Journal of ENVIRONMENTAL Treatment Techniques

J. Environ. Treat. Tech.
ISSN: 2309-1185

Journal web link: http://www.jett.dormaj.com

Study of Seismic Code Japan BCG, Europe EC8, Chile, America IBC, IS India, and New Iranian Earthquake Code

Mohammad Reza Baradaran[*1], Abolfazl Heydarpoor[2]

1- Department of Civil Engineering, Firoozabad Branch, Meymand Center, Islamic Azad University, Meymand, Iran.
2- Department of Civil Engineering, Zarghan Branch, Islamic Azad University, Zarghan, Iran.

Received: 28/07/2015 Accepted: 6/09/2015 Published: 30/09/2015

Abstract

The earthquake is one of the natural phenomena that are likely to happen in all countries of the world. Therefore, in order to maintain safety, different countries have attempted to write their own seismic Regulations and under these circumstances, the countries that have more seismicity as per the experience of the earthquake and assess the damage caused by the earthquake have written Regulations that conform to their own region. This paper reviews the Regulations in Europe and the countries such as Japan, Chile, America, India and also old and the new Regulations of Iran. In summation, it has been investigated the strong points and failings of each of them. It is worth mentioning that the old version of the Iranian Earthquake Code (Standard No. 2800 – $3_{rd.}$ Edition) & the new edition of Iranian Earthquake Code (Standard No. 2800 – 4_{th}. Edition) have been evaluated herein, and has been stated the applied modifications as well.

Keywords: Seismic Code, Earthquake, Iran, Japan, Chile, America, India.

1 Introduction

Japan is located in the center of several seismic areas. There are two areas with high and moderate seismicity in the Pacific Ocean and a moderate seismic zone in the Sea of Japan. Japan has the regulation seismic design adopted in 1981 and known by the name BCJ. This regulation has two levels of seismic forces: one for the operation and the other for safety of life. Most of the available methods in the regulation have been recognized as valid. The validity of the most existing methods in the regulation of BCG has been examined during twenty years of practical experience, as most of the structures that are designed using the Regulations have endured several major earthquakes such as the 1995 Kobe earthquake [1].

In recent years, the situation of the Europe seismic design regulation EUROCODE 8 (EC8) has been modified from the Pre- standard to the European standard mode. The new regulation should change some of the national seismic standards for some countries. Several approaches such as design criteria according to the capacity or the coefficients of the seismic force reduction, which are clearly correlated with the expected structural plasticity introduce European seismic design in a new and innovative form for steel structure [2].

Corresponding author: Mohammad Reza Baradaran, Department of Civil Engineering, Firoozabad Branch, Meymand Center, Islamic Azad University, Meymand, Iran. E-mail: mohamadrezabaradaran@gmail.com

Chile is considered as one of the most seismically active regions of the world where the largest earthquake event in the world recorded in 1960. February 27, 2010 Chilean earthquake of magnitude 8 / $8_{=}$ M_W poses one of the largest earthquakes in the universe that in spite of considerable magnitude, have left little property damages and casualties. As the number of casualties of the earthquake have been reported less than 600 people. The foregoing earthquake is considered as a testing field for the Chilean seismic regulation after the occurrence large earthquake of 1960. Chilean earthquake code is the last edition was published as NCh433.0f96 in 1996 [3].

America is considered as one of the other world's seismic zones and a substantial number of major earthquakes occurred in this region of the world. The America seismic regulation is called “IBC” which the last edition was published in 2009. The regulation is compatible with other international Regulations published by the International regulation Council. Chapter 16 of the regulation is under the title of the structural design which is based seismic design and key standard ASCE 7 is also its complementary which is used as "Minimum Design Loads for Buildings and Other Structures" [4].

India and Iran are located in one of the three zones of world's seismicity (Alpide belt) that the issue caused many casualties occurred resulting from the phenomenon of earthquakes in these countries in recent years. India seismic design code is known as the ISI [5].

Iranian code of practice for seismic resistant design of buildings (Standard No. 2800) was prepared for the first time in 1367. The third edition of the Regulations was published by the Building and Housing Research Center in

1384and also the latest version of the Regulations (Fourth Edition) was published in 1393 [6].

2 Comparisons of the Regulations of Japan BCG, Europe EC8, Chile, America IBC, IS India and Iran

Comparing between the Regulations and survey the differences among them have been always deemed complicated discussions in earthquake engineering. Standard No. 2800 of Iran is not as generally expressed as the Chilean Regulations, nor that has been able to present the parameters discussed in details such as the Regulations of America. Of course, concerning Chilean Regulations, lack of attention to detail cannot be taken into account as neglect or failure of efficiency. The results obtained of the Chilean earthquake of February 27, 2010 represent applying the provisions of the Regulations. In that earthquake, it was damaged less than 2.5 percent of engineering structures and it can be said that this regulation has been able to considerably meet the expectations of the Chilean engineers society. Considering the America Regulations also expressed a fairly substantial detail specifically reflecting the results of research and undergraduate studies show, in criteria of this leading Regulation. A parameter study in these Regulations shows a lot of common cases, but there are important differences that can be named briefly the most important ones, such as analysis method, soil classification, important factors, behavior coefficients, period, expressing irregulars and random twist, drift allowed, earthquake force distribution and load combinations. In general, it has been debated that the America Regulations specifically has been more details and also is expected to be gradually considered similar details in the other Regulations. Chilean Regulations have been a bit more conservative and with respect to the sever seismic background of Chile, can be said that taking such a position is not unexpected.

