IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Study on Innovative Shear Connector in Steel - Concrete Composite Slab - An Overview

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Abstract: Steel -concrete Composite slab consist of trapezoidal steel sheeting and concrete layer. The steel sheeting serves as both, a lost framework and a tension bearing member after hardening of concrete. The longitudinal shear between the sheeting and the concrete must be ensured by a mechanical interlock, for example shear studs, thin screws or prepressed embossments in the sheeting. These are traditional massive shear studs have to be welded to the supporting construction of the slab. Alternatively, thin screws can be drilled through the sheeting and cast into the concrete to ensure the composite action. Instead of traditional method the steel sheeting can be designed in such way that it acts as mechanical connector to concrete and ensuring in increasing the strength of concrete, the effect of this type of connector helps in increasing bending capacity of composite slab. Authors mentioned different parameters about the Performance enhancement with different composite materials, with and without embossment, different materials, methods and behaviour of the shear connectors with different shapes, effect of Embossment spacing in the field of composite deck system. The methodology adopted is to review and concise important parameters to be considered while designing the shear connector in steel -concrete composite Slab like embossment length should be large and embossment spacing should be minimum, composite deck slab to be considered as highly nonlinear problem where we can predict the behaviour by experimental and the FE analytical results, composite slabs with a trapezoidal type of profiled sheeting with and without v-notch of 0.8 mm and 1.2 mm thickness where with V notch has higher strength. The usage of big diameter screws on the other hand increases the shear bearing capacity of the composite slab for higher values of slip.

Keywords: Composite slab, Steel deck, embossment and Vertical separation.

1. Introduction

Headed shear stud connectors are essentially a steel projection. It is provided on the top flange of steel composite structure (a bridge girder, for instance) to provide necessary shear transfer between the steel girder and the composite deck and slab. Headed shear stud is the most popularly used shear connectors in the market. The other alternatives such as block or hoop type shear studs are used for very applications that require very large shear transfers. The Shear connector are designed to provide static strength to the composite structure and can bear fatigue loading.

The Shear flows are calculated at the support ends, at mid-span, and at quarter points. The shear flow profile is built along structural element. The role of Shear Connectors or studs, spaced at a distance, is to resist shear at the respective locations. From the support end to the mid-span, spacing of studs can be varied to meet the budgets.

The shear connection forms the crucial part of any composite member subjected to flexural loading. This is clearly evident in partial shear connection where the strength and ductility of the shear connection directly defines the capacity of the whole beam.it is widely acknowledged that steel decking with wide open ribs can significantly reduce the strength and ductility of the shear connection in composite beams. The approach primarily used around the world to take into account the weakening effect of this type of decking is to apply a reduction factor to the nominal strength of the same connector in a solid slab. Consequently, it is critical that the strength and behaviour of the connector in the solid slab is known and understood. composite slab consist of profile steel sheeting and concrete are widely used in building now days. The composite slab has proved to be one of the simpler, faster, lighter and economical constructions in framed building system. It has great advantage such as no form work, quick installation, reduces dimension and weight of the floors.

The casting of concrete is carried out on profile steel decking as permanent formwork. The force transfer mechanism of composite slabs can be characterized by three failure types such as Flexural failure, vertical failure and longitudinal shear failure. Longitudinal shear failure is most common failure type which is affected by the interlock on the concrete-steel deck interface. It can be increased by providing connectors such as embossments, screws and stud in steel sheeting.

Composite slab construction is carried out throughout the world. Experimental, analytical, numerical works were carried out as an aid for developing new design criteria. The objective of the paper is to review different materials, methods and behaviour of the shear connectors with different shapes, Embossment and effect of Embossment spacing in the field of composite deck system. The research significance is concise the important parameters to be considered while designing the shear connector in steel - concrete composite Slab, where each author has considered different material ,shape, embossment and its spacing, different methods to predict the behaviour.

2. Literature review

Miquel Ferrer et al (2006) [1] concluded from the finite elemental analysis that Minimum retention angle should be provided. Alternate directions of embossments (inwards and outwards) tilting not effective. Embossment length should be large and improved if located near the edges. Embossment spacing should be minimum

V. Marimuthu et al (2007) [2] have conducted experimental investigations on the 18 composite deck slabs by varying the shear spans and found that the behaviour of the embossed profiled composite steel deck slab depends produced by the numerical approach of the problem is in close agreement with the load deflection curve produced during the experiment and the slope of the curves is identical.

