



**INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH  
TECHNOLOGY**

**Experimental Study on Cold Formed Steel Composite Metal Deck Slab**

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**Abstract**

Composite deck slab is the advanced method of casting concrete slab with profile metal decking used in tensile zone. The decking acts composite with the concrete under service loading. The behavior of a composite profiled slab is extremely complex and is directly dependant on deformability and contact strength. The exact nature of the bond between concrete and steel is still not well understood because of the slip at the interface between the profiled sheet and the concrete element. Main aim of this paper is to investigate the structural behavior of composite slab with stainless steel deck. Purpose of using stainless steel deck is getting higher strength as well as corrosion resistance. As per Euro code and British code criteria, slab will be casted with different shear spans. Flexure, shear and longitudinal slip test will be performed on four full scale slabs. Test result for different shear spans will be compared.

**Keywords:** Composite metal deck slab, flexural test, shear bond capacity, longitudinal slip.

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**Introduction**

Now days in the world wide pertaining to technological development there is an enhanced intention imposed on building construction industry to improve time, economy and structural efficiency of structures. Composite slabs made of profiled steel sheet and concrete satisfy these demands by integrating several recent developments of research studies. Modern profiled steel sheets are mostly designed to act as both formwork and tensile reinforcement. Composite construction has become popular in western countries because it combines structural efficiency with speed of construction to offer an economic solution for a wide range of building types.

Composite construction refers to any members composed of more than one material. The parts of these composite members are rigidly connected by means of shear connector and mechanical interlocking through embossment such that no relative movement between the members can occur. In other words Composite construction refers to two load-carrying structural members that are integrally connected and deflect as a single unit.

Composite construction aims to make each material perform the function it is best at. Composite construction combines the better properties of the both i.e. concrete in compression and steel in tension, it helps to design a section having lesser depth and

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thereby a substantial saving in material cost is possible.

In composite metal deck slab, decking is made up by cold formed carbon steel sheet (painted or galvanized) act as a permanent formwork and as a tensile reinforcement to a concrete slab. The profiled decking is embossed for the ease of mechanical interlocking to improve shear bond characteristics of composite slab. Composite deck construction is particularly competitive for medium- or long-span structures, where there is a premium for rapid construction or where a low/ medium level of fire protection to steelwork is sufficient.

There are several limitations to design of Cold formed steel concrete constructions. Corrosion: corrosion resistance of cold-formed steel sections depends on the type and thickness of the protective treatment applied to the steel. Fire: Due to the small values of section factor the fire resistance of unprotected cold-formed steel sections is reduced. Impact: Resistance to impact is low and it may not behave in ductile manner.

To overcome the problems highlighted, cold formed stainless steel sections/corrosion resistance alloy can be efficiently used. Stainless steel's high level of corrosion resistance provides a significant aesthetic and structural design advantage. Moreover

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considering appropriate grade of steel, fire resistance can also be achieved. Stainless steels can absorb considerable impact without fracturing due to their excellent ductility and their strain-hardening characteristics. These abilities make stainless steel a low-maintenance material with a long, cost-effective service life. Both strength and stiffness improved when concrete slab acts compositely with its supporting stainless steel profiled sheeting.

**Advantages**

Fast track construction, Effective utilization of material, Longer span, prevents roof collapse in case of earthquakes, Avoid cost of plastering the bottom of slab, Safe working platform for workmen, Light weight, Service integration and Highly recyclable.

**Description of Test Specimen**

The composite slab is made of trapezoidal shape stainless steel cold formed metal deck is built and tested in this study. Chemical composition of stainless steel is given in table 1. The specimen was constructed in single span. For casting of slab, mix design of concrete used as per IS 456:2000 and IS: 10262-2009 for M20 grade of concrete. Control cube specimens were prepared. After casting of concrete, the specimen were cured by spraying water and tested after 28 days. The geometry and properties of composite metal deck slab is as per table-2

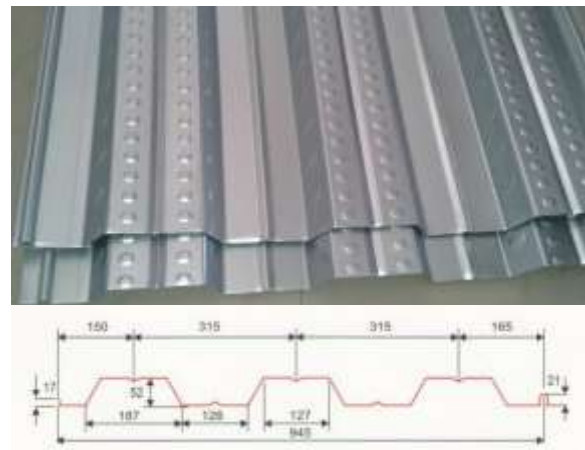
*Table 1. Chemical Composition of stainless steel*

