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ANALYSIS OF COMPOSITE COLUMNS BASED ON PERFORMANCE

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ABSTRACT

The main purpose of this study is comparison and investigation of different types of composite columns in framed structures in plastic mode under dynamic loads. In this study the performance of the MRFs with composite columns has been evaluated using 3-story structural models, considering the base reactions obtained from the non-linear analysis. The results show good performance of composite sections under the seismic loads. Also, a comparison between two types of composite sections, the full and half-embedded steel sections in concrete, has been made. The columns are designed for the construction frames with 3 floors s by Plastics Method and to study the dynamic behavior of the models were used three strong earthquakes .

Keywords: Composite columns, framed, dynamic loads, plastic mode.

INTRODUCTION

Composite column in Classical Orders of Architecture is a Roman-designed column style that combines the Greek-designed Ionic and the Corinthian orders of architecture (www.architecture.about.com, 2015). A steel-concrete composite column is a pressure section combination a concrete - steel section or a concrete filled member of steel and is typically applied as a load-resisting section in a composite framed building (Girhammar and Pan, 2007). Usual sections of composite columns with fully and partially concrete surrounded steel sections are presented in figures 1 and 2 demonstrates three typical sections of concrete filled members Gramblicka and Lelkes (2013). Remind that it is not required to supply additional reinforcement for composite members, but as an exception for need of fire accident if necessary.

In a current research, an investigation of dynamic stability of composite columns with embedded steel profile is illustrated. During the past years, the application of surrounded steel concrete columns has been raised up meaningfully in small or tall structures. Soliman *et al*. (2013) has studied to determine by experiments the new methods and specifications for investigating the maximum load behavior of concrete surrounded steel short columns. He made conclusion that confining results was clearly affected by the figure of the encased steel

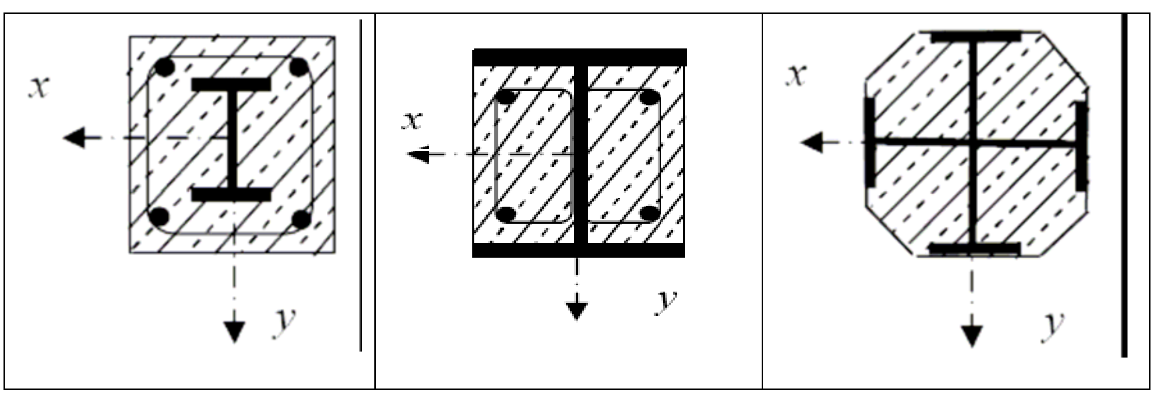

Fig. 1. Typical cross - sections of fully and partially concrete encased columns.

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section. The tube-shaped steel member makes it better the confinement than the SIB section. Between the used specifications, the ECP-SC-LRFD-2012 resulted to the most conservative results (Soliman *et al*., 2013) various methods are applied for the designation of concrete-encased composite columns in Weng and Yen (2002) studies. The analyzed member strengths according to two design codes of ACI and AISC may present suitable variance in some conditions (Weng and Yen, 2002). Ellobody *et al*. (2011) demonstrates an inelastic 3-D finite element model for eccentrically loaded concrete encased steel composite columns. The columns were pin-ended subjected to an eccentric load acting in direction of the main axis. Typically, it is obtained that the influence on the composite column strength owing to the rise-up in structural steel yield stress is important for eccentrically loaded columns with minimum eccentricity of 0.125*D* (Ellobody *et al*., 2011). The performance of concrete-encased CFST column under combined pressure and bending is investigated by An and Han (2014). A finite element analysis (FEA) model is made to investigate the behaviour of the composite column, and generally suitable agreement is obtained among the measured and predicted outcomes in terms of the failure mode, the load-deformation relation and the ultimate load (An and Han, 2014). Saw and Liew (2000) illustrates the design assessment of encased I-sections and concrete filled composite columns due to the approaches presented in Eurocode 4: Part 1.1, BS 5400: Part 5 and AISC LRFD. In some cases, outcomes resulted from the above three specifications may differ significantly. This is because of the various designation aspects admitted in these specifications. yet, the design methods are found to be mostly conservative when compared with the test results. In a composite column both the steel and concrete would resist the external loading by interacting together by bond and friction. Supplementary reinforcement in the concrete encasement prevents excessive spalling of concrete both under normal load and fire conditions (Dundar *et al*., 2008).

