International Journal of Scientific Engineering and Research (IJSER)
www.ijser.in
ISSN (Online): 2347-3878
Volume 3 Issue 3, March 2015

# Shear Connectors and Composite Deck Slab Experimental Study – State of the Art Review

**Hozaif S. Vohra[1], Mazhar Dhankot[2]**

[1]PG Scholar, Marwadi Education Foundation, Gujarat, India

[2]Associate Professor, Civil Engineering Department, Marwadi Education Foundation, Gujarat, India

**Abstract:** ***Composite structures are a new generation of structure which is very popular in modern construction practices due to its speed in construction. The load transfer from concrete to steel in composite members is through Shear Connectors. The shear connections are generally provided between the intersection of the beam and deck slab. The deck slab having steel bottom with galvanized coating does not provide much connection between steel and concrete. The control of slippage in the composite deck slab is the most important aspect to control the central deflection. Provision of grooves and other means of reducing the slippage need to be investigated in detail so that the moment carrying capacity of the composite deck slab can be enhanced.***

**Keywords:** Steel-Concrete Composite (SSC), Composite deck slab, Shear connectors, Slippage, Deflection

## 1. Introduction

Composite steel-concrete structures are used widely in modem bridge and building construction. The fact that each material (steel or concrete) is used to take advantage of its best attributes makes composite steel-concrete construction very efficient and economical. However, the real attraction of composite 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. Shear connectors are provided to transfer load from composite steel deck to the steel beam. Shear flow forces have to be resisted by the shear flow strengths of the mechanical shear connectors that are used to tie the concrete component to the steel component. The shearing force at composite beams with profiled sheet is not introduced directly through the base of the shear connect, but is transferred onto the shank of the shear connector. The increase of load produces crushing of concrete in front of the shear connector and transfer of shearing force exclusively via bending.

## 2. Literature Review

Several authors have reported the use of different types of shear connectors with different size and applications. Followings are the review of few authors.

Amar Prakash, N. Anandavalli, C. K. Madheswaran, J. Rajasankar, N. Lakshmanan [1] proposed non linear behavior of stud connected to steel-concrete composite girders numerically. 3D modeling through ABAQUS is analyzed. Specimen of 4 m length and width of 0.665 m with 3.8 m is simply supported. Maximum load observed was 360 kN analytical to 330 kN experimented. The deflection obtained 136 mm analytical to 138 mm experiment outcome. Comparison of interface slips at three different values of deflection.

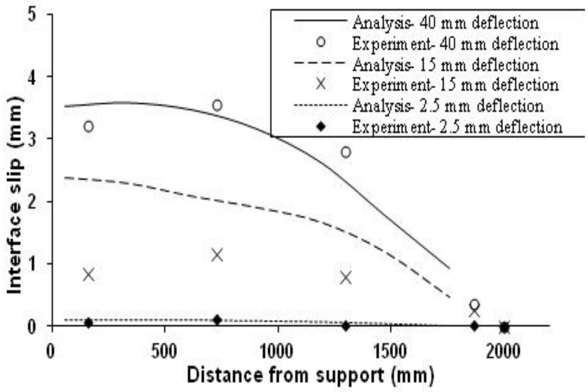


**Figure 1:** Comparison of interface slip

Hyeong-Yeol Kim, Youn-Ju Jeong [2] investigated the ultimate behavior of a SCC composite deck slab system with profiled steel sheeting and perfobond rib shear connectors. Eight specimens were prepared and develop composite deck slab for girder bridges that spans longer but weighs less than conventional reinforced concrete slab, which were evaluated using empirical m-k method.

The ultimate strength under bending was at least 20% less than RC deck. The load carrying capacity is approx. 2.5 times greater, while concrete cracking load is 7.1 times greater with total weight 2.5% lesser.


**Figure 2:** Photograph of profiled sheeting with perfobond ribs

J. Psota and T. Rotter [3] described the behavior of the new type of shear connector by utilizing concrete reinforcement mesh, which is suitably curved and welded on the top of the steel plate in some places. It also acts as an standard reinforcements also. First phase of the paper shows the pull out tests preparation.

Namdeo Adkuji Hedaoo, Laxmikant M Gupta and Girish N Ronghe [4] created the slab created by composite interaction between the deck with embossments to improve its shear bond characteristics. The results are compared and graphically represented the load-deflection curves, load-end slip curves and failure modes subject to imposed loads. The shear span used here is 300, 375, 450, 525, 600 and 675. The end slip at the ultimate load failure is between 2 to 3.6 mm. As the shear span length increased, the longitudinal shear stress of slab decreased. The results are shown below:

