STRUCTURAL DESIGN GUIDELINES FOR STEEL MOMENT-RESISTING FRAMES

I. Purpose
This bulletin provides guidelines for application of the design requirements of steel moment-resisting frame structures based on the ASCE 7, AISC 341, AISC 358 and previous recommendations from the Structural Engineers Association of Southern California (SEAOSC) Steel Committee according to 2017 LABC. Design criteria included in this bulletin are intended to summarize these standards and recommendations for quick references to steel moment-resisting frame requirements.

II. Codes, Standards, and Specification
- AISC 358-10, AISC358s1-11 Pre-qualified Connections For Special and Intermediate Steel Moment Frames for Seismic Applications including Supplemental No.1
- AISC 360-10, Specification for Structural Steel Buildings.
- ASCE 7-10, Minimum Design Loads for Buildings and Other Structures, including Supplement No. 1 and excluding Chapter 14 and Appendix 11A.
- AWS D1.1/D1.1M-2010 Structural Welding Code - Steel.

III. CONNECTION TYPES
A. Prequalified Connection

Currently, AISC 358-10 “Prequalified Connections for Special and Intermediate Steel Moment Frames for Seismic Applications” provides seven prequalified configurations of steel special and intermediate moment-resisting frames, (SMF) and (IMF) respectively, as follows:

- Reduced Beam Section (RBS),
- Bolted Unstiffened Extended End-Plate (BUEEP),
- Bolted Stiffened Extended End-Plate (BSEEP),
- Bolted Flange Plate (BFP),
- Welded Unreinforced Flange-Welded Web (WUF-W),
- Kaiser Bolted Bracket (KBB - proprietary product)
- ConXtech ConXL Moment Connection (ConXL - proprietary product)
The connections illustrated in Figure 1 are considered prequalified connections for SMF and IMF applications, subject to the design and construction limitations as described in AISC 358-10.

Use of any prequalified configuration of steel SMF and IMF in future AISC 358 supplements shall be subject to the review and approval by the Department.

**Figure 1 – RBS, BUEEP, BSEEPP, BFP, WUF-W and KAISER Connections**
B. Non-Prequalified Connection

Connections that are not described in Section A above are considered as non-prequalified connections. The non-qualified connections must be tested in accordance with Chapter K of AISC 341-10. Where connection configurations are based on previously tested SMFs or IMFs, the extrapolation of tests to only those connections shall be limited to those that are within the size and weight variation for beams and columns as specified in Chapter K of AISC 341-10.

When variations of any connection systems are proposed, project specific tests complying with Chapter K of AISC 341-10 are required for the following:

- Skewed or dual axis moment connections,
- Moment connections in the weak axis direction of the column (e.g., moment connections to the column web),
- Variations from the allowed configuration of the weld access hole at moment connections,
- Addition of haunches or cover plates,
- Additional welding and other connections not prequalified.
IV. STRUCTURAL DESIGN CRITERIA

The following design criteria shall be used for SMF and IMF designed and prequalified with AISC 358-10 and AISC 341-10 Seismic Provisions for rolled or built-up I-shaped sections (i.e., wide flange shapes):

1. The appropriate response modification coefficient, $R$, system overstrength factor, $\Omega_o$, and the deflection amplification factor, $C_d$, indicated in Table 12.2-1 of ASCE 7-10 shall be used to determine the base shear, element design forces, and design story drift.

2. The structural system used shall be in accordance with the seismic design category and height limitations indicated in Table 12.2-1 and Section 12.2.5.5 of ASCE 7-10 (for SMF) or Sections 12.2.5.6 thru 12.2.5.7 of ASCE 7-10 (for OMF and IMF)

Exception:

A greater allowable story drift may be permitted if it can be demonstrated from tests, conforming to Chapter K of AISC 341-10, that the connection provides a drift capacity of 1.6 times the proposed allowable story drift. The allowable story drift determined by this process shall not exceed that permitted by Table 12.2-1 of ASCE 7-10 for any story.

V. OTHER DESIGN CONSIDERATIONS

A. Overstrength Factor at Column Base Connection

Column base connection elements, including but not limited to, anchor bolts, base plate welds and any elements transferring shear, moment and tension mechanism shall be designed using the overstrength factor, $\Omega_o$, in accordance with Section 12.4.3.2 of ASCE 7-10. Load combinations with overstrength factor should apply to elevated structural slabs or beams supporting moment-resisting frame systems. The overstrength factor, $\Omega_o$, need not be applied to the foundation or grade beam supporting columns; provided however that the grade beams are designed and detailed to develop ductility in accordance with the provisions of Chapter 21 of ACI-318-14.

