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Experimental study on U-Shaped steel girders using different connectors

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***Abstract*---**U-shaped steel girders are a kind of structural steel that is often utilized in the construction industry. This article examines the two types of connectors used in u-shaped steel girders to determine which has the least deflection. The flexural test and compressive strength of the specimens were examined experimentally by the authors. Two u-shaped steel girders with a length of 1100mm, a span of 300mm, a depth of 100mm, a bottom plate of 75mm, and 35mm flanges each were constructed to test the endurance of two connections in this scenario. This experiment employed l-shaped angled connections and stud/shear connectors. After 28 days of curing, each specimen was tested. The effectiveness of each combination was examined in order to provide design suggestions. When compared to standard composite beams, a U-shaped steel-concrete composite girder offers stronger flexural resistance, good fire resistance, and improved sound insulation owing to the infilled concrete. However, there has been researching on the shear resistance of angle-shaped connections in U-shaped composite beams, making it difficult to determine which shear connector is best for U-shaped composite beams. According to previous studies, U-shaped composite beams with headed stud shear connections and steel angles all had an excellent flexural performance.

***Keywords*---** experimental study, U-Shaped, steel girders.

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Introduction

U- shaped girders are also referred to as flange channel or c beams. These u-shaped girders may be welded together to make i-shaped girders as well. The flat side of these u shaped girders is fastened to the wall or any flat surface to give support, and the two smaller plates are welded together to make the u shape. When positioned vertically, these u-shaped steel girders are more efficient, stronger, and durable, but they are also strong when put horizontally when the load operating on them is considered. Steel girder designs in which the concrete dect slab is supposed to serve as an integrated part of the beam are considered composite construction. The double-composite bridge concept comprises a composite bottom concrete slab in addition to the top composite slab in parts of the span having negative moment[1]. The behaviour of the original structure, a continuous steel-concrete composite deck, was compared to that of a new technique with double composite action. The results of the dynamic studies showed that the double composite action solution is more effective than the typical composite deck, with overall reductions in vertical displacements (average reductions of 11% and 17% for actual trains and the HSLM model, respectively) and deck accelerations (reductions ranging from 14 % to more than 36 %)[2]. A parametric study was conducted to determine how various elements, such as the height of the steel beam, the thickness and length of the bottom slab, the diameter of the studs, and the way they are placed, impact their capacity to fracture. By comparing the findings to the available experimental data, the recommended model is proven to be capable of accurately analysing steel-concrete composite beams[3].

Concrete slab cracking affects sectional stiffness in the continuous composite girder's negative flexural region, which may affect the reinforcement's lifetime. Double composite action is the process of adding extra concrete to the steel bottom flange to enhance local buckling strength and increase sectional stiffness[4]. Double-composite action in the negative moment zone was used to increase the flexural stiffness of composite sections and to exacerbate buckling concerns with steel plates. A mix of steel box girders and double-composite truss girders was also employed throughout the length of the bridges to permit the building of longer span bridges[5]. The concrete deck in negative moment locations is ignored in the design of continuous composite bridges since the concrete slab has no tension resistance. As a consequence of the composite section's flexural stiffness being reduced in the area of negative moments, the depth of the steel section rises. Push-out tests on lying studs and mixed stud shear connections with lying and vertical studs were used in this work to investigate the behaviour of the shear connection in the double composite section. The static strength of the shear connection was also evaluated[6]. In addition to the concrete deck slab, continuous steel composite bridges with double composite action include a concrete bottom chord at the haunches above the main piers. This bottom chord is built of concrete, making it stronger and less expensive to construct.

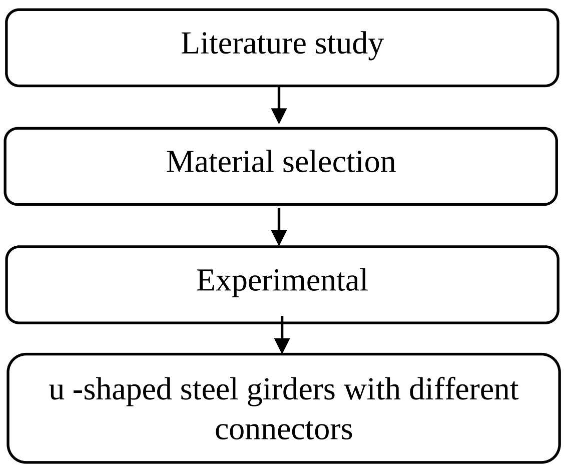
Three bridges, each with a primary span of more than 200 metres, serve as demonstrations of the design's advantages. The dispute over prestressing vs strengthening the highway slab at the piers is also discussed[7].In traditional composite beams, headed shear studs or small channels are commonly employed to transmit shear force between the wide-flange girders and the concrete slabs and to prevent the slabs from separating from the supporting wide-flange girders. Recent research in the related topic has focused on producing new types of composite beams that assist cut costs, alleviate construction difficulties associated with shear connections, or avoid certain negative steel girder behavior.

