Flextural Study on Cold Formed Steel Infilled with Construction Waste – Broken Tiles

Numburi R. Dharma Krishna[1], M. Senthil Pandian[2]

[1] *PG Student, School of Mechanical and Building Science, VIT Chennai, Chennai-600127, Tamil Nadu.*

[2] *School of Mechanical and Building Science, VIT Chennai, Chennai-600127, Tamil Nadu*

ABSTRACT

Cold formed steel are manufactured from thin steel sheet at a very low temperature. The thin sheets of steel are rolled or compressed to desired sections. The thickness of these steel products generally ranges from 0.3mm to 6mm approximately. Due to its thickness they are weak when compared to hot roll steel products. So they are infilled with concrete or other high strength materials. In this research, rectangular cold formed steel sections were considered and was infilled with concrete in which coarse aggregate is replaced with construction waste (broken tiles). In this paper, the first stage deals with the optimum percentage replacement of broken tiles which is replaced at 10%, 15%, and 20% weight of coarse aggregate. The optimum percentage replacement is then infilled to rectangular cold formed steel sections and the flexural properties for the same is studied using ANSYS software.

Keywords: Cold formed steel beams, construction waste, and broken tiles.

1. INTRODUCTION

Cold form steel is the common term for products made by rolling or pressing thin gauges of steel sheet (refer Fig 1 and Fig 2). These are thin sheets of steel products which are extensively used in building industry, and range from purlins to roof sheeting and floor decking [1]. These building materials encompass columns, beams, joists, studs, floor decking, built-up sections and other components. Generally these are available for use as basic building elements for assembly at site or as prefabricated frames or panels. These thin steel sections are cold-formed, i.e. their manufacturing process involves forming steel sections in a col state (without application of heat) from steel sheets of uniform thickness. These steel members have been used in many bridges, coaches, highway products, transmission towers and transmission poles etc. The thickness of these sheets ranges from 0.0147in. (0.373mm) to about ¼ in. (6.35mm)[2]. They are week in strength when compared to hot rolled steel since it is manufactured in low temperature. Hence they are infilled with concrete or other high strength materials.

In this paper, cold form steel is infilled with concrete in which coarse aggregate is replaced with construction waste (broken tiles). Broken tiles are replaced to coarse aggregate in such a way that the percentage weight is optimum. The optimum percentage replacement was determined from three different replacements. After replacing it is then tested under three point loading to find the flexural properties. Also, using ANSYS, models were prepared for the same and compared.

Fig 1. Cold formed steel

Fig 2. Cross section of cold formed steel

2. MATERIALS USED

Cement- In general, cement is a binder. It has an ability to bind itself independently and can also bind other materials together. Cement used in constructions are characterized as hydraulic or non-hydraulic. Ordinary Portland cement is used in this research.

Fine aggregate- Fine aggregate is natural sand which has been washed and sieved. Their particle size varies from 0.075mm to 0.425mm and the sieve analysis test shows that the soil belongs to zone 1 of soil classification.

Coarse aggregate- The particle size of these aggregates are comparatively larger than the size of fine aggregates. They vary from 4.75mm to 20mm. these aggregates tends to improve the quality and bond characteristics and generally results in a higher flexural strength of concrete.

Broken tiles- Only the broken tiles from construction waste were collected for this research. They were taken from the sites of VIT University. The size of these tiles are 20mm.

Cold formed steel- These are the products made by rolling or pressing thin gauges of steel sheet. In Indian market, these are named as CR tubes aka cold rolled. They come in 6m length and in various thickness ranging from 0.0147in. [0.373mm] to about ¼ in. [6.35mm]. In this research cross section of cold-formed steel is taken as 100mm x 50mm, 2.5mm thickness and 1m long sections.

Polyethelene glycol- Since it is impossible to cure cold formed steel in water, this chemical acts as self-curing agent. It is liquid state and it is added to water. The quantity of this chemical used in concrete equals 2% of cement content.

Properties of various components discussed above were calculated. All the preliminary tests were carried out in laboratory (refer Table 1).

Table 1. Properties of various components.

S No	Properties	Values
1	Consistency test	30%
2	Initial and final setting time	35mins & 7 hrs
3	Specific gravity of cement	3.15
4	Specific gravity of fine aggregate	2.74
5	Specific gravity of broken tiles	2.30

3. PROCEDURE

This research contains three stages. First, designing concrete mix M25 for three different percentages. Second, to find the optimum percentage replacement of coarse aggregate with broken tiles from three different percentage replacements by calculating various properties like compression strength. Third, to prepare models of cold formed steel infilled with concrete made of broken tiles and find the flexural properties.

