PROPORTIONAL LOCATION OF BRACES TO REDUCE TORSION EFFECT AND WEIGHT OF STRUCTURES

Mohammad Ghasem VETR
Professor Assistant, International Institute of Earthquake Engineering and Seismology, Tehran, Iran
vetr@iiees.ac.ir

Bahram KORDBAGH
Master of Science Student, International Institute of Earthquake Engineering and Seismology, Tehran, Iran
b.kordbagh@iiees.ac.ir:

Kiyanoush GHAZVINI
Master of Science Student, International Institute of Earthquake Engineering and Seismology, Tehran, Iran
k.ghazvini@iiees.ac.ir:

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ABSTRACT

According to the fundamental role of lateral resistance elements in tall structures, to cope with the earthquake forces and sort the elements constrains, present research as for the asymmetric posture braces is performed in the steel structures. In this study, after reviewing the effect of eccentricity of center of stiffness towards the center of mass and torsion caused by it in a building that has been implemented in the past. Also by changing the arrangement of braces, the amount of steel consumption is an important economic indicator in each of the Items is analysed. Then the displacement parameter is the criterion used for the detection of structural damage was evaluated. Finally, the base shear changes, is examined according to eccentricity.

Due to the size and geometry of the ground reality is such that Makes have an irregular structure in plan that placed under torsion. In this study, we examine a building that has been implemented in the past, and we show that near the center of mass and stiffness, and reduce the eccentricity of the appropriate layout braces, how much base shear and structure weight (steel consumption) is reduced. And also we start type of analysis to the sensitivity of the irregular structure under torsion.

In this study, two types of analysis included quasi-static and dynamic spectral analysis is studied.

INTRODUCTION

One of the important issues today in the analysis and evaluation of the structural behaviour plays an important role, is one of the biggest causes of failure of buildings, in past earthquakes, the irregularities in the structures. Looking at the statistics for 1985 earthquake devastation in Mexico the importance of this issue can be stated. 42% of the buildings in the earthquake due to torsional effects caused by asymmetric structures were destroyed or damaged generally. That 15% of the failures were due to the asymmetry of the difficulty. Most irregular due to the architectural and aesthetic issues and technical issues sometimes applied to structures

It is well-known that the lateral drift of a frame, accordingly the total structural weight, can be drastically reduced by placing braces, provided that the stiffness and strength of the beams, columns and braces are appropriately distributed. Takewaki et al. (1990) optimized a frame with K-braces at the specified locations. Kameshki and Saka (2001) optimized frames with different kinds of braces, and compared the optimization results. Although the cross-sectional properties of beams, columns and braces are optimized for each optimization problem in their study, the types and locations of braces are not considered as design variables. Hence, the optimized braced frame may be overly stiffened, because of the limitation on the types and locations of braces.

Irregularity structure can be divided into two general form irregularities in height and irregularities in plan. By examining the earthquake regulations, asymmetric structure in plan can be due to the unbalanced distribution of hardness or resistance to the balanced distribution of crime and or due to the unbalanced distribution of mass than the hardness distribution. First, the system is called the eccentricity of difficulty (SES) The second state of the system is called the eccentricity of crime (MES). Iran Standard no. 2800 also discussed the irregular buildings. Regulation is supposed irregularities in plan due to four factors: plan asymmetric with respect to the principal axes, the distance between the center of gravity and the difficulty of building more than 20% of the building dimension, sudden changes in the stiffness of the diaphragm and discontinuity in the lateral resistant components page.

CHECKING THE RELATIONSHIPS OF TORSION IN THE REGULATIONS

To consider the effects of structural irregularities in plan, special rules apply in different building regulations, have been established. More general form in this code is considered so that if the forces applied to the lateral, torsional moment of the creation of each class is calculated. In other words, the twists in each story by multiplying the story shear within the eccentricity of the design is called, is obtained.

$$T=e_D.V \quad (1)$$

(V) In the above equation is story shear and e_D is eccentricity of the design that the amount of the regulations include dynamic eccentricity and eccentricity is happening.