T. Tsalkatidis, A. Avdelas(2009)[3] presents about the shear connection between concrete and profiled steel sheeting in composite slabs is a highly nonlinear problem as far as boundary conditions, material and geometry are concerned. It can be treated as a unilateral contact problem where sticking, sliding and frictional phenomena at the interface of the bodies are all present.

Shiming Chen , Xiaoyu Shi(2011)[4] presents about the strength of concrete slabs composited with cold-formed profiled steel decks is normally governed by the longitudinal shear bond failure at the steel concrete interface. The design methods for the longitudinal shear bond strength adopted in the current construction practice such as the m-k method and partial interaction method all based on the full-size tests and the shear bond interaction between the steel deck and the concrete is treated as a contact problem considering adhesion and friction. Both geometrical and material nonlinearities are all considered in the FE model. Contrasts of the experimental and the FE analytical results indicate capable of predicting the performance and the load carrying capacity of composite slabs.

K. N. Lakshmikandhan (2013)[5]Three types of mechanical connector schemes are investigated experimentally. Three mechanical shear connector schemes develop full shear interaction. The inclusion of shear connector enhances the flexural capacity, stiffness, ductility, and energy absorption of composite deck system. The flexural capacity of composite deck slab with wire mesh is found competitive for shrinkage and temperature effects.

A**. Gholamhoseini, R.I. Gilbert , M.A. Bradford, Z.T. Chang (2014)[6]** presents the investigations on the short term testing up to failure of four types of profiled decking that are widely used in Australia. Full-scale, simply-supported slab specimens were tested in four-point bending with shear spans of either span/4 or span/6. The bond–slip relationship of each slab was found during the testing and the values of maximum longitudinal shear stress calculated using various methods are described and compared. A finite element model is proposed and verified by experimental data using interface element to model the bond properties between steel decking and concrete slab and investigate the ultimate strength of composite slabs.

S. P. Siddh, Y. D. Patil, H. S. Patil (2017)[7] presents the experimental investigations of a composite slab with profiled sheeting (Trapezoidal type) and concrete of four specimens were cast and tested to interpret the actual behaviour of the composite slab. Experiments were performed on composite slabs with a trapezoidal type of profiled sheeting with and without v-notch of 0.8 mm and 1.2 mm thickness. Two specimens were cast with 0.8 mm profile steel sheet and two specimens with 1.2 mm sheet thickness. In the results of these investigations, load versus displacement and load versus slip behaviour was observed that profile sheeting with v-notch has higher strength.

A. P. Rahmadia, W.H. Wan Badaruzzamanb, and A. K. Arifin (2013) [8] The research is a part of the development to employ a lightweight composite panel system known as profiled steel sheet medium density fiberboard (PSSMDFB), as an innovation for structural floor building. PSSMDF panel are formed from a combination of two main components, namely profiled steel sheet and medium density fiberboard attached by mechanical connectors, i.e. self-drilling screw. The objective of this research is to predict the deflection behaviour of the PSSMDF composite floor panel system. A theoretical model has yielded deflection result within 12 % accuracy compared to experimental value obtained in the laboratory. Through theoretical model it can be predicted the behaviour of the PSSMDF floor on the composite partial interaction problem. The result of this research is useful for the success of applying the PSSMDF floor system as product diversification in industrial building construction.

Naveed Rehman, Dennis Lam, Xianghe Dai and Ashraf F. Ashour(2017)[9] This paper presents an experimental study on an innovative composite floor system that can be demounted and deconstructed. In this system, the composite slab, formed with profiled metal decking, was connected to a steel beam via demountable shear connectors. A full-scale demountable composite floor system specimen was tested to ultimate load bearing capacity and compared with a similar non-demountable composite floor system specimen using conventional welded headed stud connectors. The experimental results and observations showed that the structural behaviour and load bearing capacity of both composite floor systems are very similar. However, the composite floor system with demountable shear connectors could be deconstructed after testing and the composite slab could be easily detached from the steel beam. The comparison and analysis presented in this paper indicated that the simple design methods currently provided in the Eurocode 4 for the welded shear connections could be used to assess the ultimate moment capacity of demountable composite floor systems

Simon J, Visuvasam J and Susan Babu (2017) [10] The study presence of embossments in steel sheeting and the effect of various parameters such as size, shape such as rectangular, square and circular, and the alignment of embossments. The shear capacity and ultimate strength of the composite slab using three-dimensional computational finite element modelling. Composite slab with steel sheeting with square type embossment with 50% increased size that normal sized took the highest load. From the analysis results, as size of embossment increase, ultimate load also increases.

