

Strength of CFS Floor Assemblies with Clip Angle Bearing Stiffeners

RESEARCH REPORT RP05-6

2005

REVISION 2006



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PREFACE

The primary objective of this project was to develop design provisions for the utilization of clip angles as bearing stiffeners in cold-formed steel floor assemblies. This report presents the results of 120 end-two-flange loading tests of typical floor configurations carried out to check and compare joist depth and thickness, clip angle thickness and in-line and offset loading conditions.

The project developed a design methodology for the use of clip angle bearing stiffeners in cold-formed steel floor joist assemblies. These provisions are suitable for including in the proposed *AISI Standard for Cold-Formed Steel Framing – Floor and Roof System Design* (predictor equation) and the *AISI Standard for Cold-Formed Steel Framing – General Provisions* (offset conditions). In addition, provisions for clip angle bearing stiffeners should be added to the *AISI Standard for Cold-Formed Steel Framing – Prescriptive Method for One and Two Family Dwellings* based on these results.

Research Team
Steel Framing Alliance

The Strength of CFS Floor Assemblies with Clip Angle Bearing Stiffeners

Prepared for the
STEEL FRAMING ALLIANCE
and the
STEEL STUD MANUFACTURERS ASSOCIATION

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October 17, 2005

Executive Summary

Described in this report are the results of an experimental investigation into the strength of cold-formed steel floor assemblies utilizing clip angles as bearing stiffeners. The investigation consisted of 120 end-two-flange loading tests of typical floor configurations carried out to check and compare the following variables:

- joist depth and thickness;
- clip angle thickness;
- in-line and offset loading conditions.

The main conclusions reached are as follows:

- A recommendation is proposed for a design approach to calculate the capacity of a clip angle bearing stiffener. The predictor expression adds the web crippling capacity of the joist, the web crippling capacity of the rim track, and the axial capacity of the clip angle. To simplify the calculations of the capacity of the clip angle, a reduced stress on the gross area is used in lieu of the yield stress on an effective area.
- If the loadbearing stud is offset from the centerline of the floor joist such that the stud is bearing over the joist flange, there can be a reduction in the strength of the assembly accompanied by excessive deformations. Recommendations have been made for reductions in the predicted capacity for specific situations.
- Due to the interaction of the different components in the assembly (i.e. joist, rim track, clip angle, screws, wall track, and wall stud) there is a wide scatter in the test results not captured by the parameters in the predictor equation. Consequently, a conservative approach was taken in developing the proposed equation.

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1 Introduction

Stiffeners are commonly used in cold-formed steel construction to strengthen the floor joists at bearing locations. Extensive testing has been carried out on assemblies using stud and track sections as bearing stiffeners (Fox, 2002; Fox and Schuster, 2002; Fox and Schuster, 2003), and design provisions have been incorporated into the North American Specification (AISI, 2004a). Testing has also been carried out on the effects of an offset load applied to a stiffened assembly (Fox, 2003) resulting in changes to the AISI COFS *General Provisions* (AISI, 2004b).

Clip angles are products used extensively in cold-formed steel construction that could also have an application as bearing stiffeners. Preliminary tests on floor joist assemblies carried out at the University of Waterloo (House, 2002), has shown that clip angles can develop significant capacity when used as bearing stiffeners. This work included tests on a number of configurations, focusing on the effect of clip angle length and thickness. The photograph in Figure 1.1 shows the failure mode commonly associated with these assemblies.

