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EFFECT OF RC CONFINING ELEMENTS ON STIFFNESS OF ADOBE MASONRY STRUCTURE

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Abstract — *Adobe construction in rural areas is quite common due to locally available material. In developing countries, the adobe construction is increasing due to its thermal and acoustic properties. Different types of structures have been built in ancient times from earth. From heritage point of view, the adobe construction is of great importance but we cannot ignore its disadvantages due to its mechanical properties such as lower strength of masonry units, lack of resistance to wind and rain. Adobe masonry has shown poor performance in past earthquake. The reason behind that was lower shear and tensile strength. Due to its massive weight of wall and excessive weight from roof, it attracts large forces during ground shaking which it cannot resist and fail abruptly. People are unaware and they are regularly constructing these structures in their areas where seismic hazard is high. To improve the seismic capacity of these adobe structures different schemes had been developed, but in this research we have used Reinforced Concrete (RC) components as confining elements to improve its performance during earthquake. Two models have been tested on shake table, one with vertical columns and beams and the other model with only beams at different level along the height of wall. Comparison of Lateral strength of structure in term of base shear coefficient and stiffness has been made. Addition of vertical columns has increased structural stiffness and structural strength 3.50 times and 5 times respectively that of model with beams only.*

Keywords- *Stiffness, Shake table, Seismic capacity, Adobe Masonry, Strength. RC confinements.*

I. INTRODUCTION

People has used different construction materials to build structure that it can provide them shelter which will protect them from any external hazard such as animal attack, wind storm or rain. From the past literature it has been evident that construction materials that were used at that time were naturally available materials such as stone, wood and soil. Structures have been built from soil such as rammed earth, adobe masonry. It was common practice. They were using soil mixed with water, straw and sand were used as additive to increase strength. The abundance of earthen structure in the past was because of no requirement of skilled labors, machinery and easily availability of material. Distribution of adobe masonry structures worldwide has been reported in literature. [1,2,3]. Surprisingly fifty percent of the world population lives in adobe houses [4,5].
Walls of these structures were built from sun dried bricks laid in layers with clayey soil being used as mortar. The soil has been mixed with water and straw. The mix has been left for whole night called as hibernation technique. Then the bricks unit has been made by putting the mix in molds. After drying, bricks have been used. it has been shown that the structural durability and strength is related to its masonry unit strength and durability. Greater unit strength means greater masonry strength and better capacity to resist forces. Many researchers have focused on the masonry unit strength and they have used different additives. They have used sand, straw and other cementitious materials to increase its strength. It was observed that if we control rate of drying shrinkage, control crack propagation and reduce water transfer from mortar to bricks we can increase strength of the masonry [6].
Due to its mechanical properties such as lower tensile and shear strength the masonry fails abruptly when subjected to lateral forces by ground shaking. Because of its mechanical properties these types of structures are more vulnerable to seismic excitations comparatively to other type of earthen structures [7]. Poor performance of these structures has been reported in available literature [8]. At Catholic University of Peru researchers have studied in detail its seismic behavior but yet the available literature is limited. More study is required to investigate its behavior while reinforcing the adobe masonry using different techniques resulting in safe and economical construction, that poor people can adopt it easily. The term non-engineered construction is being used for adobe construction as there are no engineering guidelines or principles available. There is no supervision being involved in these construction which leads to poor construction and being reported as major cause of its failure. Currently no design codes are available to be followed for design and its safety [8]. Structural damages have been observed in adobe masonry structure during earthquake. The separation of walls due to relative displacement resulted in corner failure. Shear failure of wall has been occurred. The main failure in these type of structure is the out of plane failure. If we can control the out of plane failure, we can increase its in-plane capacity. due to lack of proper connection between roof and walls the roof deform independently from walls and hence walls act as cantilever. Due to greater demand of forces because of its cantilever action the walls fails resulting in collapse of structure. If proper connection has been provided for roof and walls then the roof will act as diaphragm and it will control the out of plane failure of wall resulting in increase of its overall capacity. RC elements has been provided along the height to increase the out of plane capacity of these structures.

