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EQUIVALENT STATIC AND RESPONSE SPECTRUM ANALYSIS OF BRACED FRAME STRUCTURE USING ETABS V 15

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ABSTRACT

Earthquakes are the foremost unpredictable and devastating of all natural disasters that are terribly troublesome to save lots of over engineering properties and life, against it. hence so as to beat these problems we'd like to spot the seismic performance of the designed atmosphere through the event of various analytical procedures, that make sure the structures to face up to throughout frequent minor earthquakes and produce enough caution whenever subjected to major earthquake events. In order that will save as several lives as attainable.

KEYWORDS :Equivalent Static , seismic performance , analytical procedures , Equivalent Static Analysis .

INTRODUCTION :

In the present study RC frame with and without steel bracings are analyzed for a model building (G+9) located in Seismic Zone –V and Soil type II by modeling of initial bare frame. Equivalent Static Analysis and Linear Response Spectrum analysis are carried out on the models (6 models) as Bare frame, X-bracing, Forward bracing, backward bracing, V bracing and Inverted V bracing using computer software ETABS version 2015. From the different parameters such as displacement, mode period, acceleration and base shear are computed.

In which it shows that X-Bracing having more stiffness of the structure and reduces the displacement (damage) when compared with all other models.

RC Frame:

Reinforced concrete is one of the most widely used modern building materials. Concrete is "artificial stone" obtained by mixing cement, sand, and aggregates with water. Fresh concrete can be molded into almost any shape, which is an inherent advantage over other materials. Concrete became very popular after the invention of Portland cement in 19th century; however, its limited tension resistance prevented its wide use in building construction. To overcome this weakness, steel bars are embedded in concrete to form a composite material called reinforcedconcrete. Developments in the modern reinforced concrete design and construction practice were pioneered by European engineers in the late 19th century. At the present time, reinforced concrete is extensively used in a wide variety of engineering applications (e.g., buildings, bridges, dams).

Bare frames:

These are commonly made out of columns and beams. Their capacity to resist parallel loads is totally because of the rigidities of the bar section associations and consequently the moment-resisting capacities of the individual members. they're ordinarily referred to as rigid frames, as a consequence of the closures of the different individuals confining into a joint are inflexibly associated so as to verify that they all experience a comparable pivot under the activity of loads. frames are utilized as the sole parallel load opposing framework in structures with up to 15 to 20 stories.

Steel Bracings:

One of the simple, cheap and efficient methods for strengthening of reinforced concrete frames against lateral induced earthquake load is using steel bracings.The combination of reinforcedconcrete frame with steel bracing is not a common practice due to unknown behavior and performance that needs to be investigated. Research on the use of this method of retrofitting has begun since 80s in which bracings have been used indirectly together with a steel frame confined by a concrete frame.In addition to its great expenses and its possible unsuccessful economic justification, using this system may cause a dynamic interaction between steel bracing and concrete frames. Although in some cases, using additional steel frame to strengthen existing concrete frame, seems to be necessary, but in the stage of system redesigning, the additional loads transferred by cross bracings can be added to the design loads. This may eliminate the need for an expensive and sometimes bothering steel frame.Therefore, establishing a system of steel bracing in a way that it has less economic and technical problems seems to be a proper choice. In order to achieve this goal, the use of steel cross bracings which are directly connected to concrete frame is studied.

METHOD OF ANALYSIS

The present study undertaken with linear methods i.e.

1. Linear static analysis (Equivalent static lateral force method).
2. Linear dynamic analysis (Response spectrum analysis).

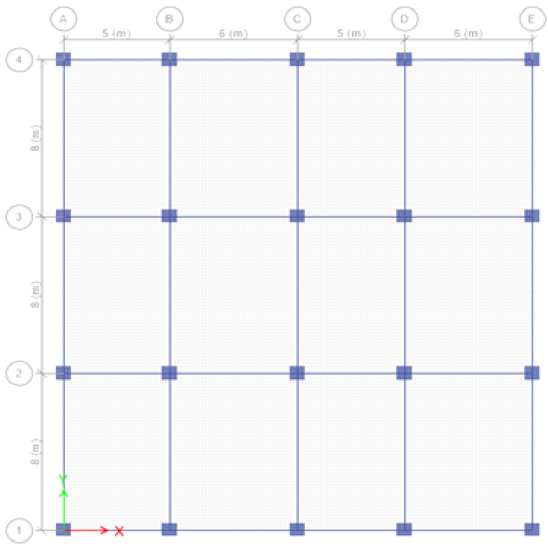
Different types of frames considered for this analysis are as follows:

Model-1: Bare frame
Model-2: RC frame with Forward Bracing.
Model-3: RC frame with Backward Bracing.
Model-4: RC frame with X Bracing.
Model-5: RC frame with V Bracing.
Model-6: RC frame with Inverted V Bracing.

