International Journal of Science and Research (IJSR)
ISSN: 2319-7064
SJIF (2022): 7.942

Investigation on Geometrically Irregular R.C.C Frame Structure Considering Effect of Soil Structure Interaction & Collision of Building Due to Earthquake

Rashmi Anandrao Bisen[1], Sanjay Bhadke[2]

[1]Research Scholar (M.Tech), Department of Civil Engineering, Tulsiramji Gaikwad-Patil College of Engineering and Technology, Nagpur, Maharashtra, India
rashmi.bisen201996[at]gmail.com

[2]Assistant Professor, Department of Civil Engineering, Tulsiramji Gaikwad-Patil College of Engineering and Technology, Nagpur, Maharashtra, India
sanjay.civil[at]tgpcet.com

Abstract: ***The concept of seismic analysis of irregular building frames with soil–structure interaction subjected to pounding effect is introduced, and the research methods were discussed. Irregular configuration either in plane or in elevation is recognized as one a matter of concern of the major cause of failure during earthquakes. Thus irregularstructures, are Based on several data, a systematic summary of the soil–structureinteraction study that considers adjacent structures were proposed as reference to ponding effect. The process in which response of soil influences the mobility of structure and the motion of structure influence the response of the soil is termed as soil-structure interaction***

Keywords: Structural interaction of soil, Seismic loads, foundations, Time history analyses, Impact loads

1. Introduction

The proposed work is based upon the seismic analysis of irregular building frame. Forthis the building frames with soil structure interaction effect is considered into account. Further those building which undergo the pounding (collision of buildings due to earthquake) effects due to in sufficient gap between them are also considered. The concept of irregular buildings, soil–structure interaction and pounding effects are all introduced and the research methods were discussed. Basedon several data,a systematic summary of the soil–structure interaction research that considers adjacent structures was proposed as a reference. Soil-structure interaction consists of the interaction between soil and the structure built upon it. The method in whichresponse of the soil influence the mobility of structure and the mobility of structure influence the response of the soil is term as a soil-structure interaction. The process in which the response of the soil influences the motion of the structure and the motion of the structure influences the response of the soil is term as a Soli structures interaction.

Brief history of past work done
Hytham Elwardany, Ayman Seleemah, Robert Jankowski & Saher El-khoriby (2019)

"Influence of soil–structure interaction on seismic pounding between steel frame buildings considering the effect of infill panels", Bulletin of Earthquake Engineering volume 17, pages 6165–6202 (2019).The present study aims to examine the influence of the soil–structure interaction or existence or absence of masonry infill panels in steel frame structures on the seismic force induced pounding-involved response of a buildings. The analysis was further extended to compared the pounding-involved behavior vs the independent behavior of structures without collisions, focusing much on sudden behavior of single frames. The effect of soil structures interaction was examined by assuming linear springs and dashpots on the foundation level. The infill panels were modeled using equal diagonal compression struts. The steel frames were assumed to have elastic–plastic behavior with 1% linear strain hardening. The dynamic contact approach was used to simulate pounding between the sidebuildings. Nonlinear finite element analysis was performed for two adjacent multi-story structures with four different configurations representing cases that can exist in reality. The seismic response of the examined cases generally highlight that ignore the soil flexibility or the contribution of the infill panels may compelling alter the response of side structures. This may give result in a wrong expectation of the seismic behavior of tall buildings exposed to structural pounding under seismic excitation.

Ahmed Abdelraheem Farghaly (2017)
"Seismic investigation of adjacent buildings subject to double pounding considering soil– structure interaction" This paper focus on the examiner of double pounding that takes place between the two adjacent buildings in some upper points at super structure in the contact zone and also at foundation level. The forces of double pounding between the two adjacent buildings, which increases by softening of the soil, give a valuable assessment of straining actions of the two adjacent buildings and change the behavior of soil under the foundations and around basement floor.

