Review on Seismic Analysis of Multistoried RC Building

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Abstract:*The seismic codes are prepared with consideration of seismology of country, accepted level of seismic risk, properties of construction materials, construction methods, and structure typologies etc. Furthermore, the provisions given in seismic codes are based on the observations, experiments & analytical case studies made during past earthquakes in particular region. In India, IS 1893 (Part1) Criteria for Earthquake Resistant Design of Structures is used as code of practice for analysis & designing of earthquake resistant buildings. In the last decade, the detailed & advanced research, damage survey was carried out by the Earthquake Engineering Sectional Committee of Bureau of Indian Standards. As a result, the huge data regarding behavior of various types of structures during earthquake was collected which gained the knowledge. This continuous effort has resulted in revision of IS 1893 (Part 1): 2002 [1]. Hence the sixth revision of IS 1893 (Part 1) was published in 2016. To implement the latest code in practice, it is necessary to understand the revised codal provisions in IS 1893 (Part 1):2016 [2] with respect to IS 1893:2002.*

The sixth revision of IS 1893 (Part 1): 2016, "Criteria for Earthquake Resistant Design of Structures" have been published by Bureau of Indian Standards recently in December 2016. In this new code many changes have been included considering standards and practices prevailing in different countries and in India. Main intention of present work to compare the behavior of building when applied with seismic load as per the code IS 1893 (part 1) 2002 and IS 1893 (part 1)2016 and seismic analysis of multi storey building i.e. G+12 storey in ETABS. The loads are applied separately based on code IS 1893 (part 1) 2002 and IS 1893 (part 1)2016 and analysis of super structure is done in ETABS software then results are compared. With the help of super structure axial load the footing is designed i.e. the sub structure of the building is analyzed in SAFE software by considering the load from super structure.

INTRODUCTION

When earthquakes occur, a building undergoes dynamic motion. This is because the building is subjected to inertia forces that act in opposite direction to the acceleration of earthquake excitations. These inertia forces, called seismic loads, are usually dealt with by assuming forces external to the building. So, apart from gravity loads, the structure will experience dominant lateral forces of considerable magnitude during earthquake shaking. It is essential to estimate and specify these lateral forces on the structure in order

to design the structure to resist an earthquake. Indian seismic code IS: 1893 has also been revised in year 2016. This paper presents the seismic load estimation of multi storied buildings as per IS: 1893(part) -2016. The process gives analysis of multi-storied building by using FEM based software and the results are used to compare old codalprovisions viz. lateral displacement, base shear, storey drift computed as per the two versions of seismic code. So, this paper deals with comparative study of IS 1893-2002 and IS 1893-2016. Model considered for this paper is multistory building using FEM based software. The height of each storey is taken as 3 meter. Analysis of the structure is done and results generated by software are compared as per IS 1893:2002 and IS 1893-2016.

LITERATURE REVIEW

S.K. Ahirwar, S.K. Jain (2008) "*Earthquake loads on multistorey buildings as per is:1893-1984 and is: 1893-2002: a comparative study" This paper presents the seismic load estimation for multistorey buildings as per IS: 1893-1984 and IS: 1893-2002 recommendations. Four multistorey RC framed buildings ranging from three storeyed to nine storeyed are considered and analyzed. The process gives a set of five individual analysis sequences for each building and the results are used to compare the seismic response viz. storey shear and base shear computed as per the two versions of seismic code.*

Keyword: *Earthquake loads, IS: 1893, RC buildings, strengthening, codal recommendations.*

Conclusion: *The seismic design approach, in both the versions, is based on designing a strong and ductile structure, which can take care of the inertial forces generated by earthquake shaking. Unlike previous version of 1984, the latest 2002 version clearly reflects that design seismic force is much lower than what can be expected during strong shaking. Forces obtained as per IS: 1893-2002 are significantly higher than that computed as per recommendations of IS: 1893-1984.*