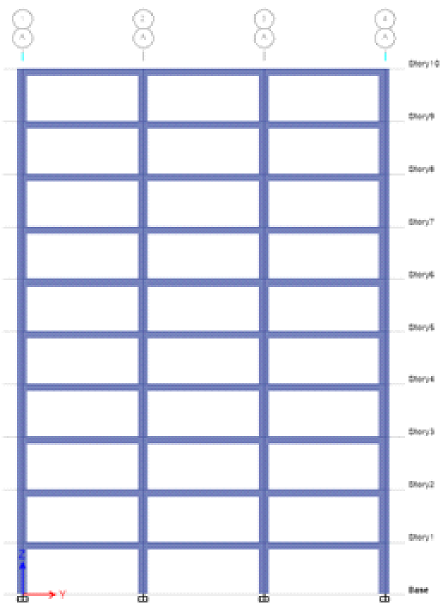
STRUCTURAL MODELING

For the analysis work, 6 models of RC framed structure with and without steel bracings of (G+9) storey are made to known the realistic behavior of building during earthquake. The length of the building is 35 and width is 22X24m. The columns are assumed to be fixed at the ground level. Linear static and dynamic analysis is used.

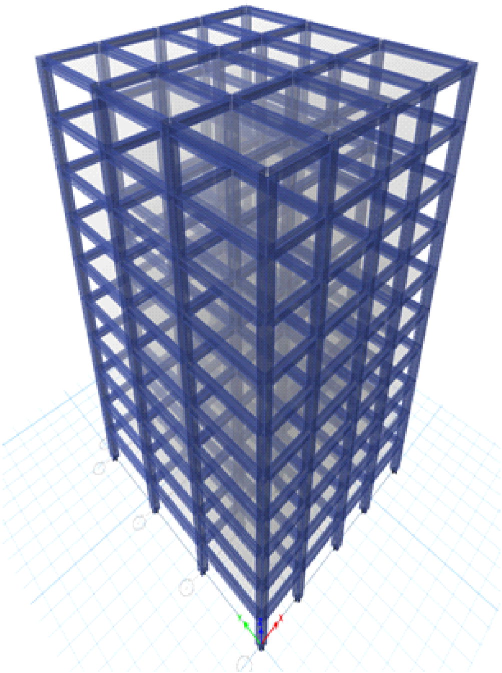
Plan:



Elevation:



3D Model:



Building Description:

• Building Data

Number of bays = 4 bay by 3 bay

i.e. Number of bays in X-direction = 4 bay

Number of bays in Y-direction = 3 bay

• Story Height

Number of Storeys = 10 Storey (G +9)

Bottom storey = 3.5 m

Other storeys = 3.5 m

• Structural Elements Dimension

Beam size = 0.50 m x 0.50 m

Column size = 0.70 m x 0.70 m

Slab thickness = 0.160 m

• Material properties

Concrete (IS456:2000)

Grade of Concrete: M30

M30 grade for column, beams and slabs

Compressive strength of concrete, fck= 30000kN/m2

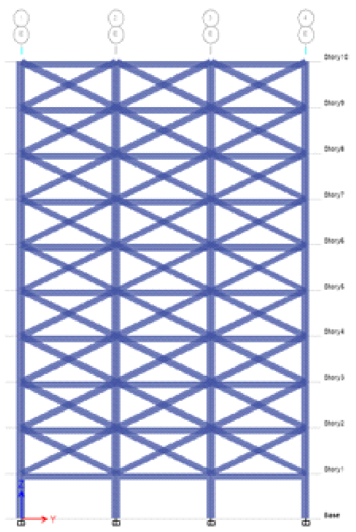
Density of Concrete (weight per unit volume) = 25 kN/m3

