COMPARATIVE STUDY OF METAL RCC COMPOSITE DECK SYSTEMS

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ABSTRACT

Composite slabs consist of profiled steel deck with reinforced concrete topping. The decking not only acts as a permanent formwork to the concrete, but also provides sufficient shear bond with the concrete and acts compositely. In recent years, the composite slabs are preferred due to light weight, low cost construction and ability to defend the natural disasters. The work presented in this paper is concerned with the evaluation of flexural strength of composite deck system analytically base on international standard and parametric variation. The research work includes study on core base analysis of metal deck composite slab for flexural capacity and limiting geometrical and material parameters under full bond. Estimation and comparison of flexural resistance as per European, British and American Code of practice using developed MS excel tool. Study on parametric variation such as different materials, profile sheet thickness and slab thickness. Analytical approaches considering the bond properties from no bond to full bond cases.

Keyword - *Cold-formed steel, deck sheet, formwork, composite slab etc*

1. INTRODUCTION

Composite decks are efficient and economical floor systems to the building units. Since last five decades, the system is one of the prevalent construction practices in many parts of the world. Composite deck refers to a structural slab system created by compositely combining the structural properties of concrete and cold formed light gauge metal steel decking. This type of deck acts as a one-way slab in which steel sheet and concrete are so interconnected that the deck and concrete act together to resist bending in longitudinal direction. The system is also referred as 'composite deck', 'composite slab' or 'composite floors. Cold formed profile decks are used as a permanent form work for a composite deck system. These profile decks also act as tensile reinforcement, if the strength of profile steel sheet is utilized. Earlier, the composite deck system was considered as an optimum solution to the building floors for high-rise steel framed structures only but in recent years, it is becoming more popular for low - medium rise steel and R.C.C. buildings. The reinforced concrete frame composite deck provides same benefits as composite decks for steel framing. Composite deck is a popular construction practice all over the world. But in India, the floor system is still at a nascent stage.

1.1 Composite Structures

Composite Steel-Concrete Structures are used widely in modern bridge and building construction. A composite member is formed when a steel component ,such as an I beam ,is attached to a concrete component, such as a floor slab or bridge deck. In such a composite T-beam the 10 comparatively high strength of the concrete in compression complements the high strength of the steel in tension. The fact that each material is used to the fullest advantage makes composite Steel-Concrete construction very efficient and economical. However, the real attraction of such construction is based on having an efficient connection of the Steel to the Concrete, and it is this connection that allows a transfer of forces and gives composite members their unique behavior.

1.2 Components of Profile Deck

The metal deck, also known as profile deck is one of the important structural parts of composite deck system. The section describes the stages of development of profile sheet from plain coil of steel.

