A More Practical Joist Specification

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Incorporated into the new IBC, the new 43rd Edition Specifications and COSP include two key changes for designers using open-web steel joists and joist girders.

OPEN-WEB STEEL JOISTS are easy to use, very economical and commonly utilized in many building applications. With the variety of uses it can be difficult to have an all-inclusive yet concise specification. In the creation of the 43rd Edition of the Steel Joist Institute *Specification*, which includes the K-series, LH/DLH-series, Joist Girders and *Code of Standard Practice* (*COSP*), a more practical approach has been taken to better define the actual uses of these products.

Provisions and products that are no longer valid have been removed. The *Specification* and *COSP* have been reviewed to better define areas that might have been subject to interpretation in the past. They also have been expanded to better establish design methods so that these products will be more flexible and simpler to specify. The result is a more practical *Specification* and *COSP*.

The revision to the 43rd *Specification* and *COSP* was prepared for inclusion by reference in the 2012 *International Building Code* (*IBC*). Due to the extent of the changes, 40 balloted revisions were included in the 43rd *Specification*. Some of these revisions include previously unpublished design checks and assumptions, better use of "mandatory" code language and reorganization of certain sections for better clarity. Most importantly, the changes are all aimed at making SJI products safer, easier to use and more economical. This article highlights just two of the changes in

the 43rd Edition of the open-web steel joist and joist girder specifications and *Code of Standard Practice* that will interest the specifying design professional.

The Code of Standard Practice

Although the *COSP* is not technically part of the *Specification*, it is a valuable document explaining the common uses of the product and the established methods for specifying open-web steel joists. The *COSP* was also modified in conjunction with the 43rd Edition to provide greater clarity and provide more flexibility in how they can be specified.

Add-Load and Bend-Check Load

Two new design terms have been introduced into the *COSP* in an effort to accommodate loads that may be difficult to locate at the time of design. Commonly these loads are designed to travel or move along the length of the joist which allows for more flexibility in design and in the field. Although manufacturers have used terms such as "traveling load," "adload" and "bend load" in the past, the *COSP* has now fully defined these types of loads. These terms are now "Add-Load" and "Bend-Check Load".

An Add-Load is a single vertical concentrated load that may occur at any panel point along the joist chord. This load is in addition to any other specified gravity loads. For design

of the chords, a concentrated load with the magnitude of the Add-Load is placed at the panel point closest to the center of the joist to maximize the design moment. For each web member, a concentrated load is placed throughout the length of the joist to maximize the design shear.

A Bend-Check Load is a vertical concentrated load used to design the joist chord for the additional bending stresses resulting from loads being applied between the panel points. The accompanying gravity load must already be included in the specified joist designation, uniform load, concentrated load or Add-Load. The Bend-Check Load is only used to add additional bending stress in the chord and does not contribute to the overall axial forces within the joist. Also, as part of the design requirements of this type of load, it must be specified whether the Bend-Check Load is to be applied at the top chord, bottom chord or both. An ideal use of this type of load is for cases when incidental loads, accounted for in the design loads, may induce additional bending stress due to their occurring at any location along the top or bottom chord of the joist.

The use of an Add-Load and/or a Bend-Check Load will aid the specifying design professional in accounting for loads that are hard to locate and gives more flexibility to the joist products. As an example, there may be a design need to have a 500 lb load occur at any location on the top or bottom chords of the joist. This can be easily defined by specifying a 500 lb Add-Load and a 500 lb Bend-Check Load on the top and bottom chords.

The use of these loads will increase the cost of the joist due to the increased weight. However, an Add-Load is more economical in many cases than trying to accommodate the same overall loading with a uniform load. Also the Bend-Check Load can diminish the need to field install web members for loads that are not located at panel points. While the joists may be more expensive than a simple uniform load design, the overall cost of the system may be less with the appropriate use of an Add-Load and Bend-Check Load.

Specifying Joists and Joist Girders

The *COSP* indicates and illustrates five methods for specifying joists.

Option 1 is to select a standard joist designation from the SJI load table. This works well for joists that are subject only to uniform loads. Joists with additional loads should be specified by one of the following appropriate options.

Option 2 is for joists supporting more than uniform loads. A standard joist designation can be selected from the SJI load table. Alternatively the designer can specify a joist type and uniform load in the designation such as 24LH300/200 where 300 lb per lineal foot (plf) is the total uniform load and 200 plf is the uniform live load. Then the magnitude and location of any additional loads can be provided on the structural plan with the note "Joist manufacturer shall design joists for additional loads at locations shown." This option works well for joists with concentrated or snow drift loads with known magnitudes and locations.

