform better. Due to casting of the reinforced concrete elements *after* laying the masonry walls, diagonal compression struts that form in the walls under lateral loading are principle elements in the load path associated with seismic forces. Designers are encouraged to consider utilizing this alternative form of construction. For further information about this initiative visit www.confinedmasonry.org.

Another resource focusing on the needs of developing countries is the World Housing Encyclopedia. At the conference we were reminded not only of the encyclopedia itself but also of the excellent tutorials that are readily available for dissemination. All professionals should study the tutorial on reinforced concrete frame buildings, and for some others, a tutorial on improving adobe housing will also be very relevant.

During the course of the conference many new technical developments were reported upon. Researchers have had considerable success in improving the seismic performance of adobe buildings using various types of plastic mesh applied to both faces of walls and tied through at close centres. Less expensive alternatives are still required. But the ultimate challenge is to achieve sustainable large-scale implementation. Only then will the seismic safety of significantly large numbers of people be improved.

If you didn't attend the conference but would like to study some of the papers presented you can visit www.14wcee.org. After reviewing the titles of papers relevant in relevant sessions contact individual authors and request a copy of their papers. Future newsletters will summarise selected papers.

Virtual Site Visit No. 15: Medium-rise commercial reinforced concrete shear wall building, Wellington, New Zealand

Fig. 1 A general view of the building site showing some of the reinforced concrete shear walls.

Reinforced concrete shear walls are designed to resist all the lateral seismic and wind forces acting on this building. Orientated along both orthogonal axes of the building plan, the shear walls will also resist any in-plan torsion rotations. Slender steel columns resist gravity forces. A general view of the building site (Fig. 1) shows some of the shear walls. Their layout separates some of the tenancies and does not disrupt architectural planning. Since the walls resist all horizontal forces, the gravity-only structure comprises shallow flooring elements and columns with relatively small cross-sectional dimensions.

Figure 2 illustrates the internal reinforcing of a typical shear wall. Vertical bars provide bending resistance against horizontal forces that act on the wall from each floor diaphragm. Horizontal steel increases the shear capacity of a wall to such an extent that in a seismic overload situation a ductile flexural plastic hinge will form at the base of a wall before brittle diagonal tension shear failure occurs. Small additional horizontal ties are placed at the each end of a wall to confine the concrete in that area and thereby increase the wall ductility. These ties are seen more clearly in Figure 3.

This building is a good example of shear walls functioning as the sole seismic force resisting system. Any moment frame action from the gravity-only columns and beams will be so minimal compared to the strength and stiffness of the shear walls that it can be neglected.

Fig. 2 Shear wall reinforcing that consists of both vertical and horizontal bars.

Fig. 3 The confined end zones of a partially cast wall.

Summary of "Seismic Vulnerability Assessment of Hospitals in Nepal"

by Ramesh Guragain and Amod Mani Dixit

from the 13th World Conference on Earthquake Engineering, August 1 – 6, 2004

Introduction

In the past, big earthquakes in Nepal have caused huge numbers of casualties and damage to structures. The Great Nepal - Bihar earthquake in 1934 reportedly killed 8519 persons and damaged 80,000 buildings in Nepalese territory. Though being a seismic country, earthquake-resistant standards have not been effectively applied and guidelines have not been published and practiced for hospital facilities in Nepal. The possibility of hospital buildings not being functional during a large seismic event is very high. The National Society for Earthquake Technology (NSET) conducted two studies "Structural Assessment of Hospitals and Health Institutions of Kathmandu Valley" and "Non-structural Vulnerability Assessment of Hospitals in Nepal" in years 2001 and 2003.

