Columns

Joist Journey

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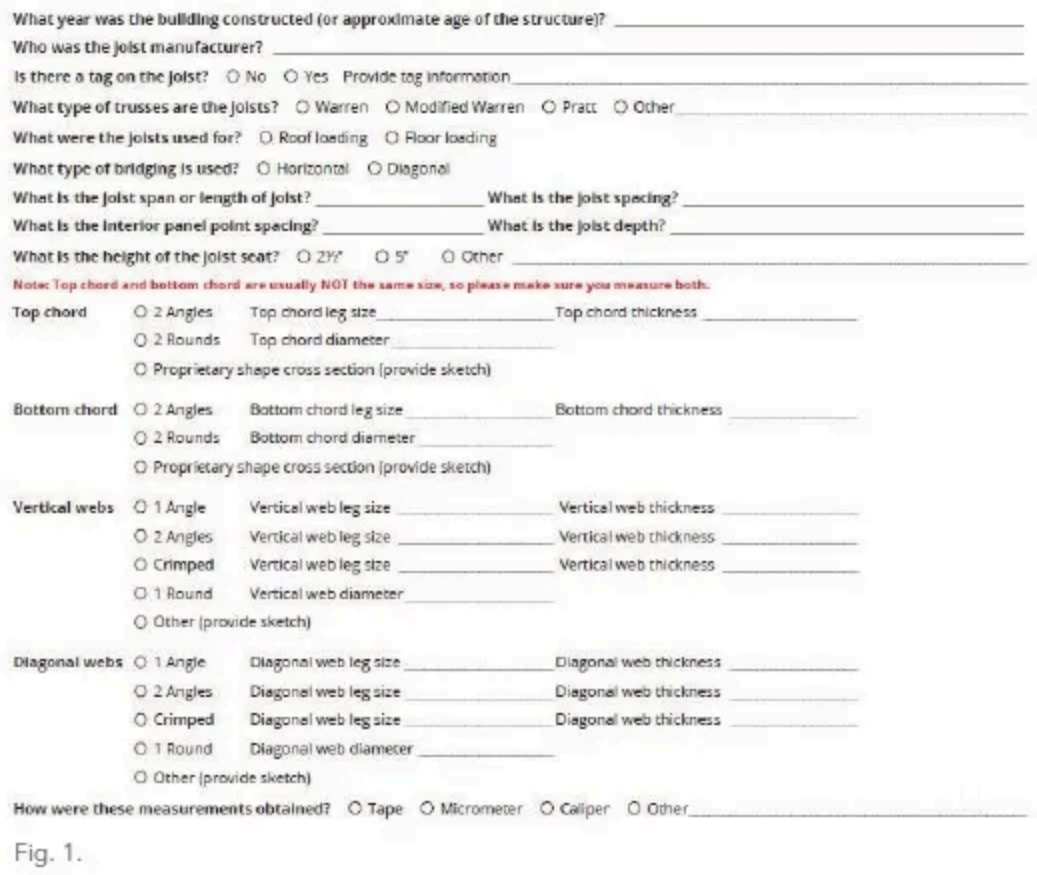
Evaluating open web steel joists for potential modification is both an art and a science.

OPEN WEB STEEL JOISTS and joist girders are key components of steel construction.

There are millions of open web steel joists and joist girders in roofs and floors of thousands of buildings throughout the United States, Mexico, and Canada. As building needs change, the joists will have new requirements as well. Additionally, as steel making and steel grades have evolved, as the specifications of open web steel joists progressively changed.

Evaluating and determining if a joist needs modification is a valuable skill that's an art and a science. The art is easier than most might think, and there are tools to assist with the science. The Steel Joist Institute (SJI), formed in 1928, has developed Technical Digest 12, *Evaluation and Modification of Open Web Steel Joist and Joist Girders,* which explains methods and techniques to evaluate and modify existing joists.

Open web steel joists have five main components. In simple terms, the chords are axial force carrying components on the top and bottom of the overall member. These members are usually horizontal, with some exceptions. The webs are members connecting the chords that transfer the shear forces. Bearing seats are the means on both ends of the joists to distribute the forces to the supporting structure and are connected to the supporting structure by welding or bolting. Welding connects all joist components. Bridging is the method for laterally bracing the chords during erection and service.



What year was the building constructed (or approximate age of the structure)? _____
Who was the joist manufacturer? _____
Is there a tag on the joist? ○ No ○ Yes Provide tag information _____
What type of trusses are the joists? ○ Warren ○ Modified Warren ○ Pratt ○ Other _____
What were the joists used for? ○ Roof loading ○ Floor loading
What type of bridging is used? ○ Horizontal ○ Diagonal
What is the joist span or length of joist? _____ What is the joist spacing? _____
What is the interior panel point spacing? _____ What is the joist depth? _____
What is the height of the joist seat? ○ 2½" ○ 5" ○ Other _____
Note: Top chord and bottom chord are usually NOT the same size, so please make sure you measure both.

