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Comparing Cracking Diagram of Lightweight Filler Concrete by Increasing the Number of Frames in Light Constructions in FEM

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Abstract

Due to existing major problems, construction with traditional techniques and for optimal use of the country's steel industry requires a specific system with pre-fabricated capability to be replaced. Present study concerns about Cold–Formed Steel constructions light filled with lightweight concrete with joint conjunctions (cap screws). Using ABAQUS software, comparison between cracking diagrams of lightweight concrete by increasing the number of their frames and constructional behavior has been made. The results indicate that lightweight filler concrete increases the load-displacement area under curve (AUC), increases strain, energy absorption capacity, ductility and behavior coefficient and finally increases its construction strength. Crack diagrams indicate that rupture in the highest amount of strain or what we call it in frames with one crater, the most cracking are in the area connected to the fulcrum, concrete connection to stud and bottom of the frame; and non-linear behavior of construction is a bending behavior but by increasing the number of frames, the highest concentration of pressure and cracks are created at the bottom of the frame. According to the shear cracking of the five crater samples, diameters cracking are evident in the middle of the walls. Normal concrete, due to the less displacement in frames with five craters, are not recommended to fill the walls in light constructions.

Key words: Cold–Formed Steel, Light weight concrete (LWC), cracking, in filled walls, ductility strength.

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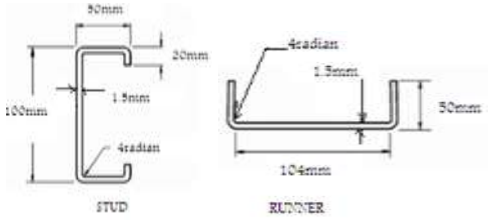
Introduction

New Method of cold formed constructions which fills inside the walls of this construction with lightweight concrete is placed in the category of buildings with cold formed steels. In order to minimize the consumed amount of steel materials and optimal use of constructional elements, thin walled sections with welded joints and screws will be used. Using these sections cause increased flexibility, increased ductility strength and reduction of materials consumption. In this article it has been shown that how increasing the number of frames in lightweight frames filled with lightweight concrete with different compressive strengths, will effect on the constructional behavior and concrete cracking. Descriptive analysis was conducted using ABAQUS software analysis in form of finite element analysis.

Analytical Models in Software

Initially, analytical frame model built in laboratory by ABAQUS software with the same stimulated experimental conditions and approximately equal and acceptable results has been obtained in the force - displacement diagram. Then the walls of one and five craters made up of light hollow steel and filled with a variety of concretes and ordinary concrete, of the thin sections named "stud" and "runner" has been modeled in a way that respectively play the role of column and pole. Stud's distance of 60 cm, wall height of 3,000 mm and wall thickness of 100 mm have been considered. Geometric details of sections are shown in **Figure 1**.

Figure 1: *Stud, Runner Sections*



Specifications of Modeled Frames Are Shown in **Table 2**.

Table 1: *Specifications of Analytical Frames Composed from Cold Formed Steel*

Specifications of Analytical Model	Model Number
Laboratory samples of ten craters frame filled with ordinary concrete	ABA[1]-C[2]-10S[3]
1 crater frame filled with ordinary concrete	ABA-C-1S
1 crater frame filled with lightweight concrete of type 1	ABA-LWC[4].NO1-1S
1 crater frame filled with lightweight concrete of type 2	ABA-LWC.NO2-1S
1 crater frame filled with lightweight concrete of polystyrene	ABA-LWC.PS-1S
1 crater hollow frame	ABA-B[5]-1S
5 craters frame filled with ordinary concrete	ABA-C-5S
5 craters frame filled with lightweight concrete of type 1	ABA-LWC.NO1-5S
5 craters frame filled with lightweight concrete of type 2	ABA-LWC.NO2-5S
5 craters frame filled with lightweight concrete of polystyrene	ABA-LWC.PS-5S
5 craters hollow frame	ABA-B-5S

