SJI Updates – Expanded Load Tables for Noncomposite Joists / Joist Girders and Development of New Composite Joist Series

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Mr. Samuelson joined Nucor Corporation in 1982 and has been employed in the Nucor Research and Development Department since that time. During the last 12 years Mr. Samuelson has been heavily involved with the coordination of research testing projects evaluating the performance of composite shortspan joists, composite longspan joists, and composite joist girders. Mr. Samuelson was involved with the development of design guidelines and load tables for Vulcraft's new VC Series composite joists. Mr. Samuelson is a member of the American Institute of Steel Construction TC5 Committee on Composite Construction and Chairman of the Steel Joist Institute's Composite Joist Committee.

SUMMARY

Steel joists are growing in recognition as being a very economical system for supporting building floors. This paper discusses the expanded load carrying capabilities of noncomposite steel joists and joist girders beyond the Steel Joist Institute's current K, LH, DLH, and Joist Girder load tables. An update is given on the work completed by the Steel Joist Institute's Composite Joist Committee which currently is preparing a Standard Specification, Recommended Code of Standard Practice, and Load Tables for composite steel joists.

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INTRODUCTION

Steel joists are widely utilized not only in roofs but also floor systems. The Steel Joist Institute in the near future will be publishing extended weight tables for LH Series joists and Joist Girders covering increased loads, spans, and larger chord angle sizes.

An update is given on the work currently being undertaken by the Steel Joist Institute's Composite Joist Committee. Currently this committee is preparing a Standard Specification, Code of Practice, and Load Tables for SJI's new composite joist series.

EXPANDED JOIST LOAD TABLES

The Steel Joist Institute is looking to develop a new joist weight table providing information beyond the current K, LH, and DLH joist series.

The Steel Joist Institute's (SJI) steel joist load tables were originally derived utilizing typical joist spacings and roof loadings. The first joist load table adopted by SJI on August 20, 1929 was for the "SJ" Series with joist depths varying from 8 – 16 inches and spans from 4 – 32 feet . Standard chords sizes were assigned a numerical value from 1 to 7. For a given joist depth, chord size, resisting moment, and maximum end reaction, the allowable uniform load was determined for spans from 4 – 32 feet. Maximum uniform load carrying capacities varied from 77 – 800 pounds per lineal foot.

In 1953 SJI adopted the "Longspan" steel joist load tables which were formatted very similar to the current SJI Longspan LH Series steel joists. Joist depths varied from 18 – 48 inches and spans from 25 – 96 feet. For standard chord sizes varying from 02 – 19, uniform load capacities were shown from 154 - 821 pounds per lineal foot.

The current SJI LH-Series Load Tables adopted on May 25, 1983 and revised May 1, 2000 have joist depths varying from 18 – 48 inches and spans from 25 – 96 feet. Standard chords vary from 02 – 17 with uniform load carrying capacities from 174 – 1068 pounds per lineal foot.

K Series joists adopted by the SJI on November 4, 1985 vary in depth from 8 to 30 inches with spans from 8 to 60 feet. In the case of K – Series joists, the maximum uniform load is limited to 550 pounds per lineal foot. With typical total floor loadings of 100 – 150 pounds per square foot, the maximum K Series joist spacings are approximately 4 feet.

When steel joists were first utilized in floor systems they were typically spaced two feet on centers. A layer of wire mesh backed paper was stretched over the joists and fastened with clips to the joist top chords. Sufficient joist bridging needed to be furnished to support the wet weight of the concrete as the wire meshed paper fabric acted only as a vertical form for the concrete.

In the 1960's 0.6C steel deck was introduced replacing wire mesh backed paper systems. The 0.6 C deck was designed so that the joists could typically also be spaced at 2 foot centers. The 0.6C metal deck provided lateral support for the joists once the deck was fastened to the joists and also provided a walking surface prior to placement of the concrete slab. As the usage of metal deck expanded within the United States, deeper 1, 1.5, 2, and 3 inch steel deck profiles have become very common. Current steel deck profiles can readily accommodate joist spacings from 4 – 15 feet, the net result being an increase in floor loading per joist.

For example a 2 inch deep metal deck supporting a 3.5 inch normal weight concrete topping has a combined deck and slab dead load of 57 pounds / square foot. With an assumed live load of 100 psf , 24 inch deep steel joists clear spanning 40 feet with joists spaced at 10 feet centers, each joist would support the following loading:

5.5 inch deep normal wt concrete supported by 2 inch high deck: 57 psf x 10 feet =		570 plf
Estimated weight of joist & bridging:		53 plf
Mechanical, electrical, floor, and ceiling:	10 psf x 10 feet =	100 plf
Live Loading:	100 psf x 10 feet=	1,000 plf
Total Loading		1,723 plf

Looking in the SJI LH Series load table for a 40 foot clear span and 24 inch deep joist, the largest joist shown is a 24LH11. The 24LH11 joist supports 768 pounds per lineal foot with the allowable uniform live load that produces an L/360 deflection being 418 pounds per lineal foot. As can be seen the load carrying capacity of the 24LH11 (768 plf) is less than half that required (1, 723 plf). Likewise the 24LH11 would have an anticipated live load deflection of L / 150 which generally would be unacceptable.