Anuradha, Dr. H. M. Somasekharaiah (2015) (SSI) Effect on the effective Behavior of Irregular R. C. Frame with the Isolated Footings", International Journal for Scientifically research| Vol. e 04, (2015).In thepresent study focuses on soil structure interaction analysis of 3D 2x4 bay 4 story RCframe planed vertical irregular building is on isolated footing supporting on soilmedium with different type of zones and soil types subjected to normal and seismicloads. There are three linear-elastic and isotropic models of the soil beneath the structure such as fixed base, spring mode land soil continuum. The analysis is carryout on RC frame irregular structure using time history analysis by the fem software sap2000. Based on the results, comparing with three models it conclude that the soil structure interaction investigate effects are lateral displacement, natural frequency, story drift and base shear increases and there os natural period is decreases.

Prakash M. Yesane, Y. M. Ghugal, R. L. Wankhade (2019)

The theory of soil– structure interaction was invented, and the research method were discussed. Based on several data, a systematic summary of the history and status ofthe soil–structure interaction theory that considers adjacent structures was proposedas a reference for researchers. This study is in the growing stage, given its complexity and simplification of the model for soil and structures, and should be carried forward for its significance.

An experiment was made to summarize the all termsin this area of study. Furthermore, parametric study on soil structure interaction behavior by various researchers is tabulated. The existing problems and the future research in this fieldwere alsoinspected

Arjit Verma*P. Pal and Y. K. Gupta* Research Scholar, M NNIT Allahabad (2019)**

The following concluding remarks may be drawn from this paper based on the study for direct approach. The effect of soil-structure interaction on the effective response of building can decrease the resonant frequency. b. The interaction effect isimportant for shear wave velocity less than 305m/sec and foundation medium is having shear wave velocity more than 305m/sec.c. participation of rocking is more for high rise structures founded on soft soils and insignificant for buildings on stiff soils. d. The stiffness and damping characteristics of these foundation medium frequency dependent and may be assumed to be constant for practical purposes. Sittipong Jarernprasert an, Enriazan-Zurita a, Jacobo Bielak a Paul C. Rizzo(2020) The importance of SSI effects on the dynamic behavior of the building foundation system, by comparing the seismic response coefficient or, perhaps better yet, the resulting drifts or peak structural displacement, with the corresponding fixed-base quantities. The results presented in this paper correspond to a structural aspect ratio, H/B¼2; we have also analyzed SSI systems with H/B¼4, obtaining very similar qualitative results. The impact of H/ B is properly considered in the examination of period elongation ratio l. The proposed access has been developed for a class of SSI systems,while it is reasonable to expect that they will apply to other foundation conditions, e.g., piles, and soil stratigraphy, the method should be additionally verified before applying it to systems whose structural behavior differs widely from the bilinear hysteretic considered here. It is also well to highlighted that only inertial interaction has been considered in this study. Kinematic interaction should be Involved if the dominant length of the incident wave is of the same order as the base (or depth) dimensions.

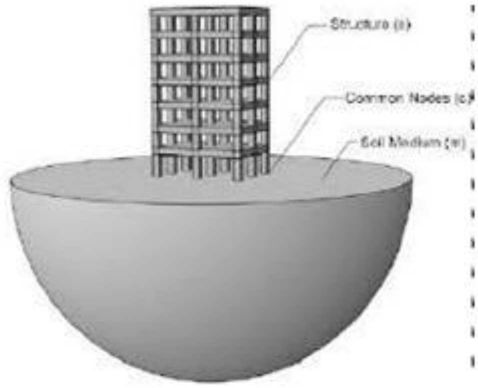
H.Matinmanesha1 and M. Saleh Asheghabadib (2011)

All soil types increase bed rock mobility in the soil-structure interface but with different degrees. The amount of addition is affected by many factors including the soil and properties, sesmic frequency content and the properties of the overlying building. Those combinations of soil condition, structural models and seismic excitations that lead to lower effective damping, will amplify the bed rock motion most significantly soil-structure models including dense sand has shorter period in comparewith loose sand and tall buildings have longer period in comparison with low-rise buildings. The combination of these two can assess the amount of amplification of each earthquake. Shorter period soil-structure systems (5 storey building over denses and) demonstrated the highest amplification for have earthquake and lowest maximum acceleration (on the soil-structure interface on earthquake. Longer period soil-structure system (20 Storey tall building on loose sand) presented the highest amplification in Low earthquake and lowest in have earthquake. Maximum principle stress on the soil-foundation interface in all models occurred beneath the columns while the lowest stress was in the middle of foundation.

