Cold Formed Steel
CSSBI Canadian Sheet Steel Building Institute
Research Note
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Strength of Floor Joists with Offset Loading on Bearing Stiffeners

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Abstract

It is common practice in cold formed steel framing to require the loadbearing elements (i.e. rafters, studs, joists) to be lined up so that the gravity loads are transferred in a direct line to the foundation. This eliminates the need for transfer beams at junction points, and is called "in-line framing". The standard details for residential steel framing allow a ¾in. offset between vertical loadbearing members to be classified as being in-line. Reported in this Research Note are the results of a research project that tested cold formed steel floor assemblies where the axial loadbearing studs were offset from the floor joist. It was concluded that the offset between the floor joist bearing stiffener and the loadbearing studs was the significant parameter. If this alignment is maintained, the ¾in. offset does not significantly affect the strength of the assembly.

Background

The CSSBI has published a prescriptive design guide for residential steel framing titled CSSBI 55-99, *Residential Steel Framing Installation Manual*. This document provides requirements for construction with cold-formed steel framing to be used in conjunction with the CSSBI S13-99, *Residential Steel Framing Member Selection Tables*. One of the requirements in the installation manual calls for "in-line" framing unless a structural load distribution member is included. In-line framing means that the "joist, rafter, truss and structural wall stud shall be aligned so that the centerline (mid width) is within ¾in. of the centerline (mid width) of the load bearing members beneath".

It is common practice in cold-formed steel construction to include bearing stiffeners in floor joists at each bearing location or point of concentrated load. An extensive study [Fox and Schuster 2002] of the behavior of bearing stiffeners has been carried out, and new design provisions are being proposed for inclusion in the *North American Specification for the Design of Cold-Formed Steel Structural Members* [CSA 2001]. The basic design equations for bearing stiffeners, however, do not recognize the influence of a ¾in. offset in the load path through the assembly. A small research project was undertaken at the University of Waterloo [Black et. al. 2002] to look at the effects on the behavior of the assembly by offsetting the load path.

Test Configurations

The test assemblies were constructed to simulate actual floor assemblies. Each specimen consisted of four floor joist pieces and was 4 feet square. The cut-away drawing in Figure 1 illustrates the details. The load was applied through a short cripple stud to one end of one of the floor joists.

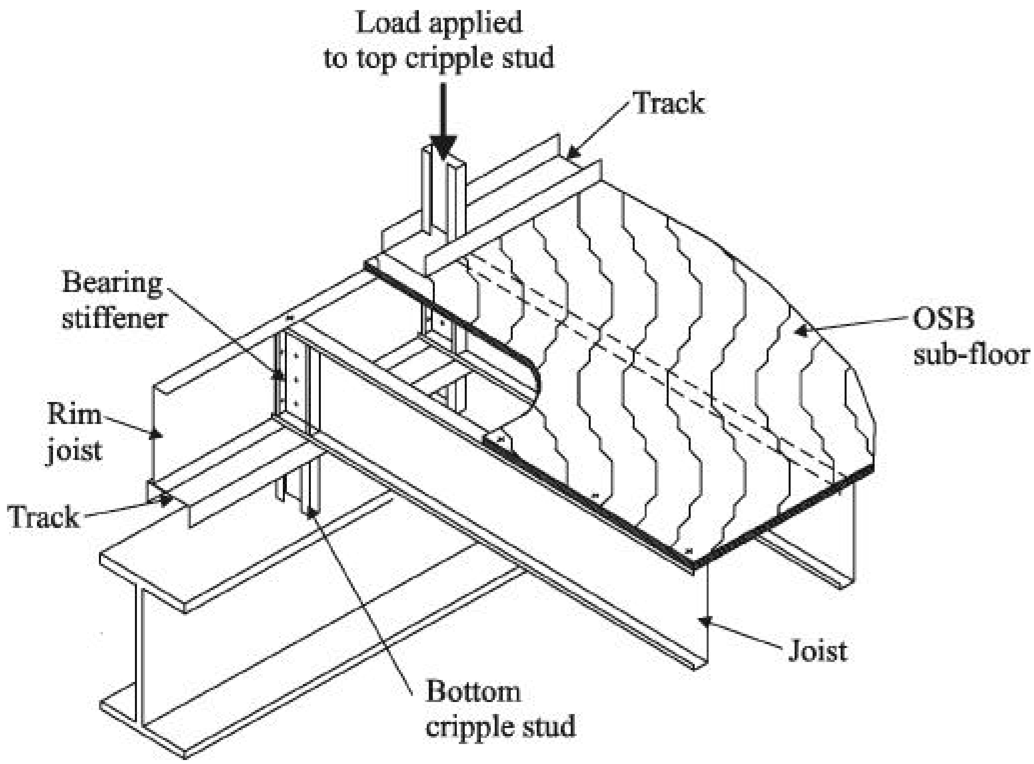

Figure 1: Cut-Away Sketch of Test Set-up

The floor joists and rim joists were 8 in. deep with an actual base steel thickness of 0.050 in. The bearing stiffeners were 3-5/8 in. stud sections with a measured thickness of 0.034 in. The sub-floor was 5/8 in. OSB. The wall framing track sections were 3-5/8 in. wide with a nominal thickness of 0.033 in. The cripple studs were 3-5/8 in. wide with a nominal thickness of 0.105 in.

The provision of the ¾in. offset between the centerlines of the various components creates a number of possible configurations: (a) the top loadbearing stud can be offset on either side of the joist; (b) the bottom loadbearing stud can be offset on either side of the joist; (c) the bearing stiffener can be attached on either side of the joist web. The behavior of the assembly will be influenced by the combinations of stud offset and stiffener location. The test configurations are illustrated in Figure 2, and were selected to cover the more common variations.