Figure 1.1. Observed damage mechanisms during 2008 Baluchistan Earthquake: In plane shear cracks in wall (Left), in plane cracks and corner failure (Middle), collapse (Right). (N. Ahmad,2011)

Figure 1.2. Total collapse of adobe houses during the Ziarat Earthquake in 2008 [9]

Figure 1.3. Typical damage caused by the Dalbandin Earthquake in 2011 [9]

II. EXPERIMENTAL SETUP AND TESTING

Two 1/3rd scaled models were built and fitted on shake table using bolts. 1st model was having vertical columns at each corner and beams at different level while 2nd model was having only beams at different level along the height of the wall. Displacement transducers were installed at roof level and at base of the model. With each displacement transducer accelerometers were also installed. The displacement transducer data was used to calculate drift ratio and accelerometer data was used to obtained the seismic demand on the structures. The models were tested using sine waves. during testing different mode shapes were observed visually from fundamental mode to higher mode and also torsion was observed due to change in stiffness of in-plane walls. Data obtained from displacement transducers and accelerometers were filtered and base line correction was applied to remove noise. Seismosignal software was used for this purpose. After analysis of data it was observed that if we plot peak values of accelerometer and drift from each run no useful results can be obtained. That’s why we analyzed each run data of accelerometers and displacement transducers for seismic demand in term of (g) and drift ratio. For each run different peak values were selected occurring at same interval of time. Then these points were plotted and trend curve was added to it. Then stiffness calculation has been made which shows the difference in stiffness’s of both models.

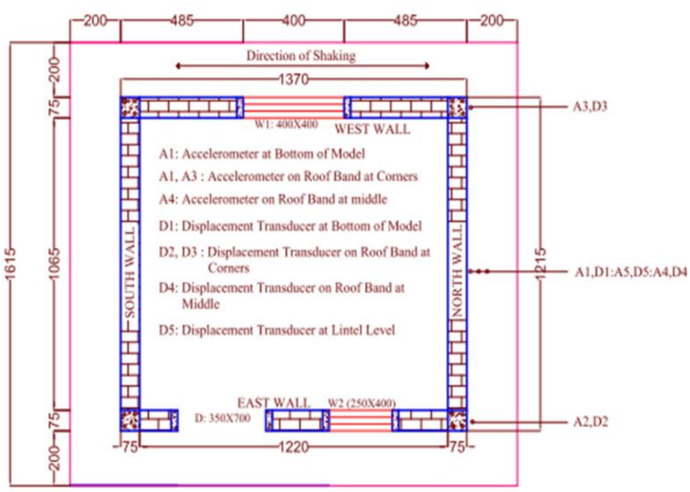


Figure 2.1. Model 1 Plan view

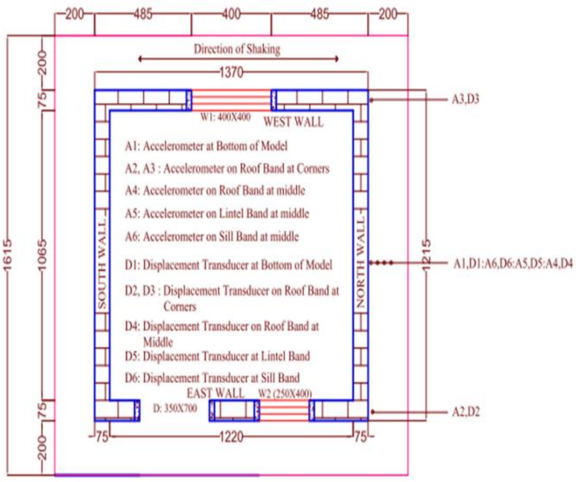


Figure 2.2. Model 2 Plan view

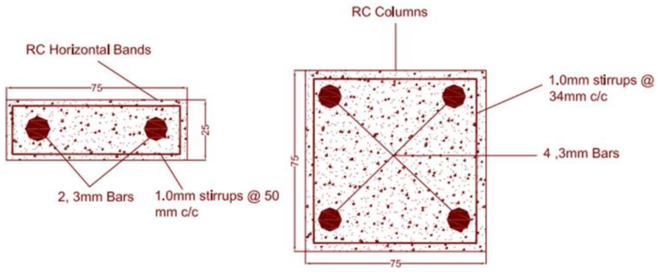


Figure 2.3. Beam and column cross section.