In the above illustration one would have to specify a "Special" joist design as the required load per lineal foot exceeds the loads listed in the SJI tables. One could specify this joist by indicating the following on the floor plans "24LH SP 1723 / 1000" .

To provide Engineers a way to determine joist weight and anticipated deflections for joists with uniform loadings greater than shown in the SJI K, LH, and DLH joist series load tables, new joist weight and deflection tables will be prepared .

It is anticipated that the new extended LH Series joist table will indicate joist weight and uniform live load that will result in a L/360 deflection . The range of parameters may extend as far as are shown below:

Spans:	10 feet – 200 feet
Joist Depth:	8 inches – 120 inches
Uniform Loads:	200 - 3000 lbs / foot
Maximum chord angle size:	6 inches x 6 inches x 0.750 inches
Bearing depths:	2.5 inches, 5 inches, or 7.5 inches

ADVANTAGES FOR WIDER JOIST SPACINGS

Placing joists at wider spacings as shown in Figure 1 can potentially have a number of advantages including the following:

- Wider joist spacings reduce the number of joist lifts during construction.
- A reduced number of joists to connect to the structural frame / walls with their associated fewer rows of bridging speeds up joist installation.
- If spray applied fireproofing is utilized, fewer joists result in reduced fire protection costs.
- Floors with wider joist spacings tend to have increased concrete slab thicknesses. Increased floor mass tends to reduce floor vibrations.
- Routing of electrical conduits and piping is facilitated with joists at wider spacings.

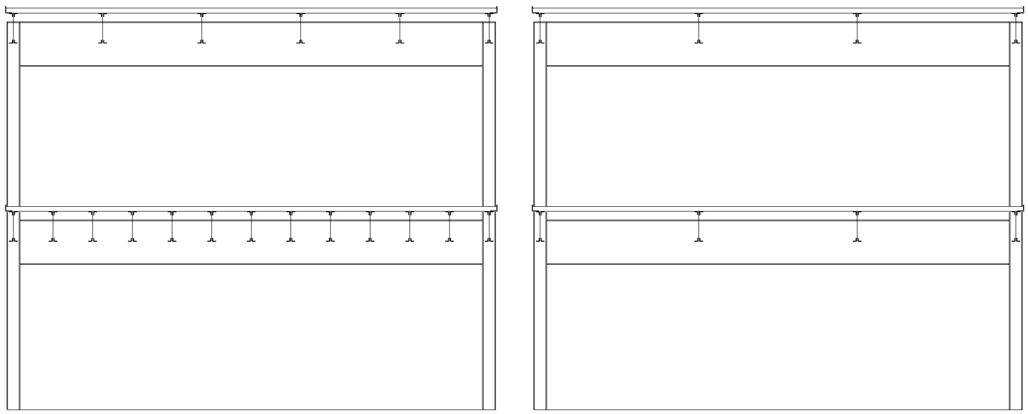

Figure 1 – “Narrow” floor and roof joist spacings vs. “Wide” floor and roof joist spacings on the right

Extended Joist Girder Series

The current SJI Design Guide Weight Table for Joist Girders indicates joist girder weights for joist girders spanning from 20 to 60 feet supporting concentrated loads from 4 to 20 kips. For the case of joist girders supporting floor joists or beams the concentrated loads many times exceed 20 kips. Looking at our above described floor joist spanning 40 feet and supporting 1,723 plf an interior joist girder would be required to support concentrated loads of 68.92 kips on 10 foot centers. These concentrated loads greatly exceed the 20 kip maximum shown in the SJI weight tables requiring the engineer to specify a “Special” joist girder.

To provide greater information for the Engineer, the SJI is potentially looking to extend the joist girder tables as shown below:

Spans:	20 feet – 130 feet
Joist Girder Depth:	16 – 120 inches
Concentrated Loads:	4 – 100 kips
Approximate joist spacings:	4, 5, 6, 8, 10, 12, and 15 feet
Maximum chord angle:	L-6 x 6 x 0.625 or L – 6 x 6 x 0.750

The previous maximum chord angle which the current joist girder tables are based on was a L- 5 inch x 5 inch x 0.500 inch with a cross sectional area of 4.75 square inches. The SJI Engineering Practice Committee is currently studying whether the maximum chord angle will be L-6 x 6 x 0.625 or L- 6 x 6 x 0.750. If the decision is made to utilize a maximum chord angle size of L- 6 inch x 6 inch x 0.750 inch angle having a cross sectional area of 8.438 square inches, one can expect the new weight table to increase the load carrying capacity by a factor of approximately 1.78 (8.438 / 4.75) . Currently the majority of joist manufacturers can furnish joist girders with L – 6 inch x 6 inch x 0.750 inch chord angles with several manufacturers furnishing chord angles up to L – 8.0 inch x 8.0 inch x 1.125 inch.

