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Seismic Analysis of Multistory Building (Soft Storey) With Comparison of IS Codes & ACI Codes using ETABS

K.N.Lakshmaiah[1], S.Nikhilendra[2],U.Narayana Reddy[3], K.Srikanth[4], G.Teja Syam[5], A.Nagarjuna Reddy[6]
Assistant Professor[1], Student[2, 3,4,5,6]
Department of Civil Engineering
Narasaraopeta Engineering College, NRT, Jntuk, India

Abstract:
In Present scenario the effect of earthquakes takes place huge roll on life and properties. since the effect of seismic forces on structures is quite significant it is important that the design of the structure must be done in best possible way to take into account these effects and there by aiming for an adequate structural response. Different international seismic codes differ significantly in parameters specified with the variations in parameters, the performance of the building varies, and hence it is necessary to do a comparative study so as to conclude which building performs better. In this project we perform the seismic analysis for G+8 RC frame using with bare frame, bare frame with slab, bare frame with slab and masonry by using ETABS software package and also studied the effect of usage the standard codes (IS & ACI). And the infill walls show the significant effect on stiffness of building and lateral displacement. Here we compared the displacement, story drift and base shear of model 1, model 2 and model 3. ETABS is also leading design software in present days used by many structural designers. Here we had also analyzed the 3 models using ETABS software for the Dynamic Analysis.

I. INTRODUCTION

Natural calamities such as earthquakes, Tsunamis, landslides, floods etc. causes severe damage and suffering to human being by collapsing many structures, trapping or killing persons, cutting off transport systems, blocking of navigation systems animals hazards etc. Such natural disasters are big challenges to the progress of development. However, civil engineers plays a major role in minimizing the damages by proper designing the structures or by proper material selections or proper constructions procedure and taking other useful decisions.

This includes understanding the earthquakes, behavior of the materials of construction and structures and the extent to which structural engineers make use of the knowledge in taking proper decisions in designing the structures made of reinforced concrete.

Structural design codes of different countries provide engineers with data and procedures for design of the various structural components. Difference, sometimes large once, could be noticed between the codes in the data given for actions (loads), in the provisions for evaluating resistance of sections, in addition to other code requirements for durability, detailing etc. In this project, a G+8 building is planned and analyzed. The analysis is carried out by using two international seismic standards-IS 1893 criteria for earthquake resistant design of structures part 1. IBC-2006 design loads for buildings and other structures. The performance of the building will be analyzed.

The seismic zone force distribution is dependent on the stiffness and mass of the building along the height. The structural contribution of infill wall results into stiffer structure thereby reducing the storey drifts (lateral displacement at floor level). This improved performance makes the structural design more realistic to consider infill walls as a structural element in the earthquake resistant design of structures.

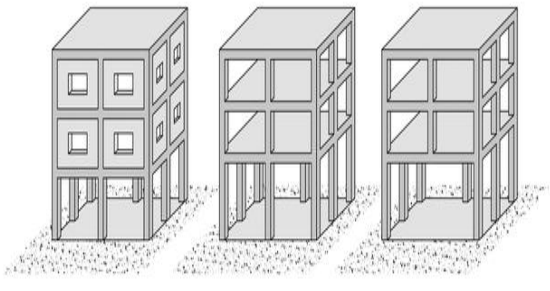

Figure.1. Typical example of first soft storey

The above fig 1 shows the first soft storey having infill with openings and Infill were usually classified as non-structural elements, and their influence was neglected during the Modeling phase of the structure leading to substantial inaccuracy in predicting the actual seismic zone response of framed structures. Masonry infill has several advantages like good sound and heat insulation properties, high lateral strength and stiffness. These help to increase the strength and stiffness of RC frame and hence to decrease lateral drift, higher energy dissipation capacity due cracking of infill and friction between infill and frame. This in turn increases the redundancy in building and reduces bending moment in beams and columns. Masonry infill has disadvantages like very high initial stiffness and compressive strength. This also induces tensional effect in the structure if not symmetrically placed. For a proper design of masonry in filled reinforced concrete frames it is necessary to completely understand their behavior under repeated horizontal loading. The only difference between the finished residential and office buildings are the type of materials used for partitions and building perimeter wall enclosures. Residential buildings commonly use masonry in fills both internally and externally. However, office buildings require as much open internal space as possible due to varying tenancy requirements.

