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EXPERIMENTAL INVESTIGATION AND COMPARISON OF COMPOSITE SLAB WITH PERPENDICULAR AND SKEW TYPE STEEL DECKING

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ABSTRACT

Composite floor is widely used in the building construction. These floors are fabricated by providing steel decks at the bottom portion and reinforced concrete at the top. It provides high strength and resistance to abrasion and fire. Even more time can be saved if the floor slabs are cast on permanent steel formwork that acts first as a working stage and then as bottom reinforcement for the slab. Arriving at an economic and efficient angle of steel sheet is one of the important aspects of the design of skew type steel decking. With increase in load, shear bond slip occurs in the tension side of the slab. In order to restrain these forces an efficient angle of steel decking needs to be evolved. The subject of the ongoing research is to determine the load carrying capacity of composite slab i.e. the concrete slab with profiled steel decking by experimental studies. The embossments are provided in the steel sheet in order to increase the shear bond characteristics between the steel sheet and concrete.

Kew words: Composite slab, Steel decking, Embossments, Load carrying capacity and skew angles.

INTRODUCTION

The casting of concrete is carried out on corrugated steel plate. The efficiency of composite slabs depends on composite action between the steel and concrete structural members. Composite slab with profiled steel decking has proved over the years to be one of the simpler, faster, lighter and economical constructions in steel-framed building systems. This system is well accepted by the construction industry due to the many advantages over other types of floor systems.

Composite slab reinforced with profiled steel decking sheet imparts positive mechanical interlock between the interface of concrete and the steel deck by means of embossments. The profiled decking sheet must provide resistance to vertical separation and

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horizontal slippage between the contact surface of the concrete and the decking sheet. It also permits the transfer of shear stresses from the concrete slab to the steel deck.

The horizontal slippage between the concrete and the steel deck will exist due to the longitudinal shear stress when the shear force of the shear connector reaches its ultimate strength. However, it is complicated to predict exactly the longitudinal shear stress under flexural loading; therefore, the longitudinal shear resistance of composite slab under flexural loading is indirectly evaluated from the empirical method. One is called m-k method (shear bond method) where m represents the mechanical interlocking and k represents the friction between concrete and steel deck and the other is partial shear connection (PSC) method as an alternative to m-k method.

Profiled steel deck performs two major functions that act as a permanent formwork during the concrete casting and also as tensile reinforcement after the concrete has hardened. Cold-formed thin-walled profiled steel decking sheets with embossments on top flanges and webs are widely used in many composite slab constructions.

Objectives

The objective of this project is to study the behaviour of composite slab with perpendicular and skew type steel decking. To evaluate and compare load carrying capacity and shear bond slippage by implementing three different angles of steel sheet in composite slab.

Scope

1. Three slab specimens of size 850 mm × 550 mm were cast for concrete grade of M20. They were cast in two different ways,
   (i) Normal type i.e. the steel deck is placed normally at 90˚ with concrete.
   (ii) Skew type i.e. the steel deck is cut and placed at 15˚ and 30˚ with concrete.
2. For these configurations the composite slabs were tested and the results of load carrying capacity were validated.
3. Efficient angle of steel deck between different angles were arrived at.

EXPERIMENTAL

Experimental program and test specimens

A total of 3 full scale composite slab specimens were cast in accordance with the

Euro code 4 Part 1.1 to determine the structural behaviour and load carrying capacity of the slab. The test is designed to provide rudimentary information on behavior of composite slabs. Experimental program includes static loading test such as monotonic loading (central point loading) on the slab. Figs. 1, 2 and 3 shows the reinforcement placed over the steel deck of 0˚, 15˚ and 30˚.

Fig. 1: Photograph of 0˚ profiled steel deck slab

Fig. 2: Photograph of 15˚ profiled steel deck slab

Fig. 3: Photograph of 30˚ profiled steel deck slab

Profiled steel decking properties

Cold formed thin profiled steel decks are used to fabricate the slab specimens. All specimens are carried out with 0.8 mm thickness, which have a cross sectional area of 990 mm^2, unit weight of 8.34 Kg/m, yield strength of 245 Mpa, section modulus of 19,552 mm^3 and moment of inertia of 5, 27, 932 mm^4. Fig. 4 elucidates the geometric shape of the profiled steel deck with embossments.

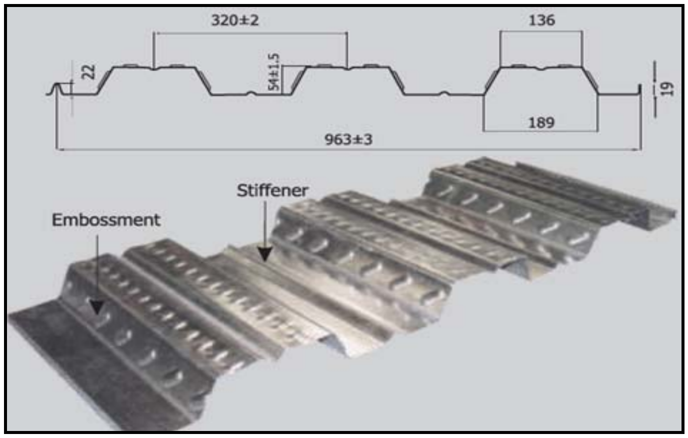

Fig. 4: Cross section of profiled steel deck

Preparation of slab specimens

A total of 3 full scale composite slab (MxDeck 54) specimens were built with 175 mm nominal depth, 550 mm width and 850 mm span length. The thickness of the profiled steel deck is 55 mm while the thickness of the concrete above the flange is 120 mm. All composite slab specimens were cast with full support on the plain surface concrete flooring in the Concrete testing laboratory.

