Available online at www.sciencedirect.com

SciVerse ScienceDirect

Procedia - Social and Behavioral Sciences 51 (2012) 1080 – 1086

Procedia
Social and Behavioral Sciences

ARTSEDU 2012

Examination of earthquake resistant design in the education of architecture

Asena Soyluk [a] *, Zeynep Yeşim Harmankaya [b]

[a] Dr., Gazi University, Maltepe Campus, Ankara, 06570, Turkey
[b] M.Sc., Gazi University, Maltepe Campus, Ankara, 06570, Turkey

Abstract

This study has been carried out to identify the knowledge of students about the irregularity of the structures and to assess the effect of power point presentation provided. It was conducted on the last year undergraduate students at Gazi University Department of Architecture. The questionnaire form designed by the researcher to collect data, was used as a pre-test to know about the students' earthquake resistant design. Then the students were provided with earthquake resistant design training. Following the training, the questionnaire was employed as a post-test to identify the effect of the training and the difference between the pre-test and post-test was determined.

Selection and/or peer review under responsibility of Prof. Dr. Ayse Çakır Ilhan.

Keywords: Irregular Buildings, Structure Knowledge, Earthquake Resistant Design, Architectural education, Power-point presentation

1. Introduction

Earthquake is one of the major problems for Turkey because of its location on the Alp-Himalayas Fault, which is one of the most active earthquake areas on the world. Being very close (about 5-30 km) to the surface, the earthquakes that occur especially on the North Anatolian fault are very dangerous [Ministry of Public Works and Settlement Government of Republic of Turkey, 2011]. In the last 58 years, 58 202 people were killed, 122 096 were injured due to earthquakes in Turkey. Moreover nearly 411 465 buildings were collapsed or heavily damaged. In brief, almost 1003 people die and 7 094 buildings collapse per year in Turkey [Turkish Republic Disaster and Emergency Management Precedency, Earthquake Department, 2012].

The investigations of damage which have occurred in past earthquakes have clarified the causes of earthquake damage in structures. There may be listed as follows:

a. Undesirable geometric configuration
b. Inadequate lateral stiffness
c. Flaws in detailing

According to experiences from past earthquakes of Turkey, the collapses or damages of buildings were directly or indirectly related to the architectural design. Since the irregularity of a building is one of the main causes of heavy damages, there has been a title called "Irregular Buildings" in Turkish earthquake code since 1998 [Specification for Structures to be Built in Disaster Areas, 1998]. Under this title, some types of buildings are

* Corresponding Author; Asena Soyluk. Tel.: +90-312-582-3657
E-mail address: asenad@gazi.edu.tr

1877-0428 © 2012 Published by Elsevier Ltd. Selection and/or peer review under responsibility of Prof. Ayşe Çakır İlhan
Open access under CC BY-NC-ND license. doi:10.1016/j.sbspro.2012.08.291

defined as irregular, and architects are advised to avoid these kinds of irregular configuration designs. However this section in the Turkish earthquake regulation is not clearly understood by the architecture students.

Architects who work on seismic regions should give adequate consideration to 'earthquake' as a design criterion when it is compared with the more ordinary ones such as customer demands, function, aesthetics and environmental factors. Under the influence of the uncommon and impressive designs of the new structures which are rising in non-seismic regions, the architectural students in Turkey could not completely recognize the importance of the earthquake's devastating impact and resistance of the structures to the lateral seismic loads. Such earthquake - resistance criteria should be instructed and emphasized in the architectural design education in earthquake zone located countries like Turkey.

2. Turkish Earthquake Code

In Turkey, there is an earthquake code that is used to determine the behavior and the earthquake resistance of the buildings [Specification for Structures to be Built in Disaster Areas, 2007]. At the beginning of this code it is mentioned about earthquake resistant buildings under the chapter of "Analysis Requirements for Earthquake Resistant Buildings". This chapter is generally dedicated to architectural design and it is most important section for architects (Harmankaya & Soyluk, 2012).

