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"Dynamic Analysis of Multistoried Regular Building"

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Abstract: *Analysis and design of buildings for static forces is a routine affair these days because of availability of affordable computers and specialized programs which can be used for the analysis. On the other hand, dynamic analysis is a time consuming process and requires additional input related to mass of the structure, and an understanding of structural dynamics for interpretation of analytical results. Reinforced concrete (RC) frame buildings are most common type of constructions in urban India, which are subjected to several types of forces during their lifetime, such as static forces due to dead and live loads and dynamic forces due to the wind and earthquake.*

Here the present works (problem taken) are on a G+30 storied regular building. These buildings have the plan area of 25m x 45m with a storey height 3.6m each and depth of foundation is 2.4 m. & total height of chosen building including depth of foundation is 114 m. The static and dynamic analysis has done on computer with the help of STAAD-Pro software using the parameters for the design as per the IS-1893- 2002-Part-1 for the zones- 2 and 3 and the post processing result obtained has summarized.
Keywords: *RCC Building, Equivalent Static Analysis, Response Spectrum Analysis, Displacement*

I. Introduction

Structural analysis is mainly concerned with finding out the behavior of a structure when subjected to some action. This action can be in the form of load due to the weight of things such as people, furniture, wind, snow, etc. or some other kind of excitation such as an earthquake, shaking of the ground due to a blast nearby, etc. In essence all these loads are dynamic including the self weight of the structure because at some point in time these loads were not there. The distinction is made between the dynamic and the static analysis on the basis of whether the applied action has enough acceleration in comparison to the structure's natural frequency. If a load is applied sufficiently slowly, the inertia forces (Newton's second law of motion) can be ignored and the analysis can be simplified as static analysis. Structural dynamics, therefore, is a type of structural analysis which covers the behavior of structures subjected to dynamic (actions having high acceleration) loading. Dynamic loads include people, wind, waves, traffic, earthquakes, and blasts. Any structure can be subjected to dynamic loading. Dynamic analysis can be used to find dynamic displacements, time history, and modal analysis. In the present study, Response Spectrum Analysis is performed to compare the results with Static Analysis.

The criteria of level adopted by codes for fixing the level of design seismic loading are generally as follows:-

(a) Structures should be able to resist minor earthquakes (< DBE), without damage.

(b) Structures should be able to resist moderate earthquakes (DBE) without significant Structural damage but with some non- structural damage.

(c) Structures should be able to resist major earthquakes (MCE) without collapse.

"Design Basis Earthquake (DBE) is defined as the maximum earthquakes that reasonably can be expected to experience at the site once during lifetime of the structure. The earthquake corresponding to the ultimate safety requirements is often called as Maximum Considered Earthquakes (MCE). Generally, the DBE is half of MCE" . During an earth quake, ground motion occur in a random fashion both horizontally and vertically, in all directions radiating from the epicenter .The ground accelerations cause structures to vibrate and induce inertial forces on them. Hence structures in such locations need to be suitably designed and detailed to ensure stability, strength and serviceability with acceptable levels of safety under seismic effects.

The magnitude of the forces induced in a structure due to given ground acceleration or given intensity of earth quake will depend amongst other things on the mass of the structure, the material, and type of construction, the damping, ductility , and energy dissipation capacity of the structure. By enhancing ductility, and energy dissipation capacity in the structure, the induced seismic forces can be reduced and a more economical structure obtained or alternatively, the probability of collapse reduced.

Dynamic analysis methods: - It is performed to obtain the design seismic force and its distribution to different level along the height of the building and to the various lateral load resisting elements for the regular buildings and irregular buildings also as defined in IS-1893-Part-1-2000 in clause 7.8.1.

(i) Regular building- (a) Those > than 40 meter height. in zone IV^{th} and V^{th}.
(b) Those > 90 meter height in zone II^{nd} and III^{rd}.

(i) Irregular building- (a) all framed building higher than 12 meter in zone IVth and Vth.
(b) Those greater than 40 meter in zone IInd and IIIrd.

II. Methods Of Analysis

(2.1) Code-based procedure for seismic analysis

Main features of seismic method of analysis based on Indian standard 1893(Part 1): 2002 are described as follows

(2.1.1) Equivalent static lateral force method
(2.1.2) Response spectrum method
(2.1.3) Square roots of sum of squares (SRSS method).
(2.1.4) Complete Quadratic combination method (CQC)
(2.1.5) Elastic time history methods.
(2.2) By IS code method for dynamic analysis:-
(2.3) By STAAD PRO software Method- for static and dynamic analysis both.

