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SEISMIC ANALYSIS OF FOUR STOREY BUILD USING EQUIVALENT STATIC METHOD

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ABSTRACT

The analysis of a structural system to determine the deformations and forces induced by applied loads or ground excitation is an essential step in the design of a structure to resist earthquake. There is a range of methods from a linear analysis to a sophisticated nonlinear analysis depending on the purpose of the analysis in the design process. In this paper seismic response of a residential G+10 RC frame building is analysed by the linear analysis approaches of Equivalent Static Lateral Force method using ETABS Ultimate2015 software as per the IS-1893-2002-Part-1. These analysis are carried out by considering different seismic zones, medium soil type for all zones and for zone II & III using OMRF frame type and for those of the rest zones using OMRF & SMRF frame types. Different response like lateral force, overturning moment, story drift, displacements, base shear are plotted in order to compare the results of the static and dynamic analysis

I. 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. The ductility of a structure is the most important factors affecting its seismic performance and it has been clearly observed that the well-designed and detailed reinforced structures behave well during earthquakes and the gap between the actual and design lateral force is narrowed down by providing ductility in the structure.

The following are the advantages of a reinforced concrete structure having sufficient ductility:

- A ductile reinforced concrete structure may take care of overloading, load reversals, impact and secondary stresses due to differential settlement of foundation.
- A ductile reinforced concrete structure gives the occupant sufficient time to vacate the structure by showing large deformation before its final collapse. Accordingly, the loss of life is minimized with the provision of sufficient ductility.
- Properly designed ductile joints are capable of resisting forces and deformations at the yielding of steel reinforcement. Therefore, these sections can reach their respective moment capacities, which is one of the assumptions in the design of reinforced concrete structures by limit state method.

Equivalent static analysis

This approach defines a series of forces acting on a building to represent the effect of earthquake ground motion, typically defined by a seismic design response spectrum. It assumes that the building responds in its fundamental mode. For this to be true, the building must be low-rise and must not twist significantly when the ground moves. The response is read from a design response spectrum, given the natural frequency of the building (either calculated or defined by the building code). The applicability of this method is extended in many building codes by applying factors to account for higher buildings with some higher modes, and for low levels of twisting. To account for

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effects due to "yielding" of the structure, many codes apply modification factors that reduce the design forces (e.g. force reduction factors).

Since the Static Equivalent method is accurate and easy for short building especially for single story building so I have decided to analyze the given building in the equivalent static analysis.

II. METHOD OF ANALYSIS

The most commonly used methods of analysis for determining the design seismic forces acting on a structure as results of ground shaking are based on the approximation that the effects of yielding can be accounted for by linear analysis of the building, using the design spectrum for inelastic systems. Forces and displacements due to each horizontal component of ground motion are separately determined by analysis of an idealized building having one lateral degree of freedom per floor in the direction of the ground motion component being considered. Such analysis may be carried out by the equivalent static procedure (static method) or response spectrum analysis procedure (dynamic method). Both the equivalent static and response spectrum analysis procedures lead directly to lateral forces in the direction of the ground motion component. The significant difference between linear static and linear dynamic analysis is the level of the forces and their distribution along the height of the structure. The equivalent static method is mainly suited for preliminary design of the building. The preliminary design of the building is then used for response spectrum analysis or any other refined method such as the elastic time history method.