Prakash Sangamnerkar (2015) *"Dynamics analysis of structures subjected to earthquake load" In present study, multi-story irregular buildings with 20 stories have been modeled using software STAAD PRO for seismic zone IV in India. Dynamic responses of building under actual earthquake, DELINA (ALASKA) 2002 have been investigated. These papers highlight the comparison of Time History Method and Response Spectrum Method.*

Keyword: *Time History Method, Response Spectrum Method, Reinforced concrete building, displacement.*

Conclusion*: Storey drift in Time History analysis is found to be 2 to 8 percent higher than that of Response Spectrum Analysis in both types of buildings i.e. regular & irregular.For high rise building it is necessary to provide dynamic analysis (Response spectrum analysis or Time history analysis) because of nonlinear distribution of forces. For important structure time history analysis should be performed it predicts the structural response more accurately. The displacement value will depend upon frequency of earthquake and natural frequency of the structure. The base shear value obtained in case of Response spectrum analysis are more as compared to Time history analysis as its depends on the frequency content of the earthquake data. Storey displacement greater in Time history analysis as compared to Response spectrum analysis. It is observed that the base shear is greater in Response spectrum analysis compared to Time history analysis thus it can be concluded that Time history analysis is economically better for designing.*

Anant Desai *"Seismic Analysis of Steel Braced Reinforced Concrete Frames"In the present study, the seismic performance of reinforced concrete (RC) buildings rehabilitated using concentric steel bracing is investigated. The bracing is provided for peripheral columns. A four storey building is analyzed for seismic zone IV as per IS 1893: 2002 4 using STAAD Pro software. The effectiveness of various types of steel bracing in rehabilitating a four storey building is examined. The effect of the distribution of the steel bracing along the height of the RC frame on the seismic performance of the rehabilitated building is studied. The performance of the building is evaluated in terms of global and story drifts. The study is extended to eight storied, twelve storied and sixteen storied building. The percentage reduction in lateral displacement is found out.*

Keyword: *Earthquake strengthening, retrofit, seismic performance, analysis, steel braced RC structures*

Conclusion: *Steel bracings reduce flexure and shear demands on beams and columns and transfer the lateral loads through axial load mechanism. The lateral displacements of the building studied are reduced by the use of X type of bracing systems. The building frames with X bracing system will have minimum possible bending moments in comparison to other types of bracing systems.*

Arvindreddy (2015) *" Seismic analysis of RC regular and irregular frame structures"In this paper an analytical study is made to find response of different regular and irregular structures located in severe zone V. Analysis has been made by taking 15 storey building by static and dynamic methods using ETABS 2013 and IS code 1893-2002 (part1). Linear Equivalent Static analysis is performed for regular buildings up to 90m height in zone I and II, Dynamic Analysis should be performed for regular and irregular buildings in zone IV and V. Dynamic Analysis can take the form of a dynamic Time History Analysis or a linear Response Spectrum Analysis.Pushover curve is obtained, the main objective to perform this analysis is to find displacement vs. base shear graph and also time history analysis will be carried out taking BHUJ earthquake.*

Keywords*: RC building, regular, irregular, equivalent static, response spectrum, pushover, time history, ETABS 2013, IS 1893-2002 and BHUJ earthquake etc…*

Conclusion*: structure built-in with stiffness irregularity will be on non conservative side and as seen from time history analysis, as storey increases behavior of stiffness irregularity and diaphragm irregularity becomes reverse.*

Muhammed Tahir Khaleel (2016)*"Seismic Analysis of Steel Frames with Different Bracings using ETSBS Software"An attempt is made to analyze the effect of seismic force on Regular and Irregular Steel framed high rise building with different bracing system and also to find the best bracing system. The building is modeled and analyzed using ETABS and sections are selected based on their capability to control the maximum lateral storey displacements. The Zone V as per IS 1893-2002 is selected for the study. Analysis is carried out by Equivalent Static Method and Response Spectrum Method.*

Key Words: *Equivalent Static Analysis, Response Spectrum Analysis, Lateral displacement, Base Shear, Bracing System,.*

Conclusion: *For both regular and irregular building, cross bracings are the best bracing system for reducing the storey displacement. It is also observed that base Shear is high in cross bracing system because of the increased stiffnes. As*

the density of steel is very high when compared to concrete, by using the bracings throughout the periphery of the structure is very uneconomical, hence the bracing has to be used in combination with other earthquake resisting system such as using Base isolators and dampers.

