What we have forgotten about Earthquake Engineering.

Perla R. Santa-Ana L.
Universidad Nacional Autonoma de México, UNAM.
Baez Santa Ana Ingenieros Consultores SA de CV

Lucia G. Santa-Ana L.
Universidad Nacional Autonoma de México, UNAM.

Jose Baez García
Baez Santa Ana Ingenieros Consultores SA de CV

SUMMARY:
Great number of studies about earthquake engineering are made every year; results of this research are applied into seismic building codes, but this knowledge does not arrive to all the people involved in the construction field. An analysis between undergraduate programs curricula of civil engineering and architecture of 20 different universities from 11 countries is presented. Results show that the approach to earthquake engineering is similar in most of the universities: seismic courses are part of structural engineering graduate program while most of the undergrad programs include seismic engineering only as part of basic design courses. Most constructions in every country are built by owners, undergrad architects and civil engineers with a very general knowledge of seismic behaviour, condition which leads to a misunderstanding of seismic codes as they applied them. The consequences of forgetting the importance of seismic matters is presented with examples of existing buildings with seismic structural problems.

Keywords: seismic engineer, structural damage, undergraduate program, courses, structural engineer.

1. INTRODUCTION

When an Earthquake strikes and causes structural damage and deaths the conscience of seismic engineers, some architects and contractors is awakened. Studies are made with the new information recorded from the earthquake, results of the research after years of studies are applied into seismic building codes, but are all the people involved in the construction field aware of future structural risk in seismic regions?

In Mexico most civil engineering undergraduate programs include only one course related to earthquake engineering and it is mainly focus into the application of regional seismic codes and basic seismic structural design principles; dynamic principles and seismic structural design modules, which would be an important element to understand the problem, are part of the graduate program, becoming unknown topics to many engineers as few of them study a graduate program. In the case of architecture undergraduate programs, they include the earthquake effects on buildings only as part of a structural design course or in some cases it is ignored at all.

This scenario lead to ask questions such as: Is it possible to make an architectural design without taking into account earthquake effects in seismic regions? Is it possible for an architect or civil engineer to design or built a construction with the knowledge got from one seismic course?

As an emergent country, constructions in Mexico are design and built by architects, civil engineers and contractors, most of them with an undergrad degree have a poor understanding of seismic codes because the lack of knowledge about seismic response. Only important or international developments are able to hire local or international structural engineers in order to make the structural design of the project. Is this a problem only in emergent countries or is it a worldwide education problem related to the concept of what would be the seismic knowledge engineers and architects should have especially in seismic countries?

The objective of this paper is to present part of the results of an study that compares architecture and civil engineering programs from universities worldwide, specially from countries affected directly by earthquakes, in order to establish what is the approach each institution gives to seismic engineering. A comparison of civil engineering undergraduate programs from 20 top rank universities settle at eleven different countries is made; twelve architecture programs with structural and seismic courses from nine countries are also presented.

The final aim of this study is to propose the integration of special seismic courses so undergraduate architects and civil engineers learn the basics of earthquake engineering, understand seismic codes, apply structural design codes correctly and get their interest about all the seismic research. It is for us to remember that if our students learn and apply this seismic knowledge correctly, our countries will suffer less damage and the population will suffer less negative effects by failing or damaged structures when an earthquake strikes.

2. INSTITUTIONS APPROACH TO SEISMIC ENGINEERING.

2.1 Universities Selected.

Twenty one universities from eleven different countries were selected and are presented at table 1.0. The process for selection of each institution considered: i) To be in a country affected by earthquakes or a country that exports civil engineers to build in other countries (i.e. England or USA); ii) To be a top rank university in its country; iii) Present a civil engineering undergraduate program with a focus on structural engineering; iv) The architectural undergraduate program should have a structural and constructive orientation; v) Have an undergraduate handbook in English.

Table 1.0. Countries and universities selected.

