EXPERIMENTAL INVESTIGATION ON EFFECT OF ANGULAR SHEAR CONNECTOR IN COMPOSITE ELEMENT

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ABSTRACT

The use of cold-formed steel sections as major structural members is still limited. This is largely due to thinness of the sections. Exploitation of composite principles seems appropriate for promoting the use of the sections to a wider range of applications. A steel-concrete composite column is a compression member, comprising either a concrete encased hot-rolled steel section or a concrete filled tubular section of hot-rolled steel and is generally used as a load-bearing member in a composite framed structure and girders used as a beam sections. Hence, a new type of composite cold-formed steel sections embedded in precast concrete plank where by usage of a new proposed shear transfer enhancement called Stud is suggested. The composite sections are partially concrete encased steel section. Results of four companion push-out specimens are presented herein, focusing on the strength and behavior of a stud enhancement. The highest load carrying capacity of the column with 60° enhancements is 68.9KN which is more than conventional composite column. Load carrying capacity of the conventional column is 35.44KN. The result shows that specimens employed with stud enhancement increase the shear capacities of the specimens as compared to those relying only on a natural bond between cold-formed steel and concrete. Stud provide the best performance in terms of strength. It is concluded that the proposed stud enhancement has sufficient strength and it is feasible. The experimental and numerical results are compared and the behavior and failure modes are discussed.

INTRODUCTION

Thin sheet steel products are extensively used in building industry, and range from purlins to roof sheeting and floor decking. 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 cold state (i.e. without application of heat) from steel sheets of uniform thickness. These are given the generic title Cold Formed Steel Sections. Sometimes they are also called Light Gauge Steel Sections or Cold Rolled Steel Sections. The thickness of steel sheet used in cold formed construction is usually 1 to 3mm. Much thicker material up to 8 mm can be formed if pre-galvanized material is not required for the particular application. The method of manufacturing is important as it differentiates these products from hot rolled steel sections. Normally, the yield strength of steel sheets used in cold-formed sections is at least 280 N/mm$^2$, although there is a trend to use steels of higher strengths, and sometimes as low as 230 N/mm$^2$. Manufacturers of cold formed steel sections purchase steel coils of 1.0 to 1.25 m width, slit them longitudinally to the correct width appropriate to the section required and then feed them into a series of roll forms. These rolls, containing male and female dies, are arranged in pairs, moving in opposite direction so that as the sheet is fed through them its shape is gradually altered to the required profile. At the end of the rolling stage a flying shearing machine cuts the member into the desired lengths. An alternative method of forming is by press-braking which is limited to short lengths of around 6 m and for relatively simple shapes. In this process short lengths of strip are pressed between a male and a female die to fabricate one fold at a time and obtain the final required shape of the section. Cold rolling is used when large volume of long products is required and press breaking is used when small volumes of short length products are produced.

**OBJECTIVES**

The objective of this project is to investigate experimentally the efficiency of the Stud in push-out test and to determine the strength and behavior of the shear transfer enhancement in steel-concrete composite construction.

- To determine the strength and slip characteristics of the stud shear connectors.
- To study the strength and behavior of the shear transfer enhancement with different orientation of angles.
- To study the modes of failure of the members under static loading.

**REQUIREMENTS OF COMPOSITE SECTIONS**

The specimen setup contains steel pipe and PVC mould on both sides. Stud connected with welded connection. Dimension of the steel section 600mm height, 110mm diameter and 2mm thickness filled with M20 grade concrete. Dimension of the stud is 20mm length and stud head is 5mm diameter.

![Fig.1 Experimental Setup of Control Specimen](image-url)
CONCRETE GRADE

- For normal concrete the concrete class is $21 \text{MPa} \leq f'c \leq 55 \text{MPa}$
- For light weight concrete the concrete class is $f'c \geq 28 \text{MPa}$
- Structural steel and reinforcement bars grade. The yield strength is $F_{y} = 415 \text{N/mm}^2$.

SHEAR ENHANCEMENT IN COMPOSITE SECTION

Shear connection, by means of either dowel connectors or rib connectors are the most widely used arrangements. The former is found in standard composite beams whilst the latter is used in profiled sheeting composite members. Shear connector is function as the holder between the concrete and steel due to the inadequate bonding. Stud is one of the economic types of shear connectors widely used in the composite construction. In building construction the studs are welded through the steel deck into the structural steel framing; in bridge construction the studs are welded directly to the framing. The head of the stud is intended to resist the pull out force while the shank of the stud and the welding are intended to resist the horizontal force.

In column section shear connectors to resist vertical shear between concrete and steel where the bottom part of the shear connector transfers the vertical shear and hold the concrete. Types of shear connectors include studs, channels, stiffened angles, and flat bars. There is variety of shapes, sizes, method of fixing and its choice is increasing to cater for changing demands. Because of both the variety and the complex mechanism by which the shear is transferred, the material properties of mechanical shear connectors are always determined empirically. The main problem for cold-formed steel-concrete composite column is on the welding of shear stud due to the light gage and thickness of the sections for cold-formed steel is too small. From this view point, this research was carried out to study the possibility and performance of the use of new proposed shear transfer enhancement called stud for application in the composite cold-formed steel-concrete columns.

METHODOLOGY

Literatures related to the composite column members with shear enhancements were collected and based on the literature survey preliminary works were performed. Fabrication of steel channel section with different angles of enhancements was done. Safe load carrying capacity of the
Concrete encased in three portion of the circular tube section. All the specimens were tested for compressive strength under static reaction type loading frame. Load was applied on the circular steel section. Behaviors of stud & concrete and their modes of failure were studied, based on the experimental results and numerical analysis, behaviour of the stud was compared. Cold-formed steel cylindrical section is used with diameter 110mm, height 600mm and thickness 2mm of steel section. Size of the PVC mould for both side same as steel section. The size of stud 20mm length and diameter of the stud head 5mm.

**Fig. 6 Experimental Setup**

**In Section with 45° shear enhancement**

In section with 45° orientation of shear enhancement, the failure occurred only on the concrete.

**Fig.11 Specimen with 45° orientation**

**In Section with 60° shear enhancement**

In Section with 60° orientation of shear enhancement the failure occurred only on the concrete.
CONCLUSION

The results show that specimens employed with shear transfer enhancements increase the shear capacities of the specimens as compared to those relying only on a natural bond between cold-formed steel and concrete. As the steel and concrete element dimensions were kept constant for all the specimens, no effects were observed from the dimensional properties. Two types of specimens investigated, stud provided the best performance in terms of compressive strength, shear transfer in composite section member.

REFERENCES

1. Shuaib, Ahmad; Fedroff, David; Sayas, BanuZeynep., Freeze-Thaw Durability of Concrete with Ground WasteTire Rubber Transportation Research Record 1574 1997.