2. Methodology

1) Direct approach
2) Indirect approach
    - Analytical methods
3) Winkler approaches
    - P-y method
4) Irregularity-
    - a) plane irregularity
    - b)Stiffness irregularity
    - pounding- two adjacent building Department

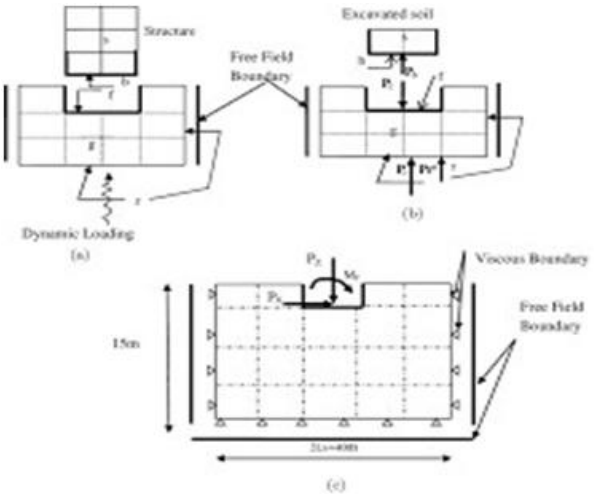
Direct Method



In this soil, foundation and structures is both molded using finite element method (FEM). The ground mobility is specify as free field motion and is apply all boundaries.

www.ijsr.net

Paper ID: SR22513223826 DOI: 10.21275/SR22513223826



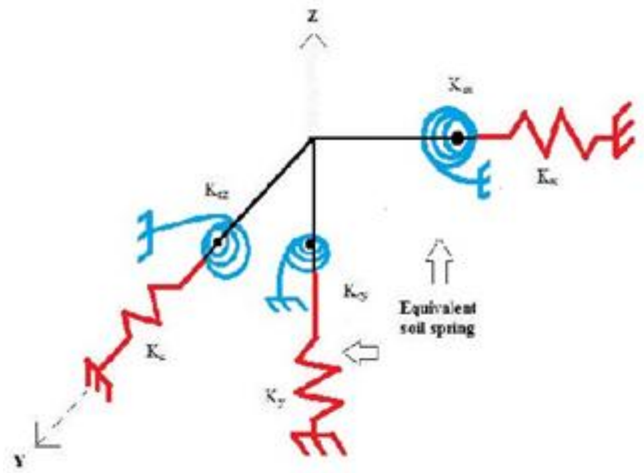


Figure 3.2: Equivalent Spring Stiffness

Substructures method

It is computationally more efficient than the direct method as most of the disadvantages of the direct method can be removed. In this method the effective input Mobility are express in term of free field motions of the soil layer initially.

Finite Element Method

Kx, Ky, Kz=Stiffness of equivalent soil springs along the translation degree of freedom along X, Y and Z-axes.

Krx, Kry, Krz=Stiffness of Equivalent rotational soil springs along the rotational degree of freedom along X, Y and Z-axes. Effect of Soil Structure Interaction is considered by equivalent springs with six degrees of freedom (DOF) as shown in fig

