Seismic analysis of a irregular buildings frames with soil structure interaction subjected to pounding effects

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Abstract : Major seismic events during the past decade such as those which have occurred in Northridge, Imperial Valley (May 18, 1940), California (1994), Kobe, Japan (1995), Turkey (1999), Taiwan (1999) and Bhuj, Central Western India (2001) have continued to be demonstrate the destructive power of earthquakes, with destruction of buildings, bridges, industrial and port facilities as well as giving increased to great economic losses. Among the possible structural damages, seismic producing pounding has been commonly observed in several earthquakes. As a result, a study on buildings pounding response as well as proper seismic hazard practice for adjacent buildings is carried out. Therefore, the need to improve seismic performance of the built environment through the development of performance-oriented procedures have been developed. To estimate the seismic demands, nonlinearities in the structure are to be considered when the structure enters into inelastic range during huge earthquakes. Despite the increase in the accuracy and efficiency of the computational tools related to dynamic inelastic analysis, engineers tend to except simplified non-linear static procedures instead of rigorous non-linear dynamic analysis when evaluating seismic demands. This is due to the problems related to its complexities and suitability for practical design applications. The push over analysis is a static, nonlinear procedure that can be used to estimate the dynamic needs imposed on a structure by earthquake ground motions. This project entitled "Seismic Pounding Effects in Buildings." aims at studying seismic gap between adjacent buildings by dynamic and pushover analysis in SAP2000.

***Keywords* – seismic effect, earthquake , elastic analysis,pounding**

I. Introduction

The process within which the response of the soil influences the motion of the structure and therefore the motion of the structure influences the response of the soil is termed as SSI. During this case neither the structural displacements nor the bottom displacements are freelance from one another. Ancient Structural Engineering strategies disregard SSI effects that are appropriate just for lightweight structures on comparatively stiff soil. Ex. low rise structures, easy rigid retentive walls. SSI effects become outstanding and should be regarded for structures wherever effects play a major role, structures with huge or deep seated foundations, slender tall structures and structures supported on a awfully soft soil with average shear rate. The projected work is predicated upon the unstable analysis of irregular building frames. For this the building frames with soil structure interaction impact is taken {into account} into account. More those building that bear the pounding effects because of too little gap between them also are thought-about. The thought of irregular buildings, soil–structure interaction and pounding effects are all introduced and therefore the analysis strategies were mentioned.

Pounding occurs when the adjacent buildings start vibrating out of phase during the seismic analysis which causes collision amongst the adjacent buildings. Pounding is one of the main causes of severe building damages in earthquake.