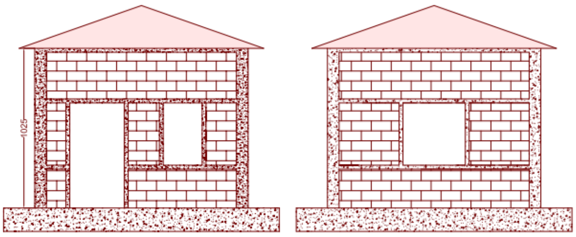


Figure 2.4. Model 1 East and West Wall

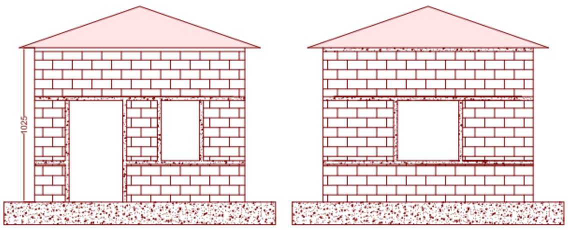


Figure 2.5. Model 2 East and West Wall

III. DATA ANALYSIS

Data obtained has been processed. Different points have been selected and then stiffness value for both models has been obtained. Stiffness value has been compared for both models in terms of base shear coefficient and drift ratio.

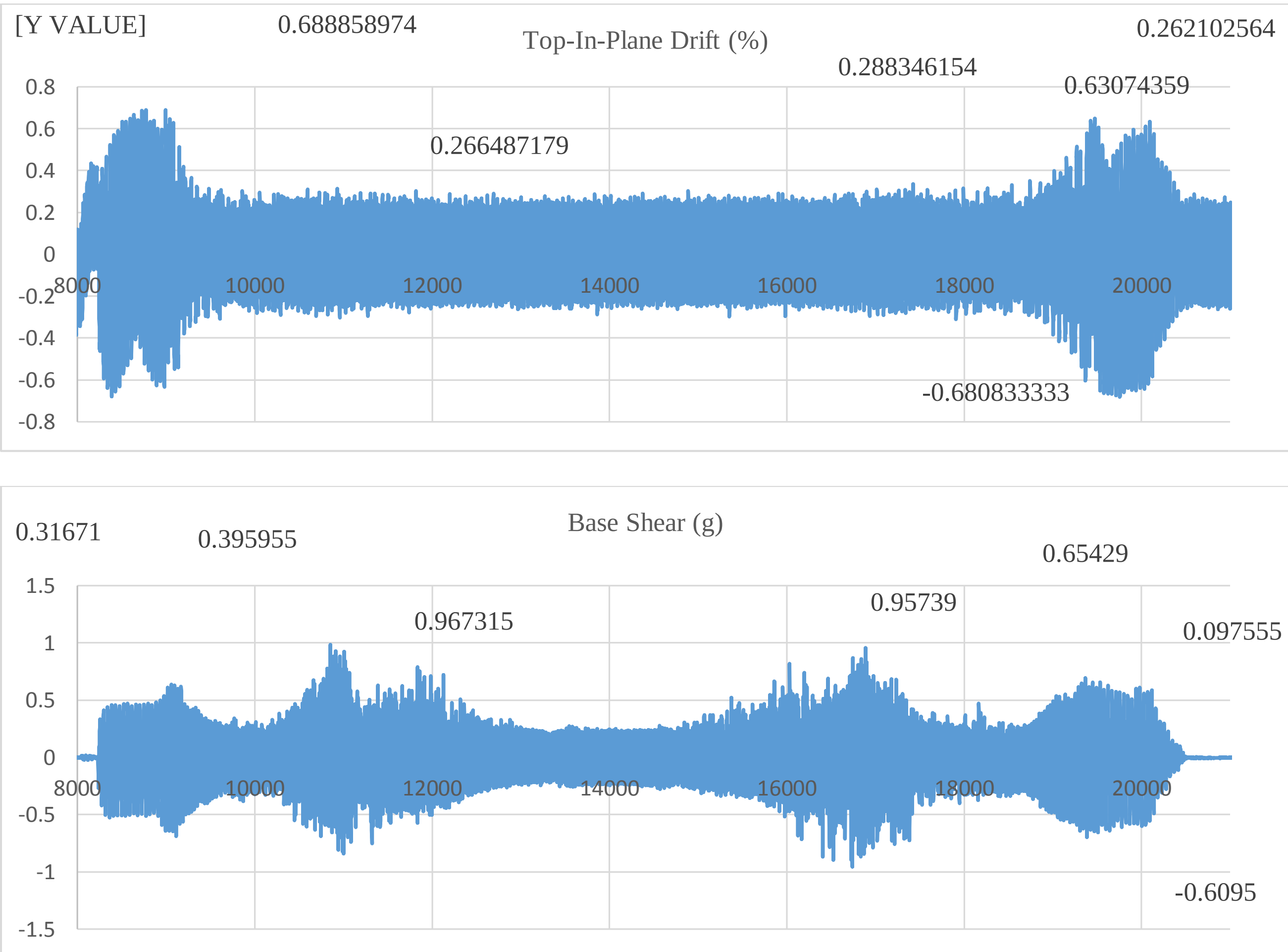


Figure 3.1. In plane drift ratio vs base shear coefficient for Model 1(R6)

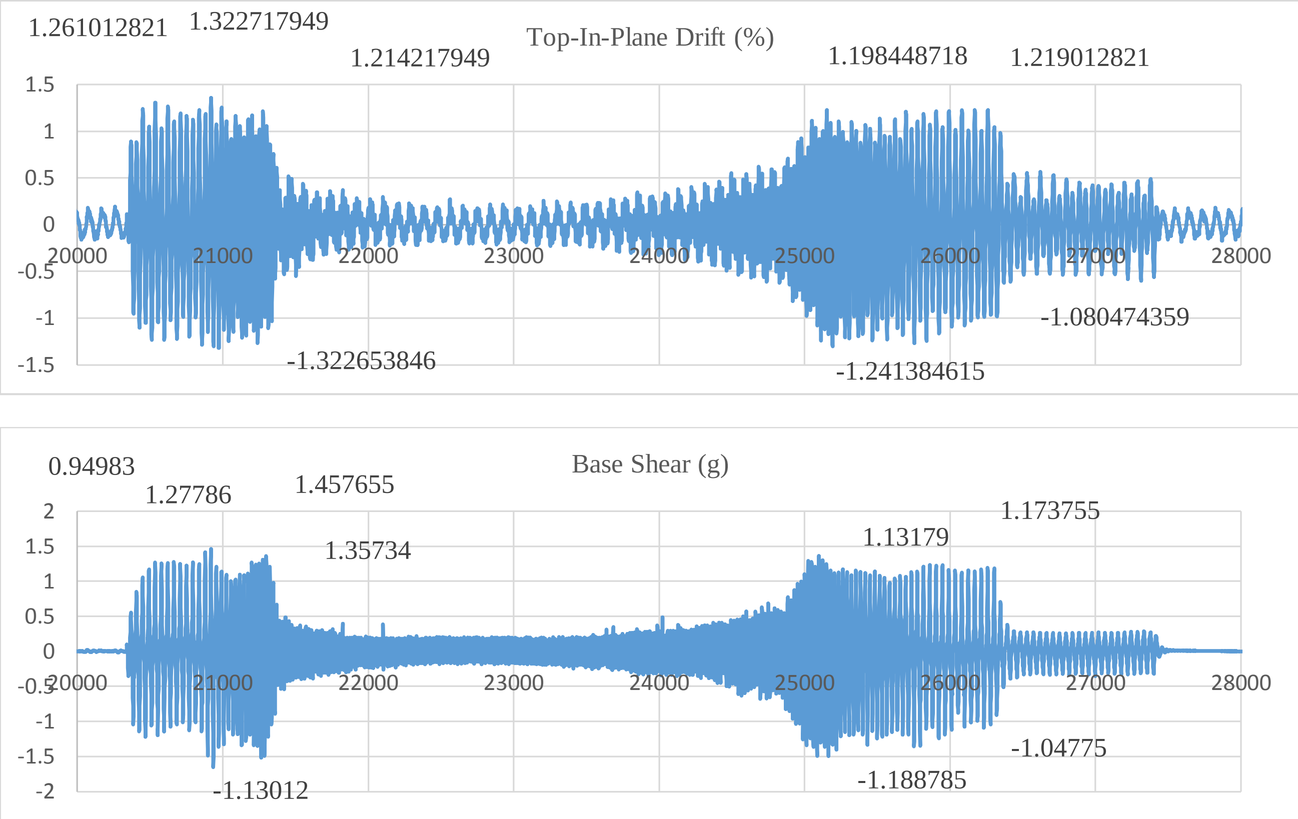


Figure 3.2. In plane drift ratio vs Base shear coefficient for Model 1 (R11)

