Bitlis Eren Univ J Sci & Technol
5 (2), 71-74, 2015

E - ISSN 2146-7706

Research Article

Investigation of an Existing RC Building with Different Rapid Assessment Methods

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Abstract

The importance of studies, researches and prevention about earthquake have risen after destructive earthquakes in the world especially in recent years . In order to reduce the damages of the earthquakes firstly the performance of buildings needs to be determined. Evaluation of all building under earthquake is impossible due to number of building stocks, time and personnel. Therefore, rapid assessment methods were developed for determine seismic safety of existing buildings.Rapid assessment methods can be used instead of detailed structural analysis because of the buildings stocks amount. These rapid assessment methods can be used for deciding which buildings need further structural analysis and decide to seismic safety level of the buildings. In this study, three of these rapid assessment methods were used for a building that was damaged after 2003 Bingöl earthquake. Japon Seismic Index Method, Canadian Seissmic Screening Method and Turkish First Stage Evaulation Method were used.The study also gives usability of these rapid assessment method. The performance score of the building was calculated sperately with the use of the mentioned three methods and then compared. Building priority ranking obtained by means of the methods were found out to be identical with each other. The priority of the existing building stocks rapid evaluation methods can be used conveniently.

Keywords: Seismic screening, RC building, rapid assesment

1.Introduction

The importance of studies, researches and prevention about earthquake have risen after destructive earthquakes in the world especially in recent years. Earthquake damages will increase according to vulnerability of urban and rural building stocks. The size of earthquakes and the negative structural features will be caused an increase in damage amount. Knowing the properties of buildings that have been negatively influenced to the seismic behavior of buildings under earthquakes will be put forward to ensure more serious approaches to reduce the level of damage risk after earthquakes. In order to reduce the damages of the earthquakes firstly the performance of buildings needs to be determined (Işık, 2015). Evaluation of all building under earthquake is impossible due to number of building stocks, time and personnel. Therefore, rapid assessment methods were developed for determine seismic safety of existing buildings. All rapid assessment methods were determine the earthquake priority of existing buildings. The other aim of these methods is to minimize the number of buildings to be analyzed in detail. In the first stage evaluation, detailed information is not necessary. In this evaluation stage, the evaluation can be carried out through collecting the information affecting earthquake behavior from outside and partly inside the structure. There are various methods about the first stage assessment of the structures in literature.

In this study, three of these rapid assessment methods were used for a building that was damaged after 2003 Bingöl earthquake. Japon Seismic Index Method, Canadian Seissmic Screening Method and Turkish First Stage Evaulation Method were used. The aim of this study is giving informations about these methods. The study also gives usability of these rapid assessment method. Results obtained from the three methods were compared with each other. This sudy was aimed to demonstrate the consistency of rapid assessment method with each other. For this aim, a building which has been damaged in 2003 Bingöl earthquake was selected for realistic results.

2.Methodology

Due to the recent destructive earthquakes in world, those efforts necessary to know earthquake risks of the existing buildings require time and cost. Various methods were developed to pursue such works within the shortest time and at minimum cost. Rapid assessment methods can be used instead of detailed structural analysis because of the buildings stocks amount. These rapid assessment methods can be used for deciding which buildings need further structural analysis and decide to seismic safety level of the buildings. This provides priority of buildings for detailed analysis. The implementation fındementals of these three methods that used in this study were presented below.

2.1 First Stage Evaluation Method for Reinforced Concerete Buildings (Turkish Method)

The first stage evaluation methods that take into consideration building characteristics and earthquake risk may be used for the purpose of determining the priorities in certain areas and the regional distribution of the buildings that may bear risk within the scope of the law promulgated by the Ministry. In case a more precise prioritization is required, also second stage evaluation methods may be employed (DRBB, 2013). It is not possible to exactly state whether buildings found out to

Received 6 August 2015
Available online December 2015

have low risk comply with the available earthquake regulations. As mentioned above, this is only an initial, first stage evaluation. Therefore, exact results can be obtained only in consequence of exact analysis methods. This method solely aims to determine the priorities of the buildings to be inspected in the second stage evaluation method.

This method can be used for existing RC buildings which have 1-7 stories. Using parameters for first stage method was given below;

•Structural system type
•Number of Story
•Current situation and visual quality
•Soft /weak story
•Vertical irregularity
•Heavy overhangs
•Irregularity in plan / torsion
•Short column
•Building regulation / pounding
•Hillside effect
•Seismicity and soil type

Performance score will calculate for RC buildings after collecting of related data's. Performance score for RC buildings was calculated as;

$$PP = TP + \sum_{i=1}^{n} O_i * OP_i + YSP \qquad (1)$$

The formulation was described as; PP- performance score; TP- base score; OP- irregularity score and YSP- Structural system score. The result scores were compared each other for risky buildings priority regionally.