The main section of the part that addresses the most to the architectural audience is the "Definition of İrregular Buildings". Irregular buildings are defined in this part as "*buildings whose design and construction should be avoided because of their unfavourable seismic behavior*". In this section, various types of geometric arrangements and structural behavior patterns in plans and elevations of buildings are identified as irregularities in terms of seismic design. As seen from Figure 1, these irregularities, first divided into two groups. The first group is about irregularities seen in plan called "A-type of irregularities" and second one is concerned with irregularities in elevation called "B-type of irregularities". Then, irregularities in plan and in elevation are further subdivided into three groups. But, the important point in the identification of such concepts is that all irregularities are defined as solely mathematical formulas.

Figure 1. Irregularities according to 2007 Turkish Earthquake Code [Specification for Structures to be Built in Disaster Areas, 2007].

A – *IRREGULARITIES IN PLAN*	B – *IRREGULARITIES IN ELEVATION*
A1 – Torsional Irregularity : The case where *Torsional Irregularity Factor* η_{bi}, which is defined for any of the two orthogonal earthquake directions as the ratio of the maximum storey drift at any storey to the average storey drift at the same storey in the same direction, is greater than **1.2**. $[\eta_{bi} = (\Delta_i)_{max} / (\Delta_i)_{ort} > 1.2]$ *Storey drifts shall be calculated in accordance with* **2.7**, *by Considering the effects of ± %5 additional eccentricities.*	**B1 – Interstorey Strength Irregularity (*Weak Storey*) :** In reinforced concrete buildings, the case where in each of the Orthogonal earthquake directions, *Strength Irregularity Factor* η_{ci} which is defined as the ratio of the *effective shear area* of any storey to the *effective shear area* of the storey immediately above, is less than **0.80**. $[\eta_{ci} = (\sum A_e)_i / (\sum A_e)_{i+1} < 0.80]$ *Definition of effective shear area in any storey* : $\sum A_e = \sum A_w + \sum A_g + 0.15 \sum A_k$
A2 – Floor Discontinuities : In any floor ; **I** - The case where the total area of the openings including those of stairs and elevator shafts exceeds 1/3 of the gross floor area, **II** – The cases where local floor openings make it difficult the safe transfer of seismic loads to vertical structural elements, **III** – The cases of abrupt reductions in the in-plane stiffness and strength of floors.	**B2 – Interstorey Stiffness Irregularity (*Soft Storey*) :** The case where in each of the two orthogonal earthquake directions, *Stiffness Irregularity Factor* η_{ki} , which is defined as the ratio of the average storey drift at any storey to the average storey drift at the storey immediately above, is greater than **1.5**. $[\eta_{ki} = (\Delta_i)_{ort} / (\Delta_{i+1})_{ort} > 1.5]$ *Storey drifts shall be calculated in accordance with* **2.7**, *by considering the effects of ± %5 additional eccentricities.*
A3 – Projections in Plan : The cases where projections beyond the re-entrant corners in both of the two principal directions in plan exceed the total plan dimensions of the building in the respective directions by more than **20%**.	**B3 - Discontinuity of Vertical Structural Elements :** The cases where vertical structural elements (columns or structural walls) are removed at some stories and supported by beams or gusseted columns underneath, or the structural walls of upper stories are supported by columns or beams underneath

The codes main advice for the designers is to avoid these irregularities altogether if possible. However, the code also defines the structural calculation assumptions and precautions to be taken in case such irregularities exist in the building. It should be noted here that because the earthquake code is not prepared with an architect-friendly approach, especially the irregularity types created by geometric arrangements such as projections in mass and gallery openings are widely misunderstood and often undeservedly objected by architects. The earthquake code does not forbid the existence of such architectural elements but simply calls for attention to the consequences of using these elements in terms of the seismic behavior of the building [Ozmen&Unay , 2008]. The authors believe that an