EFFECT OF ELEVATED TEMPERATURES ON COPPER SLAG CONCRETE

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ABSTRACT. Concrete in structures sometimes experience very high temperatures due to sudden fire. Sudden temperature increase might cause cracking and spalling of concrete. Apart from this the aggregates in concrete also expand which might cause an internal stress increase in the matrix. This paper focuses on the effects of exposing concrete made up of copper slag as fine aggregate to high temperatures of 200^0C, 400^0C and 600^0C. Concrete containing increasing quantities of copper slag is exposed to high temperatures and tested. Various concrete mixes with copper slag content of 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90% and 100% of fine aggregate are used. The concrete is also subjected to three different exposure periods of 1 hr, 2 hr and 3 hrs and its behaviour is studied and the results are presented. It is observed that copper slag concrete offers better resistance to high temperatures when compared to the nominal concrete.

Keywords: Copper slag, Industrial waste, Environmental pollution, Temperature, Exposure time, Strength

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INTRODUCTION

Concrete is an inevitable material as far as construction sector is considered and holds the second position in terms of usage after water. Concrete in structures sometimes experience very high temperatures due to sudden fire. In such situations the durability of concrete becomes an important parameter to be analysed, as it affects the useful life of the structure. The structural integrity of concrete when subjected to high temperatures is dependent on factors like the rate of temperature rise, the water/cement ratio, the type of the aggregate used and its stability. Previous observations indicate that sudden temperature increase might cause cracking and spalling. Apart from this the aggregates in concrete also expand which might cause an internal stress increase in the matrix.

In this work copper slag is used as a replacement material for fine aggregate in concrete as there is acute shortage of river sand availability. Excessive utilisation of natural resource like river sand is leading to depletion and ecological imbalance. Hence in this work river sand is reduced by various percentages and copper slag is used in the place of river sand. The effect of this reduction in sand content and presence of copper slag in concrete is studied by experimental investigations.

WHY COPPER SLAG IN CONCRETE?

Copper Slag is a glassy granular material with high specific gravity. Particle sizes are of the order of sand and have a potential for use as fine aggregate in concrete. In order to reduce the accumulation of Copper Slag and also, to provide an alternate material for sand copper slag can be utilized in concrete to act as fine aggregate. The copper slag in the granular form is utilized now as a sand blaster in finishing metal surfaces. But only 15 to 20% of the copper slag produced alone is being used. Some of it used for land filling leaving the rest unused causing environmental pollution. These fine granules of copper slag are similar to sand grains and hence can be used in concrete as a replacement of fine aggregate. The use of copper slag in concrete provides potential environmental as well as economic benefits for all related industries, particularly in areas where a considerable amount of copper slag is produced. This innovative material (copper slag) which is an industrial waste product, if effectively utilized, will reduce not only sand mining but also environmental pollution.

EXPERIMENTAL INVESTIGATIONS

In this work, M40 grade concrete is prepared with water to cement ratio of 0.4 containing copper slag as fine aggregate. Various concrete mixes differentiated by the copper slag content replacing the traditional filler in the mix ranging from 0%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90% and 100% are used. This concrete is exposed to high temperatures of 200^0C, 400^0C and 600^0C. After 28 days of water curing, the concrete is subjected to high temperatures of 200^0C, 400^0C and 600^0C with an exposure period of 1 hr, 2 hr and 3 hrs. Fig 1 shows the casting and testing of specimens.

Figure 1 Casting and testing of specimens

RESULTS AND DISCUSSIONS

From the graphs below, it can be observed that the copper slag concrete performed better than conventional concrete both when exposed to high temperatures and also when exposed to longer duration of time. This could be because of higher hardness of copper slag when compared to river sand. The performance of copper slag concrete with reference to strength has increased to the extent of 35.2%, 31.2% and 31.9% when exposed to 200^0 C temperature for 1 hr, 2 hrs and 3 hrs respectively. Similarly at 400^0 C, the increase is observed to be 33.2%, 28.4%, 28.6% for 1 hr, 2 hrs and 3 hrs exposure time respectively while at 600^0 C the increase is observed to be 37.7%, 29.0%, 24.3% respectively. A comparative study is shown in figures 11 to 16.

