EVALUATION ON IMPACT OF VERTICAL COMPONENT EARTHQUAKE GROUND ACCELERATION ON REINFORCED CONCRETE MULTI-STOREY BUILDING

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Abstract- This thesis mainly focuses on impact of vertical component earthquake ground acceleration on reinforced concrete building structures. The base of this thesis is to evaluate the effect of vertical component earthquake ground acceleration in zone V of India. To achieve these objectives medium soil profile were used to analyse selected building in linear response spectrum analyses using ETABs 2015 software. Structural responses like shear force, axial force, and bending moment as well as column due both horizontal and vertical versus horizontal earthquake ground accelerations were used as a parameters for comparison. Vertical component earthquake ground acceleration should be considered if the proposed building structure is sited around near faults.

Keywords: Horizontal earthquake component, Vertical earthquake component, internal response

I. INTRODUCTION

The thesis mainly focuses on impact of vertical component earthquake ground acceleration on reinforce concrete building structures. In the previous decades, horizontal ground acceleration of earthquake was studied broadly and taken in consideration of the design process; but the vertical ground acceleration neglected for the previous decades in design, and seldom studied from the hazard standpoint in the selected structures. However, a recent study indicates that with the increasing a lot of near fault records, the proportion of peak vertical ground acceleration-to-horizontal ground acceleration is able exceed unity. As the result of this, the effect and significance of vertical ground acceleration has become a concern in this study. Structural responses like shear force, axial force, and bending moment as well as column due both horizontal and vertical versus horizontal earthquake ground accelerations were used as a parameters for comparison.

The re-established attentiveness in the evaluation of vertical component of earthquake ground acceleration as it was observed the ratio of vertical ground acceleration-to horizontal ground acceleration be able greater in the near-fault when compared to that of far-fault records (Bozorgnia, 2004).vertical earthquake motion is represented by scaling a single design spectrum derived for horizontal components. This procedure was devised by [Newmark, 1974] and has been widely used. Generally, the scaling factor, the vertical-to-horizontal ratio, has been taken as $\frac{2}{3}$. Primary waves (P-waves) are the main cause vertical component, whilst secondary shear waves (S-waves) are the main cause of horizontal components. The wavelength of S-waves is longer than that of P-waves; it is associated with higher frequencies.

II. MODELLING AND ANALYSIS OF G+20 RCC BUILDING

To assess the effect of vertical component earthquake ground acceleration in zone V on selected building structure, first the building with two earthquake components (X and Y) was modelled. At next step, the same earthquake on the same building has been modelled with considering the effect of vertical earthquake component in addition to gravity loads. In the model, the following responses of structures like axial force, shear force and bending moment were used to evaluate effect of vertical component earthquake ground acceleration on building element. The floor plan of building which can represent the building type and structural system was displayed below. During determination of building layout, plan and elevation regularity are considered.

The internal forces in the members (such as bending moment, shear force and axial force) for earthquake cases are combined as per IS 456: 2000, IS 1893(Part 1): 2016. The load combination involving horizontal earthquake effect to be considered as given below;
Table 1: Load combination for horizontal and vertical ground acceleration.

Collapse for HEGA	Collapse for VEGA
1.5(DL+LL)	1.5(DL+LL)
1.5(DL±EQX)	1.5[DL±(EQX±0.3EQY±0.3EQZ)]
1.5(DL±EQY)	1.5[DL±(EQY±0.3EQX±0.3EQZ)]
1.2(DL+LL±EQX)	1.2[DL+LL±(EQX±0.3EQY±0.3EQZ)]
1.2(DL+LL±EQY)	1.2[DL+LL±(EQY±0.3EQX±0.3EQZ)]
(0.9DL±1.5EQX)	0.9DL±1.5(EQX±0.3EQY±0.3EQZ)
(0.9DL±1.5EQY)	0.9DL±1.5(EQY±0.3EQZ±0.3EQZ)

A response spectrum function is simply a list of period versus spectral acceleration values in the function that is assumed to be normalized. The units are associated with a scale factor that multiplies the function and that is specified when the response spectrum analysis case is defined. Linear dynamic response spectrum analyses were performed on sample building model. The response spectrum is simply a plot of the peak or steady-state response (displacement, velocity or acceleration) of a series of oscillators of varying natural frequency, which are forced into motion by the same base vibration or shock.

