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Floor Truss Creep Research: Long Term Deflection of I-Joist Floor Systems

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Editor's Note: This article was written in response to the June/July 2001 WOODWORDS article, Serviceability of Wood Framed Floor Systems in Residential Construction, by S. B. Taylor and H. B. Manbeck.

Engineered wood I-joists are becoming increasingly dominant in residential wood floor systems. Reports indicate that engineered wood I-joist floors currently account for 81 percent of the new residential floor systems market. Figure 1 illustrates a typical residential floor system with wood I-joists and OSB sheathing. The floor system typically consists of wood I-joists, spaced 16" on-center, and 23/32" OSB sheathing glued and nailed to the top flange of the joists.

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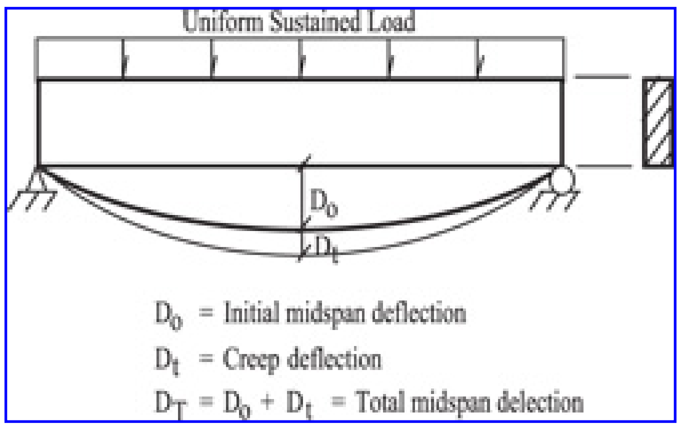

FIGURE 2: DEFINITION SKETCH FOR INITIAL, TOTAL AND CREEP DEFLECTION OF A WOOD JOIST

The overall deflection of wood floors consists of two parts. The first part is the initial deflection immediately after application of the floor load, D_o, (see Figure 2). The second part is the long term, or creep deflection, D_t, that occurs if the load is sustained for time periods of several days, weeks, months or even years (see Figure 2). The total deflection of the floor system is the sum of the immediate and long-term deflections, $D_T = D_o + D_t$. The creep ratio, D_t/D_o, is often used to characterize the long-term behavior of a wood floor system.

The long-term deflection, or creep, behavior of solid-sawn joist wood floor systems has been studied and reported by Fridley, et al. (1997). The long-term creep behavior of wood I-joist floor systems has been investigated by Pennsylvania Housing Research Center (PHRC) researchers at Penn State University. This article summarizes the recent research efforts and interprets the impact of the findings for residential builders.

DESCRIPTION OF THE FLOOR SYSTEM TESTS

Two creep deflection studies of wood floor systems were completed recently by PHRC researchers (Wisniewski, 2000; Roeder, 2002; Roeder et al., 2002). The first was an exploratory study to observe if the creep behavior of a wood I-joist floor system was different from published creep responses for solid-sawn joist floor systems. This second study was a more comprehensive follow up study to the first. The goal of this study was to directly compare the creep response of wood I-joist and solid-sawn floor systems when both were exposed to identical environmental conditions.

The first study was initiated in July 1999 to measure the creep response of an I-joist/OSB floor