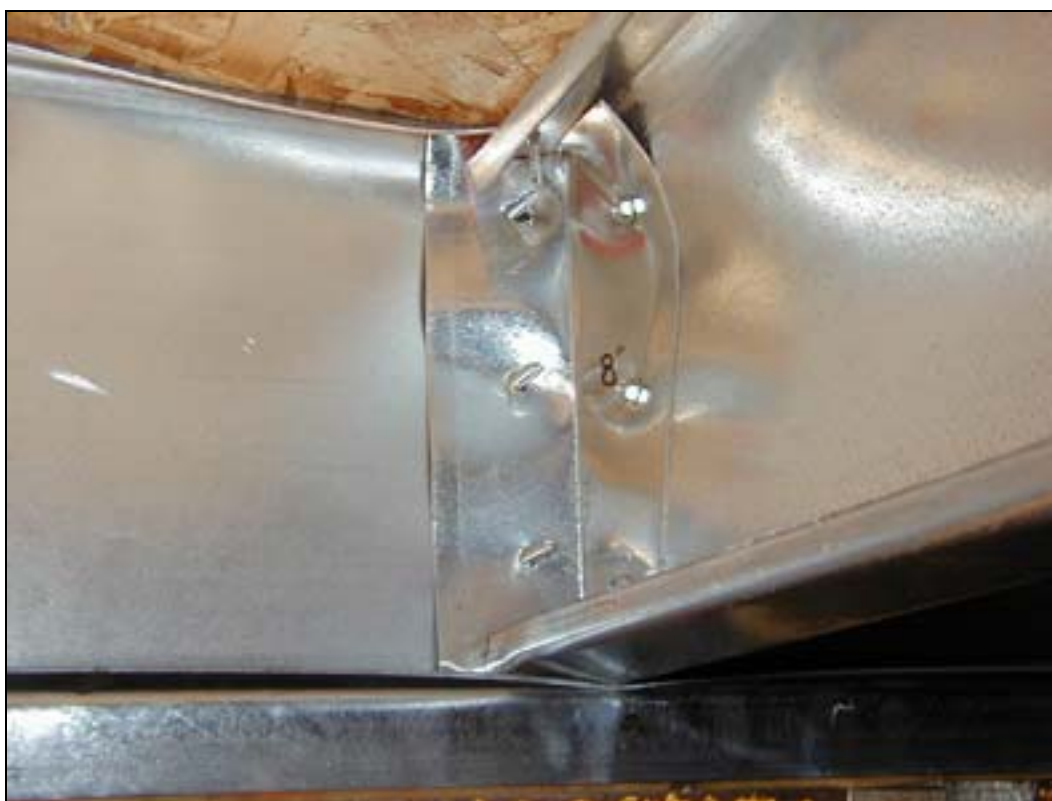


Figure 1.1: Failure of Floor Assembly with a Clip Angle Bearing Stiffener

The results from this work are presented in Figure 1.2. This plot illustrates the following conclusions:

1. Clip angles can help the floor joist assembly develop significant resistance to end-two-flange loading.
2. The length of the clip angle is a significant variable in the capacity. The strength decreases as the gap between the end of the clip angle and the joist flanges increases.
3. It is reasonable to expect that additional research could result in practical design expressions for this type of stiffened assembly.

