International Journal of Engineering and Technology, 2 (3) (2013) 209-215
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Dynamic analysis of composite columns in Inelastic state

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Abstract

The main objective of this study is analyzing Seismic behavior of composite columns in frame in inelastic state under dynamic load. Therefore, three type of composite column have been used in this paper. IPB Steel section embedded in concrete (type 1), Concrete-filled thin-walled steel sections (type 2), half concreted IPB sections (type 3) which are designed for 3 and 8 floor frame tenement in plastic way. Three earthquake accelerogram have been used for analyzing model seismic behavior and model analysis has been done in non-linear dynamic analysis with Seismostruct application. The results demonstrated that frame designed by composite columns type 1 and 3 in the flexural behavior, have similar construction behavior in the way that plasticity, softness and good function to dispose lateral forces are the same. Although Type 2 composite model have large sections, have poor performance in tolerating flexural moment. This event refers to poor role of concrete in tension. On the other hand, the amount of concrete is important in Withstand compressive forces and in constructions with high compressive forces, type 1 and 2 have better performance.

Keywords: *Use dynamic analysis, composite columns, inelastic behavior*

1 Introduction

In this study composite column include Different combinations of two materials, concrete and steel which are common in mixed column, synthetic, compound, CFT ، SRC ، RCS، TWC names. Composite column first used in 1900 that started with building bridge and constructions with combination Members which nowadays various form of this have been seen in different places and increasing its development refers to improvement of column behavior in steel and concrete which have better and More economical performance. Three general types of composite columns are summarized below:

Type1- Steel sections embedded in concrete

Type2- Concrete-filled thin-walled steel sections

Type3- half concreted steel sections

Type 1- Steel sections embedded in concrete

For the first time these column had been designed for protection of buildings against fire. These types of section are commonly used with SRC or RCS names (Reinforced Concrete & Steel).

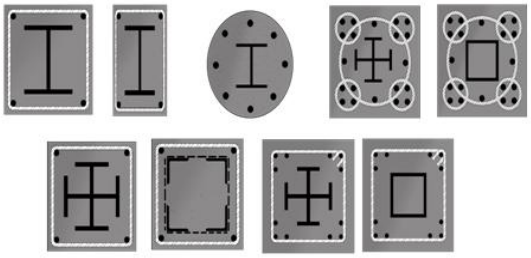

Figure.1: Type 1- Steel sections embedded in concrete

Type2- Concrete-filled thin-walled steel sections

This type of composite column has been designed to prevent local buckling of thin-walled steel columns and known as CFT (Concrete - Filled Steel Tubes) and TWC (thin walled composite column). The concrete used in these columns could by rebar reinforce or refers to type of use have been apply simple and unbar. The unique characteristics of this type of composite are No need for steel making, save formatting, high-speed of constructing, steel limiting effect on concrete, protection of concrete surfaces from impact and abrasion.

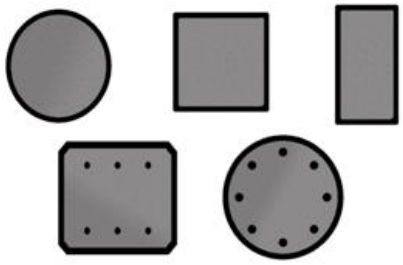

Figure.2: Type2- Concrete-filled thin-walled steel sections

Type3- half concreted steel sections

This type of composite column has been designed with various type of steel in concrete combination. The characteristics of this composite column are high plasticity, increase the strength and stiffness of the column.

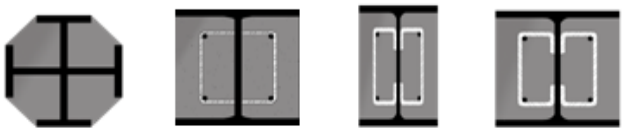

Figure.3: Type3- half concreted steel sections

2 Selecting the accelerogram

Dynamic analysis of time history of earthquake with accelerogram is one of the procedures been suggested in most of the specification of the earthquake analysis.

In this paper three Tabas ، Northridge و ChiChi have been used which general features of them have been listed in table 1. PGA is maximum earthquake acceleration, PGV is maximum earthquake velocity, Duration is duration of the earthquake and Time step is intervals data.