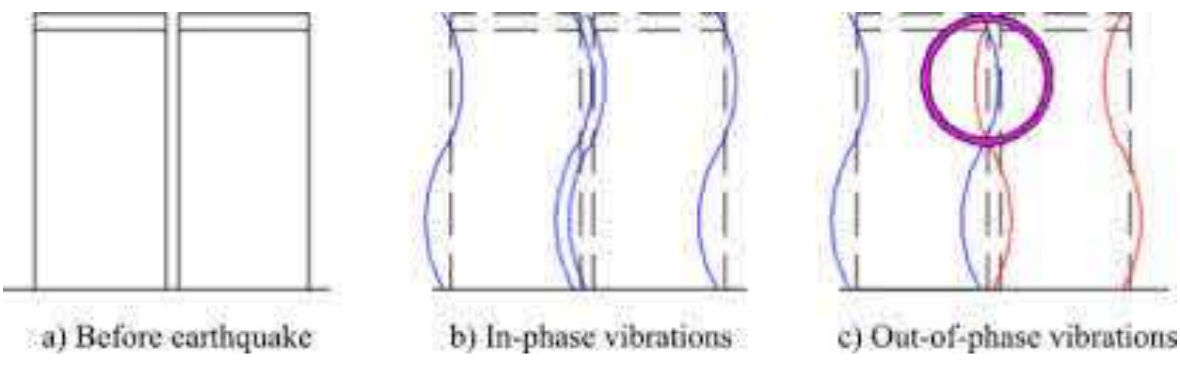


Fig 1.1 Different ways in which building can vibrates during earthquake

II. BUILDING MODEL ANALYSIS

In order to gauge the seismic gap between buildings with rigid floor diaphragms victimization nonlinear dynamic analysis a pair of a sample, the building was adopted the small print of the building as reproduced in section three.2. The finite component analysis computer code SAP2000 nonlinear is employed to form 3D model and run all analyses. The computer code is in a position to predict the geometric nonlinear behavior of house frames underneath static or dynamic loading, taking under consideration each geometric nonlinearity and material physical property. The computer code accepts static hundreds (either forces or displacements) also as dynamic (accelerations) actions and has the power to perform eigenvalues, nonlinear static pushover, and nonlinear dynamic analyses. The building used for analysis is created from an inspired arrangement, a pair of level and three-level buildings as used for analysis, the ground height of each building as a pair of.8m however the basement height is totally {different completely different} to form different cases, we've got unbroken basement height as a pair of.8mand 3.8m for various cases, the fabric used as M20 concrete and fe500 steel bars. Completely different checks like column PPM interaction quantitative relation, beam/column capability quantitative relation, column/beam capability quantitative relation, and drift level check were performed on the building to envision the steadiness of structure and where necessary the scale of a column is multiplied to pass the checks. 350x350mm and 400x400mm column, 230x300mm beam, and 130mm block are employed within the building, the block used for stairway is 125mm thick. For soil interaction, spring is employed in situ of soil and used stiffness of string to depict completely different kinds of soil.

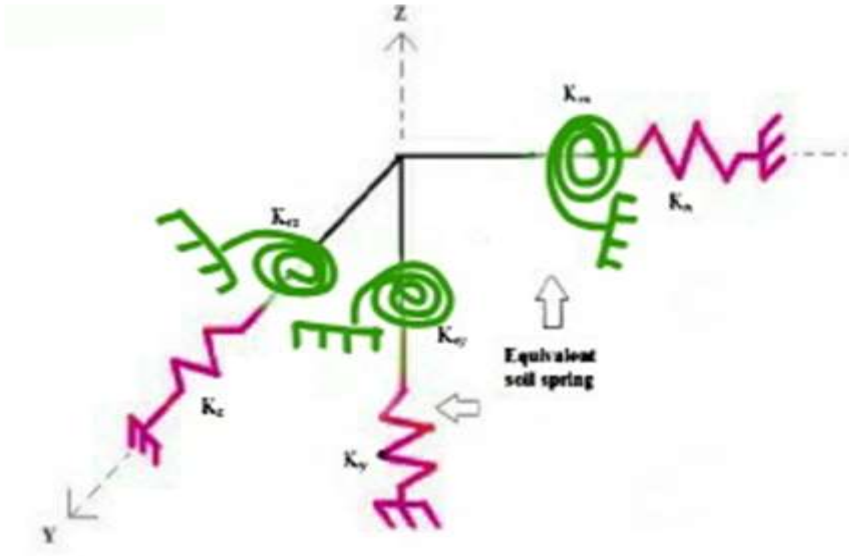


Fig 3.1 Equivalent spring thickness

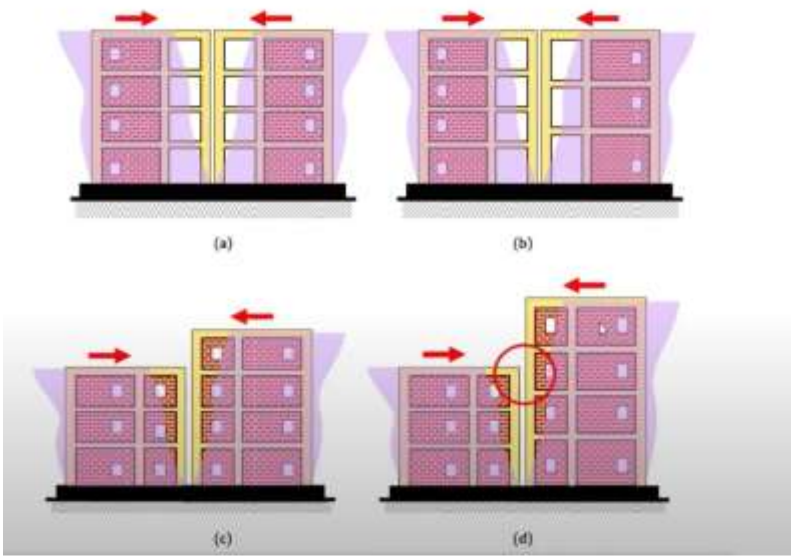


Fig 3.6: Different cases for pounding

4 models have been considered for the purpose of the study

- 1. Building with equal height and equal floor height
- 2. Building with equal height and different floor height
- 3. Building with different height and same floor height
- 4. Building with different height and different floor height

II. ANALYSIS RESULT AND DISCUSSION

SAP2000 is employed to figure the response of a 2 (G+2) and 3 construction (G+3) buildings for Non-Linear Dynamic (time history). Results from time history analysis are wont to observe and compare the ground response of all the models. Displacements and moments are compared to work out the seismic pounding gap between adjacent structures.

