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SEISMIC ANALYSIS OF HIGH RISE BUILDING

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ABSTRACT: When a structure is subjected to earthquake, it responds by vibrating. An earthquake force can be resolved into three mutually perpendicular directions-the two horizontal directions (x and y) and the vertical direction (z). This motion causes the structure to vibrate or shake in all three directions; the predominant direction of shaking is horizontal.

It is very essential to consider the effects of lateral loads induced from wind and earthquakes in the analysis of reinforced concrete structures, especially for high-rise buildings. The basic intent of analysis for earthquake resistant structures is that buildings should be able to resist minor earthquakes without damage. It resists moderate earthquakes without structural damage but sometimes non-structural damage will resist major earthquakes without collapse the major structure. To avoid collapse during a major earthquake, members must be ductile enough to absorb and dissipate energy by post-elastic deformation. Redundancy in the structural system permits redistribution of internal forces in the failure of key elements. When the primary element or system yields or fails, the lateral force certainly redistributed to a secondary system to prevent progressive failure.

Several seismic learning of structure have been developed. This paper discusses actions that have been applied for the dynamic study of irregular structures. In present study, a G+20 storey reinforced concrete composite.

The objectives of the present work is to study the behavior of a multi storied R C building irregular in plan subjected to earth quake load by adopting Response spectrum analysis.

Keywords: Base Shear; Finite Element; Fundamental Frequencies; Geometric Irregularities; Modal Displacement; Response Spectra Time History Analysis; Storey Drift.

INTODUCTION:

Structural design of buildings for seismic loadings is predominantly concerned with structural safety during major ground motions. Seismic loading needs an understanding of the structural performance under huge in-elastic deformations. Many of the structures are evaluated for earthquake forces and then designed accordingly. Several research have been carried out to analyze the response of irregular structures. Work that has been already done relating to the seismic response of vertically irregular building frames, structures with plan irregularities and those with elevation irregularities are common in the affected zone. Major failures happened because of irregularities like soft storey failure, mass irregularity failure, plan irregularity failure, shear failure. The objective of the project is to carry out response spectra time history analysis of geometrically vertical and horizontal irregular composite building frames. Horizontal structural irregularities exist in lateral load resisting system. Vertically irregular building is analyzed for their stability. Structures with vertical offsets will fall under this category. Also, a building may have no apparent offset, but its lateral load carrying elements may have irregularity.

Vertical geometric irregularity: shall be considered to exist where the horizontal dimension of the lateral force resisting system in any storey is more than 150 percent of that in its adjacent storey. Buildings with vertical offsets will fall under this category. Also, a building may have no apparent offset, but its lateral load carrying elements may have irregularity. When building is such that larger dimension is above the smaller dimension, it acts as an inverted pyramid and is undesirable.

Horizontal geometric irregularity: in the layout of vertical lateral-force-resisting elements, thus producing a differential between the centre of mass and centre of rigidity that typically results in significant torsional demands on the structure. Horizontal Structural Irregularities Exist in Lateral Load Resisting System. Horizontally Irregular Building are analyzed for their Stability.

BASIC ASPECTS OF SEISMIC DESIGN

The mass of the building being designed controls seismic design in addition to the building stiffness, because earthquake induces inertia forces that are proportional to the building mass. Designing buildings to behave elastically during earthquakes without damage may render the project economically unviable. As a consequence, it may be necessary for the structure to undergo damage and thereby dissipate the energy input to it during the earthquake. Therefore, the traditional earthquake-resistant design philosophy requires that normal buildings should be able to resist:

(a) Minor (and frequent) shaking with no damage to structural and non-structural elements;

(b) Moderate shaking with minor damage to structural elements, and some damage to non-structural elements; and

(c) Severe (and infrequent) shaking with damage to structural elements, but with NO collapse (to save life and property inside/adjoining the building).

In contrast, structural damage is not acceptable under design wind forces. For this reason, against earthquake effects is called as earthquake resistant design and not earthquake-proof design

(a) Minor (Frequent) Shaking –No/Hardly any damage

(b) Moderate Shaking – Minor structural damage, and some non-structural damage

(c) Severe (Infrequent) Shaking – Structural damage, but NO collapse

SEISMIC ZONES OF INDIA

Based on the levels of intensities sustained during damaging past earthquakes, the seismic zone map is revised with only four zones, instead of five. While Zone I has been merged to Zone II. Hence, Zone I does not appear in the new zoning; only Zones II, III, IV and V.