Chemical Composition	304 Grade
Manganese	2%
Phosphorus	0.045%
Silicon	1%
Chromium	18.00- 20.00%
Nickel	8.00-10.50%

*Table 2. Properties of composite metal deck slab specimen*

S. N.	Description	Details
1	Length of slab	1500 mm
2	Width of slab	600 mm
3	Over all thickness of slab	100 mm
4	Thickness of concrete	48 mm
5	Diameter of bar	6 mm
6	Total nos. of bars	8

7	No .of bars longitudinal direction	3
8	No. of bas in transverse direction	5
9	Type of shear connector	bolts
10	No. of shear connector	6
11	Diameter of upper portion(head) of shear	16 mm
12	Diameter of bottom portion (thread)of shear connector	12 mm
13	Height of shear connector	90 mm
14	Thickness of profile steel plate	1 mm
15	Yield strength of profile	250N/mm <sup>2</sup>
16	Elongation(%)	55
17	Area of profile	2000 mm <sup>2</sup>
18	Compressive strength of control specimen	20.8N/mm <sup>2</sup>



*Fig.1 Dimensions of Profile*



*Fig2 Specimen before casting concrete*

**Test procedure**

The four composite metal deck slabs were casted and tested in accordance with Euro code 4-Part

1.1 Two groups of two tests were carried out on stainless steel composite metal deck slabs with embossed trapezoidal profiled sheeting. One group was tested for shorter shear span and another group for longer shear span. The length of the specimen was 1500 mm. Projections of 100mm left beyond support, hence effective span of the specimen was 1300mm. The shorter shear span was considered as 215 mm and longer shear span was considered as 460mm. Tests were performed on simply supported 2-point loading condition. The schematic view of loading is shown in figure 3 and The experimental set up for the composite slab is shown in figure 4.

Load was applied by hydraulic jack via transverse and longitudinal spreader beams. In this way, two equal and concentrated line loads on the composite slab. Load was applied and measured by digital universal testing machine. The deflection under point load, mid span deflection and end slip at end was measured using dial gauge.

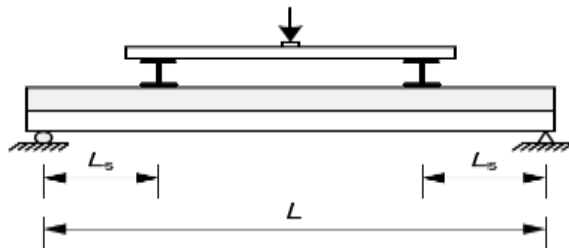


Fig.3 Schematic view of experimental test setup



Fig.4 Experimental test setup

**Results and discussion**

The test results of stainless steel concrete composite deck with varying shear span are as follows.

Table 3. Experimental results of composite metal deck slab

Slab No	Shear Span $L_s$ (mm)	Load at First Crack (KN)	Deflection Under Point Load (mm)	Deflection Under Mid Span (mm)	Failure Load (KN)	Maximum Shear Force (KN)	End Slip at Failure Load (mm)	Failure mode
CS-1	215	55.15	16	21.8	79.65	39.8	9	Shear
CS-2	215	52.4	14.8	20.1	77.15	38.5	10	Shear
CS-3	460	30.9	9.0	11.4	35.5	17.75	12	Flexure
CS-4	460	29.4	8.2	10.85	33.3	16.65	11	Flexure

Observations related to failure pattern are listed below:

1. The Effective span of the slab was 1300 mm for all slabs. The Slab CS-1 and CS-2 were tested for shorter shear span of 215mm. In slab CS-1 the first crack was

developed at 55.15kN. At first, initial shear cracks formed near the loading point and then flexural cracks

formed near the center of span at the bottom of the concrete. As the load is further increased, number of cracks at the bottom of the concrete progressively spread towards the top of the concrete at the loading point while existing ones enlarged. The failure load of the slab was observed as 79.65 KN. The deflection at failure under point load and mid span was 16mm and 21.80mm respectively. Also end slip was developed in right portion of the slab was 9 mm and vertical separation between two material was also observed. The load-deflection behaviors are observed for CS-1 & CS-2 specimen and the same is shown in Figure 5.

In slab CS-2 the same type of observation founded. First minor crack was developed at 52.4 KN under the both line load. This slab failed at load 77.15 kN. The deflection at failure under point load and mid span was 14.8mm and 20.10mm respectively. The end slip measured as 10mm and minor vertical separation between both materials were observed.

