Technical Document

Seismic Technical Guide

Seismic Separation Joint Exemption Through Analysis

Code Requirements[1]

There is a provision in the code where structural analysis may eliminate or decrease the requirements for seismic separation joints required in seismic design categories D, E and F.

ASCE/SEI 7 section 13.5.6.2.2 states, for ceiling areas exceeding 2,500 sq. ft. (232 m^2), a seismic separation joint or full height partition that breaks the ceiling up into areas not exceeding 2,500 sq. ft. shall be provided unless structural analyses are performed of the ceiling bracing system for the prescribed seismic forces that demonstrate ceiling system penetrations and closure angles provide sufficient clearance to accommodate the anticipated lateral displacement. Please refer to ASCE/SEI 7 section 13.3.2 for the necessary displacement calculations.

We have thoroughly examined in-plane analysis of lay-in panel ceilings for seismic design categories C-F. The findings of this study and our recommendations are presented in this technical guide to assist with the interpretation and application of the structural analysis. There are many factors that affect the application of a particular suspended ceiling in a seismic design category and USG recommends that the design team, consulting engineers and code officials work together to analyze these factors and determine the appropriate construction method. Because codes continue to evolve, check with a local official prior to designing and installing a suspended ceiling system.

Suspended Ceiling Behavior

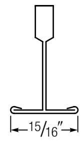
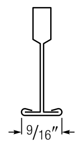
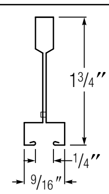
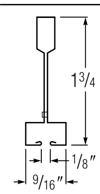
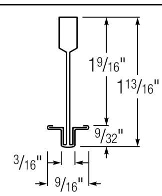
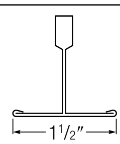
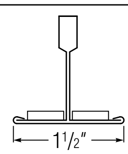
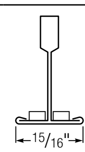
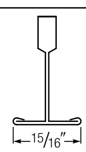
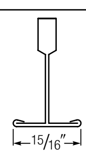
Suspended ceiling grid is designed to carry loads perpendicular to the face of the tee and the ceiling behavior is similar to a truss. The bending strength of the weak axis is low and the splices are not capable of resisting bending moments, therefore, suspended ceiling grid is best analyzed as a truss. In a truss, the members are assumed to carry only axial loads due to the reduced resistance to bending in the members and the connections.

Strength Analysis

Seismic codes assume that the weakest points in a suspended ceiling are the connections. Compression and tension force resistance is required for the splices while no buckling load is specified for the grid members. The seismic codes specify the strength requirements of the connections and the buckling capacity of USG main tees greatly exceed the connection strength requirements established by the code.

[1] See last page for Seismic Code Reference Standards

Suspended Ceiling Behavior—Strength Analysis

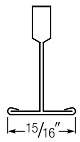
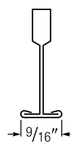
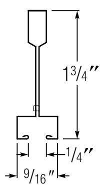
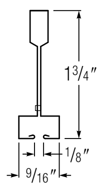
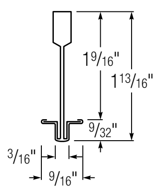
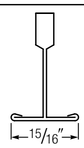
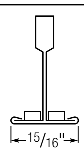
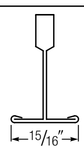
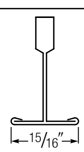
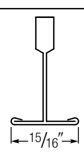
Rating[1]	USG Grid Profiles (Data Sheet)	Connection Type	Connection Values in Pounds: USG Products[2] – Tension	USG Products[2] – Compression	Code Requirements[3] – Tension	Code Requirements[3] – Compression
Heavy Duty	**DX®/DXL™** DX/DXL 26 (AC3167) 	Main Tee Splice	**>180**	**>180**	180	180
		Cross Tee Connections	**>180**	**>180**	180	180
	CENTRICITEE™ **DXT/DXLT** DXT26 (AC3040) 	Main Tee Splice	**>180**	**>180**	180	180
		Cross Tee Connections	**>180**	**>180**	180	180
	FINELINE® **DXF/DXLF** DXFH 2924 (AC3034)  **FINELINE® 1/8** **DXFF** DXFFH 2924 (AC3035) 	Main Tee Splice	**>180**	**>180**	180	180
		Cross Tee Connections	**>180**	**>180**	180	180
	IDENTITEE™ **DXI™** DXI 26 HRC (AC3281) 	Main Tee Splice	**>180**	**>180**	180	180
		Cross Tee Connections	**>180**	**>180**	180	180
	DXW™ DXW 26 (AC3037) 	Main Tee Splice	**>180**	**>180**	180	180
		Cross Tee Connections	**>180**	**>180**	180	180
	CE DXWCE 26 (AC3129)  **CE** DXCE 26 (AC3129) 	Main Tee Splice	**>180**	**>180**	180	180
		Cross Tee Connections	**>180**	**>180**	180	180
	DXLA™ DXLA 26 (AC3036) 	Main Tee Splice	**>180**	**>180**	180	180
		Cross Tee Connections	**>180**	**>180**	180	180
	ZXLA™ ZXLA 26 (AC3029) 	Main Tee Splice	**>180**	**>180**	180	180
		Cross Tee Connections	**>180**	**>180**	180	180