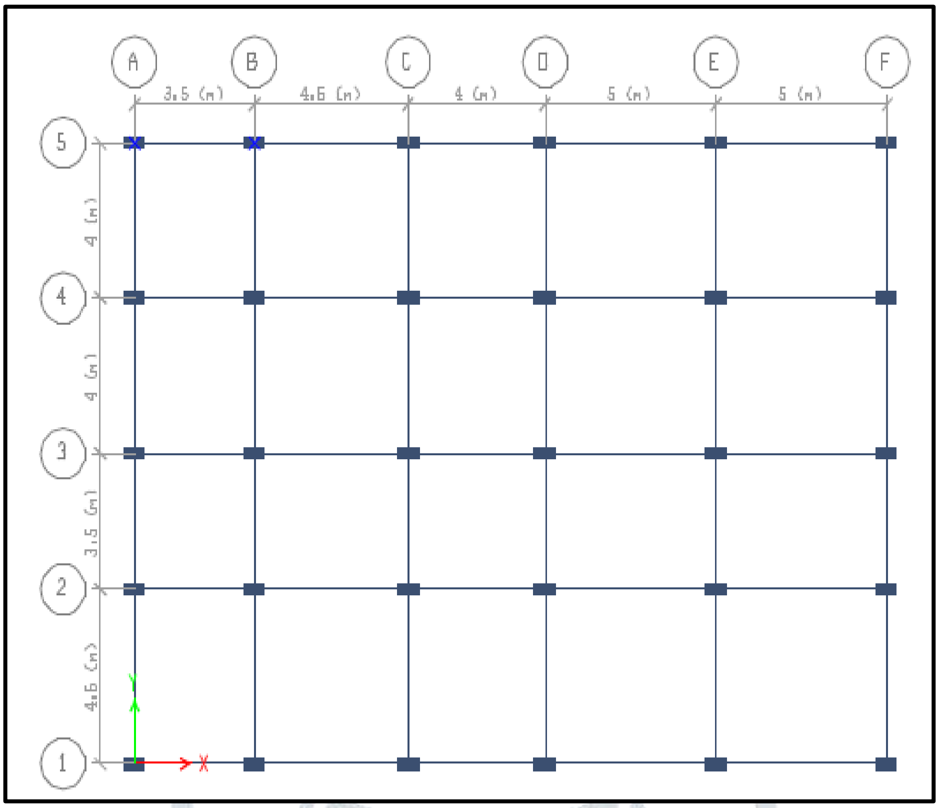

Figure 1: Floor plan for selected sample building model

The building has Ground + 20 floors with height of storeys are 3m and 3.5m for the bottom and remaining storey height respectively. The cantilever has 1.5m length. There are 5 bays in X direction and 4 bays in Y direction. Size of beam for all beams is 450X450 and size of column is 300X600. Normal-weight concrete with a characteristic cube compressive strength of 30MPa and characteristic yield strength of 415MPa for reinforcement was used in modelling. The modal is analysed for zone V and the building is analysed as moment resisting frame. The 3D of the building modelled with the aid of Software-Engineering that is ETABS and run all analysis using this software.

