AISC 342 July 15, 2020

DRAFT PUBLIC REVIEW COMMENTS

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

Public Reviewer : Ashwani Dhalwala

Section of PR Draft	Line Number of PR Draft	Comment	Background/ Rationale	COMMITTEE RESPONSE	FINAL REVIEWER RESPONSE (enter “Resolved” or “Unresolved”)
	19	Add Table of Contents	Recommended in order to readily access information in the document.	Thank you for your comments. The table of contents will be provided in the published document.	Resolved
A4	After 186	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.	Such software is routinely used in simulations in the aerospace and other important industries and is considered reliable.	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.
A5	After 222	Upper bound material properties are also required.	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.	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	After 383	Additional testing, as required for using material constitutive models for	Most material constitutive models already exist in continuum mechanics	Dictating the specific analysis methodology / type of analysis is outside the	Unresolved Refer to NIST.GCR.17-917-45 Section 4.4 which

		non linear analysis using continuum, mechanics models should be performed.	software; however, some may require fine tuning to further improve simulation of the joints.	scope of AISC 342.	recommends the use of continuum models. Its not a dictation of a specific methodology
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.

A5.4.c	**399**	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) Mazzolani (2000).	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.
B1	**After 403**	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.	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.
B2.3a	**720**	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.	These effects are accounted for in the acceptance criteria and in the determination of the strengths.	Resolved
C1	**After 786**	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	Issues raised by this comment will be considered in the next cycle.	Resolved if the statement “The issue raised by this comment may be considered for further development in the next version of AISC 342” is

		accepted procedures such as von Mises criterion at a minimum. Design/assessment should account for size and distribution of the yield zone, triaxiality, shear stresses and variation of flexural stresses. Use of non linear continuum mechanics analysis is preferred and will provide more reliable results . Single cycle damage due to pulse effects should also be assessed.”	significantly reduce ductility resulting in increase of the incidence of brittle fractures. 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) and others. 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.		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.
C1	**After 786**	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 ”	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).	Issues raised by this comment will be considered in the next cycle.	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.		
C1	**After 786**	Add "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"	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	Issues raised by this comment will be considered in the next cycle.	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.

			performance subjected to out of plane drifts. 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.		
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.

C5	**After 799**	Recommend non linear analysis with continuum mechanics models to better assess and improve the performance of existing connections.	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.
C7	**After 919**	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.	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.	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.
D2	**After 1173**	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	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.

		constitutive material properties are used.			
D5		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)	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 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	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.	Resolved See response by Peter Maranian

			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.		
D3	**After 1251**	Analysis with solid continuum mechanics based elements 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.	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.
E2	**After 1393**	Analysis with solid continuum mechanics based elements Non-linear analysis using continuum mechanics based non linear solid elements provides a significant improvement over the fiber based models as long as reliable	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.

		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:

AISC (2017), “Steel Construction Manual, 15th Edition.” *American Institute of Steel Construction*.

AISC 360, “Specification for Structural steel Buildings”, *American Institute of Steel Construction*.

Anderson, J.C., Duan, J., Xiao, Y. and Maranian, P., 2000, “Improvement of Welded Connections Using Fracture Tough Overlays”. *Department of Civil and Environmental Engineering*, University of Southern California, Los Angeles, California.

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

AWS D1.7, “Guide for Strengthening and Repairing Existing Structures”, *The American Welding Society*.

Barsom, J.M. and Rolphe, S.T., 1999, “Fracture and Fatigue Control in Structures, *3rd Edition*, *American Society of Testing Materials*.

Bertero, V.V. and Popov, E.P., 1967, “Effect of Large Alternating Strains of Steel Beams, Journal of the Structural Division”, *American Society of Civil Engineers, February*.

Blodgett, O.W., 1998, "The Effects of Constraints on Ductility in Welded Beam to Column Connections; International Conference on Welded Construction in Seismic Areas", Am*erican Welding Society*. October 1998, Maui, Hawaii.

