MODIFIED SEISMIC EVALUATION METHOD FOR REINFORCED CONCRETE BUILDINGS IN MYANMAR

Way Phyo Linn[*]   **Supervisor: Seitaro TAJIRI**[**]
MEE12613

ABSTRACT

In Myanmar, almost all RC buildings have been built without national building codes and seismic design consideration. Myanmar still does not have proper seismic evaluation methods and regulation procedures for existing RC buildings. RC structure is a typical and commonly constructed structure of urban cities in Myanmar. Therefore, developing a Seismic evaluation method for existing RC buildings is an important issue for earthquake disaster mitigation in Myanmar nowadays. This paper describes the Seismic Evaluation of existing RC buildings by the Japanese method which is based upon a performance design concept. A case study of the community center building in Tsukuba city, Ibaraki Prefecture, Japan and the lecturer house of Sagaing University in Myanmar was conducted to understand more clearly about the Japanese Seismic evaluation method. There are three different levels of screening to find the seismic capacity of RC buildings in the Japanese standard. In this study, the first and second screening methods were used to evaluate the seismic performance of the Japanese building which had minor damages on the 2011 Great East Japan earthquake and a good correlation observed is described. After that, this method was applied again to our Myanmar RC building and an attempt to adopt this method by modifying into a simple one by using the same concept in combination of the ACI method in evaluation strength is also described. This study was conducted based upon my strong desire to develop a simple method that is compatible to our structures and our engineering society. ACI-318 is already familiar for Myanmar engineers. An easy and a familiar method can be disseminated quickly. Although we have a time limitation, we need a sustainable study to make a perfect method.

Keywords: Seismic Evaluation, Disaster mitigation

1. INTRODUCTION

The population of Myanmar has considerably increased from 15 million in 1930, at the time of the Bago earthquake, to 60 million in 2012. Building typology, constructional material and construction technology are in transitional phase that is moving from traditional to the modern. In the past earthquakes, the buildings/houses constructed with traditional construction technology and material stood even after earthquakes and there were only a few loss of life. However, due to urbanization process, adaptation of new technology and material in construction of buildings without engineering input and codal practice may change the scenario and losses may dramatically increase in case of a tremendous earthquake in future. Therefore, mitigation measures need to be considered as a national plan to check and evaluate seismic performance of the buildings before a huge earthquake comes again.

---

[*]Public Works, Ministry of Construction, Naypyidaw, Myanmar.
[**]Building Research Institute (BRI), Tsukuba, Japan.

2. METHODOLOGY

In this paper, I focus on the Japanese Evaluation Method according to the 1st English version of the 2001 edition for seismic evaluation and seismic retrofit of existing RC buildings by the Japan Building Disaster Prevention Association. Earthquake resistance is not a function of lateral strength only. the seismic performance evaluation of existing buildings must involve both strength and deformability. There are three different levels of screening to find the seismic capacity of RC buildings in the Japanese standard. In this study, the first and second screening methods were used to evaluate the seismic performance of the Japanese building which had minor damage on the 2011 Great East Japan earthquake and a good correlation was observed. After that, this method was applied again to our Myanmar RC building, the lecturer house from Sagaing University and an attempt to adopt this method by modifying into a simple one by using the same concept in combination of the ACI method in evaluation strength is also described.

Myanmar once being a British colonial country, measuring and weighing with the foot-pound-second (F.P.S) system is still dominating in our environment although the government enforces to use the international system (S.I units) nowadays. Most of the people cannot guess or do not know how weigh does a kilogram or how long is a meter, including the carpenters, masons, skillful labors, co-workers and even some who are participating in construction industries. Moreover, most of the Institutes and Universities have been teaching ACI trend to their students and most of the engineers are familiar with ACI method now. That is why we attempt to adopt by modifying some hard parts of strength evaluation by a more familiar ACI method. Thus, an easy and familiar method can be disseminated quickly.

3. JAPANESE METHOD FOR SEISMIC EVALUATION OF EXISTING RC BUILDINGS

There are three levels of seismic evaluation methods in current Japanese standard guidelines. The first method is easy and conservative. In the first method, the material strength and contribution of cross sectional areas of vertical members are considered. The second method is more accurate than the first method. In the second method, the ductility or deformation capacity and strength of vertical members are considered. For the third method, the contribution of the strength and ductility of beams and diaphragm walls are also considered. The third screening level considers the failure mechanism of the structures. In all three levels of screening the determination of basic seismic index (E_0) is the same (i.e the product of F and C).