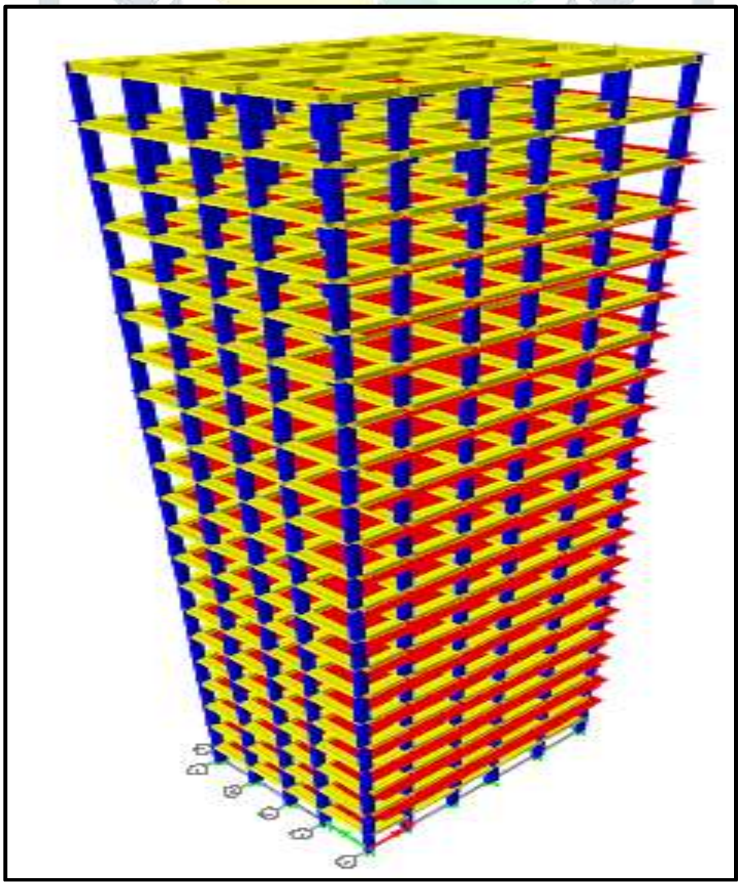

Figure 2: G+20 multi-purpose building model on structural analysis software

III. RESULTS AND DISCUSSION

To examine the effect of vertical earthquake component on the selected building structures, first the result due to three components X, Y and Z was considered. At next step, the same earthquake result has been considered without considering the effect of vertical earthquake component. In the model, responses of building frame elements caused by horizontal component vs. vertical and horizontal components have been studied. The responses at the end of selected columns were considered.

Table 2: Internal response columns under cantilever slab in axis F4 due to HEGA Vs VEGA

Story	Axial force (KN)		Shear force (KN)		Bending moment (KN.m)		Variation internal response due to VEGA in %		
	H	H+V	H	H+V	H	H+V	Axial	Shear	Bending
Story	7763.8	7851.5	70.57	70.19	136.2	135.1	1.1172	-0.545	-0.7937
Story1	7431.3	7520.4	70.98	70.81	140	139.7	1.1849	-0.237	-0.2131
Story2	7035.5	7124.5	67.81	67.7	122.3	122.1	1.2492	-0.17	-0.1669
Story3	6641.6	6729.4	72.19	72.14	129.8	129.7	1.3053	-0.071	-0.0645
Story4	6249.3	6335.1	74.99	74.99	134	134	1.3544	-0.001	0.0039
Story5	5858.5	5941.5	77.6	77.65	138.2	138.3	1.398	0.0574	0.0633
Story6	5469.3	5548.6	79.75	79.84	141.5	141.7	1.4283	0.1066	0.1136
Story7	5082.8	5156.1	81.5	81.62	144.2	144.4	1.4226	0.1492	0.1576
Story8	4697.4	4764.3	82.83	82.99	146	146.3	1.4046	0.1874	0.1976
Story9	4313.1	4373.2	83.76	83.95	147.2	147.6	1.375	0.2228	0.235
Story10	3929.9	3983	84.28	84.49	147.6	148	1.3344	0.2568	0.2717
Story11	3547.9	3594	84.38	84.62	147.3	147.7	1.2833	0.2912	0.3089
Story12	3167.2	3209.2	84.05	84.32	146.2	146.7	1.3109	0.3271	0.3482
Story13	2788.1	2826	83.27	83.58	144.3	144.9	1.3415	0.366	0.3911
Story14	2410.7	2444.4	82.05	82.39	141.6	142.2	1.3766	0.4098	0.4396
Story15	2035.5	2064.8	80.35	80.72	138.1	138.8	1.4181	0.4601	0.4956
Story16	1666.6	1690.3	78.18	78.59	133.7	134.4	1.3968	0.5201	0.5624
Story17	1305.1	1321.5	75.35	75.8	128.3	129.1	1.241	0.5902	0.6422
Story18	942.38	952.68	72.8	73.3	122.6	123.5	1.0806	0.6892	0.7465
Story19	578.58	583.99	65.13	65.62	112.2	113.1	0.9262	0.7464	0.8472
Story20	211.41	213.27	89.02	89.74	142.9	144.1	0.8726	0.8072	0.8418

In this study, the influence of vertical component earthquake ground acceleration on selected reinforced concrete frame elements has been assessed within the framework of linear response spectrum analysis (RSA). Due to this, seismic design of the structure without considering vertical component earthquake component may have risk in main skeleton of building at near faults (highly suspected area to earthquake). Vertical ground motion has magnifying effects on axial force, shear force and bending moment demand on column under cantilever slab.

IV. CONCLUSION

To sum up, the effect of vertical earthquake ground acceleration can be omitted if the building is built far from active faults. Average percentage magnification of internal response due to vertical component earthquake acceleration is high at top story compared to bottom story in the shear force and bending moment. Therefore, considering vertical component ground acceleration at near faults or highly suspected area to earthquake is tolerable.

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