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Fire protection of Fire-Resistant Steel H-section Columns under Hydrocarbon fire

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Extended Abstract

This study investigates the fire resistance performance of H-section steel columns fabricated from fire-resistant steel FR355 under various loading conditions. Through a combination of experimental fire testing and finite element (FE) analysis, the relationship between axial load ratio and the critical temperature of FR355 columns is quantified, providing essential data for fire safety engineering. Three distinct fire protection strategies: (1) unloaded, (2) loaded, and (3) performance-based fire design using realistic electric vehicle (EV) fire scenarios, are comparatively evaluated. The results demonstrates that FR355 can achieve sufficient fire resistance with notably reduced fireproofing demands, especially under loaded and performance-based approaches.

The reference section at the end of the paper should be edited based on the following:

References

[1] Y.H. Cho, M.J. Park, J.H. Ahn and E.M. Ryu, "Elevated-temperature material properties and fracture behavior of fire-resistant steel FR355," *Journal of Building Engineering*, vol. 92, 109540, 2024.
[2] Y.H. Cho, M.J. Park, J.K. Ahn and E.M. Ryu, "Elevated-temperature material properties and constitutive model of fire resistant steel for thermo-mechanical simulation," *Journal of Korean Society of Steel Construction*, vol. 36, no. 1, pp. 91-102, 2024.
[3] X. Wei, J. Liu and L. Xu, "The collapse mechanism and paths of steel frame structures under designed fire scenarios," *Structures*, vol. 76, 108942, 2025.
[4] X. Yu, Y. Shi, Y.K. Pang and K.F. Lau, "Room-and elevated-temperature material properties of structure fire-resistant weathering steel," *Journal of Constructional Steel Research*, vol. 228, 109400, 2025.
[5] H.Y. Chung, C.H. Lee, W.J. Su and R.Z. Lin, "Application of fire-resistant steel to beam-to-column moment connections at elevated temperatures," *Journal of Constructional Steel Research*, vol. 66, pp. 289-303, 2010.
[6] L.F. Bauri, A.M. Ferreira, E.A. Ariza-Echeverri, F.M.S.B. Carvalho, P.M.C.D. Gomes, R. Sonkusare, Y. Lu, T. Boll, A.P. Tschiptschin and H. Goldenstein, "New fire-resistant steel alloyed with Nb-Mo-B-Ti: mechanical properties and characterization via SEM, TEM, and APT," *Materials Characterization*, vol. 225, 115104, 2025.
[7] J. Cong, J. Fan, R.D.K. Misra, X. Xu and X. Wang, "Effect of austenitic state before ferrite transformation on the mechanical behavior at an elevated temperature for seismic-resistant and fire-resistant constructional steel," *Journal of Materials Research and Technology*, vol. 13, pp. 1220–1229, 2021.
[8] Z. Xie, Z. Song, K. Chen, M. Jiang, Y. Tao, X. Wang and C. Shang, "Study of nanometer-sized precipitation and properties of fire resistant hot-rolled steel," *Metals*, vol. 9, no. 11, 1230, 2019.
[9] Z. Zhang, Q. Yong, X. Sun, Z. Li, J. Kang and G. Wang, "Microstructure and mechanical properties of precipitation strengthened fire resistant steel containing high Nb and low Mo," *Journal of Iron and Steel Research International*, vol. 22, pp. 337-343, 2015.
[10] J. Moon, S.D. Kim, C.H. Lee, H.H. Jo, H.U. Hong, J.H. Chung and B.H. Lee, "Strengthening mechanisms of solid solution and precipitation at elevated temperature in fire-resistant steels and the effects of Mo and Nb addition," *Journal of Materials Research and Technology*, vol. 15, pp. 5095-5105, 2021.

[11] Y. Shi, C. Tu, Y. Wu, D. Liu, L. Meng and H. Ban, "Numerical investigations of fire-resistant steel welded I-section columns under elevated temperatures," *Journal of Constructional Steel Research*, vol. 177, 106464, 2021.
[12] Z. Peng and H. Mostafaei, "Fire resistance of gypsum board protected steel columns with high load ratios," *Journal of Structural Engineering*, vol. 144, 04018197, 2018.
[13] J.S. Lee, J.H. Woo, K.J. Shin and H.D. Lee, "Evaluation of fire-resistance performance for modular structures based on fireproof coating types," *Structures*, vol. 67, 107000, 2024.
[14] ABAQUS, "User's Manual," Providence, RI, 2022.
[15] KS F 2257, "Methods of Fire Resistance Test for Elements of Building Construction – Specific Requirements for Columns," Korean Standards and Certification, Korea, 2014 (in Korean).
[16] ISO 834, "Fire Resistance Tests - Elements of Building Construction," International Standard, ISO, Switzerland, 2021.
[17] CEN, "Eurocode 3: Design of Steel Structures – Part 1-2: General Rules – Structural Fire Design," EN 1993-1-2, European Committee for Standardization, Belgium, 2005.
[18] CEN, "Eurocode 3: Design of Steel Structures – Part 1-5: Plated Structural Elements – Structural Fire Design," EN 1993-1-5, European Committee for Standardization, Belgium, 2024.
[19] L. Chen, C. Luo and J. Lua, "FDS and ABAQUS coupling toolkit for fire simulation and thermal and mass flow prediction," *Fire Safety Science*, pp. 1465-1477, 2011.
[20] K. McGrattan, S. Hostikka, R. McDermott, J. Floyd, M. Vanella, C. Weinschenk and K. Overholt, "Fire dynamics simulator user's guide (sixth edition)," NIST Special Publication 1019, National Institute of Standards and Technology, Gaithersburg, MD, USA, 2013.
[21] ISO, "Fire safety engineering – Performance of structure in fire – Part 3: Example of an open car park," ISO/TR 24679-3, International Organization for Standardization, Geneva, Switzerland, 2015.