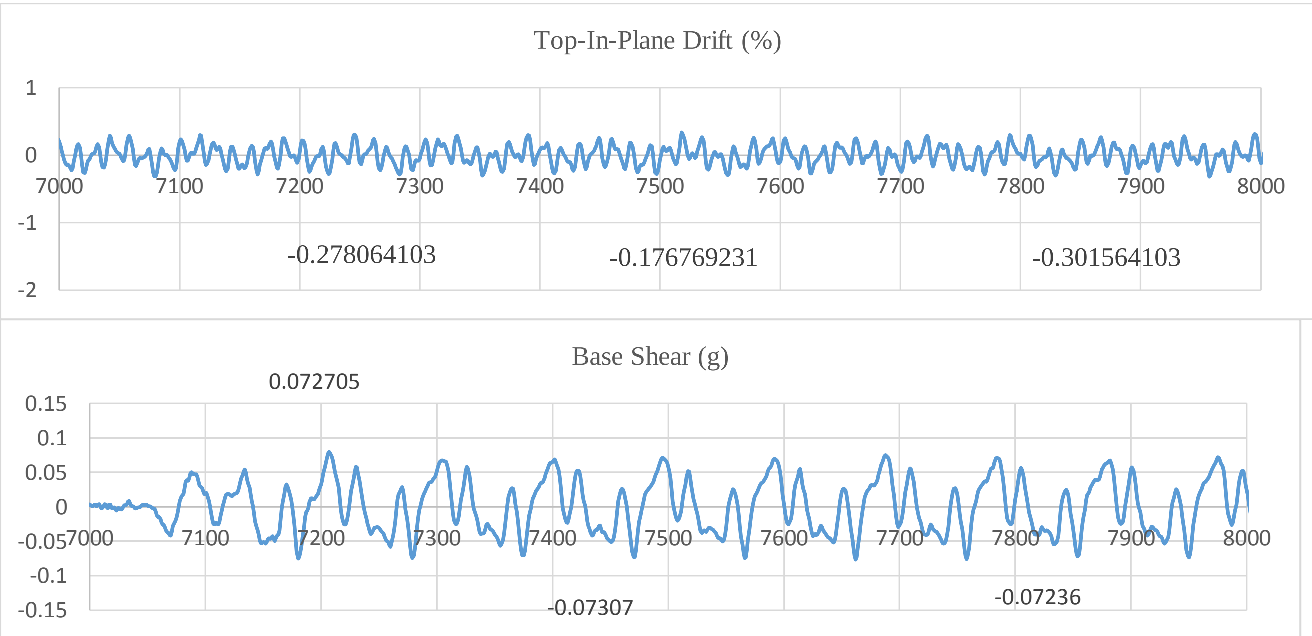
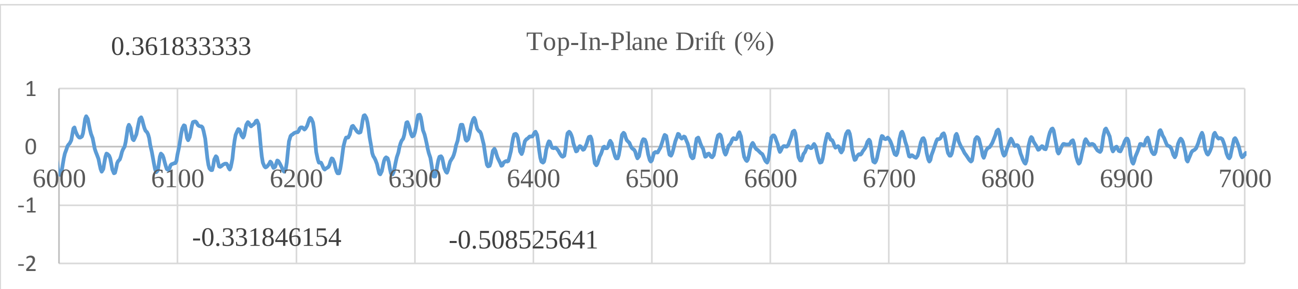