4.2 Time history analysis

Time history analysis has been role out exploitation the Imperial depression Earthquake record of might eighteen, 1940 additionally referred to as the Elcentro earthquake for getting the assorted floor responses.

KN-mm	1	2	3	4	5	6
635mm	47031.96	33472	18125	14342	55288	96145
	-41784.5	-30472	-15610	-12482	-50785	-93782
1m Apart	45180	33602	16152	19605	57754	95378
	-41655	-32379	-14122	-17027	-53992	-93565
3m Apart	41397	33384	12938	27737	60798	92663
	-40378	-34914	-11719	-23931	-58452	-91713
5m Apart	38107	35138	10805	33320	62253	89547
	-38472	-35848	-10176	-30677	-60677	-88934
Far away	37570	43984	26946	44958	62039.94	76702.25
	-36724	-44258	-28129	-43983	-61350.78	-76016.02

Fig 4.1 Displacement at different points and support moment at different distances are shown

The maximum displacement is written on the respective joint, the +ve values tells the displacement in +ve x direction and -ve values tells the displacement in -v x direction For this case we observed that the storey displacement was same for adjacent floor.The moment at the respective supports is given in the table at different distance of separation.We can see from the moment table that the moment for support of the building which are close to each other is increasing as the separation between building is increased and the moment at the far end support is decreasing .The support moment at the far ends is decreased by 20%, and the support moment at the near end is increased by almost 45% when the buildings are at sufficient distance from each other.

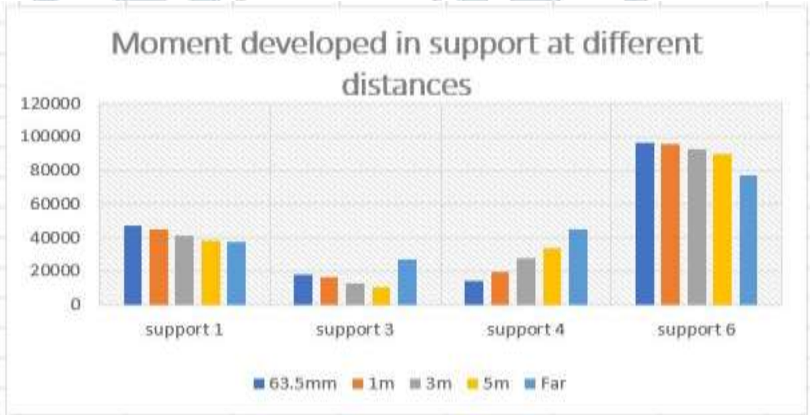


Fig 4.2 Variation in support moment at different distance between building

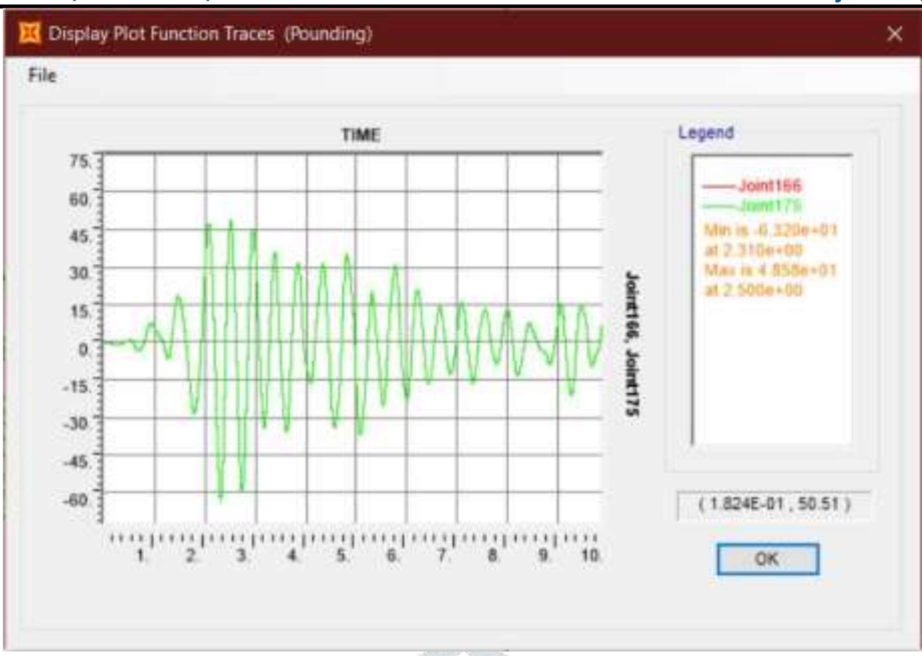
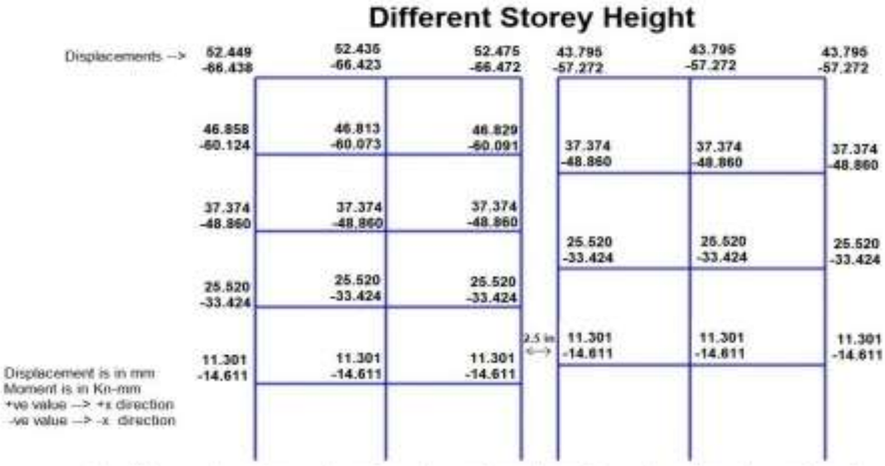


