Earthquake Behaviour of Irregular Building by Linear Static Analysis using ETABS

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Abstract - *India is prone to strong earthquake shaking and hence earthquake resistant design is essential . Seismic codes help the designer to improve the behavior of structures to withstand the earthquake effects without significant loss. The new IS 1893:2016 on Criteria for Earthquake resistant design of structures has included many changes like separate response spectra for Equivalent Linear static method and Response spectrum method for 6.0s period, Importance factor of 1.2 for residential buildings and new expression for Natural Time period for buildings with RC structural walls etc. This paper presents a case study in which seismic performance of a G+7 residential tower in zone III designed as per the earlier version of the code is checked for recommendations made by the revised code. Secondly this paper aims at the seismic load estimation and comparison for the multistory building designed as per IS 1893:2002 and IS 1893:2016 by Equivalent linear static method. Thirdly the effect of zone factor on the seismic performance of the building is studied as per IS 1893:2016 by Equivalent Linear Static method. The seismic behavior of the test building is evaluated using the structural software ETABS. The process gives a set of five individual analysis sequences for the building and the results are used to study the effect of changes made in the latest version of IS 1893.*

Keywords-**IS 1893, Equivalent linear static method.**

1. INTRODUCTION

The seismic codes are prepared taking into account the seismology of country, accepted level of seismic risk, properties of construction materials, construction methods, and structure typologies etc. In India, IS1893 (Part1) "Criteria for earthquake resistant design of structures is considered as code of practice for analysis and designing of earthquake resistant buildings. In the last decade, a detailed and advanced research and 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 improved the knowledge. This persistent effort has resulted in the revision of IS 1893 (Part1):2002. Hence the sixth revised edition of IS 1893 (Part 1) was published in 2016.

1.1. LITERATURE REVIEW

Mayur R.Rethaliya, Bhavik R.Patel, Dr.P.Rethaliya (2018) studied the revisions in various clauses of new IS 1893 (Part1):2016 as compared to old IS 1893(Part1):2002 and their effect especially, separate response spectra for Equivalent static method and Response Spectrum method separately for 6.0 periods. Expressions are provided for calculating design acceleration co efficient (Sa/g) for Equivalent Static Method and Response Spectrum method separately for Rocky/hard soils. Definition of soft story and weak story, change in definition of mass, torsion and vertical irregularities has been changed. Importance factor of 1.2 has been given in new code for residential buildings, in old code residential buildings were assigned importance factor of 1.0. Naturally it will raise the design horizontal seismic coefficient Ah. New expression for T_a for buildings with RC structural walls, requirements for rigid and flexible diaphragm has been altered, modeling of unreinforced masonry infill walls as equivalent diagonal struts etc and critical comments on that are covered.

Pooja Manoj Kale, Dr.B.H.Shinde (2019) evaluated the seismic response of RCC buildings with G+12 and G+16 stories by both equivalent static analysis and response spectrum analysis method. Seismic performance of these building models are studied for zone II, III, IV and V and compared. All the mathematical 3D models are generated using the finite element software ETABS Version 17.

Narla Mohan, A.Mounika Vardhan (2017) analysed the behavior of a multi storied RC.Building with plan irregularity subjected to earth quake load by adopting Response spectrum analysis carried out the help of FEM software ETABS. Test building has twenty stories with story height of 3m, FOUR models are used to study and analyze with different bay lengths and the number of bays and the bay-width along two horizontal direction are kept constant in each model for convenience. Zone factors for different seismic zones are taken and their corresponding effects are interpreted in the results.

Ni Ni Win, Kyaw Lin Htat (2015) presented a comparative study of Static and Dynamic analysis of multistoried RC framed building 12 storied, when subjected to earthquake loads. The analysis was done in ETABS, load combination is based on Uniform building Code-UBC 1997 and the structure was designed as per American Concrete Institute – ACI- 318-99 provisions.

The structure was analysed, firstly with static analysis and then with response spectrum method (Dynamic analysis) and the results were compared. The various seismic parameters compared are displacement, story hear, story drift and story moments. The authors concluded that for irregular buildings static analysis is insufficient and dynamic analysis must be carried out.