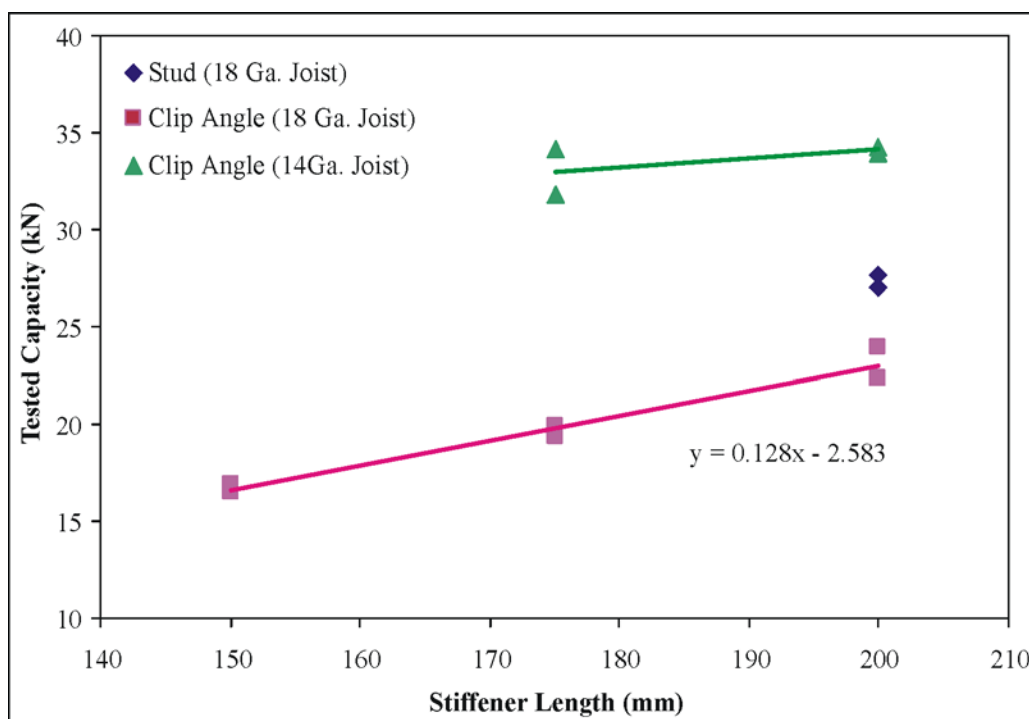


Figure 1.2: Results from Research by House et. al.

2 Objective

Following on the results of the preliminary work by House et. al., the AISI Committee on Framing Standards and the Steel Framing Alliance initiated the current project. The objective of this project is to develop predictor equations for the design of cold-formed steel floor assemblies with clip angles used as bearing stiffeners.

3 Scope

The scope of work in this project covers the following:

- a) Experimentally investigate the effects of the following parameters on the capacity of cold-formed steel floor joist assemblies with clip angle bearing stiffeners subject to end-two-flange loading:
 - i) Clip angle size and thickness;
 - ii) Joist and rim track depth and thickness;
 - iii) Number and size of screws;
 - iv) Clip angle positioned between joist flanges or on back of joist;
 - v) Load path offset.
- b) Develop predictor expressions for the ultimate strength of the assembly.

4 Test Specimens and Experimental Set-Up

4.1 Test Specimens

The test specimens were 4-foot square sections of a floor assembly constructed in accordance with standard industry practice. The assembly was sufficiently large to allow tests to be conducted at each end of the two interior joists. Four tests could be carried out on each specimen. In all cases the clip angle was cut 3/8" shorter than the joist depth in compliance with the limitation placed on bearing stiffeners in the AISI *Prescriptive Method* (AISI, 2001).

Connections to the clip angle (i.e. to joist and to rim track) were made with #8 or #10 hex head self-drilling screws following the minimum requirements of the *Prescriptive Method*. Three (3) screws were used in all of the clip angle connections. All other connections in the assembly used #10 hex head self-drilling screws. The bearing of the joist on the support was 1-1/2" wide.

4.2 Research Plan

The proposed scope of the project, as described in Section 3, included a wide range of variables. To reduce the number of tests, the combination of parameters was limited based on the following rational:

- Only 8, 10 and 12 in. joist depths were tested being representative of the common range of floor joist products.
- The joist thickness/depth combinations will be selected to provide a range of web slenderness values from 80 to 270.
- 33 and 54 mil rim track was used, which is conservative for thicker sections.
- #8 and #10 screws were used for the connection of the clip angle to the joist and track.
- The load is applied to the top of the assembly through a 362S162-103 loadbearing stud 3 in. long. The floor assembly also included a 33 mil wall track but without any sub-floor. This condition will be conservative for other assemblies with any type of sub-floor and wall track thickness.
- The loading arrangement simulates the second floor configuration loaded by a stud wall, which is the most severe condition.
- Certain configurations were tested for the offset loading conditions. The intention was to determine if the offset condition allowed by the *General Provisions* (AISI, 2004) significantly affected the strength of the assembly.