Bondy, K.D., 1996, "A More Rational Approach to Capacity Design of Seismic Moment Frame Columns." *Earthquake Engineering Research Institute*, Oakland, California.

Brandow, G.E. and Maranian, P., (2001), "Methods of Repair of Damaged Existing Welded Steel Moment Frame Buildings Including Weld Overlay Repair Techniques", *Structural Faults and Repair,* 9th International Conference, London, United Kingdom (available from the University of Edinburgh, Scotland).

Burdekin., M., (1999) "Why Size Matters in Large Structures", Gold Medal Lecture, *The Structural Engineer, The Institution of Structural Engineers,* Vol. 77/No. 20, London, United Kingdom.

Dong, P. and Zhang, J., 1998 "Residual Stresses in Welded Moment Frames and Implications on Structural Performance. International Conference on Welded Construction in Seismic Areas". *American Welding Society,* October.

Dowling, N. E., 1999, "Mechanical Behavior of Materials-Engineering Methods for Deformation, Fracture and Fatigue", *2nd Edition., Prentice Hall*.

Farrar, et al, (1975). "Investigations into Lamellar Tearing", *The Welding Institute*, London, England.

Farrar, J.C. and Dolby. R.E, (1972). "Lamellar Tearing in Welded Steel Fabrication." The Welding Institute, England.

FEMA 351, (2000). "Recommended Seismic Evaluation and Upgrade Criteria for Existing Welded Steel Moment-Frame Buildings." Federal Emergency Management Agency, June.

FEMA 352, (2000). "Recommended Post-Earthquake Evaluation and Repair Criteria for Welded Steel Moment-Frame Buildings," Federal Emergency Management Agency, June.

Kanvinde, A; Maranian, P; Joseph, L; Lubberts, J (2018). "Fracture and Fatigue Design of the Wilshire Grand Tower", Engineering Journal, the American Institute of Steel Construction, Vol. 55, pp 181-189.

Maranian, P. and Simon, W., 2002, "Static Small Component Tests on 2-inch-thick Specimens Using Weld Overlays", *The American Society of Civil Engineers*, *Journal of Materials in Civil Engineering*, Vol. 14, No. 1, January/February.

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 Exisitng Welded Moment Frame Buildings", the Structural Engineers of California Convention.

Masubuchi, K, "Analysis of Welded Structures", *Pergamon Press*, Massachusetts Institute of Technology, Cambridge, Massachusetts.

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.

Miller, D.K., 1993, "The Challenge of Welding Jumbo Shapes Part 1: The AISC Specifications". *The Welding Innovation Quarterly*, Volume X, No. 1.

Partridge, J.E., Paterson, S.R. and Richard, R.M., 2000, "Low Cycle Fatigue Tests and Fracture Analyses of Bolted-Welded Seismic Moment Frame Connections." July; STESSA 2000, Third International Conference, Montreal, Canada.

Pauley, T. and Preistley, M.J.N., 1992, "Seismic Design of Reinforced Concrete and Masonry Buildings".

Richard, R. M.; Partridge, J. E., Allen, J. and Radua, S., 1995, "Finite Elements Analysis and Tests of Beam to Column Connections", *Modern Steel Construction*, October.

Richard, R.M., Radua, R.E., Allen, J., "Damaged Tolerant Braced Frame Designs". Presented at the 2017 SEAOC Convention, September 2017.

Simon, W., Anderson, J., Compton, J., Hayes, W. and Maranian, P., 1999, "Repair of Existing Steel Moment Frame Buildings Damaged from Earthquakes Using Fracture Tough Weld Overlays", *American Institute Engineering Journal,* Fourth Quarter.

Tsai, C., Kim, D., Jaeger, J., Shim, Y., Feng, Z. and Papritan, J., 2001. "Design Analysis for Welding of Heavy W Shapes", *The American Welding Society, The Welding Journal*, February.

Wang W. (2016), "The Great Minds of Carbon Equivalent", EWI.