2.2 Canada Seismic Screening Method (NRCC)

Screening entails assessing buildings to ascertain their level of seismic risk following a simplified procedure whose main objective is to determine if the building should or should not be subjected to a more detailed investigation (Foo, 2002). Buildings can be screened using rapid visual screening methods. One of these methods is "Manual for Screening of Buildings of Buildings for Seismic Investigation" that developed by the National Research Council of Canada (NRC, 1993). This paper gives also an overview of the Canadian Seismic Screening Method.

Information for each building is collected by using parameters that given in NRC. Each parameter has a score. The scores are then used to rank all buildings of the inventory for detailed seismic evaluation. The scoring system is made up of a structural index (SI) and a non-structural index (NSI). SI is related to possible risk to the building structure and NSI is related to the risk of non-structural building components (Foo, 2003; NRC 1993). Past earthquakes have illustrated that the failure or collapse of the so-called nonstructural components has caused most casualties and property damage (McKevitt et al., 1995). The sum of structural index and non-structural index was called as Seismic Priority Index (SPI). In the assessment buildings process, a detailed investigation is performed on buildings with medium to high priority by SPI.

The methodology is based on the key factors that affect risk of seismic hazards for any building; seismicity, soil conditions, type of structure, irregularities of the structure and the presence of non-structural hazards. It is also based on the importance of the building as affected by its use and occupancy since this affects the consequences of seismic damage (NRC, 1993).

Using parameters for Canada Seismic Screening methods was given below;

•Seismicity of the region (A)
•Local soil conditions (B)
•Type of structural system (C)
•Floor system (D)
•Irregularities of the building (E)
•Importance of building (F)
•Building condition (G)
•Non-structural components (H)

In this method, each parameter was named with a letter. Each of parameters have been calculated by using coefficient that given in Canada Seismic Screening Method. In first step, structural index (SI) was calculated as;

SI = AxBxCxDxExF (2)

Then non-structural index (NSI) was calculated for each building as;

NSI = BxFxGxH (3)

Seismic priority index was calculated as the sum of structural index and not structural index as;

SPI = SI + NSI (4)

The obtained results have been compared with the limit values that given in Table 1 for decided to priority of the building.

Table 1. Priority levels for buildings in Canada Seismic Screening Method (Çelik, 2007).

Score type	Limit values	Evaluation
SI / NSI	1.0 - 2.0	Sufficient seismic safety
SPI	<10	Low priority buildings
SPI	10- 20	Middle priority buildings
SPI	>20	High priority buildings
SPI	>30	Very hazardous buildings

2.3. Japanese Seismic Index Method

Japanese Seismic Index Method (JSIM) was one of the rapid methods that used in this study. JSIM also provides the rapid evaluation for the buildings seismic safety as the other rapid assessment method that used in this study. This method has 3 research stages. The first level was used only in this study. Japanese seismic index method is just used for buildings with reinforced concrete frames, shear wall-frames or shear wall systems and this method is used to obtain the seismic safety of the these types of buildings in a fast way. In this method evaluation is done by comparing $I_S$seismic performance index to I_{SO} comparison index for each floor and each principle direction of the building individually. If $I_S > I_{SO}$ it shows that building is safe for earthquake, although $I_S < I_{SO}$ shows that seismic performance of building is unknown (Kudak, 2005).

The seismic performance of a story is represented by a Seismic Index of Structure (I_S);

$I_S = E_O \times S_D \times T$ (5)

Here, E_O is basic structural performance index and it represents, in a non-dimensional form, a kind of plastic strain energy dissipation capacity of the story. S_D is structural property sub-index and T is time deterioration sub-index. S_D and T are two non-dimensional factors obtained empirically through a field investigation, which take into account the structural configuration of the building and its time deterioration (Benavent-Climent 2011; Kömür, 2005).
Seismic Comparison index (I_{SO}) calculated for each story using the following expression:

$I_{SO} = E_S \times Z \times G \times U$ (6)

where E_S is the seismic basic index; Z seismic zone index; G is soil amplification factor and U is the importance factor for the building (Özdemir 2006).

3. Description of the Building and results

The primary school of Çeltiksuyu built in 1990's and heavy damaged during the May 2003 Bingöl earthquake (Figure 1).

