Supplemental Structural Correction Sheet
Steel Brace Frame Design
(2011 LABC)

Plan Check Submittal Date:_____

Plan Check / PCIS App #:_____

Job Address:_____

Applicant:_____Phone:_____

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For instruction and other information, read the master plan check correction sheet attached.

Obtain the following Information Bulletins, Affidavits, or Forms from our web site (www.ladbs.org)
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Reference:

AISC 341 - AISC 341-05: Seismic Provisions for Structural Steel Buildings, Including Supplement No. 1 by American Institute of Steel Construction, INC.
ASCE 7 - ASCE 7-05: Minimum Design Loads for Buildings and Other Structures by American Society of Civil Engineers.
AWS D1.1-08 and AWS D1.1/D1.1M -09 Structural Welding Code by American Welding Society.
LABC - Los Angeles Building Code 2008

I. PLAN DETAILS

A. GENERAL

1. Column splices made with fillet welds or partial joint penetration groove welds shall be located 4 ft or more away from the beam-to-column connections. When the column clear height between beam-to-column connections is less than 8 ft, splice shall be half the clear height. Detail this on the plan. ***(AISC 341- Part I -8.4a)***

2. Provide a beveled transition detail where changes in thickness and width of flanges and webs occur in complete joint penetration groove welded column splices. ***(AISC 341- Part I -8.4a, AWS D1.1-05 2.7.1, 2.16.1.1)***

3. Beveled transitions are not required when changes in thickness and width of flanges and webs occur in column splices where PJP grove welded joints are used. ***(AISC 341- 8.4a,b)***

B. ORDINARY & SPECIAL CONCENTRICALLY BRACED FRAMES (OCBF/SCBF)

1. In Built up members, bolted stitches in the built-up braces of SCBF shall not be located in the middle one-fourth of the clear brace length. ***(AISC 341- 13.2e)***

2. In a V-type and inverted V-type brace frame, a beam that is intersected by braces shall be continuous between columns and laterally braced. ***(AISC 341-13.4a (2), 14.3, 14.5c)***

3. Show Protected Zone *of SCBF* per requirements of AISC 341-13.6

4. K-type braces are not permitted for use in SCBF. ***(AISC 341-13.4b)***

5. K-type braces are not permitted for use in OCBF above seismic isolation systems. ***(AISC 341-14.5b)***

6. The use of rectangle HSS are not permitted for bracing members, unless filled solid with cement grout having a minimum compressive strength of 3000 psi at 28 days. ***(LABC- 2205.4.1.1)***

C. ECCENTRICALLY BRACED FRAME (EBF)

1. Web *of a link* shall be single thickness without doubler-plate reinforcement & without penetration. ***(AISC 341 - 15.2a)***

2. Provide full-depth web stiffeners on both sides of the link web at the diagonal brace ends. ***(AISC 341 - 15.3)***

3. Provide intermediate stiffeners on link web as required per AISC 341-15.3 (a),(b),(c),(d),(e).

4. Lateral bracing shall be provided at both the top and bottom link flanges at the ends of the link. ***(AISC 341-15.5)***

5. The intersection of the centerline of the diagonal brace and the beam outside the Link shall be at the ends of the Link or in the Link. ***(AISC 341-15.6 b)***

6. No part of brace connection shall extend over the link length. ***(AISC 341-15.6c)***

7. If the EBF system factors in the application building code do not require moment resisting connections away from the link, then beam-to-column connections away from the link are permitted to be designed as pinned in the plane of the web. ***(AISC 341-15.7)***

8. If the EBF system factors in the application building code require moment resisting connections away from the link, then beam-to-column connections away from the link shall meet the requirements for beam-to-column connections for OMF specified in Sections 11.2 and 11.5 of AISC 341. ***(AISC 341-15.7)***

9. Links in EBFs are a protected zone, and shall satisfly the requirements of Section 7.4 AISC 341. Welding on link is permitted for attachment of link stiffeners as required in Section 15.3 of AISC 341. Show protected zone on plan. ***(AISC 341 -15.7)***