University	State and Country
Universidad Nacional Autónoma de México	Mexico City, Mexico
Universidad de Chile	Santiago de Chile, Chile
Berkeley University of California	California, United States
Stanford University	California, United States
Columbia University	New York, United States
Princeton University	New Jersey, United States
Massachusetts Institute of Technology (MIT)	Massachusetts, United States
The Pennsylvania State University	Pennsylvania, United States
McGill University	Quebec, Canada
University of Toronto	Ontario, Canada
The University of British Columbia	British Columbia, Canada
University of Canterbury	Christchurch, New Zealand
The University of Auckland	Auckland, New Zealand
The University of Sydney	Sydney, Australia
University of Cambridge	Cambridge, United Kingdom
Imperial College London	London, United Kingdom
Osaka University	Osaka, Japan
Tokio University (BArch.)	Tokio, Japan
Istanbul Technical University	Istanbul, Turkey
Tsinghua University	Beijing, China
Politecnico di Torino	Torino, Italy

2.2. Seismic courses at undergraduate programs.

To establish a general pattern for the approach of seismic topics, only courses that have this theme in its syllabus (among other subjects) were written over a table; first rows establishes name of the university, program degree and average number of semesters to graduate. Fourth row presents preparatory courses for understanding the seismic performance of the structure. Rows under the title "Courses w/design seismic code" are courses that study seismic behavior while learning to apply seismic aspects that are required by design codes or seismic codes, but their approach is not deep enough because other type of effects are also taken into account (i.e. wind, snow, gravity, etc). Final rows under the title "Seismic courses per se" name courses that all their subjects are meant to study earthquakes and seismic structural response. This kind of courses will be the ideal to have in all BS Civil Engineering program with major in structures.

To get a worldwide view, universities are grouped by zones: a) Table 2. Group 1. Universities of America and Latin America, Civil Engineering Undergraduate Programs; b) Table 3. Group 2. Universities of Asia, Oceania and Europe, Civil Engineering Undergraduate programs; c) Table 4. Group 3. Universities of America, Europe, Asia and Oceania with Undergraduate Architectural programs.

Table 2.0. Group 1. American Universities, Civil Engineering Undergraduate Program.

UNIVERSITY	UNIVERSITY OF CALIFORNIA, BERKELEY	STANFORD UNIVERSITY	COLUMBIA UNIVERSITY	PRINCETON UNIVERSITY	MASSACHUSETTS INSTITUTE OF TECHNOLOGY	PENNSYLVANIA STATE UNIVERSITY
DEGREE	BS CIVIL ENGINEERING	BS MAJOR STRUCTURES & CONST	BS CIVIL ENGINEERING	B STRUCTURAL ENGINEERING	BS CIVIL ENGINEERING	B STRUCTURAL ENGINEERING
SEMESTERS	8	8	8	8	8	8
COURSES W/ INDIRECT SEISMIC APPROACH	------	Dynamics (elective) Semester 7	Dynamics and vibrations Semester 5	------	Motion based design (elective) Semester 7	Dynamics Semester 4
	Structural Engineering. Semester 7	Design of steel structures. Semester 7	Structural design. Semester 7	Design of reinforced concrete structures. Semester 5	Design of steel structures. (elective) Semester 7	Design of steel structures. Semester 7
COURSES W/ DESIGN SEISMIC CODE	Design of steel structures. Semester 8	Design of concrete structures. Semester 8	Advanced design of steel structures (elective)	Design of steel structures. Semester 6	Mechanics and Design of Concrete Structures (elective) Semester 7	Design of concrete structures. Semester 6
	Design of concrete structures. Semester 8	Integrated Civil Engineering Design Project Semester 8	Advanced design of concrete structures (elective) Semester 8	Design of Large-Scale Structures: Buildings (elective) Semester 7	Structural and Geotechnical Engineering Design	Advanced structural Design Semester 8
	------	------	Earthquake and wind engineering (elective) Semester 8	Introductory to Seismology (elective) Semester 8	Structural Dynamics and Vibrations (elective) Semester 8	------
SEISMIC COURSES PER SE	------	------		Structural Dynamics in Earthquake Engineering (elective)		

