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SEISMIC ANALYSIS OF MULTISTORIED BUILDING WITH AND WITHOUT VERTICAL MASS IRREGULARITY

Rashmi S. Patil*[1], Prof. H. S. Vidyadhar[2] and Dr. S. B. Patil[3]

[1]M. Tech Student, Corresponding author, Civil Engineering Department, PDA college of Engineering, Kalaburagi, India.

[2]Professor, Civil Engineering Department, PDA College of Engineering, Kalaburagi, India.

[3]Professor, Civil Engineering Department, Dr BATU, Lonere, India.

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***Corresponding Author**
Rashmi S. Patil
M. Tech Student, Corresponding author, Civil Engineering Department, PDA college of Engineering, Kalaburagi, India.

ABSTRACT

Structures designed for gravity loads, in general, may not be able to safely sustain the effects of horizontal earthquake shaking. Hence, it is necessary to ensure adequacy of the structures against horizontal earthquake effects. In this study, 3D Analytical model of G+15 storeyed buildings have been generated for vertical mass irregularity. Ten models are generated with difference in vertical mass irregularity and steel bracings (angle section 127mm× 95mm×12mm) analysed by using analysis tool 'ETABS Non-linear Version 9.5.0'. The parameters considered in this paper are fundamental time period, base shear and displacement. The analysis is done with two different methods namely linear static Method (Equivalent Static Method) and Linear Dynamic Analysis (Response Spectrum Analysis). In this study, the displacements values are increasing as the irregular mass shifts towards top. The base shear values are considerably high in buildings having vertical mass irregularity and as the vertical mass shifts towards top, base shear decreases.

KEYWORDS: Seismic waves, Vertical Mass irregularity, ETABS, linear Static method, Linear Dynamic method.

INTRODUCTION

Irregular buildings constitute a large portion of the modern urban infrastructure. Structures are never perfectly regular and hence the designers routinely need to evaluate the likely degree of irregularity and the effect of this irregularity on a structure during an earthquake. About 90% of all earthquakes result from tectonic events, primarily movements on the faults (Agrawal and Shrikhande et al., 2006). Structures designed for gravity loads, in general, may not be able to safely sustain the effects of horizontal earthquake shaking. Hence, it is necessary to ensure adequacy of the structures against horizontal earthquake effects (C. V. R. Murty et al., 2002). Need for research is required to get economical and efficient lateral stiffness system for high seismic prone areas. For optimization and design of high rise building with different structural framing systems subjected to seismic loads. The innovative and revolutionary new ETABS is the ultimate integrated software package for the structural analysis and design of buildings.

LITERATURE REVIEW

The R.C.C and Composite structures with one of the important consideration of Mass irregularity in the form of swimming pool at 9th floor, analysis is done using SAP 2000 software. The study shows that Composite structures having mass irregularity perform better than R.C.C. structures. Design base shear values and dead weight are reduced by 18% for composite structures, hence earthquake forces also reduced by 18% (Cholekar & Basavalingappa et al., 2015). R.C.C. building of G+10 having mass irregularity in 3rd and 6th floors and building without mass irregularity is analysed. It was observed that there is an increase of 67% in the moments of mass irregular buildings than buildings without mass irregularity (N.Anvesh, Yajdani and Pavan kumar et al., 2015). The seismic performance of G+6 storey regular and irregular Reinforced Concrete (RC) buildings using ETABS (V. 9.7.1), to evaluate the impact of vertical irregularity on RC buildings in terms of static linear and nonlinear analysis. Maximum base shear occurs in the mass irregularity building as compared to other models. (Pathi, Guruprasad, Dharmesh And Madhusudhana et al., 2014). Building model of G+ 5 storey, the building models are studied for vertical geometric irregularity in seismic zone V of India. Types of bracings considered for the study are X, V and K-type steel bracing. Lateral displacement and Storey drift increases as the amount of irregularity present in the building increases. Addition of bracings to the bare frames shows reduction in lateral displacement and storey drift (Karthik and Vidyashree et al., 2015). Modelling of the building for five different systems viz. unbraced frame, Chevron Braced

Frame, Eccentrically Braced Frame, Single Diagonal Braced Frame and X Braced Frame under same loading conditions is done using ETABS. Use of Chevron braced frame system is more efficient than any other braced frame system (Odedra and Tarachandani et al., 2016).