Table.1: Accelerogram details

Record	*PGA (g)*	*PGV (cm/s)*	*Duration (s)*	*Time step(s)*
Tabas	0.406	26.5	25	0.02
Northridge	0.358	27.5	40	0.02
Chi Chi	0.364	55.4	150	0.004

3 Non-linear application

Obtaining non-linear model we should choose an application that has this capability below and could choose appropriate geometric for combined sections and good model for this construction behavior.

With this application we must be able to model steel section embedded in concrete without equivalent moment of inertia It means that if it is possible we could obtain Stress and Strain anywhere in the section compound and also could consider non-linear effect in study, specially non-linear from inelastic behavior of materials.

This application also should be perform non-linear dynamic analysis and has capability of 3-d modeling of construction frames with composite member and various floors.

Regarding to special behavior of members and Cracks and reduces hardness on them under reciprocating behavior and concrete features in high compressive strength, Low tensile strength and cracks creations on this members, special option should be existed in application for modeling this features.

Considering the points mentioned above, Seismostruct application has been used for modeling mixed sections and ETABS have been used for modeling this features.

4 Selected systems

Two types of construction frames, similar plan and number of 3and8 floors have been used compared different type of composite columns which have shows figure 4 of modeled frame plan.

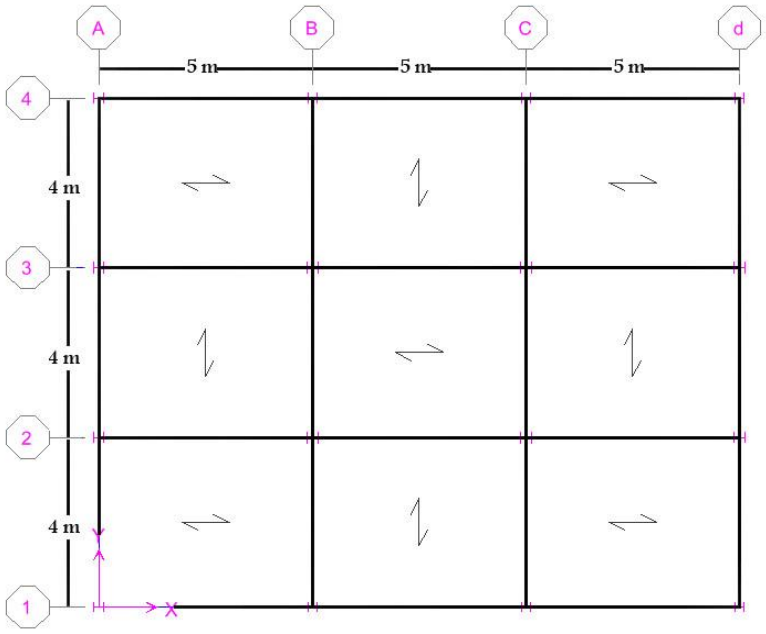

Figure.4: Model ‘s plan for 3 and 8 strories

5 Plastic Design

This project is a three floor frame model been designed with steel column. Obtained sections from modeling frame in plastic method in 1 and 2 axes have been shown in figure 5 and 6.

6 Analysis results

Changing is a fundamental factor in comparing constructions which shows the Structural flexibility on lateral loads. After designing with plastic method under time history analysis with presented accelerogram, studied construction placed in third chapter. The results represented maximum structural shift between three accelerograms. So we worked on analyzing floors shift and their drifts in models.

In table2 the result obtained with Northridge ، Tabas و ChiChi have been shown that these results included of maximum Roof displacement in Y and X axes.