2. LITERATURE REVIEW

In this chapter, the literature pertaining to various method of metal RCC composite deck system conducted by earlier researchers is presented. Merool1 et. al [1] have studied the experimental study on composite deck with different aspect ratio. In this paper, two composite deck specimens with different aspect ratio having one wavelength width and three wavelength width are tested. Panchal [2] have studied the advanced design of composite steel-concrete structural element. In the present work, a simplified method of composite slabs, beams and columns design is used and software is developed with pre- and post- processing facilities in VB.NET. Vohra and Dhankot [3] have studied the shear connectors and composite deck slab experimental study. The shear connections are generally provided between the intersection of the beam and deck slab. Kalamkar and Akhare [4] have studied the analytical study on behaviour of composite slabs with profiled steel decking. This paper aims at studying the behavior of composite slabs under flexural loads. The strength of composite deck slabs depends on the strength of contact between the profiled steel sheeting and concrete layer. Ananalytical 3-D finite element model of composite slab is developed and the interface between profiled steel sheet and concrete is modeled with the help of contact elements in ANSYS 11.0 Multi physics utility tool. Lam and Ashour [5] have studied the experimental study on demountable shear connectors in composite slabs with profiled decking. This paper presents an experimental study on shear strength, stiffness and ductility of demountable shear connectors in metal decking composite slabs through push-off tests. Ríos et.al [6] have studied the numerical modelling of the shear-bond behaviour of composite slabs in four and six-point bending tests. The steel-concrete interface was simulated with a non-linear shear behaviour law (s-s) which properly defines the shear-bond behaviour of composite slabs. Nguyen et.al [7] have studied the temperature profile and resistance of flat decking composite slabs in- and post-fire This paper presents the experimental and numerical results on fire resistance of the composite slabs using flat profiled decking with vertical webs and top flanges embedded in concrete based on a series of tests including heat transfer, ISO834 standard fire, and post-fire residual strength tests. Emami and Kabir [8] have studied the performance of composite metal deck slabs under impact loading. This paper investigates the behavior of composite metal deck slabs under repeating impact loading. The shear bearing capacity between the concrete slab and metal deck was provided by the embossments on the metal deck. The study is carried out in two parts; laboratory tests and the numerical modeling. Shen et al. [9] have studied the Structural behaviour of stud shear connections in composite floors with various connector arrangements and profiled deck configuration. This paper investigates the structural behaviour of stud shear connections in composite floors with various connector arrangements and profiled deck configurations. Langarudia and Ebrahimnej [10] have studied the Numerical study of the behavior of bolted shear connectors in composite slabs with steel deck. In this paper, with a numerical study, welded shear stud connectors were replaced with new bolted shear ones and the effects of parameters, such as: concrete strength, different positions, heights and diameters of the shear connectors, and the type and thickness of the steel deck, as well as the effect of the reinforcement arrangement on the behavior of these connectors, are evaluated. In the present topic, a number of papers published so far have been surveyed, reviewed and analyzed. A substantial amount of work has been conducted on metal RCC composite deck system in the past. Over the past five decades, several studies were carried out to understand the behaviour of composite deck by performing experimental investigations and numerical modeling on a number of full-scale and small-scale specimens. The research was concentrated on different aspects of deck behaviour such as: development of empirical method for strength prediction, behaviour of simply supported and continuous composite deck, testing on new bond patterns and various end restraints of deck. Few studies demonstrated the behaviour of composite deck by small scale push off or pull out tests. As per reported literature, the procedure for strength analysis of composite deck is based on m-k method or partial shear connection method which is then based on data from large scale testing.

3. RESULT ANALYSIS

3.1 Thickness of Deck Sheet Variation Effect on Moment Resistance Capacity

The comparative analysis for flexural capacity considering full interaction case between deck sheet and concrete is done as per European Standard EN 1994-1-1:2004, American Steel Deck Institute-ANSI: 2011, British Standard BS-5950: Part-IV:1994, and Indian Standard. The stress block in European and British Standard assume rectangular in shape and for Indian standards partly parabolic and partly rectangular shape is used. American Standard follows the cracked section and uncrack moment of inertia and simple bending theory to calculate the flexural capacity of the deck slab. All countries have different factors of safety for profile deck. The comparison is done with different codes and thickness variation for profile configuration as shown in fig.1. Other properties such as overall depth of deck 150 mm, grade of concrete 25 MPa and grade of steel 340 MPa are considered. The results of flexural capacity using four International standards versus thickness of a profile deck sheet are summarized as per Chart- 1.

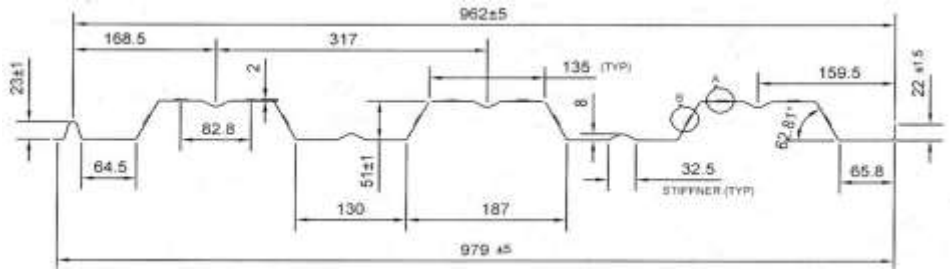

Fig -1: Deck Sheet Profile

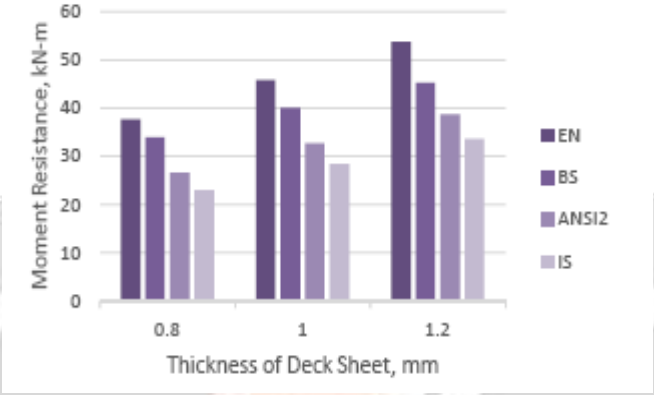

Chart -1: Thickness of Deck Sheet Variation Effect on Moment Resistance Capacity

3.2 Thickness of Slab Variation Effect on Moment Resistance Capacity

The comparison is done with different codes and thickness variation for deck slab depth. Other properties such as thickness of profile sheet 0.8 mm, grade of concrete 25 MPa and grade of steel 340 MPa are considered. The results of flexural capacity using four International standards versus thickness of a deck profile are summarized as per chart- 2.