UNIVERSITY	MC GILL UNIVERSITY	UNIVERSITY OF TORONTO	UNIVERSITY BRITISH COLUMBIA	UNIVERSIDAD NACIONAL AUTONOMA MEXICO	UNIVERSIDAD DE CHILE	
DEGREE	BS CIVIL ENGINEERING	BS CIVIL ENGINEERING	BS CIVIL ENGINEERING	BACHELOR CIVIL ENGINEERING	BACHELOR CIVIL ENGINEERING	
SEMESTERS	8	8	8	9	8	
COURSES W/ INDIRECT SEISMIC APPROACH	Dynamics Semester 4	------	------	------	------	
	Design of steel structures. (elective) Semester 7	Steel and timber design. Semester 5	Design of concrete structures. Semester 7	Structural design. Semester 7	Structural design. Semester 7	
COURSES W/ DESIGN SEISMIC CODE	Advanced design of concrete structures (elective) Semester 7	Reinforced concrete design I (Semester 6)	Engineering Design and Analysis I. Semester 7	Steel design structures (elective). Semester 8	Design of concrete structures. Semester 8	
	Design Project and Professional Practice. Semester 8	Structural Design I. (elective) Semester 8	Advanced structural steel design (elective) Semester 8	Masonry and Concrete design stuctures (elective). Semester 8		
		Group Design Project. Semester 8	Design of timber Structures.(elective) Semester 8			
SEISMIC COURSES PER SE	------	------	------	------	Structural Dynamics. Semester 8	

All selected programs for civil engineering propose an average of 8 semesters a bachelor degree, (except Politecnico di Torino that has only 6 semesters); All programs curricula have similar seismic

courses that are taken in the same period (from 6th to 8th semester).

Considering that the mean number of modules for each program is 33 and that the courses relative to earthquake effects are on average 3.5 per program, it can be stated that seismic courses represent only 10.6% of the undergraduate civil engineering program.

Table 3.0. Group 2. Oceania, Asia and Europe Universities, Civil Engineering Undergraduate Program.

UNIVERSITY	UNIVERSITY OF SYDNEY	UNIVERSITY OF CANTERBURY	UNIVERSITY OF AUCKLAND	OSAKA UNIVERSITY	TSINGHUA UNIVERSITY
DEGREE	BE CIVIL ENGINEERING (STRUCTURAL)	B OF ENGINEERING	BE CIVIL ENGINEERING	CIVIL ENGINEERING	B CIVIL ENGINEERING
SEMESTERS	8	8	8	8	8
COURSES W/ INDIRECT SEISMIC APPROACH	------	------	------	------	Dynamics Semester 3
	Introduction to Structural Concepts & Design Semester 4	Structural Analysis(elective) Semester 7	Structures and Design (elective) Semester 7	Design of structures. Semester 4	Reinforced Concrete Design Semester 6
COURSES W/ DESIGN SEISMIC CODE	Concrete Structures I Semester 5	Structural Design Semester 6	Multistorey Building Design (elective) Semester 8	Soil Mechanics II and Excercises Semester 5	Steel structures project design Semester 6
	Steel Structures I Semester 6		Advanced structural concrete (elective) Semester 8	Steel Structures Semester 6	
	Civil Engineering Design Semester 8			Concrete Structures. Semester 6	
	------	Structural Systems (elective) Semester 7	Structural Dynamics Semester 6	Structural Dynamics. Semester 6	Theories of Seismic design. Semester 8
SEISMIC COURSES PER SE		Steel structures seismic design (elective) Semester 8			Tall building structures and Seismic design. Semester 8
		Concrete structures seismic design (elective)Semester 8			

UNIVERSITY	UNIVERSITY OF CAMBRIDGE	IMPERIAL COLLEGE LONDON	ISTANBUL TECHNICAL UNIVERSITY	POLITECNICO DI TORINO	
DEGREE	M ENGINEERING	M ENG CIVIL ENGINEERING	BS CIVIL ENGINEERING	CIVIL ENGINEERING	
SEMESTERS	8	8	8	6	
COURSES W/ INDIRECT SEISMIC APPROACH	------	Dynamics Semester 6	Dynamics Semester 3	------	
	Structural Materials and design Semester 5	Steel Structures and Design I and II Semester 6 & 7	Reinforced Concrete I Semester 6	Structural Engineering Semester 5	
COURSES W/ DESIGN CODE SEISMIC	Concrete and masonry structures. Semester 7	Concrete Structures I. Semester 6	Steel design I (elective) Semester 6	Building Technology and details. Semester 8	
	Structural steelwork (elective) Semester 7		Structural Systems. Semester 8		
	Dynamics in civil engineering (elective) Semester 8	Structural Dynamics. Semester 8	------	------	
SEISMIC COURSES PER SE		Engineering Seismology. Semester 8			
		Earthquake Engineering. Semester 8			

Because few schools of architecture have taken into account the technical aspects, just one table was made (Table 5.0), presenting only the structural courses of each institution´s program, so they can be compared and conclude where the seismic approach in architecture is missing.