A. Definitions

***1) Storey*:** when the multi-story building or the residential building is constructed in that when the floor to floor gap will be there that is the story

***2) Soft storey*:** A soft storey is one in which the lateral stiffness is less than 70 percent of that in the storey above or less than 80 percent of average lateral stiffness of the three storey above. The stiffness is less as compared to the above storey due to no in fills at that storey level.

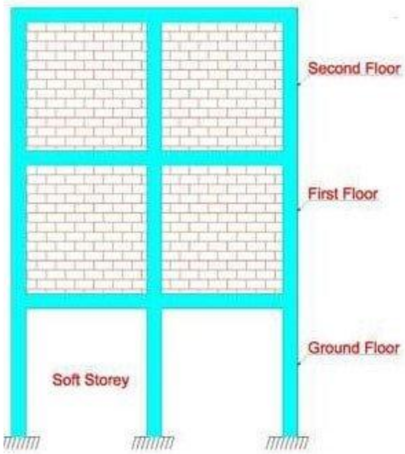

Figure.2. soft storey

***3) Story Drift*:** is defined as the difference in lateral deflection between two adjacent stories. During an earthquake, large lateral forces can be imposed on structures; Lateral deflection and drift have three primary effects on a structure; the movement can affect the structural elements (such as beams and columns); the movements can affect non-structural elements (such as the windows and cladding); and the movements can affect adjacent structures. Without proper consideration during the design process, large deflections and drifts can have adverse effects on structural elements, nonstructural elements, and adjacent structure

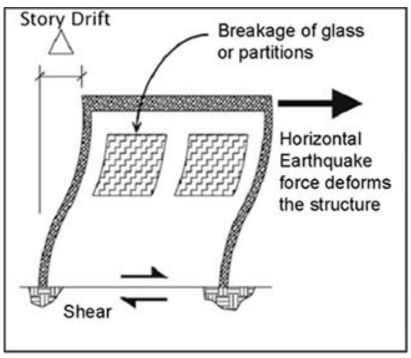

Figure.3. Storey Drifts

***4) Base shear*:** Is an estimate of the maximum expected lateral force that will occur due to seismic ground motion at the base of a structure

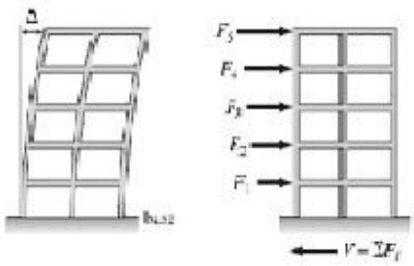

Figure.4. Base Shear

B. Objectives

Following are some objectives of this dissertation work.

1. The main objective of this dissertation is focus on the behavior of RC frame buildings with bare frame, bare frame with slab element and first soft storey. And analysis based on IS Codes and ACI Codes.
2. To study the effect of displacement, storey drifts and Base shear of bare frame, bare frame with slab element, and soft storey (3 models) of building.
3. To analyze the RC frame for dynamic analysis in relation to the storey drift and displacements, base shear using software ETABS with IS Codes and ACI Codes.
4. To study the comparison between the displacement, storey drifts and base shear for three models according to IS codes and ACI codes.
5. To investigate the bare frame, soft storey behavior RC frame building for all cases so as to arrive at suitable practical conclusion for achieving earthquake resistant RC frame building.
6. To identify the storey drift where there is exceeds its permissible values of storey drifts i.e.0.004h.
7. To promote safety without too much changing the constructional practice of reinforced concrete structures.

II. METHODOLOGY AND MATERIALS USED

The multi-storey building is modeled with G+8 stories with Soft Storey and dynamic analysis has been done by response spectrum Analysis.