Top chord
○ 2 Angles Top chord leg size _____ Top chord thickness _____
○ 2 Rounds Top chord diameter _____
○ Proprietary shape cross section (provide sketch)

Bottom chord
○ 2 Angles Bottom chord leg size _____ Bottom chord thickness _____
○ 2 Rounds Bottom chord diameter _____
○ Proprietary shape cross section (provide sketch)

Vertical webs
○ 1 Angle Vertical web leg size _____ Vertical web thickness _____
○ 2 Angles Vertical web leg size _____ Vertical web thickness _____
○ Crimped Vertical web leg size _____ Vertical web thickness _____
○ 1 Round Vertical web diameter _____
○ Other (provide sketch)

Diagonal webs
○ 1 Angle Diagonal web leg size _____ Diagonal web thickness _____
○ 2 Angles Diagonal web leg size _____ Diagonal web thickness _____
○ Crimped Diagonal web leg size _____ Diagonal web thickness _____
○ 1 Round Diagonal web diameter _____
○ Other (provide sketch)

How were these measurements obtained? ○ Tape ○ Micrometer ○ Caliper ○ Other _____

Fig. 1.

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Manufacturers will not have the exact same method for building joists, but even Fig. 1. With minor differences, open web products are simple and amazingly strong.

Each project is different, and the evaluator will need to gather as much information as possible on the existing structure. Sometimes, fact finding is easy. Other times, it's arduous and time-consuming.

The older the building, the less likely information such as shop bills or drawings will be available. On projects completed within the last 20 years, it's likely the joist manufacturer can be contacted, and it may have all the necessary information.

Older projects with limited available information make joist engineering an art and less exact. The art is careful approximation based on

available data and facts to determine enough information to employ the more formulaic and precise science.

Evaluation questions to ask are listed in the Joist Investigation Form (Figure 1) , found on the website or in Appendix A of Technical Digest 12. They're a strong basis for creating a guideline or checklist for information gathering.

With enough information, you can zero in on which specification was used for the joist design. You can also make some safe assumptions on the loading. Just by identifying the seat depth, you can usually assume the joist is either a K-series (2½ in.) Or LH-Series (5 in.).

Part of the art of joist design is understanding most manufacturers do not purchase angle stock that would match angle sizes in the 16th Edition *Steel Construction Manual* (current and previous editions can be found at aisc.org/manuals). In fact, for joist use, you would likely find a 2 in. By 2 in. Angle in seven different leg thicknesses, ranging from .137 in. To ¼ in.

To practice the art, take a micrometer thickness reading on the bottom chord. Determine the maximum tensile force by multiplying the bottom chord cross sectional area by $0.6F_y$. From there, based on the effective depth of the joist, a maximum moment capacity can be determined. The design uniform load, *w*, can be determined by back calculating $M = (wL2)/8$.

The SJI has resources to assist the engineer with the evaluation and modification process. Technical Digest 12 has many examples of different joists. Additionally, SJI's webinars include examples from Technical Digest 12 in even more detail. Ideally, the required number of repairs is minimized, and evaluating the existing joist only for the required loads is key. The act of reinforcing or repairing joists is a matter of balancing the benefits of a stronger joist with the actual requirements. Designers should never gamble on safety, and using

building code load cases for an appropriate force can minimize the number of repairs.

In the field, labor is always more expensive than material. The goal is to minimize the different materials or add more material if it reduces the required labor.

The last part of the process is communicating the modification to the jobsite— arguably the hardest part. Generally, happenings in the field are not usually under the direction of the specifying engineer. Communicating to the field is an art, not a rigid formula.

Here is an example of general notes for communicating modifications from Technical Digest 12:

• No modification that affects the strength of a steel joist or steel joist girder shall be made without the approval of the project structural engineer of record. See OSHA 29 CFR 1926. 757 (7).

• The details used herein were taken from the typical details provided in SJI Technical Digest 12 and require verification cation and approval by the structural engineer of record.

• All repairs shall be done in a professional and quality manner. Workers performing repair are responsible for the workmanship of the repair.

• All steel shall be a minimum yield of Fy = 50 ksi, unless noted otherwise.

• All welding shall be performed by a welder currently certified in accordance with the AWS requirements.

The welder must be qualified for the welding positions required to properly install the reinforcing.

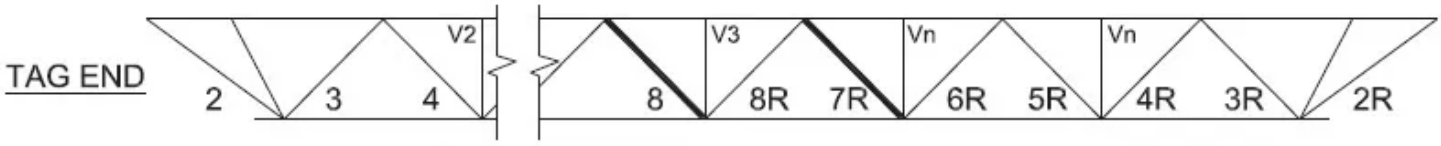

Fig. 2.