10. Complete-joint-penetration groove welds (if used) attaching the link flanges and the link web to the column are Demand Critical Welds, and shall satisfy the requirement of Section 7.3b of AISC 341. Show on plan these CJP welds (if used) as “Demand Critical Welds”. ***(AISC 341-15.9)***

II. CALCULATIONS

A. GENERAL

1. The total static design base shear in a given direction shall be determined per Section 12.8 of ASCE 7.

2. Use amplified loads ***where*** required by Sections 12.3.3.3 or 12.10.2.1 of ASCE 7. In addition to the load combination specified in 91.1605.2 and 91.1605.3, ***use the special*** seismic load combinations per Section 1605.1 and Section 12.4.3.2 / 12.14.3.2 of ASCE 7.

3. The elastic drift or horizontal displacements of the structure shall be computed as required in ASCE 7-12.8.6 and shall be amplified as required in ASCE 7-12.8.6. Story drift limits shall be determined as specified in ASCE 7-12.12

4. Orthogonal earthquake effects shall be included in the analysis as required in ASCE 7-12.5.3 and 12.5.4.

5. When $P_u/\varphi P_n$ ***(LRFD)*** or ΩC ***Pa/Pn (ASD)*** for columns is greater than 0.4, then ***the amplified seismic load factor must be included in the column design***. ***(AISC 341 - 8.3)***

6. R, ΩO and C_d shall be based on ASCE 7- Table 12.2-1

7. Foundation of the steel frame shall be designed to resist applicable sliding shear, uplift force, and/or moment.

8. Column splices shall be designed per requirements of AISC 341-8.4a and 8.4b. Welded column splices that are subject to a calculated net tensile shall be shall satisfy both of the following requirements:

   a. PJP weld if used shall have the capacity at least equal to 200 percent of the required strength.

   b. The available strength for each flange splice shall be at least equal to 0.5 RyFyAf (LRFD) or (0.5/1.5)RyFyAf (ASD), where Af is the flange area of the smaller column connected.

9. The required strength of column bases shall be calculated in accordance with AISC 341 - 8.5a,b,c

B. SPECIAL CONCENTRICALLY BRACED FRAMES (SCBF)

1. Bracing members shall have slenderness ratio Kl/r < 4 $\sqrt{E / F_Y}$, for braces with 4 E/Fy < Kl/r # 200 see exception of AISC 341-13.2a ***(AISC 341-13.2a)***

2. When the effective net area of brace is less than gross area, the required tensile strength of the brace shall be based upon the limit state of fracture in the net section, and shall be greater than the lesser of the following: ***(AISC 341-13.2b)***

   a. RyFyAg (LRFD) or RyFyAg /1.5 (ASD)

   b. The maximum load effect, that can be transferred to the brace by the system.

3. Along any line of bracing, braces shall be deployed in alternate directions such that, for either direction of force parallel to the bracing, at least 30% but no more than 70% of the total horizontal force is resisted by brace in tension, unless the available strength of each brace in compression is larger than the required strength resulting from the application of the appropriate load combinations stipulated by the applicable building code including the amplified seismic load. See AISC SP-13.2 for definition of " a line of bracing". ***(AISC 341-13.2c)***

4. Columns and Braces shall be seismically compact λ (the width-thickness ratios of its compression elements) shall not exceed λps from Provisions Table I-8-1. ***(AISC 341-13.2d, 8.2b)***

5. Design the stitches of a built-up bracing members for a minimum shear strength equals to the design tensile strength of the each element. The spacing of the stitches shall be uniform and not less than two stitches shall be used. Bolted stitches are not permitted within the middle one-fourth of the clear brace length. ***(AISC 341-13.2e)***

6. Distribute stitches uniformly over the length of a built-up bracing member such that the slenderness ratio *l/r* of individual elements between the stitches does not exceed 0.4 times the governing slenderness ratio of the entire member. ***(AISC 341-13.2e)***