(2.1.1) Equivalent Static Analysis:-

All design against seismic loads must consider the dynamic nature of the load. However, for simple regular structures, analysis by equivalent linear static methods is often sufficient. This is permitted in most codes of practice for regular, low- to medium-rise buildings. It begins with an estimation of base shear load and its distribution on each story calculated by using formulas given in the code. Equivalent static analysis can therefore work well for low to medium-rise buildings without significant coupled lateral-torsional modes, in which only the first mode in each direction is considered. Tall buildings (over, say, 75 m), where second and higher modes can be important, or buildings with torsional effects, are much less suitable for the method, and require more complex methods to be used in these circumstances.

(2.1.2) Response Spectrum Method:-

The representation of the maximum response of idealized single degree freedom system having certain period and damping, during earthquake ground motions. The maximum response plotted against of un-damped natural period and for various damping values and can be expressed in terms of maximum absolute acceleration, maximum relative velocity or maximum relative displacement. For this purpose response spectrum case of analysis have been performed according to IS 1893.

III. Modeling And Analysis

For the analysis of multi storied building following dimensions are considered which are elaborated below. In the current study main goal is to compare the Static and Dynamic Analysis of symmetrical (Rectangular) building.

Static and Dynamic Parameters:-

Design Parameters- Here the Analysis is being done for G+30 (rigid joint regular frame) building by computer software using STAAD-Pro.

Design Characteristics: - The following design characteristics are considered for **Multistory rigid jointed plane frames**

Table 1 Design Data of RCC Frame Structures

S.No	Particulars	Dimension/Size/Value
1.	Model	G+30
2.	Seismic Zones	IInd , IIIrd
3.	Floor height	3.6M
4.	Depth of foundation	2.4M
5.	Building height	114M
6.	Plan size	25Mx45M
7.	Total area	1125Sq.m
8.	Size of columns	0.9Mx0.9M
9.	Size of beams	0.3Mx0.50M
10	Walls	(a)External-0.20M
		(b)Internal-0.10M
11.	Thickness of slab	125mm
12.	Earthquake load	As per IS-1893-2002
13.	Type of soil	Type -II, Medium soil as per IS-1893
14.	Ec	5000√fck N/ mm2(Ec is short term static modulus of elasticity in N/ mm2)

15.	Fck	0.7√fc k N/ mm2(Fck is characteristic cube strength of concrete in N/ mm2
16.	Live load	3.50kN/ m2
17.	Floor finish	1.00kN/ m2
18.	Water proofing	2.500kN/ m2
19	Specific wt. of RCC	25.00 kN/ m2
20.	Specific wt of infill	20.00 kN/ m2
21.	Material used	Concrete M-30and Reinforcement Fe-415(HYSD Confirming to IS-1786)
22.	Reinforcement used	High strength deformed steel Confirming to IS-786. It is having modulus of Elasticity as 2 00 kN/ mm2
23.	Static analysis	Equivalent static lateral force method.
24.	Dynamic analysis	Using Response spectrum method
25.	Software used	STAAD-Pro for both static and dynamic analysis
26.	Specified characteristic	compressive strength of 150mm cube at 28 days for M-30 grade concrete - 30N/ mm^2
27.	Fundamental natural period of building	Ta = 0.075 h0.75 for moment resisting RC frame building without infill's Ta = 0 .09 h /√d for all other building i/c moment resisting RC frame building with brick infill walls Where h = height of building d = base dimension of building at plinth level in m along the considered direction of lateral forces.
28.	Zone factor Z	As per Is-1893-2002 Part -1 for different. Zone as per clause 6.4.2.

Table 2 Zone categories

seismic zone	IIND	IIIrd	IVth	Vth
Z	**0.1**	**0.16**	**0.24**	**0.36**
seismic intensity	**Low**	**moderate**	**severe**	**very severe**