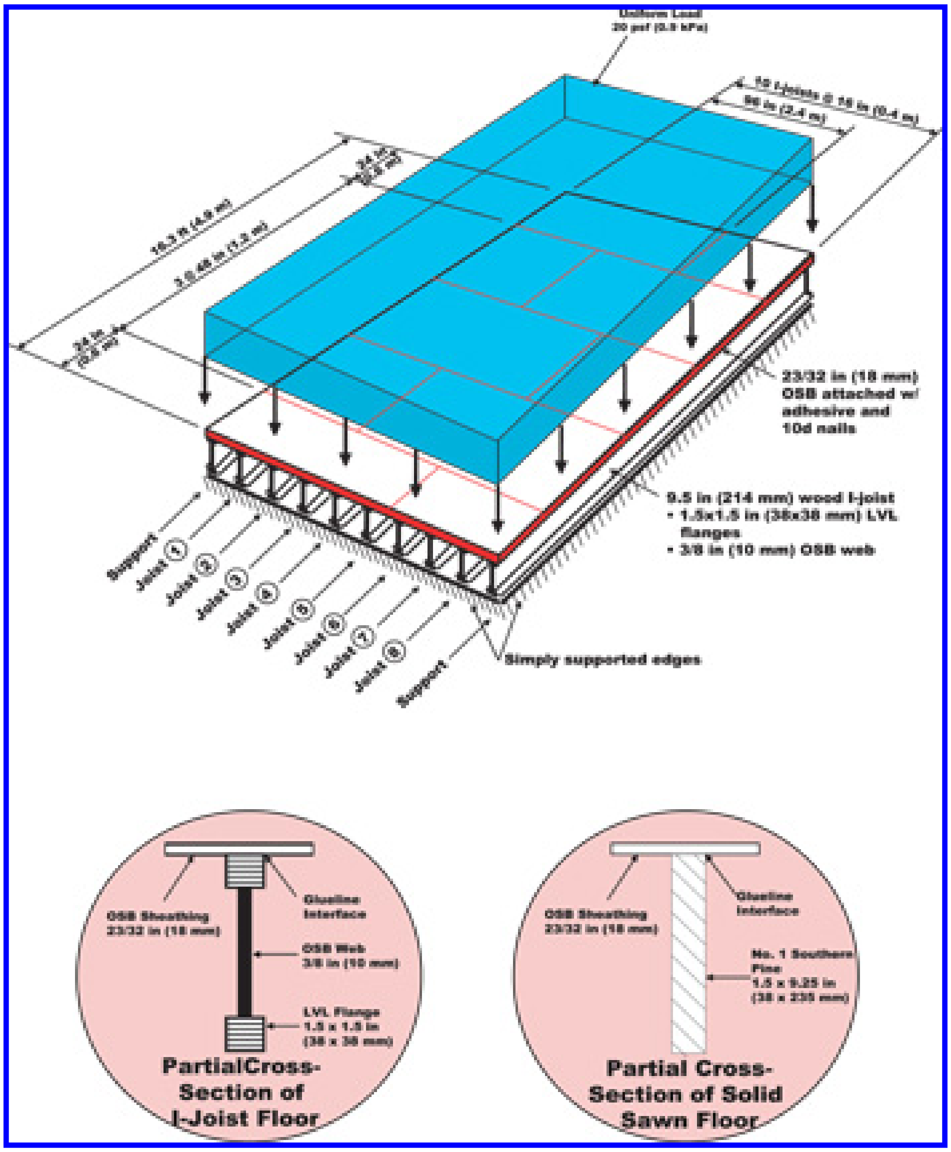

FIGURE 1: TYPICAL ENGINEERED WOOD I-JOIST FRAMED/OSB SHEATHED FLOOR SYSTEM

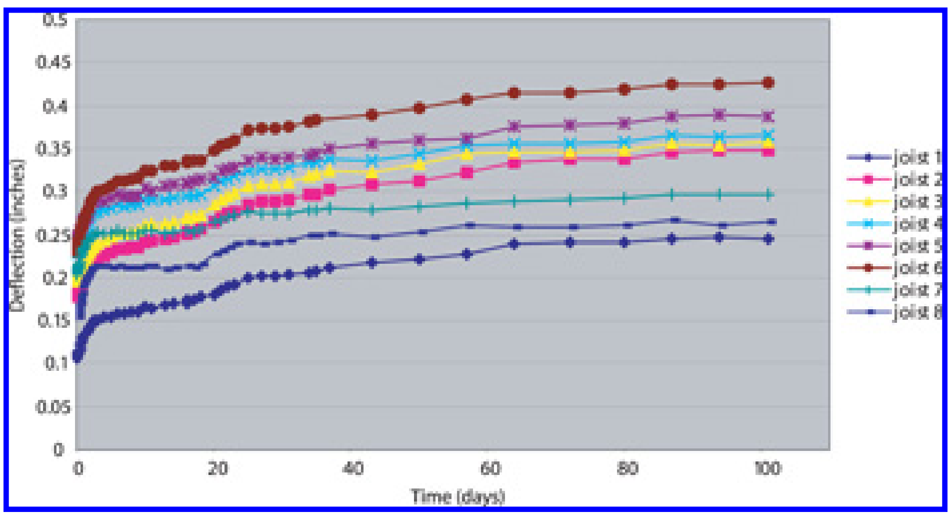

FIGURE 3. TOTAL MIDSPAN DEFLECTION OF EACH I-JOIST WITHIN FLOOR 3 OF STUDY 2, SET 2.