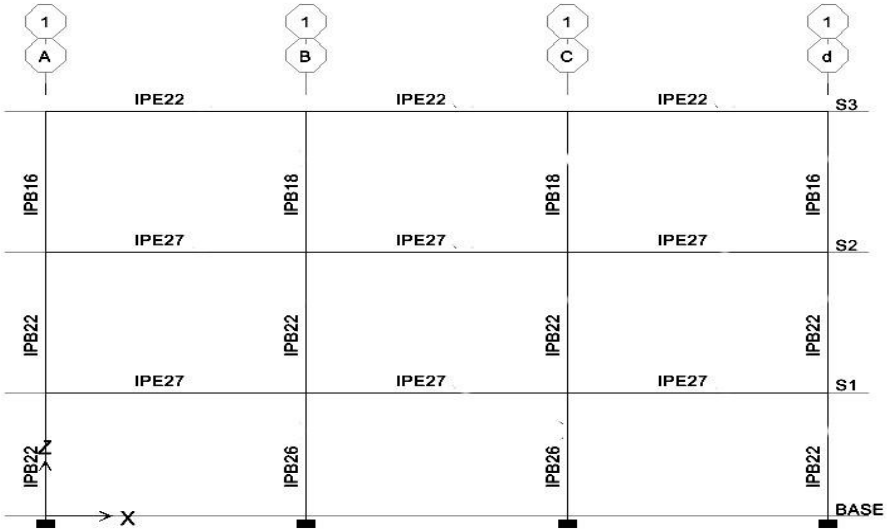

Figure.5: Plastic design of model 3-1 in frame.1

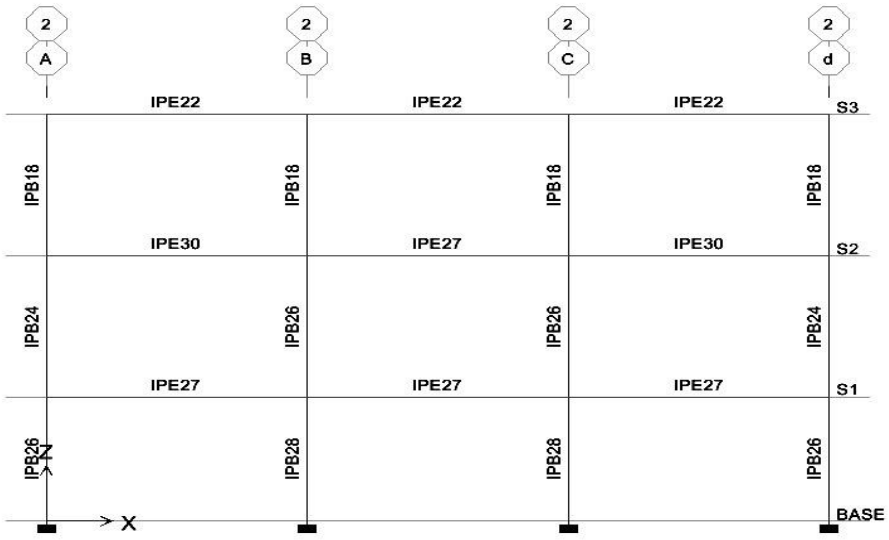

Figure.6: Plastic design of model 3-1 in frame.2

Table.2: maximum roof displacement in 3 stories models

Model 3-4		*Model 3-3*		*Model 3-2*		*Model 3-1*		*Model*
X	Y	X	Y	X	Y	X	Y	*Axis*
5.8	*11.3*	*4.6*	*8.2*	*5*	*8.6*	*4.5*	*9.2*	*Northridge*
5.1	*10*	*4.2*	*6.7*	*4.2*	*7.1*	*3.6*	*7.5*	*Tabas*
16	*18.5*	*13.2*	*13.7*	*14.5*	*15.6*	*11.4*	*15.7*	*ChiChi*

Maximum displacement floor diagram in third floor models demonstrated that model 3-4 (composite type 3) have maximum displacement in the last floor and the other third floor models have similar behavior but have a little difference.

