BEHAVIOUR OF HIGH STRENGTH CONCRETE EXPOSED TO FIRE

Prof. Deshmukh Yogesh R.
ABMSP's APCOER, PUNE.
yogeshyrd21@gmail.com

Abstract: The increased use of high strength concrete in buildings has resulted in concern regarding the behavior of such concrete under fire. In particular, spalling at elevated temperatures, as identified in studies in laboratories, is of particular concern. This paper provides structural behaviour and the principal influences of high temperature in concrete are loss of compressive strength and spalling, the forcible ejection of material from a member of high strength concrete column and normal strength concrete column. Though a lot of information has been gathered on both phenomena, there remains a need for a broader understanding of the response of concrete structures to different heating regimes and the performance of complete concrete structures subjected to realistic fire exposures. There is a lack of information derived from large-scale tests on concrete buildings in natural fires. So we experimenting fire test on Four Reinforced concrete column in laboratory to get actual behavior of concrete columns.

Keywords: *high strength concrete, fire resistance, high temperatures behavior, reinforce concrete column, spalling.*

INTRODUCTION

The increased use of high strength concrete (HSC) in buildings has resulted in concern regarding the behavior of such concrete expose to fire. In particular, spalling at elevated temperatures, as identified in studies by testing in laboratory.

Current concrete designs raise concerns about concrete spelling during fire particularly under compressive stresses and high heating rates. High strength concrete columns would be more prone for explosive spelling due to their low permeability and high brittleness. This paper represents an experimental program on the behavior of high strength concrete columns under fire. The research includes testing reinforced high strength concrete columns subjected to various loading levels and heating rates. We used to trace the structural behavior of reinforced concrete columns at elevated temperatures. A comparison is made of the fire resistance performance of HSC columns with that of normal strength concrete (NSC) columns. The factors that influence the thermal and structural behavior of HSC concrete columns under fire conditions are discussed. The results presented will generate data on the fire resistance of high performance concrete columns and contribute to identifying the difference in behavior between HSC and NSC columns.

RESEARCH SIGNIFICANCE

The objective of this paper is to report the main outcomes of a parametric experimental study on the effect of loading and heating rates on explosive spelling of high strength concrete columns and normal strength concrete column under fire. The paper includes the test methodology, main results, conclusions and measured parameters including temperatures of high strength concrete column and normal strength concrete column.

THE EXPERIMENTAL STUDIES

Test Specimens

The experimental program was designed to cover rational range of loading levels and heating rates. The tests involved 4 reinforced concrete columns of a section 150mmx150 mm and 720 mm height. Each column was reinforced with four 12mm diameter steel bars and connected with 20 steel ties (6mm diameter) at 48 mm intervals in the middle and 24 mm at the ends. Ties were located more often near the ends to prevent any possible local column failure near the loading points.

We use tested,Type 10 portland cement and other all tested materials like course aggregate amd fine aggregate, water and good quality of other cementitious material and fibre. The average compressive cylinder strengths of the concrete, measured 7 and 28 days after pouring and on the day of the testing. The moisture condition at the center of the column was also measured on the day of the test. The moisture conditions of Columns are approximately equivalent to those in equilibrium with air should be near about of 70% relative humidity (RH), 65% RH and 70% RH, respectively, at room temperature.

Type-K Chromel-alumel thermocouples, 0.91 mm thick, were installed at midheights in the columns for measuring concrete temperatures at different locations in the cross section.