Asymmetry with eccentricity (e_s) the distance between the center of mass (CM) and the hardness (CR) is shown. Edge of the plan that difficulty center is closer to it call hard side and against edge is called the soft side. (Riddell et al, 1999)

Regulations for balancing and near the center of mass and the center of the stiffness, expressed design eccentric Relationship as the following expression.

$$e_{D1} = \alpha e_s + \beta b \quad (2)$$

$$e_{D2} = \delta es - \beta b \quad (3)$$

Design force of resistance elements is the greatest value of the consideration of the above equations. First relation is called the eccentricity of the initial design and second relation is called the eccentricity of the second design. The first term shows the eccentricity of the dynamic relationship that is due to the unbalanced difficulty distribution. And the second term is due to other factors such as accidental eccentricity of the torsional motion, errors of calculation and distribution of live load. Second term fully is function of the plan dimensions. In the above equation (e_s) eccentricity of the mass and stiffness of the system and (b) is the plan dimension in the perpendicular direction to the earthquake. (δ, β, α) are Fixed parameters that have different in different regulations. The values of these parameters states in several regulations in Table 1. (Chopra et al, 1991)

Table1. δ, β, α of various regulations

Australia	Iran	New Zealand	Europe	Canada	Mexico	America	country
	IBC-99	NZC-84	EC8	NBC85	MFDC-77	UBC-88 ATC-3	Code
A1	1	1	$1+e_1/e_s$	1.5	1.5	1	α
0.05	0.1	0.1	0.1	0.1	0.1	0.05	β
0.5	1	1	1	0.5	1	1	δ

HISTORY RESEARCH

In 1991 Goel & Chopra studied valid the irregular in plan in 6 seismic world regulations. And design force changes are given for elements of both the structure in Fig. 1 according to this chart, the design elements of the software changes are related the values of the parameter (α) and (e_s). However, due to the different values of α in building regulations the greatest increase in regulations designed to force Mexico and Canada with α = 1.5, the lowest increase in American and New Zealand regulations with α = 1 occurs. Also according to this chart reduction in the design of the hardware elements have relationship with the as values and coefficient δ. Decrease due to the regulations of the US, Mexico and New Zealand, with δ = 1 is greater than the decrease of δ = 0.5 is Canada's regulations. It should be noted that reduce the design force in the hard side of structure in some regulations as UBC88, Peru and India not allowed. (Chopra et al, 1991)

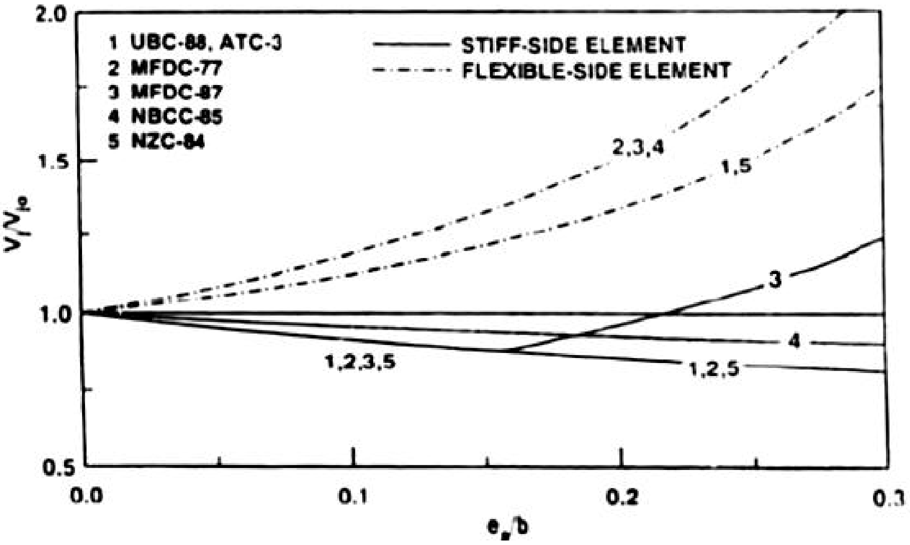


Figure1.elements design force of the asymmetrical system, is Normalized by the amount of symmetric system

Another study by Lee took place in 1988, predict the effect of torsion with static analysis, modal analysis and time history analysis has been done. The results show that the predicted effects of torsional mode used in the analysis is reasonably close to the time history analysis results in all cases. As predicted by static analysis, torsional effect is exaggerated to show. Exaggerate the expected effect of twisting by static analysis the fact that the effect of the mass moment of inertia of each story has not been considered in static analysis. Studies Mazzolani & Calderoni show that the base shear produced by modal analysis usually about 10% to 30% lower than the base shear is obtained by static analysis. It means static result, even if is less accurate but in some cases safer than modal analysis. Common solution proposed in most regulations earthquake, the use of static analysis for regular structures and modal analysis for irregular structures, is Conservative just for structures that show the seismic behavior. That is why Canada has established regulations that increasing the modal analyze result to amount of base shear equal to 90% static analysis, while regulations SEAOC increases this value to 100% in symmetrical buildings. Standard no. 2800 in the clause relate to correction of reflections, Increase this amounts to 80% in regular structures and Increase this amounts to 100% in irregular structures.