SayyedJavad (2018) *"comparative study of seismic analysis of various shapes of building by Indian code and American code"This research article is intended to compare the seismic analysis of various shapes of high rise buildings with different International Codes. Two different famous structural building codes have been adopted. Those are Indian Standard and American Standard.Infrastructures of Gulf countries are always notable as they mainly follow AMERICAN standards & EURO standards for construction development. In view of the demand of such code of practice across the developing countries like India, an attempt is made to compare AMERICAN standards with INDIAN standards under Seismic Forces.*

Keyword: *Symmetric and Asymmetric structures, Response Spectrum Method, INDIAN standards, AMERICAN standards, Storey shear, Base shear, Storey drift.*

Conclusion:*Base shear For RCC Frame is maximum according to IS-1893:2002 as compared with ASCE 7-10. Storey displacement is considerably reduces in American Standard as compare to Indian Standard. Displacement for Square-Type model is 0.17 time more in case of Indian standard but for C-Type model displacements variations are reduced up to 0.14 times in case of Indian code as compare to American Standard along both X-direction and Y-direction because of high ground acceleration. For Square-Type maximum drift is 0.15 times more than Indian Standard. Similarly for C-Type model drift is 0.21 times higher in Indian standard as compare to American standard.*

Giuseppe Oliveto and Massimo Marletta (2005) *"Seismic retrofitting of reinforced concrete buildings using traditional and innovative techniques"The seismic retrofitting of reinforced concrete buildings not designed to withstand seismic action is considered. After briefly introducing how seismic action is described for design purposes, methods for assessing the seismic vulnerability of existing buildings are presented. The traditional methods of seismic retrofitting are reviewed and their weak points are identified. Modern methods and philosophies of seismic retrofitting, including base isolation and energy dissipation devices, are reviewed. The presentation is illustrated by case studies of actual buildings where traditional and innovative retrofitting methods have been applied.*

Keywords: *Pushover Analyses, Seismic Vulnerability, Seismic Retrofitting, Base Isolation.*

Conclusion:*The paper then considers the retrofitting of buildings vulnerable to earthquakes and briefly describes the main traditional and innovative methods of seismic retrofitting. Examples drawn from the professional, editorial and research activity of the senior author are used to illustrate the problems in a simple way. Among all the methods of seismic retrofitting, particular attention is devoted to the method which is based on stiffness reduction. This method is carried out in practice by application of the concept of springs in series, leading in fact to base isolation. One of the two springs in series represents the structure and the other represents the base isolation system.*

B. Srikanth (2013) *"Comparative Study of Seismic Response for Seismic Coefficient and Response Spectrum Methods" In this thesis, the earthquake*

response of symmetric multi-storied building by two methods are studied. The methods include seismic coefficient method as recommended by IS Code and modal analysis using response spectrum method of IS Code in which the stiffness matrix of the building corresponding to the dynamic degrees of freedom is generated by idealizing the building as shear building. The responses obtained by above methods in two extreme zones as mentioned in IS code i.e. zone II and V are then compared. Test results Base Shears, Lateral Forces and Storey Moments are compared.

Keywords *- Earthquake analysis, Modal analysis, Response spectrum analysis, Seismic coefficient method, SRSS.*

Conclusion*: The Seismic Coefficient Method is conservative at top floors compared to response Spectrum method and vice-versa. As storey moments are high in Seismic Coefficient Method when compared to response spectrum method, it is suggested to relay on Response Spectrum Method even in symmetric multi-storied buildings for seismic analysis and design.*

AbhijeetBaikerikar (2014) "*Seismic Analysis of Reinforced Concrete Frame with Steel Bracings" In present study we have used square grid of 20m in each direction of 5m bay in each direction, software used is ETABS 9.7.0, we have compared the results of bare frame and braced frame and found the result that braced frame significantly lower the lateral displacements and drifts compared to bare frame and thus resisting earthquake forces efficiently. The study has been carried out for the Zone V and soft soil as specified in IS 1893-2002.*

