Testing post-fire brittle fracture susceptibility of butt welded steel joints

An expert assessing the suitability of steel structural components embedded in the bearing structure of a building object, which has survived a fire incident, when formulating his recommendations regarding post-fire capability of these components to safely resist the loads applied to them usually bases his opinion on post-fire damage inventory of deformations and distortions present in the structure. Only rarely a need for the additional material testing necessary to verify whether and if so to what extent the fire exposure affected the basic physical properties of the material, determining its post-fire strength is noticed. At the same time, in the conventional procedure applied to arrive at the final conclusions regarding this bearing capacity there is no place for addressing the brittleness of steel, exhibited post fire. Ignoring the susceptibility of structural steel to initiation, and as a consequence, weakly restrained propagation of brittle fractures exhibited post fire seems to be very dangerous, as this phenomenon may result in the risk of rapid destruction, not preceded by any signs of impending imminent danger. Special tests are required to allow for drawing reliable conclusions in this aspect. In this proposal we intend to broaden the scope of such research and relate it not only to the base material but more so to the welded joints, as the bearing capacity of these joints determines the safety of whole building structures. The research on welded joints seems to be qualitatively unique in this aspect, as in such joints several zones are present, undoubtedly differing in the response exhibited to the action of high temperature. These are as follows: the base material, the weld material, and the heat affected zone separating these two materials. The scenarios of forecast fire action may widely differ. Therefore our research is planned to identify the scenarios critical for tested joints that are such, which would result in the highest degradation of said joints. It is assumed for instance, that the fire exposure time will determine the post-fire susceptibility to brittle fracture exhibited by the joint material. We also intend to check, how given steel grade and the joint as a whole would react to the fire when the fire temperature would be sufficiently high to allow for initiation of the austenitic phase change. We intend to check as well, how the firefighting action conducted by fire fighters affects the joint material brittleness exhibited post fire, i.e. how rapid cooling of the hot steel affects the potentially occurring phase changes, and to what extent the situation would change when the fire would be let to self extinguish itself. The knowledge we intend to gain during the proposed experiments seems to be the key for assuring the required safety level to the users of structures revitalized post fire. Therefore experiments are planned on the material cooled after thermal treatment simulating fire exposure following several different development scenarios. The instrumented Charpy impact strength test will constitute the basis for classification here. By this test we intend to find out how the particular sample fracturing phases are affected by the changes in the fire development scenarios. For each tested case we will check not only how the fracture surface obtained turned out to be a brittle one, but also in which scenarios predominately plastic fractures could be expected. The tests proposed above shall be accompanied by post-fire strength tests, hardness tests and by very detailed observations of microstructure, permanently changed by the preceding fire action. It is widely known, that permanent changes in the steel microstructure are introduced by the welding process itself, and depend on the distance to the heat source. However, in general after welding the weld material proves to be stronger than the adjacent base material. This is a result of appropriately selected welding technology. In fire conditions the exposure of the weld material to high temperature is of random character in the terms of both space and time. Thus such exposure usually results in changes weakening the material, which after cooling does not completely regain its initial characteristics. Under these circumstances the precipitates of various types constitute an additional factor, usually making the situation worse. The deleterious influence of such precipitates may not be disregarded, if the post-fire durability forecast is to be sufficiently reliable.