By assessing the structural and non-structural components against possible earthquakes, expected performances of hospitals were evaluated and compared with standard risk acceptance matrices. The results show that about 80% of the hospitals assessed in the study fall in the unacceptable performance level for new construction and a remaining 20% of the hospitals are at a life safety to collapse prevention performance level. Recommendations were made to improve the seismic performance of different hospitals on a priority basis. Fixing of all equipment and contents, strengthening of critical systems, training to hospital personnel and provisions to some redundancies in critical systems were the proposed activities to implement in first phase. Seismic retrofitting of hospital buildings, further strengthening of critical systems and provision of extra redundancies in the systems were the activities for second phase implementation as proposed. Considering the opportunity of immediate implementation of non-structural risk mitigation, some examples of mitigation options to solve the problems were developed during the study.

The National Society for Earthquake Technology-Nepal (NSET) conducted a project "Structural Assessment of Hospitals and Health Institutions of Kathmandu Valley" with WHO-Nepal and the Ministry of the Health, HMGN in 2001. The assessment estimated that most of the hospitals would withstand the occasional earthquake of MMI VII without collapsing. It was found that 10% of the hospitals might be functional, 30 % partially functional, and 60% out of service. The major cause of possible functional loss was considered to stem from non-structural damage and one of the recommendations of the project was to conduct detailed non-structural assessment of major hospitals.

Methodology

Identification of Building Typology

The typology classification in this study is global, and is based on the performance of different types of buildings during past earthquakes. Building typologies defined in BCDP a Nepal National Building Code document, was taken as basis while defining the different building typologies. The types of buildings considered are:

- Type 1: Adobe, stone, adobe & stone, stone & brick-in-mud.
- Type 2: Un-reinforced masonry made of brick in mud.
- Type 3: Un-reinforced masonry made of brick in lime, brick in cement, and well-built brick in mud, stone in cement (well built brick in mud: with wooden bands, corner posts with very good wall/area ratio and proper connection; original courtyard type).
- Type 4: Reinforced concrete ordinary-moment-resistant-frames (OMRF)
  - A: ORMF with more than three stories;
  - B: ORMF less or equal to three stories.
- Type 5: Reinforced concrete intermediate-moment-resistant-frames (IMRF).
- Type 6: Reinforced concrete special-moment-resistant-frames (SMRF).
- Type 7: Other (must be specified and described).

Vulnerability Factors Identification

The appropriate vulnerability factors for different types of buildings were selected using the set of appropriate checklists available in a FEMA publication. The basic vulnerability factors related to building systems, lateral force resisting systems, connections, diaphragms, geologic and site hazard, and non-structural hazards were evaluated based on visual observation of buildings and sites. Critical vulnerability factors that were necessary to check with quick calculations were identified in this step. Some specific vulnerability factors like integrity of different structural components, bonding between two wythes of stone masonry wall, flexible roofing and flooring system, interaction of structural/non-structural components were also checked in this step. In addition, provision of seismic detailing was also checked wherever detail construction drawings were available.

Non-Structural Vulnerability Assessment

Identifying Critical Systems and Facilities

Identification of critical systems and essential functions of hospitals was carried out based upon the functional requirements of the hospital during and after an earthquake. The main critical systems and facilities, in each hospital which will be important for continued functionality of the hospital after an earthquake, were identified after visiting the hospital.

Assessment of Individual Components

All the identified critical systems and facilities were visited to evaluate the vulnerability of the individual components. All equipment and components were rated against two earthquakes, i.e. a medium size earthquake (MMI VI-VII) and a severe earthquake (MMI VIII-IX), in terms of different levels of damage. Four levels of damage - very high, high, medium and low were taken in this case. Vulnerability reduction options, implementation priority and cost estimation for implementation of mitigation options were identified for all equipment.

Assessment of Systems' Vulnerability

Based on the assessment of the individual components of the respective systems, the critical systems and medical facilities were examined to find out the possible level of damage in the two earthquake scenarios. Mitigation options for each system were identified and critically evaluated in terms of ease and cost of implementation and their expected efficiency in relation to vulnerability reduction.

Identification of Vulnerability Reduction Measures

Considering the opportunity of immediate implementation of non-structural risk mitigation measures, some examples of mitigation options to solve the problems were developed. The purpose was to guide the hospital maintenance division to start implementation. Some representative problems from different hospitals were taken and solutions were provided using illustrative graphics. One of the examples prepared during the study follows.