Modulus of Elasticity of concrete, Ef = $(5000\sqrt{fck})$ = 27.38 X106kN/m2

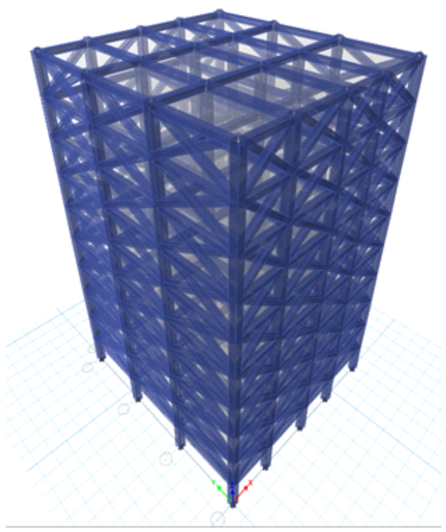
Poisson's ratio of concrete = 0.2

Steel (IS456:2000)
Grade of Steel: Fe250 (for steel bracing)

Elevation of X Bracing:



3D Model of RC Frame with X Bracing:



RESULTS AND DISCUSSION

The research work is carried out on earthquake analysis to compare the dynamic response of RCC multi-storeyed building with and without Steel Bracing. Totally six models are considered for the linear dynamic analysis which includes response spectrum analysis, modal analysis, Equivalent static force method. Mode period, modes shapes are obtained from modal analysis. Base shear, storey displacement and acceleration results are obtained from Equivalent static force method and acceleration from response spectrum analysis for zone-5, medium soil (i.e., type-2) as per IS 1893-2002(part-1) are obtained.

5.1 Mode Period:

Table 5.1: Comparison of Mode Period of Different Models:

Models	Modes		
	Mode 1	Mode 2	Mode 3
Bare Frame	1.848	1.573	1.437
X-Bracing	0.572	0.544	0.421
F-Bracing	0.865	0.76	0.553
B-Bracing	0.865	0.761	0.553
V-Bracing	0.683	0.673	0.463
/\-Bracing	0.672	0.658	0.463

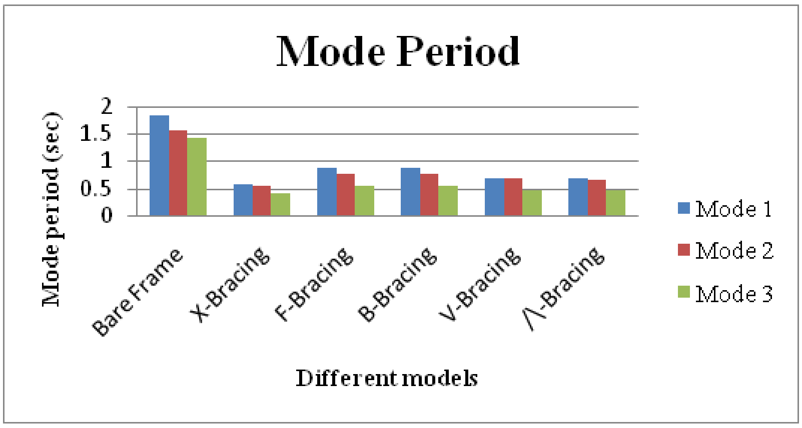


Figure 5.1: Comparison of Mode Period of different models.

From above Fig 5.1 It shows that the modal analysis is carried out and the mode period of the structure for that analysis are found to be 1.848 sec in X-X direction and the mode period as 1.573 sec in Y-Y direction for bare frame without Steel Bracings.

The mode period of the structure is found to be 0.572 sec in X-X direction and 0.544 sec in Y-Y direction for the structure with X Bracings.

The mode period of the structure is found to be 0.865 sec in X-X direction and 0.760 sec in Y-Y direction for the structure with Forward Bracing.

The mode period of the structure is found to be 0.865 sec in X-X direction and 0.761 sec in Y-Y direction for the structure with Backward Bracing.

The mode period of the structure is found to be 0.683 sec in X-X direction and 0.673 sec in Y-Y direction for the structure with V Bracing.