[1] Heavy Duty is required for IBC Seismic Design Category D-F and Intermediate Duty is required for IBC Seismic Design Category C. Reducing the hanger wire spacing on main tees can achieve heavy duty load carrying capacity values to satisfy this requirement, but does not change the duty classification of the main tee. Please refer to SC2499 for additional information.

[2] All DONN® suspension systems – DX®/DXL™, FINELINE® DXF™, FINELINE® 1/8 DXFF™, CENTRICITEE™ DXT™/DXLT™, IDENTITEE™ DXI, CE™, DXW™, DXLA™, and ZXLA™ – meet and exceed the connection value requirements for Seismic Design Categories C, D, E, and F.

[3] IBC Seismic Design Categories C, D, E, and F. IBC Seismic Design Categories A and B do not have connection value requirements.

Suspended Ceiling Behavior—Strength Analysis

Rating[1]	USG Grid Profiles (Data Sheet)	Connection Type	Connection Values in Pounds: USG Products[2] — Tension	USG Products[2] — Compression	Code Requirements[3] — Tension	Code Requirements[3] — Compression
Intermediate Duty	**DX®/DXL™** DX/DXL 24 (AC3167) 	Main Tee Splice	**>180**	**>180**	60	60
		Cross Tee Connections	**>180**	**>180**	60	60
	Centricitee™ DXT/DXLT DXT 24 AC3040 	Main Tee Splice	**>180**	**>180**	60	60
		Cross Tee Connections	**>180**	**>180**	60	60
	Fineline® DXF/DXLF DXF 2924 (AC3034)  **Fineline® 1/8 DXFF** DXFF 2924 (AC3035) 	Main Tee Splice	**>180**	**>180**	60	60
		Cross Tee Connections	**>180**	**>180**	60	60
	Identitee™ DXI™ DXI 24 HRC (AC3281) 	Main Tee Splice	**>180**	**>180**	60	60
		Cross Tee Connections	**>180**	**>180**	60	60
	DXLA™ DXLA 24 (AC3036) 	Main Tee Splice	**>180**	**>180**	60	60
		Cross Tee Connections	**>180**	**>180**	60	60
	CE DXCE 24 (AC3129) 	Main Tee Splice	**>180**	**>180**	60	60
		Cross Tee Connections	**>180**	**>180**	60	60
	ZXLA™ ZXLA 24 (AC3029) 	Main Tee Splice	**>180**	**>180**	60	60
		Cross Tee Connections	**>180**	**>180**	60	60
Light Duty	**AX™** AX 26 (AC3041) 	Main Tee Splice	**>180**	**>180**	N/A	N/A
		Cross Tee Connections	**>180**	**>180**	N/A	N/A
	DXSS DXSS 24 (AC3068) 	Main Tee Splice	**>180**	**>180**	N/A	N/A
		Cross Tee Connections	**>180**	**>180**	N/A	N/A

[1] Heavy Duty is required for IBC Seismic Design Category D-F and Intermediate Duty is required for IBC Seismic Design Category C. Reducing the hanger wire spacing on main tees can achieve heavy duty load carrying capacity values to satisfy this requirement, but does not change the duty classification of the main tee. Please refer to SC2499 for additional information.