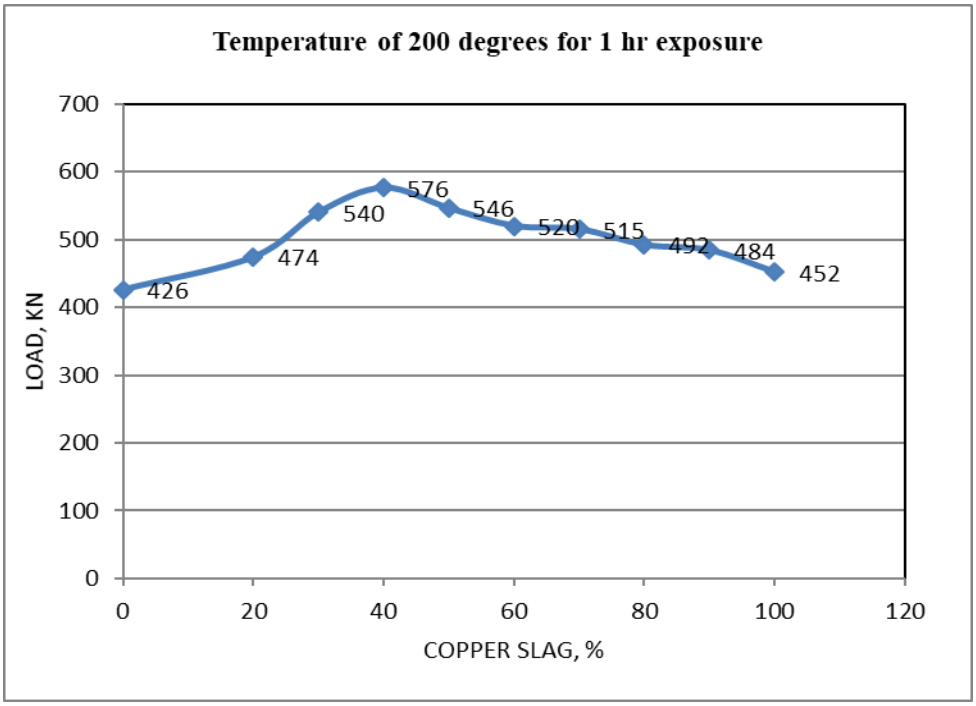

Figure 2 Behaviour of Copper slag concrete hrs at 200^0 C temperature after exposure for 1 hr

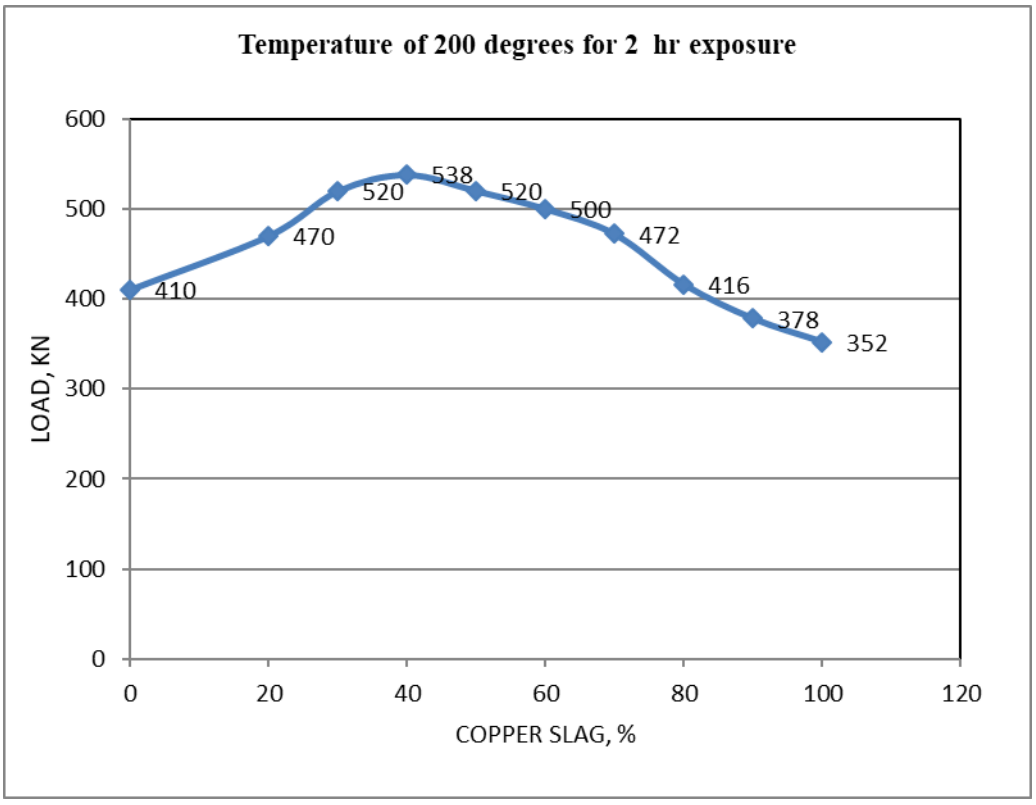

Figure 3 Behaviour of Copper slag concrete hrs at 200^0 C temperature after exposure for 2 hrs

