12

Evaluation and Modification of Open Web Steel Joists and Joist Girders

TECHNICAL DIGEST TWELVE

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FOREWORD

This Technical Digest is another addition to the series of Steel Joist Institute publications designed to give the reader information regarding the application and usage of steel joists and Joist Girders.

Technical Digest No. 12 concerns itself with the evaluation of existing steel joists and Joist Girders to carry additional loads not accounted for in their original design. The technical digest also addresses situations where the configuration and/or the original geometry of the steel joists or Joist Girders needs to be modified in the field.

This and other SJI Technical Digests serve to highlight specific areas of design and/or application for the benefit of architects, building inspectors, building officials, designers, engineers, erectors, students and others.

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BACKGROUND

Evaluation and modification of joists is often required due to additional loads such as roof top units, underhung conveyors, loading increases, field deviations or damage, or other changes not contemplated in the original specification for the joists or Joist Girders. The purpose of this digest is to present procedures, and to suggest details, for the modification or strengthening of open web steel joists and Joist Girders. Both open web steel joists and Joist Girders will be referred to as joists in this digest.

GLOSSARY

ASD (Allowable Strength Design) Method of proportioning structural components such that the allowable strength equals or exceeds the required strength of the component under the action of the ASD load combinations.

Allowable Strength* Nominal strength divided by the safety factor, R_n/Ω.

Available Strength* Design strength or allowable strength as appropriate.

Bearing The distance that the bearing shoe or seat of a joist or Joist Girder extends over its masonry, concrete or steel support.

Bridging A member connected to a joist to brace it from lateral movement.

Buckling Limit state of sudden change in the geometry of a structure or any of its elements under a critical loading condition.

Buckling Strength Nominal strength for buckling or instability limit states.

Camber An upward curvature of the chords of a joist or Joist Girder induced during shop fabrication. Note, camber may be provided in addition to the pitch of the top chord.

Chords The top and bottom members of a joist or Joist Girder. When a chord is comprised of two angles there is usually a gap between the members.

Cold-Formed Steel Structural Member Shape manufactured by press-braking blanks sheared from sheets, cut lengths of coils or plates, or by roll forming cold- or hot-rolled coils or sheets; both forming operations being performed at ambient room temperature, that is, without manifest addition of heat such as would be required for hot forming.

Composite Section Combined existing member and reinforcing member.

Connection Combination of structural elements and joints used to transmit forces between two or more members. See also splice.

Deck A floor or roof covering made out of gage metal attached by welding or mechanical means to joists, beams, purlins, or other structural members and can be galvanized, painted, or unpainted.

Design Load Applied load determined in accordance with either LRFD load combinations or ASD load combinations, whichever is applicable.

Design Strength* Resistance factor multiplied by the nominal strength, ϕR_n.

End Diagonal or Web The first web member on either end of a joist or Joist Girder which begins at the top chord at the seat and ends at the first bottom chord panel point.

End Welds Welds at the ends of an existing member or the reinforcing member.

Existing Member The member originally supplied in the joist or Joist Girder.

Filler A rod, plate or angle welded between a two angle web member or between a top or bottom chord panel to tie them together, usually located at the middle of the member.

Joint Area where two or more ends, surfaces or edges are attached. Categorized by type of fastener or weld used and the method of force transfer.

Joist A structural load-carrying member with an open web system which supports floors and roofs utilizing hot-rolled or cold-formed steel and is designed as a simple span member. Currently, the SJI has the following joist designations: K-Series including KCS, LH-Series and DLH-Series.

Joist Girder A primary structural load-carrying member with an open web system designed as a simple span supporting equally spaced concentrated loads of a floor or roof system acting at the panel points of the member and utilizing hot-rolled or cold-formed steel.

Load Force or other action that results from the weight of building materials, occupants and their possessions, environmental effects, differential movement, or restrained dimensional changes.