[2] All Donn® suspension systems – DX®/DXL™, Fineline® DXF™, Fineline® 1/8 DXFF™, Centricitee™ DXT™/DXLT™, Identitee™ DXI, CE™, DXW™, DXLA™, and ZXLA™ – meet and exceed the connection value requirements for Seismic Design Categories C, D, E, and F.

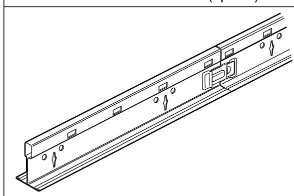
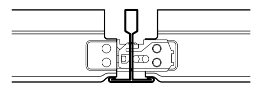
[3] IBC Seismic Design Categories C, D, E, and F. IBC Seismic Design Categories A and B do not have connection value requirements.

Suspended Ceiling Behavior

Deformation Analysis

Following are four factors that may contribute to suspended ceiling deformation in a seismic event. The engineer of record should consider these factors when eliminating or minimizing the seismic separation joint through analysis. In addition to these factors, the project address is required to determine the seismic coefficients.

Connection Displacement

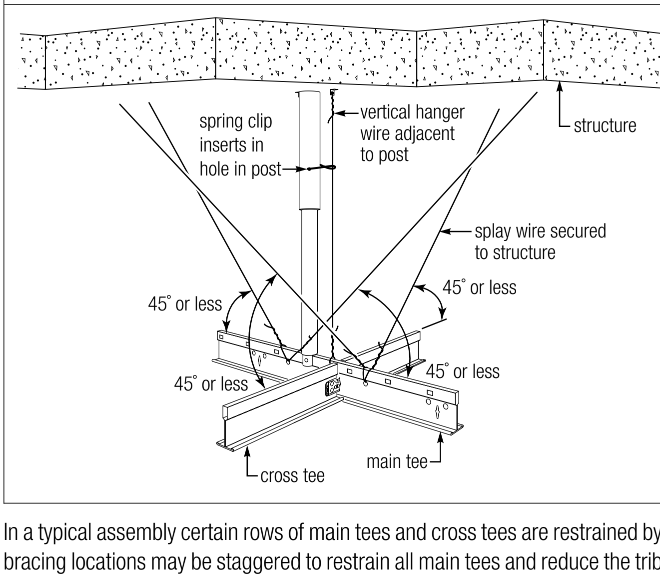
Suspension System	
USG Main Tee Connection (splice)	USG Cross Tee Connection (clip to clip)
	
≤ 0.015in.	≤ 0.007in.

Deformation Values[1]

[1] Actual displacement in the connections are closer to 0.006 in. Due to the various factors that may impact the overall values, the maximum values are listed.

In keeping with the truss correlation the bending strength of the grid members is not considered. Main tees are spliced together and can be treated as a continuous axial member. Cross tees are locked to each other and they can also be treated as a continuous axial member. Deformation within the ceiling is caused by movement within the splices and elastic deformation within the grid members. The largest component is typically movement within the splices. The movement perpendicular to the main tees can be calculated by adding the movement of the cross tee splices to the axial, elastic deformation within the cross tees. Movement perpendicular to the cross tees can be calculated by adding the movement of the main tee splices to the axial, elastic deformation within the main tees.

Typical Lateral Brace



In a typical assembly certain rows of main tees and cross tees are restrained by the lateral bracing. These bracing locations may be staggered to restrain all main tees and reduce the tributary area of the brace. Restrained rows will deform less than the unrestrained rows. In a 2 ft. x 4 ft. system the collective deformation value of the unrestrained cross tees yields a maximum ceiling length of 428 ft. before 3/4.in. deflection will accumulate[1]. In a 2 ft. x 2ft. system the collective deformation value of the unrestrained cross tees yields a maximum ceiling length of 214 ft. before 3/4 in. deflection will accumulate[2]. In restrained rows with bracing at 12 ft. o.c. the brace will engage before 3/4 in. deformation is reached. Assuming truss behavior, in the

Deformation Analysis

unrestrained rows there is nothing preventing this deformation from accumulating.[3] Therefore, assuming the lateral brace is the controlling factor when analyzing deformation, certain assumptions concerning deformation from contributing factors other than connection displacement are necessary.