Improving Safety of Operation Theatres

Almost all equipment in the operation theatres of Nepalese hospitals were found to be on rollers or roller trolleys without any fixity and are therefore highly vulnerable. However, for everyday use this equipment must be flexible and mobile and cannot be permanently fixed (Fig. 4). Thus a special system for anchoring the equipment is necessary; anchoring which can fix the equipment during operations and can be removed afterwards. The system can be a steel frame consisting of vertical and horizontal angles attached to the equipment rack (Fig. 5). The system should have a numbers of chains, straps, hooks and guide bars in the rack for fixing and securely placing the equipment in the rack. The frame can then be fastened in a location near to the operation table during the operation. By providing anchor bolts in the ceiling and in the floor of the room the equipment rack can be placed in position near the OT table. Similarly, anchor bolts should be provided in the walls in appropriate locations so that the equipment can be removed and fixed in a safe placed when not used.

Fig. 4 Equipment in operation theatres which were not fixed and therefore vulnerable in the event of an earthquake.

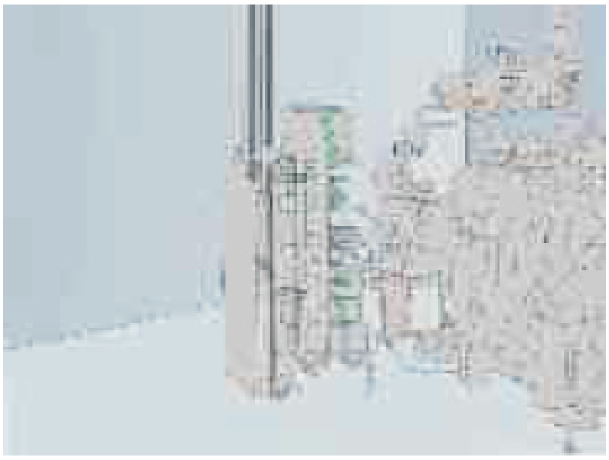

Fig. 5 An example of a vertical steel frame system as a solution to improve safety in operating theatres.

Key Findings and Recommendations

The comparison of the expected seismic performance of the hospitals with the risk assessment matrix gave the result that about 80% of the hospitals assessed fall in the unacceptable performance area for new construction i.e. they are in the situation beyond the FEMA Collapse Prevention Building Performance Level**,** in severe earthquake and the remaining 20% of the hospitals pose life safety to collapse prevention performance level.

The result shows an alarming situation and demanded immediate reconstruction of most of the hospital buildings to achieve a standard acceptable level of safety. However the study recommended the approach of a gradual level of increasing safety considering the socio-economic condition of the country and the fact that medium level earthquakes are more frequent than the severe ones. Thus, priority-wise recommendations are made to improve the seismic performance of each hospital. The seismic vulnerability of different systems, the feasibility of implementing mitigation options, and importance of the different critical systems after an earthquake are taken as basis for the prioritization of recommended actions.

Summary of "Seismic Risk Assessment of Current Buildings of Algiers City" by Mohamed Belazougui, Mohemil N, Farsi, Abdelkader Remas, Mahmoud Bensaibi, and Bahim Mezazigh from the 13th World Conference on Earthquake Engineering, August 1 – 6, 2004

Introduction

Due to the concentration of economic infrastructure and population, Algiers, the capital of Algeria requires attention to protect the city and its people against the risks and consequences of a seismic event. Accordingly, the Algerian authorities have conducted a seismic vulnerability and risk study in order to estimate the potential losses of Algiers City, with a margin of acceptable error. The main objective of this analysis was to identify the zones or districts that would be more exposed to seismic risk. As a result, Algerian authorities are able to localise places for concentrated intervention, and the appropriate means of intervention, in preparation for a seismic event and therefore reduce its negative impact on population and socio-economic assets.