system subjected to a uniformly distributed sustained total load of 20 pounds per square foot (psf), the floor design dead plus sustained live load (see Figure 1). The sustained loads were applied to this floor for 280 days. In this floor the OSB sheathing was glued to the top of the joists with a low strength (shear strength = 150 pounds per square inch [psi]) elastomeric polyurethane construction adhesive. The glueline was clamped with 8d common nails spaced 6" on-center on the edges and 12" on-center in the field. All gluelines were allowed to cure for at least three weeks prior to load application. The environmental temperature and humidity in the test area were allowed to vary during summer and winter months. In the winter the air was maintained at 70°F; in summer the temperature varied with outside air temperature. In the winter the relative humidity in the vicinity of the test floor fell below 30 percent for extended periods of time until a humidification system was added to keep the relative humidity above 30 percent. The materials used in the study floor consisted of 9.5" deep composite wood I-joists and 23/32" tongue and groove (T & G) OSB sheathing. The I-joists were fabricated with 1.5" x 1.5" flanges and a 3/8" OSB web. The study floor consisted of ten, 16' I-joists spaced 16" on-center. The overall floor dimensions were 12' x 16'.

The second study was initiated

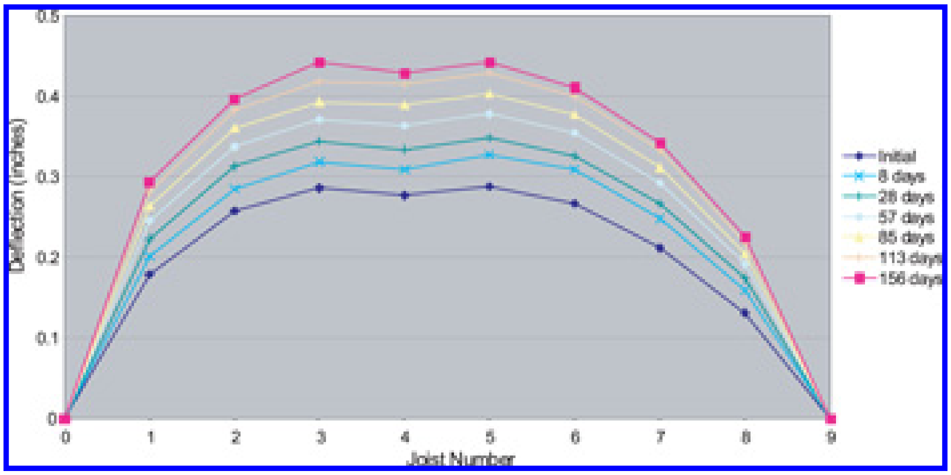

FIGURE 4. TOTAL MIDSPAN DEFLECTION PROFILE FOR I-JOIST FLOOR 3 OF STUDY 2, SET 2.

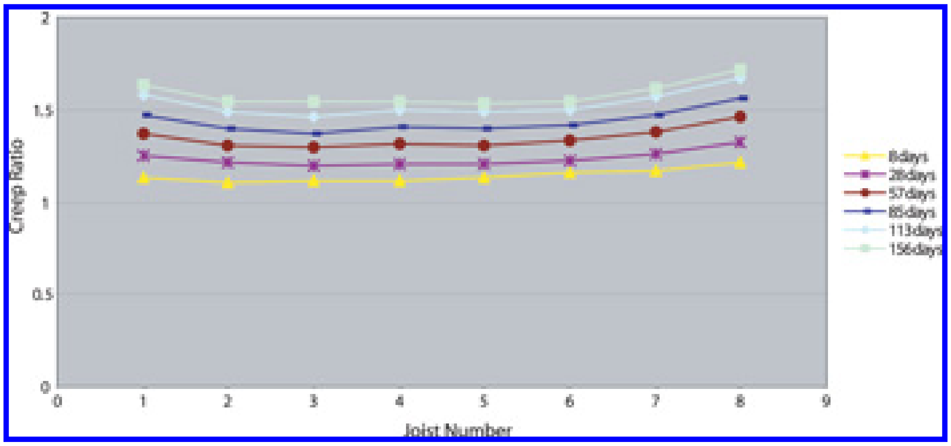

FIGURE 5. CREEP RATIOS FOR I-JOIST FLOOR 3 OF STUDY 2, SET 2.

in August 2001 and was conducted in two sets of three floors each. Each set of three floors included two I-joist/OSB floors identical to the floors used in the first study in 1999 except that a higher strength elastomeric adhesive (shear strength = 450 psi) was used to attach the sheathing to the joists. Each set of three floors also included one solid-sawn joist floor (see Figure 2). The construction of the solid-sawn floor was identical to the I-joist floors in the set except the I-joists were replaced with nominal 2 x 10 No. 1 southern pine joists. The published bending stiffness (EI) of the solid-sawn joists was 1.68E8 lb-in2; the average initial deflection of the middle four joists for set 1 and 2 solid-sawn floors was 0.224 in. and 0.226 in., respectively. The average measured bending stiffness (EI) of a random sample of six wood I-joists was 1.56E8 lb-in2 and 1.57E8 lb-in2 for set 1 and set 2 floors, respectively. Average initial deflection for the middle four I-joists for the two floors of set 1 was 0.267" and 0.274" respectively. Corresponding initial deflections for the two I-joist floors of set 2 were 0.280" and 0.290".