[1] ABAQUS
[2] Concrete
[3] Span
[4] Light Weight Concrete
5 Bare

Specifications of Materials

Specifications of steel and concrete materials used in the analysis are shown in **Table 3** parts of: (Jan G.M. van, 2004; Wischers G, Manns W, 1978; D. Saradhi Babu,T, K. Ganesh Babu, T.H. Wee., 2005; Mehta, P.K. 1986; ACI, 2008; Chandrupatla, Tirupathi R. and Belegundu, Ashok D,2002)

Total Compressive Strength (Mpa)	**The Poisson Coefficient**	**Modulus of Elasticity (Mpa)**	**Density kg**/m	**Materials Used**
6.4	0.2	12000	1106.34	LWC.NO1
2.7	0.2	7500	735.22	LWC.NO2
2.3	0.2	2100	779	LWC.PS.NO1
28	0.2	21000	2400	NC6

Table 2: *Specifications of Filler Concrete and Cold Formed Steel of the Frame*

Analysis method in software

A model which largely is able to solve the issue of modeling concrete in the FEM program is damage model of plasticity which has the ability to analyze reinforced concrete under different loading whether periodic or steady.

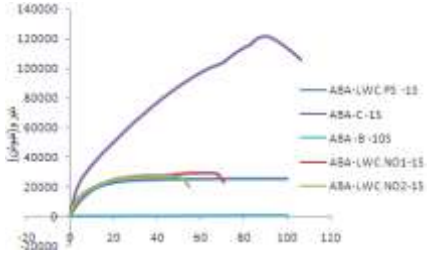
Selecting the most appropriate meshing method during performing the program has a decisive influence. Meshing method of concrete blocks (rectangular shape) by three-dimensional and 8-node elements has been conducted. Applied loads are gravity and lateral. The software automatically considers weight sections. Distribution of lateral loads is increasing and the pattern (concentrated

load) is used in accordance with the 2800 standard. In this study fittings are in form of joint and slip friction coefficient is considered equal to 0.25. To prevent damage to constructional and non - constructional elements against excessive displacements, relative lateral displacement of a level must not exceed a certain amount. Therefore, the relative lateral displacement of a level should be limited and analysis should be considered in form of nonlinear static of an increased load.

Force – Displacement Diagram

To compare the results with experimental observations, desired sample of ten craters frame has been achieved using finite element software and similar analyzed experimental conditions and displacement - force diagram. The obtained maximum base shear difference is almost equal to %8.8 which is acceptable.

Figure 2: *Comparison of the Diagram of Force-Displacement Samples in the Lab and Finite Element Analysis*



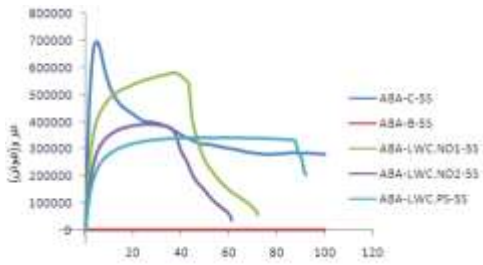


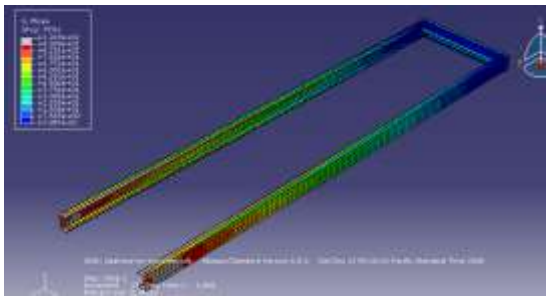
Figure 4: Comparison of Force-Displacement Diagrams for Models of *ABA-LWC.NO1-5S* and *ABA-LWC.NO2-5S*.

