

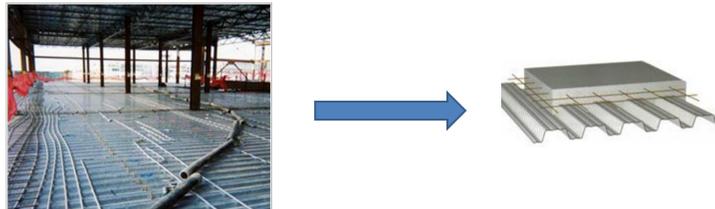
Mechanical Enhancement Of Composite Decks

Civil Engineering

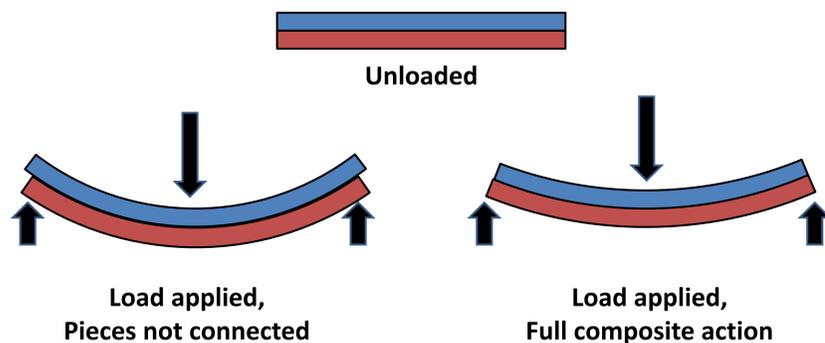
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Introduction

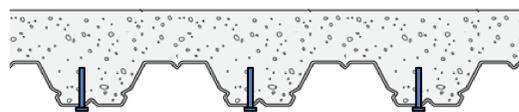
Many buildings make use of composite decks as either floors or roofs. A composite deck consists of concrete poured over a corrugated piece of light gage steel deck. In addition, steel rebar is cast within the concrete as reinforcement. A cross section of a typical composite deck is shown below.



Typically, the strength of the composite deck is calculated by only taking the steel rebar and the concrete into account – the light gage steel deck is disregarded. This is because the concrete is not mechanically connected to the steel deck. If the concrete could be mechanically connected to the steel deck, the strength and rigidity of the deck could be greatly increased (see below).

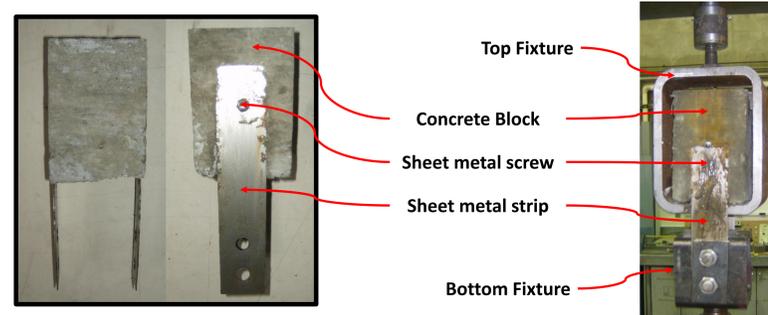


It is anticipated that the concrete can be anchored to the corrugated steel deck both economically and effectively by drilling sheet metal screws through the steel deck prior to placing the concrete (a cross section is shown below). Calculations indicate that this connection might prove so effective that steel reinforcement within the concrete (known as rebar) might be done away with entirely.

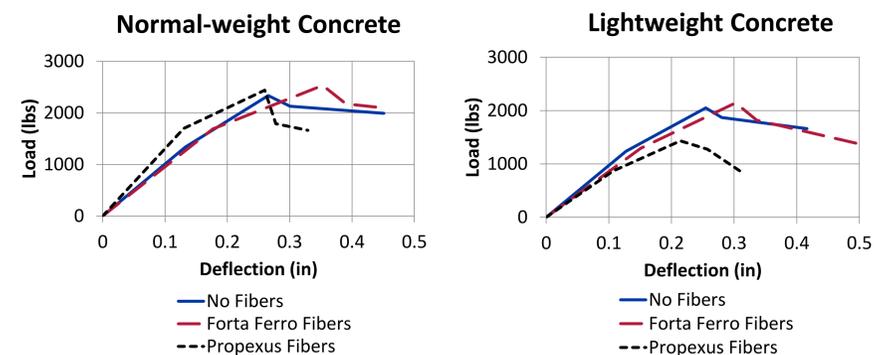


Experimental Validation of Connection Strength

Predicted values for the strength of the embedded sheet metal screw were based primarily on design equations from ACI 318. These design equations are typically meant for much larger embedded fasteners, and are typically very conservative. For that reason, it was deemed necessary to experimentally validate the strength of the connection. In all cases, the experimentally validated strength exceeded that predicted by ACI equations. The strength of the connections was tested with specimens as shown below (left). These specimens were loaded in tension using a hydraulically actuated machine (right).