Concrete of mix grade M20 is utilized. 10 mm and 8 mm diameter reinforcing rods are used as main and distribution reinforcement respectively. Cross section of the test specimen is shown in Fig. 5.

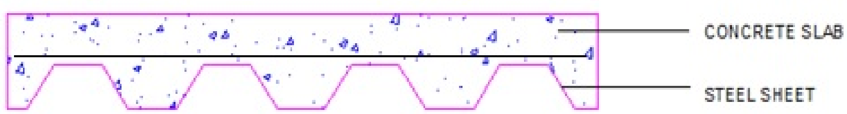

Fig. 5: Cross section of test specimen

Test setup description

The illustrative view of arrangement for the simply supported composite slab with a span of 0.85m subjected to a central point loading. The entire experimental setup of composite slab is shown in Fig. 6.

Loading is given by a single hydraulic jack system placed on a steel ball of diameter 63.5 mm and weight 1.05 Kg, which is at the mid span of slab specimen and the load is measured with the help of dial gauge at the point of application. Displacement transducer is placed precisely at the mid-span to measure deflections as shown in Fig. 7.

Fig. 6: Experimental test setup

Fig. 7: Deflection transducer location during testing

Testing practice

The composite slab specimen is placed on the steel mould and the loading point is marked absolutely at the centre of the specimen. A steel ball is placed on it, over which hydraulic jack is placed. Load is applied gradually by single hydraulic jack system at an increment of 4 kN. This similar procedure is repeated for all the three slab specimens having a skew-ness of. slab0˚, slab15˚ and slab30˚, respectively.

RESULTS AND DISCUSSION

Load deflection behaviour

In all the three slab specimens (slab0˚, slab15˚ and slab30˚) the load deflection behaviour are observed. Fig. 8 indicates the load deflection curves for all slab specimens.

The initial crack was formed in the mid span at the bottom tensile zone of the concrete and on further increase in load the cracks extended towards the top of the concrete. From Fig. 8 it is perceived that the load carrying capacity of slab 30˚ is greater when compared to slab0˚ and slab15˚ and also the load carrying capacity of slab15˚ is more than slab0˚. In addition to that it is observed that the deflection of slab30˚ is less when compared to slab0˚ and slab15˚. Therefore when skew-ness of profiled steel sheet increases, the load carrying capacity increases and deflection decreases.

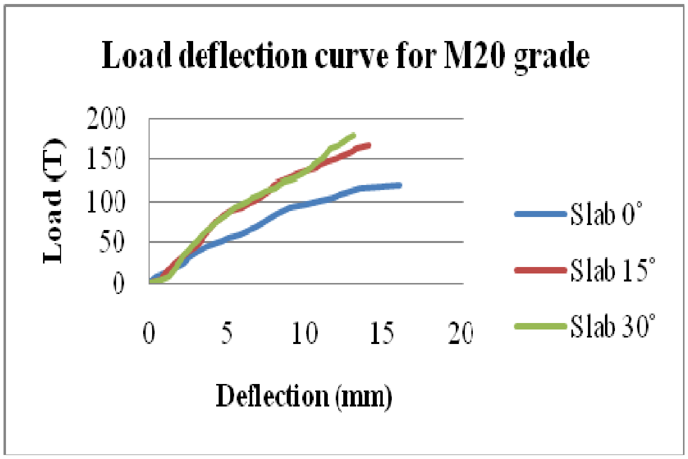

Fig. 8: Comparison of load-deflection curves of composite slabs

The initial and final crack load for concrete of grade M20 with three distinct angles 0˚, 15˚ and 30˚ are shown in Table 1 and Fig. 9.