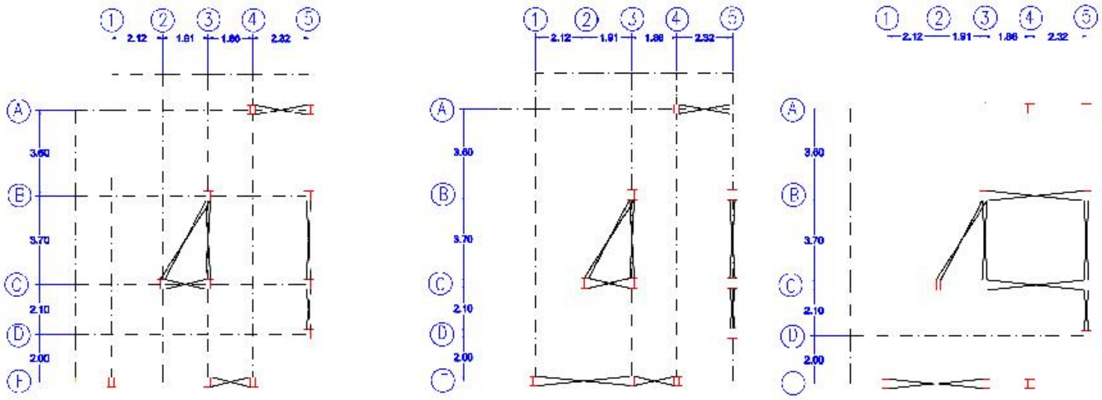
THE AIM OF THE RESEARCH

Regard to the size and geometry of the ground reality is such that we can construct irregular in plan, placed under torsion, In this study, we examined a building that has been implemented in plan, the past, we show that with the close up center of gravity and center of hardness and reduce of eccentricity, by using a suitable location for braces. How much weight of structure and base shear (steel consumption) decreases. As well we analysis the sensitivity of irregular structure under torsion. In this study, two types of quasi-static and dynamic spectral analysis has been studied. Economic parameters, is the main objective of the present study.in addition Measure displacement and base shear changes have been checked.

METHODOLOGY AND SAMPLE INTRODUCTION

Economic parameter of the project was the main objective of the present study and in addition to its criterion displacement and base shear variation are reviewed. Three structure of the sample were studied to determine the effect of asymmetric location of braces in steel structures. The structure located on soil type 2 and type of used steel is St-37. The structure was six-story that designed per Iranian building and seismic code for very high seismicity zone areas. Height of first story is 5.5 m and height of the other stories is 2.7 m.

The present study has tried to obtain the most economical state of the structure to close down the center of mass and stiffness with shift braces. Different arrangement of braces is shown in Fig. 2.



Model 1 Model 2 (the model has been implemented) Model 3

Figure 2. arrangement of braces

Model 2 is shown in Fig. 2 the model has been implemented in reality. Here we try to change the location of braces in order to have a model with less weight and a model with more weight than when implemented. Table 2 shows the characteristics of the materials used and the characteristics of the soil are given in detail.

Table2.materials used and the soil specifications

Steel materials:

7850 kg/m3	Unit weight (W)
2.039*106 kg/cm2	Elasticity modulus (E_s)
0.3	Poisson's ratio(u)
2400 kg/cm2	Yield stress(f_y)
3700 kg/cm2	Breaking stress (f_u)

Concrete materials:

2500 kg/m3	Unit weight (W)
2.1*105 kg/cm2	Elasticity modulus (E_c)
0.2	Poisson's ratio(u)
210 kg/cm2	compressive strength(f'_c)
3000 kg/cm2	Yield stress of longitudinal bar(f_y)
2300 kg/cm2	Yield stress of stirrup (f_{ys})

Specification's soil:

k_s	q_a	Soil
1.8 kg/cm3	2 kg/cm2	Type 2

Overload used in the modelling, applied matching shown in Table 3.