Spring Constant

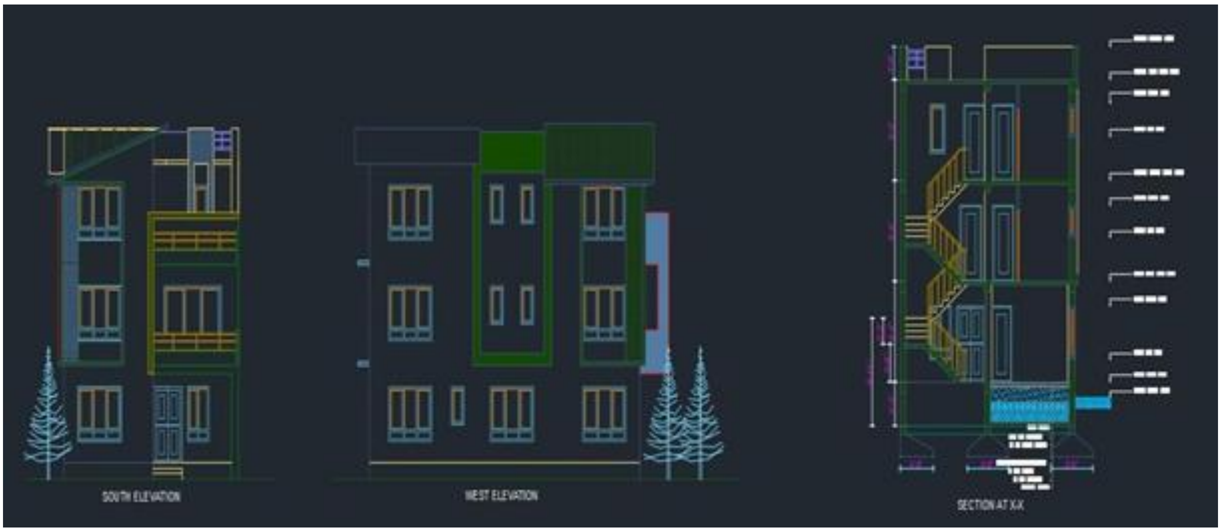
		Moment of inertia	AREA
LENGTH(x)	9	0.75	108
WIDTH(y)	12	1	
HEIGHT(z)	1	1296	

NO.	Strata	Modulus of Elasticity	Poisson Ratio(M)	Shear Modulus(G)	Unit Weight(KN/m3)
1	Soft Soil	15000	0.45	10875	16
2	Medium Soil	50000	0.4	35000	16
3	Hard Soil	120000	0.4	84000	18
4	Rocky Basalt	15000000	0.3	9750000	
5	Fixed	-	-	-	-

	Soft Soil	Medium Soil	Hard Soil	Rocky Basalt
Translation X	469949.8337	407383.0497	977719.3193	97273095.55
Translation Y	327884.5127	1022283.61	2453480.664	268027299.4
Translation Z	338759.5127	1052283.61	2525480.664	274527299.4
Rotation About X	45477.27273	134166.6667	322000	32035714.29
Rotation About Y	18937.63604	55869.65422	134087.1701	13340305.19
Rotation About Z	9224154.228	29686933.15	71248639.56	8269931377

BuildingPlan

Paper ID: SR22513223826 DOI: 10.21275/SR22513223826



Seismic Analysis

For the examination of seismic responses there is necessary to carry out earthquake analysis of structure. The study can be performed on the basis of external action,

The various behavior of structure or structural component, and the type of structural model selected. Based on the type of external action and behavior of structure, the analysis can be further classified as:

1) Linear Static Analysis,
2) Nonlinear Static Analysis
3) Linear Dynamic Analysis; and
4) Nonlinear Dynamic Analysis.

Linear static examination or equivalent static method can be used for regularstructure with limited height. Linear dynamic examination a can be performed byresponse spectrum method. The significant difference between linear static and linear dynamic examination is the level of the forces and their distribution along the height of structure. Nonlinear static analysis is an improvement over linear static ordynamic examination in the sense that it allows inelastic behaviour of structure. Anonlinear dynamic examination is the only method to describe the actual behavior of a structure during an earthquake. The method is based on the direct numerical integration of the differential equations of motion.

Nonlinear time history analysis

It is the most realistic and accurate analysis method available. It is also referred as "time history analysis". The old data of seismic activity is collected and using this data, seismic loading is applied on structure model incorporating elements within elastic force-deformation relationship and p-delta effect.