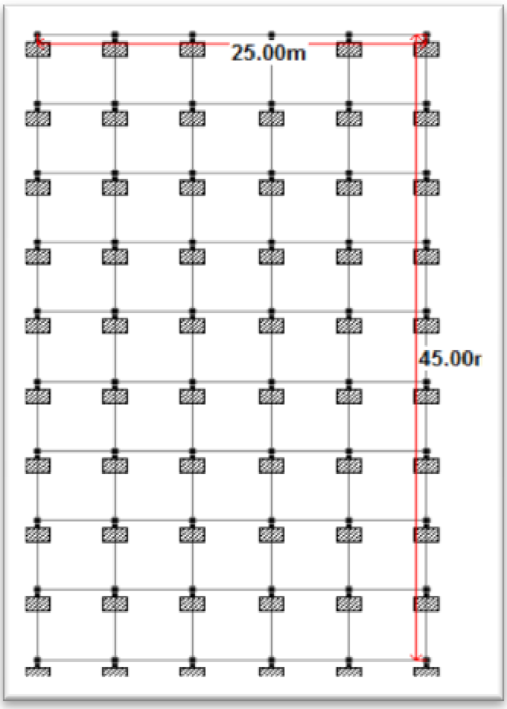

Fig. 1 Plan of Regular Building

Fig. 2: 3-D Model of Regular Building

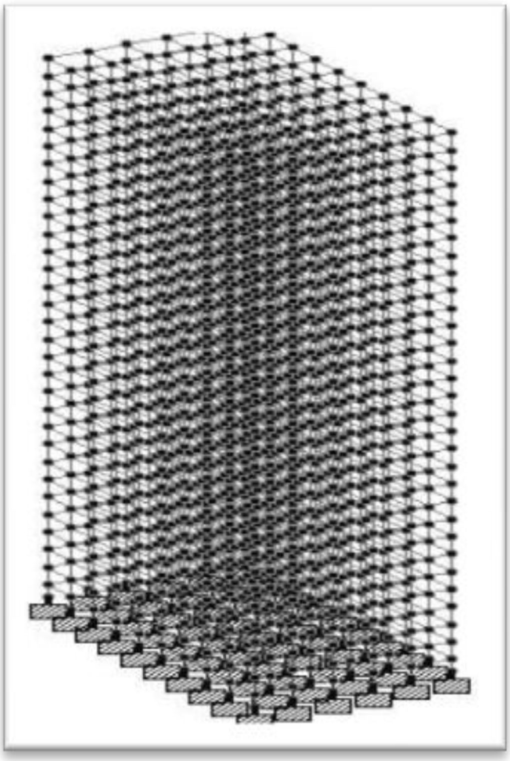

Fig. 2: 3-D Model of Regular Building

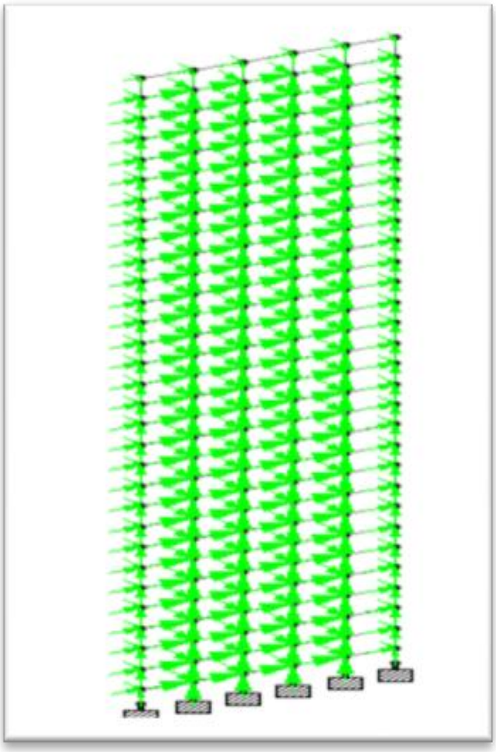

Fig.3: Response Spectrum loading (Dynamic Loading)

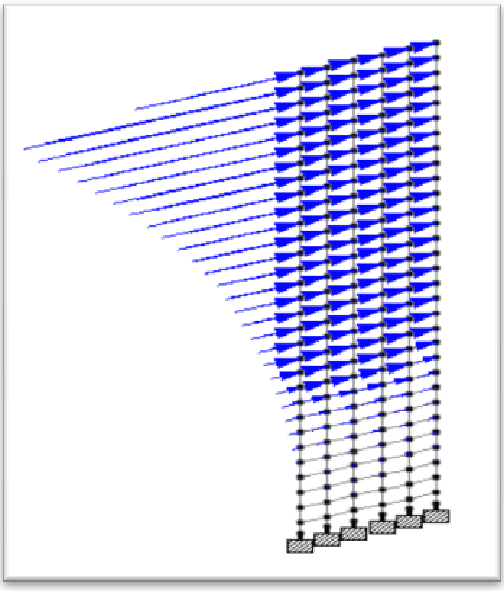

Fig.4: Earthquake Loading (Dynamic Loading)

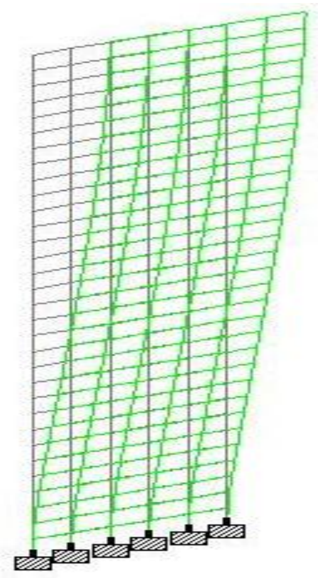

Fig.4: Deflection diagram (Dynamic Loading)

IV. Results And Discussions

The above RCC frame structure is analyzed both statically and dynamically and the results are compared for the following three categories namely Axial Forces, Torsion and Moment at different nodes and beams and the results are tabulated as shown below.