Comparing the range of the Iranian Code (Standard 2800) with the spectrum of the world's seismic Regulations posed such as EC8, BCJ and IS, and also after spectral analysis and comparison of the base shear forces and relative displacement in frames 3, 6, 9 and 12 storey, the following results will be achieved:

- During the short period and in the field of the spectral acceleration of Regulations almost conform to the code BCJ and while that shear force differs from one another and it is due to the different behavior coefficients in the Regulations.
- Base shear force of spectrum EC8 has the ascending mode, at the first, by the height increasing and prolongation of the period and then the descending status so that the base shear force of 12-storey building is 40% less than the base shear force of 9-storey building so it seems that the effect of whip force is not properly considered and seems the modal analysis is required that in the high frequency period However, in other Regulations by increasing the number of classes and to increase the period of structure can be seen clearly the effect of the whip force which is tangible in the Japan Regulations.
- In mid-rise buildings that have period about 1 to 3 seconds, given that the 2800 code elastic range during this time interval is a little more than the elastic range of the IS & EC7 Regulations; in addition to this, by increasing the height, the drift rises in the Iranian code and is ahead of both Regulations EC8 and IS in the form of 12–story building as well. It appears that due to the high behavior coefficient (R) of the moment frame in 2800 shows the shear force and the displacement less than usual.
- Base shear force of the spectrum EC8 is still raised by increasing the height range BCJ, and this is due to the high range and low coefficient behavior ($R_=3.\ 33$) of the regulation so that even quantities of the shear range of 2800 are more than an average of 40% static shear mode and this is dependent on the seismicity circumstances of Japan.
- Experimental period does not differ too much in each of Regulations and in merely a short building, the period considered in Japan Regulations is much lower than the rest of Regulations. Experimental period is extracted from the Iranian Code and this is because of the conditions assumed in the modeling.

3 Summary of Iranian Code of Practice for Seismic Resistant Design of Buildings (Standard No. 2800 – 3rd edition)

The goal of this Regulation is determination of the minimum standards and regulations for the design and construction of the building against the effects of the earthquake, so that with respect to this is expected the following issues:

A. Maintaining the stability of the building in the event of a severe earthquake, be minimized casualties and also building is able to resist against the mild and moderate earthquakes without significant structural damage.
B. Buildings with high importance must be able to keep their capacity utilization in the event of mild and moderate earthquake and also in buildings with moderate importance be minimized the structural and non-structural damages.
C. Buildings with very high importance keep their ability to operate during the severe earthquake without major structural damage without interruption.
D. This regulation is used for the design and construction of buildings of reinforced concrete, steel, wood and masonry materials. It should be noted that the specific structures such as dams, bridges and jetties and marine structures and nuclear power plants and traditional buildings are made with clay or mud are not subject to these regulations.

In the Regulations has been expressed on the main issues in terms of architectural considerations and concerns structural configuration and discuss torsion control and avoid short columns and avoid the use of different structural systems in various stretches in plan and elevation. Buildings in terms of importance, shape and structural systems were grouped and the equivalent static analysis and dynamic analysis methods are used to calculate the earthquake forces. The equivalent static analysis is used for the following:

A. Regular buildings with a height of less than 50 meters from the base level
B. Irregular buildings up to 5 floors or with a height of less than 8 meters from the base level
C. Buildings in which the upper part of lateral stiffness is considerably less than the lower part of lateral stiffness, provided that:

1. Each of the two is regular structures alone.
2. The medium hardness of the lower classes is at least 10 times the average hardness of the upper classes.
3. The fundamental period of oscillation of the structure is not more than 1.1 times the upper fundamental period, assuming that the separation is intended and it's been assumed tangly.

Dynamic analysis methods can be used on all of the buildings, but to use them for buildings that are not subject to the above conditions is required.

As in static analysis has been defined(the third edition of the Regulations), by calculating the base shear force V or the sum of forces in each of the extensions of the earthquake, once the quake is calculated that factors such as the earthquake factor C, the entire weight of building W, the acceleration of the design basis A, the building reflection coefficient B, the building importance factor I and the building behavior coefficient R are involved therein, and considering the base shear force should be provided to meet V_min = 0.1 AIW or (B / R) _min = 0.1. Then the calculated base shear force V is distributed in the elevation of the building in conformity with the following equation:

$$F_i = (V - F_t)\frac{W_i h_i}{\sum_{j=1}^{n} W_i h_i}$$

$$F_t = 0.07TV \quad , \quad \text{if} \quad T \leq 0.7\text{sec} \quad \rightarrow F_t = 0$$

This base shear force is also distributed in the plan of the building. Then, the vertical force caused by the earthquake which is the vertical component effect of the earthquake acceleration in the building is considered in computations in the following cases:
A. The beams that their span is more than 15 meters, with columns and their wall support.
B. The beams that endure significantly concentrated vertical in comparison with other loads transferred to the beam comply with their wall support
C. In the case of a concentrated load is at least equal to half the total load on the beam, it is considered to be a significant burden.
D. Balconies and projections, which are constructed in the form of cantilevers.