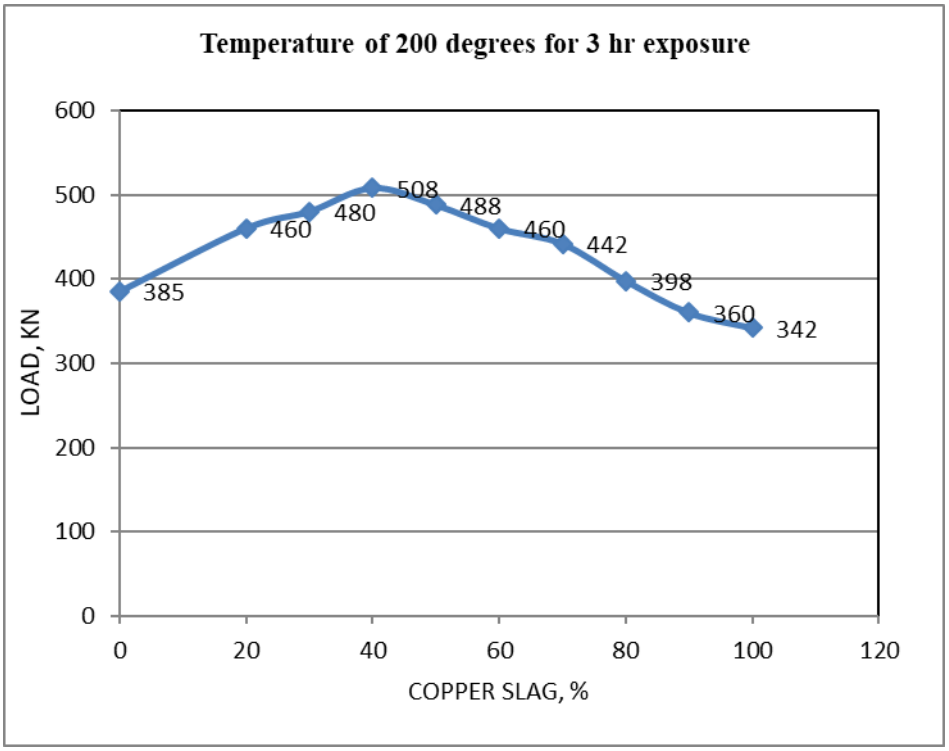

Figure 4 Behaviour of Copper slag concrete hrs at 200^0 C temperature after exposure for 3 hrs

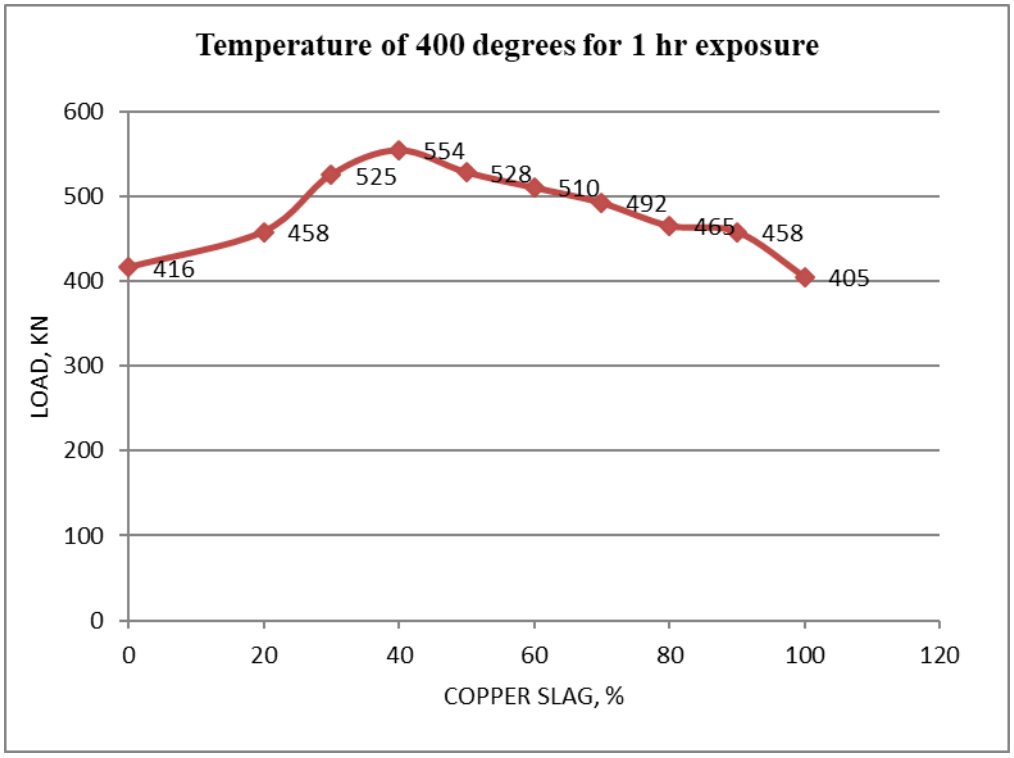

Figure 5 Behaviour of Copper slag concrete hrs at 400^0 C temperature after exposure for 1 hr