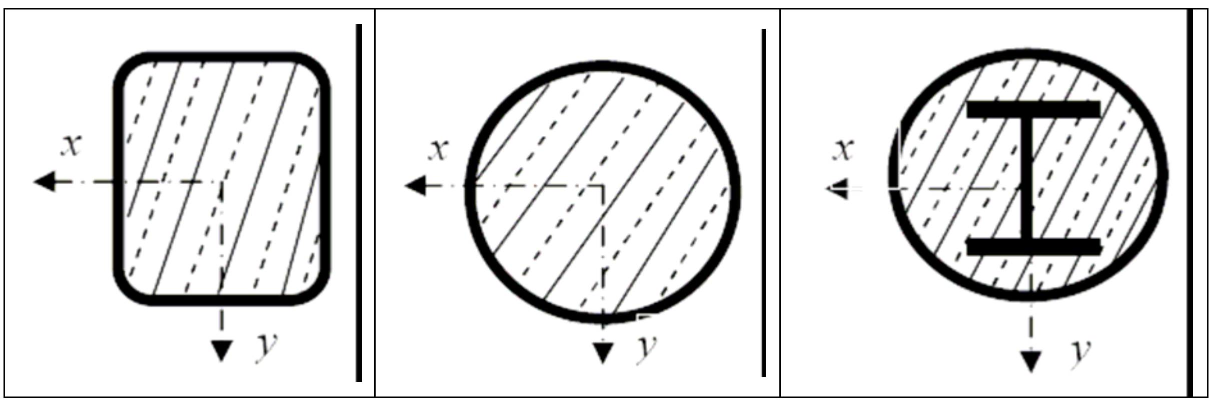

Fig. 2. Typical cross-sections of concrete filled tubular sections.

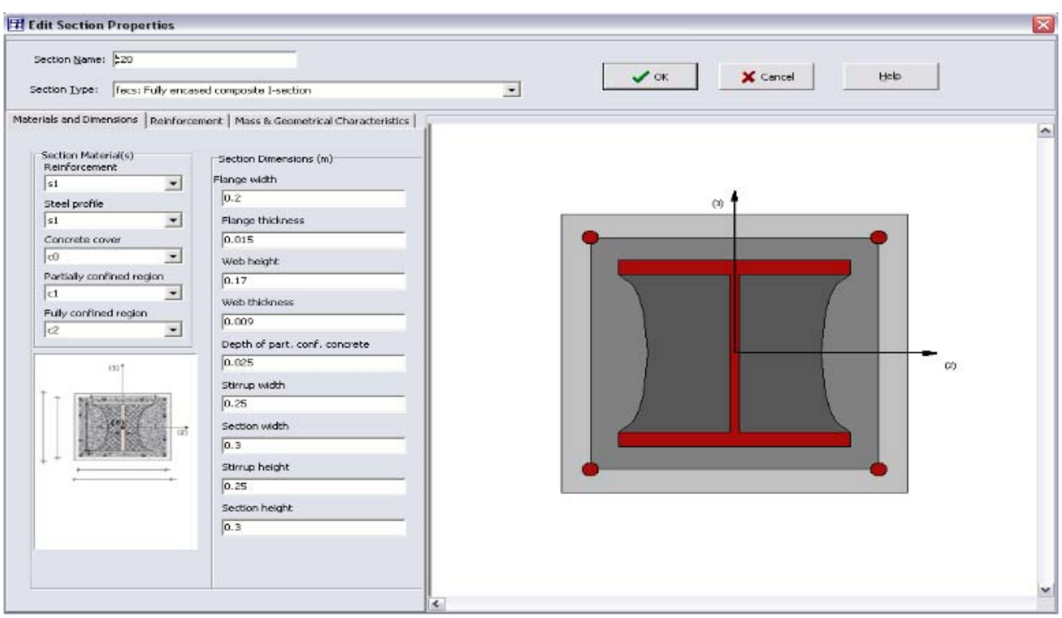

Fig. 3. Composite columns of type 1 models in Seismostruct software.