In addition to the equivalent static method, the earthquake lateral force is determined by using the dynamic analysis methods in which a dynamic reflection of the structure shows the earth movement caused by the quake. These methods include spectral analysis method and time history analysis that the details have been described in the Third Edition 2800 Code. The application of any of these two methods in the buildings included this regulation is optional. All the parameters that can be used in dynamic analysis, such as mass, acceleration of the base and the values that have defined the equivalent static analysis.

4 Differences and Changes in the New Design Code for Buildings in Earthquake (Standard No. 2800)

In the third edition of the Iranian Earthquake (Standard No. 2800) design is carried out by AST method, While in the fourth edition, the design is performed by LRFD method and of the latest version of ASCE and regulations of America's steel and concrete are applied to improve the new edition and it is a combination of the Iran seismicity circumstances and the quake experiences in the past.

It is discussed on the issues such as Geotechnical considerations, the applicable limit of the Regulations and discussing parts of the facade and other non-structural components and other non-building structures.

On the building reflection coefficient formula B, classification of seismic ground, the percentage turnout live load and snow load and the period of oscillation T, lateral force distribution earthquake in building height, the effect of P-Δ, the relative lateral shift classes and the lateral effects of the earthquake on the diaphragms, the new edition of the Code of 2800 has undergone changes concerning the conditions and formula.

On the calculation of seam discontinuity and grouping of buildings, terms of use of the equivalent static analysis method, the combination of the systems in height, calculation of buildings against the reversal, vertical force caused by the earthquake have been the changes in the provisions discussed and also some new items have been added to the fourth edition.

Regarding the issues such as irregular geometry in height, the cantilever column system, structural uncertainty coefficient ρ, added factor of resistanceΩ_0, soil-structure interaction effect and the simplified method for analyzing and designing had not been proposed in the third edition of the 2800 Code, while in the fourth edition the issues raised. In this regard, lateral force of the earthquake on building components and components Additional formula F_p which was presented in the third edition has been deleted in the fourth edition and it is no longer used. Applying the vertical force caused by the earthquake is mandatory in the whole structures for buildings that are located in the zones with very high risk. Considering the uncertainty regarding the structure and additional resistance is determined by applying specified coefficients.

5 The Difference between Allowable Stress Design Method (asd) & Final Resistance (lrfd)

1. Elastic method: until 1950, these structures were designed as per ASD or allowable stress design method or in other words, designing the members of this type steel structure took place in such a way that members due to of the loads entered not to leave their elastic limit. Using this method has had continued in most countries of the world, including Iran and Iran's internal regulations and the national building regulations was developed as per this method.
2. Plastic method or plastic: from 1980, to enhance the quality of materials and improve the quality of implementation, plastic or ultimate strength *LRFD* method was substituted as a more scientific & an economical method in some countries with the elastic method or ASD, so it has been conducted in the fourth edition of the Iranian regulation against earthquake. In this method (*LRFD*), the members of the constructions will be allowed due to the load caused by the load of the elastic out and reach to limit their plastic or plastic and make it increase the strength members and reduce construction cost and is a more economical structure.

In Iran by 2014, most of the buildings were designed by the ASD design, however with the new edition of the 2015 earthquake regulations and regulations for the steel design was based on the LRFD method.

6 Conclusions

After comparing the amounts obtained from the resolution of various issues on the basis of both Editions of the Regulations 2800, it can be realized that there are many advantages In the analysis and design of structures against earthquakes, according to the fourth edition (LRFD method) compared to the analysis and design of structures as per the third (ASD method) including that the load factor in LRFD method is based on the assurance of occurring them. For example, the live load factor to be considered more than the dead load coefficient, as well as cost reduction and optimal design of structures against earthquakes by reducing the effective weight of the structures and shear of classes is one of the fundamental changes.

References

1. Regulation of Earthquake – Standard 2800 - Third Edition 2005.
2. Regulations of Earthquake - Standard 2800 - Fourth Edition 2014.
3. M. Azhari. M, Mir Bagheri. S. R, “Design of Steel Structures”, Volume IV , Seismic design issues.
4. Tavakoli. H, Manaf poor, A R, “Comparison of seismic regulations in Iran, Chile and America”, 2011.
5. Hemati. S, Kashefi. S, Gerami. M, “Comparison of the spectrum seismic design codes in Iran, India, Japan and Europe” 2012.