Scientific Journal of Impact Factor(SJIF): 3.134

e-ISSN(O): 2348-4470
p-ISSN(P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 2,Issue 5, May -2015

A Consecutive Modal Pushover Procedure for Nonlinear Static Analysis Of Symmetric-Plan of High Rise Building to Compare the Raft Foundation and Pile Foundation

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Abstract-*Frequent field test concluded that the foundation type is very important for the high rise building. The upper layer of 200–300m below the Ahmedabad city is mostly alluvium, formed by the meandering Sabarmati River. Here in this work performance of tall building is studied by varying types of foundations for Ahmedabad region. Behavior of tall building is evaluated by performing non-linear static (push over) analysis using Finite element model developed in SAP2000.*

Key words: - *Tall building, Ahmedabad region, different foundation,SSI, SAP2000*

I. INTRODUCTION

Most of the civil engineering structures involve some type of structural element with directcontact with ground. When the external forces, such as seismic load, act on these systems, neither the structural displacements nor the ground displacements, are independent of each other. The process in which the response of the soil influences the motion of the structure and the motion of the structure effects the response of the soil is explained by the phenomenon Soil-Structure Interaction (SSI). In Earthquake phenomenon the earthquake waves travel always with kinetic energy from ground to the surrounding soil mass as well as the structure part in contact with soil. A fraction of the kinetic energy released from earthquakes waves is transferred into structure through soils. The exact estimation of transfer of wave energy from soil to structure and again from structure to soil broadly can be divided into two phenomena like first one is kinematic interaction and second one inertial interaction. Soil structure interaction parameters such as stresses and displacements in both structure and support systems are depends up on relative stiffness of superstructure, foundation system and supporting soil mass. Type of foundation system is one of the governing parameter on which interaction parameter depends.In this paper asymmetrical high rise building modeled along with the homogenous sandy soilstrata. The structure is provided with two different type of foundation systems 1) Raft foundation and 2)pile foundation and interaction parameters like displacements and stresses are studied at differentpoints under consideration by push over analysis (nonlinear static analysis). It has been observed that displacements and stresses changes with foundationsystem provided.

II. NUMERICAL MODELING

2.1 Description of Structure

All high-rise buildings are 15 m×15 m in plan and divided into three bays in each direction. All bays are 5 m. The story heights were equal to 3m for all structure. They are assumed to be vertically-regular. The depth of raft foundation is 1m taken as per minimum criteria given in Indian Standard code for raft foundation. And for the pile foundation the diameter of the pile is 500mm and depth of the pile is taken as 10m. In this analysis number of floors are varies from 5 to 25 with two types of foundations which are mention above. Initially finite element model is prepared in the SAP2000 for the push over analysis. Raft foundation system with a dimension 15mx15m with design uniform thickness 1m and a concrete Grade M-35 with rebar material Fe-415 is provided for the modeling. For pile foundation system pile of 0.5 m diameter is provided with 10m pile depth.

2.2 Soil Property

A local unbounded homogeneous deep clayey soil for the Ahmedabad region is taken considered with the engineering properties like drained unsaturated unit weight 16.7kN/m^3, Poisson's ratio (η) 0.3 and modulus of sub grade reaction (k_s) 731574.9 kN/mis modeled with SAP2000. In the SAP2000 the model of the structure is modeled using the wrinkle's model.