A) Analytical Modeling – ETABS

The ETABS software is used in the present investigation to develop RC frame Model and to carry out the analysis. Linear dynamic analysis of the building Models is performed on ETABS. For the Modeling of the G+8storey RC building with first soft storey, were consider line element was used for beams(230mm x 300mm) and columns(230mm x480mm) and concrete element for slabs in the present investigation, Brick materials are used for masonry infill as internal walls(115mm) and external walls(230mm). The base of structure was fully fixed by constraining all the degrees of freedom. An RC building code comparison of Indian and American codes on medium soil was analyzed and the displacement, storey drifts, and base shear, the mode shapes around the structure due to different load combinations were obtained. Linear dynamic analysis was performed using response spectrum method

B) Building description

The Modeling of the G+8storey with bare frame, bare frame with slab element, full wall element structure, first soft storey
Model 1: Bare frame
Model 2: Bare frame with slab element.
Model 3: Building has full walls with external walls (230mm thick) and internal walls (115mm thick) in all storey's have and slab element.

C) Analyzing the data

Linear dynamic analysis has been performed as per IS 1893 (Part 1): 2002 for each model using ETABS analysis package. Lateral load calculation and its distribution along the height are done.

Table.1. Data Relation to the Rc Frame Building Models

Type of frame	Ordinary moment resisting RC frame OMRF) fixed at the base
Seismic zones	III
Number of storey	G+8storey
Floor height	3 m
Depth of Slab	150 mm
Size of beam	(230 × 300) mm
Size of column	(230 × 480) mm
Spacing between frames in x-direction	4 m
Spacing between frames in y-direction	6 m
Materials	M 25 concrete, Fe 415 steel and
Infill	Masonry
Thickness of external infill walls	230 mm
Thickness of external infill walls	115 mm
Density of concrete	25KN/m^3
Density of infill	20 KN/m^3
Type of soil	Medium soil
Seismic zone	As per IS (1893-2002)
Seismic zone factor, Z	For zone III: 0.16
Importance Factor, I	1
Response spectrum analysis	Linear dynamic analysis
Plinth height above ground level	3 m
Type of the building	OMRF(Ordinary moment resisting RC frame)

D) Materials used

1) Concrete

Concrete with following properties is considered for study.

- Characteristic compressive strength (f_{ck}) = 25 MPa
- Poisons Ratio = 0.2
- Density = 24KN/m^3
- Modulus of Elasticity (E) = 5000 x $\sqrt{f_{ck}}$= 25000 MPa

2)Steel

Steel with following properties is considered for study.

- Yield Stress (f_y) = 415 MPa
- Modulus of Elasticity (E) = 2x10^5MPa

3) Masonry infill

- Clay burnt brick, Class A, confined unreinforced masonry
- Compressive strength of Brick, f_m= 10 MPa
- Modulus of Elasticity of masonry (E_i)= 550 x f_m= 5500 MPa
- Poisons Ratio = 0.15

E) Analyzed Building Models

- Model 1: Bare frame modeling
- Model 2: Bare frame with slab elements
- Model 3: Bare frame with slab elements and Infill wall (Soft story)
- All the models are analyzed with IS and ACI codes by the method of Response Spectrum Analysis(RSA

