## DRAFT PUBLIC REVIEW COMMENTS

(Public Review Period: May 1 to June 15, 2020)

Public Reviewer: Ashwani Dhalwala

<table>
<thead>
<tr>
<th>Section of PR Draft</th>
<th>Line Number of PR Draft</th>
<th>Comment</th>
<th>Background/ Rationale</th>
<th>COMMITTEE RESPONSE</th>
<th>FINAL REVIEWER RESPONSE (enter “Resolved” or “Unresolved”)</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>19</td>
<td>Add Table of Contents</td>
<td>Recommended in order to readily access information in the document.</td>
<td>Thank you for your comments. The table of contents will be provided in the published document.</td>
<td>Resolved</td>
</tr>
<tr>
<td>A4</td>
<td>After 186</td>
<td>Component properties can be established by use of non linear continuum mechanics software provided a reasonable estimate can be made of the upper and lower bounds of the material constitutive properties.</td>
<td>Such software is routinely used in simulations in the aerospace and other important industries and is considered reliable.</td>
<td>Dictating the specific analysis methodology / type of analysis is outside the scope of AISC 342.</td>
<td>Unresolved Refer to NIST.GCR.17-917-45 Section 4.4 which recommends the use of continuum models. Its not a dictation of a specific methodology.</td>
</tr>
<tr>
<td>A4</td>
<td>After 222</td>
<td>Upper bound material properties are also required.</td>
<td>This is because one frame may have lower bound properties and the opposite frame may have upper bound properties. This in turn increases both lateral and torsional forces in the system.</td>
<td>AISC 342 is following ASCE 41 strategy of accounting for material variability by considering expected and lower-bound strengths.</td>
<td>Unresolved Based upon structural mechanics principles, considering lower bound strength alone is not acceptable. Upper bound strength needs to be considered as originally explained.</td>
</tr>
<tr>
<td>A5</td>
<td>After 383</td>
<td>Additional testing, as required for using material constitutive models for</td>
<td>Most material constitutive models already exist in continuum mechanics</td>
<td>Dictating the specific analysis methodology / type of analysis is outside the</td>
<td>Unresolved Refer to NIST.GCR.17-917-45 Section 4.4 which</td>
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</table>
### A5.2 After 185 (page A-5)

**Upper bound of default values for parallel frames located at opposite sides of the lateral force resisting system may also be required.**

Recommended in order to establish worst case scenario as this will result in higher forces and in the frame with upper bound of default material properties.

AISC 342 is following ASCE 41 strategy of accounting for material variability by considering expected and lower-bound strengths.

Unresolved Based upon structural mechanics principles, considering lower bound strength alone is not acceptable. Upper bound strength needs to be considered as originally explained.

### A5.4.c (b) 375

Add: “Where chemical properties on steel are unknown, carry out chemical tests on demand critical components to establish chemical properties including alloying components such as manganese and non-metallic components such as Sulphur. Also establish Carbon Equivalent and Carbon Content”

Refer to Wang (2016) Carbon content can affect the DBTT and therefore fracture performance

The issue raised by this comment may be considered for further development in the next version of AISC 342.

Resolved if the statement “The issue raised by this comment may be considered for further development in the next version of AISC 342” is made.

### A5.4.c 399

Add; “(f) Where significant through thickness demands occur, test for the potential for laminar tearing. Testing for lamellar tearing may be carried out using the Watanabe test or similar appropriate methods. Also establish toughness variation across thickness of the material.”

Refer to Farrar and Dolby (1972) and Farrar (1975) Low toughness in the middle third of the thickness may govern fracture performance since it is also subjected to highest thru thickness triaxiality”.

The issue raised by this comment may be considered for further development in the next version of AISC 342.