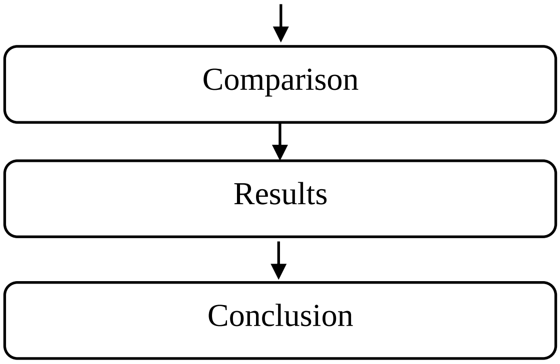
Materials and Methodology

Materials Properties

Cement is a substance used in construction that sets, hardens, and clings to other materials in order to bind them together. Cement is typically used to bind sand and gravel (aggregate) together rather than on its own. Masonry mortar is made from cement combined with fine aggregate, while concrete is made from sand and gravel. Concrete is the most frequently used substance on the earth, second only to water in terms of consumption. Cements used in construction are typically inorganic, based on lime or calcium silicate, and are classified as either non-hydraulic or hydraulic, depending on their capacity to set in the presence of water (see hydraulic and non-hydraulic lime plaster). River sand may be replaced by manufactured sand. It comes from the crushing of hard granite rocks. It is dust-free, thus it fits the grading requirements for the provided structure. It has a cubical form and is made by high-carbon steel striking rocks and then going through a rock-on-rock process. The particle size of the sand ranges from 150 microns to 4.75mm in suitable proportion. Because of the rapid growth of building employing M Sand, the demand for sand has skyrocketed. M Sand's transportation costs were low. The majority of coarse aggregates are utilized in the preparation of concrete for construction. Sand, gravel, crushed stone, and other granular and irregular materials are used to make it. Coarse aggregates are a natural substance created by blasting and crushing rocks in quarries. Before employing the aggregate in concrete, it is essential to wash it. The size and strength of the aggregates will have a variety of effects on the concrete, therefore they must be carefully chosen.

Methodology





Preliminary test

The goal of this research was to look at the flexural behaviour of composite beams with angle and shear connections in U-shaped steel girders, as well as the results of compression and flexural tests. Ambient curing is done for Testing specimens.