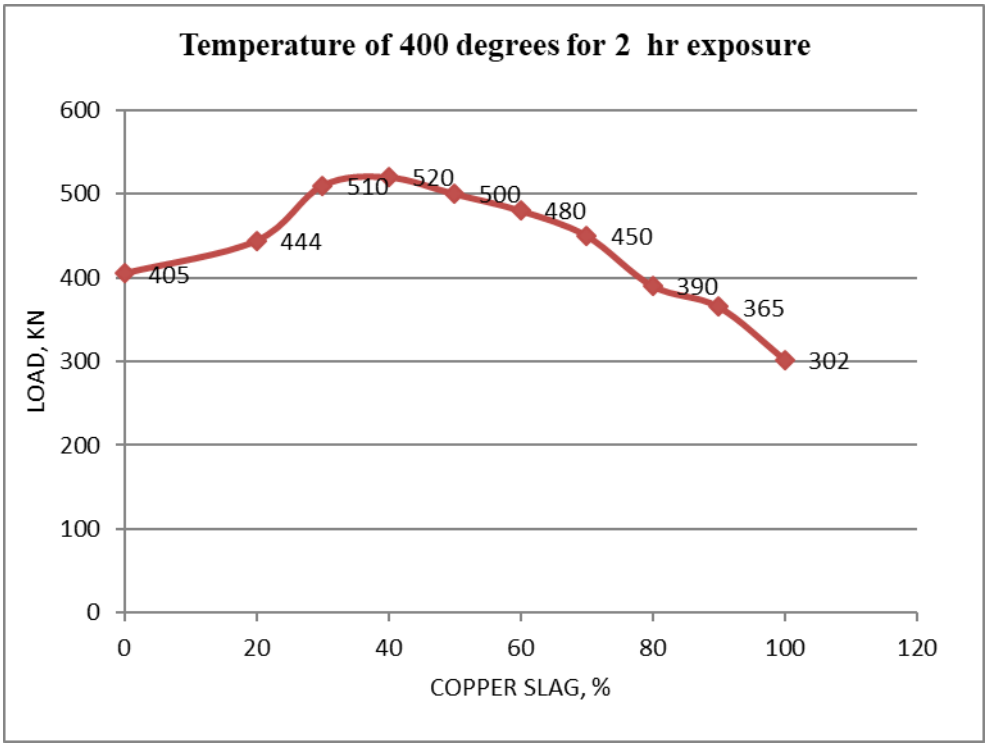

Figure 6 Behaviour of Copper slag concrete hrs at 400^0 C temperature after exposure for 2 hrs

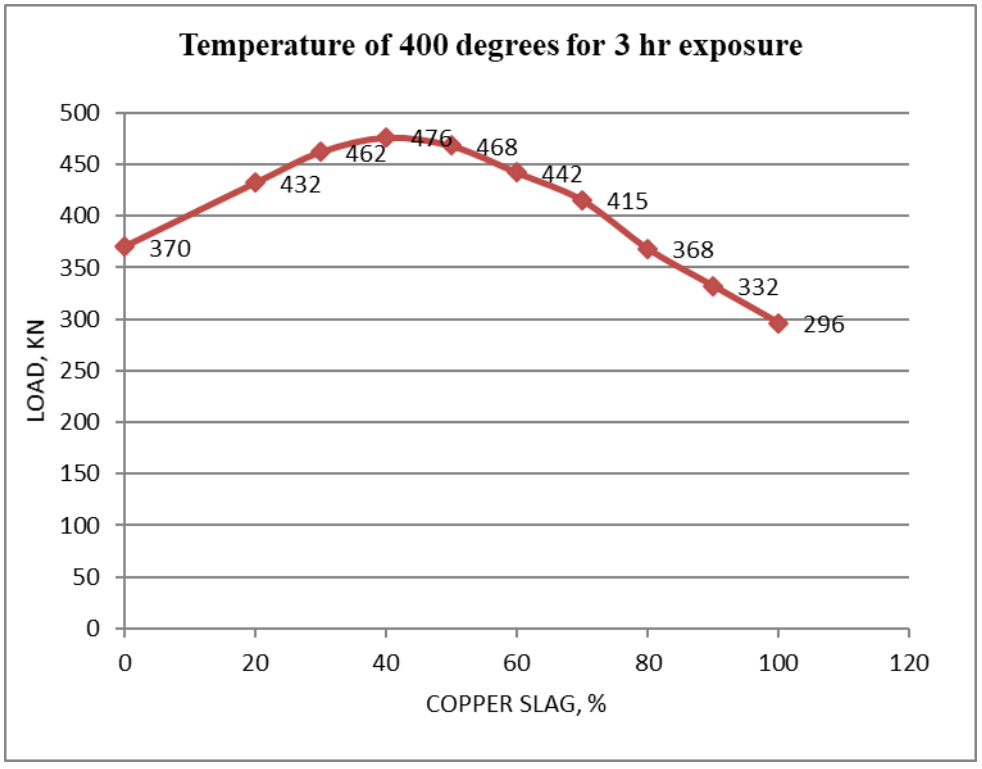

Figure 7 Behaviour of Copper slag concrete hrs at 400^0 C temperature after exposure for 3 hrs