Anoj Surwase, Dr. Sanjay K.Kulkarni and Prof. Manoj Deosarkar (2018) investigated the seismic load estimation for multistory buildings as per IS 1893:2002 and IS-1893:2016 clauses. The scope of this study is to learn relevant Indian standard code are used for design of various building elements such as beam, column, slab, foundation and staircase using FEM based software ETABS under the seismic load and wind load acting on the structure. The project base shear, time period, maximum story displacement are studied.

Akash Panchal and Ravi Dwivedi (2017) carried out analysis and design of G+6 existing RCC framed structure as per IS 1893(Part1):2002 for different seismic zones using STAA.PRO. The variation of steel percentage, maximum shear force, bending moment and deflection in different seismic zones are compared. They concluded that the steel percentage, maximum shear force, bending moment and deflection values increase from Zone II to Zone V.

P.S.Grigosavi. Prof.M.S.Kalamare and Mr.N.R.Sutar (2019) compared the design forces of a multistory building obtained as per IS 1893:2016 with that obtained by the earlier 2002 version by Dynamic analysis using FEM based software. The authors concluded that IS 1893:2016 is more conservative for Earthquake analysis of multistory buildings.

1.2. OBJECTIVE

To study the seismic response of a G+7 multi storied building frame by linear static analysis as per IS1893:2002 and IS1893:2016.

1.3. SCOPE

The seismic analysis of the proposed multistoried building frame were carried out by Equivalent Linear Static analysis using ETABS for the two versions of Indian standard code IS 1893 and different seismic zones. Then comparative study of the seismic responses from the static analysis is performed.

2. METHODLOGY

2.1. EQUIVALENT LINEAR STATIC METHOD

The Equivalent static and Dynamic seismic analysis are the two methods to make earthquake resistant structures. The static method is the simplest one because it required less computational effort and is based on formulae given in the code of practice. This procedure does not need Dynamic analysis however it accounts for the dynamics of building in an appropriate manner. First, the design base shear is computed for the whole building and it is then distributed along the height accordingly. The lateral forces at each floor levels thus obtained are then distributed to individual lateral load resisting elements.`

2.2. BUILDING DESCRIPTION

The study is carried out on an irregular RCC framed building with 8 stories.

Table-1: Analysis Data

Plan Dimensions	52x52 m
Total height of building	25.2 m
Height of each story	3.05 m
Height of Parapet	1.2 m
Size of beams	250 x 600 mm
Occupancy	Residential
Thickness of Slab	125 mm
Thickness of walls	250 mm
Seismic Zone	Zone III
Soil Condition	Medium
Response reduction factor	5
Importance factor	1, 1.2
Floor finish	1.25 KN/m^2
Live load	2 KN/m^2
Grade of concrete	M 35
Grade of Steel	Fe 500
Density of concrete	35 KN/m^3

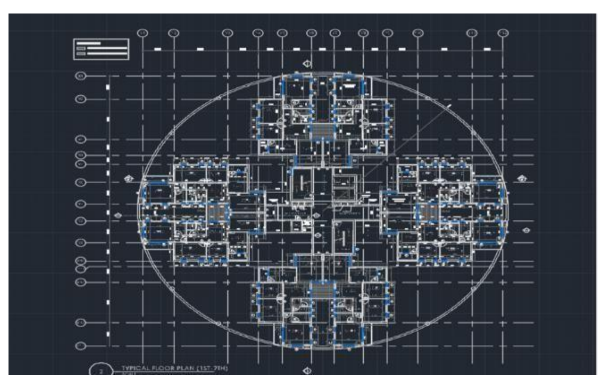

Fig.1.Typical Floor Plan

2.3. MODELLING

The building is modeled using the finite element based software ETABS. The 3D building model generated in ETABS is given in fig.2. Five building models of the same structure are generated using ETABS as per IS 1893:2002 and IS 1893:2016 for different seismic zones.