Figure 3.3. In plane drift ratio vs Base shear coefficient for Model 2 (R3)



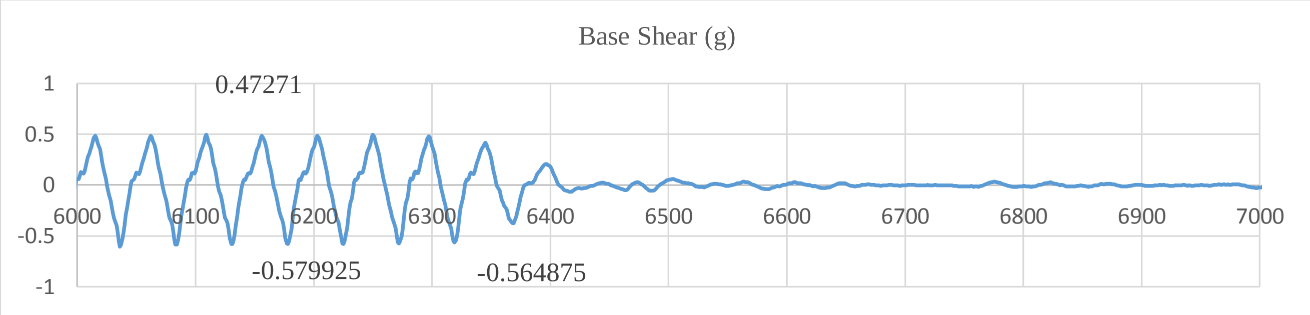


Figure 3.4. In plane drift ratio vs Base shear coefficient for Model 2 (R6)

IV. RESULTS

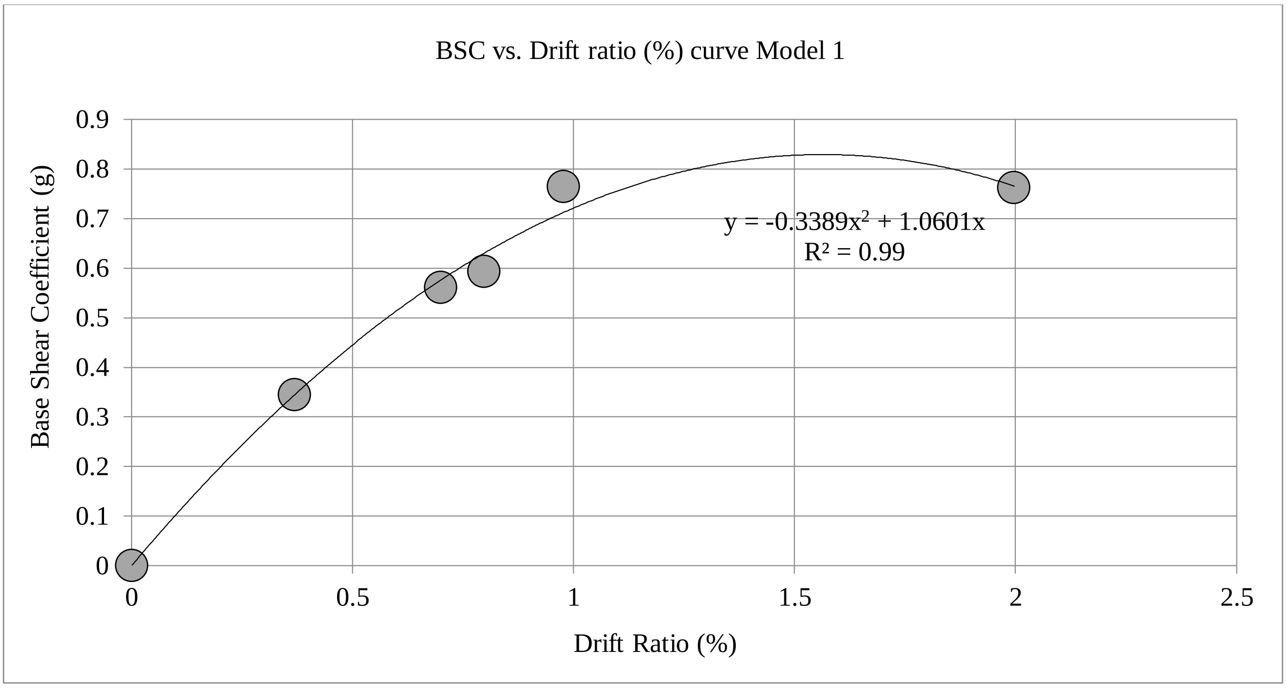


Figure 4.1. In plane drift ratio and base shear coefficient capacity curve Model 1