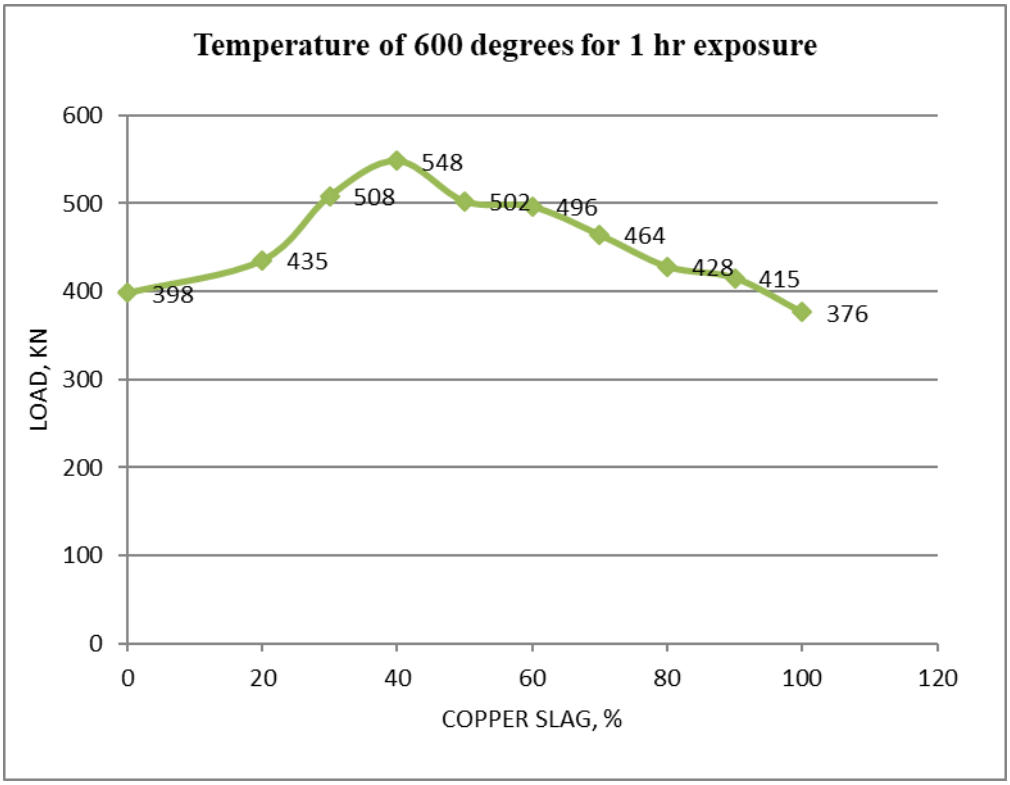

Figure 8 Behaviour of Copper slag concrete hrs at 600^0 C temperature after exposure for 1 hr