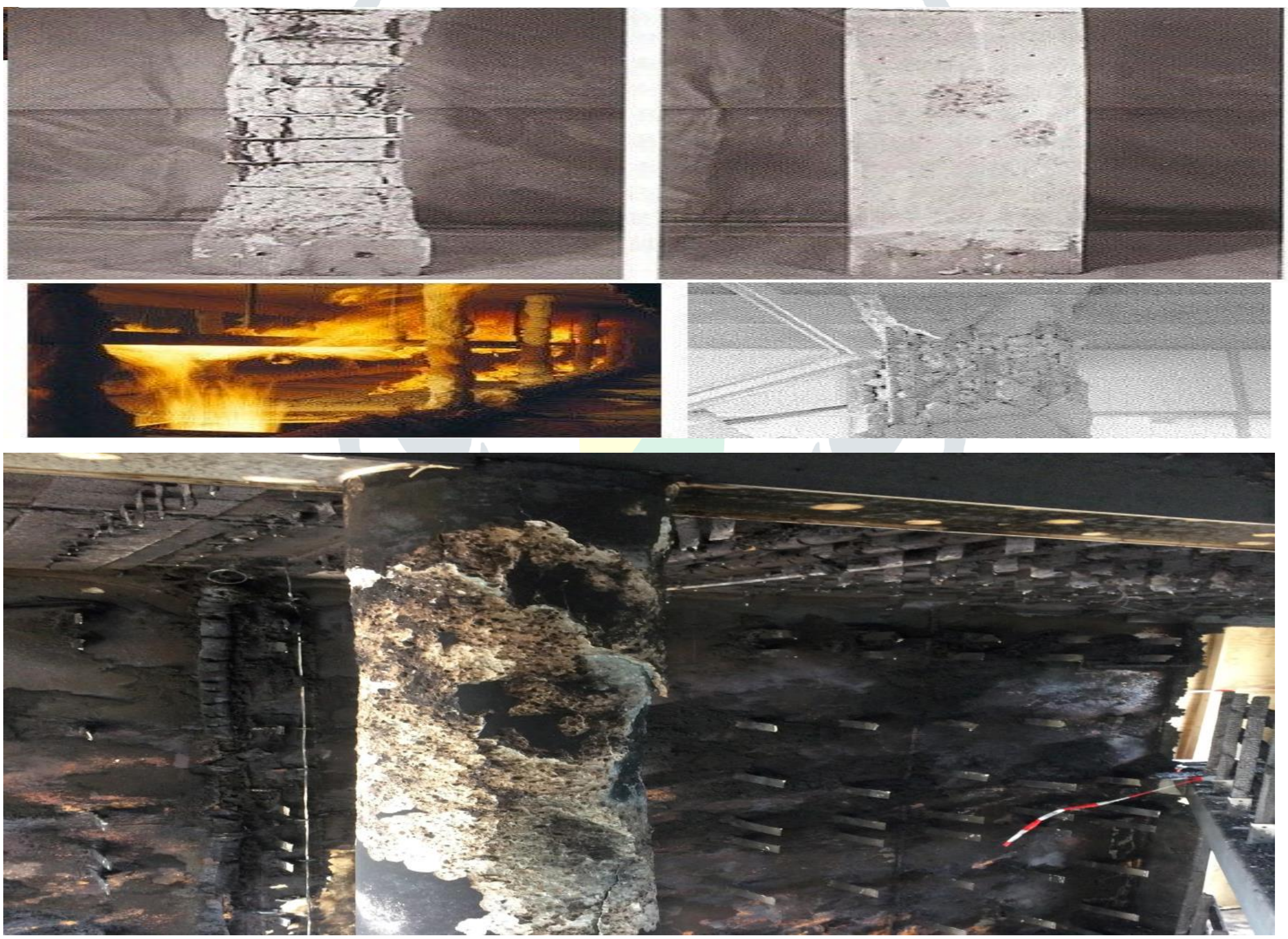

FIG 1 : Excessive spalling

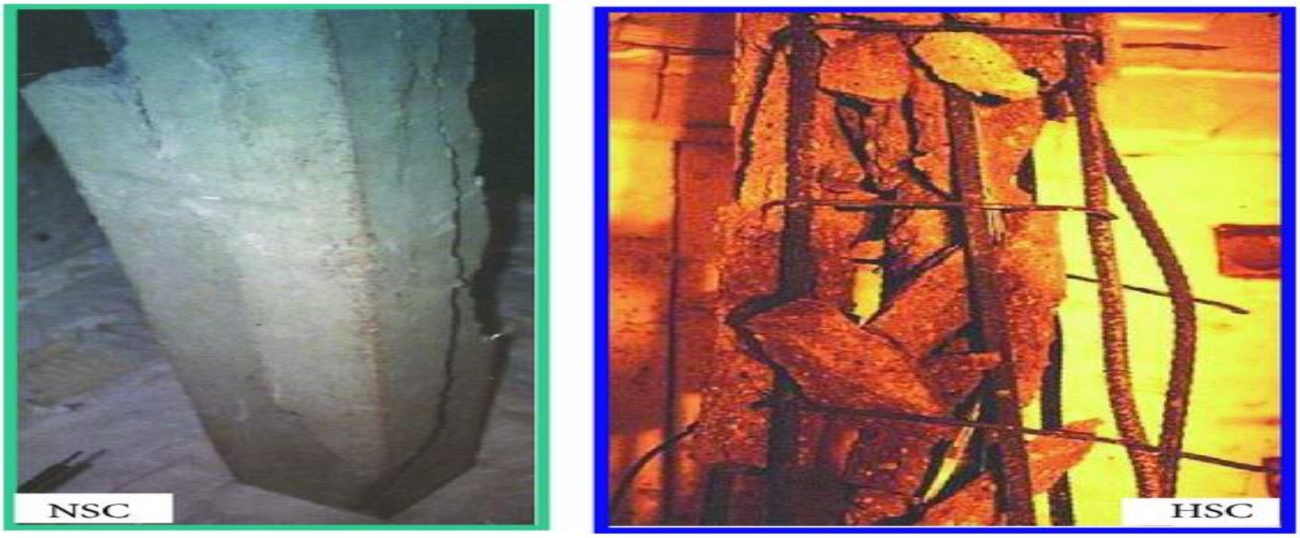

FIG2 : HSC and NSC column after fire

Test Apparatus

The tests were carried out by exposing the columns to heat in a furnace specially built for testing loaded columns. The furnace consists of a steel framework supported by four steel columns, with the furnace chamber inside the framework. The test furnace was designed to produce conditions, such as temperature, structural loads and heat transfer, to which a member might be exposed during a fire.