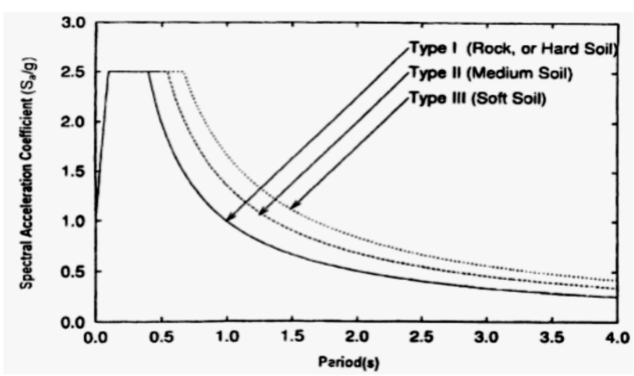
Methodology

Design horizontal seismic coefficient (Ah) for a structure shall be determined by the following expression:

$$A_h = \frac{ZISa}{2Rg}$$

Where,
Z=Zone factor=0.16(for 3rd zone)
I=Importance factor=1.5(for important building)
R=Response reduction factor=5
Sa/g=Average response acceleration coefficient
For medium soil site

$$\frac{Sa}{g} = \begin{cases} 1+15T & 0.00 \le T \le 0.10 \\ 2.50 & 0.10 \le T \le 0.55 \\ \frac{1.36}{T} & 0.55 \le T \le 4.00 \end{cases}$$



Structural Modeling and analysis

The Technology Innovation and Industry Relations contains 15 working modules, one auditorium, two stores, one common facility, three stair cases, one electrical room , one big display area and other necessary rooms.

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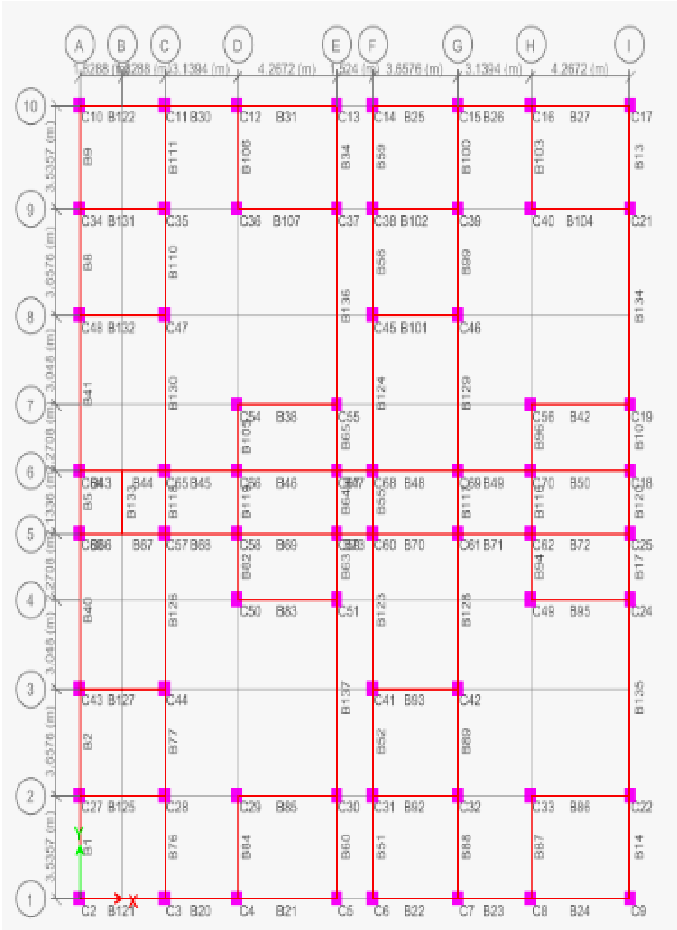