SEISMIC ANALYSIS AS PER THE IS CODE

When a structure is subjected to earthquake, it responds by vibrating. An earthquake force can be resolved into three mutually perpendicular directions the two horizontal directions (x and y) and the vertical direction (z). This motion causes the structure to vibrate or shake in all three directions; the predominant direction of shaking is horizontal. All the structures are primarily designed for gravity loads-force equal to mass time's gravity in the vertical direction. Because of the inherent factor of safety used in the design specifications, most structures tend to be adequately protected against vertical shaking. Vertical acceleration should also be considered in structures with large spans, those in which stability for design, or for overall stability analysis of structures. IS 1893 (part 1) code recommends that detailed dynamic analysis, or pseudo static analysis should be carried out depending on the importance of the problem. IS 1893(part1): 2002 recommends use of modal analysis using response spectrum method and equivalent lateral force method for building of height less than 40 m in all seismic zones.

WIND ANALYSIS

The basic wind speed (Vb) for any site shall be obtained IS 875-1987(3) and shall be modified to get the design wind velocity at any height (Vz) for a chosen structure. Vz = Vb k1k2 k3
Where,
Vz = design wind speed at any height z in
m/s,
Vb = Basic wind speed in m/s,
k1 = probability factor (risk coefficient),
k2 = terrain roughness and height factor and
k3 = topography factor.

The basic wind speed map of India, as applicable at 10 m height above mean ground level for different zones of the country selected from the code. The design wind pressure at any height above mean ground level shall be obtained by the following relationship between wind pressure and wind velocity.
Pz = 0.6 Vz
2
Where,
Pz = wind pressure in N/m^2 at height z and Vz = design wind speed in m/s at height z.

MODELING AND ANALYSIS COMPUTER PROGRAM

In this study a computer program has been developed to analyse the reinforced concrete buildings under wind and earthquake loads taking into account the new changes in the IS-1893 PART-1 2002.The program calculates the base shear that resist the design lateral loads. It calculates also the centre of mass and the centre of rigidity of the building. Moments, lateral shear forces and the additional shear forces due to torsion on each vertical element resisting lateral load at the each floor are also calculated. All the results are illustrated graphically by the program to clearly showing the results.

BUILDING CONFIGRATION

The building model in the study has twenty storeys with constant storey height of 3m. FOUR models are used to analyse with equal bay lengths and the number of Bays and the bay-width along two horizontal directions are kept constant in each model for convenience. Different values of ZONE FACTOR are taken and their corresponding effects are interpreted in the results. Other details are given below:

PARAMETERS	ZONE II	ZONE III	ZONE IV	ZONE V
Seismic zone factor	0.10	0.16	0.24	0.36
Basic wind speed	44 m/s	39 m/s	47 m/s	50 m/s
Response reduction factor	5	5	5	5
Importance factor	1	1	1	1
Soil condition	Medium	Medium	Medium	Medium
Slab thickness	0.150 m	0.150 m	0.150 m	0.150 m
Beam size	0.45x0.25 m	0.45x0.25 m	0.45x0.25 m	0.45x0.25 m
Column size	0.75x0.75 m	0.75x0.75 m	0.75x0.75 m	0.75x0.75 m
Live load	2 kN/m^2	2 kN/m^2	2 kN/m^2	2 kN/m^2
Dead load	4.5 kN/m^2	4.5 kN/m^2	4.5 kN/m^2	4.5 kN/m^2
Floor finish	1.1Kn/m^2	1.1Kn/m^2	1.1Kn/m^2	1.1Kn/m^2
Material properties	M_{30}	M_{30}	M_{30}	M_{30}

Building configuration data.

LOADING:

Loading on tall buildings differ from loading on lowrer buildingin it saccumulation into much larger structural forces,in the increased significance of wind loading ,and in the greater importance of dynamic effects. There are three types of load considered in this structural an alysisand design.They are gravity loads that include dead load and live load, wind and earthquake loads.