Figure 1.Çeltiksuyu Regional Primary Education School Building

Building is totally three storeys that comprised a ground storey and two normal storeys. The dimensions of the building are 17.17m×33.74m rectangular in the plan. The columns are 0.30x0.50m. Internal beams are 0.20x0.70m and outer beams are 0.30x0.70m dimensions. Height of floor is 0.12m. The structural system has a very smooth axis system in the plan. The ground story of the building has been totally collapsed. The columns in the first story have been significant damage (Celep, 2003).
The blue prints of the heavy damaged Çeltiksuyu Regional Primary Education School Building were given in Figure 2.
Furthermore, the plan of the Çeltiksuyu had been improved and applied to other schools in the region. Several schools have been built in the area by using the same blue prints.

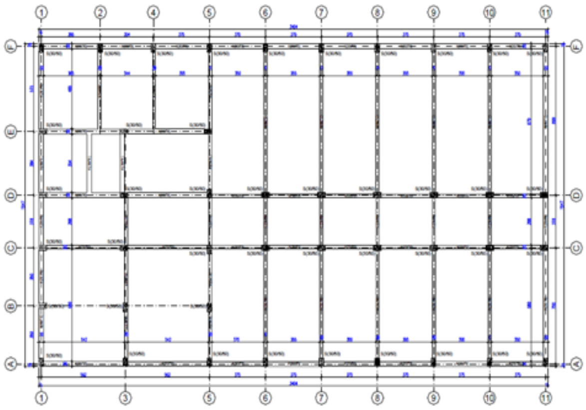

Figure 2. Blue print of Gedikbulak (Celep, 2003)

Result obtained from Turkish first stage evaluation method for the building was given in Table 2.

Table 2. Result of assessment using Turkish screening method

Number of Story	Earthquake zone	Risk zone	Base score	Structural system (RCF)	Soft/weak story	Heavy overhangs	Short columns	Visual quality	Hill/slope effect	Vertical irregularity	Plan irregularities	Pounding	Total score of irregularities	Performance score (PS)
3	I	I	80	0	-25	0	0	-50	0	0	0	0	-75	5

The evaluation result of the building for Canada seismic screening method was given in Table 3.

Table 3. Result of assessment using Canada Seismic Screening Method

A	B	C	D	E	F	G	H	SI	NSI	SPI
5	1.25	3.5	1	2	1.5	4	1	49.22	7.5	56.72

The result of eaulation of the building according to Japanese Seismic Index method was given in Table 4.

Table 4. Result of assessment using Japanese Seismic Index method

E_s	0.8
Z	0.7
G (Z1)	1
U (School Building)	1
$I_{SO} = E_S.Z.G.U$	0.56
n (Number of story)	3
I (Critical story)	1
C_W (Bearing capacity of RC walls)	0
C_C (Bearing capacity of columns)	0.077
f_{cd} (Strength of concrete) (kg/cm^2)	120
W (Weight of a story) (kg)	159.10^4
F_w(Coefficient of ductility of RC walls)	1
a_1 (Displacement coefficient: If C_W=0, a_1=1	1
E_O	0.077
S_D	1
T	1
$I_S = E_O.S_D.T$	0.077
I_S / I_{SO}	0.1375

4. Results

Due to the recent destructive earthquakes in world, those efforts necessary to know earthquake risks of the existing buildings require time and cost. Various methods were developed to pursue such works within the shortest time and at minimum cost. Rapid assessment methods can be used instead of detailed structural analysis because of the buildings stocks amount. These rapid assessment methods can be used for deciding which buildings need further structural analysis and decide to seismic safety level of the buildings. This provides priority of buildings for detailed analysis.

The performance score of the building was calculated sperately with the use of the mentioned three methods and then compared. Building priority ranking obtained by means of the methods were found out to be identical with each other. The priority of the existing building stocks rapid evaluation methods can be used conveniently.

In Turkish first stage evaluatin method the performance score of building was obtained as 5. This shows the building is in the first priority for evaluation.

In Canada seismic screening method,

SI/NSI = 49.22/56.72 = 0.87 value was obtained. This value is under sufficient seismic safety. SPI value for the building is 56.72 and this shows that the building is in the very hazardous buildings (Table1).

In Japanaese seismic index method the performance score of building was obtained as:

I_S / I_{S0} = 0.1375 < 0.4 detailed structural analysis.

I_S< I_{S0} seismic safety of building is uncertain.

The primary school of Çeltiksuyu built in 1990's and heavy damaged during the May 2003 Bingöl earthquake.

The results confirms that the building that high risk. Evaluation results and real situation of the building is consistent with each other. It can be said that rapid assessment method can be used easily for existing building.

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