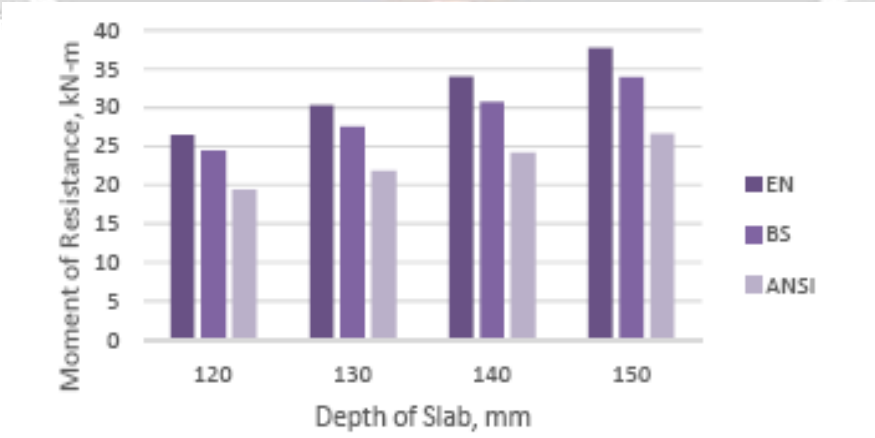

Chart -2: Thickness of Slab Variation Effect on Moment Resistance Capacity

3.3 Grade of Concrete Variation Effect on Moment Resistance Capacity

The moment resistance capacity of slab is based on the position of the neutral axis position of slab hence grade of concrete directly affects the capacity of slab. Other properties of deck slab like sheet thickness 0.8mm, yield strength of deck material 340MPa and overall deck slab depth considered for analysis is 150mm. The results of flexural capacity using four International standards versus thickness of a deck profile are summarized as per chart- 3.

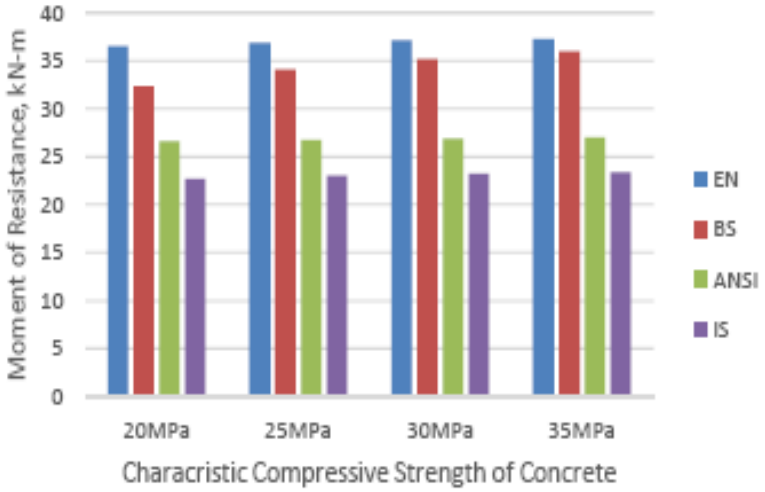

Chart -3: Grade of Concrete Variation Effect on Moment Resistance Capacity

3.4 Thickness of Deck Sheet Variation Effect on Shear Bond Resistance

For metal deck slab empirical parameters according to European Standard are calculated as per Parametric Test. The other properties such as overall depth of deck slab is 150 mm, grade of concrete 25 MPa and grade of deck sheet 340 MPa are considered. The results of Shear Bond Resistance factors using two different international standards versus thickness of a profile deck sheet are summarized as per chart- 4.

