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

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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 modern 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.

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 1: Comparison of interface slip

Figure 2: Photograph of profiled sheeting with perfobond ribs
Namdeo Adkuji Hedao, 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:

Table 1: Result with variations of height of studs.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Φ(mm)</th>
<th>F_{max}(kN)</th>
<th>U_{max}(cm)</th>
<th>d_{max}</th>
</tr>
</thead>
<tbody>
<tr>
<td>H=76mm</td>
<td>19</td>
<td>506.9</td>
<td>9.24</td>
<td>0.0188</td>
</tr>
<tr>
<td>H=88mm</td>
<td>19</td>
<td>481.3</td>
<td>6.48</td>
<td>0.0143</td>
</tr>
<tr>
<td>H=102mm</td>
<td>19</td>
<td>481.4</td>
<td>6.54</td>
<td>0.0149</td>
</tr>
</tbody>
</table>

[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.

Table 2: Results considering the change in diameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Φ(mm)</th>
<th>F_{max}(kN)</th>
<th>U_{max}(cm)</th>
<th>d_{max}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Φ =16mm</td>
<td>102</td>
<td>437.68</td>
<td>3.84</td>
<td>0.0133</td>
</tr>
<tr>
<td>Φ =19mm</td>
<td>102</td>
<td>481.46</td>
<td>6.54</td>
<td>0.0149</td>
</tr>
<tr>
<td>Φ =22mm</td>
<td>102</td>
<td>506.28</td>
<td>9.29</td>
<td>0.0151</td>
</tr>
</tbody>
</table>

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

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.

[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.

The results are shown below:
and the values are taken from the past or it is deflection relationship or load slippage relationship.

the support connection is highly critical when it comes to concrete, and also the shear behavior between this is very complex and transfer prediction and calculation is very complex and Chang [10] proposed longitudinal shear failure between A. Gholamhoseini, R.I. Gilbert, M.A. Bradford, Z.T. ex

However, with the increase in loading and bending connectors between the steel and concrete composite. controlled by introduction different types of shear that the slippage in the composite deck slab can be achieved, but the maximum flexural capacity was neglected. The numerical model is also shown for accuracy and reliably prediction of the results.

4. 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


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