Effect of Fire Induced Restraint on Fire Resistance of Reinforced Concrete Beams

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ABSTRACT

The effect of fire induced restraint on the fire response 0f reinforced concrete (RC) beams is addressed in this paper. A macroscopic finite element model, capable of tracing the behavior of restrained RC beams from pre-fire stage to collapse in fire is used in the analysis. The model is applied to investigate the effect of five parameters; namely, degree of axial restraint. span-to-depth ratio, fire scenario, load level, and Iailure criteria on the fire response of restrained RC beams. Through the results of the parametric study, it is shown that the five parameters have significant influence on fire resistance of RC beams. It is also shown that, fire induced restraint has negative effect on fire resistance of slender RC beams having high span-to-depth ratio.

Keywords: Restraint effect, fire resistance, high temperature, reinforced concrete beams

INTRODUCTION

Reinforced concrete (RC) structural systems are quite frequently used in high-rise buildings and other built infrastructure due to a number of advantages they provide over other materials. When used in buildings, the provision of appropriate fire safety measures for structural members is an importanr aspect of design since fire represents one of the most severe environmental conditions to which structures may be subjected in their life lime. The fire resistance of RC members is generally established using prescriptive approaches which are based on either standard fire resistance tests or empirical calculation methods **[I]**.

RC beams can develop significant restraint forces during fire exposure. The degree of restraint is dependent on the support conditions and will determine the behavior and fire resistance of RC beams. The effect of axial restraint on the fire resistance of RC beams depends on the vertical location of the restraint force. Generally, the axial restraint force in an RC beam is expected to improve the fire resistance of the RC beam through the arch action associated with axial. restraint, which increases the strength and the stiffness of the beam under fire exposure [2]. However, axial resrraint forces may Icad to spalling of concrete or buckling of the beam (particularly for slender beams) which in turn might reduce the fire resistance of RC beams. Thus, it is essential [o investigate and quantify the influence of fire induced restraint forces on the response of RC beams. At present, there is limited information on the fire induced restraint effects in RC beams. The reported studies in the literature 13,4, 51do not fully take into consideration the combined and inter-dependent effect of different parameters, such as axial restraint and span-to-depth ratio of the beam, under various loading and fire scenarios.

Thus, there have been only limited studies on evaluating the fire performance of RC beams (mostly unrestrained RC beams fabricated with normal strength concrete (NSC)) [4, 5j. Further, much of the current knowledge on the fire behavior of RC beams is based on standard fire resistance tests under