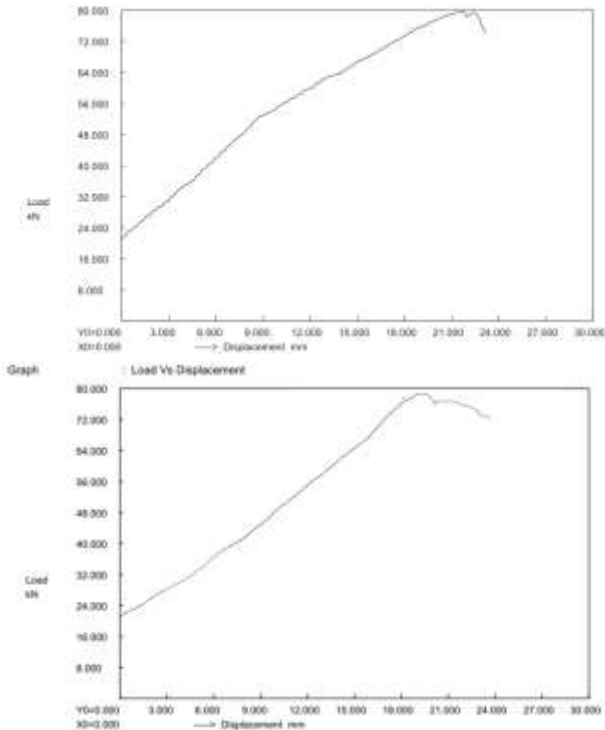


Fig.5 Load-Deflection curves of shear span 215mm

2. The slab CS-3 and CS-4 was tested for longer shear span of 460 mm. In the slab CS-3 first crack was observed at 30.90 kN. At first initial flexural cracks developed at the bottom of the concrete near the center of span and then shear cracks formed near the loading points. The end slip started at right portion of the slab at 31 kN leading to failure in composite action. As the load was further increased, end slip was also increased with vertical separation between two materials and numbers of flexural cracks were formed in between the loading points and the initial cracks at the center broaden and the slab failed at load 35.50 KN. The deflection at failure under point load and mid span was 9mm and 11.40mm respectively. The load-deflection behaviors were observed for CS-3 & CS-4 specimen and the same is shown in Figure 6.

In slab CS-4 same type of observation founded. First flexural crack was developed at mid span at load 29.40KN and the slab failed at load 33.50 KN. The deflection at failure under point

load and mid span was 8.2mm and 10.85mm respectively. End slip was developed at right end of the slab was 11mm and the vertical separation between two materials was observed.

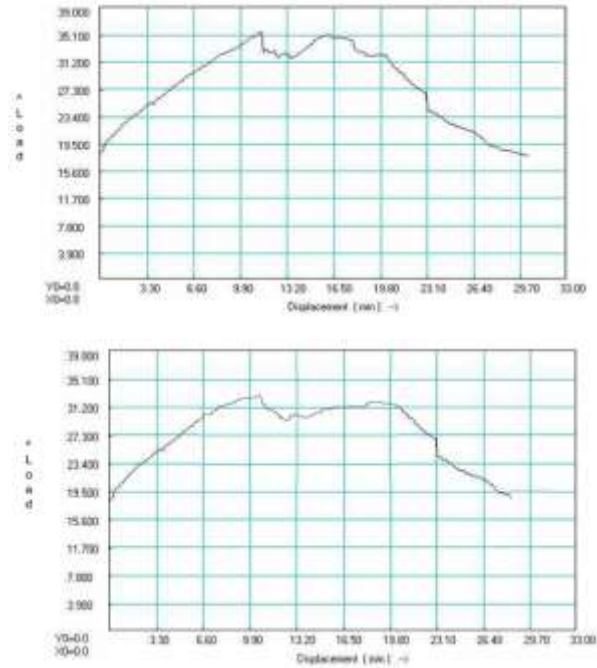


Fig.6 Load-Deflection curves of shear span 460mm

### Conclusion

Experimental studies have been carried out on four cold formed stainless steel profile deck with varying shear span, the following conclusions are derived:

1. The behavior of the stainless steel profiled composite steel deck slab depends mainly on the shear span, for the shorter shear spans, strength of the slab is governed by shear bond failure, whereas for longer span is governed by flexural failure.
2. Slab CS-1 and CS-2, having shorter shear span gives higher value of failure load than slab CS-3 and CS-4, having longer shear span, thus the ultimate failure load of the composite slab decreases from shorter to longer span and moves towards the midspan.
3. In shorter and longer shear span of slab, the maximum deflection is found under the mid span.



4. In CS-3 and CS-4 the end slip started at early stage causing to failure of composite action and cracks started in concrete leading to failure of slab.
5. Horizontal slip at ends are found in shorter shear span CS-1 and CS-2, which is accompanied by vertical separation between the stainless steel and concrete. While, long shear span CS-3 and CS-4 showed horizontal slip at the ends at the time of failure.

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