1. Mix design for M25 grade concrete.

Concrete mix for M25 grade concrete was designed under BIS method. Also, mix for three different percentage replacements i.e. for 10%, 15% and 20% were designed (refer Table 2 and Table 3).

Table 2. Mix design for convectional concrete of grade M25

Proportion	Water [Kg]	Cement [Kg]	Fine agg. [Kg]	Coarse agg. [Kg]
Per m3	197.1	438	636.7	1182.6
Ratio	0.45	1	1.45	2.7

Table 3. Mix design for different percentage replacements

% replacement	Water [Kg]	Cement [Kg]	Fine agg. [Kg]	Coarse agg. [Kg]	Broken tiles [Kg]
10	197.1	438	636.7	1064.3	99.3
15	197.1	438	636.7	1033.7	148.9
20	197.1	438	636.7	984.1	198.5

2. Finding the optimum percentage

To infill concrete with broken tiles in cold formed steel beams, an optimum percentage replacement is to be calculated among 10%, 15% and 20% replacement of total weight of coarse aggregate. This was calculated by finding the compression strength of concrete made by replacing these percentages of broken tiles.

18 cubes of size 0.1m x 0.1m x 0.1m were casted and kept for self-curing to find both 7day and 28day compression strength (refer Table 4).

Table 4. Compression strength of concrete cured for 7-days & 28 days

% replacement	7-day strength [N/mm^2]	28-day strength [N/mm^2]
10	18.05	28.6
15	17.54	27.81
20	17.19	27.28

From the above compression strengths of concrete with broken tile replacements at 10%, 15% and 20% weight of coarse aggregate, it is concluded that 10% replacement of coarse aggregate with broken tiles is optimum among other two percentage replacements.

3. Analysis

To analyze the flexural properties of cold formed steel infilled with concrete, ANSYS v12 was used. Flexural properties like deformation, normal stress and strain were observed. Two cases were

considered in this analysis. First, analyzing cold form steel without any concrete infillement and second, cold formed steel infilled with concrete made of broken tiles. For 100KN point load at the center, the flexural properties observed as.

a. Deformation (refer Fig 3a, 3b)

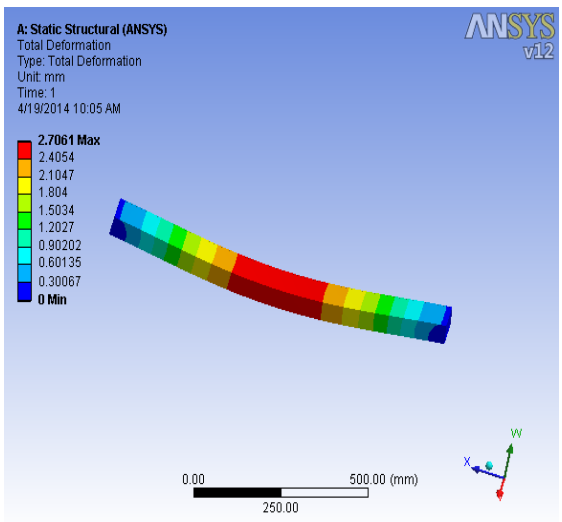

Fig 3a. Cold formed steel with concrete

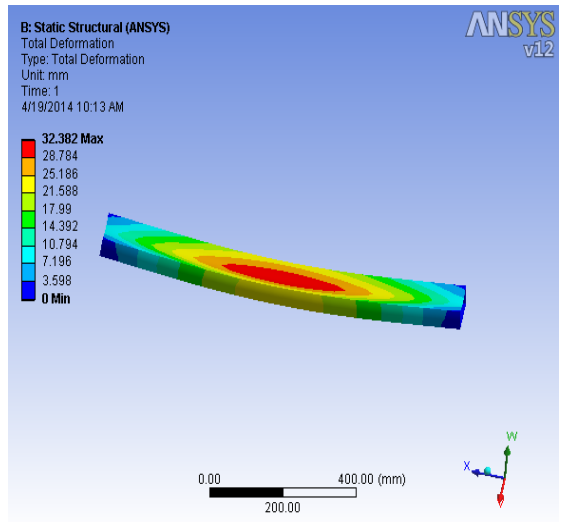

Fig 3b. Cold formed steel without concrete

b. Normal stress (refer Fig 4a, 4b)