To know the seismic capacity of buildings, it is necessary to calculate the seismic index of the structure (I_S) first. The seismic index (I_S) is an index which represents the seismic performance of the structure. The value of I_S can also be defined as the value of maximum elastic response shear coefficient of the story concerned. The seismic performance of the structures becomes higher as the value of I_S larger. The seismic index of the target structures (I_S) is calculated with following basic Eq. (1) in all three methods. Basic concept is the same for all three methods in seismic evaluation.

$$I_S = E_0 \ S_D \ T \tag{1}$$

Then, seismic index of the target structure (I_S) is compared with seismic demand index of target structure with the following equation.

$$I_{S0} = E_S \, Z \, G \, U \tag{2}$$

If I_s value is larger, the structure is considered to have enough seismic capacity to resist assumed earthquake motions. The structure is assumed to have some seismic resistance capacity but it is not enough if the value of I_{S0} is larger than I_S. The recommended value of I_{S0} is 0.8 for the first screening and 0.6 for the second and third screenings which are based upon the past earthquake damaged buildings and experiences. After satisfying the above equation, the target building should also be satisfied by the following Eq. (3) to ensure the minimum story strength. It is observed from the past earthquakes that the building which has relatively high I_S index can also suffer severe damage or

still be vulnerable if the value of $C_{TU} \times S_D$ index is less than 0.3. Actually, this checking is verifying the minimum strength of the structure to get a safe seismic performance.

$$C_{TU} S_D \geq 0.3\ Z\ G\ U \tag{3}$$

3.1. First Level Screening Method of Seismic Evaluation

The first screening level screening considers only the vertical members. All columns and walls are conservatively assumed as brittle members. The seismic capacity is calculated based on the cross-sectional area of the vertical members, average shear stress and concrete strength. This procedure is suitable for non-ductile structures with many walls, or structures with no or little ductility. The vertical elements are divided into three groups depending upon h_0/D values of different column and wall types. The basic seismic index (E_0) of the target structure is obtained by using following two equations. They depend upon the target buildings which have extremely short column or not. The larger value would be taken from the Eq.(4) and (5).

$$E_0 = \frac{n+1}{n+i}\left(C_W + \alpha_1 . C_C\right)F_W \tag{4}$$

$$E_0 = \frac{n+1}{n+i}\left(C_{SC} + \alpha_2 . C_W + \alpha_3 . C_C\right)F_{SC} \tag{5}$$

3.2. Second Level Screening Method of Seismic Evaluation

In the second level, the axial force and reinforcement are considered to calculate the strengths and ductility of the vertical members. The vertical elements are classified into five different categories. The ductility indexes F of all vertical members are grouped into three different groups in maximum. In the second level seismic evaluation, shear force at ultimate flexural capacity and ultimate shear capacity of columns and walls are calculated, and then their results were compared. The effective strength factor α can be taken from the standard according to their different ductility F. The cumulative strength index C_T of each story can also be calculated by the sum of the strength C with multiplication of the story shear modification factor $(n+1)/(n+i)$. There are two basic equations in the second level screening. Eq.(6) is the ductility- dominant basic seismic index of the structure and Eq.(7) is strength-dominant basic seismic index of the structure.

$$E_0 = \frac{n+1}{n+i}\sqrt{E_1^2 + E_2^2 + E_3^2} \tag{6}$$

$$E_0 = \frac{n+1}{n+i}\left\{C_1 + \sum_j \alpha_j C_j\right\}F_1 \tag{7}$$

The strength index C in the second screening method is the ratio of the ultimate load-carrying capacity of the vertical members in the story concerned to the weight of the building including live load for seismic calculation supported by the story concerned. For ultimate lateral load-carrying capacity of the vertical members (Q_u), minimum value must be chosen from Q_{mu} and Q_{su}.

$$C = \frac{Q_U}{\sum W} \tag{8}$$

4. MODIFICATION OF JAPANESE METHOD TO AN ADOPTIVE METHOD BY IMPLEMENTATION OF ACI STRENGTH EVALUATION

In Myanmar, as a British colonial country, measuring and weighing with the foot-pound-second (F.P.S) system is still dominating in our environment and Yangon Technological University or former R.I.T (Rangoon Institute of Technology), Mandalay Technological University and others have been

teaching ACI trend to their students and most of the engineers are familiar with ACI method now. An attempt to modify and adopt the Japanese in order to be easy and familiar is carried out in this study. The concept is the same with the Japanese method but substituting the strength evaluation of the vertical members by ACI method and the ductility factor evaluation is followed by the first level screening of the Japanese method. The sample Lecturer House building from case study II was used again to evaluate with this modified method.