Compressive strength

Table 3.1
Compressive strength

SPECIMEN	DAYS	Compressive strength (MPa)
	7	14.3
A	28	19.6
	7	13.9
B	28	21.8

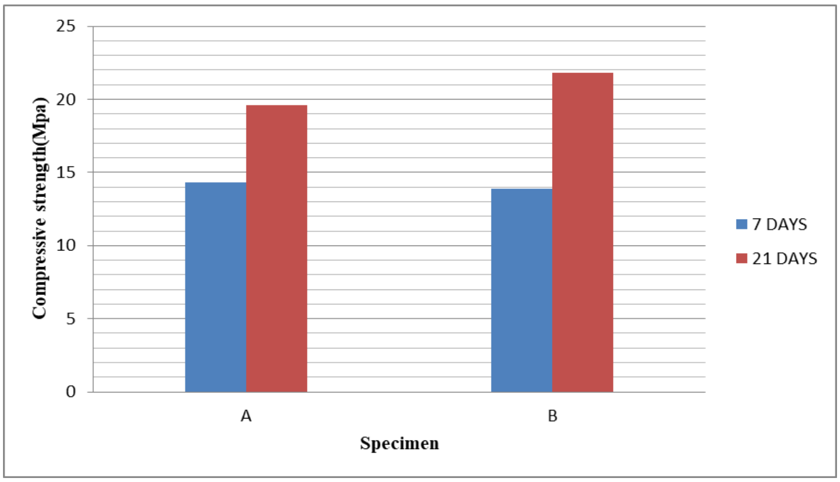


Figure 3.1. Compressive strength

Flexural test

Table 3.2
Flexural test

Specimen	Days	Flexural test (MPa)
A	28	2.86
B	28	2.94

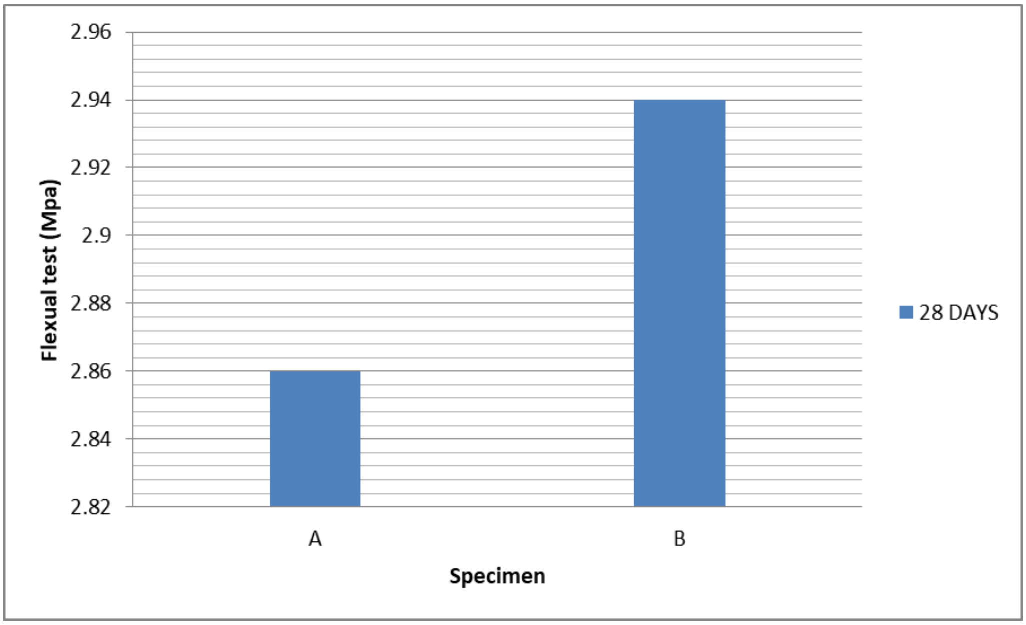


Figure 3.2. flexural test

Results and Discussions

Experimental

Three composite beams were selected from the analytical findings of the composite model for experimental work on this inquiry, and a composite beam specimen was constructed and casted to highlight the comparison between analytical and experimental work. The specimens CB-1, CB-3, and CB-5 were selected for experimental work based on analytical findings, and the detail portion of the specimen is depicted in the image below.

Figure 4.1

Figure 4.2

Following the preparation of the composite beam and mould work, a concrete mix ratio of 1:1.5:3 with a water cement ratio of 0.52 is selected and cast. The concrete findings are shown in the result and discussion section.

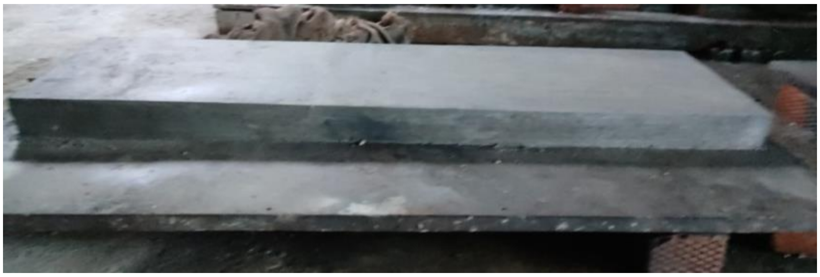


Figure 4.3

Test setup

All specimens were to be bent at four points, with one end fastened and the other simply supported. Figure 4.4 depicts the test setup in further detail. At one-third distance from the specimen, two equal point loads were applied. The interior beam segment (the portion between the point loads) was subjected to pure bending for each specimen loaded by this setup, whereas the exterior beam segments (the portion from one end of the beam to the adjacent point load) were subjected to constant shear and linearly increasing bending moment.