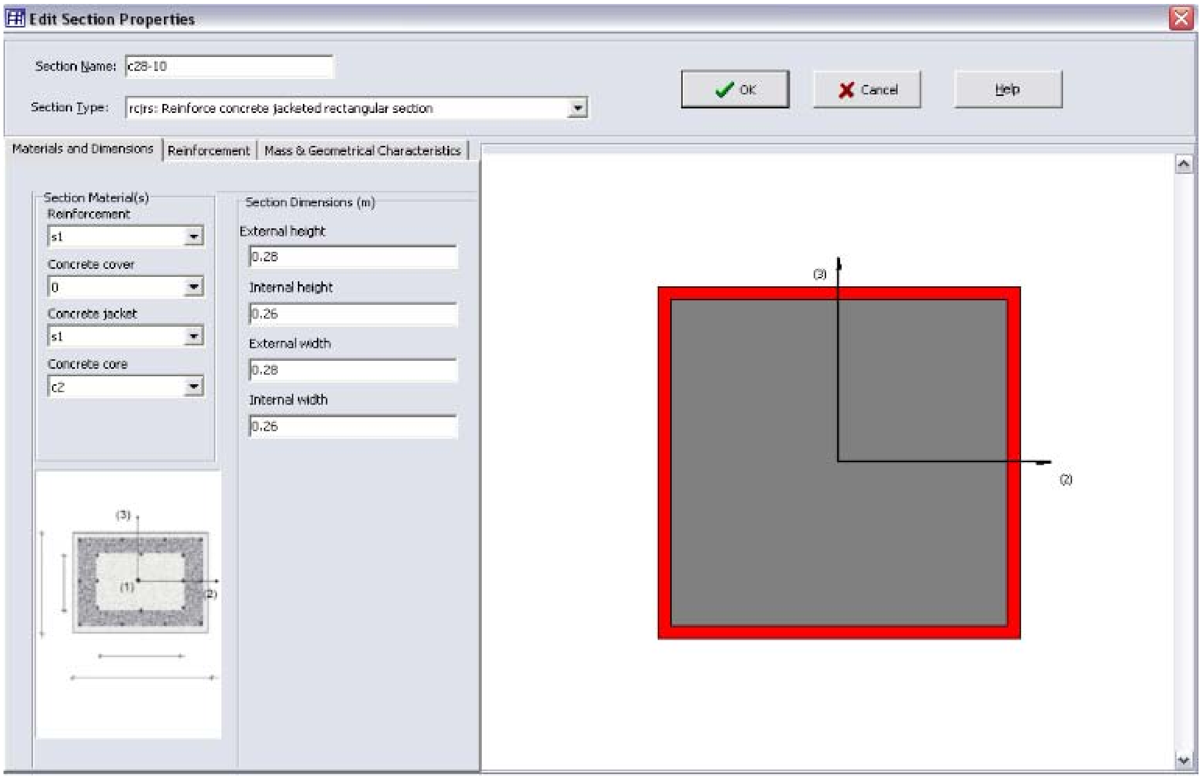

Fig. 4. Composite column of type 2 models in Seismostruct software.