Resolved if the statement “The issue raised by this comment may be considered for further development in the next version of AISC 342” is made.
<table>
<thead>
<tr>
<th>A5.4.c</th>
<th>399</th>
<th>Add: “(g) Where significant strain rates can occur (such as the Southern California Basin), tensile tests are to be carried out simulating strain rates.” Refer to Maranian and Dhalwala (2019) and Mazzolani (2000).</th>
<th>The issue raised by this comment may be considered for further development in the next version of AISC 342.</th>
<th>Resolved if the statement “The issue raised by this comment may be considered for further development in the next version of AISC 342” is made.</th>
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<tbody>
<tr>
<td>B1</td>
<td>After 403</td>
<td>Recommend non linear analysis with continuum mechanics models to better assess and improve the simulation of joint performance and simulation local buckling in the post yield range. Non-linear analysis using continuum mechanics based non linear solid elements provides a significant improvement over the other models as long as reliable constitutive material models. The software is used by Lawrence Livermore Laboratories and other agencies for accurate simulation of structural systems and joints.</td>
<td>Dictating the specific analysis methodology / type of analysis is outside the scope of AISC 342.</td>
<td>Unresolved Refer to NIST.GCR.17-917-45 Section 4.4 which recommends the use of continuum models. Its not a dictation of a specific methodology.</td>
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<td>B2.3a</td>
<td>720</td>
<td>Add: “The effects of uncontrolled local buckling shall be accounted for” Bertero and Popov (1967) It should be clarified how uncontrolled actions are to be accounted for. For example, uncontrolled local buckling of flanges and web of steel moment frame connections with the potential to fracture due to low cycle fatigue. Brittle fracture due to pulse effects can also cause joint fracture and result in instability.</td>
<td>These effects are accounted for in the acceptance criteria and in the determination of the strengths.</td>
<td>Resolved</td>
</tr>
<tr>
<td>C1</td>
<td>After 786</td>
<td>Add: “For Deformation Controlled Actions, where biaxial or triaxial stresses occur in components/joints these require to be checked for ductility by...” It should be recognized that certain stress/strain conditions result in cause triaxiality and plane strain conditions that do not permit shear flow and...</td>
<td>Issues raised by this comment will be considered in the next cycle.</td>
<td>Resolved if the statement “The issue raised by this comment may be considered for further development in the next version of AISC 342” is made.</td>
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<tr>
<td>C1</td>
<td>After 786</td>
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<td>Add: “For Force Controlled Actions, where biaxial or triaxial stresses occur in components/ joints these require to be checked for strength by accepted procedures such as von Mises criterion. Assessments should account for shear stresses and variation of flexural stresses. Single cycle high stresses and resulting fracture due to pulse effects should be evaluated.”</td>
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<td>Issues raised by this comment will be considered in the next cycle.</td>
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It should be recognized that certain stress conditions can cause principal stresses that exceed material capacity. Please note, we understand this to be consistent with the intent of AISC Steel Construction Manual statements in “Fatigue and Fracture Control” p.2-38. Regarding triaxial stresses, refer to Blodgett (1998), Dowling (1999). Regarding variation of stresses, refer to Richard et al (1995). |

Resolved if the statement “The issue raised by this comment may be considered for further development in the next version of AISC 342” is made. |

Strongly recommend that a supplement be issued, as a number of issues described in the original comments need to be considered to assure acceptable performance of steel frames subjected to earthquake motions especially those caused by thrust faulting.
Regarding single cycle damage, refer to partial discussion in FEMA 440 and by others.
This is applicable to all lateral resisting systems including collectors and chords.