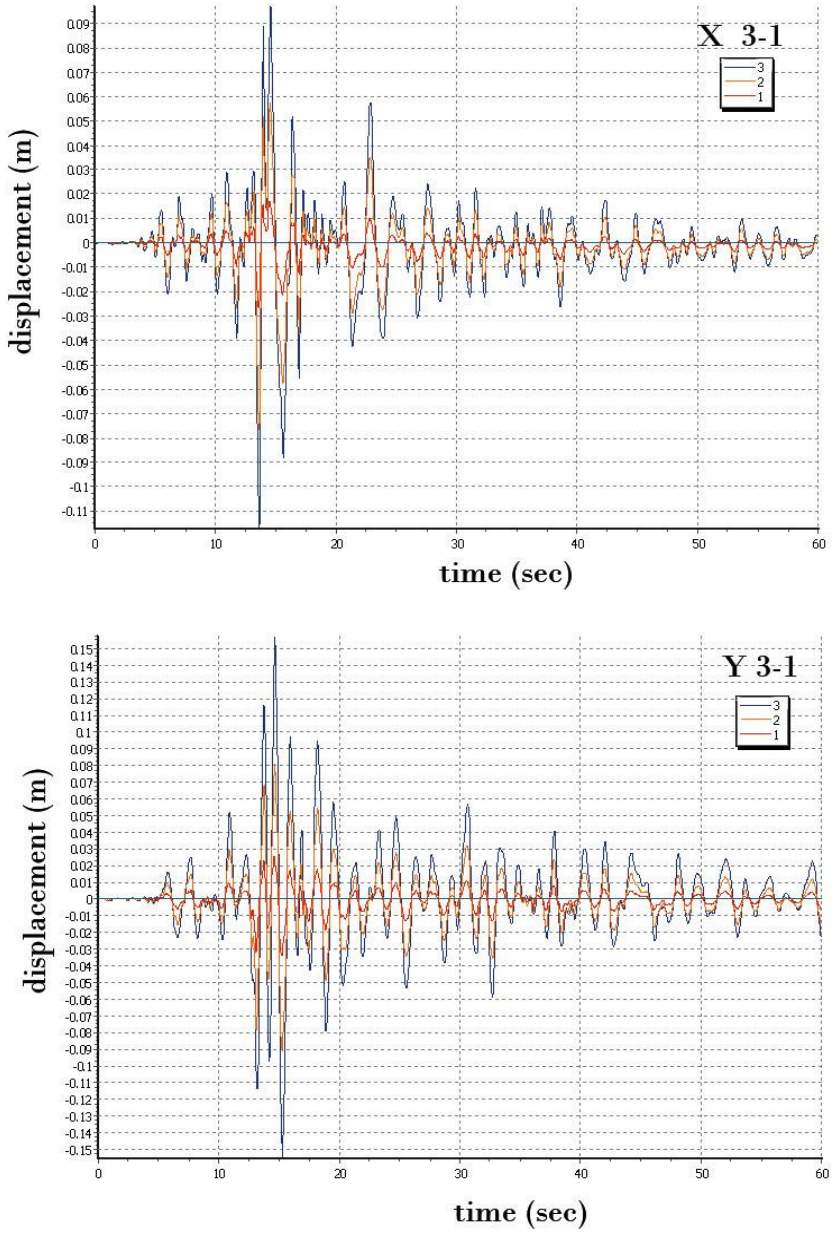

Figure.7: Time history response of story drifts during Chichi

Maximum drift floors in third floors models demonstrated that drift in first and second floor is almost equal but in third floor, maximum drift occurred in model 3-4. The results from comparison of 3-storey drift models demonstrated that steel model 1-3 have 20% less drift than model 4-3 and so on 2-3, 38% and 3-3, 40%.

According to 2800 specification, permitted drift in non-linear state for third floor model for 0.025 have been consider 2.5 % and almost all of drift are in standard range.