The results of this seismic vulnerability and risk study were obtained using the RADIUS method and the European Macroseismic Scale (EMS 92). The study assumed an earthquake of magnitude of 6.5 generated by the Bouzaréah Fault at 10:00am in the morning. Results from the study are synthesized in tables and maps which represent the losses and damages (in terms of buildings and human lives) in the city. The geographic parameters of Algiers City were limited to 26 districts. The study allowed the Algerian authorities to take arrangements to put the necessary tools in place (emergency plan, politics of prevention, etc.) to mitigate the risks identified.

Methodology

Two methodologies were used to estimate the losses and damage as follows:

a) RADIUS (Risk Assessment Tools for Diagnosis of Urban Areas Against Seismic Disaster) which was developed within the framework of the international decade of the United Nations for the prevention against natural disasters (IDNDR : International Decade for Natural Disaster Reduction, 1990-1999); and

b) The second methodology used is a direct method which is the European Macroseismic Scale (EMS 92). This methodology defines 6 different categories of buildings (6 classes of vulnerability) from A to F.

Algiers earthquake hazard

The Algiers region has experienced in recent history several earthquakes from moderate to strong ones. Recently, the Zemmouri earthquake (May 21st, 2003, M_s = 6.8) caused significant losses.

Description of the existing buildings

Algiers has consisted of a semicircular extension around the historical centre "Casbah", since the 17th and 18th centuries. The old residences of the Casbah are built in poor masonry, slightly tied horizontally by wooden beams.

Around this urban nuclei, old colonial constructions were built (Fig. 6) dating from the 19th century and the beginning of the 20th century. The buildings consist of several storeys (up to 12), generally not horizontally and vertically tied.

A third belt of individual constructions consisting primarily of buildings of medium-low construction (three storeys) are located on the hills surrounding the centre of the city. These structures are generally made of reinforced concrete, or in tied masonry, but not designed according to the seismic code.

The most recent constructions are buildings ranging from five to nine storeys designed according to the seismic code. The quality of construction is however neither always satisfactory, nor uniform. 22 000 of these residences (Fig. 7), were built in the suburbs of the city.

It is important to note that the majority of the administrative buildings of Algiers City are old buildings dating from the colonial period. These constructions, of which some have up to eight storeys, were not designed according to a seismic code. These structures are made of reinforced concrete or heavy masonry with flexible low stories permitting large entries. This compromises the capacity of these buildings to support significant earthquake forces.

The majority of the hospitals are old and obviously not resistant to earthquakes.

RADIUS Method

Input data parameters are magnitude, epicentre, depth and occurrence time. The analysis made considered the

Fig. 6 Examples of old colonial masonry buildings.

Fig. 7 New reinforced concrete building in the Bab-Ezzouar district.

following data: magnitude 6.5 generated by the fault of Bouzaréah at depth of 12 km, and occuring at 10:00am during a working day of week. The epicentral distance is taken equal to 5 km, and the attenuation laws are the ones of Joyner and Boore.

This method supposes that the majority of the inhabitants are in workplaces, children are in schools, hospitals are operating normally, etc. The analysis which combines these seismic data, the nature of the ground, the constructive type and the density of population led to the results of the study.

This scenario gives an average damage total of 20% for the studied area. This is equivalent to losses of approximately 62 515 dwellings. In terms of area, the losses would be more than 3 750 000 m^2 of floors, which represents financial losses of more than 700 000 000 USD. With regard to casualties, it is anticipated that there will be more than 3000 dead people, with more than 40 000 injured.

EMS-92 Scale

Two seismic intensities VIII and IX were considered to apply the vulnerability functions of European scale EMS-92. This generated the following results:

- Financial losses: 826 300 000 USD for intensity VIII of EMS-92;
- Financial losses: 1 558 000 000 USD for intensity IX of EMS-92;
- Human losses: Not given.

Conclusion

The study, with its limits (as only 26 districts studied, and lifelines not considered) provided useful information about the vulnerability of the Algiers and its weak points. These simulations and the knowledge generated from them provide a good indication of what will happen if an earthquake occurs. Tshis information can help to set priorities for the use of the limited resources that the city and the country is able to offer. It is essential to make strong decisions and develop an effective seismic disaster mitigation strategy in order to protect the city against seismic events.