Test Conditions and Procedure

The columns were installed in the furnace by bolting the endplates to a loading head at the top and to a hydraulic jack at the bottom. The conditions of the columns were fixed-fixed for all tests. For each column, the length exposed to fire was approximately 3000 mm. At high temperature, the stiffness of the unheated column ends, which is high in comparison to that of the heated portion of the column, contributes to a reduction in the column effective length. In previous studies, it was found that, for columns tested fixed at the ends, an effective length of 2000 mm represents experimental behavior. All columns were tested under concentric loads. The load intensity, defined as the ratio of the applied load to the column resistance, varied slightly from Column HSC1 to HSC2 to determine the influence of load on fire resistance. The load was applied approximately 45 min before the start of the fire test and was maintained until a condition was reached at which no further increase of the axial deformation could be measured. This was selected as the initial condition for the axial deformation of the column. During the test, the column was exposed to heating controlled in such a way that the average temperature in the furnace followed, as closely as possible. The load was maintained constant throughout the test. The columns were considered to have failed and the tests were terminated when the hydraulic jack, which has a maximum speed of 76 mm/min, could no longer maintain the load.

Results and Discussion

After testing the specimens, the temperature-time curves is to be plotted for the external surface and for various depths in concrete columns HSC1, HSC2, HSC3 and NSC1 respectively. The measured temperature in the furnace follows the standard temperature-time curve and reason of failure of the columns is to check at given temperature and time.

All three columns failed in compression mode or in tension mode is to be observed. In the NSC and HSC column, significant spalling occurred until the failure of the column is to be find out.

The decreased fire resistance for HSC columns and NSC column, can be attributed to the thermal and mechanical properties of HSC. Further, the spalling phenomenon, which resulted in the decrease in the cross-section of the column, also contributed to lowering the fire resistance in the HSC columns. It can be attributed to the type of aggregate and other materials used in the concrete mix, as explained above.

EXPECTED CONCLUSIONS.

- The effect of types of aggregate, supplementary cementitious material and fibres on HSC and NSC column.
- The comparison between HSC and NSC column at various temperature and Time.

References

[1] Ali F. A., Connolly R. , and Sullivan P. J. E. "The Spelling Of High Strength Concrete at Elevated Temperatures." Journal Of Applied Fire Science,(1970).

[2] Connolly R. "Outcomes of a major research on fire resistance of concrete columns". Fire Safety. 2004.

[3] Audun Borg, S. welch, " Performance of concrete in fire: a review of the state of the art, with a case study of the Windsor tower fire "

[4] Benmarce, A.& Guenfoud, M. "Behavior of axially restrained high strength concrete column under fire".

[5] Disamu Yoshitake1, Koji Baba, Tetsuo Ito and Koji Nakagawa "Behaviour of fibre reinforced concrete under fire temperature"

[6] Faris A. Ali Nadjai, Paul Glackin Silcock, "Structural Performance Of High Strength Concrete Columns In Fire"

[7] H.L. Zhu and T.T. Lie "Fire Resistance Evaluation of Reinforced Concrete Columns" (Year 1993)

[8] Haack, A. 'The European State of the Art of Concrete and Fire Safety in Tunnels', Japan Concrete Institute Annual Convention (2003).

[9] Hertz, K. D. & Sorensen, L. S. "Test method for spalling of fire exposed concrete ". Fire safety J., 2005.40(5):466.10.

[10] Luke Bisby, Hossein Mostafaei, Pierre Pimieta "White Paper on Fire Resistance of Concrete Structures" (Year 2014).11.

[11] MohammadMahdi Raouffard, Minehiro Nishiyama, "Fire Resistance of Reinforced Concrete Frames Subjected to Service Load: Part 1. Experimental Study" (Year 2015)12.

[12] Sullivan, P.J.E., Terro, M.J. and Morris, W.A., Critical Review of Fire-Dedicated Thermal and Structural Computer Programs". Journal of Applied Fire Science, Vol. 3 (1997).13.

[13] Venkatesh R. Kodur, M. A. Sultan, "Structural behaviour of high strength concrete columns exposed to fire" (Year 2010).14.

[14] Yakudima Akibu Ghali, Ruban Sugumar and Hassan Abba Musa , "Impact Of Fire On Steel Reinforcement In Reinforced Concrete Structures " (Year 2015)