A Feasibility Study on Combined RCS Moment Frames with Concrete and Steel Frames in Upper Level Management

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ABSTRACT: RCS structures refer to construction built using a system of reinforced concrete (RC) supports and steel frame (S) beams have been recognized to possess several advantages in terms of structural performance and economy compared to pure RC and steel frames. All of the materials are of the highest quality in order to achieve rational structures, withstand great force and at the same time allow wide spaces between supports. This type of construction allows for large open structures like warehouses for heavy loads and shopping centers. In the present paper the design procedure is validated through the testing of a real case study in Tehran which aims to achieve the management targets. For this reason a detailed comparison feasibility study on technical, economical and management conditions between usual structures (steel and concrete) with RCS were performed. At the first by ETABS three models for steel, concrete and RCS structure with similar basic characteristics were constructed. Then by MSP the performance timing of each of them with total required costs, time and personnel were extracted. At the end to clear the obtained results, by use of finite element method, a C# computer code namely "J.A.D" was generated to design the structures and project timing performance. The obtained results showed that the generated code can detect and process of civil operation data and capable to provide higher quality output diagrams with an upper resolution and accuracy.

[Hamed Jami, Abbas Abbaszadeh Shahri and Heidar Dashti. **A Feasibility Study on Combined RCS Moment Frames with Concrete and Steel Frames in Upper Level Management.** *Life Sci J* 2012;9(4):3515-3521]. (ISSN: 1097-8135). http://www.lifesciencesite.com. 520

Keywords: Management, RCS structure, "J.A.D" C# computer code

INTRODUCTION:

RCS frames are one of the most recent practical bending frames in cases of large spans and moderate height. Reinforced concrete frames, due to increasing in depth of beam and loss of architectural space, are not suitable; therefore RCS frames were proposed to improve these systems (Chopra, 1995).

From the construction viewpoint, these systems are usually built by first erecting a steel skeleton, which allows the performance of different construction tasks along the height of the building (Griffis, 1986). Structurally, the connections between steel beams and RC columns have been reported to possess a good strength and stiffness retention capacity when subjected to large load reversals (Kanno, 1993; Parra-Montesinos and Wight, 2000a).

Utilizing compressive strength of concrete in columns and stiffness and strength of steel beams which makes them suitable for long spans, results in a cost effective hybrid system, which behave well under both gravity and lateral loads (ASCE ,1994).

In seismic design, reduced forces due to different causes like, damping, ductility, excess resistance and …, are calculated from dividing linear seismic spectra to a factor named is behavior coefficient (ATC, 1996; C.M.Uang, 1991). Several researchers such as Deierlein et al. (1988), Kanno (1993), Kim and No-guchi (1997) and Parra-Montesinos and Wight (2000b) were compared the accuracy of design equations to predict the shear strength of RCS joints between ultimate experimental and predicted strength. However, their use has been limited to low or moderate seismic regions due to lack of appropriate design guidelines for RCS frames in high seismic risk zones.

DATA GATHERING AND MODELS

Structural steel members, have high second moments of area, which allow them to be very stiff in respect to their cross-sectional area. Concrete is a material with relatively low tensile strength and ductility. The reinforcement is usually, though not necessarily, steel reinforcing bars (rebar) and is usually embedded passively in the concrete before it sets. The studied building which is located in Tehran was modeled by ETABS for three kinds of structures (Steel, Concrete and RCS) with similar basic characteristics as shown in figures1 to 3.