Fig 4.3 Displacement graph of the top storey

In fig 4.3 we see in legends two joints; these two joints are from top storey of both buildings .From this graph we see the displacement of the top storey at different time, and since both buildings where of same height ang same floor height there displacement graph is overlapping. The maximum displacement for both building in +xe direction is 48.58mm and -ve direction is 63.2mm, taking maximum deflection is 63.2mm

So total gap between both the building should be 63.2 + 63.2mm = 126.4mm so they will not collide. Displacement per storey is 0.0158m

4.2.2 Analysis of model with Buildings of equal height and different floor height



KN-mm	1	2	3	4	5	6
63.5mm apart	33483	23915	8423	6986	22938	40972
	-33450	-24357	-8176	-6861	-23521	-42005
1m apart	35014	28361	6132	8200	23658	40308
	-34150	-27722	-6149	-7931	-24675	-41320
3m apart	33460	31081	9717	11878	25168	38924
	-32062	-30428	-10003	-12043	-26274	-40086
5m apart	31031	31503	1440	14651	25380	36893
	-29888	-31297	-14877	-14737	-26575	-37886
for away	20164	23724	17275	17172	20824	25151
	-19198	-23676	-17449	-16905	-21790	-26362

Fig4.4 Displacement at different points and support moment at different distances are shown

The maximum displacement is written on the respective joint, the +ve values tells the displacement in +ve x direction and -ve values tells the displacement in -ve x direction For this case we observed that the storey displacement is different for top storey and the displacements for the below floors are same as seen from the figure. The moment at the respective supports is given in the table at different distance of separation. We can see from the moment table that the moment for support of the building which are close to each other is increasing as the separation between building is increased and the moment at the far end support is decreasing.

The support moment at the far ends is decreased by 40%, and the support moment at the near end is increased by approx. 100% when the buildings are at sufficient distance from each other.