MODELLING

The Reinforced Concrete building models used in this study is G+15 storied, have same floor plan with 5m bays along longitudinal direction and 4.5m bays along transverse direction. The storey height is 3m for all the stories. The live load taken has 3 KN/m^2 for all floors and no live load on roof, while the floor finish load is taken as 1 kN/m^2 on all other floors. Thickness of brick wall over all floor beams is taken as 0.230 m. Thickness of slab is taken as 0.15 m. The unit weight of reinforced concrete is 25kN/m^3 and brick masonry is taken as 20 kN/m^3. The compressive strength of concrete is 25 N/mm^2 and yield strength of steel reinforcements is 415 N/mm^2.The modulus of elasticity of concrete and steel are 25000 N/mm^2 and 2×10^5 N/mm^2 respectively. All the structures have been considered to be located in seismic region V with an importance factor 1 and sub-soil type 2 (medium) and response reduction factor 5 (SMRF). Model 1 is regular frame, model 2 is regular frame with heavy mass on 6th floor, model 3 is regular frame with heavy mass on 11th floor, model 4 is regular frame with heavy mass on top storey and model 5 is regular frame with heavy mass on 6th, 11th and top storey. Models 6th to 10th are same as that of model 1st to 5th respectively with steel bracings. The model is prepared of G+15 Storey. The regular building model is without mass irregularity as shown in figure 1. The model 1 regular building is as shown in figure 2. Heavy mass, it is taken as SIL (Superimposed Load) 20 KN/m^2 on 6th floor and on RF (Roof) as shown in figures 3 and 4 respectively.

RESULTS AND DISCUSSION

Results of the building models studied are presented and discussed in detail. The results of fundamental natural period of vibration, lateral displacements and storey drifts are included for building models and compared. The fundamental time period of 10 models are 2.5515, 3.2642, 3.3379, 3.499, 3.7132, 2.4837, 2.6315, 2.7928, 2.9178 and 3.2122 respectively.

The Base shear in X-direction of 10 models are 3656.62 KN, 4959.56 KN, 4722.09 KN, 4612.27 KN, 4965.51 KN, 3603.02 KN, 4023.54 KN, 3761.61 KN, 3598.49KN and 4104.66KN respectively. Base shear in y-direction of 10 models are 3612.7KN, 4408.09 KN, 4217.31 KN, 4136.17 KN, 4443.11 KN, 3264.09 KN, 3571. 44 KN, 3364.09 KN, 3571.44 KN, 3365.23 KN, 3236.93 KN and 3679.61 KN respectively.

The Storey displacement values in X-direction of Models (Linear static analysis) are tabulated in table 1.

Table 1: The Storey displacement values in X-direction of Models (Linear static analysis).

Storey	Model 1 Disp-X	Model 2 Disp-X	Model 3 Disp-X	Model 4 Disp-X	Model 5 Disp-X	Model 6 Disp-X	Model 7 Disp-X	Model 8 Disp-X	Model 9 Disp-X	Model 10 Disp-X
GF	1.203389	1.455263	1.387033	1.388285	1.460456	1.073888	1.180605	1.105707	1.059604	1.207903
1	3.951328	4.802704	4.57906	4.585579	4.823123	3.544994	3.896237	3.651131	3.500505	3.989753
2	7.501022	9.160235	8.73792	8.756389	9.207651	6.76385	7.43112	6.969389	6.685698	7.618302
3	11.45412	14.033998	13.39676	13.43743	14.12442	10.36826	11.38406	10.6899	10.26225	11.68922
4	15.590721	19.139651	18.29092	18.36855	19.29572	14.15237	15.52298	14.6036	14.03233	15.97275
5	19.782184	24.301861	23.26413	23.39884	24.55546	17.99412	19.70239	18.58814	17.88164	20.32964
6	23.947431	29.397694	28.21815	28.43592	29.7929	21.8164	23.81583	22.56756	21.74073	24.6701
7	28.031576	34.335793	33.08736	33.41995	34.92939	25.56761	27.7812	26.49172	25.56517	28.95838
8	31.997129	39.093572	37.8288	38.31236	39.94135	29.21451	31.59104	30.32769	29.3271	33.17466
9	35.844526	43.673172	42.42393	43.09535	44.82523	32.74448	35.25624	34.05998	33.0149	37.31007
10	39.874905	48.453801	47.25031	48.21096	50.03563	36.45715	39.0912	38.00316	36.99589	41.76711
11	43.520772	52.71848	51.51268	52.86658	54.78833	39.80299	42.53632	41.4711	40.73486	45.86058
12	46.736301	56.438944	55.04014	56.88597	58.94484	42.75721	45.57554	44.22951	44.20904	49.40498
13	49.465882	59.54315	57.9043	60.35951	62.56093	45.26602	48.15614	46.44635	47.37703	52.52727
14	51.64134	61.949304	60.10673	63.29944	65.62775	47.26783	50.21558	48.1866	50.18475	55.26668
15	53.206266	63.601003	61.61734	65.65396	68.08515	48.7144	51.70448	49.44182	52.5588	57.57781
RF	54.195068	64.563987	62.50168	67.35597	69.86132	49.62742	52.6452	50.23972	54.37322	59.34627