UPDATE ON WORK COMPLETED BY THE SJI COMPOSITE JOIST COMMITTEE

The SJI Composite Joist Committee is nearing completion of a standard specifications for the design of composite joists by all SJI member companies. This specification currently written in a “LRFD” format will likely be revised to a “UNIFIED” format covering both “LRFD” and “ASD” consistent with the 2005 “AISC Standard Specification for Structural Steel Buildings”.

The new SJI composite joist specification will define ASTM standards for the steel utilized in the manufacture of the composite joist chords and web sections, ASTM standards for the welded shear studs, acceptable welding electrodes, nominal stresses in the chords and webs, maximum slenderness ratios, and equations for calculating stresses in the chords, webs, and concrete slab under the design loading. Equations for determining the capacity of shear studs welded to top chord angles where the ratio, d_{stud} / top chord angle thickness $\leq$ 3.0 are shown. Specifications for determining the required number of rows of either horizontal or diagonal bridging are outlined. Required minimum end anchorage for each end of a composite joist based on whether the joist is sitting on masonry, concrete, or steel are indicated. To assure that the composite joists are safely erected, a section on erection stability and handling provides guidance on the minimum number of rows of bridging required before releasing the hoisting cables. Welded shear studs are commonly utilized to develop composite action between the concrete slab and steel composite joist top chord. Suggested placement details for welded shear studs on double angle joist top chords are discussed.

To supplement the Specifications, the Composite Joist Committee is preparing a “Recommended Code of Standard Practice for Composite Steel Joists.” The Code of Standard Practice helps to define the various roles and responsibilities of the building owner, specifying design professionals, joist manufacturer, and contractors. When field load testing is required, suggested loading procedures to be followed are suggested. Items not normally included in the estimate but which may be quoted and identified as separate items include headers, erection bolts, slab reinforcement, shear studs and / or ferrules, horizontal trusses, and moment plates. When composite steel joists are subjected to concentrated loads, suggested methods for showing supported loads are presented. Information required to be shown on the Plans and Specifications is listed.

Composite joist load tables are being developed following the design procedures outlined in the SJI Composite Joist Specifications. The composite joist load tables will indicate for a given composite joist span, joist depth, and uniform loading the following items:

- Composite Joist weight (pounds per lineal foot)
- Uniform composite live load that will produce a deflection of L/360 (pounds per lineal foot)
- Size and quantity of welded shear studs per joist
- Noncomposite moment of inertia (in^4)
- Rows of bridging required
- Joist seat depth

Composite joist spans will vary from 20 feet to 120 feet with total factored uniform loads from 300 – 4500 plf. The SJI Composite Joist Load Tables will provide the design professional with a tool for estimating composite joist costs for “Typical” floors.

To supplement the Load Tables, a SJI Composite Joist Design Parameters Checklist has been developed that can be completed and sent to the joist manufacturer indicating specific joist geometry, concrete depth, deck height, design loads, and deflection requirements. Given this information the joist manufacturer can prepare an exact design and cost estimate.

COMPOSITE vs. NONCOMPOSITE JOISTS

When decreased floor to floor height becomes very important, composite joists can support the same uniform load utilizing a shallower steel joist depth. With the concrete slab locked to the underlying steel joist, the compression from the composite loading is transferred from the joist top chord up into the concrete. This transfer of load into the concrete allows the joist top chord size to be significantly reduced along with a reduction in joist bottom chord size.

Composite joists have composite moments of inertia that are in the range of three –five times stiffer than noncomposite joists with the same size chord angles. Therefore when designing shallow floors where deflection controls the design, increased economy can be achieved with composite joists.

When welded shear studs are utilized to develop composite action in a steel joist, one must have a large enough floor project to justify the mobilization of the stud welding equipment. The savings in steel weight for the composite vs. noncomposite joists must be larger than the associated cost for furnishing and installing the shear connection.

Noncomposite and composite steel joists are ideally suited for use in commercial applications where large column free areas are desired. Simplified erection and connections due to standard end bearing seats result in faster construction. SJI Member companies can easily customize and optimize each joist design for the particular loading and serviceability requirements.

CONCLUSIONS

The Steel Joist Institute is actively involved with the development of new noncomposite LH series load tables, composite joist load tables, and expanded joist girder load tables "Tailored" specifically toward floor applications. When completed, these design tools will facilitate the potential increased usage of steel joists in building floor applications.

Steel joist construction provides the building owner with numerous advantages including a reduced building weight and associated reduced foundation cost, a reduced construction time period, very economical cost per square foot of floor area, and an environmentally friendly material that is easily recycled.