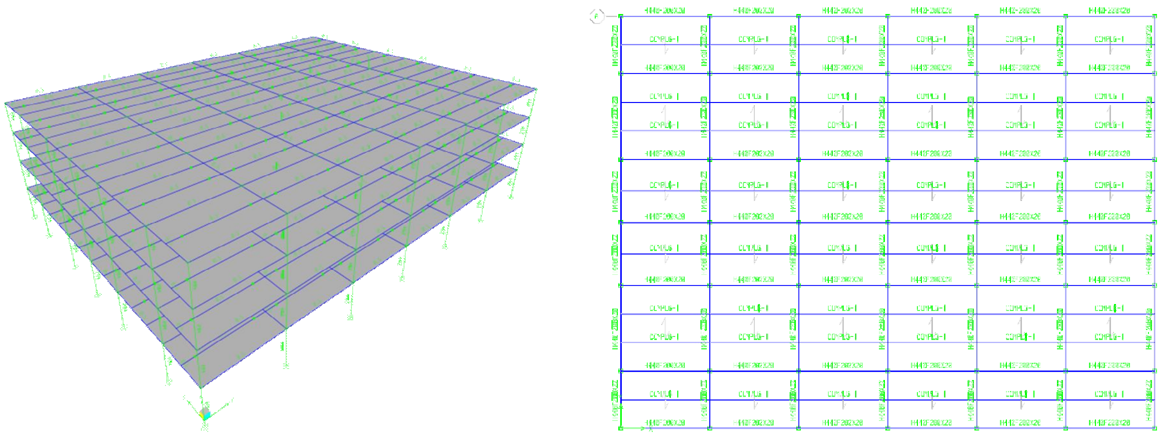

Figure1. ETABS model of steel structure for the case study

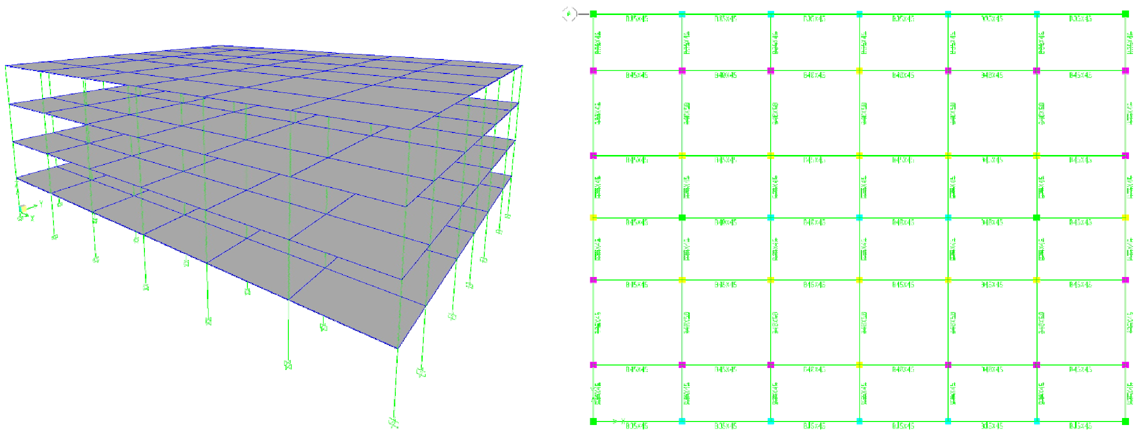

Figure2. ETABS model of concrete structure for the case study

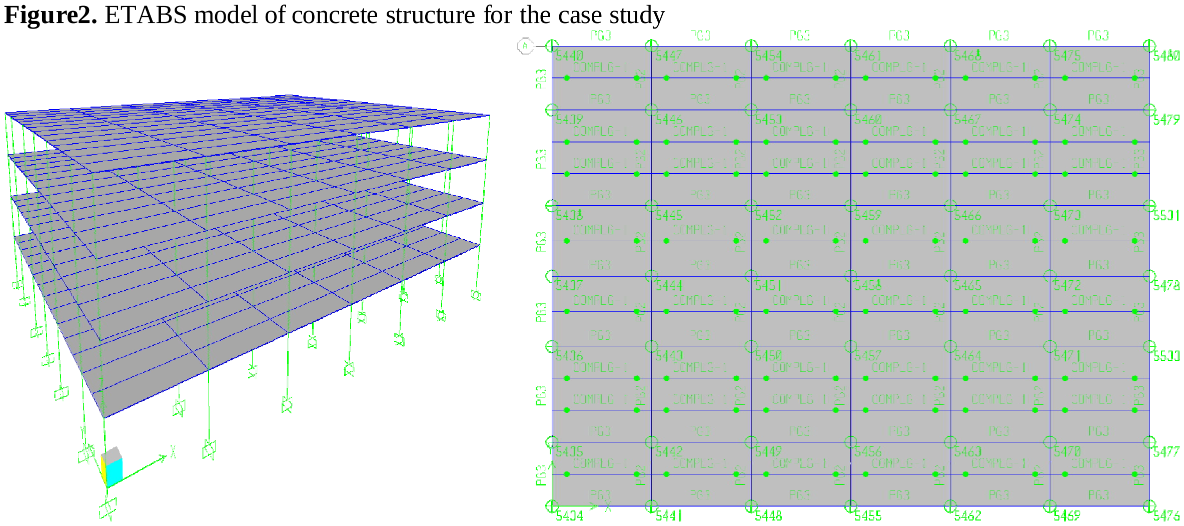

Figure3. ETABS model of RCS structure for the case study

By obtained results of the constructed models, the authors would be decided to generate a C# computer code namely "J.A.D" to analyze the results of the models and MSP software outputs. This code is capable to draw the requested diagrams and can analyze the applied earthquake loads on the structure. The start screen of the generated code is shown in figure4.

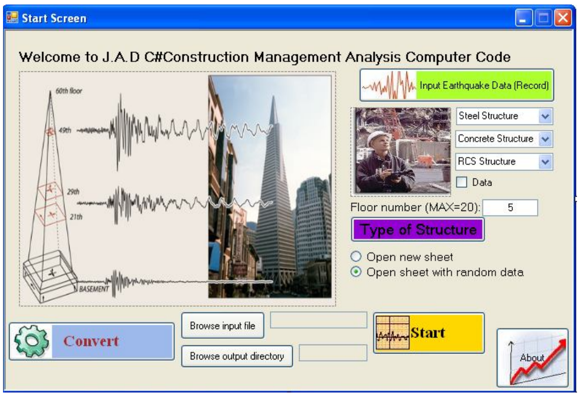

Figure4. Start screen of generated computer code

Obtained results of the mentioned code are given in tables (1) to (3) and comparative plotted diagrams by "J.A.D" are indicated in figures 5 to 7.

Table (1). Comparison of physical progress