B. Protected Zones for SMF and IMF Connections

The region at each end of the beam subject to inelastic straining shall be designated as a protected zone and shall meet the requirements of Section D1.3 of AISC 341-10. Unless a prequalified connection is used in accordance with Section K1 of AISC 341-10, cyclic testing is required for the qualification of the connection in accordance with Section K2 of AISC 341–10.
Unless otherwise permitted per Section D3 of AISC 341-10, discontinuities created by fabrication or erection operations and attachments or penetrations within the protected zones are prohibited. This requirement shall be clearly identified on the structural drawings. Figure 2 below shows recommended details to prohibit attachments or penetrations in the protected zones. Furthermore, it is recommended this detail be shown on other appropriate construction documents, including the architectural, mechanical, electrical or plumbing drawings. The importance of avoiding attachments or penetrations within the protected zones should be discussed during the preconstruction meeting with the various contractors and subcontractors prior to commencement of construction work.

Note: While the AISC 341-10 does not require protected zones for OMF connections, it is good practice to minimize or limit, whenever possible, attachments within this defined area.

Figure 2 – Protected Zone
VI. QUALITY CONTROL AND QUALITY ASSURANCE

Quality control and quality assurance shall be in accordance with Chapter J of AISC 341-10. Details regarding welding and welding inspection shall be in accordance with AWS D1.1-10 Steel Structural Welding Code, D1.8-09 Steel Structural Welding Code - Seismic Supplement, Chapter I of AISC 341-10 and Chapter 3 of AISC 358-10.

A quality assurance plan is required to be provided with every structural plan for steel moment frames. Quality Assurance (QA) Standard Plans shall be attached to and made part of the approved structural plans, per Chapter J of AISC 341-10. The Engineer of Record shall submit a separate quality assurance plan complies with all the minimum requirements.

As an option, the Engineer of Record can amend and use LADBS’s Quality Assurance Standard Plans as a template to satisfy the current AISC 341-10, Chapter J requirements. Providing that if any modification or mixing and matching from the standard plans, the amended plans shall be no less meeting Chapter J requirement as LADBS intended. The QA Standard Plan can be obtained at www.ladbs.org.
TABLE 1
SUMMARY OF DESIGN COEFFICIENTS, FACTORS AND DEFORMATION FOR
STEEL MOMENT-RESISTING FRAMES SYSTEMS IN SEISMIC DESIGN CATEGORY D

<table>
<thead>
<tr>
<th>SMF</th>
<th>CONNECTION TYPE</th>
<th>STANDARD</th>
<th>SECTION</th>
<th>BUILDING AND STRUCTURE TYPES</th>
<th>DESIGN COEFFICIENTS AND FACTORS</th>
<th>SEISMIC DESIGN CATEGORY</th>
<th>OCCUPANCY CATEGORY</th>
<th>ALLOWABLE STORY DRIFT LIMIT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>D</td>
<td></td>
<td>4 Stories</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4 Stories</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4 Stories</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4 Stories</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4 Stories</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4 Stories</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4 Stories</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4 Stories</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4 Stories</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4 Stories</td>
</tr>
</tbody>
</table>

FOOTNOTE:

a. Response modification coefficient R, for use throughout the standard. Note R reduces forces to a strength level, not an allowable stress level.
b. Reflection amplification factor, Cd, for use in ASCE 7-10 Sections 12.2.5.6, 12.2.5.7, and 12.2.5.8.
c. NL = Not Limited, NP = Not Permitted, DL = Dead load in accordance with ASCE 7-10 Sections 12.2.5.6, 12.2.5.7, 12.2.5.8.

As a covered entity under Title II of the Americans with Disabilities Act, the City of Los Angeles does not discriminate on the basis of disability and, upon request, will provide reasonable accommodation to ensure equal access to its programs, services and activities.
TABLE 2
SUMMARY OF DESIGN COEFFICIENTS, FACTORS AND DEFORMATION FOR
STEEL MOMENT-RESISTING FRAMES SYSTEMS IN SEISMIC DESIGN CATEGORY E