Floor Type	Study (Set)	Creep Ratio	Days to Deflection Stabilization
Solid-sawn	Study 2 (Set 1)	1.75	87[1]
Solid-sawn	Study 2 (Set 2)	1.66	115[2]
Solid-sawn	Study 2 Average	1.71	101
I-Joist	Study 1	1.73	168
I-Joist	Study 2 (Set 1)	1.54	72[1]
I-Joist	Study 2 (Set 2)	1.52	106[2]
I-Joist	Study 2 Average	1.53	89

[1] Set 1 floors were initially loaded in July/August when average daily temperature and relative humidity were 81°F and 78 percent, respectively.

[2] Set 2 floors were initially loaded in December when average daily temperature and relative humidity were 73°F and 47 percent, respectively.

TABLE 1: FINAL CREEP RATIOS FOR THE TEST FLOOR SYSTEMS.

The first set of three floors was load tested with the 20 psf sustained-load for 101 days between August and November 2001 (the creep deflection had stabilized by this time). The second set of three floors was load tested with the 20 psf sustained load for 154 days between December 2001 and May 2002. The temperature and humidity in the vicinity of the test floors in the second study were allowed to vary in a manner similar to the variation experienced in a residential home in the Northeastern U.S. In winter the temperature was maintained at 70°F; in summer the temperature was always above 70°F, but varied closely with outside temperature. The average daily temperature and humidity for the first set of floors were 77.5°F ± 3.9 F and 56.4 percent ± 17.5 percent, respectively. The corresponding environmental conditions for the second set of floors were 74.3°F ± 2.6 F and 48.3 percent ± 8.8 percent, respectively. In contrast to the first study in 1999, the relative humidity never fell below 30 percent.

For both studies, the midspan deflection of each wood floor joist was measured using dial gauges with a least reading of 0.0005". Deflections were measured immediately after the load was applied and then periodically until the deflection stabilized at a constant value. The creep ratio of each joist was then computed at selected time intervals for each floor.

SUMMARY OUTCOMES

A typical plot of the midspan deflections of all the joists of one of the I-joist floors of the second study is shown in Figure 3. The total midspan deflection profiles of all the floor joists for the same test floor immediately after and 8, 28, 57, 85, 113 and 156 days after application of the 20 psf sustained load are shown in Figure 4.

The final creep ratio after deflection stabilization, the ratio of the total midspan joist deflection to the immediate midspan joist deflection (D_T/D_o) after 8, 28, 57, 85, 113 and 156 days of loading, for each joist of the same floor is shown in Figure 5. For this floor the creep ratios were nearly equal for all joists with an average ratio for all joists of 1.57. All the test floors of both studies showed similar trends although the number of days required for stabilization and the magnitude of the final creep ratio differed between the two studies. Table 1 shows the number of days after which the total deflections stabilized and the final average creep ratios for each set of test floors.

The average final creep ratio of the I-joist/OSB floor of the first study was 1.73. The average final creep ratios of the I-joist/OSB floors of the second study were 1.54 and 1.52 for set one and set two, respectively. The average creep ratio for the four I-joist floors of the second study was 1.53. These differences were undoubtedly due to two factors. First, the adhesive used in the second study was stiffer than the adhesive used in the first study and was more similar to adhesives used in the modern construction industry. Second, the relative humidity swings during portions of the first study were abnormally large for a typical residential application. Abnormally large swings in relative humidity and very low relative humidities (less than 30 percent) followed by periods of higher relative humidity have been shown to increase the creep deflection of wood-based joists.

The average final creep ratio of the I-joists of the second study was 1.53. The average final creep ratio of the solid-sawn joists of the second study was 1.71. This shows that the long term deflection of wood I-joist floor systems is slightly less than the long term deflection of solid-sawn wood floor systems provided the construction details and the environmental exposure conditions are identical for both.

BUILDER IMPACT

Builders can use I-joist floor systems with confidence. Elastomeric adhesives with shear strength of at least 450 psi are recommended for all floor systems. The shear strength of most construction grade adhesives meets or exceeds this strength level. The long term deflection performance of properly glued wood I-joist system is equal to or better than the creep performance of glued solid sawn floor systems when exposed to identical thermal (temperature and relative humidity) conditions.

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