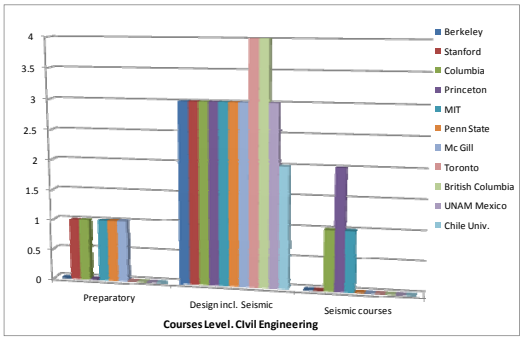
Table 4.0. Group 3. All Universities Architectural undergraduate program.

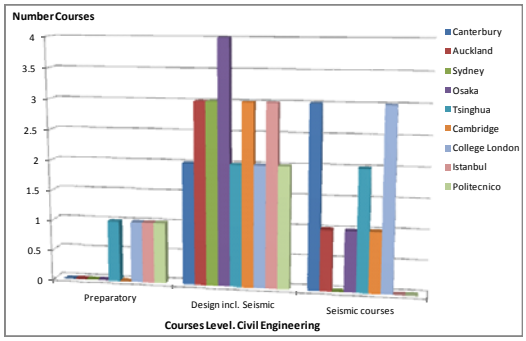
UNIVERSITY	UNIVERSITY OF CALIFORNIA, BERKELEY	STANFORD UNIVERSITY	PRINCETON UNIVERSITY	MASSACHUSETTS INSTITUTE OF TECHNOLOGY	MC GILL UNIVERSITY	UNIVERSIDAD NACIONAL AUTONOMA MEXICO
DEGREE	B ARTS MINOR STRUCTURAL ENG	BSE MJR ARCHITECTURAL	BSE ARCHITECTURE	BS ARCHITECTURE	BS ARCHITECTURE	BACHELOR ARCHITECTURE
SEMESTERS	8	8	8	8	8	8
COURSES W/ INDIRECT SEISMIC APPROACH	------	------	------	------	------	------
	Structure, Construction & Space	Design of Steel Structures	Structural Design	Building Structural Systems 1	Structural Steel&Timber Design	Building construction IV. Seismic codes
COURSES W/ DESIGN CODE SEISMIC	Special Topics in Building Structures	Integrated Building Design	Design of Reinforced Concrete Structures		Foundations & Concrete Design	
	Design and Computer Analysis of Structure	Building Systems	Design of Large-Scale Structures: Buildings			
SEISMIC COURSES PER SE	Seismic Design & Construction	------	Structural Dynamics& Earthquake	------	------	------

UNIVERSITY	UNIVERSITY OF AUCKLAND	KYOTO UNIVERSITY	TSINGHUA UNIVERSITY		UNIVERSITY OF CAMBRIDGE	ISTANBUL TECHNICAL UNIVERSITY
DEGREE	BAS ARCHITECTURE	B ARCHITECTURE	B ARCHITECTURE		B ARCHITECTURE	BS CIVIL ENGINEERING
SEMESTERS	8	8	8		8	8
COURSES W/ INDIRECT SEISMIC APPROACH	------	------	------		------	------
	Design technology II	Reinforced Concrete Structure I	Building Construction I		Principles of Structural Design	Steel structures
COURSES W/ DESIGN CODE SEISMIC	Design technology III	Steel Structure I	Building Construction II		Advanced Studies in Construction Technology,	Reinforced concrete structures
		Building Systems Design				Buliding element design
SEISMIC COURSES PER SE	------	Earthquake Resistant Structures	------		------	------

2.3. Analysis of the approach of each Curricular Program.

Taking into account the number of courses and the approach some of this modules have to seismic topics (i.e. level of understanding and application of earthquake effects), histograms of the number of courses and their level of seismic approach were made for each group of universities and are presented in the next figures (fig 1-4).