Discussion of Test Results

The tested capacities of each assembly are also shown in Figure 2. These values are the average of two tests of identical specimens.

Case 1 is the "base line case" and provides a load path that is in a direct line through the studs and bearing stiffener. Case 2 has the stiffener attached to the back of the joist, which results in a reduction in capacity of approximately 18% compared to Case 1. As a matter of interest, the capacity of this assembly calculated according to the bearing stiffener design provisions being proposed for the NA Specification would be 4.72 kips. This shows that the effect of the rim joist and sub-floor increases the capacity of the assembly by at least 35%.

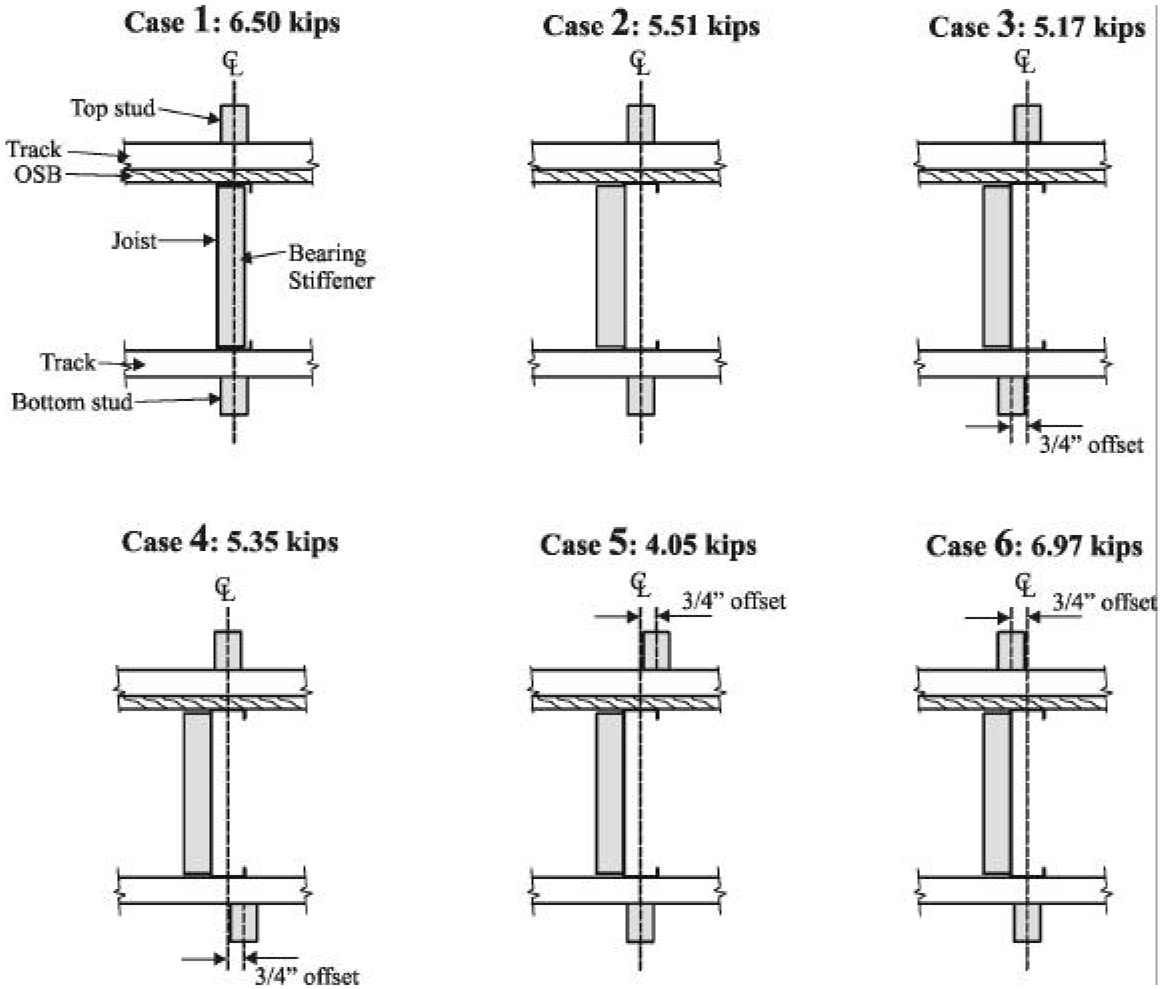

Figure 2: Offset Load Cases

Cases 3 and 4 investigated varying the offset of the bottom loadbearing stud. There was no significant difference in strength with variations in the bottom stud offset (i.e. compare Cases 2, 3 and 4). It was originally expected that the failure of the assembly would be initiated at this bottom stud location since there was no sub-floor to distribute the load as there is under the top stud. However, in all of the tests the failure initiated at the top of the joist. This can be attributed to distribution of load through the rim joist and sub-floor to the other bottom cripple studs supporting the specimen.

Cases 5 and 6 investigated varying the offset of the top loadbearing stud. Case 5 clearly shows the effect of the offset of the top stud from the bearing stiffener. In all other tests except Case 5 the failure mode was web crippling of the joist followed by local buckling of the stiffener. In Case 5, the failure was punching of the top loadbearing stud through the sub-floor. This occurred even though there was a track between the sub-floor and the stud. Case 6 shows that if the top stud is located over the stiffener, the results are comparable to Case 1 with the stiffener between the joist flanges.

Conclusions

This article has described a pilot study investigating the significance of the ¾in. offset allowed with in-line framing. It was found that the significant variable affecting the capacity of the assembly was the offset between the upper loadbearing stud and the bearing stiffener. A reduction in strength of as much as 40% was observed.

References

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