Josef Holomeka, Miroslav Bajera, Martin Vilda (2017) [11] In this paper, thin screws are drilled through the sheeting and cast into the concrete to ensure the composite action or to strengthen the composite slab in reconstructions locally. The usage of the screws is not limited to the steel supporting frames. It describes laboratory tests of the composite slabs with cast screws of various diameters and the effect of the screws on the bending capacity of the slab in combination with prepressed embossments. The small diameter screws contribute to the longitudinal shear resistance at the small magnitudes of slip and behaviour tends to be brittle. The usage of big diameter screws on the other hand increases the shear bearing capacity of the composite slab for higher values of slip. The slab behaviour tends to be ductile.

Yazdan Majdi a, Cheng-Tzu Thomas Hsu b, Mehdi Zarei b (2014) [12] the structural behaviour of a new type of composite floor system is explored through finite element modelling. The new composite floor incorporates cold-formed (light-gauge) steel profiles as the joist on bottom, a corrugated steel deck as the formwork for concrete, a continuous hat channel (furring channel) as the shear connector and finally a concrete slab on top. A local bond-slip model is applied to simulate the slip of the shear connector inside the concrete slab. A nonlinear analysis is performed on the composite floor considering all different types of structural nonlinearities and the behaviour of the system is monitored from beginning of loading all the way to a defined point of failure. Results of finite element analyses are compared with experimental data.

Naveed Rehman et.al(2018)[13] did experimental investigations on an innovative composite floor system that can be demounted and deconstructed. In this system, the composite slab, formed with profiled metal decking, was connected to a steel beam via demountable shear connectors. A full-scale demountable composite floor system specimen was tested to ultimate load bearing capacity and compared with a similar non-demountable composite floor system specimen using conventional welded headed stud connectors. The experimental results and observations showed that the structural behaviour and load bearing capacity of both composite floor systems are very similar. However, the composite floor system with demountable shear connectors could be deconstructed after testing and the composite slab could be easily detached from the steel beam. The comparison and analysis presented in this paper indicated that the simple design methods currently provided in the Eurocode 4 for the welded shear connections could be used to assess the ultimate moment capacity of demountable composite floor systems

3. Result &Discussions

Experimental and numerical based investigations on an innovative shear connector in steel -concrete composite Slab, where each author has considered different material, shape, embossment and its spacing, different methods to predict the behaviour.while designing the shear connector in steel -concrete composite Slab like embossment length should be large and embossment spacing should be minimum, composite deck slab to be considered as highly nonlinear problem where we can predict the behaviour by experimental and the FE analytical results, composite slabs with a trapezoidal type of profiled sheeting with and without v-notch of 0.8 mm and 1.2 mm thickness where with V notch has higher strength. Composite slab with steel sheeting with square type embossment with 50% increased size that normal sized took the highest load. The small diameter screws contribute to the longitudinal shear resistance at the small magnitudes of slip and behaviour tends to be brittle. The usage of big diameter screws on the other hand increases the shear bearing capacity of the composite slab for higher values of slip.

4. Conclusion

Review of literature indicates a big importance for shear connector in steel -concrete Composite slab. While designing the shear connector in steel -concrete composite slab like embossment length should be large and embossment spacing should be minimum, composite deck slab to be considered as highly nonlinear problem where we can predict the behaviour by experimental and the FE analytical results, composite slabs with a trapezoidal type of profiled sheeting with and without v-notch of 0.8 mm and 1.2 mm thickness where with V notch has higher strength. shear connector enhances the flexural capacity, stiffness, ductility, and energy absorption of composite deck system and square type embossment with 50% increased size that normal sized took the highest load. The usage of big diameter screws on the other hand increases the shear bearing capacity of the composite slab for higher values of slip.

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