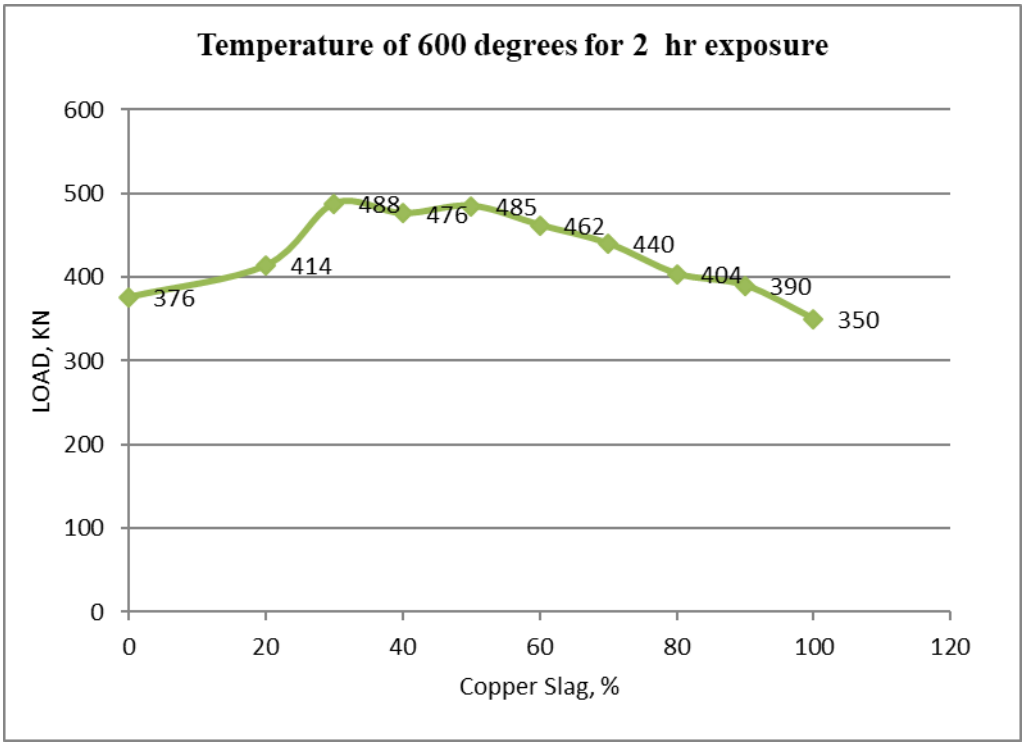

Figure 9 Behaviour of Copper slag concrete hrs at 600^0 C temperature after exposure for 2 hrs

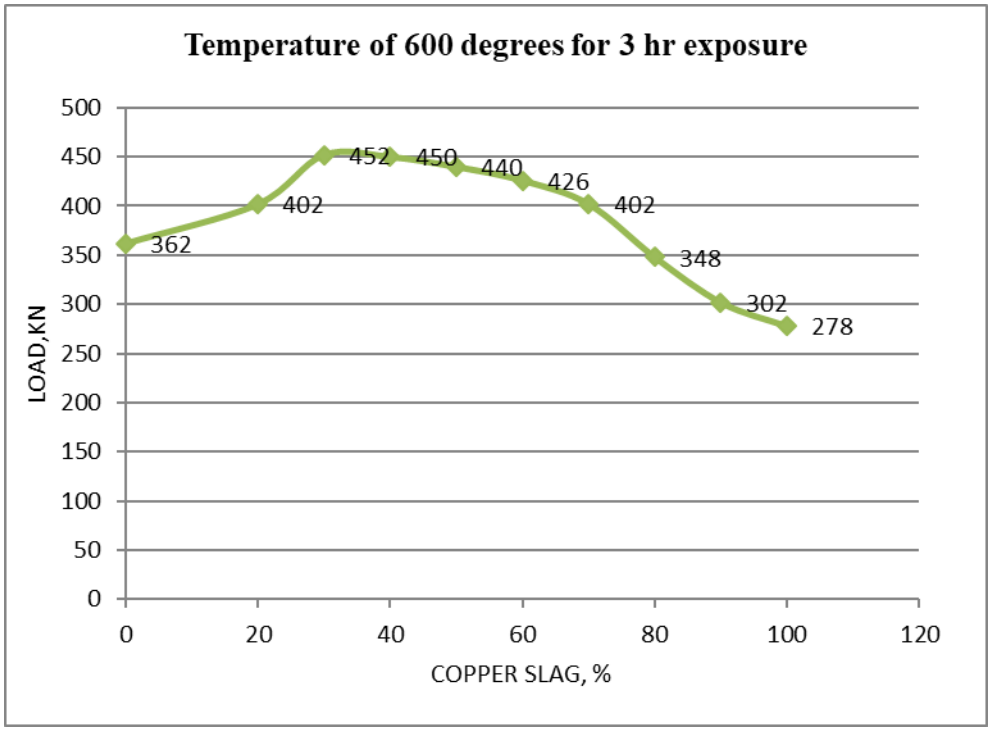

Figure 10 Behaviour of Copper slag concrete hrs at 600^0C temperature after exposure for 3hrs