Summary of "Evaluation of housing losses in recent earthquakes in Latin America" by Mario Rodríguez and Marcial Blondet, from the 13th World Conference on Earthquake Engineering, August 1–6, 2004

Introduction

Several recent earthquakes in different areas of Latin America have caused an important toll of casualties and injuries, damage in housing construction and significant losses in the local and national economies. This paper reviews the observed performance of housing construction in the following earthquakes: 1999 Armenia, Colombia; 1985, Michoacan, Mexico; 1997 Oaxaca, Mexico; 2001 San Salvador, El Salvador; 2001, Arequipa, Peru; and 2003, Colima, Mexico.

The study reveals that masonry construction is the most common solution for housing construction in Latin America. Mainly two types of masonry are used: adobe (sun-dried mud blocks) and confined brick masonry (masonry with vertical RC tie-columns to confine brick walls and RC bond beams along walls at floor levels). During the recent earthquakes analysed, adobe construction and unconfined brick masonry had the highest rate of damage or collapse, and in general good performance was observed in confined brick masonry.

The paper also discusses several examples of good and bad housing construction practices. Some events such as the 2001 San Salvador earthquake pointed out the importance of avoiding construction in areas prone to landslides or liquefaction by conducting proper planning in an urban development. Some recommendations are give to reduce seismic vulnerability of housing construction in Latin America.

Conclusions

1. Some earthquakes such as the 1999 Colombia and the 2001 San Salvador earthquakes point out the importance of conducting appropriate identification of soft soils for avoiding construction of poor housing or at least for improving quality construction and detailing in housing construction. Stronger participation and interaction of local engineering communities, government officials and owners seems necessary for achieving these goals.
2. Poor construction quality and poor structural detailing contributed to the collapse or damage of housing in most earthquakes analysed in this study.
3. Local construction techniques and materials have shown promising results for safe, low cost housing construction in seismic regions of Latin America, as in the case of the use of bamboo in Colombia and retrofitted adobe dwellings in Peru. It is important to explore local solutions rather than just trying to adopt housing construction from other local regions.
4. In several Latin American regions, intraplate earthquakes have produced more damage to masonry dwellings than interplate events with higher magnitudes. This fact should be considered in future plans for reducing seismic vulnerability in seismic risk areas in Latin America.

Book Review: "Seismic Design for Architects: Outwitting the Quake" by Andrew Charleson, published by Architectural Press, Oxford, 2008, 281 pages, reviewed by Carol Yung

The title of the book, "Seismic Design for Architects: Outwitting the Quake", outlines the ambitious intentions of its author Andrew Charleson. Upon further examination, the reader is not disappointed at the thorough approach of the author, reinforced by not only the density of material presented, but also by the ease at which seemingly complex concepts are communicated with such simplicity. The book focuses on the core knowlege that architects require to "outwit the quake", emphasising design principles and processes over technical data and analysis. This qualitative approach is emphasised by the author's substantial use of visual material, and the exclusion of civil engineering structures like bridges, wharfs and dams.

The author draws upon his structural engineering experience designing in the southern tip of the Pacific Rim of Fire, a region susceptible to frequent seismic behaviour, followed by twenty years teaching in a School of Architecture. Although the book is suitable for a wide audience, its intended readership is primarily those designing buildings, ranging from architectural students to architects. With a few exceptions, Charleson recognises both the reality of architectural practice, and the tendency of architects to prefer to leave calculations to structural engineers. Accordingly, he emphasises principles and concepts of seismic design, rather than code requirements and calculations.

The chapter sequences of the book reflect a general progression in complexity. Charleson begins with summarizing earthquakes and their actions before moving onto how buildings resist earthquakes and seismic design approaches. Charleson outlines the entire design process through his coverage of horizontal and vertical structure, foundations, building configuration and non-structural elements.

