



TECHNICAL DIGEST 12

EVALUATION AND MODIFICATION OF OPEN-WEB STEEL JOISTS AND JOIST GIRDERS



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The information presented in this publication has been developed by James M. Fisher, PhD, PE, Consulting Engineer for the Steel Joist Institute in conjunction with the SJI's Engineering Practice Committee and Perry S. Green, PhD, Technical Director and is produced in accordance with recognized engineering principles and is for general information only. The SJI and its committees have made a concerted effort to present accurate, reliable, and useful information on the evaluation, modification and strengthening of steel joists and Joist Girders. The information contained in this digest should not be used or relied upon for any specific project without competent professional assessment of its accuracy, suitability and applicability by a licensed professional engineer or architect. The publication of the material contained in this Technical Digest is not intended as a representation or warranty on the part of the Steel Joist Institute. Any person making use of this information does so at one's own risk and assumes all liability arising from such use.

Federal Regulations Governing Erection of Joist Products

Steel joists and Joist Girders must be erected in accordance with the Occupational Safety and Health Administration (OSHA), U.S. Department of Labor 29 CFR Part 1926 Safety Standards for Steel Erection. The erection of Open Web Steel Joists is governed by Section 1926.757 of this Federal Regulation.

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by

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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 need 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.

TABLE OF CONTENTS

ACKNOWLEDGEMENT	i
FOREWORD	i
TABLE OF CONTENTS	ii
BACKGROUND	iii
GLOSSARY	iv
Chapter 1 EVALUATION OF EXISTING JOIST STRENGTH	1
Chapter 2 METHODS OF SUPPORTING ADDITIONAL LOAD	7
Chapter 3 DESIGN APPROACHES FOR STRENGTHENING JOISTS	19
Chapter 4 DESIGN APPROACHES FOR MODIFYING JOISTS - SHORTENING AND LENGTHENING	80
Chapter 5 OTHER CONSIDERATIONS	87
Chapter 6 SUMMARY	91
REFERENCES	92
Appendix A Joist Investigation Form	93
Appendix B Common Properties of Equal Leg Angles with Leg Sizes 2 in. or Less	94

BACKGROUND

Evaluation and modification of joists is often required due to the addition of roof top units, underhung conveyors, loading increases, field deviations, 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

NOTES:

Terms in **Bold** and their definitions come from the AISC AND AISI STANDARD Standard Definitions for Use in the Design of Steel Structures, 2004 Edition, First Printing April 2005.

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

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. In general, 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, this is 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” encompass by reference the following:

ANSI/SJI-K1.1 Standard Specification for Open Web Steel Joists, K-Series;

ANSI/SJI-LH/DLH-1.1 Standard Specifications for Longspan Steel Joists, LH-Series and Deep Longspan Steel Joists, DLH-Series; and

ANSI/SJI-JG-1.1 Standard Specifications for Joist Girders.

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.

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.

A number of items that may help determine the original design information is 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