Experimental Investigation of Cold Formed Steel Sheet to Slip Failure Mechanism with Numerical Method Using ABAQUS

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***Abstract*— This study aims to understand the steel–concrete slip mechanisms In numerical study the specimen is modelled by dove tailed CF sheet with one-rib forms of composite member with embossment and without embossment with 3 different forms of embossment which is not available in the market by using cylindrical specimens for pull out test and they are tested for 7,14,28 days of curing and its dependence on geometrical and physical parameters, in order to improve designs for steel decking for composite slabs. A numerical methodology to build FEM models has been developed to arrive the longitudinal slip mechanism of composite specimen in ''pull-out'' tests. The chosen sections shall be modelled by using the Finite element software ABAQUS 6.10. After refining the model, the Non-linear numerical analysis of material and geometric shall be performed using Finite Element Software, ABAQUS 6.10.then the load vs. slip is arrived for various specimen and the maximum slip resisting embossment is recommended for manufacturing of CF sheets the percentage of deviation in results between various embossment shapes are compared.**

Keywords*— *Slip Mechanism, Embossment, , Pullout Test

I. INTRODUCTION

The longitudinal slip between the steel sheet profile and the concrete in composite slabs is usually an inefficient failure mode, since it‘s associated ultimate loads are far from ultimate bending moments. This slip is associated to longitudinal shear forces developed in simple bending. In order to improve the longitudinal shear strength, the current cold-formed steel sheet profiles present a repeated embossment pattern, of countless shapes and sizes, all along the span of the composite slab.

The present paper is devoted to fully understand the interaction mechanisms between steel sheet and concrete in composite slabs, by analysing the results of validated __pull-out'' test of reduced slab specimens in order to corroborate FEM results (ANSYSs code) and to analyse the dependence of slip resistance on steel sheet surface conditions. Thus, a FE methodology is established to design and improve steel sheets by analysing the sensibility of shear resistance in relation to: embossing depth and slope, sheet thickness, tilting angle, length, width and spacing of embossment and profiling angle of rib shape (from trapezoidal to dovetailed).

Other geometrical or physical parameter can be easily analysed with this methodology the mechanical basis Composite slabs prevent the longitudinal slip between steel sheet and concrete in simple bending, thanks to embossments on the sheet. Its function is the same as corrugations on reinforcing bars for concrete, but the resistant mechanism is quite different. In reinforced concrete, wedge effect of corrugations transforms the longitudinal slip to radial compression of the steel rebar and radial tension of concrete; both phenomena have a very high stiffness.

In composite slabs, on the other hand, wedge effect of the embossments on steel transforms the longitudinal slip to different actions between steel sheet and concrete, such as local bending of steel sheet especially important because of its very low stiffness and posterior vertical separation between both elements especially significant in open rib profiles. Therefore, the predominant physical phenomenon to be simulated by FEM is sliding contact with friction between steel and concrete surfaces, with pressures induced by wedge effect of embossments, specifically in the case of pull-out test.

II. Scope And Application Of Composite Structure With CF Sheets

In general, there are limited experimental reports on the shear resistances of typical interfacial shear between CFS and solid concrete slabs with local aggregates Moreover, while it is commonly reckoned that the presence of any tensile force in the headed shear stud will reduce its shear resistance significantly, there are few test data in the literature on combined shear and tensile resistances in solid concrete slabs Hence, in order to provide technical guidance and design data on the structural behaviour of the interfacial shear connections for construction a pull-out tests were carried out to obtain the shear resistances of the composite member in standard pull-out tests where the embossing faces are under direct longitudinal shear force,

A. *Applications of cold-formed steel*

Cold-formed shapes can be used for entire buildings and for complete roof, floor and wall systems. They can also be used as individual framing members such as studs, joists and truss members.

From structural standpoint, the cold-formed steel can serve as both primary structures and secondary structures. An example of the cold-formed steel used as primary structures is the steel stud load-bearing wall. Steel studs providing the lateral support to exterior wall finish are usually secondary structures since they rely on the primary structure for support.

B. *Regular decks*

Floor decks, roof decks and wall systems are the prime applications for cold-formed steel in panel form. These are made in both simple, or single-component types, as well as more complex units made up of several elements.