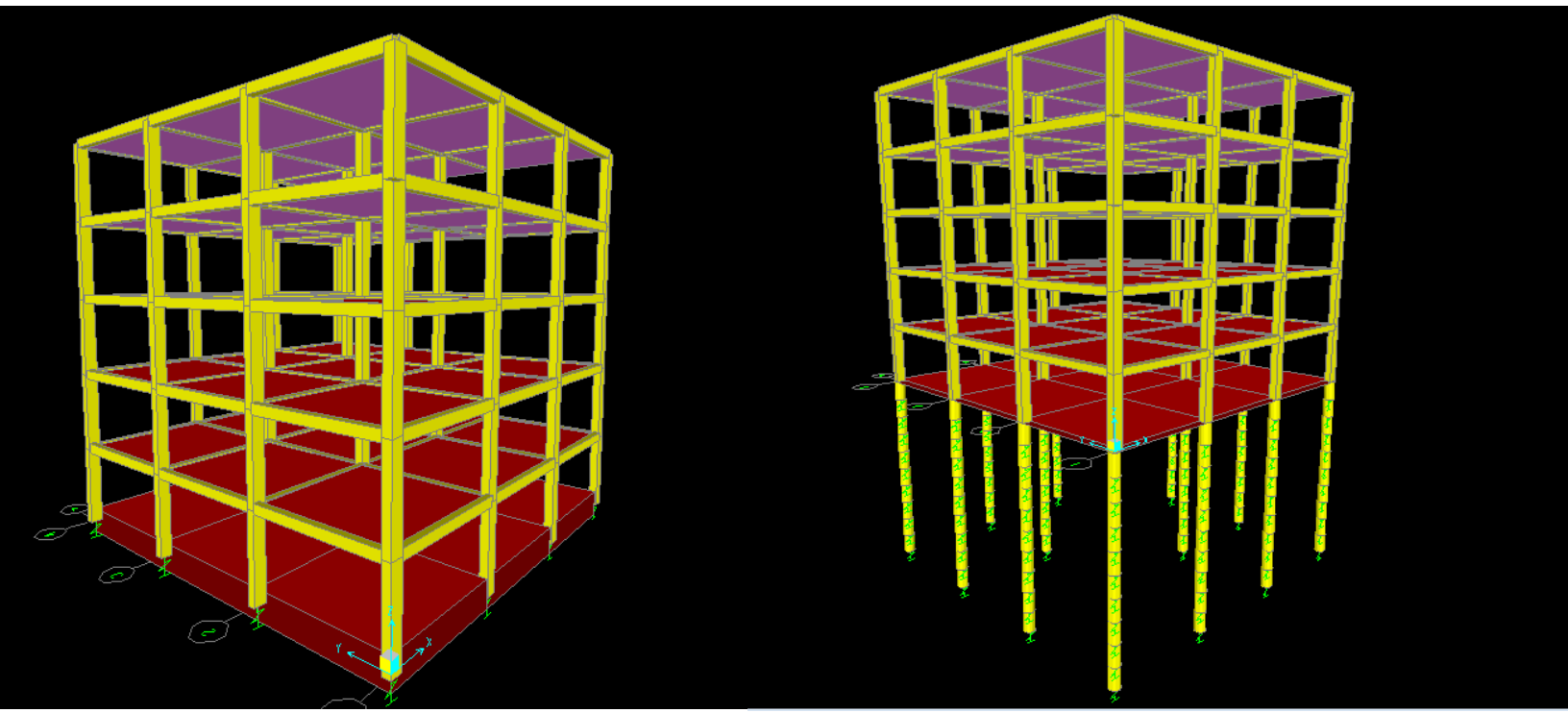


Figure-1 Numerical Modeling of Raft Foundation and Piled Raft Foundation.

2.3 Element Selection in SAP2000

In SAP2000 framed superstructure is modeled with 2D-Beam element and Piles with 2D element and raft and slab are area elements.

2.4 Push over Analysis(Non-Linear Static Analysis)

Push over analysis is nonlinear static analysis. Linear or elastic analysis gives only the elastic capacity of the structure where the first yield occurs. But the nonlinear analysis gives the actual behavior of the structure from starting the first yield to the collapse of the structure. The name says that in this method the structure is push in the horizontal direction and the behavior of the building is recorded in the form of the top deflection.The main aim of this method is to generate the push over curve.This push over curve gives the capacity of the structure so that it is also known as the capacity curve.There are main three primary elements in the push over analysis are capacity curve, demand curve and performance point.The capacity curve is the curve of lateral load vs. roof deflection curve which shows the capacity of the building which is already mentioned earlier.The demand curve is the curve of spectral acceleration vs. spectral displacement. This curve represents the actual demand of the building during the ground motion.Spectral acceleration means the maximum respective acceleration of the building. And the spectral displacement is the maximum displacement of the building.The demand curve is nothing but the conversion of the response spectrum curve to the acceleration displacement response spectrum (ADRS)Demand represents the earthquake ground motion and capacity represents the structural stability to resist the seismic demand.Performance point is the interaction point between the capacity curve and demand curve. This point gives the global response of the structure and that point is the actual behavior of the structure because of for performance point particular spectral acceleration and spectral displacement the demand from ground motion and capacity of the structure remain same. In this analysis the unit displacement is considered at the extreme top point of the structure.