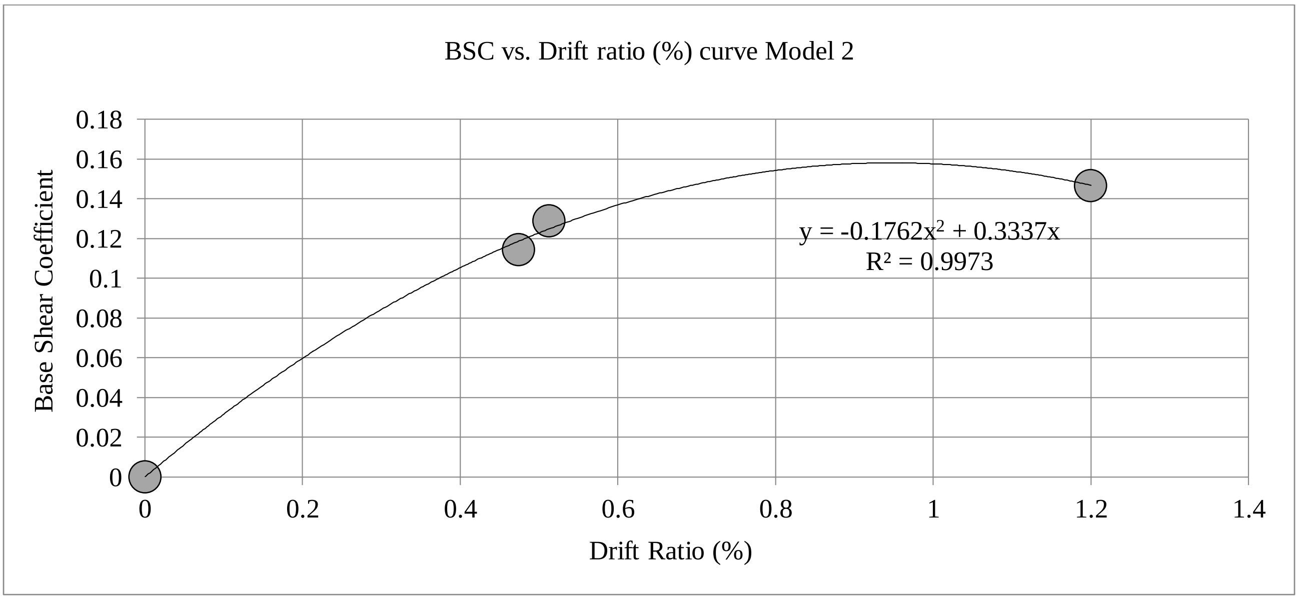


Figure 4.2. In plane drift ratio and base shear coefficient capacity curve Model 2

Derivative of the equations which shows the trends of the plotted points has been taken. 0.2% drift ratio value has been used for calculation of stiffness. The resulted value of BSC/Drift ratio is 0.925 for Model 1 and 0.263 for Model 2.

V. CONCLUSIONS

1. The addition of vertical columns at each corner has increased lateral stiffness 3.50 times that of model with beams only.
2. The maximum base shear coefficient of model with vertical columns and horizontal beams is 0.83.
3. The maximum base shear coefficient of model with only horizontal beams is 0.16
4. The strength of model 1 due to addition of vertical columns has increased 5 times that of model 2.

VI. RECOMMENDATION

1. The model 1 has been recommended to be used in seismic zone where base shear coefficient demand is less than 0.83
2. The model 2 has been recommended to be used in seismic zone where base shear coefficient demand is less than 0.16
3. Seismic assessment of base model should be made and also different seismic parameters should be derived, such as Response modification factor and Ductility.

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