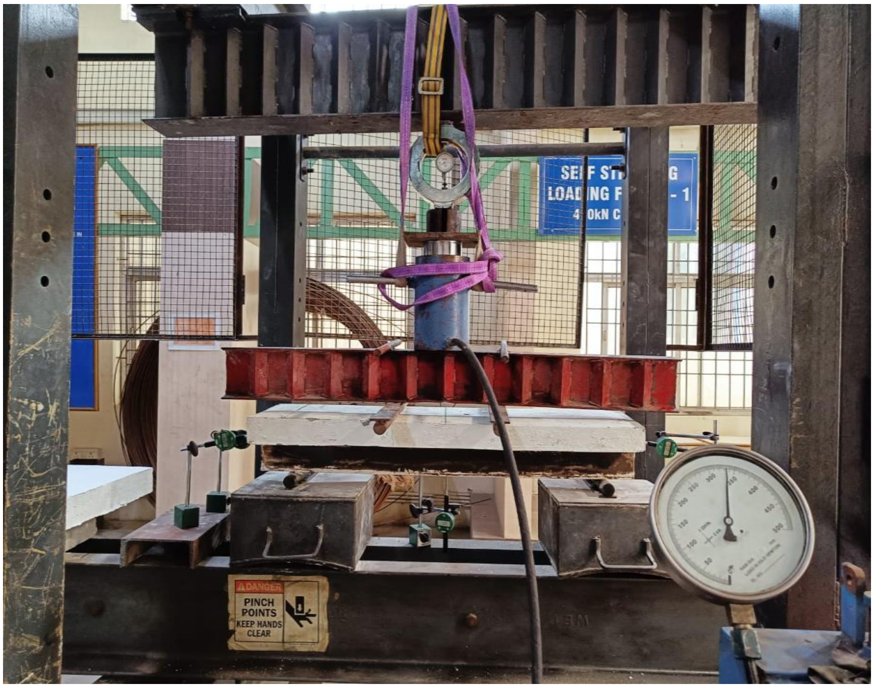


Figure 4.4

Experimental results

Load on each specimen was monotonically increased with load increment of 5kN per step at speed of 5kN/min up to the elastic limit of each specimen. Then the load increment is stopped at 300kN per step till the ultimate state. The load increments were controlled with force control protocol during the tests. The load was sustained for 3 min at the end of each step to note the observations and recording the progressively developed damages in each specimen. Below details gives the detailed results of experimental work on composite beam

Load point and maximum deflection

Deflection refers to the part from the structural element when the member is under the load at the centre, there will be a slight curve at mid span. For instance, when the beam is under load max deflection will occur at the centre of the beam and at the load point.