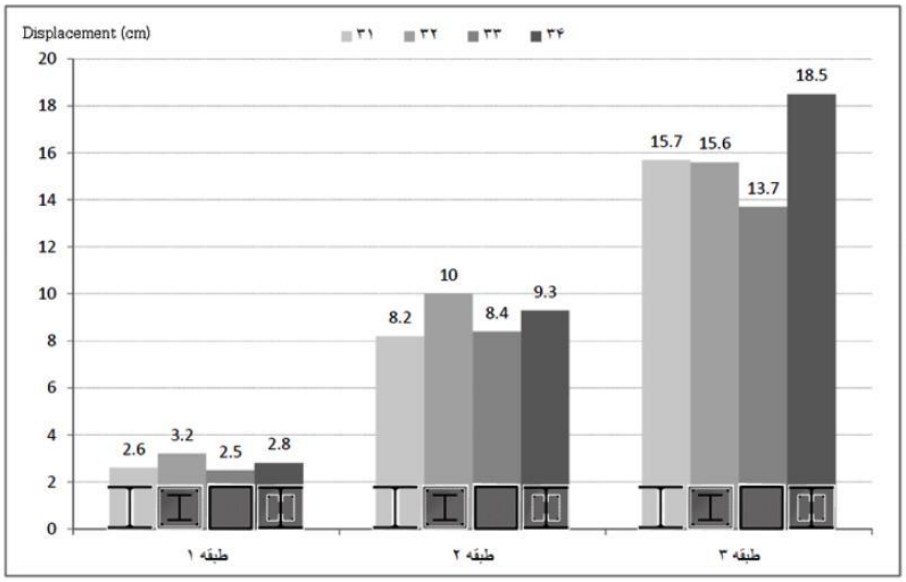

Figure.8: maximum story displacement in 3- story models

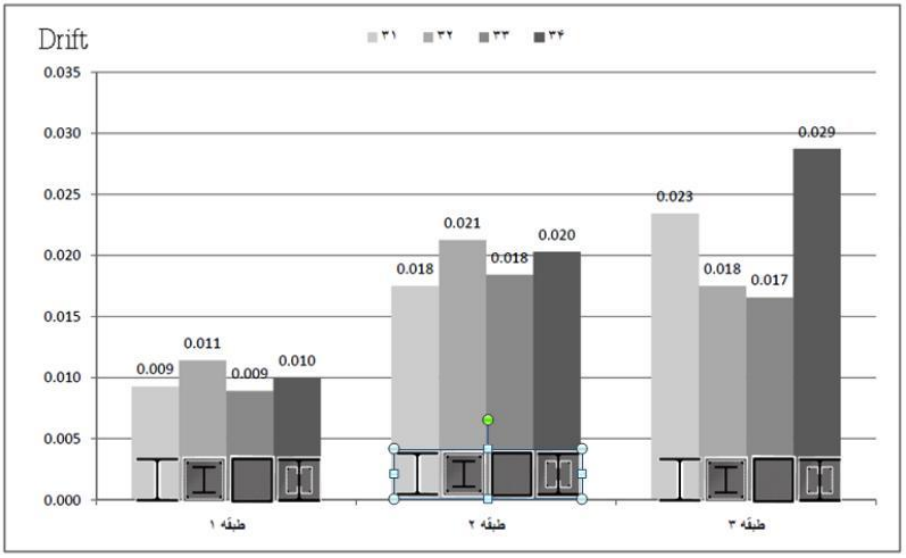

Figure.9: maximum story druft in 3- story models

7 Conclusion

The main objective of this study is analyzing Seismic behavior of composite columns in frame in inelastic state under dynamic load. So in this paper, three type of composite column in 3and 8 floor construction frame have been used to compare the behavior of different types of composite columns. For designing constructions, first we built a steel construction in plastic method then worked on designing composite column in plastic method and simultaneously compared steel columns with composite columns. The results included of comparison of Relative displacements of the general classes and comparison of forces and bending moment of column toward plastic capacity and backrest reactions and etc. figures, tables and diagrams have been presented and results have been summarized as below:

1. In comparison of maximum displacement and floor drift, 3and8 floor models designed with type 3 composite column had maximum flexibility and after that with a little less flexibility type 1 composite column. Steel constructions had minimum flexibility.

Although three floor models had more correction coefficients of accelerogram and endured stronger earthquakes, there were no appreciable differences in term of displacement and drift.

2. Base Cut and base moment results in three floors models demonstrated that steel model had maximum amounts and model 2-3 had minimum amounts and the amounts of models 3-3 and 4-3 were close to model 2-1. In eight floor models, steel models and type 2 composite had maximum base cut and base moment. Comparing to models 2-8 and 4-8, these models were stiffer and had inappropriate performance system against lateral loads could not dispose earthquake forces well. But models 4-8 and 2-8 with type 1 and 4 composite column had minimum cut base and base moments amounts and had a good plasticity, Flexibility and good performance in disposing lateral forces.
3. In comparison of exist moment with moment of plastic in all models, we had seen that most of the column entered in plastic area in three floors models and 3-3 had maximum amounts and minimum amount referred to 4-3 models. In eight floors models, most of 3-8 model columns entered in plastic area and maximum and minimum amounts referred to models 3-8 and 2-8, respectively.
4. In comparison in ratio of exist axial forces to plastic amounts for various models we had seen that none of column entered in plastic area and the criterion was bending moment. In three floors models 22% of plastic capability had been used and in eight floor models for type 1, 2 and 3 composite column 29%, 32%, 35 of plastic capability, respectively. Results demonstrated that type 1 and 2 composite column in eight floor models have similar amount of Interaction of axial force and these amounts was lesser than type 3 composite column. Considering that consumption of concrete amounts in type 1 and 2 composite sections was more than doubled consumption of type 3 composite column amounts, so it resulted that the concrete amount of section have important role in Withstand compressive forces and in construction with high compressive forces, type 1 and 2 section composite have better performance.
5. In comparison of interaction of total axial force ration and bending moment, it had been demonstrated that type 2 composite column had maximum amounts and type 1 and 3 had minimum amounts which Most of this difference is due to the bending stress in type 2.

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