Numerical Simulation and Analysis of Axially Restrained Steel Cellular Beams in Fire

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Abstract : This paper presents the development of a finite element model to study the large deflection behavior of restrained stainless steel cellular beams at elevated temperature. Cellular beams are widely used for efficient utilization of raw materials to facilitate long spans with faster construction resulting sustainable design solution that can enhance the performance and merit of any construction project. However, their load carrying capacity is less than the equivalent beams without opening due to developing shear-moment interaction at the openings. In structural frames due to elements continuity, such beams are restrained by their adjoining members which has a substantial effect on beams behavior in fire. Stainless steel has also become integral part of the build environment due to its excellent corrosion resistance, whole life-cycle costs, and sustainability. This paper reports the numerical investigations into the effect of structural continuity on the thermo-mechanical performance of restrained steel beams with circle and elongated circle shapes of web opening in fire. The numerical model is firstly validated using existing numerical results from the literature, and then employed to perform a parametric study. The structural continuity is evaluated through the application of different levels of axial restraints on the response of carbon steel and stainless steel cellular beam in fire. The transit temperature for stainless steel cellular beam is shown to be less affected by the level of axial stiffness than the equivalent carbon steel cellular beam. Overall, it was established that whereas stainless steel cellular beams show similar stages of behavior of carbon steel cellular beams in fire, they are capable of withstanding higher temperatures prior to the onset of catenary action in large deflection, despite the higher thermal expansion of stainless steel material.

Keywords : axial restraint, catenary action, cellular beam, fire, numerical modeling, stainless steel, transit temperature