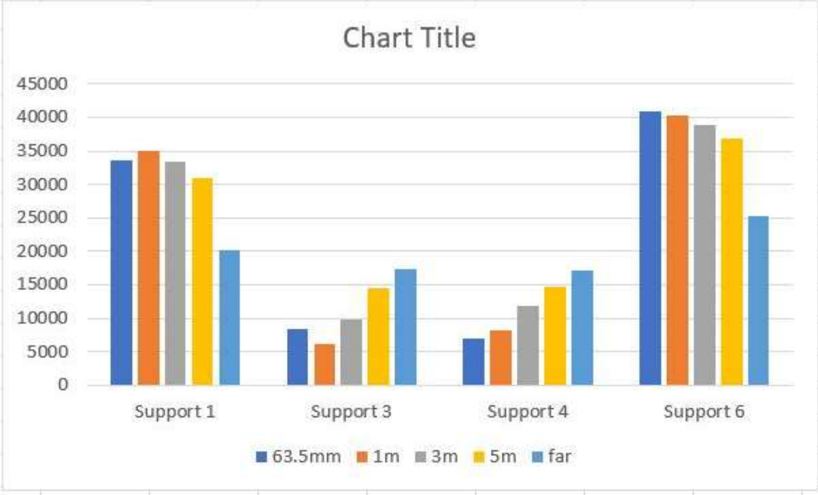


Fig 4.5 Variation in support moment at different distance between building

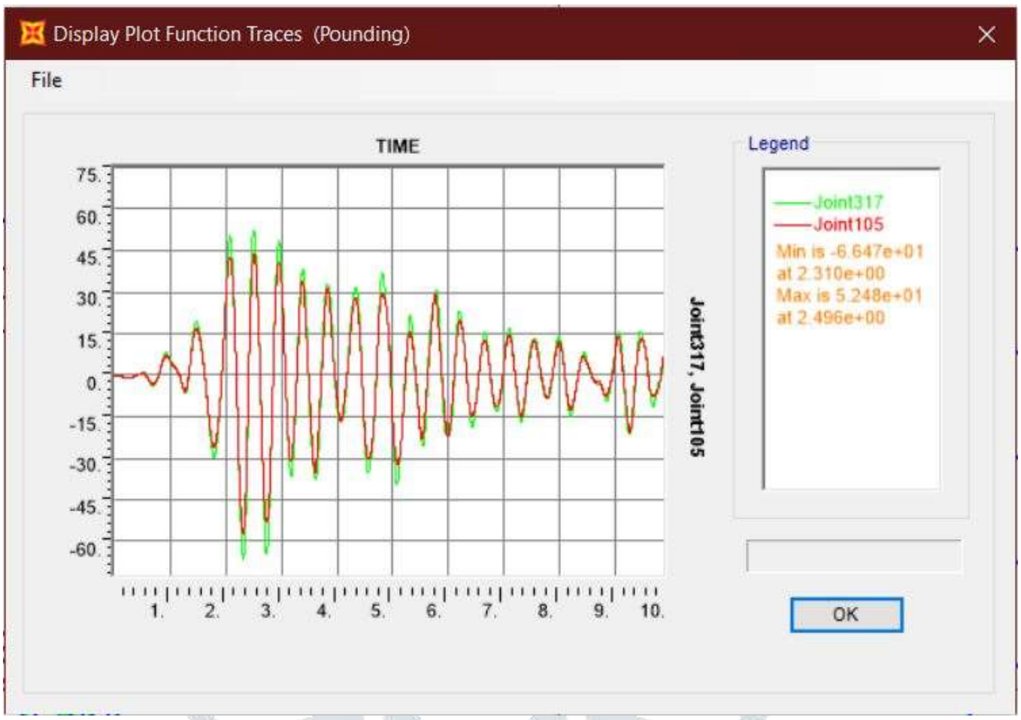
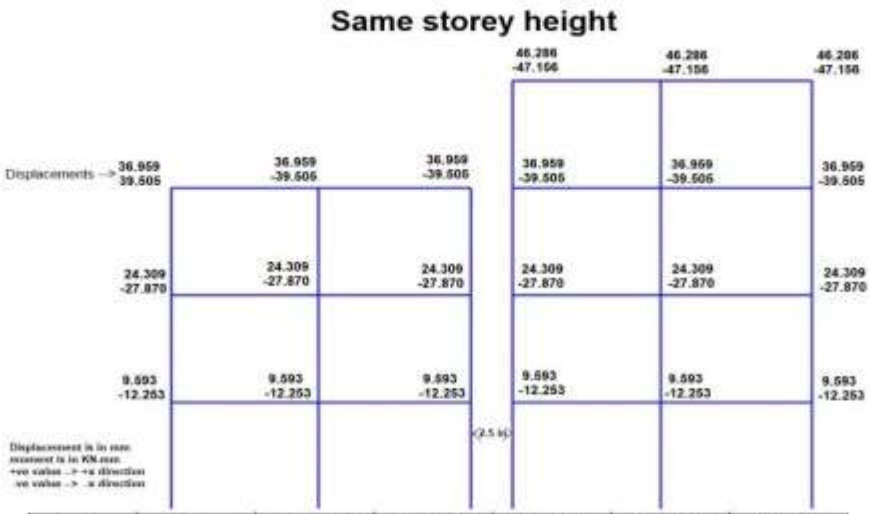