The mode period of the structure is found to be 0.672 sec in X-X direction and 0.658 sec in Y-Y direction for the structure with Inverted V Bracing.

This shows that X-bracing having lesser mode period and Bare frame having large mode period when compared to other model.

Base shear:

Table 5.2:Comparison of Base shear on Bare Frame and Different types of Bracings X-X and Y-Y direction.

Models	Base Shear kN			
	ESLM		RS	
	EQX	EQY	RSX	RSY
Bare Frame	3771.911	3771.911	4361.499	3771.509
X-Bracing	7347.38	7684.993	7868.998	7681.998
F-Bracing	6148.65	6431.182	7415.928	6431.056
B-Bracing	6148.65	6431.182	7407.878	6431.094
V-Bracing	6147.221	6457.928	6506.676	6457.914
/\-Bracing	6174.221	6457.928	6544.718	6457.919

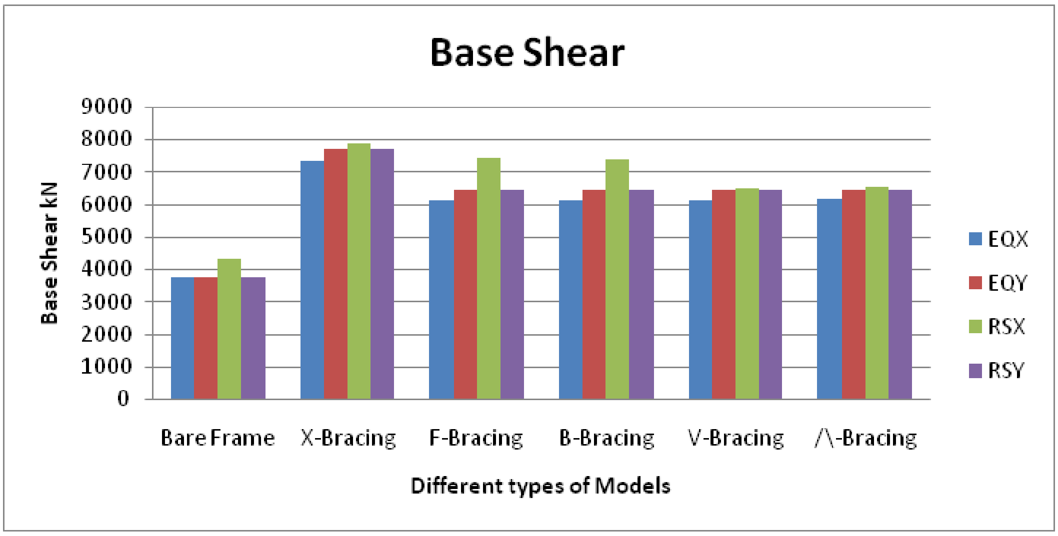


Figure 5.20:Comparison of Base shear on Bare Frame and Different types of Bracings X-X and Y-Y direction.

From the above Fig 5.20 it was observed that decrease in base shear in model-1(bare frame) was nearly 49%, 39%, 39%, 39%, 40% when compared to X bracing, Forward bracing, Backward bracing, V bracing, /\ bracing respectively along X-direction. Similarly 50%, 41%, 41%, 42%, 42% along Y-direction in Equivalent static lateral force method and for Response spectrum method it is observed that decrease in base shear in model-1(bare frame) was nearly 45%, 41%, 41%, 33%, 33% when compared to X bracing, Forward bracing, Backward bracing, V bracing, /\ bracing respectively along X-direction. Similarly 50%, 41%, 41%, 41%, 41% along Y-direction for zone-V, medium soil.

Storey Displacement:
Bare Frame:

Table 5.3: Displacement of bare frame

No. of Stories	ESLM		RSM	
	X(mm)	Y(mm)	X(mm)	Y(mm)
Story 10	78.6	108.8	73.8	85.9
Story 9	75	103.6	70.9	82.3
Story 8	69.6	96.1	66.6	76.4
Story 7	62.6	85.9	60.9	69.7
Story 6	54.1	74.4	53.8	62
Story 5	44.7	60.8	45.5	51.7
Story 4	34.5	46.6	36.2	41.2
Story 3	24	32.1	25.9	29.1
Story 2	13.7	17.9	15.2	16.7
Story 1	4.7	5.9	5.3	5.6