The range of variables tested is listed in Table 4.1 and include the following:

- Joist depth (8, 10 and 12 inches).
- Joist thickness (43, 48, 54, 75, 97 and 103 mils).
- Rim track thickness (33 and 54 mil).
- Clip angle size (1-1/2" x 1-1/2").
- Clip angle thickness (30, 43, 60, 75 and 103 mil).
- Clip angle 3/8" less than the depth of the joist as prescribed by the *Prescriptive Method* for bearing stiffeners.
- 3 screws located at quarter points along length of clip angle.
- Test assemblies 1 through 17 used #8 screws to connect the clip angle to both the joist and rim track. Test assemblies 18 through 29 used #10 screws.
- Clip angle location (inside joist flanges or on the back of web).
- Bearing condition (joist bearing on a second floor exterior stud wall).
- Offset loading (i.e. 3/4" offset from centerline of loadbearing stud from centerline of joist).

Table 4.1: Test Configurations

Assembly Number	Joist Depth (in)	Joist Thickness (mils)	Clip Angle Thickness (mils)	Clip Angle Location	Load Offset
1A-1 & 2	8	103	60	Inside	In-Line
1B-1 & 2			75		
2A-1,2,3 & 4	8	48	75	Inside	In-Line
2B-1,2 & 3				Back	In-Line
3A-1 & 2	8	48	60	Inside	In-Line
3B-1,2 & 3				Back	In-Line
4A-1,2 & 3	8	48	60	Inside	Offset L
4B-1,2 & 3				Back	Offset L
5A-1,2 & 3	8	48	60	Inside	Offset R
5B-1 & 2				Back	Offset R
6A-1 & 2	10	54	60	Inside	In-Line
6B-1 & 2				Inside	Offset R
7A-1 & 2	10	54	75	Inside	In-Line
7B-1 & 2				Back	In-Line
8A-1 & 2	10	103	60	Inside	In-Line
8B-1 & 2			75		
9A-1 & 2	12	48	60	Inside	In-Line
9B-1,2 & 3			75		
10A-1 & 2	12	75	60	Inside	In-Line
10B-1 & 2			75		
11A-1,2 & 3	12	48	75	Inside	In-Line
11B-1 & 2		75			
12A-1 & 2	12	75	60	Back	In-Line
12B-1 & 2			75		
13A-1 & 2	10	54	60	Back	In-Line
13B-1 & 2			75		
14A-1 & 2	10	54	75	Inside	In-Line
14B-1 & 2		103			
15A-1,2 & 3	8	48	75	Inside	In-Line
15B-1 & 2		103			
16A-1 & 2	12	48	60	Inside	Offset R
17A-1 & 2	8	48	75		
18A	8	75	103	Inside	In-Line
18B				Inside	Right
18C			43	Inside	In-Line
18D				Inside	Left
19A	8	75	30	Inside	In-Line
19B				Inside	Right
19C				Back	In-Line
19D				Back	Right

Table 4.1: Test Configurations (Cont'd)

Assembly Number	Joist Depth (in)	Joist Thickness (mils)	Clip Angle Thickness (mils)	Clip Angle Location	Load Offset
20A	8	48	30	Inside	Right
20B				Inside	Left
20C				Back	In-Line
20D				Back	Right
21A	8	48	103	Inside	Right
21B				Inside	Left
21C				Back	In-Line
21D				Back	Right
22A	10	43	30	Inside	In-Line
22B				Inside	Right
22C				Back	In-Line
22D				Back	Right
23A	10	75	103	Inside	Right
23B				Inside	Left
23C				Back	In-Line
23D				Back	Right
24A	12	48	43	Inside	In-Line
24B				Inside	Right
24C				Back	In-Line
24D				Back	Right
25A	12	54	43	Inside	Right
25B				Inside	Left
25C				Back	In-Line
25D				Back	Right
26A	12	54	103	Inside	Right
26B				Inside	Left
26C				Back	In-Line
26D				Back	Right
27A	8	75	103	Back	In-Line
27B				Back	Right
27C			30	Back	In-Line
27D				Back	Right
28A	10	103	103	Back	In-Line
28B				Back	Right
28C			43	Back	In-Line
28D				Back	Right
29A	10	97	30	Inside	Right
29B				Inside	Left
29C				Back	In-Line
29D				Back	Right