Figure 5: Comparison of Force-Displacement Diagrams for Models of *ABA-LWC.PS -5S* , *ABA-B-5S*, *ABA-C-5S*, *ABA-B-1S*, *ABA-C-1S ABA-LWC*, *PS-1S ABA-LWC*, *NO1-1S* and *ABA-LWC.NO2-1S.*

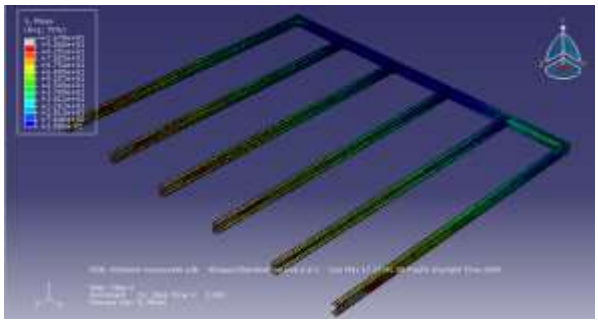
In the figure above displacement for 5 craters frames and one crater frame have been shown. As it is self-explanatory, filling walls with concrete increases displacement amount and maximum base shear level. Comparing frames filled with concrete and frames filled without concrete shows that filling walls with concrete will increase the AUC of force-displacement which indicates the energy absorption capability.

Distribution of Cracking Diagram

In this part of the model frames with one crater and frames with 5 hollow craters filled with lightweight concrete has been demonstrated. As it stands in the models of hollow frames, the greatest tension is observed at the foot of the column.



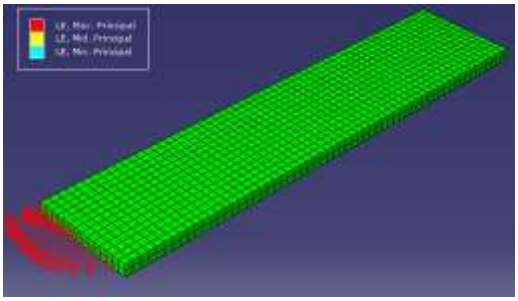
(A)



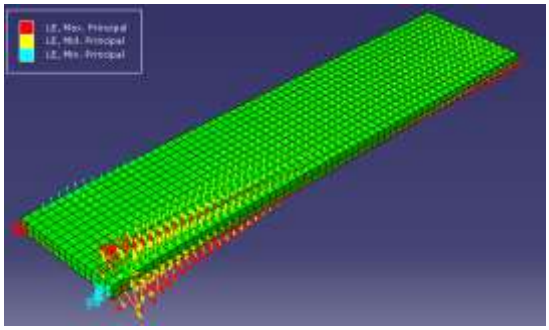
(B)

Figure 5: *Diagram of Tensile Stress in Steel for the Models of (A) ABA-B-1S and (B) ABA-B-5S.*

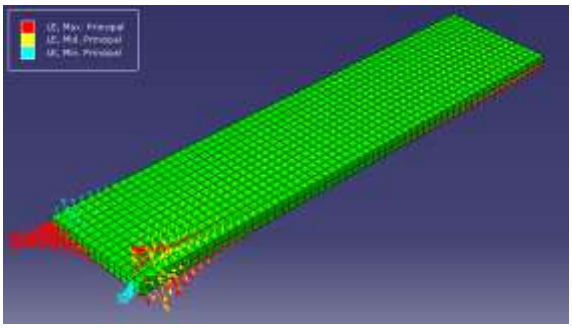
Concrete cracking depends heavily on non-linear behavior of materials, stress - strain diagram and stress intensity. Normal vectors shown in *Figures 6* and *7* indicate stress concentration, locations of maximum damages and cracks in the concrete. Also, direction of vectors is perpendicular to created cracks. According to the figures, the largest concentrations of tensions and cracks have been created at the bottom of frame. Also according to the shear failure of 5 craters samples, the diagonal cracks are evident in the middle of the walls. While for models with single crater the most frequent cracking are in areas of concrete connection with the studs and at the bottom of the frame.