The propagation of the ground mobility throughout the structure generates all complete response histories for any quantity of interest (e.g. displacements, Stress resultants) leading to a wealth of data. While different levels of complexity are possible by the modeling choices, different ground mobility records will produce demands that vary considerably. This record-to-record variation dominates the application of dynamic methods. In SAP2000 there is inbuilt time functions, so ELECENTRO time function is used it hasmagnitude of earthquake up to 0.2763g and there is high variation of magnitude also you can see its graph in fig

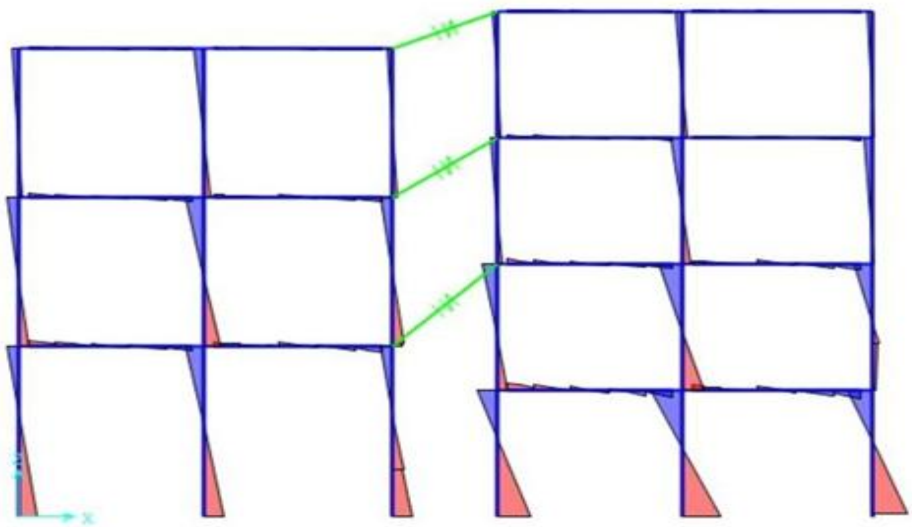
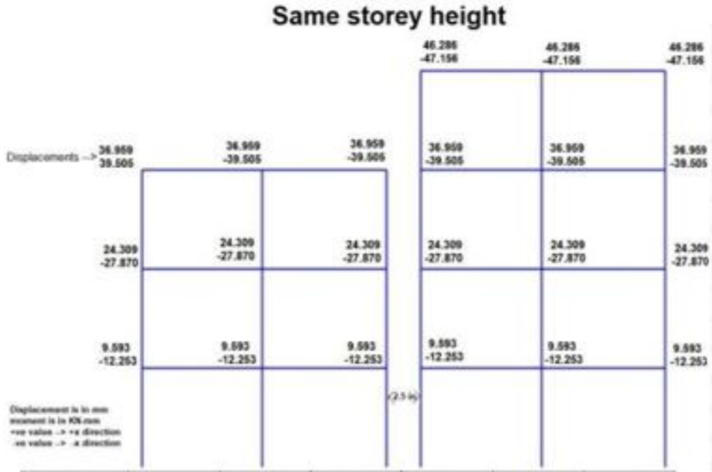
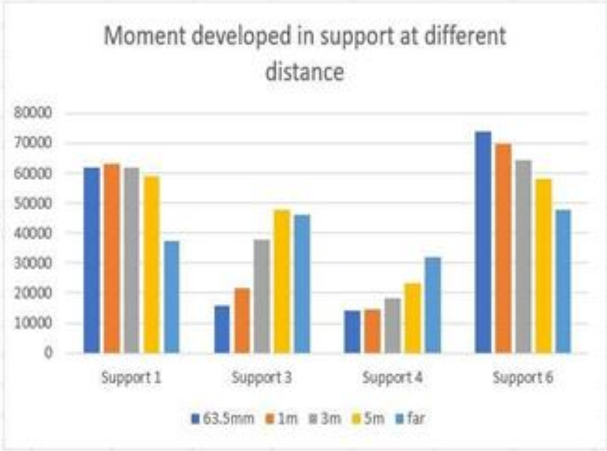


Figure: G+2 and G+3frame with hard soil as base (moment3-3)

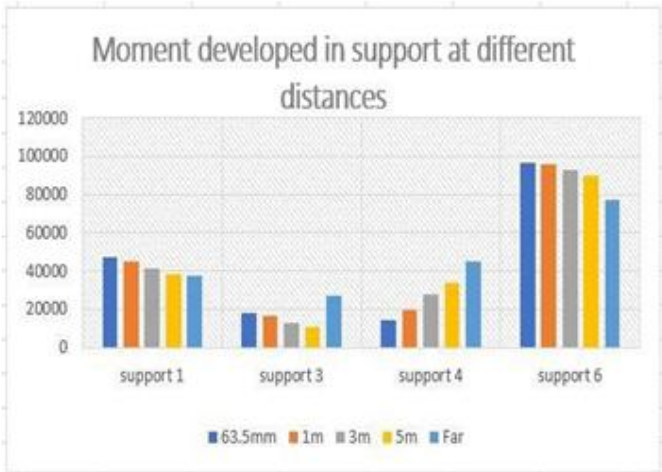
.