Option 3 is for joists using Add-Loads and Bend-Check Loads. The uniform load of the joist can be designated as either a uniform load or as a standard SJI designation method listed in Option 2. For additional point loads where exact locations are not known, or for incidental loads, or both, an Add-Load and Bend-Check Load can meet the design need. An example of suggested design notes is in the *COSP* that can be used to define an Add-Load and/or Bend-Check load.
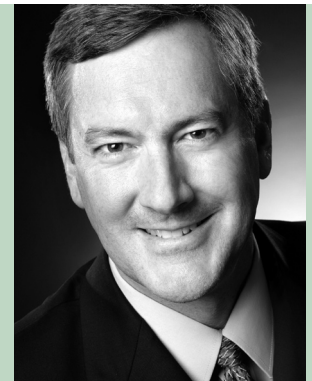
Option 4 illustrates the use of KCS series joists. These joists are used when it is easier to specify the required shear and moment capacities of the joist rather than numerous loads and locations that may occur on the joist. It is inappropriate to add additional loads or to use an Add-Load and Bend-Check Load with KCS series joists.

Option 5 is for joists with numerous loads and load combinations including wind and seismic cases. Unless noted otherwise on the contract documents the joist manufacturer will use the load combinations in the applicable national building code. If regional building codes are specified, it is desirable to note any additional requirements that must be met in the design of the joists. For an ASD design using *IBC 2006*, the following load cases are used:

Basic Load Combinations
1. D
2. $D + L$
3. $D + (L_r$ or S or $R)$
4. $D + 0.75L + 0.75(L_r$ or S or $R)$
5. $D + (W$ or $0.7E)$
6. $D + 0.75(W$ or $0.7E) + 0.75L + 0.75(L_r$ or S or $R)$
7. $0.6D + W$
8. $0.6D + 0.7E$

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MARK	DESIGNATIONS*	LOADING (plf)**			WIND PRESSURE ******		AXIAL/MOMENT TRANSFER DETAILS @ GRIDS	ADD-LOAD TL/LL (in kips)	BEND-CHECK LOAD (in kips)		TOP CHORD AXIAL			Minimum MOMENT of INERTIA (in**4)	REMARKS
	Joists: (TL/LL in plf) Girders: (TL/LL in kips)	DL (plf)*****	LL (plf)****	Lr/S/R (plf)	Downward W (+) plf	Net Uplift W (-) plf			TC	BC	W WIND (kips)	E SEISMIC (kips)	Em SEISMIC (kips)		
J1	28K7	95 plf for W&E*	200 plf for defl	180 plf		160	7/S8 @ 2,3,4	0.5/0.0			W=15.0	E=18.5			See LD1 for addtitional loads
J2	28K7	95 plf for W&E*				160	8/S8 @ 4,5; 6/S8 @ 6				W=15.0	E=18.5	Em=30.0		
T1	32LH224/128					180	9/S8 @ 7; 10/S8 @ 8				W=18.0	E=23.4			
T2	32LH224/129					160	9/S8 @ 7,8,9	1.0/1.0	0.5		W=15.0	E=23.4			
T3	32LH224/130					160	11/S8 @ 4; 12/S8 @ 6				W=15.0	E=25.2	Em=50.0		
T4	32LH09	95 plf for W&E*				160	11/S8 @ 7,8,9				W=15.0	E=25.2	Em=50.0		
G1	30G5N7.1K/3.4K					250	1/S8 @ A; 4/S8 @ B				W=25.0	E=125.0			
G2	30G5N7.1K/3.4K					250	3/S8 @ B,C,D,E,F				W=25.0	E=125.0	Em=200.0		
G3	48G6N11.2K/6.0K					300	2/S8 @ A; 4/S8 @ B	2.5	1.0	0.5	W=27	E=125.0			
G4	48G6N11.2K/6.0K					300	2/S8 @ C,D,E,F,G				W=27	E=125.0			
G5	52G7N14.4K/6.3K					500	2/S8 @ A; 4/S8 @ B				W=30	E=125.0			
G6	52G7N14.4K/6.3K					500	1/S8 @ G,E; 3/S8 @ A				W=30	E=125.0	Em=250.0		

*Joist designations are to include all uniform gravity loads.

**Loading values are not required if designation loading values are correct for deflection and load combinations.

****LL (plf) are to be used for deflection and load combinations if Lr/S/R is not speicfied, if Lr/S/R is specified that value will be used for loads combinations.

*****When standard SJI designations are used the dead load is required for load conditions with wind or seismic.

******When no Wind Load is specified it is assumed that it does not govern.

Add-Load = definition per COSP

Bend-Check Load = definition per COSP

Values in this table shall be multiplied by the factors in ASCE7-05 section 2.4.1 by the joist designer.

Special Seismic Load Combinations

    9. $D + 0.7E_m$
    10. $D + 0.525E_m + 0.75L + 0.75(L_r \text{ or } S \text{ or } R)$
    11. $0.6D + 0.7E_m$

When using these combinations it is important that all the loads are clearly defined, including uniform dead load and live load. It is important to recognize that the red live loads listed in the load table for standard SJI joist designations are shown only for deflection and may not reflect the actual live load value. Due to these load combinations, noting simply that an additional top chord axial load is required is not adequate any more. For the load cases listed in the building codes an additional top chord axial load must be classified as wind (W) or seismic (E or E_m). In the case of seismic it is very helpful to indicate whether the loads are factored, listed axial load = $0.7E$ or unfactored, listed axial load = E_m. Whereas it is the responsibility of the specifying design professional to provide the design loads, a proven effective method is to communicate this information in a load table. An example of such a table is shown below and can be modified to meet the actual requirements.