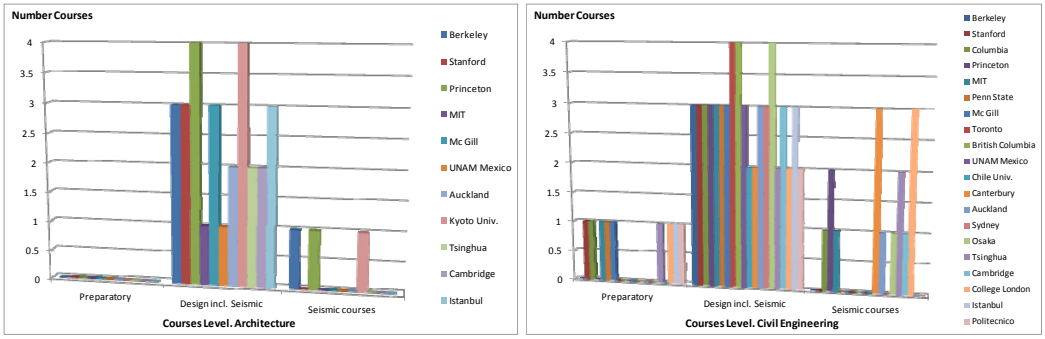


Figures 1 and 2. Histograms of number of courses and approach to seismic effects. Left: Group 1 of Universities (Table 2). Right: Group 2 of Universities (Table 3).

For group one American Universities (fig.1), it can be concluded that more than 50% of the civil engineering programs approach seismic engineering through structural design courses, making students to learn and consider earthquake effects applying seismic codes requirements. Less than a third of Civil Engineering schools in this group have specific seismic courses for undergrad students,

even though their majors are structural. Only five of eleven institutions have "Dynamic course" as compulsory module but they do not have a sequential course to applied dynamic effects over structural systems.

The approach of learning seismic engineering through application of seismic codes requirements may present one problem: if the student doesn´t understand the seismic origin of codes requirements, wrong interpretations can be made generating ill structural and design solutions. In this group the most complete seismic engineering program found is the one proposed at Princeton curricula; it includes seismology principles, structural dynamics and structural design with seismic effects.



Figures 3 and 4. Histograms of number of courses and approach to seismic effects. Left: Group 3 of Universities (Table 4). Right: All groups of Universities with Civil Engineering Undergrad program.

Group two, Asia, Oceania and Europe Universities programs (fig. 2). Programs curricula have more specific seismic compulsory modules giving more emphasis to seismic engineering. This universities also have structural design courses where seismic effects are considered and seismic codes are applied. Canterbury, Cambridge, Osaka and Tsinghua University focus most of their structural design courses to earthquake effects while Imperial College of London offer three mandatory seismic modules. This institutions have a complete civil engineering program with a very good approach to seismic behaviour and seismic design, desirable for every university whose students will work in seismic countries. Only Turkey and Italy have an approach similar to American and Latin American universities.

Group three, Architecture undergrad program with major in construction or structural (fig. 3). Less than half of architecture schools considered earthquake modules into their curricula. Three of eleven institutions have one seismic course. It can be resume that most architecture programs have a basic or poor level of approaching seismic engineering; only Kyoto, Berkeley and Princeton have a more complete seismic curricula presenting an excellent technical program including earthquake design.

3. PROPOSAL FOR UNDERGRADUATE PROGRAMS.

3.1. Is there a Worldwide seismic education problem?

Programs for civil engineer or civil and environmental engineer have been growing in different areas, so the undergrad level gives a general education and if you need to know about earthquake engineering a graduate level must be taken. But what happens with bachelors that do not continue with a graduate level and get licensed? According to the US Department of Education at 2009, 1,601,368 bachelor's degree were conferred by postsecondary degree-granting institutions; in this same year only 656,784 master's degrees were conferred meaning that 40% of students get to graduate level.