LRFD (Load and Resistance Factor Design) Method of proportioning structural components such that the design strength equals or exceeds the required strength of the component under the action of the LRFD load combinations.

Material Joists, Joist Girders and accessories as provided by the seller.

Nominal Strength* Strength of a structure or component (without the resistance factor or safety factor applied) to resist the load effects, as determined in accordance with the Standard Specifications.

Preload Force Force in the existing member not removed by shoring.

Reinforcing Member The added member(s).

Required Strength* Forces, stresses, and deformations produced in a structural component, determined by either structural analysis, for the LRFD or ASD load combinations, as appropriate, or as specified by the Standard Specifications.

Resistance Factor, ϕ Factor that accounts for deviations of the actual strength from the nominal strength, deviations of the actual load from the nominal load, uncertainties in the analysis that transforms the load into a load effect and for the manner and consequences of failure.

Safety Factor, Ω Factor that accounts for deviations of the actual strength from the nominal strength, deviations of the actual load from the nominal load, uncertainties in the analysis that transforms the load into a load effect and for the manner and consequences of failure.

Slenderness Ratio The ratio of the effective length of a column to the radius of gyration of the column about the same axis of bending.

Span The centerline-to-centerline distance between structural steel supports such as a beam, column or Joist Girder or the clear span distance plus four inches onto a masonry or concrete wall.

Specified Minimum Yield Stress Lower limit of yield stress specified for a material as defined by ASTM.

Specifying Professional The licensed professional who is responsible for sealing the building Contract Documents, which indicates that he or she has performed or supervised the analysis, design and document preparation for the structure and has knowledge of the load-carrying structural system.

Splice Connection between two structural members joined at their ends by either bolting or welding to form a single, longer member.

Stability Condition reached in the loading of a structural component, frame or structure in which a slight disturbance in the loads or geometry does not produce large displacements.

Standard Specifications Documents developed and maintained by the Steel Joist Institute for the design and manufacture of open web steel joists and Joist Girders. The term “SJI Standard Specifications” encompasses by reference the following:

ANSI/SJI-100 - 2020 Standard Specifications for K-Series, LH-Series, and DLH-Series open web Steel Joists and Joist Girders.

ANSI/SJI-200 - 2015 Standard Specifications for CJ-Series Composite Steel Joists.

Structural Analysis Determination of load effects on members and connections based on principles of structural mechanics.

Tagged End The end of a joist or Joist Girder where an identification or piece mark is shown by a metal tag. The member must be erected with this tagged end in the same position as the tagged end noted on the placement plan.

Webs The vertical or diagonal members joined at the top and bottom chords of a joist or Joist Girder to form triangular patterns.

Yield Point First stress in a material at which an increase in strain occurs without an increase in stress as defined by ASTM.

Yield Strength Stress at which a material exhibits a specified limiting deviation from the proportionality of stress to strain as defined by ASTM.

Yield Stress Generic term to denote either yield point or yield strength, as appropriate for the material.

Note:

***** These terms are usually qualified by the type of load effect, e.g., nominal tensile strength, available compressive strength, design flexural strength.

1 CHAPTER 1
EVALUATION OF EXISTING JOIST STRENGTH

In order to determine the capacity of the existing joist system, information must be found that describes the as-built design of the joists. There is the possibility that the existing joists may have been over specified. In addition to considering the existing joist design, the building usage may have changed, such that the mechanical loads or other dead or live loads may have increased or decreased from the design loads used at the time of the original installation of the joists. In some cases, the joists may have been damaged during the construction process. Examples are shown in Figures 1.1, 1.2 and 1.3.

Several items that may help determine the original design information are the following:

1. The original contract structural documents.
2. Final joist erection drawings used at time of construction.
3. The year the job was constructed.
4. The joist identification tag. The tag may give information regarding the manufacturer, year of construction, manufacturer's job number, mark number, and possibly a joist size. The tag is normally wired to a web member at one end of the joist.

Figure 1.1
Joist Top Chord Damaged During Construction