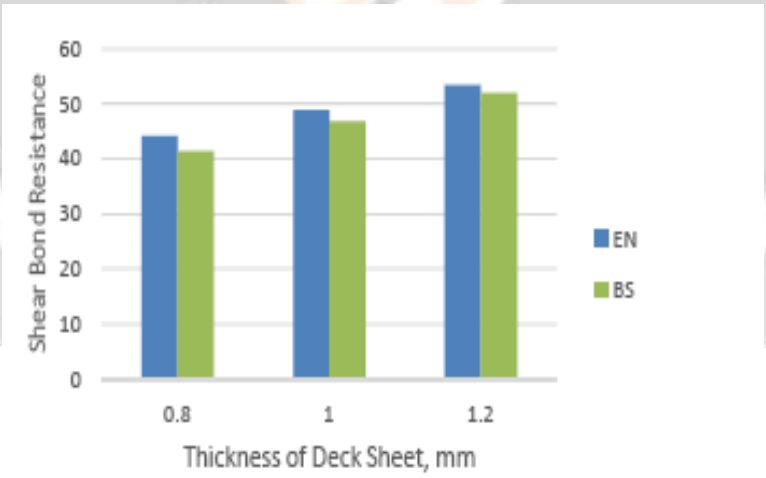

Chart -4: Thickness variation effect on shear bond resistance

3.5 Fire resistance capacity

At the time of fire, strength of material is reducing with time. To increase the fire resistance period of deck slab the extra reinforcement is required to insert in deck slab. European Standard considered the contribution of deck sheet in fire resistance capacity of slab up-to deck sheets yield strength gets null. The British Standard does not consider the contribution of deck sheet in fire resistance capacity of deck slab. The properties such as overall depth of deck slab is 150 mm, grade of concrete 25 MPa and grade of deck sheet 340 MPa are considered. The reinforcing bar of 415MPa grade for fire resistance is considered at 30mm above the deck bottom. The results of Fire Resistance of deck slab for 60min fire using two different international standards versus thickness of a profile deck sheet are summarized in chart- 5.

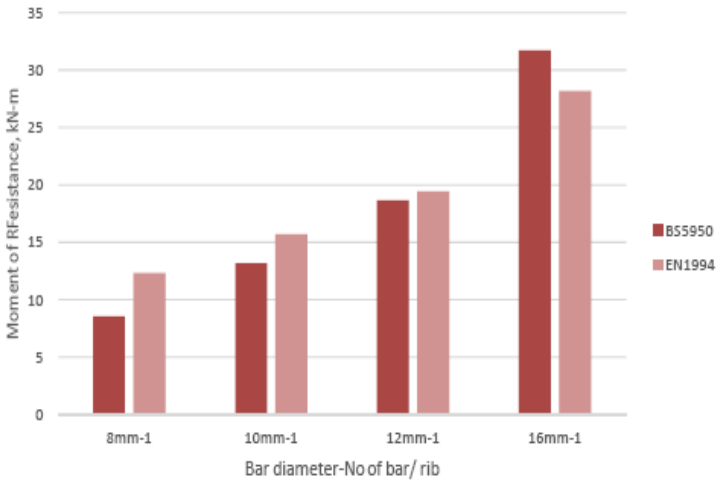

Chart -5: Moment of Resistance in Fire Vs Bar diameter effect

4. RESULT DISCUSSION

The work comprises on theoretical studies for flexural capacity of the composite metal deck slab. In that regard, a comprehensive review is carried to study governing parameters and flexural capacity with various codes of practice. The standards investigated include: European standard EC4, British standard BS-5950-4 and American Standard SDI C-2011. Based on the code studies, generalized program tool is prepared to design composite metal deck slab in construction stage and Limit state stage with parametric variations. The developed program is compared with 'ComFlor' software. These studies are useful to design the metal deck formwork and composite metal deck slab.

5. CONCLUSIONS

Composite slabs consist of profiled steel deck with reinforced concrete topping. The decking not only acts as a permanent formwork to the concrete, but also provides sufficient shear bond with the concrete and acts compositely. In recent years, the composite slabs are preferred due to light weight, low cost construction and ability to defend the natural disasters. Studies are carried out on existing international standards, considering full interaction between deck sheet and concrete. The work comprises on theoretical studies for flexural capacity of the composite metal deck slab. In that regard, a comprehensive review is carried to study governing parameters and flexural capacity with various codes of practice. The standards investigated include: European standard EC4, British standard BS-5950-4 and American Standard SDI C-2011. Based on the code studies, generalized program tool is prepared to design composite metal deck slab in construction stage and Limit state stage with parametric variations. The developed program is compared with 'ComFlor' software. These studies are useful to design the metal deck formwork and composite metal deck slab.

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