IMPROVEMENT OF FIRE RESISTANCE OF REINFORCED CONCRETE COLUMNS BY USING DIAMOND TIE CONFIGURATION

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Abstract

As per the Indian codal guidelines, the ties in reinforced concrete columns are provided either as rectangular or circular depending on the shape of column. In addition to perimeter ties, single or multi-legged crossties are also provided for larger sections. At ambient temperatures, it has been observed that decrease in tie spacing is beneficial as it increases moment capacity of the section leading to better confinement. However, in case of fire the positive effects of decrease in tie spacing beyond 100 mm have not been observed. Considering that the transverse and circumferential cracks are observed in columns due to thermal gradients as known from literature review, the diamond tie configuration was adopted in reinforced concrete columns. Three reinforced concrete columns of full-scale size, 3.15 m each, (two control and other with diamond configuration) are loaded at service load with maximum expected load eccentricity. They are subjected to ISO-834 standard fire curve in a furnace. It is observed that there is an improvement in fire resistance by 150% for column with diamond configuration as compared to rectangular tie configuration with crossties. Further, it is observed that there was no appreciable variation in the amount of spalling for columns with diamond configuration. This indicated better confinement during fire for columns with diamond configuration. It also indicates that diamond configuration of ties reduces the effect of thermal gradient cracks in limiting the fire resistance of RC columns particularly at decreased tie spacing.

Keywords: Column, Concrete, Confinement, Eccentricity, Fire resistance, Tie spacing.

1. INTRODUCTION

The recent incidents of fire worldwide have been seen to cause extensive damage to multi-story Reinforced Concrete (RC) framed structures. Columns being the load bearing elements in a structure become weak links during fire. Predominantly, the major damage to the structures has been seen to occur due to failure of columns. If observed quantitatively, at an average building fires lead to death of 2500 people annually in India alone [1]. The structures need preventive fire measures, post fire repairs as well as retrofitting. However, most of the structures have been seen to get damaged beyond repair due to absence of fire regulating mechanisms. This leads to considerable loss in terms of economic aspects of infrastructure. As it is seen that most fires can be controlled within first to second hour of its ignition [2], the idea is to improve the fire resistance requirements of the buildings especially of the columns so that the structures remain serviceable even after fire.

In India, the codal guidelines for Reinforced Concrete (RC) columns are based on limit states of failure and serviceability as given in IS-456 (2000) [3]. It can be observed that the design of RC columns at ambient temperature is based on the nature of loading and the mode of buckling. Further, ductility requirements are also considered during design of RC columns in IS 1392 (1993) [4]. Accordingly, there are various reinforcement detailings, section geometries and cover criteria available for RC columns in different building design codes. It has been seen that the fire resistance of all column patterns is dependent on the geometrical, structural, loading and fire scenarios [5,6]. Out of many influencing parameters, the work of Serega [7], and Shah and Sharma [8] have illustrated that decrease in transverse reinforcement spacing leads to increase in the fire resistance of RC columns. However, Serega [7] also illustrated that decrease in transverse reinforcement spacing below 100 mm has no positive role in improving the fire resistance of RC columns. In the work of Buch and Sharma [9], it was seen that with increase in thermal gradients/temperature gradients (the variation in temperature over a space of the column section), the spalling amount (the falling of slabs of concrete) also increases for RC column. Accordingly, thermal gradients were seen to increase