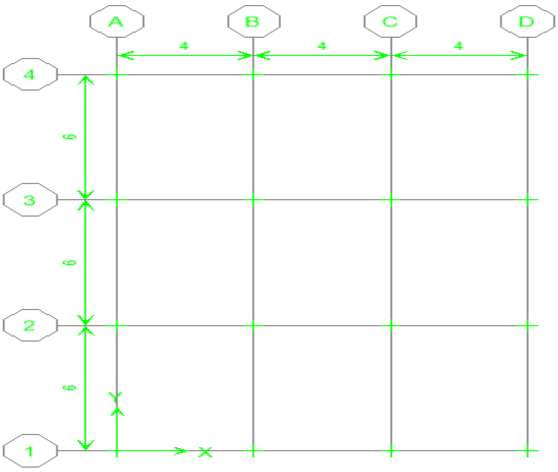

Figure.5. Plan of the building

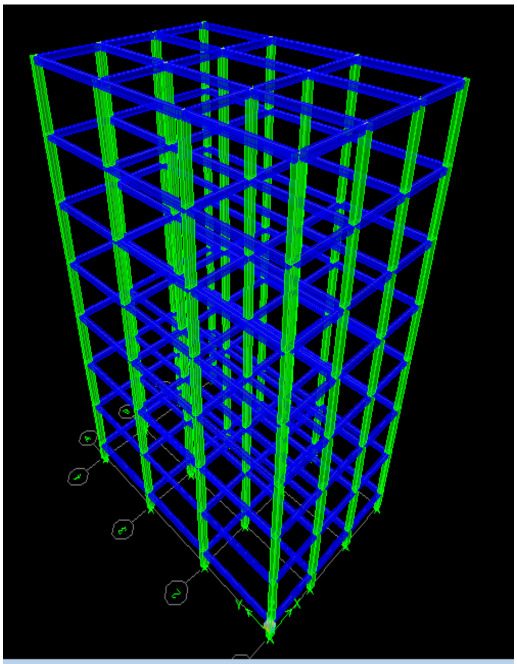

Figure.6. model 1: bare frame

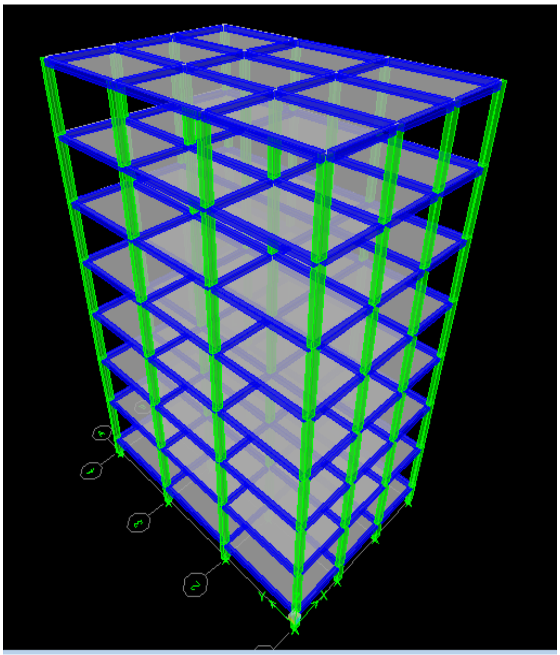

Figure.7. model 2: bare frame with slab element

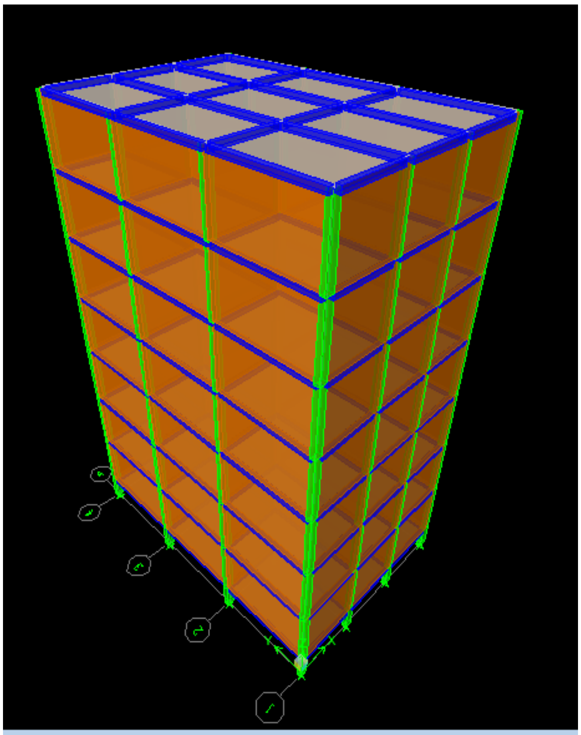

Figure.8. **model 3:bare frame with slab element and with infill's (soft story)**

III.RESULTS AND DISCUSSIONS

A) Discussions on Comparison of displacements for IS and ACI codes in Model 1

Table.2. Displacements For Is and Aci Codes

MODEL 1 (Displacements)		
Story	IS CODE	ACI CODE
BASE	0	0
STORY1	0.0902	0.0013
STORY2	0.3203	0.0061
STORY3	0.5524	0.0117
STORY4	0.7758	0.0172
STORY5	0.9801	0.022
STORY6	1.1536	0.026
STORY7	1.2844	0.0289
STORY8	1.3675	0.0307