<table>
<thead>
<tr>
<th>URS</th>
<th>CONNECTION TYPE</th>
<th>STANDARD</th>
<th>SECTION</th>
<th>BUILDING AND STRUCTURE TYPES</th>
<th>DESIGN COEFFICIENTS AND FACTORS</th>
<th>SEISMIC DESIGN CATEGORY Structural System Limitations and Building Height Limit 1</th>
<th>OCCUPANCY CATEGORY Allowable Story Drift Limit 1, 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>MF</td>
<td>Prequalified Connections</td>
<td>ASCE 358</td>
<td>Table 2.1, Any Building Types</td>
<td>R-0.3, D-0.3, G-0.3</td>
<td>NL NL NL NL</td>
<td>0.025h, 0.025h, 0.015h, 0.015h</td>
<td>1.5 1.5 1.5 35 NL NL</td>
</tr>
<tr>
<td>MF</td>
<td>Prequalified Connections</td>
<td>ASCE 358</td>
<td>Chapter K</td>
<td>Any Building Types</td>
<td>R-0.3, D-0.3, G-0.3</td>
<td>NL NL NL NL</td>
<td>0.025h, 0.025h, 0.015h, 0.015h</td>
</tr>
<tr>
<td>MF</td>
<td>Prequalified Connections</td>
<td>ASCE 358</td>
<td>Table 2.1, Any Building Types</td>
<td>R-0.3, D-0.3, G-0.3</td>
<td>35 35 20 NL</td>
<td>0.025h, 0.025h, 0.015h, 0.015h</td>
<td>1.5 1.5 1.5 35 NL NL</td>
</tr>
<tr>
<td>MF</td>
<td>Prequalified Connections</td>
<td>ASCE 358</td>
<td>Chapter K</td>
<td>Any Building Types</td>
<td>R-0.3, D-0.3, G-0.3</td>
<td>35 35 20 NL</td>
<td>0.025h, 0.025h, 0.015h, 0.015h</td>
</tr>
<tr>
<td>MF</td>
<td>Prequalified Connections</td>
<td>ASCE 358</td>
<td>Section E1</td>
<td>Metal Buildings</td>
<td>R-0.3, D-0.3, G-0.3</td>
<td>65 20 20 1</td>
<td>0.025h, 0.025h, 0.015h, 0.015h</td>
</tr>
</tbody>
</table>

FOOTNOTE:

a. Response modification coefficient R, for use throughout the standard. Note R reduces forces to a strength level, not an allowable stress level.
b. Reflection amplification factor, Cd, for use in ASCE 7-10 Sections 12.2.5.6, 12.2.5.7, 12.2.5.8, 12.2.5.9.
c. NL = Not Limited, NP = Not Permitted, DL = roof or floor tributary dead load in accordance with ASCE 7-10 Section 12.2.5.6, 12.2.5.7, 12.2.5.8. WDL = exterior wall tributary dead load in accordance with ASCE 7-10 Section 12.2.5.6, 12.2.5.7, 12.2.5.8.
d. The tabulated value of the overstrength factor, Ωo, is permitted to be reduced by subtracting one-half for structures with flexible diaphragms, but shall not be taken as less than 2.0 for any structure except cantilever column system.
e. See ASCE 7-10 Section 12.2.5.5 for limitations for steel SMFs in structures assigned to Seismic Design Category D through E.
f. See ASCE 7-10 Section 12.2.5.6 and 12.2.5.8 for limitations for single-story steel OMFs and IMFs in structures assigned to Seismic Design Category D through F.
g. See ASCE 7-10 Section 12.2.5.7 for limitations for steel OMFs and IMFs in structures assigned to Seismic Design Category D through E.
h. See ASCE 7-10 Section 12.2.5.9 for limitations for steel IMFs in structure assigned to Seismic Design Category D through F.
i. See ASCE 7-10 Section 12.12.1.1 for the allowable story drift for seismic force-resisting systems comprised solely of moment frames in Seismic Design Category D through F.
j. See ASCE 7-10 Section 11.2 for the allowable story drift for seismic force-resisting systems comprised solely of moment frames in Seismic Design Category E through F.
k. See ASCE 7-10 Section 11.2 for the allowable story drift for seismic force-resisting systems comprised solely of moment frames in Seismic Design Category F through E.
l. See ASCE 7-10 Section 11.2 for the allowable story drift for seismic force-resisting systems comprised solely of moment frames in Seismic Design Category F through E.
m. Miscellaneous structures may include, but not limited to, walkways, canopies, penthouse, stairs towers, and other non-building structures not part of the lateral resisting system of a building.

As a covered entity under Title II of the Americans with Disabilities Act, the City of Los Angeles does not discriminate on the basis of disability and, upon request, will provide reasonable accommodation to ensure equal access to its programs, services and activities.

Page 8 of 9
As a covered entity under Title II of the Americans with Disabilities Act, the City of Los Angeles does not discriminate on the basis of disability and, upon request, will provide reasonable accommodation to ensure equal access to its programs, services and activities.