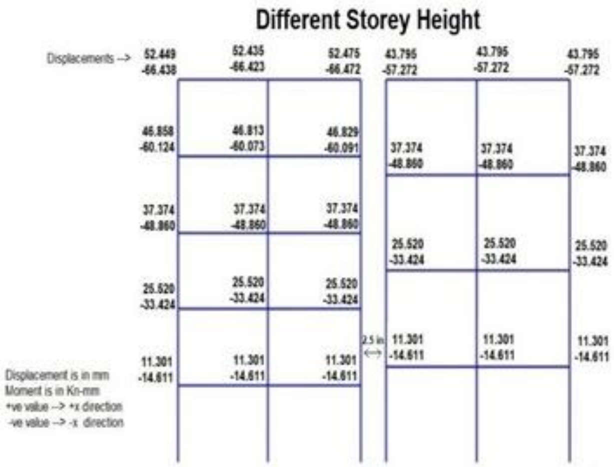
2.5 in.	69112.21	67806	228237.7	14534.37	37931.31	78153.15
	-68659.46	-67435	-22176.7	-14125.11	-37587.47	-78513.21
1 m	69647.48	71890.8	31827.3	16039.55	39422.26	74569.12
	-70302.9	-72898	-315025	-15709.2	-39138.5	-74764.4
3m	69037.63	74404	39458.82	17868	40659	70594
	-70460.7	-76494	-39962.4	-16672	-38582	-70889
5m	67563.19	77450	45959	19405	41579	66770.8
	-69434.8	-78263	-46632	-18895	-37195	-67360.6
Far away	15467.24	23844.73	22983	34613	37481	38523.51
	-15820.7	-24954.6	-24329	34960	-37222	-36361.6

Fig 9: Moment at the support when the buildings are _ apart from eachother (Kn-mm) and displacement at joint when building is 2.5in apart



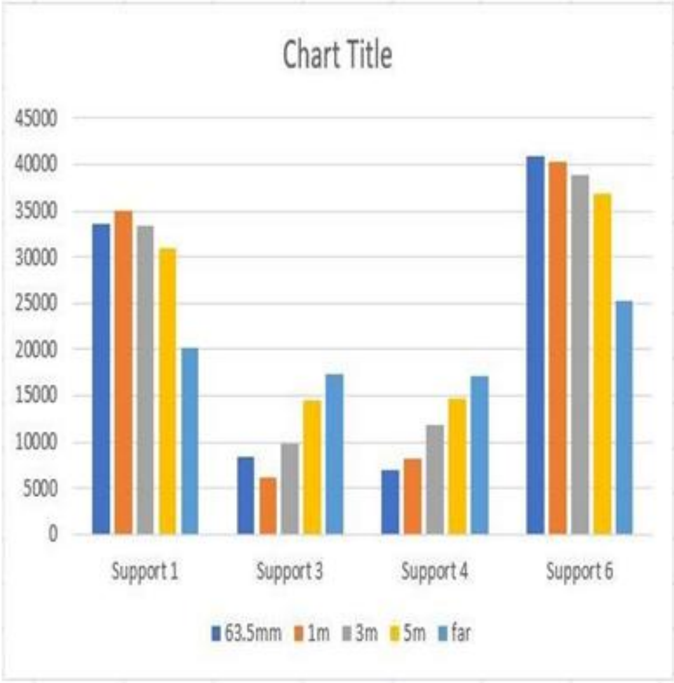
KN-mm		1	2	3	4	5	6
635mm		47031.96	33472	18125	14342	55288	96145
		-41784.5	-30472	-15610	-12482	-50785	-93782
1m Apart		45180	33602	16152	19605	57754	95378
		-41655	-32379	-14122	-17027	-53992	-93565
3m Apart		41397	33384	12938	27737	60798	92663
		-40378	-34914	-11719	-23931	-58452	-91713
5m Apart		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