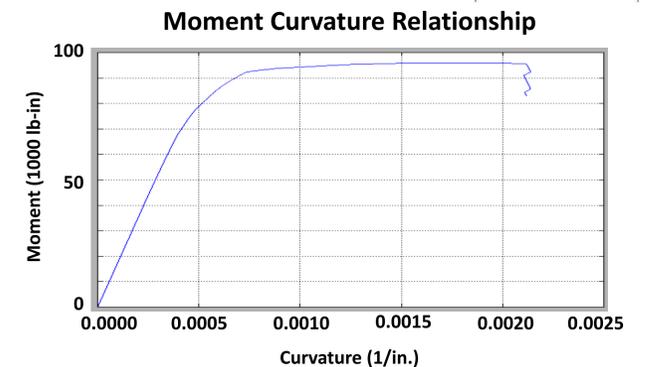
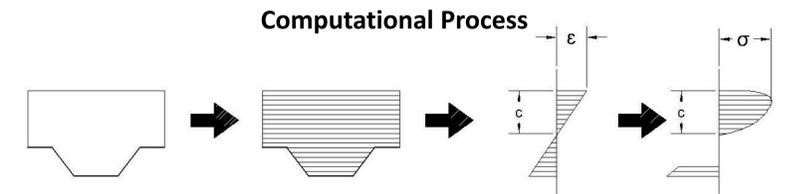
A total of 6 different concrete mixes were used (both lightweight and normal-weight, using no fibers, Forta Ferro fibers, or Propexus fibers). For each mix, 5 identical specimens were constructed and tested. After the data was appropriately filtered, the curves shown below emerged. The graph on the left shows load as a function of deflection for normal-weight concrete, and the graph on the right shows the same data for lightweight concrete.



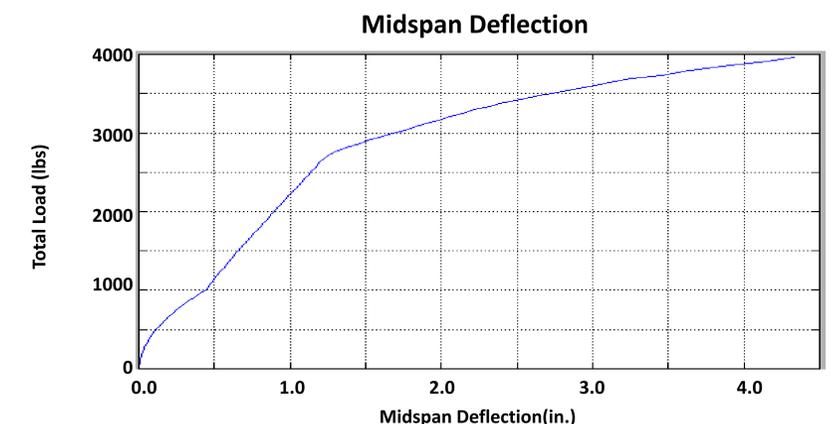
It is interesting to note that the Propexus fibers did not appear to increase the ductility or strength of the connection. In addition, specimens utilizing Forta Ferro fibers only achieved modest gains in ductility.

Section Modeling and Simulation

Using the material stress-strain curves and the geometry of the section a moment-curvature plot was developed. This was accomplished by discretizing the cross-section into a series of horizontal strips, and then calculating the curvature and moment for various strain values.



The moment-curvature relationship, along with the experimentally developed load-displacement curves for the shear connections, were used to calculate the expected deflection of a span. The midpoint deflection of a span is shown below for a 36 in. span subject to two equally-spaced point loads of equal magnitude. The vertical axis shows the total load placed on the beam.



Acknowledgements

I would like to thank Dr. Tehrani, Steve Scherer, and Derrick Gangbin for their help and guidance. In addition the following companies provided much support:



Conclusions and Future Work

The preliminary results presented here indicate that the addition of shear connectors between the concrete and steel deck will increase the strength of the deck. If these results are held up after the flexural testing of actual pieces of composite deck, this method will offer an alternative to tradition steel reinforcement of decks.

Currently, a set of 24 composite deck beams are curing, and will be testing in mid May. These beams make use of the same 6 concrete mixes used above, and each is 36 inches long. The midspan deflection should be similar to that predicted above.

It is interesting to note that the connections that used Propexus fibers displayed less ductility than the plain concrete mixes. In addition, connections using Forta Ferro fibers displayed only small increases in ductility. Therefore, it might be more cost effective to increase the thickness of the deck than to use reinforcing fibers. However, the ductility that the fibers add to the net section might warrant the use of fibers for high seismic applications.