Permanent metal deck forms are fabricated from lightweight steel in thickness that vary from 0.020 to 0.075 inches (0.50 to 1.9mm) and depths of 2, 3, and 4-1/2 inches

(51, 76 and 115mm), depending on slab thickness and design span. Permanent metal deck forms are usually galvanized.

Permanent metal deck forms are designed to support the wet weight of concrete, a construction load, reinforcing steel and the weight of the form itself.

Composite metal deck forms also provide the tension reinforcement for the slab. The embossments provide interlock between the deck and the concrete. The ribs are generally trapezoidal in shape for roof and floor deck applications, although they may vary by manufacturer. The panels may be punched with a pattern of holes to absorb sound.

C. Multi-function deck

Some deck systems use cellular cold-formed steel shapes to permit lightweight floors that reduce deadweight. These floor systems can provide electrical power, communications and data cable distribution as well as heating and air conditioning ducts.

This eliminates separate space requirements in floors, walls and ceilings for ductwork or conduit systems. The modular construction possible with cold-formed steel sections permits access to many points in the deck, making it easy to rearrange wiring or ventilation outlets

III. TESTING METHODS

A. Existing method

In experimental study the specimen is casted by two confronted one-rib forms of composite slab .specimens are casted with CF sheets back to back at the middle of the cubes such as with embossment , without embossment and with shear connector for pull out test and they are tested for 7,14,28,54,90 days of curing .

A thick steel sheet(5 mm) joints and stiffens both forms . Upper tension load is applied to the cold-formed steel sheet prolongation. Steel screwed bars are inserted in concrete and used as bottom tension elements.

Lateral forces to reproduce the own weight of the concrete are applied at the upper and lower ends of the concrete block by means of pre-stressed springs and controlled by a load cell.. In spite of some obvious differences of behaviour between pull-out test and real slab bending, pull-out test is a very simple and cheap way to evaluate exclusively the longitudinal slip strength of new sheet designs, using a reduced dimensions sheet prototype

B. Proposed method

Specimens are casted with CF sheets at the middle of the cylinder such as with embossment, without embossment for pull out test and they are tested for 7, 14, 28 days of curing then the casted specimens are tested by pull out method in UTM and the results are plotted through graph for load vs slip for failure mechanism of composite structure for various types of CF sheets From the experimental results it has been clear that the maximum slip was resisted by chevron shape embossment because of its maximum shear key action.

The following are the different shapes of embossment selected for this test

1. Chevron shape embossment
2. Rectangular shape embossment
3. Tablet shape embossment

IV. NUMERICAL METHOD

The chosen sections shall be modelled by using the Finite element software ABAQUS 6.10. After refining the model, the Non-linear numerical analysis of material and geometric shall be performed for various embossments shapes the ABAQUS model is shown in the figure 1

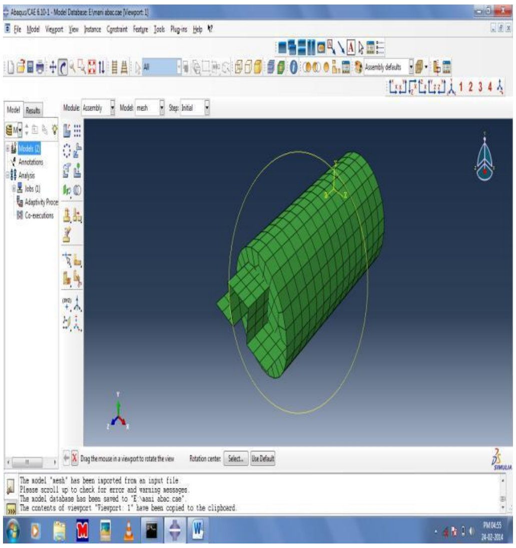

Figure 1. Numerical pull out model

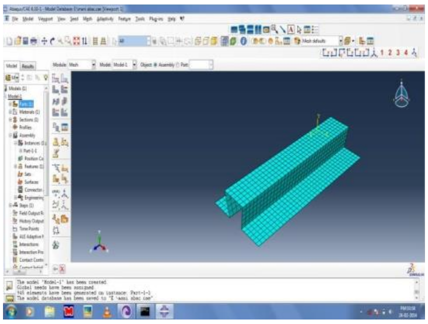

Figure 2. Numerical pull out model (CF sheet)