2.4.1 Steps for the push over analysis

1. Create the computer model of the structure.
2. Classify the element as primary and secondary.
3. Apply the lateral load to the structure
4. Record the base shear and the top deflection of the building.
5. Repeat the step 3 and 4 until the target displacement reaches or the structure is collapse.
6. Draw graph of the lateral load vs. top defalcation.
7. Convert response spectrum curve to ADRS curve and draw it on a graph paper.
8. Convert the lateral load vs. top deflection curve to the capacity curve or spectral acceleration vs. spectral displacement curve. And draw on the same graph of demand curve.

2.5 Loading

In this analysis dead load, live load and earthquake load is included. For the dead load density of concrete is taken as the 25 kN/m^3. Live load considers 4 kN/m^2on each floor. And for the earthquake load is taken as per IS 1893:2002.

III RESULT

Push over curves for the raft foundation and pile foundation are shown in figure-2 and figure-3 for the 5 story building.

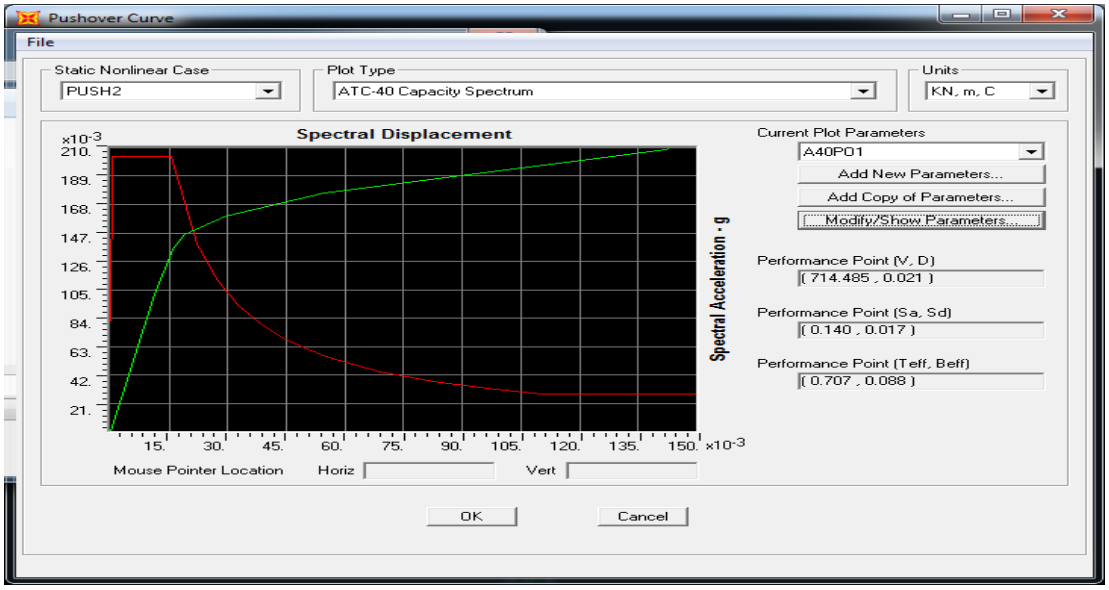
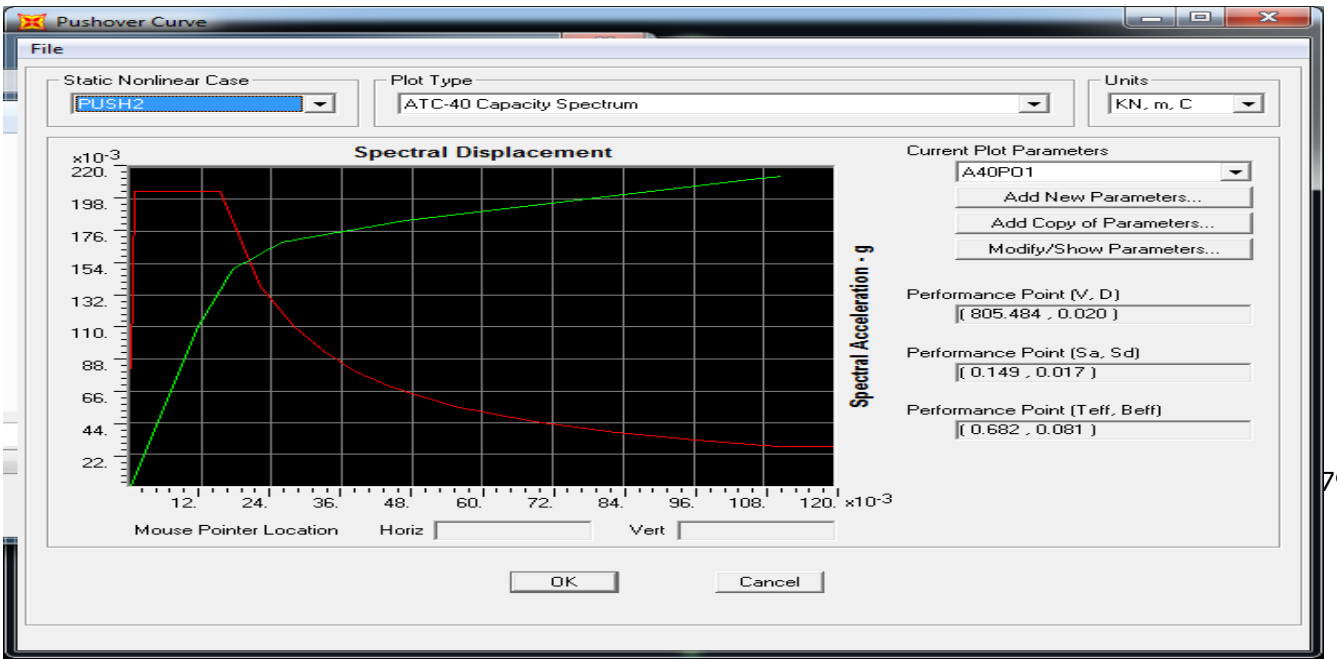