Fig 4.6 Displacement graph of the top storey

In fig 4.6 we see the displacement graph of the both the buildings, the graphs show the motion of the buildings where same but the magnitudes where different, the graph in green colour is of buildings with more floors. The maximum displacement of the 1st building in +xe direction is 52.48mm and -ve direction is 66.47mm so maximum deflection is 66.47mm. For 2nd building the maximum displacement in +ve direction is 41.94mm and in -ve direction is 55.41mm, Maximum displacement is 55.41mm,
So total gap between both the building should be 66.47 + 55.41mm = 121.88mm so they will not collide.
The displacement per storey for 1st building is 0.0133m and displacement per storey for 2nd building is 0.013

4.2.3 Analysis of model with Buildings of different height and same floor height



63.5mm	61841.58	57567.84	15956.01	14185.65	34138.05	74006.1
	-61754.1	-56992.2	-14165	-14889.6	-34214.8	-71274.1
1m Apart	63259.99	62846.53	21811.59	14534.73	36649.9	69560.95
	-64862.9	-64427.6	-21712.3	-14205.5	-37565.7	-67538.5
3m Apart	61745.16	67656.43	37904.32	18430.43	39644.2	64166.52
	-65033.7	-71547.3	-38331.1	-17656.9	-38786.9	-64106
5m Apart	59166.35	72927.2	47593.1	23172.92	41161.45	58280.81
	-60732.9	-71435.9	-48519.1	-21758	-35448.2	-56083.3
Far Away	37483.51	53714.91	45916.52	32143.35	41039.73	47626.27
	-36698.7	-52814.8	-45386.1	-30638.5	-35110.3	-40980.2

Fig 4.7 Displacement at different points and support moment at different distances are shown

The maximum displacement is written on the respective joint, the +ve values tells the displacement in +ve x direction and -ve values tells the displacement in -ve x direction For this case we observed that the storey displacement is same for adjacent storey.

The moment at the respective supports is given in the table at different distance of separation. We can see from the moment table that the moment for support of the building which are close to each other is increasing as the separation between building is increased and the moment at the far end support is decreasing. The support moment at the far ends is decreased by 40% for shorter building and decreased by 36% for taller building, and the support moment at the near end is increased by approx. 100% when the buildings are at sufficient distance from each other.