Table 1: Initial and final crack load

S. No.	Grade of concrete	Steel deck angle	Initial crack load (T)	Final crack load (T)
1	M20	0˚	1.6	12
2	M20	15˚	6.8	16.8
3	M20	30˚	4.4	18

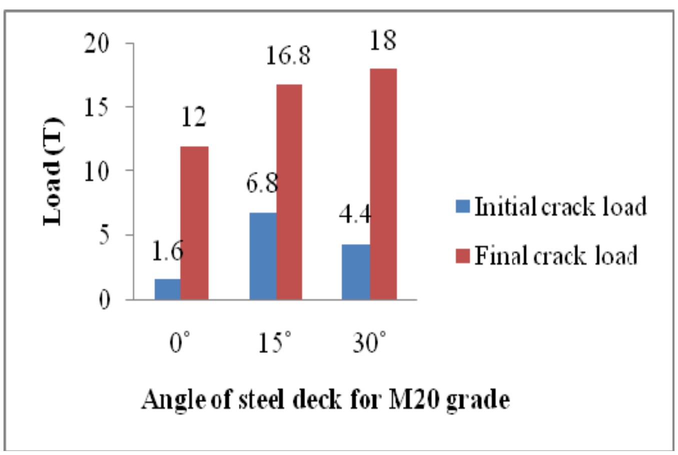

Fig. 9: Initial and final crack load

Slip behaviour of composite slab

The end slip is observed and it is shown in Figs. 10, 11 and 12 for slab0˚, slab15˚ and slab 30˚, respectively. The first crack appears after 80% of the total ultimate loading.

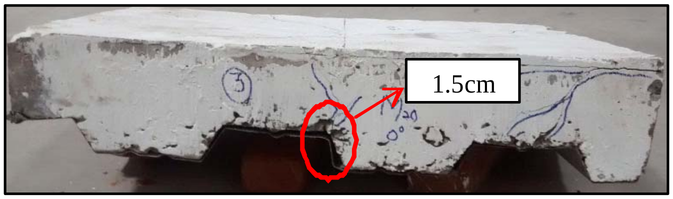

Fig. 10: Slip behaviour for slab 0˚

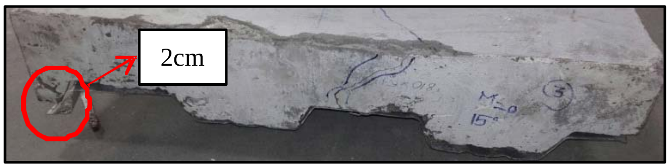

Fig. 11: Slip behaviour for slab 15˚

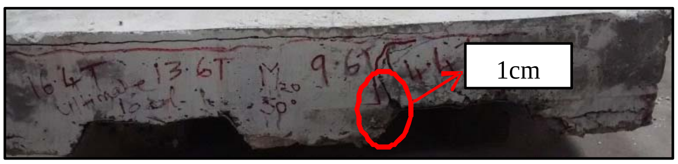

Fig. 12: Slip behaviour for slab 30˚

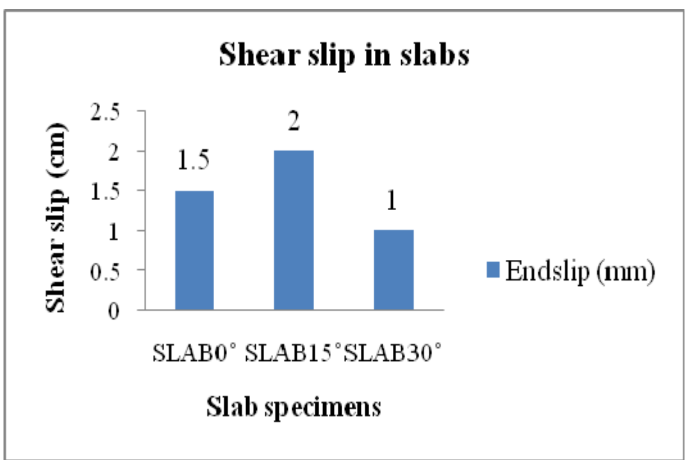

Fig. 13: End slip behaviour of composite slabs

For slab 0˚ the slip behaviour is in the range of 0 to 1.5 cm and for slab 15˚ the end slip in the range of 0 to 2 cm and for slab 30˚ the end slip is in the range of 0 to 1 cm, which is very less when compared with slip values obtained by Namdeo et al.[4] In case of slab 0˚ and slab 30 the slip was observed in the trough regions whereas in the slab 15˚ slip is observed in the crest region of the composite slabs. In crest region the deflection will also contribute to the slip and hence higher maximum slip is observed in slab 15˚.

CONCLUSION

(i) The load carrying capacity of slab 15˚ and slab 30˚ are 16.8 T and 18 T, which is 28.57% and 33.33% higher than slab 0˚.

(ii) The increase in load carrying capacity of slabs with skew angle is due to increased stiffness.

(iii) The initial and final crack load for slab15˚ is 6.8T and 16.8T, which is 76.4% and 28.57% greater than slab 0˚

(iv) Similarly in slab 30˚, the initial and final crack load is 4.4T and 18T, which is 63.6% and 33% greater than slab 0˚.

(v) The mid-span deflection of slab 15˚ and slab 30˚ are 14.06 mm and 13.05 mm, which is 13.86% and 22.68% lesser than slab 0˚.

(vi) The end shear slip for slab 15˚ and slab 30˚ are 2 cm and 1 cm, which is 25% greater and 50% lesser than slab 0 ˚.

(vii) The increase in shear slip of slab 15˚ is due to deflection of the slab, which will lead to increased slip in the crest region.

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