date	12/04/02	12/04/09	12/04/16	12/04/23
Steel structure	0.71	16.23	31.29	43.32
Concrete structure	2.26	6.64	8.24	10.64
RCS structure	0.77	10.96	14.37	17.16

date	12/04/30	12/05/07	12/05/14	12/05/21	12/05/28
Steel structure	54.74	62.74	68.5	75.28	82.2
Concrete structure	13.68	24.12	31.79	33.15	35.88
RCS structure	27.71	37.96	40.77	49.87	61.86

date	12/06/04	12/06/11	12/06/18	12/06/25	12/07/02	12/07/09
Steel structure	89.62	97.01	100			
Concrete structure	38.18	45.1	54.98	58.11	60.6	62.8
RCS structure	64.84	69.19	85.96	89.37	92.16	97.84

date	12/07/16	12/07/23	12/07/30	12/08/06	12/08/13	12/08/20	12/08/23
Concrete structure	68.97	78.68	83.15	85.43	87.47	92.82	100
RCS structure	100						

Table (2). Comparison of financial progress

date	12/04/02	12/04/09	12/04/16	12/04/23	12/04/30	12/05/07	12/05/14
Steel structure	0.15	19.74	38.55	52.36	65.19	72.27	75.63
Concrete structure	4.19	7.04	7.43	8.59	13.83	25	31.98
RCS structure	0.66	13.95	16.6	17.49	31.71	40.71	42.19