<table>
<thead>
<tr>
<th>C1</th>
<th>After 786</th>
<th>Add &quot;Where significant strain rates can occur due to thrust faulting which can result in significant increase in vertical and horizontal accelerations and result in high strain rates, account for change in nil ductility regarding fracture toughness&quot;</th>
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<tbody>
<tr>
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<td>Reference Barsom and Rolphe (1999), Maranian and Dhalwala (2019), Mazzolani (2000). Thrust fault earthquakes occur in Southern California that can cause significant vertical and horizontal accelerations and result in high strain rates that can appreciably effect fracture toughness due to the phenomena causing shift in the nil ductility and shift of the DBTT curve thus reducing fracture toughness. Also, note the following regarding limitation of current state of the art: a) Southern California specific ASCE 7 seismic loads do not adequately consider design for seismic motions measured and return periods observed during several previous Southern California earthquakes since 1857. b) Tests and second order analyses for plastic zone</td>
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<td>Issues raised by this comment will be considered in the next cycle.</td>
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<td>Resolved if the statement &quot;The issue raised by this comment may be considered for further development in the next version of AISC 342&quot; is made. Strongly recommend that a supplement be issued, as a number of issues described in the original comments need to be considered to assure acceptable performance of steel frames subjected to earthquake motions especially those caused by thrust faulting.</td>
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</table>
c) Fracture tests and analyses for plastic zone performance subjected to out of plane drifts.
d) Fracture tests and analyses for plastic zone performance subjected to high strain rates.
e) Single cycle damage tests, analyses and assessment considering effect of single cycle damage on steel frame performance.
f) Understanding limitations of tests and analyses.
g) This is applicable to all lateral resisting systems including collectors and chords.

<p>| C3 | After 628 | Recommend non linear analysis with continuum mechanics models to better assess and improve the simulation of joint performance. | Non-linear analysis using continuum mechanics based non linear solid elements provides a significant improvement over the other models as long as reliable constitutive material models. The software is used by Lawrence Livermore Laboratories and other agencies for accurate simulation of structural systems and joints. | Dictating the specific analysis methodology / type of analysis is outside the scope of AISC 342. | Unresolved Refer to NIST.GCR.17-917-45 Section 4.4 which recommends the use of continuum models. Its not a dictation of a specific methodology. |</p>
<table>
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<tr>
<th>C5</th>
<th>After 799</th>
<th>Recommend non linear analysis with continuum mechanics models to better assess and improve the performance of existing connections.</th>
<th>Non-linear analysis using continuum mechanics based non-linear solid elements provides a significant improvement over the other models as long as reliable constitutive material models are used and is recommended.</th>
<th>Dictating the specific analysis methodology / type of analysis is outside the scope of AISC 342.</th>
<th>Unresolved Refer to NIST.GCR.17-917-45 Section 4.4 which recommends the use of continuum models. Its not a dictation of a specific methodology.</th>
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<td>C7</td>
<td>After 919</td>
<td>Non-linear analysis using continuum mechanics based non-linear solid elements provides a significant improvement over the other models as long as reliable constitutive material models are used and is recommended.</td>
<td>Gusset plate performance can be significantly affected by out of plane performance and fracture due to pulse effects. This mechanism is not being considered and may significantly degrade performance of the gusset plate connection. The software is used by Lawrence Livermore Laboratories and other agencies for accurate simulation of structural systems and joints.</td>
<td>Dictating the specific analysis methodology / type of analysis is outside the scope of AISC 342.</td>
<td>Unresolved Refer to NIST.GCR.17-917-45 Section 4.4 which recommends the use of continuum models. Its not a dictation of a specific methodology.</td>
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<tr>
<td>D2</td>
<td>After 1173</td>
<td>Analysis with solid continuum mechanics based elements is recommended. Non-linear analysis using continuum mechanics based non-linear solid elements provides a significant improvement over the fiber based models as long as reliable</td>
<td>The software is used by Lawrence Livermore Laboratories and other agencies for accurate simulation of structural systems and joints.</td>
<td>Dictating the specific analysis methodology / type of analysis is outside the scope of AISC 342.</td>
<td>Unresolved Refer to NIST.GCR.17-917-45 Section 4.4 which recommends the use of continuum models. Its not a dictation of a specific methodology.</td>
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<td><strong>D5</strong></td>
<td><strong>Recommend, use of keepers and collar brackets for collapse prevention. Recommend use of weld overlays for the repair and/or enhancement to minimize potential of fractures. These may be considered as additional requirements to adding new lateral resisting system(s)</strong></td>
<td><strong>Despite the good intent of this document, due to the substantial unknowns and potential issues regarding collapse prevention, in our opinion, there remains insufficient confidence in achieving measures to address all potential issues. Thus, the possibility of localized partial collapse, occurring as a result of fractures at joints, even with the addition of new lateral resisting systems, remains significant and below normal acceptable confidence levels. Although the document has included a thorough and impressive array of formula, based upon known steel research directed towards their application with ASCE 41, it lacks sufficient use of fracture mechanics and thus the ability to assess the potential for fractures. This does not appear to be consistent with the intent of AISC Steel Construction Manual statements in “Fatigue and Fracture Control” p.2-33. To address the significant unknowns occurring from</strong></td>
<td><strong>AISC 342 provides acceptance criteria limits for collapse prevention, which avoids the need for keeper and collar brackets. Furthermore, such retrofits are outside of the scope of 342 and left to the user. There is not sufficient test data to support the use of weld overlays as a retrofit solution.</strong></td>
<td><strong>Resolved See response by Peter Maranian</strong></td>
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</table>
all potential issues, there may be many solutions that could provide a means of reducing the potential of localized partial collapse. One method is providing keepers or collar brackets immediately below seismic force resisting connections and other connections that could potentially fracture and lead to partial collapse during a seismic event. Furthermore, the weld overlay method, previously mentioned, has been shown to minimize the potential for fractures.