7. Design the bracing connections (including beam-to-column connection if part of the bracing system) for the lesser of the following:

    a. The expected yield strength, in tension, of the bracing member, determined RyFyAg (LRFD) or RyFyAg /1.5 (ASD)

    b. The maximum load effect, indicated by analysis that can be transferred to the brace by the system. ***(AISC 341-13.3a)***

8. Address the design flexural strength of the bracing connection in the direction the brace will buckle. The minimum required flexural strength of the bracing connections shall be equal to or greater than the expected nominal flexural strength of the brace $1.1R_yM_p$ (LRFD) or $(1.1/1.5)R_yM_p$ (ASD), about critical buckling axis of the brace (see exceptions by use of gap at the end of brace). ***(AISC 341-13.3 b)***

9. The design of the gusset plate of the bracing connection shall include the required compressive strength based on buckling limit states that is at least equal to 1.1RyPn (LRFD) or (1.1/1.5)RyPn (ASD), where Pn is the nominal compressive strength of the brace member. ***(AISC 341-13.3c)***

10. V-type and inverted V-type SCBF shall meet the following requirements:

    a. The required strength of beams intersected by braces, their connections, and supporting members shall be determined based on the load combinations of the applicable building code assuming that the braces provide no support for dead and live loads. For load combination that include earthquake effects, the earthquake effect, E, on the beam shall be determine as follows:

        i. The forces in all braces in tension shall be assumed to be equal to RyFyAg.

        ii. The forces in all adjoining braces in compression shall be equal to .3Pn

    b. Beams shall be continuous between columns. Both flanges of beams shall be laterally braced, with a maximum spacing of $L_b = L_{pd}$, as specified by Equation A-1-7 and A-1-8 of Appendix 1 of the AISC Specification. Lateral braces shall meet the provisions of Equation A-6-7 and A-6-8 of Appendix 6 of AISC Specification, where Mr = Mu =RyZFy(LRFD) or Mr = Ma =RyZFy/1.5(ASD), as appropricate, of the beam and Cd = 1.0 as a minimum, one set of lateral brace is required at the point of intersection of the V-type (or inverted V-type) bracing, unless the beam has sufficient out-of-plane strength and stiffness to ensure stability between adjacent brace points. ***(AISC 341-13.4a)***

11. In addition to meeting requirements of Section 8.4, column splices in SCBF shall meet:

    a. At least 50 percent of the lesser available flexual strength of the connected members.

    b. The required shear strength shall be at least ΣMpc/H (LRFD) or ΣMpc /1.5H (ASD), where Σmpc is sum of nominal plastic flexual strengths of columns above and below the splice.

(AISC341-13.5)

12. Use *R* value of 6 for the base shear determination. Table 12.2-1 of ASCE 7.

13. The use of rectangle HSS **are not permitted** for bracing members, unless filled solid with cement grout having a minimum compressive strength of 3000 psi at 28 days. The effects of composite action in the filled composite brace shall be considered in the sectional properties of the system were it results in the more severe loading condition or detailing. ***(LABC - 2205.4.1.1)***

C. ORDINARY CONCENTRICALLY BRACED FRAMES (OCBF)

1. OCBF braces are required to have slenderness Kl # 4 (E/Fy) to be used in K, V or inverted V-type configurations. ***(AISC 341-14.2)***

2. Braces shall be seismically compact λ (the width-thickness ratios of its compression elements) shall not exceed λps from Provisions Table I-8-1. (AISC 341-14.2 and 8.2b), for OCBF above the seismic isolation system, braces shall be compact sections, λ shall not exceed λp,from Specification Table B4.1. ***(AISC 341-14.5a, 8.2a)***

3. OCBF is permitted up to 35 feet building height in Seismic Design Category D, E and, in single-story buildings up to a height of 60 ft where the roof dead load does not exceed 20 psf and in penthouse structures. ***(ASCE 7 - Table 12.2-1 ,footnote j)***