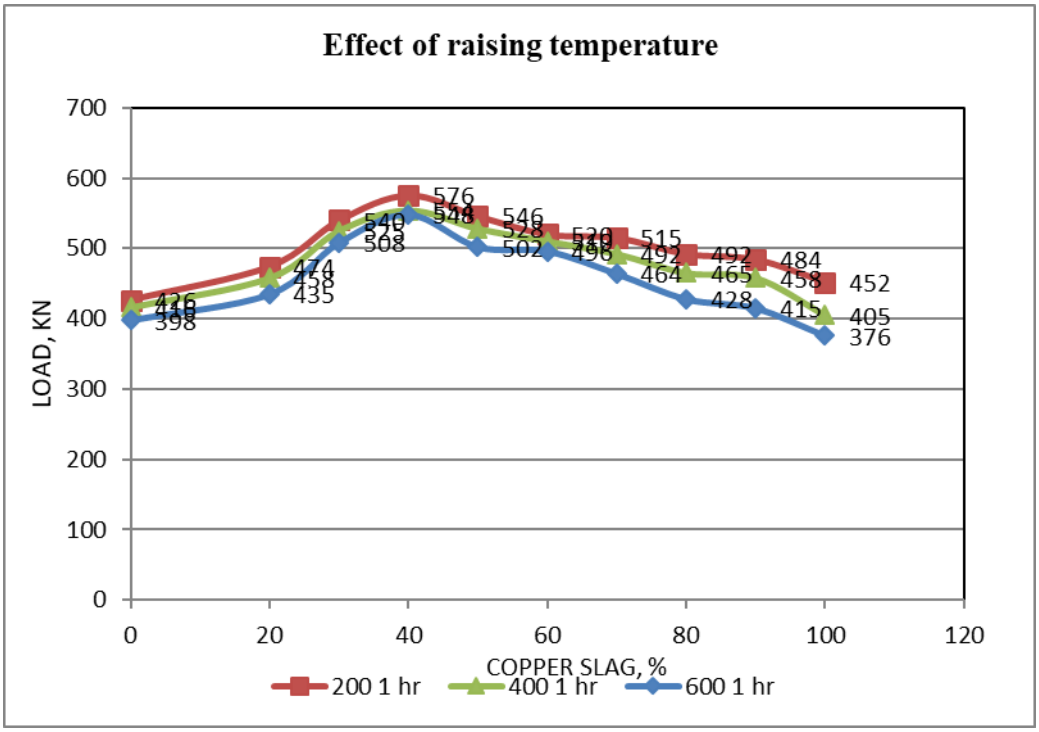

Figure 11 Comparison of behaviour of Copper slag concrete after exposure for 1hr at different temperatures

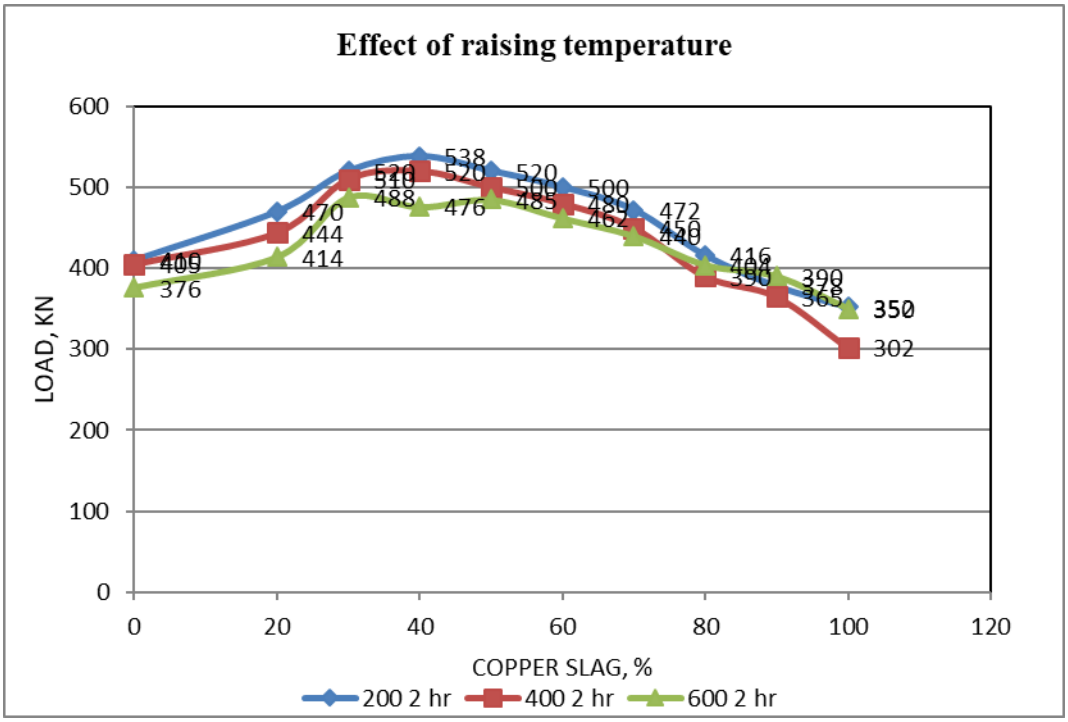

Figure 12 Behaviour of Copper slag concrete after exposure for 2hrs at different temperatures