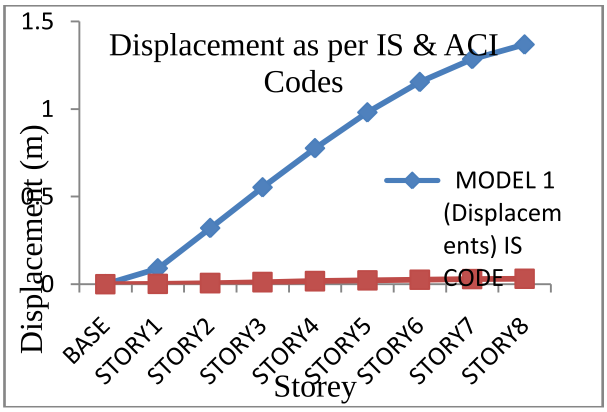

Figure.9.

In IS codes displacement is increases bottom to top storey we can observe the graph is randomly increase. In ACI codes displacements are increases base storey to top storey in that displacement small. We can observe the two codes displacements are differently in that displacement more in Indian code compare to the ACI code, Less displacement structure has more stiffness.

B) Discussions on Comparison of displacements for IS and ACI codes in model 2

Table .3. Displacements For Is and Aci Codes

MODEL 2 (Displacements)		
Story	IS CODE	ACI CODE
BASE	0	0
STORY1	0.1488	0.1858
STORY2	0.529	0.6588
STORY3	0.9136	1.1312
STORY4	1.2856	1.5794
STORY5	1.6288	1.9829
STORY6	1.9241	2.3211
STORY7	2.1517	2.5752
STORY8	2.3012	2.7387

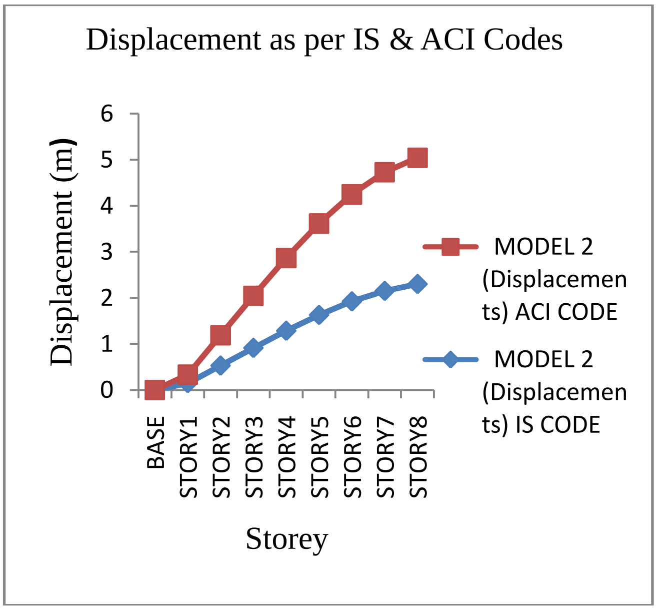

Figure.10.

In model 2 displacement ACI code is more compared to the IS code. In model1 is more displacement in IS code because of in modei1 bare frame in model2 bare frame with slab.in the model2 increase displacement bottom to top but bare frame is more displacement compared to bare frame with slab

C) Discussions on Comparison of displacements for IS and ACI codes in model 3

Table.4. Displacements For Is And Aci Codes

MODEL 3 (Displacements)		
Story	IS CODE	ACI CODE
BASE	0	0
STORY1	0.3468	0.0012
STORY2	0.3776	0.0038
STORY3	0.4086	0.007
STORY4	0.4401	0.0107
STORY5	0.4719	0.0146
STORY6	0.5037	0.0185
STORY7	0.5354	0.0221
STORY8	0.5669	0.0255

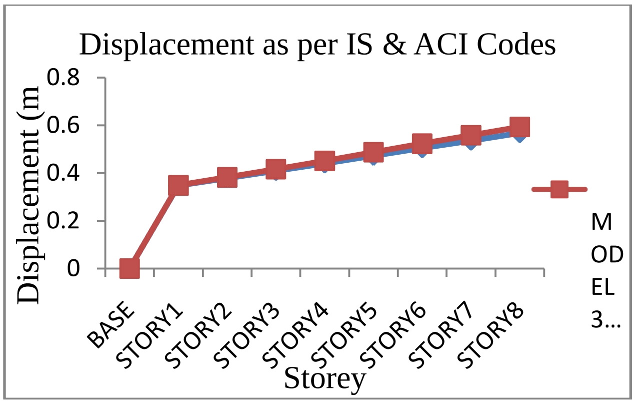

Figure.11.