The Storey displacement values in y-direction of Models (Linear static analysis) are tabulated in table 2.

Table 2: The Storey displacement values in y-direction of Models (Linear static analysis).

Storey	Model 1 Drift-X	Model 2 Drift-X	Model 3 Drift-X	Model 4 Drift-X	Model 5 Drift-X	Model 6 Drift-X	Model 7 Drift-X	Model 8 Drift-X	Model 9 Drift-X	Model 10 Drift-X
GF	0.000401	0.000485	0.000462	0.000463	0.000487	0.000358	0.000394	0.000369	0.000353	0.000403
1	0.000916	0.001116	0.001064	0.001066	0.001121	0.000824	0.000905	0.000848	0.000814	0.000927
2	0.001183	0.001453	0.001386	0.00139	0.001462	0.001073	0.001178	0.001106	0.001062	0.00121
3	0.001318	0.001625	0.001553	0.00156	0.001639	0.001201	0.001318	0.00124	0.001192	0.001357
4	0.001379	0.001702	0.001631	0.001644	0.001724	0.001261	0.00138	0.001305	0.001257	0.001428
5	0.001397	0.001721	0.001658	0.001677	0.001753	0.001281	0.001393	0.001328	0.001283	0.001452
6	0.001388	0.001699	0.001651	0.001679	0.001746	0.001274	0.001371	0.001326	0.001286	0.001447
7	0.001361	0.001646	0.001623	0.001661	0.001712	0.00125	0.001322	0.001308	0.001275	0.001429
8	0.001322	0.001586	0.00158	0.001631	0.001671	0.001216	0.00127	0.001279	0.001254	0.001405
9	0.001282	0.001527	0.001532	0.001594	0.001628	0.001177	0.001222	0.001244	0.001229	0.001378
10	0.001343	0.001594	0.001609	0.001705	0.001737	0.001238	0.001278	0.001314	0.001327	0.001486
11	0.001215	0.001422	0.001421	0.001552	0.001584	0.001115	0.001148	0.001156	0.001246	0.001364
12	0.001072	0.00124	0.001176	0.00134	0.001386	0.000985	0.001013	0.000919	0.001158	0.001181
13	0.00091	0.001035	0.000955	0.001158	0.001205	0.000836	0.00086	0.000739	0.001056	0.001041
14	0.000725	0.000802	0.000734	0.00098	0.001022	0.000667	0.000686	0.00058	0.000936	0.000913
15	0.000522	0.000551	0.000504	0.000785	0.000819	0.000482	0.000496	0.000418	0.000791	0.00077
RF	0.00033	0.000321	0.000295	0.000567	0.000592	0.000304	0.000314	0.000266	0.000605	0.000589

CONCLUSION

More mass means higher inertia force. Therefore, lighter buildings sustain the earthquake shaking better. The vertical acceleration during ground shaking either adds to or subtracts from the acceleration due to gravity. Since factors of safety are used in the design of structures to resist the gravity loads, usually most structures tend to be adequate against vertical shaking. ETABS is an integrated analysis, design and drafting of buildings systems tool. ETABS dynamic analysis capabilities include the calculation of vibration modes using Ritz or Eigen vectors, response-spectrum analysis and time history analysis for both linear and nonlinear behaviour. According to the results, it is concluded that the fundamental natural time period of the building increases with the increase in vertical mass irregularity. The base shear values (i.e. Fx an Fy) are considerably high in buildings having vertical mass irregularity and as the vertical mass shifts towards top, base shear decreases. Displacement values of buildings with vertical mass irregularity are more compared to the regular building. The displacements values are increasing as the irregular mass shifts towards top.

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