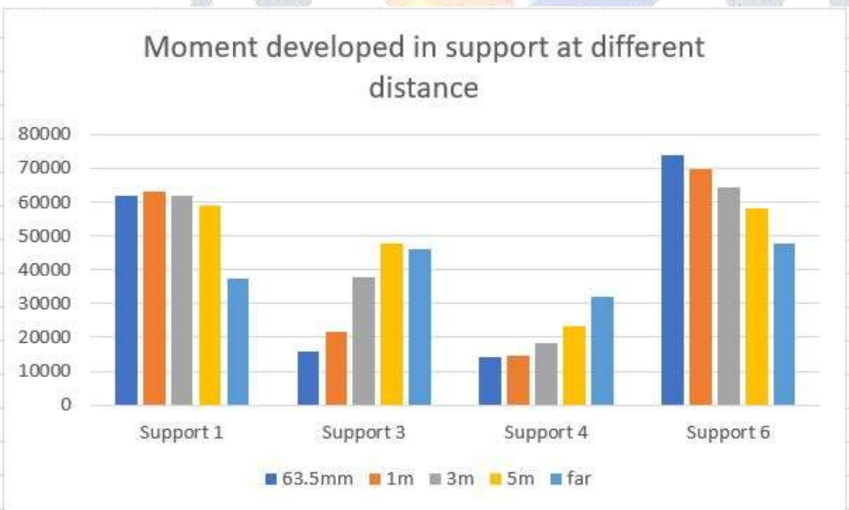


Fig 4.8 Variation in support moment at different distance between building

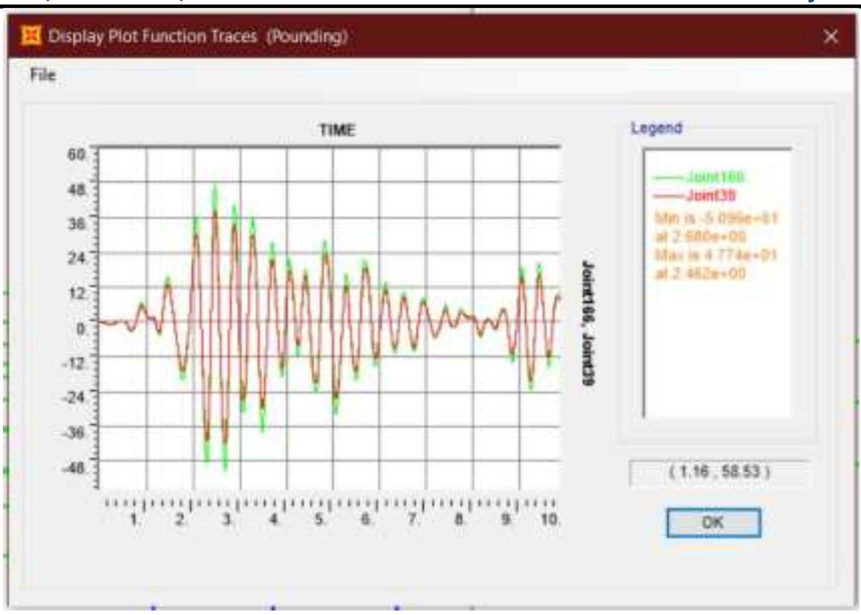
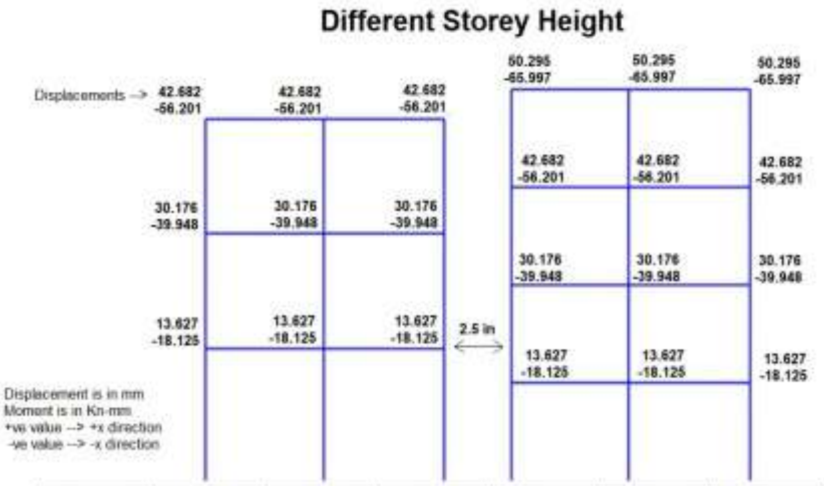


Fig 4.9 Displacement graph of the top storey

In fig 4.9 we see that the graph of displacement of the top storey of both the buildings, the green colour graph is of the taller building. Since the floor height were same the motion of both the buildings were similar. The maximum displacement of the shorter building in +xe direction is 37.47mm and -ve direction is 41.39mm, maximum deflection is 41.39mm. For taller building the maximum displacement in +ve direction is 47.74mm and in -ve direction is 50.96mm, maximum displacement is 50.96mm,
So total gap between both the building should be 41.39 + 50.96mm = 92.35 mm so they will not collide.
The displacement per storey for shorter building is 0.0138m and displacement per storey for taller building is 0.0128m

4.2.4 Analysis of model with Buildings of different height and different floor height



KN-mm	1	2	3	4	5	6
635mm	37646	29847	13851	19051	70680	122085
	-32838	-26312	-16533.7	-24107	-61162	-118350
1m Apart	36488	30346	125211	25533	74527	123076
	-32469.82	-27204	-16294.62	-26993	-64603	-117025
3m Apart	32678	29101	11379	36557	77929	118288
	-31951	-29817	-16220	-30717	-70055	-113549
5m Apart	30621	30621	13307	42449	78640	113399
	-30781	-30780	-15928	-33619	-72820	-109679
Far Away	25762.7	30665	19159	51167	74624	95519
	-26125	-31630	-19972	-48260	-72377	-93306

Fig 4.10 Displacement at different points and support moment at different distances are shown

The maximum displacement is written on the respective joint, the +ve values tells the displacement in +ve x direction and -ve values tells the displacement in -ve x direction.For this case we observed that the storey displacement of shorter building is same as the storey below it of the taller building.The moment at the respective supports is given in the table at different distance of separation.We can see from the moment table that the moment for support of the building which are close to each other is increasing as the separation between building is increased and the moment at the far end support is decreasing.The support moment at the far ends is decreased by 32% for shorter building and decreased by 22% for taller building, and the support moment at the near end is increased by approx. 44% when the buildings are at sufficient distance from each other.