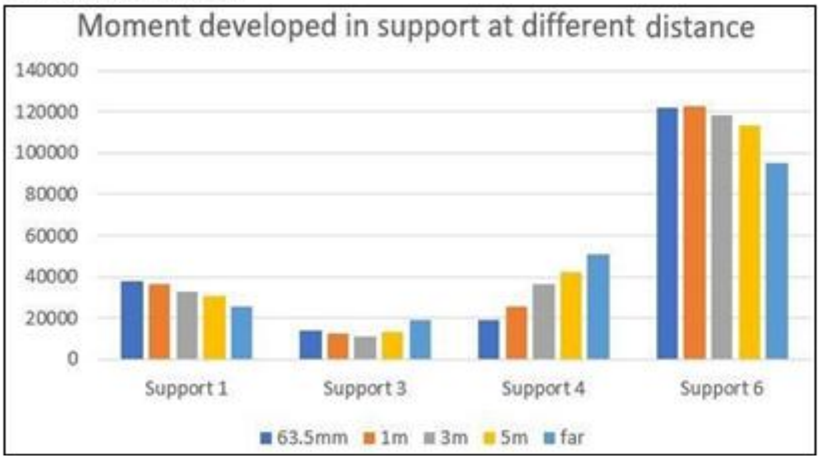
Fig 10: Moment at the support of the buildings when both the structure are _ apart and displacement at the joint when building are 2.5in apart



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

Fig 11 : Moment at support of buildings when both structure are _ apart and displacement of joint when building are 2.5in apart





3. Conclusion

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 analyzing the structure. Based on the observations from the examiner results, the following conclusions can be drawn. It was found that minimum seismic gap can be provide 0.015mper storey. The floor responses due to earthquake excitation in the 5-storey building and Four storey combination and three storey and fourstorey combination with different storey height were higher than other combinations. The displacement increases as the spacing between the building increased. Reduction in moment is observed to be 41.63% for buildingframes spaced faraway that of closely spaced frames. Soil structure interaction also studied and is marked that as the soil was getting stifferthe SSI effect became less significant as a result the structure maximum drift decreased. Department of Civil Engineering

References

[1] Sittipong Jarernprasert Enrique Bazan-Zurita Jacobo Bielakba Paul C.Rizzo Associates, Pittsburgh, PA15235,USA-on soil structure interaction.-15June 2012

[2] H. Matinmanesha 1and M. Saleh Asheghabadib Anuradha, Dr. H. M. Somasekharaiah, (2019)

[3] Dhanalakshmi P, Ramesh BM, Dr K Manjunatha, Manu Priya, (2017) Seismic Analysis of Vertically Irregular Building Shaikh A. Aijaj*, G. S. Deshmukh**

[4] Hytham Elwardany, Ayman Seleemah, Robert Jankowski &Saher El-khoriby,“Influenceofsoil–structure interaction on seismic pounding between steel frame tall buildings considering the effect of infill panels”, Bulletin of Earthquake Engineering volume17, pages 6165–6202(2019).

[5] Ahmed Abdelraheem Farghaly, “Seismic examination of adjacent buildings subjected to double pounding considering soil–structure interaction”, International Journal of Advanced Structural Engineering volume 9, pages 51–62(2017).

[6] Dhanalakshmi P, Ramesh B M, Dr K Manjunatha, Manu Priya, “Earthquake vulnerability of plan irregular RC frame buildings with soil-structure

interaction", International Research Journal of Engineering and Technology (IRJET), 4(10), (2017).
[7] Anuradha, Dr. H. M. Somasekharaiah, "Soil Structure Interaction Effect on the Dynamic Behavior of Irregular R.C. Frame with Isolated Footings", International Journal for Scientific Research & Development|Vol.3, Issue 04, (2015).
[8] Prakash M. Yesane, Y. M. Ghugal, R. L. Wankhade Department of Applied Mechanics, Government College of Engineering, Karad, India.