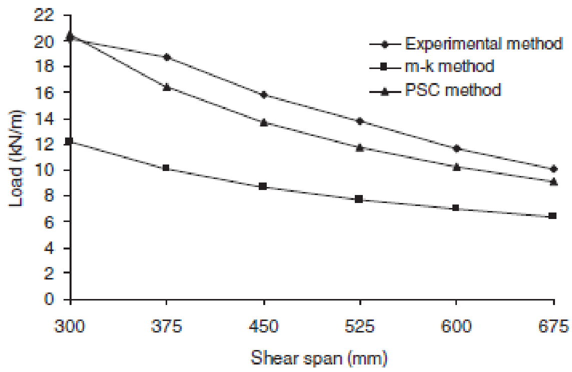


**Figure 3:** Failure/design load to shear span under flexural loading.

[5] Investigated the behaviour composite deck slab under hogging moment. The steel deck contributes to the negative moment capacity to the positive moment capacity. The simple analytical model predicts the ultimate negative moment capacity and moment–curvature relation of the composite slabs. A certain degree of ductility was observed in the slab which depends on amount and type of reinforcement. The ductility can also be improved by using steel reinforcement of higher ductile, high-yield mild steel. The ductility observed here is based on a constant moment region which is less severe than that of a peaked moment region commonly experienced.

P. Patil, M. Shaikh [6] presents 3D numerical models of SCC beams to simulate their behavior, with emphasis on the beam slab interface. Simulations were carried out using version 14.0 ANSYS.
The objective is to verify the influence of the amount, diameter and height of shear connectors in composite beams. These verifications were made by analysis of longitudinal slip in the slab-beam interface, the vertical displacement at mid-span and the bearing capacity of composite beams.

**Table 1:** Result with variations of height of studs.

| Parameter | Φ(mm) | $F_{max}$(kN) | $U_{max}$(cm) | $d_{max}$ |
|---|---|---|---|---|
| H=76mm | | 506.9 | 9.24 | 0.0188 |
| H=88mm | 19 | 481.3 | 6.48 | 0.0143 |
| H=102mm | | 481.4 | 6.54 | 0.0149 |

**Table 2:** Results considering the change in diameter

| Parameter | Φ(mm) | $F_{max}$(kN) | $U_{max}$(cm) | $d_{max}$ |
|---|---|---|---|---|
| Φ =16mm | 102 | 437.68 | 3.84 | 0.0133 |
| Φ =19mm | 102 | 481.46 | 6.54 | 0.0149 |
| Φ =22mm | 102 | 506.28 | 9.29 | 0.0151 |

[7] Evaluated the behavior of Y-type perfobond rib shear connector(A new type of connector) which is superior in shear resistance and ductility than conventional perfobond rib shear connector. Various types of the proposed Y-type perfobond rib shear connectors are examined to evaluate the effect of design variables such as strength of concrete, transverse rebar, thickness of rib having Y-shape angle. It was also proven that Y-shape angle are effective on shear resistance and ductility. It is indicated that Y-type perfobond rib shear connector has higher shear resistance and ductility than the conventional perfobond rib shear connector.

The same relative slip, the Y-type perfobond showed 12% higher shear resistance. The ductility of the Y-type perfobond rib shear connector was 255% of that of the conventional perfobond specimen and shear resistance has been increased by 8%.  S. Ranković, D. Drenić [8] researched the mechanism of failure and basic criteria for defining of the shear connectors strength on composite slabs with profiled sheet.

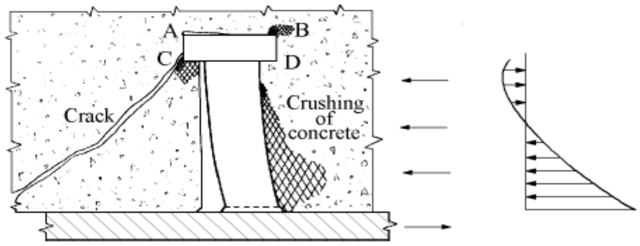


**Figure 4:** Failure model of headed stud

The shearing force at composite beams with profiled sheet is not introduced directly through the base of the shear connect, but is transferred onto the shank of the shear connector. The increased load produced crushing of concrete in front of the shear connector and transfer of shear force exclusively via bending. The maximum strength is reached either due to the failure of concrete or due to the failure of the shear connector above the weld.

V. Marimuthua, S. Seetharamana, S. Arul Jayachandrana, A. Chellappana, T. Bandyopadhyayb, D. Duttab [9] experimented the study of the shear bond behavior of the embossed composite deck slab under simulated imposed loads using m–k values. The experimental evaluation of m–k values for composite deck slabs were carried out using cold formed profiled sheets with rectangular dishing type embossments. The shape, size and frequency of the embossment, shear spans of 320 mm, 350 mm and 380 mm, 850 mm, 950 mm and 1150 mm are adopted. The load deflection behavior and slip behavior of the slabs were experimented and the results were compared accordingly. The behavior of the sheet nearer to shear span depends on the shear bond failure while the larger shear span depends on the flexure capacity of the slab.