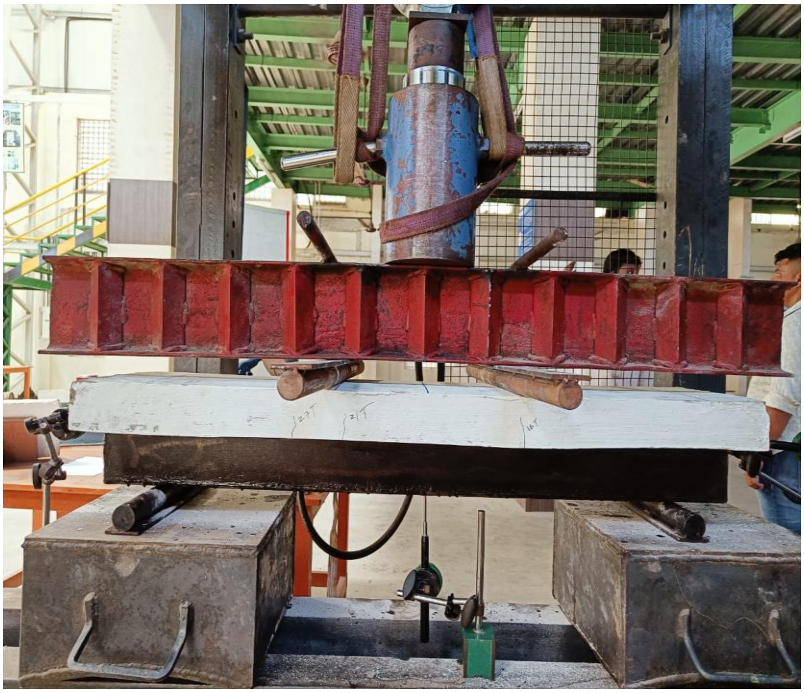


Fig 4.3a – Deflection after testing

Angle Welded to Flange

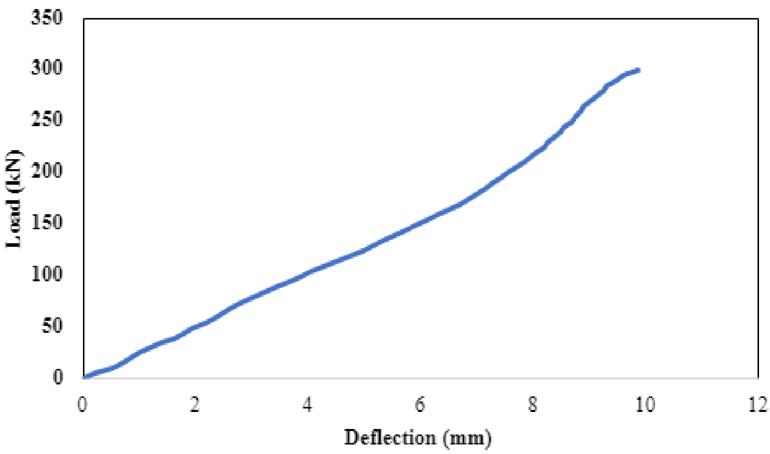


Fig 4.2.2a – max deflection

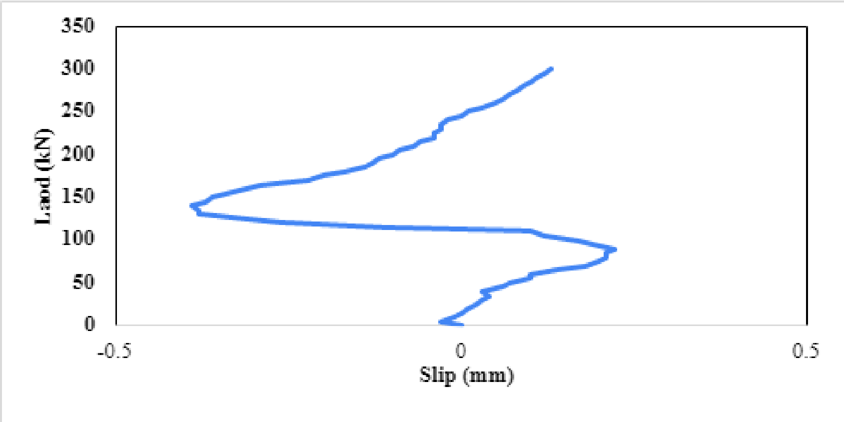


Fig 4.2.2b concrete slip

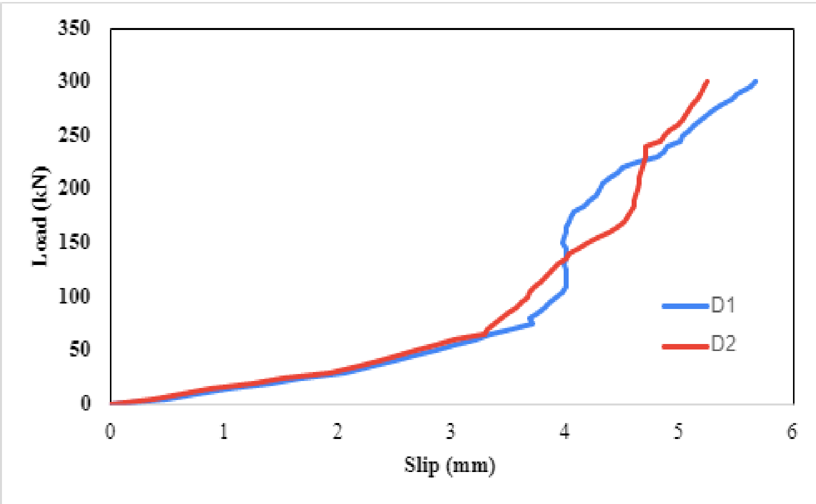


Fig 4.2.2c steel slip

Headed stud connector

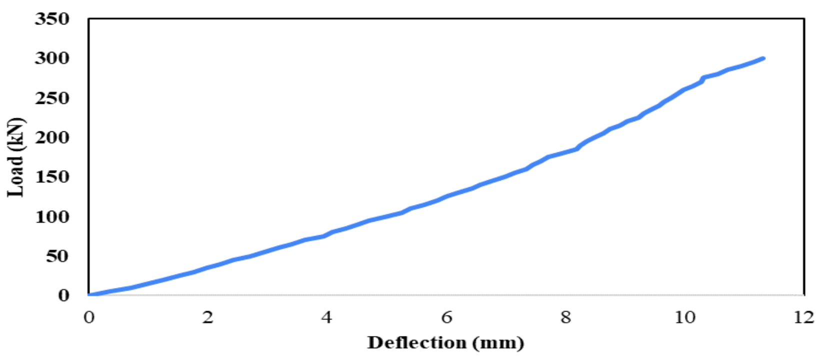


Fig 4.2.3a – max deflection

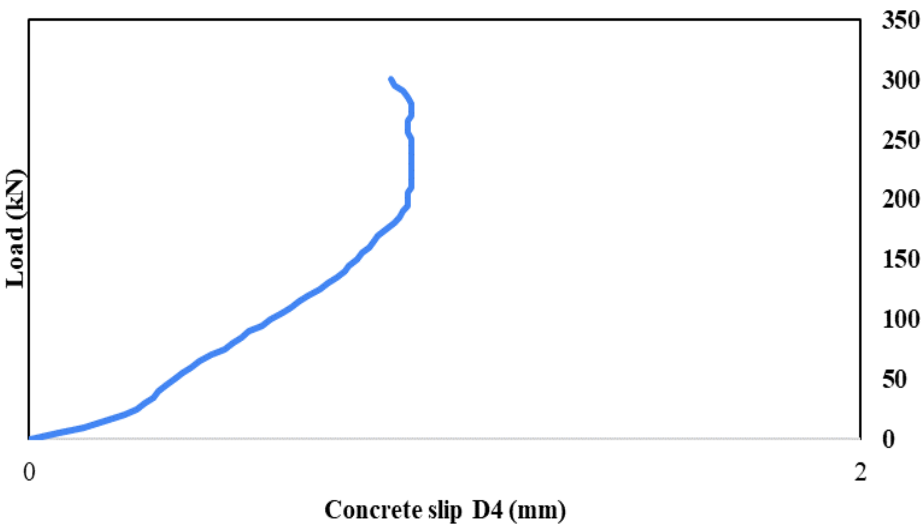


Fig 4.2.3b concrete slip

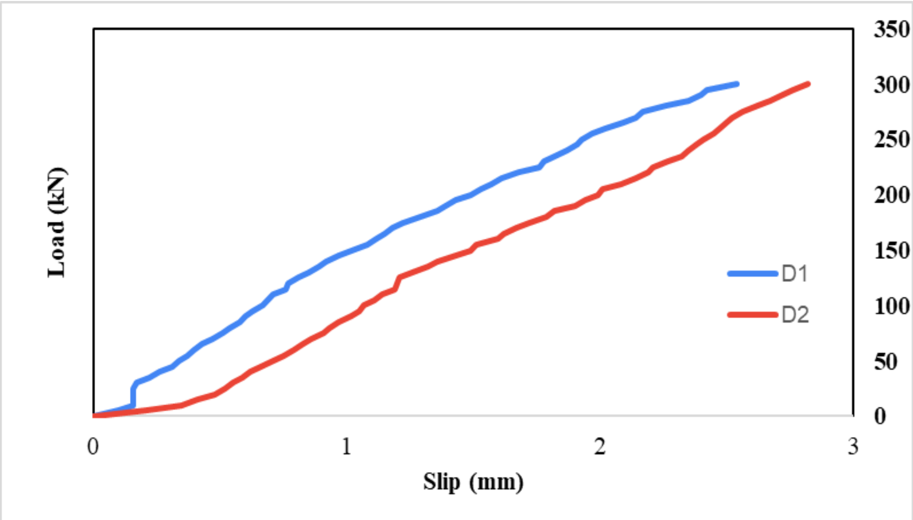


Fig 4.2.3c steel slip

Conclusion

Both the specimens and the speciments in this experimental investigation of employing angle connectors and stud/ shear connectors in composite steel beams were subjected to deflection and cracking. When compared to angle connections, stud connectors had greater deflection. In this experiment, the angle connection had less deflection than the stud connectors, and these angle connectors had better load bearing capability. Due to the lower deflection seen during this testing, angle connections are more effective than stud connectors.

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