[1] [3/4 in. x 4 ft. / 0.007 in.]
[2] [3/4 in. x 2 ft. / 0.007 in.]
[3] Weak axis bending capacity of the tees is limited but does exist; therefore the engineer of record may consider this and perform additional calculations which may expand the maximum ceiling area without separation joints.

Bracing Wire Elongation

A certain amount of wire elongation should be assumed.

Example

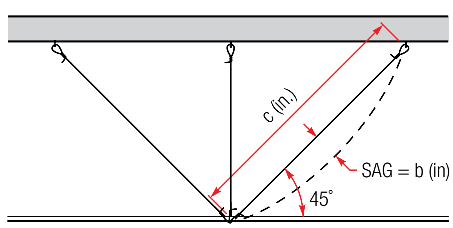
$$\Delta_E = \frac{PL}{AE}$$

P = axial force (lbf.)
L = length (in.)
A = area of the wire (in^2)
E = modulus of elasticity ($lbf./in^2$)

Bracing Wire Catenary

The tautness of the bracing wires may vary by factors such as installation and plenum depth. Typically the bracing wires will contain a slight curve caused by the force of gravity. During a seismic event this curve can enlarge and diminish during the movement cycles due to axial seismic forces on the bracing wire. If these are not taut, the ceiling will move until the slack is taken up.

Example



a - arch length (in.)

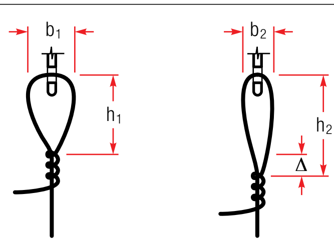
$$a = 0.0349 \times \frac{4b^2 + c^2}{8b} \times \text{SIN}^{-1}\left(\frac{8bc}{8b^2 + 2c^2}\right)$$

$$\Delta_C = a - c$$

Loop Straightening

The brace wires are typically fastened to the main tees and structure with loops. During a seismic event these loops may elongate allowing an increase in movement. Both the connection to the structure and connection to the grid member shall be considered.

Example



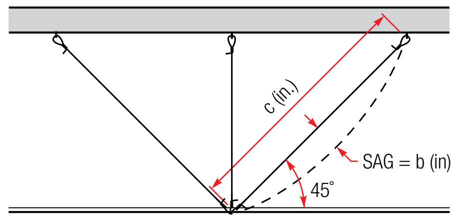
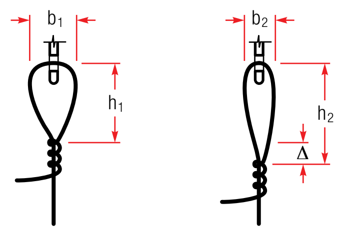
$$A_1 = A_2 = \frac{b_1\, h_1}{2} = \frac{b_2\, h_2}{2}$$

$$\Delta_{LS} = h_2 - h_1 \quad \text{(at each end)}$$

Suspended Ceiling Behavior

Deformation Analysis

Summary – Suspension System Deformation Analysis

Bracing Wire Elongation	Bracing Wire Catenary	Loop Straightening
		
Sample Formulas		
$\Delta_E = \frac{PL}{AE}$	a - arch length (in.) $a = 0.0349 \times \frac{4b^2 + c^2}{8b} \times \text{SIN}^{-1}\left(\frac{8bc}{8b^2 + 2c^2}\right)$ $\Delta_C = a - c$	$A_1 = A_2 = \frac{b_1 h_1}{2} = \frac{b_2 h_2}{2}$ $\Delta_{LS} = h_2 - h_1$ (at each end)

Note: A structural engineer should be consulted for each project. Always check with a local official prior to designing and installing a ceiling system. Other restrictions and exemptions may apply. This is only intended as a quick reference.