In model 3 we are observe the graph the displacement values are approximately because of the model 3 bare frame with slab and infill walls so the displacement is compare to other two models. we can see observe the graph base displacement value is more because of no infills base so it is diplace some distance after less displacement

D) Discussions on comparison of drifts in 3 models for IS Codes

Table.5. Drifts For Is Codes

Drift (m) - As per IS codes			
Story	Model 1	Model 2	Model 3
STORY1	0.00155	0.00252	0.00588
STORY2	0.00165	0.00268	0.00022
STORY3	0.00167	0.00271	0.00022
STORY4	0.00162	0.00263	0.00023
STORY5	0.00149	0.00242	0.00023
STORY6	0.00127	0.00208	0.00023
STORY7	0.00097	0.00161	0.00023
STORY8	0.00062	0.00106	0.00022

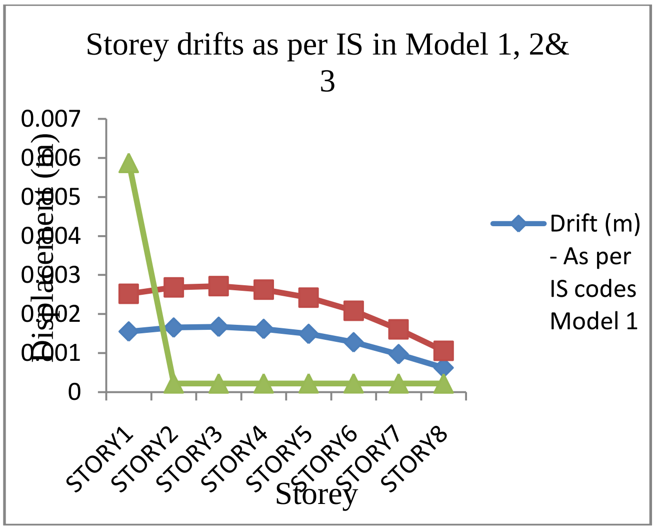

Figure.12.

Drift: the difference between two storeys displacement is called drift. Drift is more occurring in model 3 because in model 3 having bare frame with slab element and within fills.By taking graph data in model 3 drift is more occurring at storey 1.In model 1&2 storey drift is more at storey 3.In model 3 storey drift is same at storey 7 to storey 4.

E) Discussions on comparison of drifts in 3 models for ACI Codes

Table.6. Drifts For Aci Codes

Drifts (m)- As per ACI codes			
Story	Model 1	Model 2	Model 3
STORY1	0.00086	0.00315	0.004922
STORY2	0.00139	0.00334	0.000022
STORY3	0.0016	0.00333	0.000026
STORY4	0.00155	0.00316	0.000029
STORY5	0.00139	0.00285	0.00003
STORY6	0.00114	0.00239	0.000029
STORY7	0.00084	0.00179	0.000027
STORY8	0.00052	0.00115	0.000024

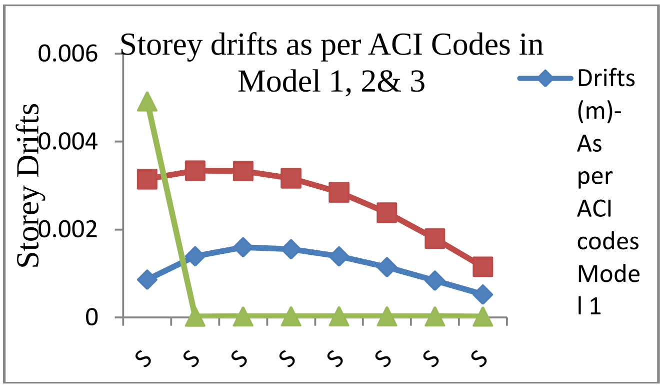

Figure.13.