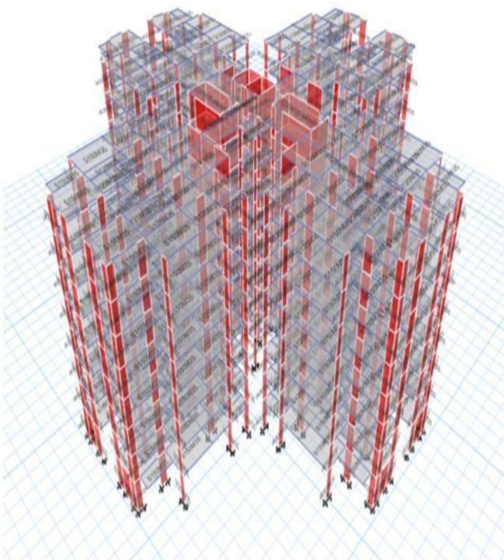

Fig-2: 3D view of G+7 building

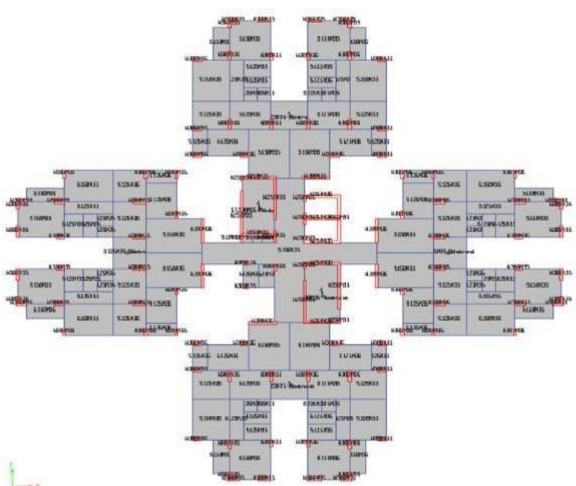

Fig-3: Structural Plan

Brief description of all the models are given below.

Model I : For IS 1893:2002, Zone III
Model II : For IS 1893:2016, Zone II
Model III : For IS 1893:2016, Zone III
Model IV : For IS 1893:2016, Zone IV
Model V : For IS 1893:2016, Zone V

2.4. SEISMIC ANALYSIS

The building models generated are subjected to Static seismic analysis. Different parameters such as base shear, drift and displacement are obtained for all the 3D models. The seismic behavior of the test building as per the early and new versions of IS 1893 is compared. Zone factors for different seismic zones are taken and their corresponding effects are interpreted in the results.

3. RESULTS

The results are tabulated below.

A.COMPARISON OF OLD AND NEW IS1893

Table-2: Values of Base Shear

No.	IS Codes	Base Shear (KN)	
		X dirn.	Y dirn.
1	IS 1893-2002	3623.34	4019.23
2	IS 1893-2016	5179.60	5179.60
	% Increase	42.95	28.87

Table-3: Values of Story Drift

Story	IS Codes	Story Drift	
		X dirn.	Y dirn.
4	IS 1893-2002	0.000611	0.000062
4	IS 1893 - 2016	0.000889	0.000064
	% increase	45.49	3.22

Table- 4: Values of Max. Lateral Displacement

Story	IS Codes	EQx (mm)		EQy (mm)	
		X	Y	X	Y
8	IS 1893- 2002	12.07	0.70	2.78	13.04
8	IS 1893 - 2016	17.00	1.00	4.00	17.00
	% Increase	40.75	42.65	43.72	30.31

Table-5: Values of Lateral Force

Story	IS Codes	EQx (KN)	EQy (KN)
8	IS 1893 - 2002	1244.10	1380.03
8	IS 1893 - 2016	1778.45	1778.45
	% Increase	42.95	28.87

B. COMPARISON OF SEISMIC ZONES

Table -5: Values of Base shear

Zones	Base Shear (KN)	
	X dirn.	Y dirn.
Zone II	2210.43	2521.74
Zone III	5179.60	5179.60
Zone IV	5305.04	6052.18
Zone V	7957.56	9078.27

Table -6 : Values of Lateral Force

Zones	Lateral Force (KN)	
	EQx	EQy
Zone II	758.96	865.8601
Zone III	1778.45	1778.95
Zone IV	1821.52	2078.0643
Zone V	2732.91	3117.0965

Table -7: Values of Lateral Displacement

Zones	Displacement(mm)	
	X dirn.	Y dirn.
Zone II	7	4
Zone III	17	1
Zone IV	18	1
Zone V	27	1