5.   CASE STUDY OF THE JAPANESE AND MYANMAR BUILDINGS

5.1. Case Study of A Community Center Building in Japan

The seismic performance of a Community Center Building in Tsukuba City, Ibaraki Prefecture, Japan which is a two-story reinforced concrete structure with concrete load bearing walls was evaluated as a case study in this paper. It was built in 1980 with old building codes before the revision in consideration of ultimate capacity design. . The height of the story for the first floor is 3.5 m and the second floor is 6 m. The first floor has a floor area of 499.17 m^2 and the second floor has 338.79 m^2. It has some minor damages by the 2011 Great East Japan Earthquake (Tohoku Earthquake). The building has some cracks on the interior and exterior reinforced concrete walls on both directions by the Tohoku Earthquake. The cracks are visible and from 0.2mm to 0.45mm wide. They are the minor damages and the damage levels of I and II.   A cylinder test was conducted after being damaged by the 2011 Tohoku Earthquake and the compressive strengths for the 1st floor are 40.1, 36.1, 34 N/mm^2 and 2nd floor are 36, 29.1, 37.4 N/mm^2 respectively.   By using the standard deviation method, the compressive strength (F_c) 25.4 N/mm^2 is obtained and that value was used in this case study of the seismic evaluation.
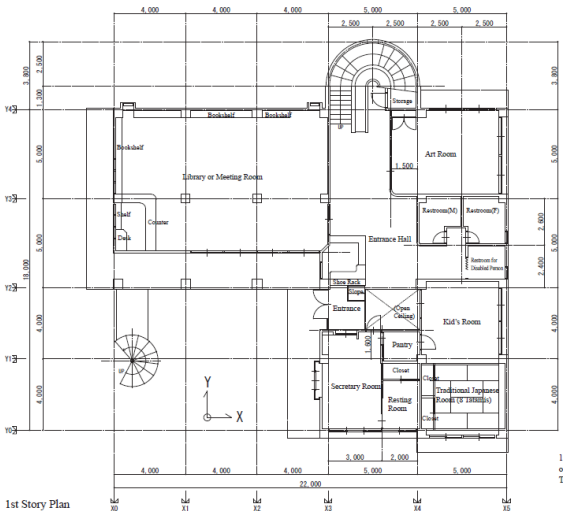

Figure 1. First floor plan of the community

center building

Photo 1. The community center building

5.2. Case Study of a Lecturer House from Myanmar

The seismic evaluation was conducted for a lecturer's house designed by our department using the Japanese Method to compare the results. This building was built in 2012. It was situated in the Sagaing University Campus. It was a two-story RC building with brick infill wall. The brick infill walls were designed as non-structural elements and their strengths were neglected in this evaluation. Cube tests for compressive strength were carried out during under construction period and the mean value of these strengths, 17.24 newton per millimeter square was used in this evaluation. The yield

strength of the steel reinforcement (deformed bar) used in this calculation was 275 newton per millimeter square. This two-story RC building has a floor area of 108 square meters in the second floor and 95 square meters in the first floor. The story height of the first floor is 3.05 meters (10 feet) and the second floor is 3.35 meters (11 feet).
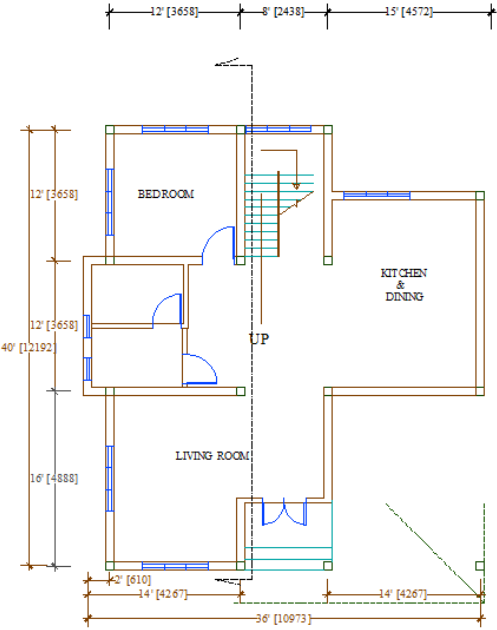

Figure 2. First floor plan

Figure 3. Front elevation

5.3. Results of Seismic Evaluation for Japanese building and Myanmar building

The calculated results of the Community Center Building and Myanmar Lecturer House Building are compared as shown in the table below.