Bridging

The sizing of bridging historically has been governed only by slenderness ratio limits. The limit for horizontal bridging is $L/r < 300$. For diagonal bridging, the limit is $L/r < 200$, where the connected intersection of the "X" is considered a braced point and L is the distance from the connection at the joist chord to the connection near the middle of the bridging piece. However, both horizontal and diagonal bridging meet a strength requirement and resist a compressive axial bracing force. The horizontal component of this force is now clear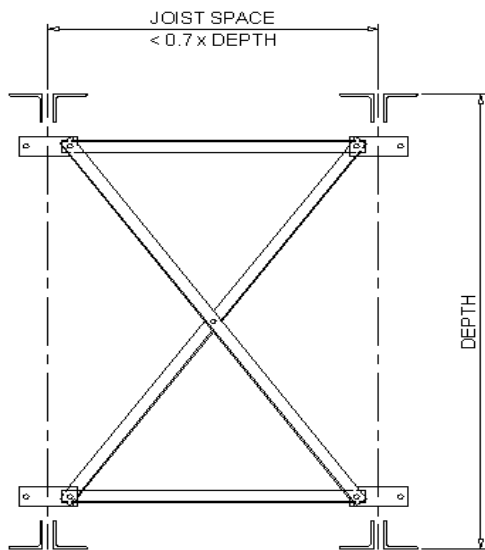ly identified as P_{br} in the new *Specification* and *COSP*. When installed separately, both horizontal and diagonal bridging must be capable of resisting the force P_{br} in compression.

For horizontal bridging, the slenderness ratio limit often governs and sufficient compressive strength is achieved at the slenderness ratio limit. However, for larger joist designations and certain joist spacings, the required compressive strength can control. This is why, for example, 1 by 1 horizontal bridging angles can be used for a 5-ft 0-in. spacing on a 24K6 joist, but not on a 24K12. The horizontal bridging charts in the *COSP* have been updated, adjusting the allowable joist spacing for various bridging sizes, while also displaying the required compressive strength, P_{br}.

As an alternative to selecting horizontal bridging from the chart based on bridging size, joist designation (chord section number) and joist spacing, a new chart has been added to the *COSP*. Table 2.7-1c provides the maximum allowable bridging force, P_{br}, for various combinations of joist spacing and bridging size, which can be used in conjunction with the equations provided in the *Specification* for computing P_{br}.

For diagonal bridging, the bridging force, P_{br}, is the horizontal component. The axial force in the diagonal bridging member is then a function of the angle of the diagonal member relative to the horizontal plane. The deeper the joist and the narrower the joist spacing, the more axial bridging force increases relative to the horizontal component.

For the most typical combinations of joist spacing and joist depth, the slenderness ratio limit of 200 for diagonal bridging provides sufficient compressive strength to resist the horizontal bridging component, P_{br}. In the rare cases where L/r of 200 would not provide adequate strength, there are two options. The bridging member size can be increased, or horizontal bridging can be provided in addition to the diagonal bridging. With the addition of horizon-

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JOIST SPACE
< 0.7 x DEPTH
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DEPTH

▲ Example of new bridging requirement.

Conclusion

Although this article has highlighted a few key revisions in the 43rd Edition of the SJI *Specification* and *COSP*, there are many more equally significant items that have not been noted. These revisions are the culmination of years of research and a concerted effort to have a more practical and concise specification, so that the use of open-web steel joist products is simpler. In 2011, the SJI will be conducting webinars to explain the changes in more detail. Visit the SJI website, **www.steeljoist.org**, to learn more about new publications and educational opportunities. **MSC**

tal members, the behavior of the diagonal bridging changes and can be considered acting in tension only. In tension, by meeting the slenderness ratio limit, the member size will always have adequate strength for the full range of SJI designations. In the 43rd Edition, it was decided to require the addition of horizontal members for narrow and deep joist spaces. As noted, this changes the forces in the bridging to a tension system, rather than impose a compressive strength requirement.

The bridging figure above demonstrates the new requirement that appears in new Table 2.7-3 in the *COSP*. When the joist depth is 52 in. or greater, and the joist spacing is less than 0.7 times the joist depth, horizontal members are required in addition to the diagonal members. For example, 72DLH joists spaced less than 4 ft, 2 in. apart would require both diagonal bridging and horizontal members, with the required horizontal member size shown in Table 2.7-3. For 72DLH joists spaced 4 ft, 2 in. or more, diagonal bridging with a slenderness ratio limit of 200 or less is adequate.

The possibility of narrow spaces and deep joist becomes more likely with a new expansion of the DLH-series Load Tables in the 43rd Edition. In the tables the maximum depth for a DLH joist increases from 72 in. to 120 in. and the maximum span increases from 144 ft to 240 ft.