4.1 Comparison of Axial Forces for Vertical Members Zone IInd and IIIrd

TABLE N0 3 COMPARISION OF AXIAL FORCES FOR VERTICAL MEMBER						
		STAIC ANALYSIS		DYNAMIC ANALYSIS		
		Zone II	Zone III		Zone II	Zone III
Node	L/C	Axial Force kN	Axial Force kN	L/C	Axial Force kN	Axial Force kN
301	1 EQX	918.53	1032.884	1REX	1065.099	1124.085
302	1 EQX	210.962	244.333	1REX	243.985	265.202
303	1 EQX	40.298	47.845	1REX	46.666	51.996
304	1 EQX	40.298	47.845	1REX	46.666	51.996
305	1 EQX	210.961	244.333	1REX	243.985	265.201

4.2 Comparison of Torsion for Vertical Members Zone IInd and IIIrd

TABLE N0 4 COMPARISION OF TORSION FOR VERTICAL MEMBER						
		STAIC ANALYSIS		DYNAMIC ANALYSIS		
		Zone II	Zone III		Zone II	Zone III
Beam	L/C	Torsion kNm	Torsion kNm	L/C	Torsion kNm	Torsion kNm
301	1 EQX	-0.445	-0.433	1REX	2.689	2.625
302	1 EQX	-0.246	-0.239	1REX	1.642	1.597
303	1 EQX	-0.268	-0.261	1REX	1.737	1.692
304	1 EQX	-0.268	-0.261	1REX	1.737	1.691
305	1 EQX	-0.246	-0.239	1REX	1.642	1.597

4.3 Comparison of Moment for Vertical Member Zone IInd and IIIrd

TABLE N0 5 COMPARISION OF MOMENT FOR VERTICAL MEMBER						
		STAIC ANALYSIS				DYANAMIC ANALYSIS
		Zone II	Zone III		Zone II	Zone III
Beam	L/C	Moment-Z kNm	Moment-Z kNm	L/C	Moment-Z kNm	Moment-Z kNm
301	1 EQX	86.59	93.887	1REX	106.054	108.466
302	1 EQX	163.584	177.025	1REX	208.093	212.348
303	1 EQX	170.362	184.488	1REX	215.817	220.316
304	1 EQX	170.362	184.488	1REX	215.817	220.316
305	1 EQX	163.584	177.025	1REX	208.093	212.348

4.4 Comparison of Displacement for Vertical Member Zone IInd and IIIrd

TABLE N0 6 COMPARISION OF DISPLACEMENT FOR VERTICAL MEMBER						
		STAIC ANALYSIS				DYANAMIC ANALYSIS
		Zone II	Zone III		Zone II	Zone III
Beam	L/C	X-Trans mm	X-Trans mm	L/C	X-Trans mm	X-Trans mm
301	1 EQX	31.376	33.881	1REX	43.372	43.996
302	1 EQX	31.377	33.882	1REX	43.373	43.997
303	1 EQX	31.378	33.883	1REX	43.374	43.998
304	1 EQX	31.378	33.883	1REX	43.374	43.998
305	1 EQX	31.377	33.882	1REX	43.373	43.997

V. Conclusion:

The results as obtained zone II and zone III using STAAD PRO 2006 for the Static and Dynamic Analysis are compared for different categories under different nodes and beams.

As per the results in Table No 3 zone II and zone III, we can see that there is not much difference in the values of Axial Forces as obtained by Static and Dynamic Analysis of the RCC Structure.

As per the results in Table No 4 zone II and zone III, we can see that the values for Torsion at different points in the beam are negative and for Dynamic Analysis the values for Torsion are positive.

As per the results in Table No 5 zone II and zone III, we can see that the values for Moment at different points in the beam are 10 to 15% higher for Dynamic Analysis than the values obtained for Static Analysis for the Moment at the same points.

As per the results in Table No 6 zone II and zone III, we can see that the values for displacement at different points in the beam are 17 to 28 % higher for Dynamic Analysis than the values obtained for Static Analysis for the displacement at the same points.

The performance of RCC Framed Structure is analyzed for zone II and III both Static and Dynamic Analysis and the results are tabulated. It can be concluded that the results as obtained for the Dynamic Analysis are higher than the values as obtained by Static Analysis for the same points and conditions.

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