Comparison of Displacement for Different Stories of Bare Frame

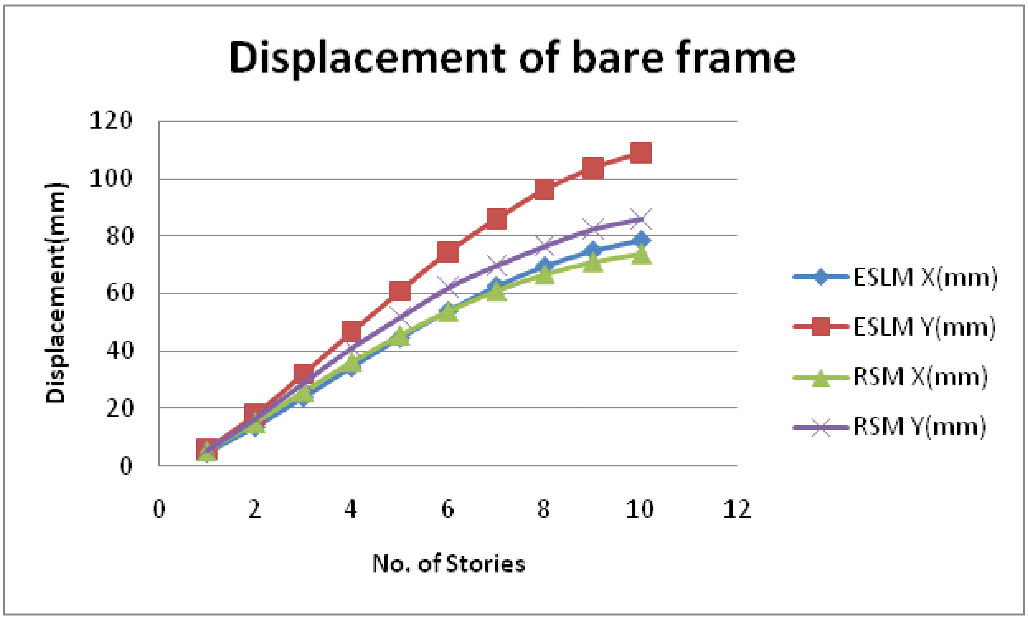


Figure 5.20: Graph of Displacement for Bare Frame

From above fig(5.20) It is observed that there is an increase in displacement nearly 94% in storey 10 compared to ground floor along X-direction and 95% along Y- direction in ESLM , similarly 92% to 93% along X and Y direction in RS method. This shows that stiffness participates more in ground floor when compared to top floors both in ESLM and RS.

RC Frame with X Bracing:

Table 5.4: Displacement of X Bracing

No.of stories	ESLM		RSM	
	X(mm)	Y(mm)	X(mm)	Y(mm)
Storey 10	13.7	15.2	12.2	12.7
Storey 9	12.9	14.5	11.6	12.2
Storey 8	11.9	13.5	10.9	11.6
Storey 7	10.8	12.4	10.1	10.8
Storey 6	9.7	11.2	9.2	10
Storey 5	8.5	9.9	8.3	9.1
Storey 4	7.4	8.6	7.4	8.1
Storey 3	6.3	7.3	6.4	7
Storey 2	5.3	6.1	5.6	6
Storey 10	4.2	4.7	4.5	4.6