What can be done to give students a better training and understanding of seismic matters with the same short time of a bachelor degree? To find the answer we should look at the curricula of civil

engineering with structure majors at Princeton, Osaka, University of Canterbury or the Imperial College of London. With five courses oriented to seismic engineering (two specific courses about seismology and earthquake engineering and three structural design modules with emphasis in seismic design) can make the difference in the future engineer or architect for a better understanding of this natural phenomena and its effects on structures.

The program of architecture is a more complex problem; many universities considered architecture as an art and design phase that doesn't need of seismic or other load effects. Structural engineers are hired to satisfy their artistic architectural design, but what happens in small places or emerging countries where the architect not only design but also is the contractor and structural designer? Also licensed architects must know the effects of earthquakes in their projects in every subject: structural, plumbing, electrical, mechanical, design, etc. A good example of an architectural program oriented to constructions or structures is the one of the University of Kyoto with four courses with focus on seismic topics and codes requirements.

All institutions located at seismic countries must include in their undergrad curricula for civil engineers with major in structures & construction and architects with major of construction, at least two specific courses of earthquake engineering, so they can learn the seismic behaviour of a structure, its seismic variations and the impact of the structural design. Courses of structural design of elements with different materials should emphasize the seismic effects and code requirements.

3.2. Proposal for integrating seismic topics into undergraduate programs.

Analyzing the courses written over the tables and its syllabus, it can be established the number of minimum courses an undergrad student should take to get a better understanding of seismic engineering: i) Dynamic or better yet Dynamic of structures; the subjects of this course makes us to understand the physics of the seismic effect and most important the consequences over all kind of structures; ii) Structural Seismic Design; a course whit focus on the synthesis of the dynamic structural system response with the seismic codes parameters and special recommendations; iii) Design of structures: behaviour of concrete, steel or timber including earthquake effects and code requirements. Research studies about seismic behaviour and effects over structural and non-structural elements should be part of every seismic course.

With the previous courses in mind one instructional strategy proposal arises to make it easier and to get a constructive and meaningful knowledge about seismic matters: a) Structural dynamics. Joining the dynamic concepts with structural behaviour over one small project built by students into scale and tested in small shaking table; b) Structural Seismic Design. Making the synthesis of the dynamic response of a structure and translating the effect to the seismic codes requirements gives the student the chance to understand on a better way seismic codes and in the future a correct application of them; c) Design Structures: course concentrate only in the structural design of every material most used (i.e. concrete, steel, timber) using seismic codes, seismic construction details and reading seismic research about material behaviour under earthquake effects.

Having civil engineers and architects with bachelor degree with a good understanding of seismic effects will reduce the seismic risk in more towns, cities and countries, especially those designing in high seismic countries.

4. MEXICO'S AND EMERGING COUNTRY CASE.

4.1. Background problem.

Mexico has a general educational problem; with a population of 112,337,000 at 2010 only 0.34% were in that year students registered in engineer and architectural undergrad program. Only 10%

approximately of those registered students graduate and 2% continue with graduate studies (figure 5).

With this numbers in mind, it is important to have the most complete civil engineering and architectural bachelor programs and they must include seismic principles and its effects on structural and architectural design. Most of the universities in the country have similar civil engineer programs, where only three courses study seismic effects as part of their subjects: structural design, design of concrete structures and design of steel structures.

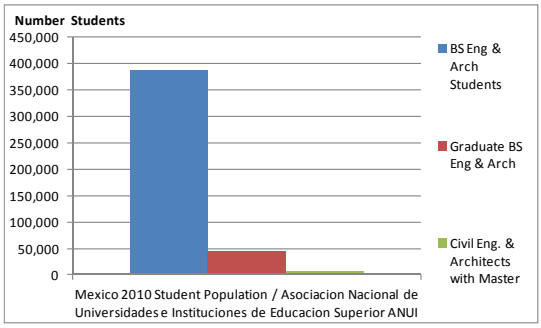


Figure 5. Mexico's Civil Engineering and Architect students in 2010; first column are students that finish undergraduate school, second column are graduate with bachelor degree and third row are graduate students.

Just as the American Universities, this approach is dangerous because it is based in the application of seismic codes requirements and it depends on the professor experience or understanding to explain correctly the seismic background of Mexican codes.