Conclusion

Δ_T = Total Deflection = $0.707 \times (\Delta_E + 2\Delta_{LS} + \Delta_C)$

$\Delta_T <$ 3/4" or allowable clearance whichever is less

Seismic separation joints are not required when structural analyses are performed on the ceiling bracing system for the prescribed seismic forces that demonstrate ceiling penetrations and closure angles or channels provide sufficient clearance to accommodate the anticipated lateral displacement. The typical maximum allowable displacement is 3/4 in. for most ceiling systems. Therefore seismic separation joint are not required when the engineer of record determines the total deflection is less than 3/4 in. or the allowable clearance, whichever is less.

Seismic Code Reference Standards

	Installation Guidelines for Suspended Ceilings			
International Building Code (IBC)	2003 IBC ⬇	2006 IBC ⬇	2009 IBC ⬇	2012 IBC ⬇
American Society of Civil Engineers (ASCE)	ASCE7-02 ⬇	ASCE7-05 ⬇	ASCE7-05 ⬇	ASCE7-10 ⬇
Ceilings Interior Systems Construction Association (CISCA) or **ASTM International (ASTM)**	CISCA Zones 0-2 CISCA Zones 3-4	CISCA Zones 0-2 CISCA Zones 3-4	CISCA Zones 0-2 CISCA Zones 3-4	ASTM E580

International Building Code (IBC) defines Seismic Design Categories A, B, C, D, E, and F.
www.iccsafe.org

ASCE/SEI 7 Minimum Design Loads for Buildings and Other Structures
American Society of Civil Engineers/Structural Engineer Institute (ASCE/SEI)
www.asce.org

Guidelines for Seismic Restraint for Direct-hung Suspended Ceiling Assemblies (Zones 3-4)
Recommendations for Direct-hung Acoustical Tile and Lay-in Panel Ceilings (Zones 0-2)
CISCA Ceilings & Interior Systems Construction Association (CISCA)
www.cisca.org

ASTM Internationl E580/E580M Standard Practice for Installation of Ceiling Suspension Systems for Acoustical TIle and Lay-in Panels in Areas Subject to Earthquate Ground Motions.
ASTM International (formerly American Society for Testing and Materials)
www.astm.org

Further References

USG Seismic Ceiling Resource Center
Seismic Technical Guides
seismicceilings.com

Product Information
See usg.com for the most up-to-date product information.

Installation
Must be installed in compliance with ASTM C636, ASTM E580, CISCA, and standard industry practices.

Code Compliance
The information presented is correct to the best of our knowledge at the date of issuance. Because codes continue to evolve, check with a local official prior to designing and installing a ceiling system. Other restrictions and exemptions may apply. This is only intended as a quick reference.

Purpose
This seismic technical guide (STG) is intended as a resource for design professionals, to promote more uniform criteria for plan review and jobsite inspection of projects. This STG indicates an acceptable method for achieving compliance with applicable codes and regulations, although other methods proposed by design professionals may be considered and adopted.

ICC Evaluation Service, Inc., Report Compliance
Suspension systems manufactured by USG Interiors, Inc., have been reviewed and are approved by listing in ICC-ES Evaluation Report 1222. Evaluation Reports are subject to reexamination, revision and possible cancellation. Please refer to usgdesignstudio.com or usg.com for current reports.

L.A. Research Report Compliance
Donn brand suspension systems manufactured by USG Interiors, Inc., have been reviewed and are approved by listing in the following L.A. Research Report number: 25764.

Notice
We shall not be liable for incidental and consequential damages, directly or indirectly sustained, nor for any loss caused by application of these goods not in accordance with current printed instructions or for other than the intended use. Our liability is expressly limited to replacement of defective goods. Any claim shall be deemed waived unless made in writing to us within thirty (30) days from date it was or reasonably should have been discovered.

Safety First!
Follow good safety/industrial hygiene practices during installation. Wear appropriate personal protective equipment. Read MSDS and literature before specification and installation.

Manufactured by
USG Interiors, Inc.
550 West Adams Street
Chicago, IL 60661

usg.com
seismicceilings.com
sustainableceilings.com
usgdesignstudio.com

SC2545/rev. 11-11

Printed in U.S.A.