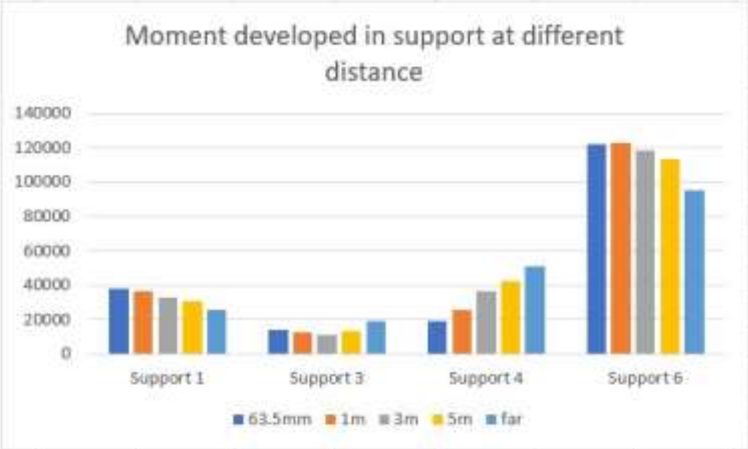


Fig 4.11 Variation in support moment at different distance between building

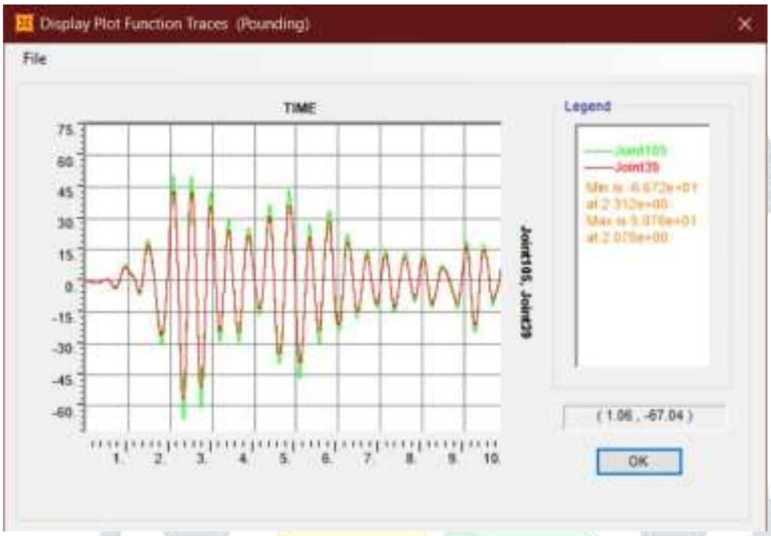


Fig 4.12 Displacement graph of the top storey

In fig 4.12 we see the top storey displacement of both the buildings, the green colours line shows the displacement of the taller building. The maximum displacement of the shorter building in +xe direction is 43.78mm and -ve direction is 56m, maximum deflection is 56mm. For taller building the maximum displacement in +ve direction is 50.76mm and in -ve direction is 66.72mm, maximum displacement is 66.72mm,So total gap between both the building should be 56 + 66.72mm = 112.72mm so they will not collide. The displacement per storey for shorter building is 0.0187m and displacement per storey for taller building is 0.0167m

CONCLUSION

The purpose of this study has been to analyse seismic pounding effects between buildings with soil interaction and to observe the structural behaviour in the post elastic range. For this, SAP2000, a linear and non-linear static and dynamic analysis and style program for 3 dimensional structures has been used.

Dynamic analysis has been administered to understand about the deformations, natural frequencies, and time periods, floor responses displacements. The non-linear dynamic analysis or time history is performed on the structure to find out displacements and behaviour of the structure during earthquake. The models that have been studied are two 3 storeys (G+2) building with different storey height, 4 storey (G+3) building, and 5 storeys (G+4) building of which have been created in SAP2000.

The first phase of the study involves the creation and analysis of the model and Non-linear dynamic analysis have been carried out on the above models. The structure passed all the check before analysing the structure. Based on the observations from the analysis results, the following conclusions can be drawn. It was found that minimum seismic gap can be provide 0.015m per storey.

In the second phase of the project Nonlinear dynamic analysis with Elcentro earthquake excitation data as input is administered on those models to observe the behaviour of the structure under earthquake excitation. The floor responses due to earthquake excitation in the 5-storey building and 4 storey combination and 3 storey and 4 storey combination with different storey height were higher than other combinations.

If we consider maximum displacement; the displacement increases as the spacing between the building increased. It is observed that; the building frames 82 with different storey height exhibits 8% and 23% higher defection than building frames with same storey height at top and bottom level respectively. When the buildings are kept close to each other they hit each other as due to insufficient space between them and therefore the moment at the support close to each other have less moment as compared to the buildings spaced far apart .Reduction in moment is observed to be 41.63% for building frames spaced faraway that of closely spaced frames. Soil structure interaction also studied and is noted that as the soil was getting stiffer the SSI effect became less significant as a result the structure maximum drift decreased.

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