The case for architectural program is critical; few undergrad programs take into account seismic design with one mandatory course: basic seismic design according to Mexican seismic codes; other programs curricula have two more courses based on the effects of seismic codes during structural design of reinforced concrete or steel structures.

The lack of courses about seismic subjects in undergraduate programs make that most of students forget they live in a seismic zone and that every building must be design taking its effects into account, using correctly seismic codes and making the correct structural details during its construction.

In Mexico only special constructions need the seal of a certified structural engineer, this is around 15% of all the constructions built in the country. The 85% constructions remaining are certified by architects and engineers (Director Responsable de Obra, DRO) that know the construction codes of the zone but most of them doesn't apply this codes correctly or just doesn´t apply them because they don´t understand them. The results of seismic research made in Mexico does not reach undergraduate students; as a consequence seismic effects are not taken into account by most of the population constructions, causing great damages to small villages, towns or cities (i.e. Oaxaca Earthquakes on march 20-27, 2012) endangering lives.

4.2. Example of lack of seismic knowledge.

Unfortunately many contractors and designers today in Mexico (structural engineers, architects or just civil engineers) do not understand the consequences of a wrong structural seismic configuration. Maybe it is not their fault, because they did not learn earthquake effects at school.

We present two cases of first soft story structures. Two relative new buildings (2005) constructed at Mexico City are shown at figures 6 and 8. Case 1: Building at figure 6 is grounded over soft soil (Mexico's city center) and have an structural system of concrete rigid frames; masonry walls should not be structural but because they are anchored to the frames, they will tend to work as shear walls.

Even though this structures are adequate for gravity loads, their columns will have strength problems during a strong earthquake; figure 7 is an interior look of the same building, where beams with depth of 70 cm joined to a reinforced concrete column of 40 x 40 cm base and depth generating a week column-strong beam effect.

Case 2: A condo building is presented at figure 8. This building has a structural system of concrete rigid frames and masonry shear walls at upper levels. At floor level columns not only have a relative small transversal section but have 6 m of height. It is grounded on compressible soil, with a seismic acceleration coefficient of 0.40g. This structure will suffer damages during a relative strong earthquake because of its soft story.

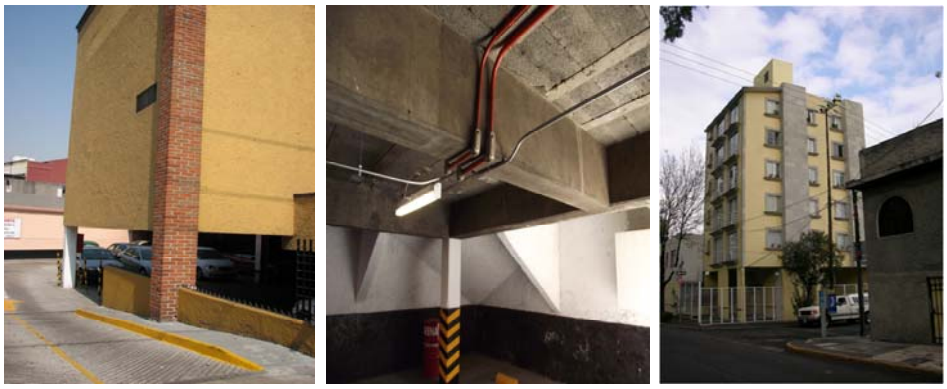


Figure 6, 7 and 8. Soft story buildings at Mexico City. Left: Exterior image of an office building at Colonia Doctores. Center: Interior view of office building. Right: Condo building at Colonia Nativitas.

This cases show the lack of seismic structural behaviour understanding; both buildings blue prints were authorized by someone who knows Mexican seismic codes, but doesn't understand them. Unfortunately this cases are not the only ones in Mexico City and in all our country.

5. CONCLUSIONS.

Universities' programs curricula in countries with seismic exposure and from universities whose graduate students will work and design projects in seismic countries were analyzed. Civil Engineering and Architecture programs have great number of subjects to learn during undergraduate period, but professionals that will construct and design on every aspects (structural, mechanical, architectural, etc.) must be aware of the seismic effects, understand seismic principles and learn to apply seismic codes requirements correctly; we must remember that even in advanced countries not every student gets to graduate studies and in many emergent countries to get graduate studies is a minority.