Comparison of Displacement for Different Stories of X bracings

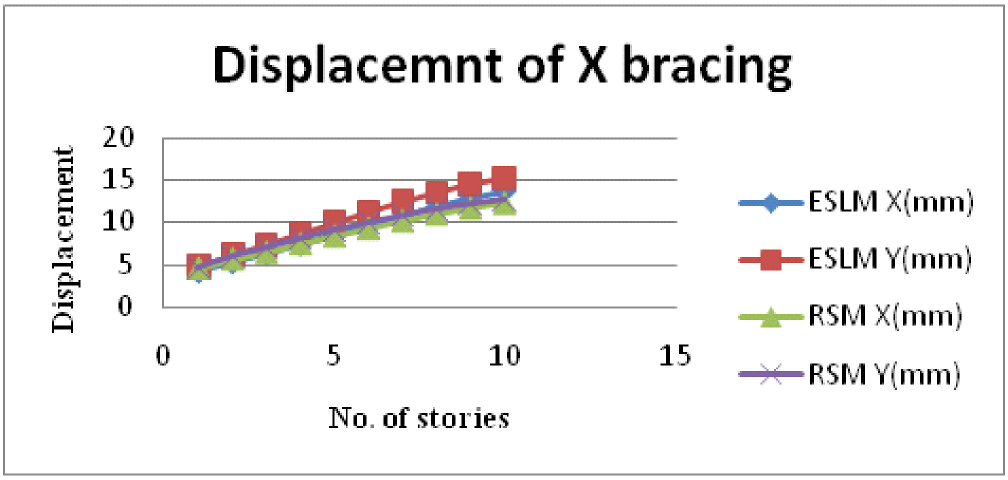


Figure 5.21: Graph of Displacement of Different Stories of X Bracings.

From above fig(5.21) It is observed that there is an increase in displacement nearly 69% in storey 10 compared to ground floor along X-direction and 70% along Y- direction in ESLM , similarly 63% to 64% along X and Y direction in RS method. This shows that stiffness participates more in ground floor when compared to top floors both in ESLM and RS.

Acceleration:

Acceleration in X-X Direction:

Acceleration of Different models in X-X Direction:

No.of Stories	RSM					
	X-X(mm/sec²)					
	Model 1	Model 2	Model 3	Model 4	Model 5	Model6
Story10	1917.57	1696.32	2230.72	2229.43	1840.04	1821.7
Story9	1454.59	1584.82	2032.76	2031.94	1697.97	1690.12
Story8	1294.51	1465.52	1847.85	1847.14	1550.73	1551.31
Story7	1257.82	1347.45	1701.75	1701.06	1421.46	1426.46
Story6	1276.29	1235.97	1577.8	1577.21	1307.31	1312.52
Story5	1389.46	1133.56	1485.48	1485.21	1208.77	1210.39
Story4	1380.17	1039.53	1389.74	1389.86	1113.55	1109.81
Story3	1338.65	949.19	1268.24	1268.64	1008.57	999.97
Story2	1136.77	863.61	1113.96	1114.52	887.96	876.29
Story1	523.32	729.82	734.71	735.26	628.42	618.36

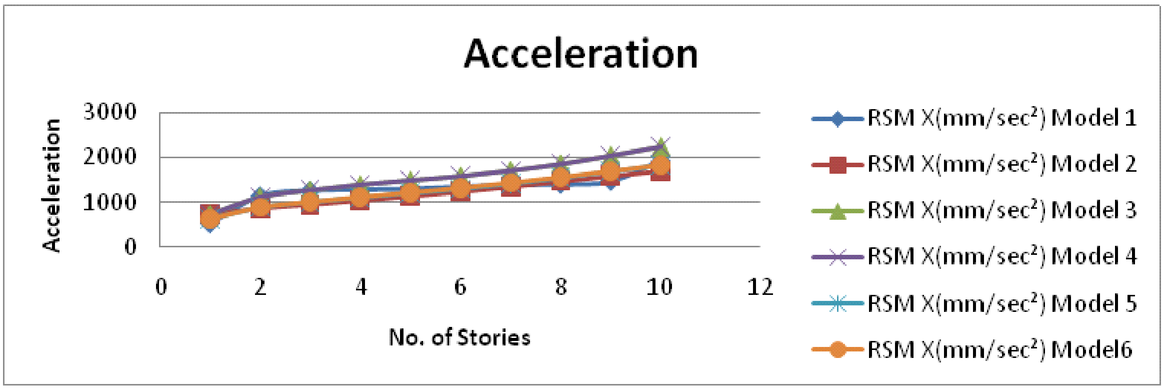


Figure 5.26: Comparison of Acceleration for Different Models in X-X Direction.

From above fig(5.26) It is observed that there is an increase in displacement nearly 73%, in storey 10 compared to ground floor along X-X direction in model 1(bare frame),57% in model 2 (RC frame with X bracings), 67% in model 3(RC frame with Forward bracings), 67% in model 4 (RC frame with Backward bracings),65% in model 5(RC frame with V bracings),66% in model 6(RC frame with /\ bracings).This shows that stiffness is less in bare frame when compared with all other models.