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<tbody>
<tr>
<td>D3</td>
<td><strong>After 1251</strong></td>
<td>Analysis with solid continuum mechanics based elements &lt;br&gt;Non-linear analysis using continuum mechanics based non linear solid elements provides a significant improvement over the fiber based models as long as reliable constitutive material properties are used.</td>
<td>The software is used by Lawrence Livermore Laboratories and other agencies for accurate simulation of structural systems and joints.</td>
</tr>
<tr>
<td>E2</td>
<td><strong>After 1393</strong></td>
<td>Analysis with solid continuum mechanics based elements &lt;br&gt;Non-linear analysis using continuum mechanics based non linear solid elements provides a significant improvement over the fiber based models as long as reliable</td>
<td>The software is used by Lawrence Livermore Laboratories and other agencies for accurate simulation of structural systems and joints.</td>
</tr>
</tbody>
</table>
constitutive material properties are used.

**E2** After 1587
Recommend use of a more accurate analysis using continuum mechanics software in order to assess out of plane local buckling and fracture.

Several failures and fractures of EBFs were observed in the aftermath of the Christ Church Earthquake. All of these were observed to be due to out of plane motions.

Dictating the specific analysis methodology / type of analysis is outside the scope of AISC 342.

Unresolved
Refer to NIST.GCR.17-917-45 Section 4.4 which recommends the use of continuum models. Its not a dictation of a specific methodology.

**E4** After 1633
Recommend Non Linear dynamic analysis of the beam-column joint of the shear wall assembly.

The beam-column joint of the steel plate shear wall acts as a moment connection. However, stress and strain distributions are significantly different from a typical moment connection and the connection may be subject to fracture.

Use of nonlinear dynamic analysis is permitted. TC 7 does not wish to mandate it for all cases.

Resolved
Highly recommend a statement that the performance of beam-column joints of the shear wall assembly be assessed for fracture.

**References:**


ASCE/SE 41 *Seismic Rehabilitation of Existing Buildings*, The American Society of Civil Engineers.


10


Maranian, P., 2009, “Reducing Brittle and Fatigue Failures in Steel Structures”, American Society of Civil Engineers.

Maranian, P and Dhalwala A; 2019, “Considerations regarding the Repair & Retrofit of Existing Welded Moment Frame Buildings”, the Structural Engineers of California Convention.

Mazzolani F., (2000), Moment Resisting Connections of Steel Frames in Seismic Areas”, includes “Influence of the type of Seismic Ground Motions”, Gioncu,V; Mateescu, G; Tirca, L; Anastasiadis, A. CRS Press.