Table3.Loads

200 kg/m^2	Dead load
150 kg/m^2	Live load
350 kg/m^2	Live load
150 kg/m^2	Snow Load

PARAMETERS AND SEISMIC ANALYSIS SOFTWARE

To 3D linear analyse also for design of steel members in selected models, used ETABS. And the lateral earthquake forces applied with two methods: dynamic spectral analysis method and 3D pseudo static analysis method.

SPECTRAL DYNAMIC ANALYSIS

In this method, structural dynamic analysis is performed assuming linear behaviour, the modal analysis is determined by the structural vibration modes then, according to the frequency of each mode by refer to the design spectrum the maximum response achieved in any mode and in each step, the combination of statistics, reflected modes are combined and finally, after this analysis, should be equivalent to the amount base shear of the spectral dynamic analysis with base shear of pseudo static analysis, you should also check the adequacy of mods.

It should be noted in each floor earthquake force proportional to its weight and its distance from the ground but in spectral dynamic analysis earthquake force of each floor by combining base shear modes are obtained.

INVESTIGATION OF ECONOMIC PARAMETERS

In design and construction of steel structures, one of the main economic indicators for assessing the acceptability of the project is the amount of steel is used. Fig. 3 shows the total amount of steel used in samples.

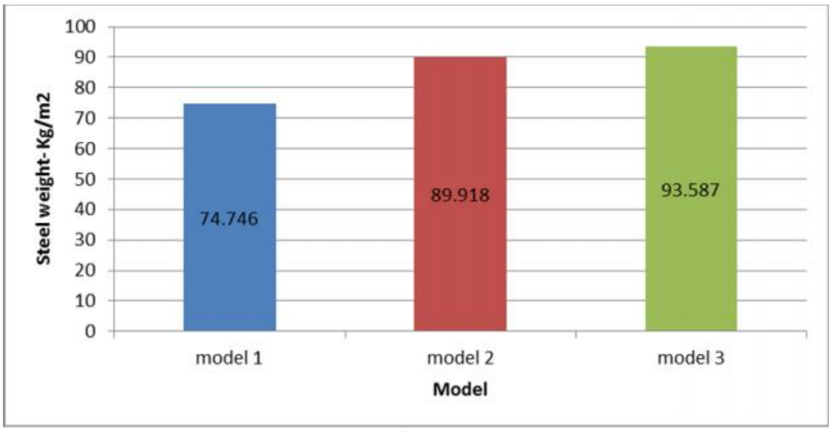


Figure 3. Figure the amount of steel used in the models.

According to these figures the least amount of steel used is observed in model 1.

EVALUATION OF DISPLACEMENT

One important criterion structural response to lateral force is the parameters associated with displacement. One of these parameters is the maximum displacement in each floor that values for different models in Fig. 4 are presented.

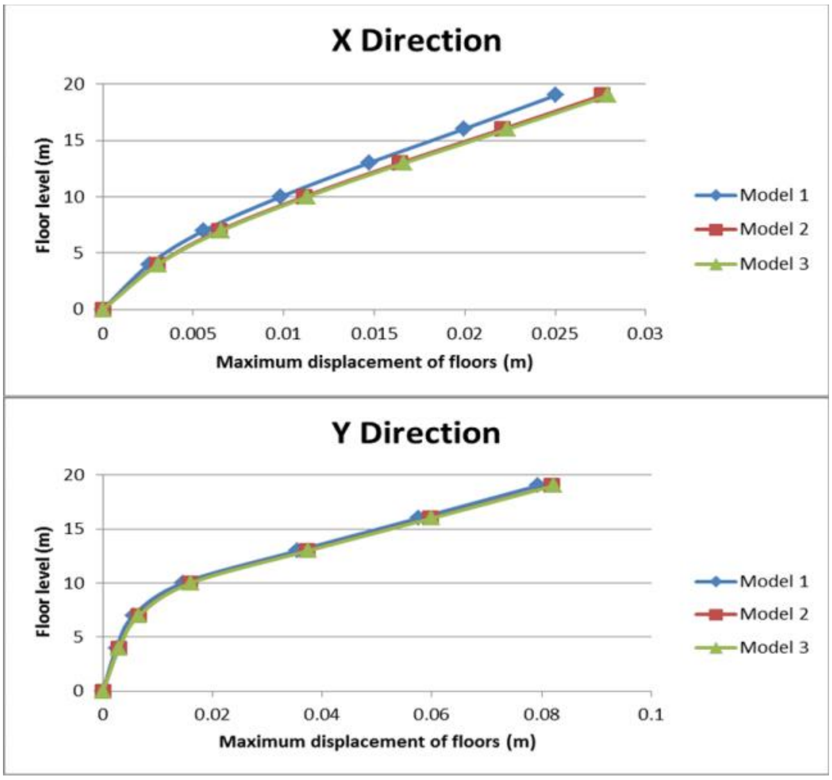


Figure 4. The maximum displacement of floors in different models

BASE SHEAR VARIATIONS

To change the alignment of braces and therefore the values of eccentricity is expected to change the base shear values. As Table 4 shows the base shear in Model 1 is the lowest.