Charleson's book offers excellent descriptions and definitions of key concepts, a number of which are punctuated by simple, but detailed and effective illustrations. He also uses a number of seismic design case

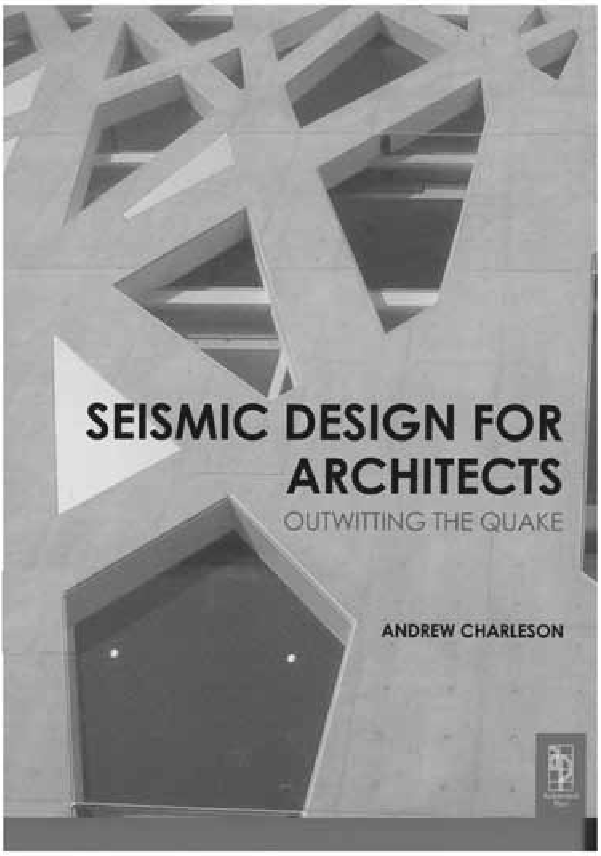

Fig. 8 The cover of Andrew Charleson's book "Seismic Design for Architects: Outwitting the Quake".

studies to enhance the content of the book, including Le Corbusier's Villa Savoye in Paris. The book is also characterized by the author's use of simple analogies and examples to illustrate complex concepts, the most simple of which is his choice of finger clicking to represent the build up of tectonic strain, and the subsequent release of energy.

Despite already managing a dense coverage of the design process, the author also manages to situate the design process within a social context, focusing on issues often encountered in seismically active developing countries. Charleson stresses the need for designers to be prepared for the possibility of negative initial reactions to the introduction and implementation of reliable seismic design practices. Challenging traditional building approaches which are more than often strongly embedded in a country's construction culture requires careful management, justification and professional insistence.

Charleson's chapter entitled "Earthquake Architecture" is dedicated to a theme that resonates throughout his book - the dual role of structure within architecture. Not only should structure be designed to resist loads, but integrated and contributing to the articulation of the design concept or structural action. The author discusses options for expressing seismic resistances in both macro and micro settings – including urban planning, building form and building elements – utilising a number of examples such as the Nunotani Headquarters building, Tokyo and the Museum of New Zealand Te Papa Tongarewa to illustrate these expressions of seismicity through design. Effectively, there is no need for buildings that are required to comply with structural codes to be solely functional and mundane.

The underlying basis for Charleson's book is that structure is an integral part of the design process, instilled with the capacity for enhancing architectural functions, qualities and expression. Through "Seismic Design for Architects", Charleson demonstrates how complying with seismic design codes and regulations need not limit the scope for architectural innovation and high design outcomes in regions susceptible to seismic activity.

The book's excellent approach and extensive content is essentially driven by the role of the architect in seismic design, and is a valuable tool in the understanding and generation of design in seismically active landscapes.

"Seismic Design for Architects" can be purchased online at Amazon (www.amazon.com) or alternatively, a copy of this publication can also be obtained by contacting Architectural Press, Linacre House, Jordan Hill, Oxford OX2 8DP, United Kingdom. Postage and handling costs may differ between suppliers.

Earthquake Hazard Centre
Promoting Earthquake-Resistant Construction in Developing Countries

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