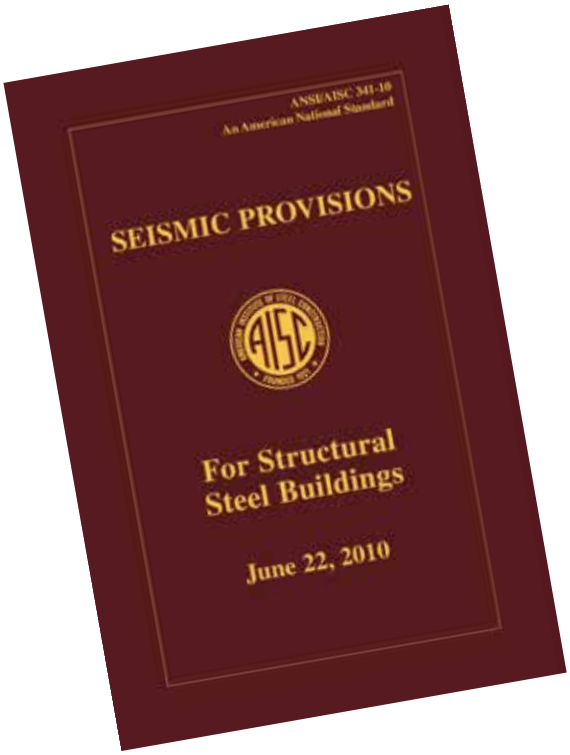
Slenderness limits
for built-up box links in EBFs in the AISC *Seismic Provisions*.



Setting Limits

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THE OPTION TO USE built-up box sections as links in eccentrically braced frames (EBF) is new to the 2010 AISC *Seismic Provisions for Structural Steel Building (ANSI/AISC 341-10)*. Section F3 of the *Seismic Provisions* addresses the analysis and design of EBFs, including such design considerations as link stiffeners, member and welding requirements and the available shear strength for links.

However, Table D1.1 lacks an explicitly stated width-to-thickness ratio limit for webs of box-shaped links. While the table does include limits for webs of built-up boxes used as beams or columns, the limits for webs of box-shaped links are more stringent so that they may sustain the repeated cycles of large inelastic deformations anticipated in such links during severe earthquakes.

Section F3.5b of the Commentary provides guidance for the use of box-shaped links by referencing the width-to-thickness ratio criteria developed based on parametric studies and experiments (see "Tubular Links for Eccentrically Braced Frames, I and II," both in the May 2008 issue of *Journal of Structural Engineering*). The purpose of this technical note is to illustrate these recommended criteria and suggest their inclusion in future editions of the *Seismic Provisions*. (For a comprehensive presentation, see "Overview of the Development of Design Recommendations for Eccentrically Braced Frame Links with Built-Up Box Sections," in the First Quarter 2013 issue of AISC's *Engineering Journal*).

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Recommended Limits

The Commentary to the *Seismic Provisions* recommends that:

1. For built-up box links with link lengths $e \le 1.6M_p/V_p$ (defined interchangeably in the literature as "short links" or "shear links"), it is recommended that the web width-to-thickness ratio be limited to $1.67\sqrt{E/F_y}$.
2. For built-up box links with link lengths $e > 1.6M_p/V_p$ (defined as "intermediate and long links"), it is recommended that the web width-to-thickness ratio be limited to $0.64\sqrt{E/F_y}$.

In the foregoing recommendations, e is the EBF link length, M_p and V_p are the plastic moment and shear strength as specified

Description of Element	Width-to-Thickness Ratio	λ_{hd} Highly Ductile Members	λ_{md} Moderately Ductile Members
Webs of built-up box sections used as EBF links	h/t_w	$0.64\sqrt{E/F_y}$	$1.67\sqrt{E/F_y}$

▲ Table 1 – Proposed Modification to Table D1.1 of the 2010 AISC *Seismic Provisions*

in the *Seismic Provisions*, E is the modulus of elasticity and F_y is the specified minimum yield strength of the steel.

A proposed modification is being discussed for the *Seismic Provisions*. Table 1 in this article reflects the information proposed for inclusion in *Seismic Provisions* Table D1.1. Additionally, an exception is proposed for inclusion in Section F3.5b(1):

> Exception: Flanges of links with box-shaped sections are permitted to satisfy the requirements for moderately ductile members. Webs of links with box-shaped sections with link lengths, $e \le 1.6M_p/V_p$, are permitted to satisfy the requirements for moderately ductile members.

Findings from research by Berman and Bruneau also led to the following compactness and stiffener recommendations:

1. All links should have flanges satisfying: $b/t \le 0.64\sqrt{E/F_y}$
2. Short links should have webs satisfying: $h/t \le 1.67\sqrt{E/F_y}$
3. Short links should have web stiffeners if: $h/t > 0.64\sqrt{E/F_y}$
4. Webs of intermediate and long links should satisfy: $h/t \le 0.64\sqrt{E/F_y}$ and no stiffeners are required.

Table 2 systematically presents these limits, cross-referencing (as Cases A to E) how the issues are addressed either by the *Seismic Provisions* or by the above proposed changes that implement the recommendations included in the Commentary to *Seismic Provisions* Section F3.5b.

▼ Table 2 – Summary of Compactness and Stiffening Requirements

	$e \le 1.6M_p/V_p$ (short link)	$e > 1.6M_p/V_p$ (intermediate and long links)
Flange b/t	$b/t \le 0.64\sqrt{E/F_y}$ (CASE A)	$b/t \le 0.64\sqrt{E/F_y}$ (CASE A)
Web h/t	$h/t \le 1.67\sqrt{E/F_y}$ in all cases (CASE B)	$h/t \le 0.64\sqrt{E/F_y}$ all cases (CASE C)
	if $h/t > 0.64\sqrt{E/F_y}$ then stiffeners required (CASE D)	No stiffeners required (CASE E)

CASE A: Not covered by the 2010 AISC *Seismic Provisions*. The first sentence of the exception recommended above provides the limit appropriate for all link lengths (i.e., short, intermediate and long links).
CASE B: Not covered by 2010 AISC *Seismic Provisions*. Together with the proposed Table 1, the second sentence of the exception above will provide the proper limit for short links.
CASE C: Not covered by 2010 AISC *Seismic Provisions*. The limits recommended in Table 1, together with the second paragraph of AISC *Seismic Provision* Section F3.5b(1) (which requires links to satisfy the requirement in Table D1.1 for highly ductile members), would provide the limits appropriate for intermediate and long links.
CASE D: Currently covered by 2010 AISC *Seismic Provisions* Sections F3.5b(5)(a) and F3.5b(5)(b).
CASE E: Currently covered by 2010 AISC *Seismic Provisions* Section F3.5b(5)(c).

Recommended

An additional entry into Table D1.1 of the *Seismic Provisions* and an additional paragraph to Section F3.5b(1) have been proposed to ensure that box-shaped links incorporated into eccentrically braced frames will be designed in compliance with the limits supported by research and recommended in Section F3.5b of the Commentary to the *Seismic Provisions*. These limits are intended to ensure that these links will be able to sustain the large inelastic deformations expected during large earthquakes. MSC

The Seismic Provisions are available as a free download at www.aisc.org/epubs.