Keywords: *Bare Frame, Base Shear, Bracing, Response Spectrum Analysis, Lateral Displacements, Lateral Drifts, Time Period, Concentrically Braced Frames, Lateral Load Resistance.*

Conclusion: *From the above results it is clear that Bare Frame produces larger displacements and drifts compared to other two bracing. Bracings in middle has the lowest time period compared to other cases. Bracing in middle gives the lowest displacement values followed by Bracings at corners. Bare Frame has the minimum base shear compared to other cases because the bracings are not included in the Bare Frame. Minimum drift is given by Case 2 Bracings in middle, overall Case 2 Bracings in middle performs better than Case 3 Bracings at corners because of the continuity of braces being maintained by Case 2 Bracings in middle.*

V.Mhalungkar (2012) *"seismic analysis of high rise steel frame building with and without bracing" In this paper the linear time history analysis is carried out on high rise steel building with different pattern of bracing system for Northridge earthquake. Natural frequencies, fundamental time period, mode shapes, inter story drift and base shear are calculated with different pattern of bracing system. Further optimization study was carried out to decide the suitable type of the bracing pattern by keeping the inter-story drift, total lateral displacement and stress level within permissible limit. Aim of study was to compare the results of seismic analysis of high rise steel building with different pattern of bracing system and without bracing system.*

Keywords: *Time history analysis, high rise steel building, bracing pattern.*

Conclusion: *The result of the present study shows that bracing element will have very important effect on structural behavior under earthquake effect. Bracings in both direction bases shear increases up to 38%. The displacements at roof level of the*

building with different bracing style is reduces from 43% to 60%. Modal time period is also reduced up to 65%. The diagonal brace-B shows highly effective and economical design of bracing style.

Mohamed SaadEldin, Arafa El-Helloty (2014) *"Effect of Opening on Behavior of Raft Foundations Resting on Different Types of Sand Soil" In this paper, the elasto – plastic finite element analysis is carried out using the three-dimensional PLAXIS program to study the effect of opening position and type of soil on behavior of raft foundations under columns loads. The analysis has been done for raft foundations with middle, edge, and corner opening positions and the results are obtained for three different types of soil which are loose sand, medium dense sand and dense sand soil. The effect of opening positions and type of soil on behavior of raft foundations is presented in graphical form and it is discussed.*

Keywords: *Raft foundation, mat foundation, soil, opening, loose sand, medium dense sand, dense sand, settlement, moment.*

Conclusion: *The settlement of soil and the moment in raft increase for raft with mid, edge and corner opening positions when it is compared with the reference raft for different types of soil. Mid opening positions have the smallest effect on the settlement of soil and the moment in raft while the corner opening positions have the biggest effect on the settlement of soil and the moment in raft for different types of soil. Loose sand soil has the biggest effect on the settlement of soil and the moment in raft while the dense sand soil has the smallest effect on the settlement of soil and the moment in raft for different opening positions. There is no much variation in the settlement of soil and moment in raft with mid and edge opening positions.*

CONCLUSION:

- *Forces obtained as per IS: 1893-2002 are significantly higher than that computed as per recommendations of IS: 1893-1984.*
- *If the forces are non linearly distributed in high rise building it is necessary to provide dynamic analysis (Response spectrum analysis or Time history analysis).*
- ***X*** *bracing system provides minimum bending moment and will reduce the storey displacement for both regular and irregular building when compared to other type of bracing systems.*
- *Displacement for Square-Type model is 0.17 time more in case of Indian standard but for C-Type model displacements variations are reduced up to 0.14 times in case of Indian code as compare to American Standard along both X-direction and Y-direction because of high ground acceleration.*
- *For Square-Type maximum drift is 0.15 times more than Indian Standard. Similarly for C-Type model drift is 0.21 times higher in Indian standard as compare to American standard.*

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