(A)

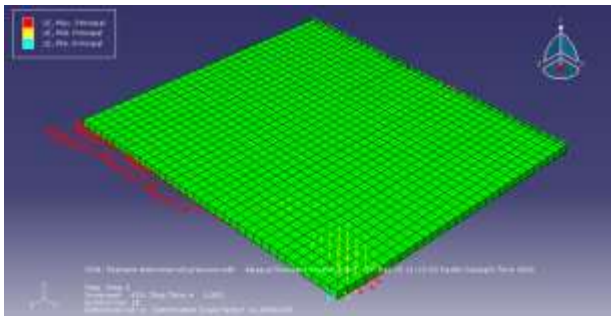


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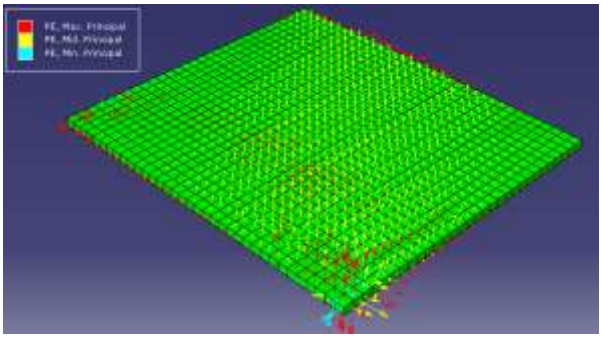


(C)

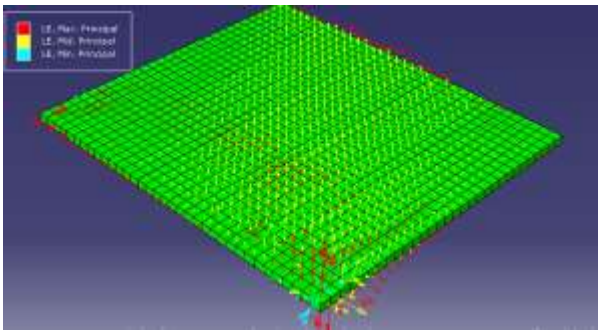
Figure 6: *Concrete Cracks Diagram for Models of: (A) ABA-C-1S (B) ABA-LWC.NO1-1S and ABA-LWC.NO2-1S and (C) ABA-LWC.PS -1S*



(A)



(B)



(C)

Figure 7: Concrete Cracks Diagram for Models of: (A) *ABA-C-5S*, (B) *ABA-LWC.NO1-5S* and *ABA-LWC.NO2-5S*, (C) *ABA-LWC.PS -5S*.

Results and Findings

The results of present research include:

- According to the diagram obtained from hallow and filled walls with one crater it has been concluded that in the hollow walls Most of the stress concentration and failure is located at the foot of the columns. In the filled walls with one crater, most stress concentration is located at the bottom of the frame and Non-linear behavior of constructions is flexural behavior. In walls with five craters, most damages have occurred in middle areas of the frame and Non-linear behavior of constructions is in form of shear behavior and it causes increased shear strength in the shear load.
- Cracking in the walls with five craters are shear form and diametric and it happens in the middle area but in the walls with one crater cracking occurs in the area of connection with fulcrum.
- The use of concrete increases the AUC of the force – displacement and increases strain, energy absorption capacity, ductility and increases constructions' strength. Due to the use of concrete with different strengths it can be concluded that the wall filled with polystyrene concrete withstands lower total force because of lower compressive strength, but because of mechanical properties and stress-strain curve, this type of concrete has the most displacement amount between four types of concrete and as a result its rupture and failure happens later. Also lightweight concrete type 1 in comparison with lightweight concrete type two, because of having high compressive strength has lower displacement and higher total force. Normal concrete because of having lower displacement in the frames with 5 craters for filling walls in the lightweight constructions are not recommended.

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