Fig : Centre Line Plan

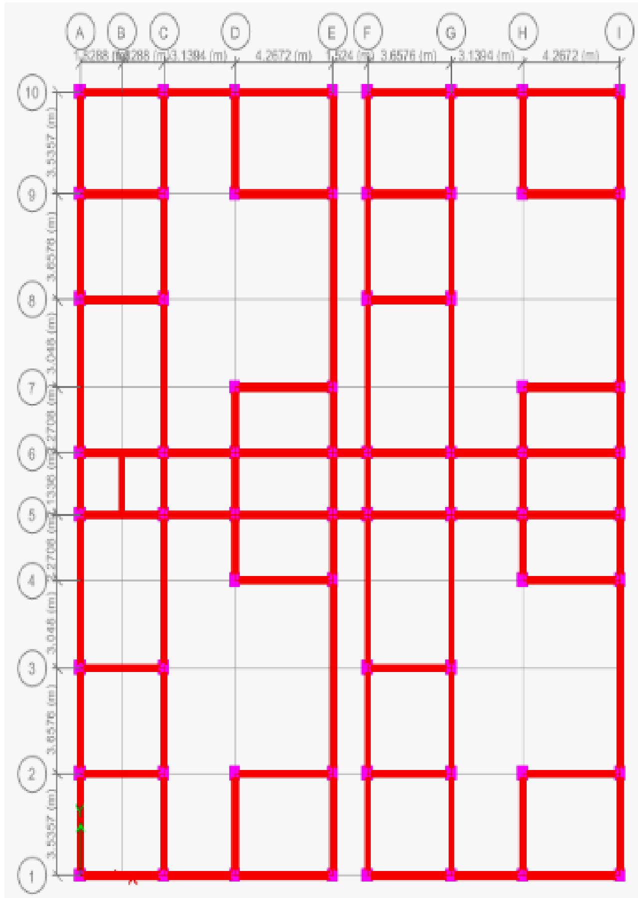

Fig : Beam Column Layout

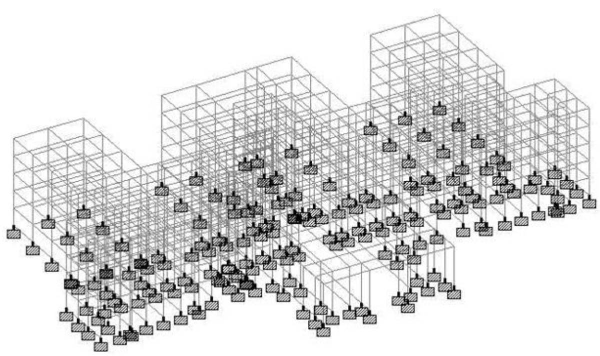

Fig Isometric view of TIIR building

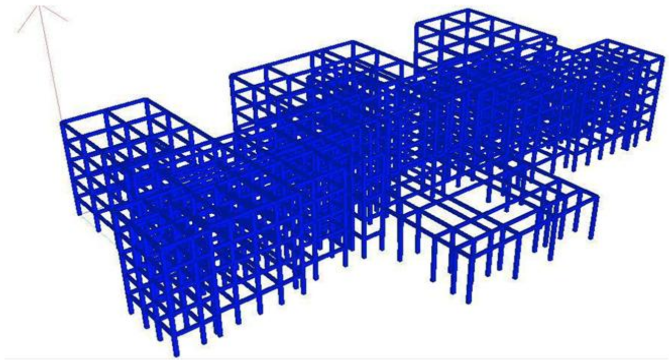

Fig3.6, 3D view of TIIR building

Materials Property

I have used M_{25} concrete and Fe_{415} steel while analyzing the given school buildings.

Table Concrete property

Young's Modulus (E)	21718.5 MPa
Poisson's Ratio (nu)	0.17
Density	24.0261 KN/m^3
Thermal coefficient (a)	10^{-5} /c̊
Critical Damping	0.05

Table Steel property

Young's Modulus (E)	205000 MPa
Poisson's Ratio (nu)	0.3
Density	76.8195 KN/m^3
Thermal coefficient (a)	$1.2*10^{-5}$ /c̊
Critical Damping	0.03

loads on structure

The structure is analyzed and designed for live load, dead load, and seismic load as per IS-1893-2002. The following figures show the different load acting on building