GRAVITY LOADS

Dead loads are defined as gravity loads that will be accelerated laterally with the structural frame under earthquake motion. Liveloads are defined as gravity loads that do not accelerate laterally at the same rate as the structural frame when the structure under goes earth quake motion.

LATERAL LOADS

There are certain loads that are almost al way sapplied horizontally ,and the semust often be considered in structural analysis and design. Such loads are called lateral loads. Some kinds of lateral loads that are important for structures are wind load and earth quake load.

WIND LOAD

The forces exerted by wind son buildings increase dramatically with the increased in Building heights.For building of upto about10 stories and of typical proportion, the design is rarely affected by wind load. Above this height, however ,the increase in size of structural member to account for wind loading, incurs cost pre that increase progressively with height.

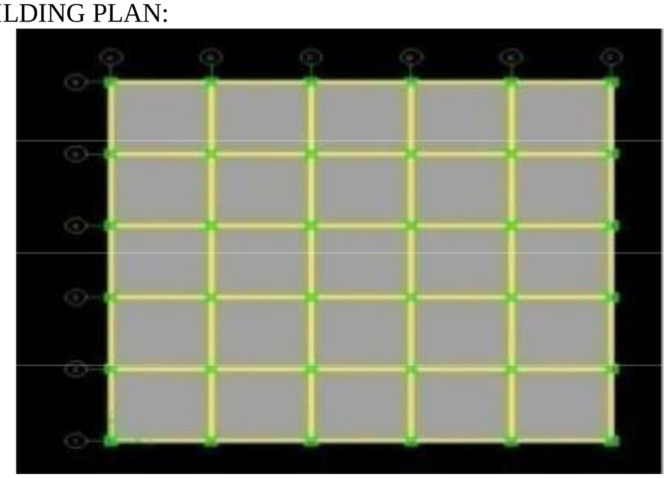
EARTHQUAKE LOAD

Earth quake load consists of the inertial forces of the building mass that result from the shaking of its foundation by a seismic disturbance .Other severe earth quake forces may exist ,and such as those due to land sliding, subsidence, active faulting below the foundation, or liquefaction of the local sub grade as a result of vibration. Where as earth quake so ocur ,their intensity is relative inversely proportion to the irfrequency of occureence; severe earth quakes are rare, moderate ones more often, and minor ones are relatively frequent.

LOAD COMBINATIONS

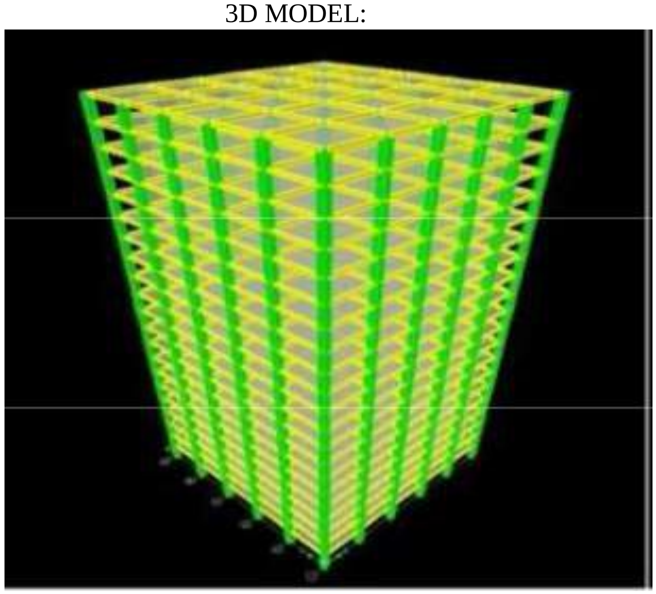
The various loads should, therefore, be combined in accordance with the stipulations in the relevant design codes. In the absence of such recommendations, the following loading combinations are made. The most unfavorable effect in the building, and structural member concerned may be adopted. It should also be recognized in load combinations that the simultaneously occurrence of maximum values of earthquake, Wind and imposed loads.