Acceleration in Y-Y Direction:
Acceleration of Different models in Y-Y Direction:

No.of Stories	RSM					
	X-X(mm/sec²)					
	Model 1	Model 2	Model 3	Model 4	Model 5	Model6
Story10	1917.57	1696.32	2230.72	2229.43	1840.04	1821.7
Story9	1454.59	1584.82	2032.76	2031.94	1697.97	1690.12
Story8	1294.51	1465.52	1847.85	1847.14	1550.73	1551.31
Story7	1257.82	1347.45	1701.75	1701.06	1421.46	1426.46
Story6	1276.29	1235.97	1577.8	1577.21	1307.31	1312.52
Story5	1389.46	1133.56	1485.48	1485.21	1208.77	1210.39
Story4	1380.17	1039.53	1389.74	1389.86	1113.55	1109.81
Story3	1338.65	949.19	1268.24	1268.64	1008.57	999.97
Story2	1136.77	863.61	1113.96	1114.52	887.96	876.29
Story1	523.32	729.82	734.71	735.26	628.42	618.36

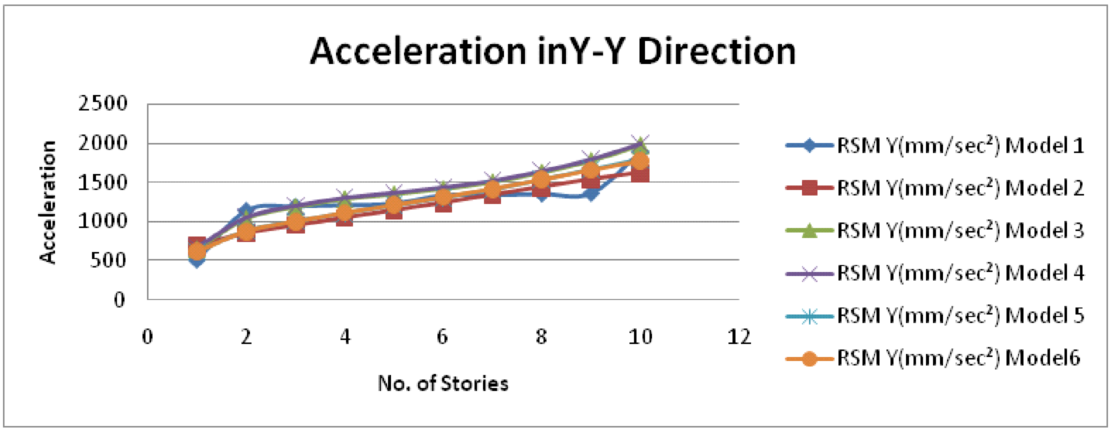


Figure 5.27:Comparison of Acceleration for Different Models in Y-Y Direction

From above fig(5.27) It is observed that there is an increase in displacement nearly 72%, in storey 10 compared to ground floor along Y-Y direction in model 1(bare frame),57% in model 2 (RC frame with X bracings), 66% in model 3(RC frame with Forward bracings), 66% in model 4 (RC frame with Backward bracings),65% in model 5(RC frame with V bracings), 65% in model 6(RC frame with /\ bracings). This shows that stiffness is less in bare frame when compared with all other models.

CONCLUSION:

1.Mode period decreases when effect of steel bracings are considered in Reinforcement Concrete frames when compared to bare frame.The mode period of building depends on distribution of mass and stiffness along the building.

2.Provision of steel bracings results in reducing displacement in X bracing, Forward bracing, Backward bracing, V bracing, /\ bracing when compared to Bare frame

X bracing models gives less displacement when compared with all other bracing models (Forward, Backward, V and /\ Bracing).

3.The maximum Base shear is induced in Model 2(X bracing) when compared with all other models (Bare frame, Backward, Forward, V and /\ bracings). This shows that mass participation factor is more in X bracing compared with all other models.

4.Acceleration values are more in Forward and backward bracings when compared with X bracing, V bracing, /\ Bracing, bare frame. This shows that stiffness participates more when compared with mass precipitation.
5.Based on the above conclusion it shows that X bracing shows better performance (followed by /\ bracing) and its reduce displacement both in X-Y direction compared with all other models.