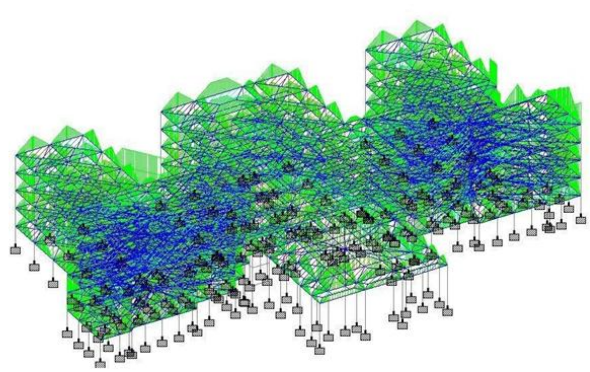

Fig dead load and live load are acting on TIIR building

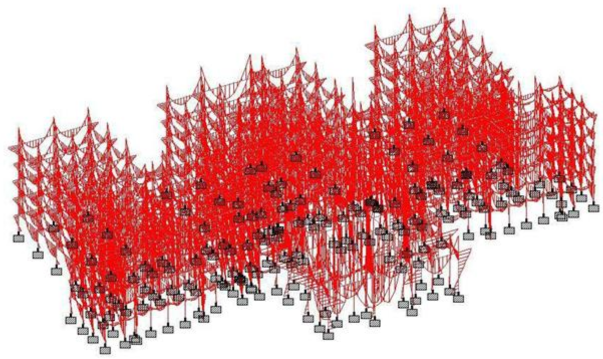

Fig bending diagram due to dead load and live load

Summary of support reactions are shown in the following table

			Horizontal	Vertical	Horizontal	Moment		
	Node	L/C	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
Max Fx	218	5 GENERATE	**115.772**	1072.228	-1.749	-9.418	0.352	-306.293
Min Fx	219	5 GENERATE	**-115.758**	1072.261	-1.745	-9.401	-0.362	306.232
Max Fy	116	5 GENERATE	1.340	**2382.394**	-28.206	-31.432	0.090	-2.247
Min Fy	180	5 GENERATE	3.716	**-134.117**	15.044	19.177	-1.296	-9.823
Max Fz	79	5 GENERATE	12.997	935.268	**54.227**	98.634	-2.615	-15.051
Min Fz	212	5 GENERATE	-4.775	581.367	**-181.036**	-497.272	8.542	12.716
Max Mx	79	5 GENERATE	12.997	935.268	54.227	**98.634**	-2.615	-15.051
Min Mx	212	5 GENERATE	-4.775	581.367	-181.036	**-497.272**	8.542	12.716
Max My	212	5 GENERATE	-4.775	581.367	-181.036	-497.272	**8.542**	12.716
Min My	216	5 GENERATE	4.781	581.359	-181.034	-497.263	**-8.544**	-12.742
Max Mz	219	5 GENERATE	-115.758	1072.261	-1.745	-9.401	-0.362	**306.232**
Min Mz	218	5 GENERATE	115.772	1072.228	-1.749	-9.418	0.352	**-306.293**

Summary of beam end forces are shown in the following table

Table Summary of beam end forces

	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
Max Fx	617	5 GENERATE	116	**2382.394**	-1.340	-28.206	0.090	31.432	-2.247
Min Fx	449	5 GENERATE	254	**-197.734**	-3.716	15.044	-1.296	101.173	19.902
Max Fy	516	5 GENERATE	266	99.663	**423.328**	-0.001	0.000	-0.228	1521.050
Min Fy	516	5 GENERATE	267	99.663	**-423.327**	-0.001	0.000	-0.242	1521.041
Max Fz	1131	5 GENERATE	615	490.980	-16.306	**243.065**	-35.500	1010.362	19.630
Min Fz	455	5 GENERATE	212	581.367	4.775	**-181.036**	8.542	497.272	12.716
Max Mx	501	5 GENERATE	263	4.600	126.240	-23.418	**228.423**	46.713	27.833
Min Mx	507	5 GENERATE	265	4.615	126.234	23.418	**-228.422**	-46.713	27.822
Max My	1131	5 GENERATE	248	483.028	-16.306	243.065	-35.500	**1253.427**	35.935
Min My	455	5 GENERATE	260	517.750	4.775	-181.036	8.542	**-951.019**	-25.485
Max Mz	516	5 GENERATE	266	99.663	423.328	-0.001	0.000	-0.228	**1521.050**
Min Mz	462	5 GENERATE	267	1008.644	115.758	-1.745	-0.362	-4.557	**-619.836**