PLAN AND 3D MODEL OF BUILDING PLAN:



Bare frame model in 2D view

3D MODEL:



Bare frame model in 3D view.

LITRETURE RIVIEW

Chavan, Jadhav (2014) studied seismic analysis of reinforced concrete with different bracing arrangements by equivalent static method using Staad Pro. software. The arrangements considered were diagonal, V-type, inverted V-type and X-type. It was observed that lateral displacement reduced by 50% to 60% and maximum displacement reduced by using X-type bracing. Base shear of the building was also found to increase from the bare frame, by use of X-type bracing, indicating increase in stiffness.

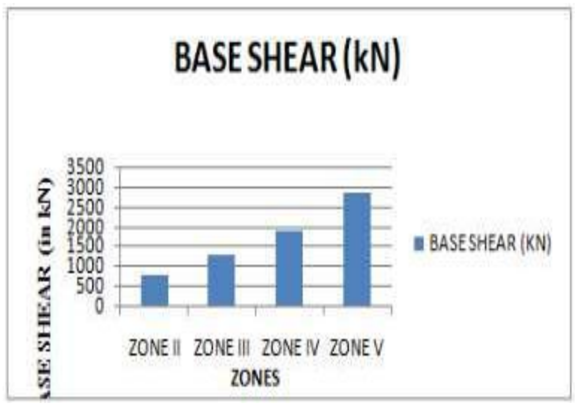
Kappos , Manafpour (2000) presented new methodology for seismic design of RC building based on feasible partial inelastic model of the structure and performance criteria for two distinct limit states. The procedure is developed in a format that can be incorporated in design codes like Eurocode 8. Time-History (Non-linear dynamic) analysis and Pushover analysis (Non-linear Static analysis) were explored. The adopted method showed better seismic performance than standard code procedure, at least in case of regular RC frame building. It was found that behaviour under "life-safety" was easier to control than under serviceability earthquake because of the adoption of performance criteria involving ductility requirements of members for "life-safety" earthquake.

V RESULTS AND DISCUSSION:

BASE SHEAR

ZONES	BASE SHEAR (kN)
ZONE II	802.6
ZONE III	1284
ZONE IV	1926
ZONE V	2889

Base shear values for different zones



Variation of Base shear values For Different Zones of INDIA

RESULT
Beam Displacement Detail Summary

Maximum and minimum displacements of beam members are discussed in the above table with accordance to load cases. The maximum resultant displacement is 30.

Displacements shown in italic indicate the presence of an offset

	Beam	L/C	d (m)	X (mm)	Y (mm)	Z (mm)	Resultant (mm)
Max X	578	12:GENERATE	3.000	**20.860**	-6.071	0.095	21.726
Min X	583	14:GENERATE	3.000	**-20.861**	-6.071	0.095	21.726
Max Y	231	2:LOAD CASE	5.200	0.000	**0.393**	8.110	8.119
Min Y	457	5:GENERATEI	3.900	-0.014	**-22.458**	-0.012	22.458
Max Z	598	13:GENERATE	1.500	-0.000	-8.167	**23.809**	25.171
Min Z	620	15:GENERATE	1.500	-0.000	-8.167	**-23.809**	25.171
Max Rst	471	13:GENERATE	2.600	0.014	-19.405	23.261	**30.292**

Maximum and minimum Beam End Displacement

The result shown here in the table shows us the Maximum and minimum Beam end displacement coming under different load cases applied in this study. The maximum beam end displacement in the building is 28.097.

Displacements shown in italic indicate the presence of an offset

	Beam	Node	L/C	X (mm)	Y (mm)	Z (mm)	Resultant (mm)
Max X	578	199	12:GENERATE	**20.860**	-6.071	0.095	21.726
Min X	583	204	14:GENERATE	**-20.861**	-6.071	0.095	21.726
Max Y	394	169	1:LOAD CASE	13.140	**0.214**	0.000	13.141
Min Y	585	206	5:GENERATEI	0.057	**-17.379**	0.000	17.379
Max Z	580	201	13:GENERATE	0.008	-8.198	**23.805**	25.177
Min Z	592	213	15:GENERATE	0.008	-8.198	**-23.805**	25.177
Max Rst	588	209	15:GENERATE	-0.050	-15.094	-23.698	**28.097**

Maximum and minimum Beam End Force

The above table gives us the maximum and minimum Beam end forces coming in different beams at different nodes under different load cases.