Figure-2 Push over Curve of the Raft Foundation for 5 Story Structure

As shown in figure-2 the push over curve spectral acceleration vs. spectral displacement (push over curve) for raft



foundation. In this curve the performance point is given by SAP2000 is where the demand curve and capacity curve is intersect is (0.140, 0.017).

Figure-3 Push over Curve of the Pile Foundation for 5 Story Structure

As shown in figure-3 the push over curve spectral acceleration vs. spectral displacement (push over curve) for pile foundation. In this curve the performance point is given by SAP2000 is where the demand curve and capacity curve is intersect is (0.140, 0.017).

Table-1 Comparison of the Spectral Displacement for the Raft Foundation and Pile Foundation

Total No. Story	Spectral Acceleration	Spectral displacement	
		Raft Foundation	Pile Foundation
5	0.14	0.017	0.017
10	0.08	0.033	0.033
15	0.05	0.051	0.055
20	0.03	0.074	0.082
25	0.02	0.099	0.12

IV CONCLUSION

In order to carry out push over analysis on a symmetric high rise structure with respect to loading in plan of 15m×15m and floor height is taken as 3m for each floor is analyzed for the pile foundation and raft foundation with varying the number of floor from 5 to 25. The structure is modeled in the SAP2000. The push over analysis is done for the same modeled using displacement control method of push over with unit displacement at the top.

It has been observed that spectral displacement of the pile foundation is more than raft foundation for the almost same acceleration. In this analysis up to the 10 floor the spectral displacement is almost same. But after the 10 story the spectral displacement is respectively increased in the pile foundation with compare the raft foundation.

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