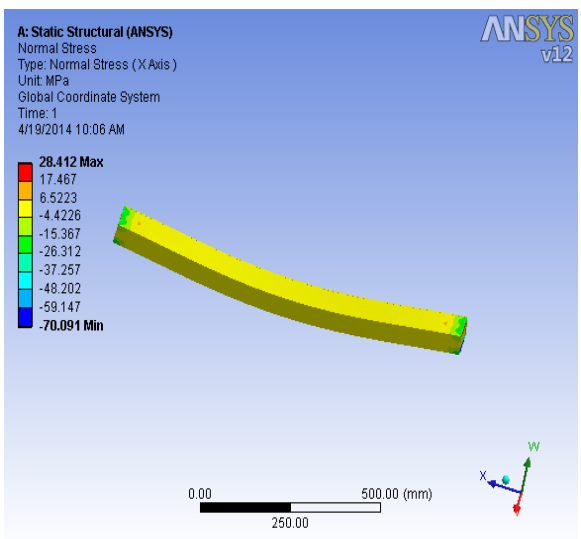

Fig 4a. Cold formed steel with concrete

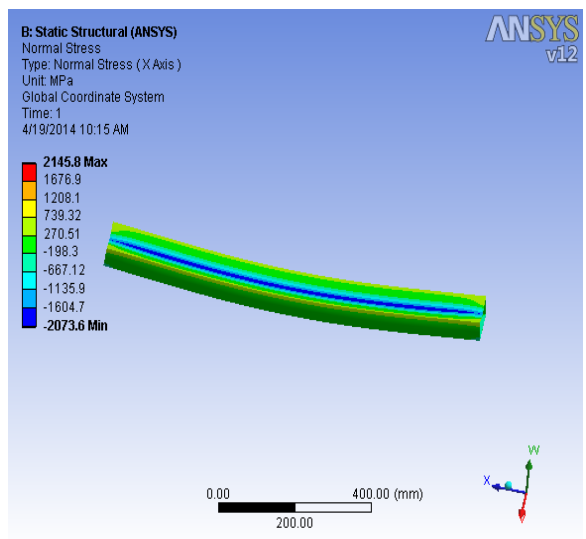

Fig 4b. Cold formed steel without concrete

c. Normal strain (refer Fig 5a, 5b)

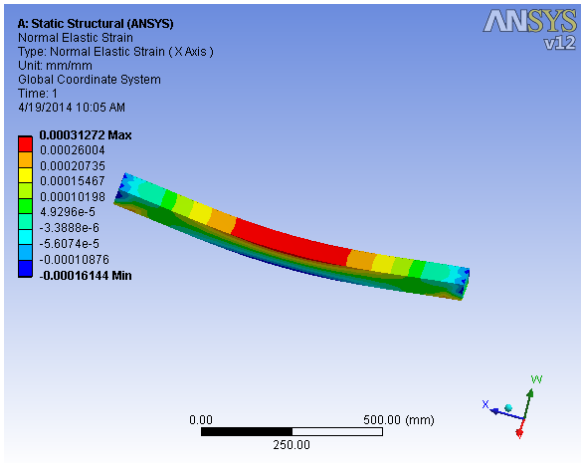

Fig 5a. Cold formed steel with concrete

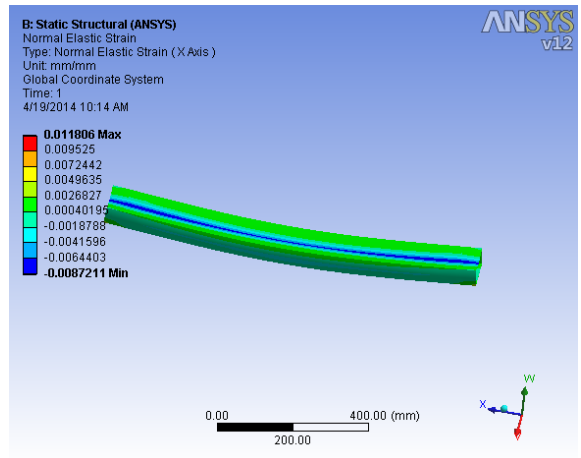

Fig 5b. Cold formed steel without concrete

4. RESULTS

In case of deformation, cold formed steel infilled with concrete made of broken tiles have less deformation when compared to the deformation cold formed steel without concrete. Deformation was reduced to almost 29%

In case of stress and strain, cold formed steel infilled with concrete shows better performance. Stress and strain were vey less when cold formed steel is compared with and without concrete (refer Table 5)

Table 5. Stress Strain values of cold formed steel with and without concrete

Flexural property	Infilled with concrete	Without concrete
Strain	3.1 x 10-4	0.0118
Normal stress	28.412 MPa	2145 MPa

5. CONCLUSION

Flexural properties were studies for cold formed steel with concrete made of construction waste (broken tiles) and cold formed steel without concrete. Since broken tiles were used as the partial replacement of coarse aggregate the properties were observed to be less.

From this research, it is concluded as cold formed steel infilled with concrete made of broken tiles has shown better results when compared to cold formed steel beams without concrete.

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