Critical node displacements are shown in the following table

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Table Summary of node displacement

			Horizontal	Vertical	Horizontal	Resultant	Rotational		
	Node	L/C	X mm	Y mm	Z mm	mm	rX rad	rY rad	rZ rad
Max X	1036	7 GENERATE	13.336	-1.878	-0.020	13.468	0.000	-0.000	-0.001
Min X	619	5 GENERATE	-1.105	-0.117	1.204	1.639	-0.000	0.000	-0.000
Max Y	254	5 GENERATE	0.010	0.272	8.058	8.063	0.004	0.000	-0.000
Min Y	1132	5 GENERATE	0.205	-5.020	-1.211	5.168	-0.001	-0.000	-0.000
Max Z	1104	2 LOAD CAS	0.394	0.002	12.208	12.215	0.001	0.000	-0.000
Min Z	608	5 GENERATE	0.290	-1.094	-3.085	3.286	0.004	-0.000	0.000
Max rX	245	5 GENERATE	0.003	-1.205	8.678	8.761	0.019	-0.000	-0.001
Min rX	264	5 GENERATE	-0.019	-0.900	6.445	6.507	-0.022	0.001	-0.001
Max rY	264	5 GENERATE	-0.019	-0.900	6.445	6.507	-0.022	0.001	-0.001
Min rY	260	5 GENERATE	0.016	-0.900	6.446	6.509	-0.022	-0.001	0.001
Max rZ	267	5 GENERATE	-0.251	-1.703	1.850	2.528	0.000	0.000	0.012
Min rZ	266	5 GENERATE	0.243	-1.703	1.853	2.529	0.000	-0.000	-0.012
Max Rs	1078	7 GENERATE	13.256	-3.396	-0.031	13.684	0.000	-0.000	-0.000

III. REINFORCE CONCRETE DESIGN

Detailing of beam and column

In Technology Innovation and Industry Relations building, M_{25} and Fe_{415} are used. Two types of section are used beam section (0.45x0.4) and columns (0.5x0.45).

From those beams and columns on from each are chosen for showing their reinforcement details.