Fig. 2. »

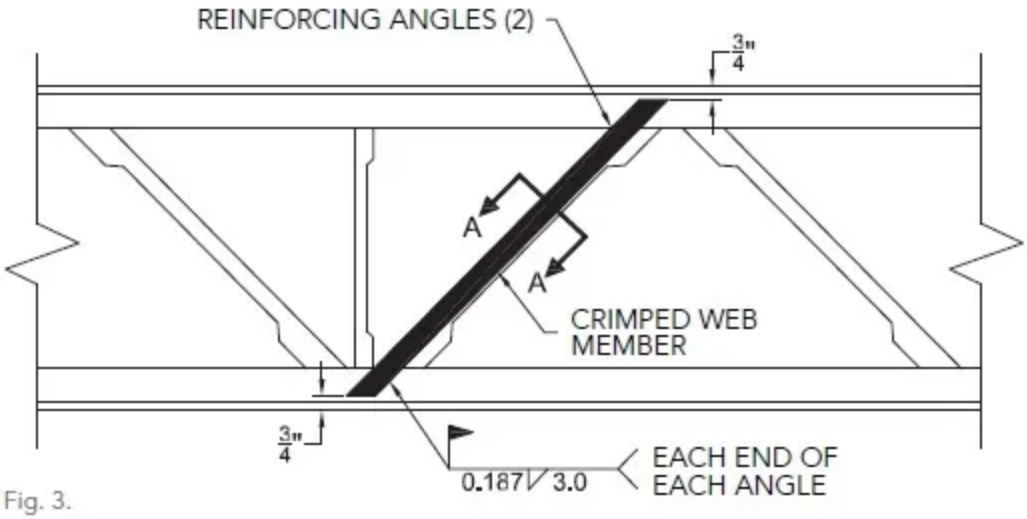

Fig. 3.

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• All welds are to be made using E70XX electrodes. Weld requirements are as specified in the details above.

• Repairs shall be inspected by an AWS certified weld inspector.

A critical part of communicating to the field is sequenced step-by-step instructions. Even a simple repair of replacing a damaged web requires some instruction. Here is an example of field repairs procedures that explains the damaged web should not be removed until after the new web is in place:

• Measure and cut the reinforcing angle to proper length.

• Place reinforcing angles on side(s) of damaged web. Use two L2×2×¼ F_y=36 ksi.

• Weld reinforcing angle to chords in accordance with the provided repair sketch.

• Remove the damaged web without damaging joist chords.

Clear details and sketches make work in the field significantly easier. The details and sketches should clearly show which members on the joist need repair. Figure 2 is one example of a sketch, and Figures 3 and 4 show clear and definite sketches, helping the field labor achieve the intended result.

One reason steel is the best material in a circular building economy is because it's flexible in design and relatively easy to strengthen and modify, and joists are no exception. Readily available resources make joist evaluation and modification navigable rather than daunting. With each project, your art and science skills will be enhanced.

In addition to Technical Digest 12, the SJI provides two live webinars every year, one on the evaluation of existing joists and the other on the modification of existing joists.

The SJI also has free tools that can be downloaded at www.steeljoist.org. These tools include Historical Load Tables, Steel Joist Uplift Analysis Tool, Joist Girder Analysis Tool and the Joist and Joist Girder Reinforcement Tool.

All of these resources can help you quickly grow comfortable with the process of evaluating and modifying open web steel joists and optimizing their use in your projects.

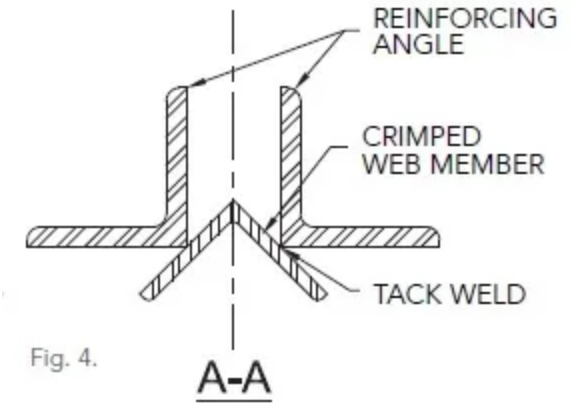

Fig. 4.

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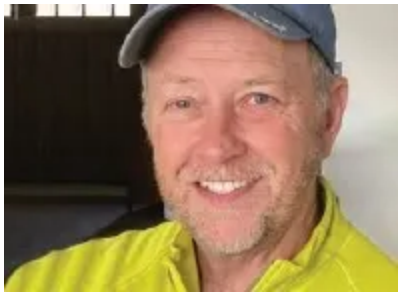

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