12/05/21	12/05/28	12/06/04	12/06/11	12/06/18	12/06/25	12/07/02	12/07/09
80.67	85.96	92.06	98.16	100			
32.36	32.75	37.98	43.22	55.92	57.3	57.68	62.15
50.39	64.21	66.9	69.9	88.95	91.6	92.49	98.29

12/07/16	12/07/23	12/07/30	12/08/06	12/08/13	12/08/20	12/08/23
67.38	79.93	82.24	82.63	86.21	91.44	100
100						

By consideration of the performed analysis and to show better resolution of obtained results a detailed separately comparison was executed and the results are given in tables (4) to (6) and figures 8 to 10 respectively.

Table (3). Development of human resources

date	12/04/02	12/04/09	12/04/16	12/04/23
Steel structure	0.14	5.97	22.69	43.4
Concrete structure	0.69	6.14	11.26	16.14
RCS structure	0.19	4.09	8.24	17.59

12/04/30	12/05/07	12/05/14	12/05/21	12/05/28	12/06/04	12/06/11	12/06/18	12/06/25
61.42	67.63	73.1	79.01	85.64	91.54	97.41	100	
20.24	23.77	30.66	35.78	40.9	44.99	49.09	54.47	60.29
26.29	31.04	39.47	47.86	54.87	61.36	70.2	79.09	83.24

12/07/02	12/07/09	12/07/16	12/07/23	12/07/30	12/08/06	12/08/13	12/08/20	12/08/23
65.41	69.75	73.84	78.46	84.93	90.05	94.42	98.52	100
92.59	98.76	100						

Figure5. Comparison of physical progress for three kinds of structure

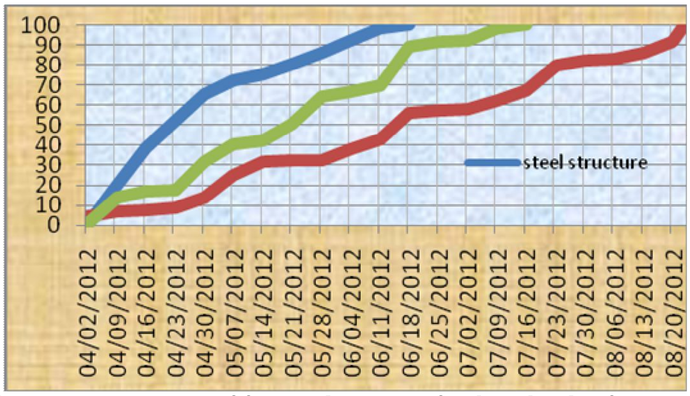

Figure6. Comparison of financial progress for three kinds of structure

Table (4). Comparison of the number of required personnel for three kinds of model

Steel structure	Concrete structure	RCS structure
224	---	---
---	852	---
---	---	624

Table (6). Comparison of the required performance time (day) for three models

Steel structure	Concrete structure	RCS structure
64	---	---
---	124	---
---	---	87

Table (7). Comparison of the required cost (Rials) for three models

Steel structure	Concrete structure	RCS structure
8660000000	---	---
---	5160000000	---
---	---	7600000000

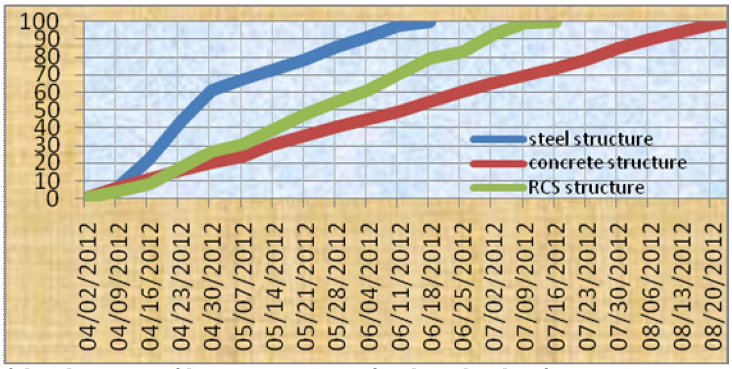

Figure7. Comparison of development of human resources for three kinds of structure