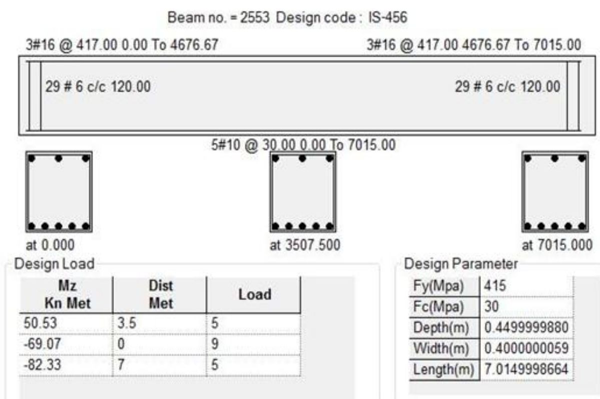

Fig reinforcement details of beam

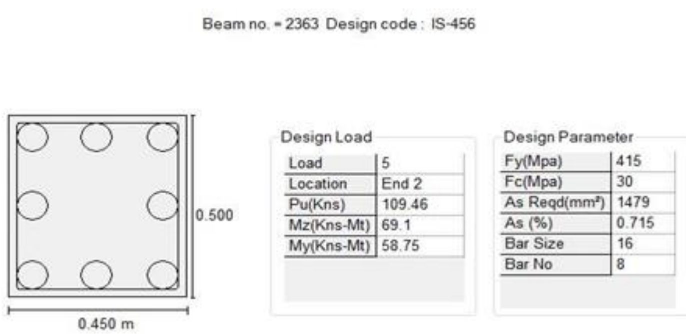

Fig reinforcement details of column

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IV. SEISMIC EVALUATION

Equivalent static performance

In recent years the topic of seismic loads and analysis has become of increasing importance in both Europe and the United States. This is due largely to the frequency of large magnitude seismic events that have been witnessed, often in large metropolitan areas, typically resulting in tragic loss of life. As a direct result greater efforts have been made to understand and quantify loads that might be experienced during an earthquake.

This interest also extends to the expanding boundaries of science. Optical and radio telescopes are being continuously used to increase and improve humanity's knowledge of the universe surrounding us. By their very nature these instruments are extremely sensitive to vibratory disturbances. They are also located in remote regions such as northern Chile or Hawaii which are active seismic zones. Proper consideration of seismicity is important in guaranteeing a long design life for the telescope.

Historically, seismic loads were taken as equivalent static accelerations which were modified by various factors, depending on the location's seismicity, its soil properties, the natural frequency of the structure, and its intended use. The method was refined over the years to enable increasingly adequate designs. The underlying design philosophy was basically unchanged; some modifications were made to the coefficients as a result of strong earthquakes. Other modifications to account for new information were introduced by specifying acceptable structural details for different construction materials.

However, this method was developed in order to design buildings and not telescopes. These two applications have some important differences. Buildings have longer periods of vibration. They are also designed as regular frames and can be simplified as two-dimensional frames. Telescopes, on the other hand, are deflection controlled structures with short periods of vibration, composed largely of orthogonal, closely spaced modes.

All design against earthquake effects 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 and begins with an estimate of peak earthquake load calculated as a function of the parameters 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 of significance. 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 both Euro code 8 and IBC require more complex methods to be used in these circumstances. However, it may still be useful, even here, as a 'sanity check' on later results using more sophisticated techniques.

This approach defines a series of forces acting on a building to represent the effect of earthquake ground motion, typically defined by a seismic design response spectrum. It assumes that the building responds in its fundamental mode. For this to be true, the building must be low-rise and must not twist significantly when the ground moves. The response is read from a design response spectrum, given the natural frequency of the building (either calculated or defined by the building code). The applicability of this method is extended in many building codes by applying factors to account for higher buildings with some higher modes, and for low levels of twisting. To account for effects due to "yielding" of the structure, many codes apply modification factors that reduce the design forces (e.g. force reduction factors).

V. CONCLUSION

The all loads are applied on the structure according to IS1893 (2002) and different combination of loads were generated by STAAD Pro software .by considering the all specification for 3nd zone in seismic zones of India. The amount of concrete and reinforcement with different diameters which are suggested by Software are as follows

Total volume of concrete required = 1967.17m^3

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Table details of reinforcement

Bar diameter (in mm)	Weight (in N)
6	168899.98
8	120480.06
10	241525.55
12	330177.47
16	84288.70
20	66666.16
25	18887.04
Total weight	1030925.00

REFERENCES

1. *R. Clough,, and J. Penzien, Dynamics of Structures, McGraw-Hill, New York. 1993*
2. *Structural Engineers Association of California, Recommended Lateral Force Requirements and Commentary, Structural Engineers Association of California, Sacramento, 1996*
3. *Williams,. Seismic Design of Buildings and Bridges, Engineering Press, Austin.1998*
4. *Paz,. Structural Dynamics, Van Nostrand Reinhold, New York, 1985*
5. *IS-1893 part 1 2002 criteria for Earthquake resistant Design of structures.*
6. *IS-456-2000 plain and Reinforced cement concrete code of practice.*
   Earthquake Resistant Design of Structures (English) 1st Edition by Manish Shrikhande and Pankaj Agarwal.