A. Numerical Results And Graphs Forchevron Shape Embossment (60x30 Mm)

Pull out test on cold formed steel sheet with chevron embossment (60x30 mm)

TABLE I. LOAD VS SLIP

LOAD (KN)	SLIP(mm)
35	6
30	4
25	3
20	2
15	0
10	0
5	0
0	0

Pull out test by numerical analysis on cold formed steel sheet with chevron embossment (60x30 mm)

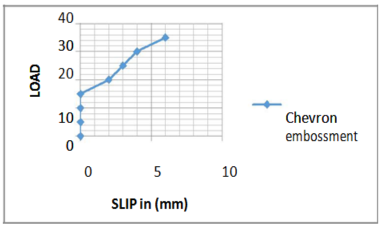

Figure 3. Load Vs Slip Graph

B. .Numerical Results And Graphs Forrectangular Shape Embossment (25x21 Mm) Pull Out Test On Cold Formed Steel Sheet With Rectangular Embossment (25x21 Mm)

TABLE II. LOAD VS. SLIP

Load (KN)	SLIP(mm)
35	11
30	8
25	5
20	2
15	2
10	2
5	1
0	0

Pull out test by numerical analysis on cold formed steel sheet with rectangular embossment (25X21 mm)

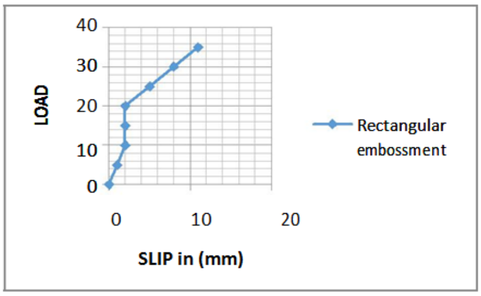

Figure 4. Load Vs Slip Graph

C. Numerical Results And Graphs Fortablet Shape Embossment (25x5mm)

Pull out test on cold formed steel sheet with tablet embossment (25X5mm)

TABLE III. LOAD VS SLIP

LOAD (KN)	SLIP(mm)
35	14
30	11
25	7
20	4
15	4
10	2
5	1
0	0

Pull out test by numerical analysis on cold formed steel sheet with tablet embossment (25X5mm)

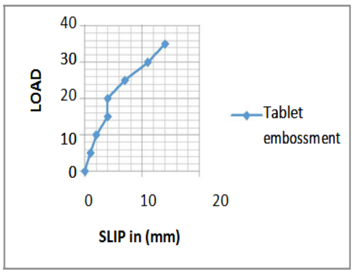

Figure 5. Load Vs Slip Graph

D. Numerical Results And Graphs For Without Embossment

Pull out test on cold formed steel sheet without embossment

TABLE IV. LOAD VS. SLIP

LOAD (KN)	SLIP(mm)
35	19
30	15
25	13
20	9
15	5
10	5
5	1
0	0

Pull out test by numerical analysis on cold formed steel sheet without embossment

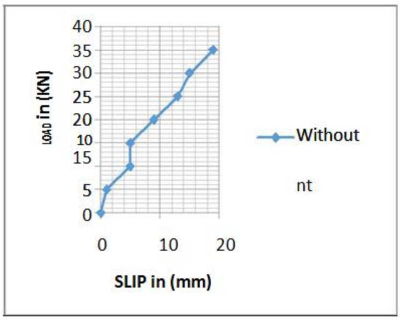

Figure 6. Load Vs Slip Graph

V. CONCLUSION

Specimens are modelled with CF sheets at the middle of the cylinder such as with embossment, without embossment for pull out test and they are tested for 7, 14, 28 days of curing. Then the modelled specimens are tested by pull out method using ABAQUS software and the results are plotted through graph by load vs slip for failure mechanism of composite structure for various types of CF sheets. From the numerical results it has been clear that the maximum slip was resisted by chevron shape embossment because of its maximum shear key action. The maximum slip occurred by numerical method for chevron, rectangular, tablet and without embossment are 6,11,14,19 mm respectively. The results shows that the chevron shape embossment is embossment is 0.5 times more slip resistant then without embossment sheet.

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