4. **Beams** in V-type and inverted V-type OCBF and **Columns** in K-type OCBF shall be continuous at bracing connections away from the beam-column connections and shall meet the following requirements:

    a. The required strength shall be determined based on the load combinations of the applicable building code assuming that the braces provide no support for dead and live loads. For load combination that include earthquake effects, the earthquake effect, E, on the beam shall be determine as follows:
        i. The forces in all braces in tension shall be assumed to be equal to RyFyAg. For V-type and inverted V-type OCBF, the forces in braces in tension need not exceed the maximum forces that can be developed by the system.

        ii. The forces in all adjoining braces in compression shall be equal to 0.3Pn

    b. Both flanges shall be laterally braced , with a maximum spacing of $L_b = L_{pd}$, as specified by Equation A-1-7 and A-1-8 pf App. 1 of the AISC Specification. Lateral braces shall meet the provisions of Equation A-6-7 and A-6-8 of App. 6 of AISC Specification, where Mr = Mu =RyZFy(LRFD) or Mr = Ma =RyZFy/1.5(ASD), as appropriate, of the beam and Cd = 1.0 as a minimum, one set of lateral brace is required at the point of intersection of the bracing, unless the beam has sufficient out-of-plane strength and stiffness to ensure stability between adjacent brace points. ***(AISC 341 -14.3)***

5. The required strength of OCBF bracing connection shall be determined as follows:

    a. For the limited state of bolt slip, the required strength of bracing connection shall be that determined using load combinations stipulated by the applicable building code, ***not including*** the amplified seismic load.

    b. For other limit states, the required strength of bracing connections is the expected yield strength, in tension, of the brace, determined as RyFyAg(LRFD) or RyFyAg/1.5(ASD), as appropriate. ***(See AISC 341-14.4 for Bracing Connection exceptions)***

6. Use R value of 3.25 for the base shear determination. ***(ASCE 7- Table 12.2-1)***

7. Design members and connections, other than brace connections, based on load combinations ***per LABC Sections 1605.2, 1605.3*** and for the special seismic load ***combinations*** per Section 1605.1.

8. Comply with AISC 341-14.5 for OCBF above Seismic Isolation Systems. K-type braced frame are not permitted in OCBF above Seismic Isolation Systems. ***(AISC 341-14.5)***

D. ECCENTRICALLY BRACED FRAMES (EBF)

1. Links and Columns shall be seismically compact λ (the width-thickness ratios of its compression elements) shall not exceed λ_{ps} from AISC 341-Table I-8-1. ***(AISC 341-15.2a ,8.2b)***

2. The required shear strength of Link members V_u shall not exceed member, $\varphi_v V_{pa}$ ***(LRFD) or*** V_{pa}/Ω_v ***(ASD).*** ***(AISC 341-15.2b)***

3. If the required axial strength P_u ***(LRFD) or*** P_a ***(ASD)*** in a Link member exceeds $0.15P_y$ *(LRFD)or* (0.15/1.5)*Py* (ASD*)*, the following shall be met per AISC SP-15.2b:

   a. The design shear strength of the link shall be the lesser of φ_v Vpa and 2 φ_v Mpa /*e* (LRFD) or V_{pa} / Ω_v and 2 $(M_{pa} /e)/\Omega_v$ (ASD)

   b. The length of the link shall the link shall not exceed:
      i. $[1.15 - 0.5\rho'(A_w /A_g)]1.6\ M_p /V_p$ when $\rho'(A_w /A_g)$ $0.3 nor
      ii. $1.6\ M_p /V_p$ when $\rho'(A_w /A_g) < 0.3$

4. The link rotational angle is the inelastic angle between the link and the beam outside the link when the total story drift is equal to the design story drift, Δ. The link rotation angle shall not exceed the following values:

   a. 0.08 radians for link length $1.6M_p/V_p$

   b. 0.02 radians for link length $2.6M_p/V_p$

   c. Value shall be determined by linear interpolation for link length between $1.6M_p/V_p$ and $2.6M_p/V_p$ ***(AISC 341-15.2c)***

5. Link-to-column connections must be capable of sustaining the maximum link rotation angle based on the length of the link, as specified in AISC 341-15.2c*.* The strength of the connection measured at column face shall equal at least the norminal shear strength of the link, Vn as specified in AISC 341 -15.2b at the maximum link rotation angle.

