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Ductility of Light Steel Frame Structures in filled to Light Weight Concrete Materials

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Abstract

This paper is carried out to determine the feasibility of the use of load bearing wall made of light weight concrete, LWC, and cold formed steel, CFS, under earthquake loads. The study uses finite element method where the finite element model for the composite wall are developed using ABAQUS. Using the cold-formed steel structures, CFS, has some advantages such as speed of construction, high seismic resistance, high temperature isolation and high voice resistance. Application of light weight concrete, LWC, in the walls of CFS has proved some benefits for user and improves the performance of structures. Current study evaluates the stiffness and lateral strength of the CFS structures subjected to LWC as infill materials. The finite element method was considered for push-over analysis in this paper. The analytical examine variable was strength of concrete.. The lateral strength and drift of all analytical models were indicated a substantial improvement. In the other words, using the LWC was caused increasing the strength, Ductility of CFS buildings.

Key Words: *Ductility; Light Weight Concrete (Lwc); Infilled Walls; Cold-Formed Steel.*

Introduction

In order to providing enough quality in construction process and reach to a optimum consumption of steel material, using a prefabricated system is necessary. Reduced time of construction is more important in industrial building construction. LSF structures are the best solution of current demand. Using the LWC in LSF wall is an innovation that be registered as a patent in Iran in name of Poly Van House, P.V.H. The effect of LWC in structural behaviour of LSF wall is considered as the main goal of current research. Analytical modelled was made by finite element software program, ABAQUS (H. Parastesh, H. Bagheri, N. Hosseinjani., 2009).

Geometric Details

The LSF wall sections are consisted of stud and runner elements that have C channel and U shape sections. The stud distance was 600mm (see Figure 1). The wall thickness and height was considered 100 mm and 3m in all analytical models. Compression strength of LWC is variable examined parameter (Jan G.M. van Mier., (2004); Mehta, P.K., (1986); Y.S. Tian, J. Wang, T.J. Lu., (2004); Y.S. Tian, J. Wang, T.J. Lu., (2004). The normal concrete, foam concrete was considered as the second parameters. The details of all models were illustrated in Table 1.

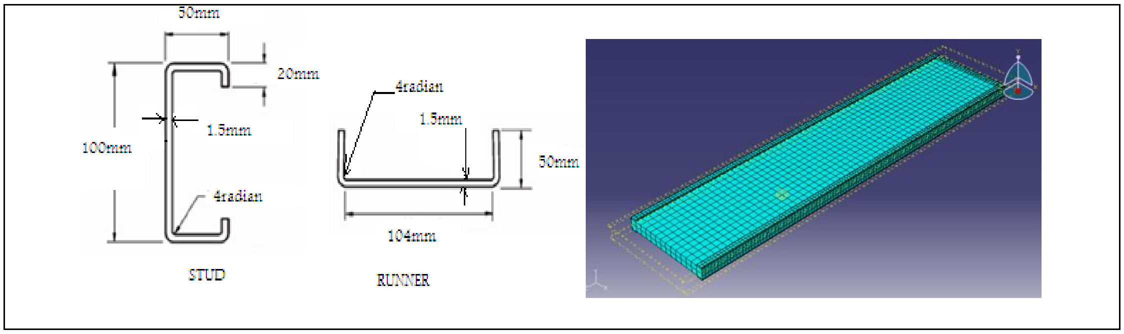

Figure1: The geometrical details of cold formed steel

Table1: The specifications of analytical frames of cold formed steel samples in ABAQUS

specifications of analytic models	Number OF Models
10-spans frame in filled to normal concrete model in laboratorial condition	ABA[1]-C[2]-10S[3]
1-span frame in filled to normal concrete	ABA-C-1S
1-span frame in filled to light weight concrete.no1	ABA-LWC[4].NO1-1S
1-span frame in filled to light weight concrete.no2	ABA-LWC.NO2-1S

Material Properties and FE Method

In order to analysis of LSF walls infilled to concrete, modeling of cold-formed steel and cracked concrete is necessary. The ABAQUS software program has enough capability to modeling of concrete and light gauge steel materials. In concrete materials, the damage plasticity index is applied in nonlinear push over analysis (Priestley, M. J. N., Seible, F., and Calvi, G. M., (1996); Wang, P.T, Shah S.P, Naaman A.E., (1978); Wischers G, Manns W., (1978)). The material properties of steel and concrete are shown in Table 2.

Table2: The specifications of different types of concrete and cold formed steel used to fill in the frame in analysis of finite elements

Compressive strength (Mpa)	Poisons coefficent	Modulus of elasticity (Mpa)	Density kg/m^3	Type of concrete/steel
6.4	0.2	12000	1106.34	LWC.NO1
2.7	0.2	7500	735.22	LWC.NO2
28	0.2	21000	2400	NC5
370	0.3	210000	785	CFS[6]

The cold-formed sections of stud and runner elements are defined separately the concrete elements. As shown in Figure 1, all analytical models are subjected to distributed gravity loads on the top of the wall and lateral load as a displacement load on the top of stud. In order to providing the real condition of sliding, in contact surface of steel and concrete elements, the contact elements are used with friction factor, μ, 0.25.