In this study adequate programs with a complete seismic approach were found; unfortunately they represent only 30% of the undergraduate programs analyzed. Taking those programs as an example of what can be done, it was proposed in this study that there should be at least 4 courses with seismic approach: dynamic of structures, Structural seismic design, design of structures concrete and steel. The main purpose of this courses will be to explain the effects of earthquakes over structures, how structural systems will respond to seismic effects and to detailed design of structural elements so all code requirements can be fulfil. Research about seismic studies must be part of the syllabus of all seismic courses.

A special effort should be made in emerging countries like Mexico; universities have to work harder in the curricula for architecture and civil engineering programs, including more seismic courses as mandatory. With bachelors in engineers and architecture better prepared with a more complete understanding of seismic engineering and earthquake effects, countries can expect less structural damages and less casualties as consequence.

REFERENCES

College of Engineering (2012). *Undergraduate Handbook 2011-2012*, University of California, Berkeley. Available from: http://coe.berkeley.edu/students/Advising%20handbk%2010-11%20correct%20format%20copy.pdf/view > [06 January 2012].

Department of Civil & Natural Resources Engineering (2012). *2012 Undergraduate Handbook*, University of Canterbury. Available from: <http://www.civil.canterbury.ac.nz/becivil.shtml> [05 January 2012]

Department of Civil Engineering (2012). *Civil Engineering undergraduate program*, University of Toronto. Available from: <http://www.civil.engineering.utoronto.ca/programs/undergraduate/civ.htm>. [10 January 2012]

School of Engineering and Applied Science (2012) *Engineering Sciences courses.* Columbia University. Available from: < http://bulletin.engineering.columbia.edu/undergraduate-degree-tracks-2> [5 January 2012]

Civil and Environmental Engineering (2012). *Undergraduate curriculum* University of California, Berkeley. Available from: < http://www.ce.berkeley.edu/undergrad/curriculum?destination=node%2F81> [6 January 2012]

Departamento de Ingenieria Civil (2011). *Plan de Estudios (Enero 2011)*, Universidad de Chile. Available from: http://www.ingcivil.uchile.cl/index.php?option=com_content&task=view&id=70&Itemid=279 [4 January 2012]

Department of Civil and Environmental Engineering (2011). *Structural Engineering Academic Program Planning Pages*, Princeton University. Available from: <http://www.princeton.edu/cee/undergraduate/requirements/structural/> [16 January 2012]

Department of Civil and Environmental Engineering (2011). *Architecture and Engineering Academic Program Planning Pages*, Princeton University. Available from: http://www.princeton.edu/cee/undergraduate/requirements/architecture/. [10 January 2012]

Department of Civil and Environmental Engineering (2011). *Undergraduate Handbook.* Pennsylvania State University. Available from: < http://www.engr.psu.edu/ce/undergraduate.html> [20 January 2102]

Department of Architecture (2011) *2011-2012 Undergraduate Program*, Massachusetts Institute of Technology. Available from: http://architecture.mit.edu/handbook/undergraduate-students [15 January 2012]

School of Engineering (2011). *2011-2012 Handbook for Undergraduate Engineering Programs*, Stanford University. Available from: < http://cee.stanford.edu/prospective/undergrad/consideringCEE.html > [11 January 2012]

Civil Engineering (2011). *Undergraduate Program Courses*, McGill University. Available from: <http://www.mcgill.ca/civil/undergrad/courses/> [16 January 2012]

Civil Engineering (2011) *Undergraduate Program and Courses*, University of Toronto. Available from: <http://www.civil.engineering.utoronto.ca/programs/undergraduate/civ.htm > [15 January 2012]

Civil Engineering (2011) *Bachelor of Applied Science*, University of British Columbia. Available from: <http://www.calendar.ubc.ca/vancouver/index.cfm?tree=12,195,272,37 > [16 January 2012]

Facultad de Ingenieria. *Plan de estudios de la carrera de ingenieria civil*, Universidad Nacional Autónoma de México. Available from: <http://www.ingenieria.unam.mx/paginas/Carreras/planes2010/ingCivil_Plan.htm > [19 January 2012]