Table 4. Base shear variations by applying the eccentricity of the models

Model	XCOM	YCOM	XCR	YCR	e_{sx}(m)	e_{sy}(m)	e_s(m)	Earthquake applied to X-direction
								Vx (kgf)
1	4.925	3.609	6.063	2.914	1.138	0.695	1.333443	100117.42
2	4.91	3.635	6.235	4.111	1.325	0.476	1.407907	103841.87
3	4.89	3.594	6.247	1.033	1.357	2.561	2.898305	104678.72

BASE SHEAR SENSITIVITY ANALYSIS OF IRREGULAR STRUCTURES

In this study, spectral dynamic and pseudo static analysis have been performed and the base shear sensitivity analysis is evaluated.

Base shear values for each of these analyses are shown in Table 5.

Table 5. Base shear values for spectral dynamic and pseudo static analysis

Model	Pseudo static analysis		Spectral dynamic analysis	
	Earthquake applied to X-direction	Earthquake applied to Y-direction	Earthquake applied to X-direction	Earthquake applied to Y-direction
	V	V	V	V
1	100117.42	100117.42	119597.5056	120391.5058
2	103841.87	103841.87	122518.5181	123431.2636
3	104678.72	104678.72	123174.1815	124113.8294

As shown in Fig. 5 for irregular structures, base shear values of pseudo static analysis less than the spectral dynamic analysis.