Table 1 The result comparison of Japanese and Myanmar building

Evaluation Method	Story	Direction	Case study I (Japanese Bld.)			Case study II (Myanmar Bld)			I_{s0}
			I_s	$C_{TU} S_D$	Evaluation	I_s	$C_{TU} S_D$	Evaluation	
1st level screening	2	X	1.66	-	Safe	0.49	-	Not safe	0.8
	1		1.7	-	Safe	0.37	-	Not safe	
	2	Y	1.42	-	Safe	0.49	-	Not safe	
	1		1.82	-	Safe	0.35	-	Not safe	
2nd level screening	2	X	1.22	0.96	Safe	0.83	0.32	Safe	0.6
	1		1.15	1.37	Safe	1.16	0.27	Not safe	
	2	Y	0.81	1.01	Safe	0.88	0.34	Safe	
	1		1.05	0.54	Safe	0.49	0.25	Not safe	

According to the above results the community center building is safe. It is found to be agreeing with the real practice because that building has only minor damages in the damage level of I and II according to Japanese Guidelines by the Great East Japan Earthquake. But our Myanmar building is not safe if it were judged by the Japanese demand index. There is a big difference between the seismicity of Myanmar and Japan. Therefore, setting up an appropriate demand index for a country is an important issue in disaster mitigation and that is a key role factor to keep the alive its evaluation method. By comparing the results of case study I and II, Myanmar buildings are significantly lower in strength but the ductility indices are apparently larger than the Japanese values.

The following table shows the comparison of the results of the modified adopted method and Japanese method.

Table 2 Comparison of Is values

(a) X-direction

Story	Modified method	1st level screening	2nd level screening
2	0.37	0.49	0.83
1	0.35	0.35	<0.3

(b) Y-direction

Story	Modified method	1st level screening	2nd level screening
2	0.37	0.49	0.88
1	0.32	0.37	<0.3

The seismic indices in the second level screening are higher because in the second level screening the ductility dominant factor in all members are considered. The strengths evaluated by the ACI have a little higher value so the seismic indices obtained by the interaction of these strength and ductility index have a bit higher value. But all are in consistent behavior and likely to be in same results.

6. CONCLUSIONS

Results from case study I proved that the results from the Japanese Standard and Guidelines for Seismic evaluation level I and II screening coincide with the situation of the building struck by the 2011 Great East Japan earthquake. Therefore, these evaluation methods are good enough to be adopted for checking the seismic performance of existing and new RC low rise buildings in Myanmar after making some modifications and simplifications. However, this modified evaluation method is a first stepping stone to become a typical evaluation method for RC buildings in Myanmar.

The sustainable study and research works have to be carried out for better accuracy and precision of this method. Research and survey works should be in sustainable action to set up a basic seismic demand index for Myanmar.

7. RECOMMENDATION

It is recommended to evaluate the ductile RC structures with relatively weak beams by the third level screening method. A good result is desirable for a low rise RC structure up to six stories. Japanese equations used in this evaluation method are the empirical formula which is based on experiments. The vertical member size and reinforcements of Myanmar buildings are fairly smaller than the Japanese buildings and therefore there may have some errors. It is also recommended to develop another modification to simplify the procedure that is most likely required to be able to get results in rapid assessment to use the procedure on a daily basis, as the first level screening of the Japanese method. Another option is the automation with computer aided for the process interacting with the dominant ductility feature of each vertical member.

ACKNOWLEDGEMENTS

REFERENCES

Arthur H. Nilson, David Darwin, Charles W. Dolan, 2004, Design of Concrete Structures,
Kaminosono, T., 1992, International Symposium on Earthquake Disaster Prevention, Volume II, pp. 44-53.
The Japan Building Disaster Prevention Association (JBDPA) (1st English Version 2001)." JBDPA