The signs of the forces at end B of each beam have been reversed. For example: this means that the Min Fx entry gives the largest tension value for an beam

				Axial	Shear		Torsion	Bending	
	Beam	Node	L/C	Fx (kN)	Fy (kN)	Fz (kN)	Mx (kNm)	My (kNm)	Mz (kNm)
Max Fx	35	8	5:GENERATEI	**14.1E+3**	-4.374	0.000	0.000	-0.000	-5.609
Min Fx	34	7	1:LOAD CASE	**-236.660**	47.936	-0.000	-0.000	0.000	219.254
Max Fy	457	182	5:GENERATEI	-18.068	**540.024**	-0.004	0.130	0.016	740.195
Min Fy	468	194	5:GENERATEI	-18.068	**-540.024**	0.004	-0.130	0.016	740.194
Max Fz	579	182	5:GENERATEI	678.102	-22.661	**277.839**	0.593	-398.609	-26.408
Min Fz	591	194	5:GENERATEI	678.102	-22.661	**-277.839**	-0.593	398.609	-26.408
Max Mx	455	185	5:GENERATEI	-8.336	162.320	0.005	**1.765**	-0.016	109.294
Min Mx	451	181	5:GENERATEI	-8.336	224.144	-0.005	**-1.765**	0.009	263.853
Max My	579	200	5:GENERATEI	583.850	-22.661	277.839	0.593	**434.909**	41.574
Min My	591	212	5:GENERATEI	583.850	-22.661	-277.839	-0.593	**-434.909**	41.574
Max Mz	457	182	5:GENERATEI	-18.068	540.024	-0.004	0.130	0.016	**740.195**
Min Mz	37	10	14:GENERATE	10.4E+3	-121.107	-0.000	0.000	0.000	**-373.813**

Maximum beam displacement

The maximum beam displacement coming for span 3m, 5m and 6.5m are 0.0044mm, 1.023mm and 3.048mm respectively. The allowable limits as per IS: 456 are 12mm,20mm and 26mm respectively for 3m, 5m and 6.5m.

BEAM	L/C	LENGTH (m)	Max (mm)	Distance (m)	allowable limits(mm)
598	5 combination 1.5(DL+LL)	3	0.044	2.250	12
600	5 combination 1.5(DL+LL)	5	1.023	2.083	20
601	5 combination 1.5(DL+LL)	6.5	3.048	3.250	26

Storey drift

STORY	HEIGHT (METE)	LOAD	AVG. DISP(CM) X	AVG. DISP(CM) Z	DRIFT(CM) X	DRIFT(CM) Z	RATIO	STATUS
BASE=	0.00						ALLOW. DRIFT = L / 1	
12	33.00	5	0.0000	0.0000	0.0000	0.0000	L /999999	PASS
		6	0.0000	0.0000	0.0000	0.0000	L /999999	PASS
		7	1.6619	0.0000	0.0267	0.0000	L / 11238	PASS
		8	0.0000	1.8959	0.0000	0.0362	L / 8293	PASS
		9	-1.6619	0.0000	0.0267	0.0000	L / 11238	PASS
		10	0.0000	-1.8959	0.0000	0.0362	L / 8293	PASS
		11	0.0000	0.0000	0.0000	0.0000	L /999999	PASS
		12	2.0774	0.0000	0.0334	0.0000	L / 8990	PASS

After the analysis we get the maximum drift in the building is 2.077 cm under different

combinations of load which is safe as per IS 1893-2002.

CONCLUSIONS

The main conclusion of the study is as follows

1. The fundamental natural period calculated by AUTOCADD matches with that calculated by IS 1893:2002.
2. The displacement of beam coming in the building is within the limits of Indian standards. This building is safe for area coming under earthquake zone II.
3. The maximum drift in the building is 2.077 cm which is safe as per IS 1893-2002.
4. The maximum beam displacement of 3m span beam is 0.044mm and allowable displacement is 12mm.