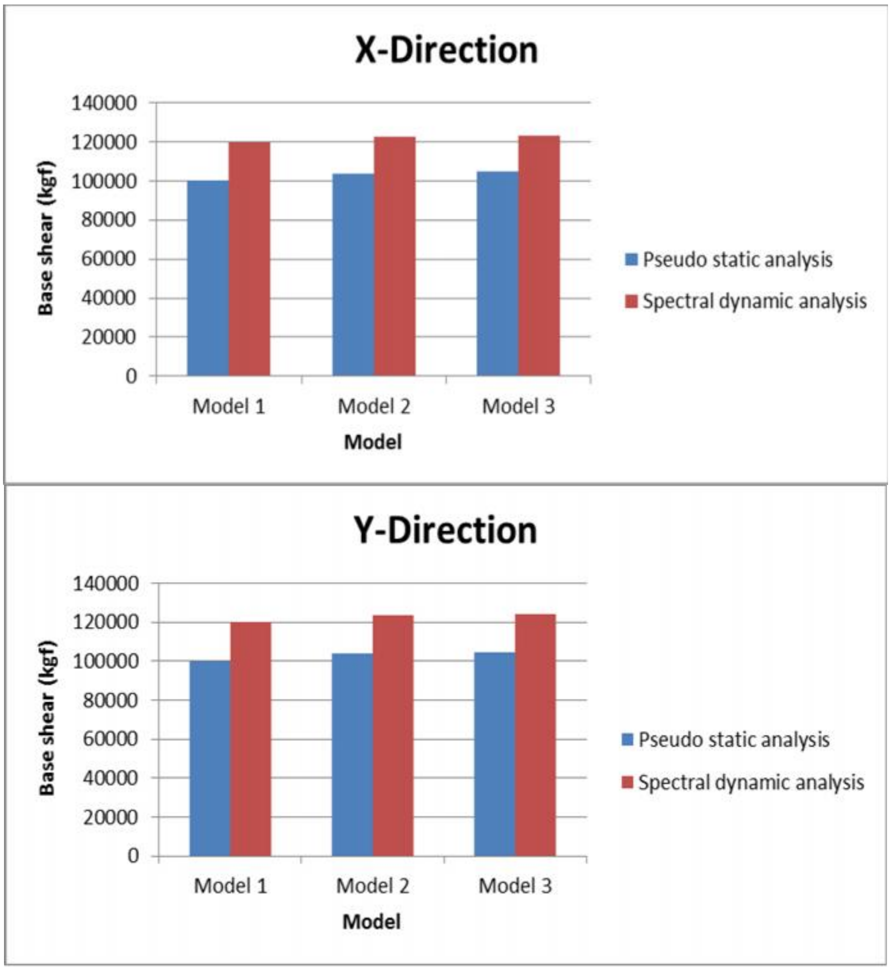


Figure 5. Base shear compare to the pseudo static and spectral dynamic analysis

COMPARE NATURAL PERIOD OF THE FIRST THREE MODES IN DIFFERENT MODELS

For a better understanding of the behaviour of the model, the natural period of the first three modes are shown in Fig. 6.

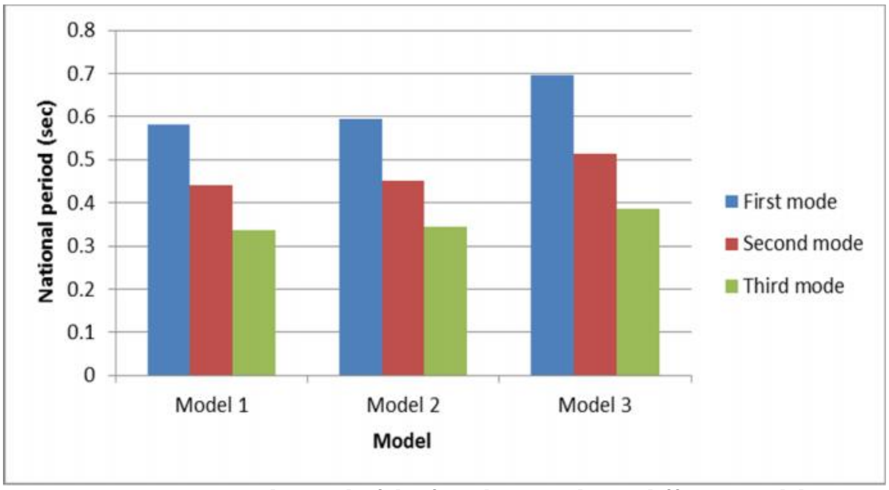


Figure 6. Compare natural period of the first three modes in different models

ECONOMIC COMPARISION OF THE MOMENT RESISTING FRAME WITH BRACED FRAME

Economic comparison of the moment resisting frame with braced frame is discussed in this section. This comparison is shown in Fig. 7.

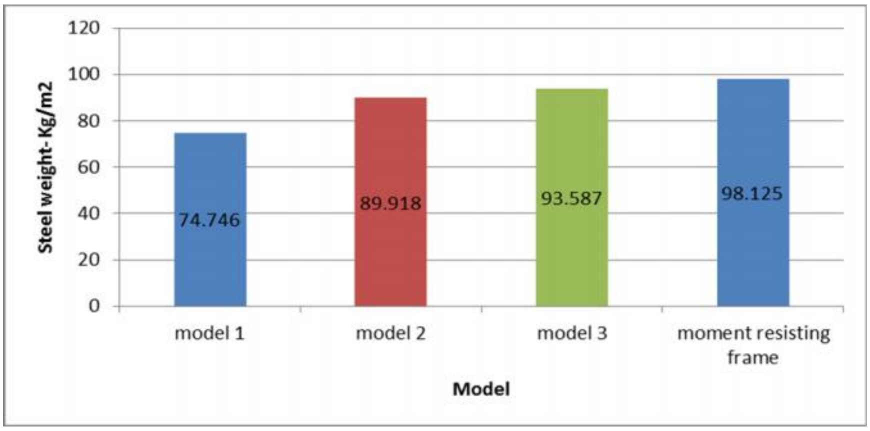


Figure 7. Economic comparison of the moment resisting frame with braced frame

CONCLUSIONS

Proper bracing arrangement with minimum eccentricity can reduce the total used steel. This reduces in the massive structure is very impressive.

With increasing eccentricity, displacement of each story that measure to approximate the structural damage is increased.

With increasing eccentricity, base shear increases. (Torsion in a way that reduces the precipitation should be denied and critical state, the maximum base shear must be considered.)

In irregular structures, pseudo static analysis result base shear less than spectral dynamic analysis and hence in irregular structures using static analysis is not allowed (As also mentioned in the codes).

Moment resisting frame in irregular structures is far more economical than braced frame is a suitable arrangement.

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