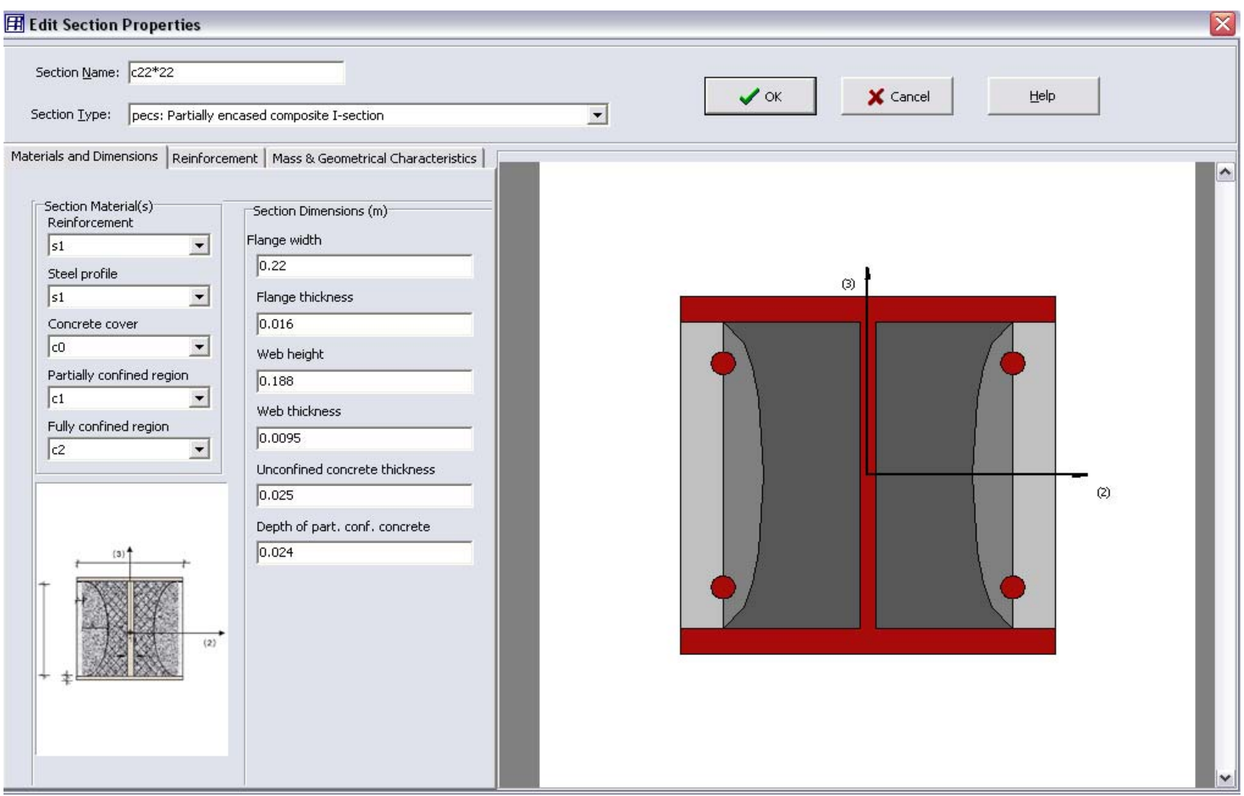

Fig. 5. Composite column of type 3 models in Seismostruct software.

MATERIALS AND METHODS

Research Method

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, Kobe, Duzce 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	0.506	22.5	35	0.02
Kobe	0.458	23.5	60	0.02
Duzce	0.464	52.4	170	0.01

Non-linear application

Obtaining non-linear model we should choose an application that has this capability below and could choose appropriate geometric for combined section 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. In Seismostruct software, there are many models to choose for beam, columns, wall and roof. Examples of sections that have been used in this project are: 1-Type 1 composite column, figure 3 is modeled by FECS (Fully Encased Composite I-Section) section, can be define a variety of materials and dimensions for the various section. 2-Type 2 composite column, figure 4 is modeled by RCJRS (Reinforce Concrete Jacketed Rectangular Section) , can be define a variety of materials and dimensions for the various sections and 3-Type 3 composite column. Figure 5 is modeled by PECS (Partially Encased Composite I-Section), can be define a variety of materials and dimensions for the various sections.

Analytical Modeling

The plastic moment of composite column sections are calculated using the following formulas:

$$N_P = \alpha_b \sigma_{br} F_b + \sum \alpha_a \sigma_F F_a \tag{1}$$

$$y = \frac{\alpha_a \sigma_F (F_a + 2 b_a c)}{\alpha_b \sigma_{br} b + 2 \alpha_a \sigma_F b_a} \tag{2}$$

$$M_P = \alpha_a \sigma_F [F_a \frac{d-y}{2} - b_a c(y-c)] + \alpha'_a \sigma'_F F'_a \frac{d'}{2} \tag{3}$$

Where; α_b is reduction factor for concrete, F_a is section area of steel, α_a is reduction factor of steel, σ_{br} is compressive strength of concrete, F_b is section area of concrete, and σ_F is yield strength of steel.

Maximum displacement floor diagram in third floor models demonstrated that (composite type 3) have maximum displacement in the last floor and the other third floor models have similar behavior but have a little difference (Table 2).

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 type3. The results from comparison of 3-storey drift models demonstrated that steel model have 20% less drift than type3 and so on type1, 38% and type2, 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.

CONCLUSION

The main objective of this study is analyzing Seismic

Table 2. Maximum roof displacement in 3 stories models.

Type3		Type2		Type1		Steel		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	Kobe
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	Duzce

behavior of composite columns in frame in inelastic state under dynamic load. So in this paper, three type of composite column in 3 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. In this study, it became clear that the frame is designed with columns of type 1 and 3 in the flexural behavior of composite structures have a roughly similar. Flexibility, softness and performance accessories for the disposal of the properties of these two sections are. Composite model of type 2 with large sections, but the poor bear the bending moment, and this goes back to the weak role of concrete in tension but the compressive strength of concrete is important to bearing presser and for composite structures with the high levels of type 1 and 2 are better.

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