The storey Drift is Maximum occurring in model 3 because in model 3 having bare frame with slab element and with infills. From the above graph we observed that is, model 3 having Maximum storey drift at storey 1 and the model 2 having Maximum storey drift at storey 2. Same as model1 having Maximum storey drift is at storey 4.

F) Discussions on comparison of base shear in 3 models for IS codes

Table.7. Base Shear In Is Codes

Base Shear(KN)- As per IS codes			
Story	Model 1	Model 2	Model 3
STORY1	46.04	72.15	1440.87
STORY2	44	72.08	1439.88
STORY3	43.41	71.17	1419.24
STORY4	41.73	68.54	1359.18
STORY5	38.35	63.28	1239.12
STORY6	32.71	54.48	1038.51
STORY7	24.22	41.24	736.78
STORY8	12.31	22.67	313.35

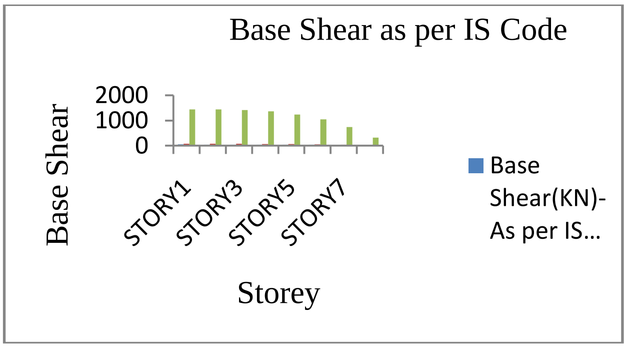

Figure.14.

In IS code shows the base shear is less compared to the ACI codes in Model 1 base shear is less because of in this we have only bare frame is considered. In Model 2 more base shear compared to Model 1 because of slab load is acting . In Model 3 base shear is very high compared to Model 1&2 because of infill walls are present.

G) Discussions on comparison of base shear in 3 models for ACI codes

Table.8. Base Shear Aci Codes

Base Shear (KN)- As per ACI codes			
Story	Model 1	Model 2	Model 3
STORY1	204	90.63	2266.77
STORY2	202.6	90.25	2241.74
STORY3	195.29	87.88	2126.71
STORY4	181.14	82.73	1930.48
STORY5	159.42	74.21	1653.05
STORY6	129.59	61.85	1294.43
STORY7	91.18	45.23	854.6
STORY8	43.82	23.97	333.58

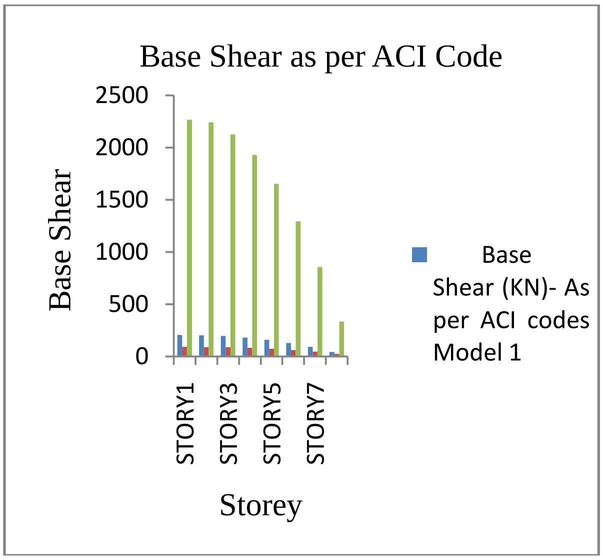

Figure.15.

In Model 1 we observed base shear is more compared to Model 2 due to the variation in codes. In Model 3 base shear is more compared to Model 1&2. Base shear is more in ACI codes compared to IS codes in Model 3.

IV. CONCLUSION

The IS code methods describing very insufficient guidelines about infill wall design procedures. Software like ETABS is used as a tool for analyzing the effect of infill on the structural behavior. It is observed that ETABS provide overestimated values of storey drift, lateral displacement and base shear. According to relative values of all parameters, it can be concluded that provision of infill wall enhances the performance in terms of displacement, storey drift and lateral stiffness.

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