Chart-1 Story drift as per IS 1893-2002

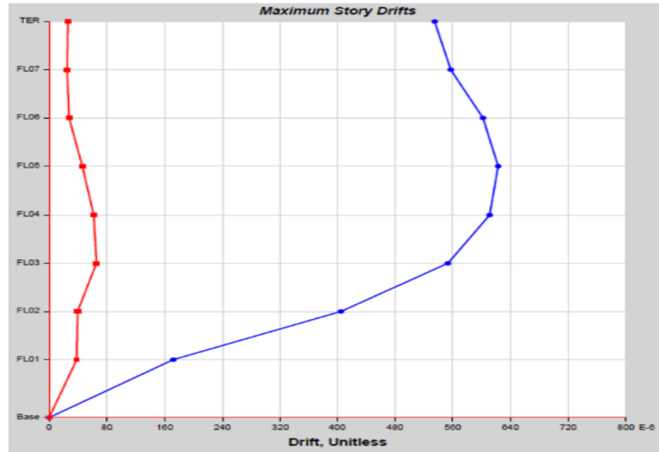

Chart – 2 Story drift as per IS 1893-2016

Chart -3 Maximum displacement along EQX as per 1893-2000

Chart-4 Maximum displacement along EQX as per IS 1893-2016

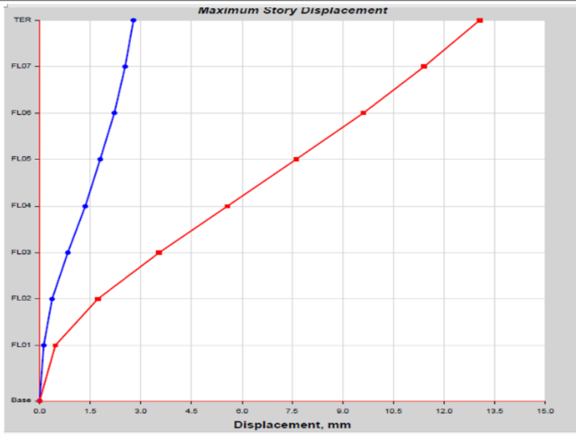

Chart – 5 Maximum displacement along EQY as per IS 1893-2002

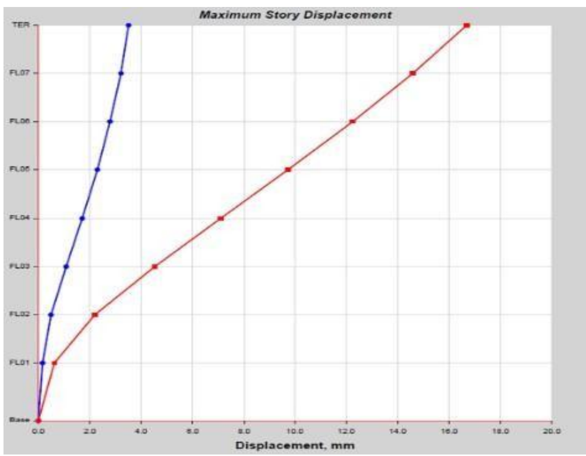

Chart -6 Maximum displacement along EQY as per IS 1893-2016

Table-8: Values of Overturning Moment

Zones	Overturning Moment (KNm)	
	X dirn.	Y dirn.
Zone II	-0.224	1.541
Zone III	-0.525	3.614
Zone IV	-0.537	3.699
Zone V	-0.806	5.549

4. CONCLUSIONS

1. In general there is considerable increase in the seismic response of buildings after analyzing by new code IS 1893:2016 with respect to IS 1893:2002.

2. Base shear and lateral force values increase significantly in IS 1893:2016 analysis compared to IS 1893:2002. New IS 1893:2016 has provided response spectra for Equivalent Static Method and Response Spectrum method separately for 6.0s periods. Expressions are provided for calculating design acceleration coefficient (Sa/g) for Equivalent Static Method and Response Spectrum method separately for Rocky/hard soils, medium soils and soft soils. It will alter the values of base shear.

3. Similarly there is a significant increase in values of lateral drift and displacement. As per IS 1893:2016 for structural analysis, the moment of inertia shall be taken as 70% of gross moment of inertia of columns and 35%of gross moment of inertia of beams for RC and masonry structures. This clause of code takes into account the cracked section properties. So, the lateral deflection, drifts etc. will increase.

4. As a result there is an increase in the sizes of lateral load resisting members and reinforcement. Ultimately the structural strength and safety towards earthquake forces will increase.

5. The Base shear and lateral force values of the structure increases as the seismic zone factor increases. It rises by more than 250% for Zone V when compared to Zone II. Similarly the story displacement increases by more than 280% as the Zone changes from two to five. The values of overturning moment are negative in X-direction and maximum in Y- direction.

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