6. Link -to-column connections shall satisfy the above requirements by one of the following:

   a. Use a connection prequalified for EBF in accordance with AISC 341 - Appendix P.

   b. Provide Qualifying cyclic test results in accordance with AISC 341 - Appendix S.

   c. Provide reinforced link-to-column connections per exception of AISC 341-15.4. ***(AISC 341-15.4)***

7. Braces shall be compact sections, λ shall not exceed λp,from AISC Specification Table B4.1. ***(AISC 341-15.6a, 8.2a)***

8. Provide lateral bracing at top and bottom flanges of the Link ends. The required strength of each lateral brace shall be Pb = 0.06 Mr /ho, where ho is the distance between flange centroids, and Mr= RyZFy (LRFD) or Mr= RyZFy /1.5 (ASD). ***(AISC 341-15.5)***

9. Design diagonal brace for combined axial and flexural strength based on load combinations including seismic effects by at least **1.25** RyVn where,Vn is the nominal shear strength of the link, as defined in Section 15.2b. ***(AISC 341 -15.6a)***

10. Beam outside the link shall be designed for combined axial and flexural strength based on load combinations including seismic effects by at least **1.1** RyVn where,Vn is the nominal shear strength of the link, as defined in Section 15.2b. ***(AISC 341-15.6b)***

11. The required strength of the diagonal brace connections, at both ends of the brace, shall be at least equal to the required strength of the diagonal brace as defined in AISC SP-15.6a. The diagonal brace connections shall also satisfly the requirement of AISC 341- 13.3c. ***(AISC 341-15.6c)***

12. Design the beam-to-column connection away from the link as a moment connection OMF per AISC-SP-11.2 &11.5, if the EBF system factors (R) is required per applicable building code for moment-resisting connection. ***(AISC 341-15.7)***

13. Use R value in accordance with Table 12.2-1 of ASCE 7

14. Design EBF column per AISC 341-8.3 with load combinations per building code, except that the seismic load E shall be 1.1 RyVn ***of all links above the level under consideration***, where Vn is as defined in Section 15.2b. ***(AISC 341 -15.8)***

15. Provide web stiffeners at the diagonal brace ends of the Link. Web stiffeners shall meet the design requirements as per AISC 341-15.3.

16. Design the fillet weld connection between the Link stiffener and the Link web as per AISC 341-15.3.

III. NOTES ON PLANS

A. GENERAL

1. The seismic design, fabrication, and erection of structural steel shall be in accordance with **Part I** of the Seismic Provisions for Structural Steel Buildings published by the American Institute of Steel Construction. ***(AISC 341-05)***

2. Welding shall be performed in accordance with **Appendix W** and a Welding Procedure Specification (WPS) as required in AWS D1.1 and approved by the Engineer of Record. Specify the required "Welding Procedure Specification" on plans.

3. All complete-joint-penetration groove welds used in the Seismic Force Resisting System shall be made with a filler metal that has a minimum CVN toughness of 20 ft-lbs at minus 20E F and 40 ft-lbs at 70E F.

4. Discontinuities in weld created by errors or by fabrication or erection operations, such as tack welds, erection aids, air-arc gouging and flame cutting, shall be repaired as required by the Engineer of Record.

5. All bolts used as a part of the seismic force resisting system shall be fully tensioned high strength bolts.

6. The specification and Fabrication for steel frames shall comply with attached Welding and Fabrication procedures.

B. SPECIAL CONCENTRICALLY BRACED FRAMES (SCBF)

1. Splices shall be located per requirement of AISC 341-8.4a, 8.4b

2. Provide protected zone per AISC 341-13.6

C. ECCENTRICALLY BRACED FRAMES (EBF)

1. No part of the brace-to-beam connection shall extend over the Link length. If the brace resists a portion of the Link end moment, the connection shall be designed as an Fully-Restrained moment connection. ***(AISC 341-15.6c)***

2. Links are a protected zone. ***(AISC 341-15.9)***

ADDITIONAL CORRECTIONS	**Code Sec. No.**