1 ABAQUS
2 Concrete
3 Span
4 Light Weight Concrete
5 Normal Concrete
6 Cold Form Steel

Analytical Verification

It is important to have a reliable FE models in applied analysis. Therefore, verification of models is so essential. An experimental result that tested in ref. 4 is compared to analytical models in ABAQUS so illustrated in Figure 2. Based on the results, the analysis has the same behavior of experimental results except that the maximum point of load that is acceptable.

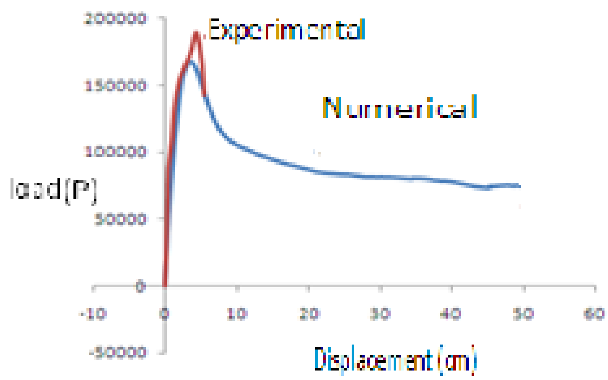

Figure2: comparison between load-displacement curves of 10 spans frame infilled to normal concrete models in two laboratorial and numerical conditions

Effect of Filling the walls with LWC in the Load-Displacement Curves

In this part, the results of analysis (lateral load-displacement curves, energy dissipation, and ductility) are presented for all models. Since all models were subjected to non linear push over analysis, the lateral load-displacement curves for one module models are shown in Figure 3.

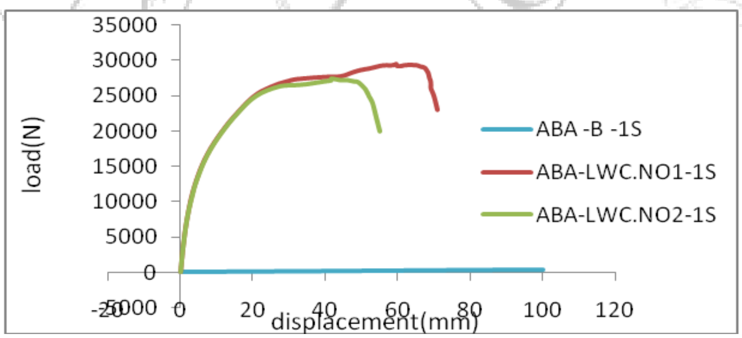

Figure3: Comparison of load-displacement curves for ABA-B-1S,ABA-LWC.NO1-1S, ABA-LWC.NO2-1S modeles

So indicated in curves, using the concrete increases the base shear and lateral displacement in compare to bare frame. The maximum displacement and maximum lateral load.is gained in LWC.NO1-1S model. Energy dissipation is depended to consumption area of load-displacement curve. Comparison of all models shows that all in filled wall specimens increase this area and improve the energy dissipation factor. In LWC. NO.1 model, the energy dissipation criteria is more than LW.NO2.

Effect of filling the walls with LWC in Ductility

The main goal of seismic study of structure is the improvement of ductility factor that dissipated the earthquake energy in event. The ductility factor is defined as follow equation:

$$\mu_{\Delta} = \frac{\Delta_u}{\Delta_y} \quad (1)$$

That Δy and Δu are the yield displacement and ultimate displacement. The ductility factors for all models are calculated in Table 3.

Table 3: Plasticity Ratio of analysis frames

plasticity Coefficient $\mu_{\Delta} = \frac{\Delta_u}{\Delta_y}$	Reforme corresponding to resistance ultimate 'Δ_u' (mm)	Reforme corresponding to yield point (mm). Δ_y	spesifications of analyzed modeles
2.28	51.5	22.5	ABA-C-10
14.39	64.77	4.5	ABA-LWC.NO1-1S
6.82	40.52	5.94	ABA-LWC.NO2-1S

As shown in Table 3, LWC.NO1-1S model gains the maximum ductility in compare to the others because of mechanical properties of foam concrete materials. Therefore; using the LWC in LSF structures improve substantially the ductility factor of structure.

Conclusion

Application of LWC infilled materials are caused to increase the lateral strength, ductility and energy dissipation in LSF walls. Some of the research conclusions are described as follow:

- The ABAQUS software program provides enough compatibility to experimental test in infilled LSF walls.
- Using the infilled materials increase the energy dissipation and ductility.
- The maximum ductility is depended on LWC.NO1 model because of material properties.

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