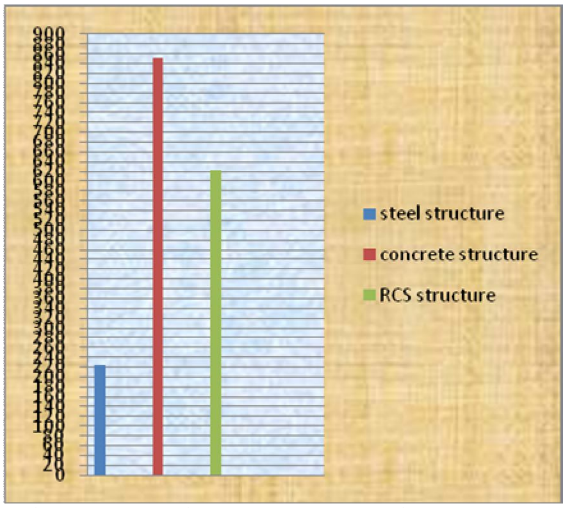

Figure8. Comparative diagrams of the number of required personnel for three kinds of model

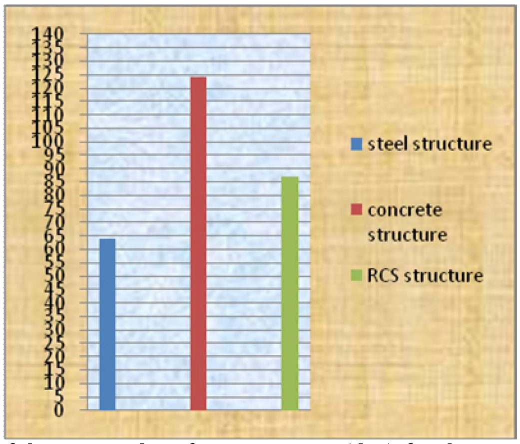

Figure9. Comparative diagrams of the required performance time (day) for three models

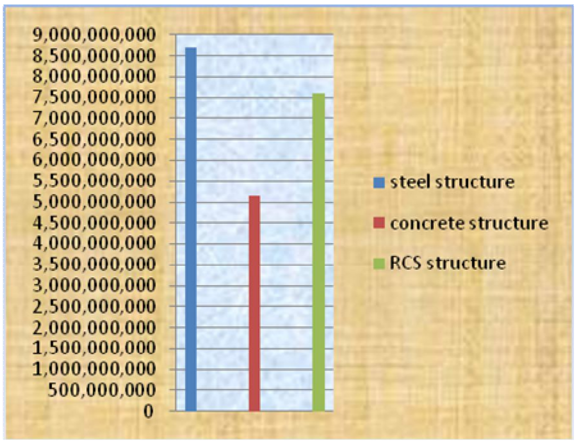

Figure10. Comparative diagram of the required cost (Rials) for three models

CONCLUSION AND DISSCUSION:

This paper presents a practical model to predict the advantages of RCS structures versus steel and concrete ones. The experimental program included the testing of real case study RCS connections in Tehran. The proposed model was based on the state of generated GUI computer code, which was defined through the development of a detailed analysis of a case study. In addition, the generated code and model was capable of predicting the earthquake loads in three discussed structures. Results from the testing of physical progress, required costs and development of human resources in RCS versus steel and concrete structures show that hybrid structures consisting of RC columns and steel beams are suitable for use with lower risk in upper level of construction management. In addition, good agreement was found between experimental results and the calculated and predicted by the proposed model.

The results and resolution of outputs of the generated GUI in comparison with other available softwares shows good agreement with practical and indicated that this code can employed as a good, strong and reliable tool for this type of analysis.

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