**Table 3:** Details of shorter shear span loading and its behavior

| No | Shear span $L_s$(mm) | Failure load (kN) | Behaviour |
|---|---|---|---|
| 1 | 320 | 55.625 | First stage: Shear cracks were formed near the loading point and sudden drop in the capacity. |
| 2 | 350 | 52.191 | Second stage: Carried additional load by reinforcement mesh provided at centre of the concrete. Flexure also at loading point. |
| 3 | 380 | 47.340 | Slip: Slip was observed from the early stage of loading and the rate of slip was higher after first stage. |

**Table 4:** Details of longer shear span loading and its behavior

| No | Shear span $L_s$(mm) | Failure load (kN) | Behaviour |
|---|---|---|---|
| 1 | 850 | 22.612 | Flexure cracks were formed in between the loading points accomplished by a sudden drop in the capacity. |
| 2 | 950 | 26.920 | Additional load was resisted by nominal reinforcement mesh provided at centre of the concrete. |
| 3 | 1150 | 16.391 | Slip: Rate of slip is comparatively higher. |

A. Gholamhoseini, R.I. Gilbert, M.A. Bradford, Z.T. Chang [10] proposed longitudinal shear failure between the concrete and the steel decking the most common type of failure at the ultimate load. The bond–slip relationship of each slab was determined during the testing. The values of maximum longitudinal shear stress is also calculated. Post-cracking bending moment capacity in all slabs was achieved, but the maximum flexural capacity was controlled by slip at the concrete–steel interface in the shear span and the plastic flexural capacity of the slabs is neglected. The numerical model is also shown for accuracy and reliably prediction of the results.

## 3. Discussion

Based on the review of the above researches it is observed that the slippage in the composite deck slab can be controlled by introduction different types of shear connectors between the steel and concrete composite. However, with the increase in loading and bending moment in the composite deck slab, it was observed that the support connection is highly critical when it comes to reducing the slippage in the slab. The tests are carried out from the literature survey results mainly in the load deflection relationship or load slippage relationship. Because of the negligible friction between steel and concrete, and also the shear behavior between this is very complex the definite connection is therefore not possible and the values are taken from the past or it is experimented.

## 4. Conclusion

Form the literature review it is concluded that, the shear transfer prediction and calculation is very complex and iterative. There is no bonding between these two materials to act as one. Hence it is required to provide a connection with sufficient anchorage so as to induce a proper load transfer pattern in the composite deck slab along with the shear connectors.

## References

[1] Amar Prakash, N. Anandavalli, C. K. Madheswaran, J. Rajasankar, N. Lakshmanan, Three Dimensional FE Model of Stud Connected Steel-Concrete Composite Girders Subjected to Monotonic Loading, International journal of Mechanics and Applications, 2011; 1(1): 1-11.
[2] Hyeong-Yeol Kim, Youn-Ju Jeong, Ultimate Strength of a Steel-Concrete Composite Bridge Deck Slab with Profiled Sheeting, Engineering structures 32(2010) 534-546.
[3] J. Psota and T. Rotter, New Conception of the Shear Connector for Composite Bridge Decks, Procedia engineering 40(2012) 387-392.
[4] Namdeo Adkuji Hedaoo, Laxmikant M Gupta and Girish N Ronghe, Design of Composite Slabs with Profiled Steel Decking: A Comparison between Experimental and Analytical Studies, International journal of Advance structural engineering 2012.
[5] L. H. Lee, S. T. Quek. K. K. Ang, Negative Moment Behaviour of Cold-formed Steel Deck and Concrete Slabs, Journal of constructional steel research 57(2001) 401-415.
[6] P. Patil, M. Shaikh, A Study os Effect of Shear Connectors in Composite Beam in Combined Bending and Shear by ANSYS, IJITEE volume- 3, Aug 2013.
[7] Sang-Hyo Kim, Kyu-Tae Choi, Se-Jun Park, Seung-Min Park, Chi-Young Jung, Experimental Shear Resistance Evaluation of Y-type Perfobond rib Shear Connector, Journal of constructional steel research 82(2013) 1-18.
[8] S. Ranković, D. Drenić, Static Strength of the Shear Connectors in Stee-Concrete Composite Beams-Regulations and Research Analysis, Architecture and civil engg, volume-2 2002, pp. 251-259.
[9] V. Marimuthua, S. Seetharamana, S. Arul Jayachandrana, A. Chellappana, T. Bandyopadhyayb, D. Duttab, Experimental studies on Composite Deck Slabs to Determine the Shear-bond Characteristics (m-k) values of the Embossed Profiled Sheet, Journal of constructional steel research 63(2007) 791-803.
[10] A. Gholamhoseini, R.I. Gilbert, M.A. Bradford, Z.T. Chang, Longitudinal Shear Stress and Bond–slip Relationships in Composite Concrete Slabs, Engineering Structures 69 (2014) 37–48.
[11] Eurocode 1994-2004, Design of composite steel and concrete structures - Part 1-1: General rules and rules for buildings.

## References

**Hozaif Shabbirbhai Vohra** was born in 1992 in Junagadh, Gujarat. He receives his Bachelor of Engineering degree in Civil Engineering from the Government Engineering College, from Gujarat

Technological University in 2013. At present he is Final year student of Master's degree in Structural engineering from Marwadi Education Foundation Group of Institutions, Gujarat Technological University

**Prof. Mazhar Dhankot** completed masters in CASAD from L. D. engineering college, Ahmedabad. Currently as an associate Professor at Marwadi Education Foundations Group of Institute. He has an industrial and Academic experience of more than 14 years. At present is pursuing PhD in Base Isolation System. He has published about 10 papers in National and International conferences.