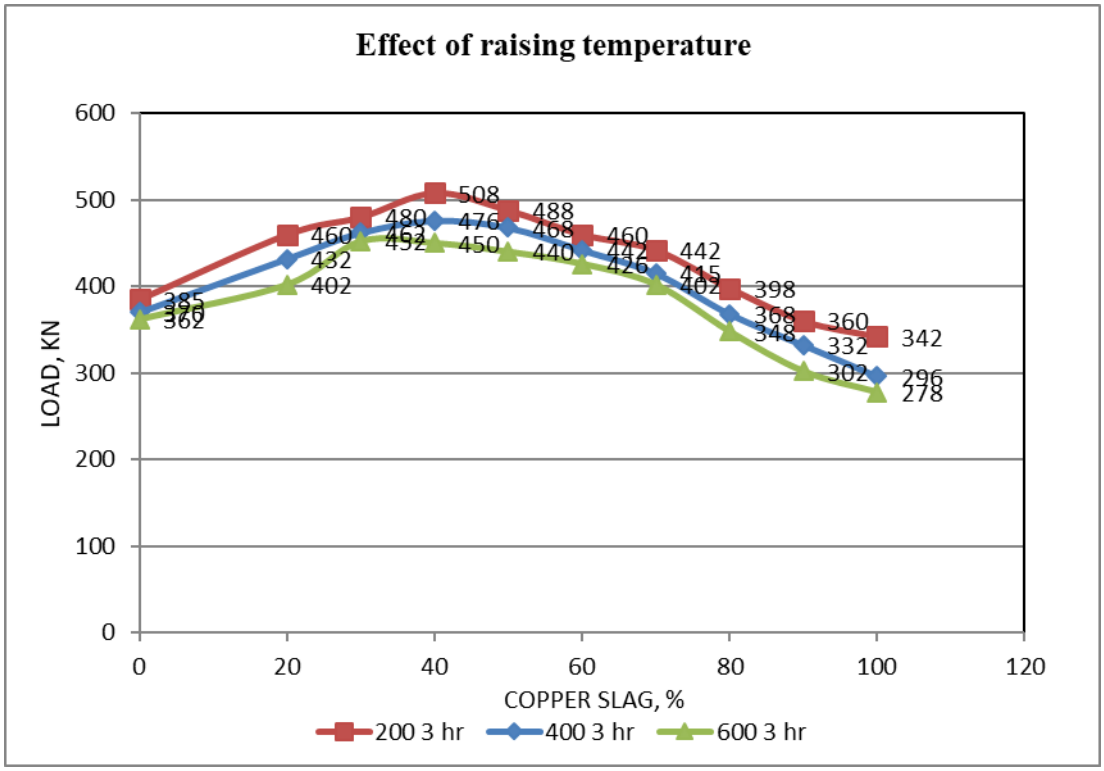

Figure 13 Behaviour of Copper slag concrete after exposure for 3hrs at different temperatures

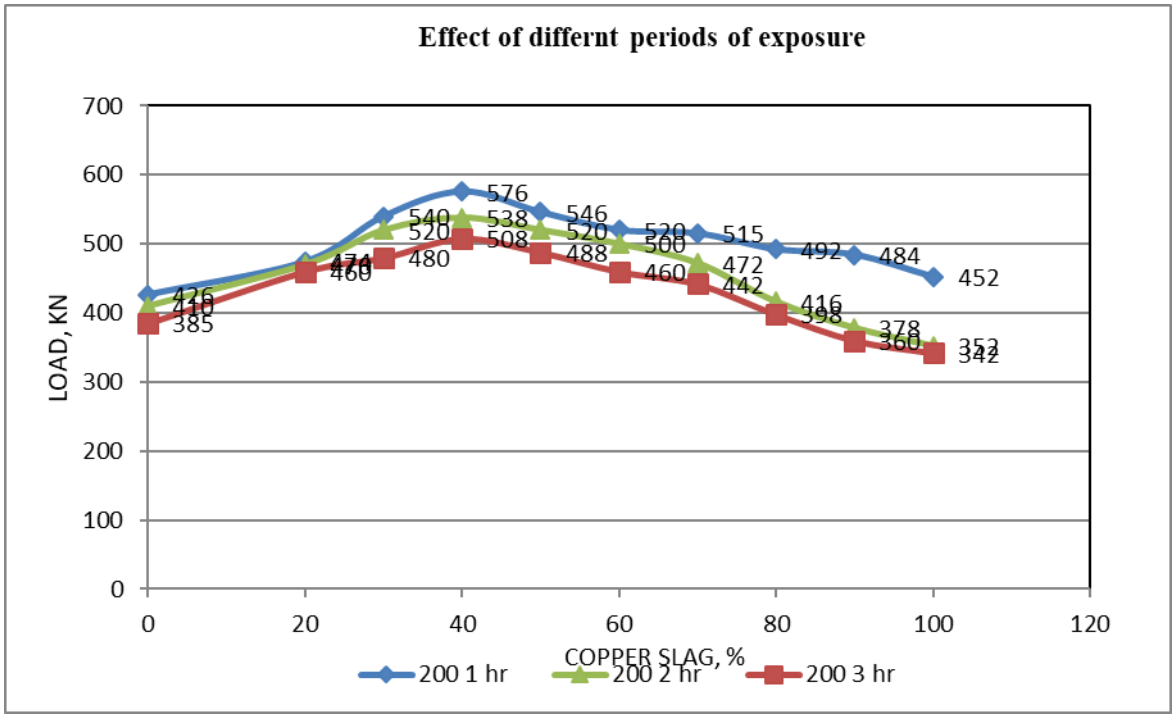

Figure 14 Behaviour of Copper slag concrete at 200° C when exposed for different periods

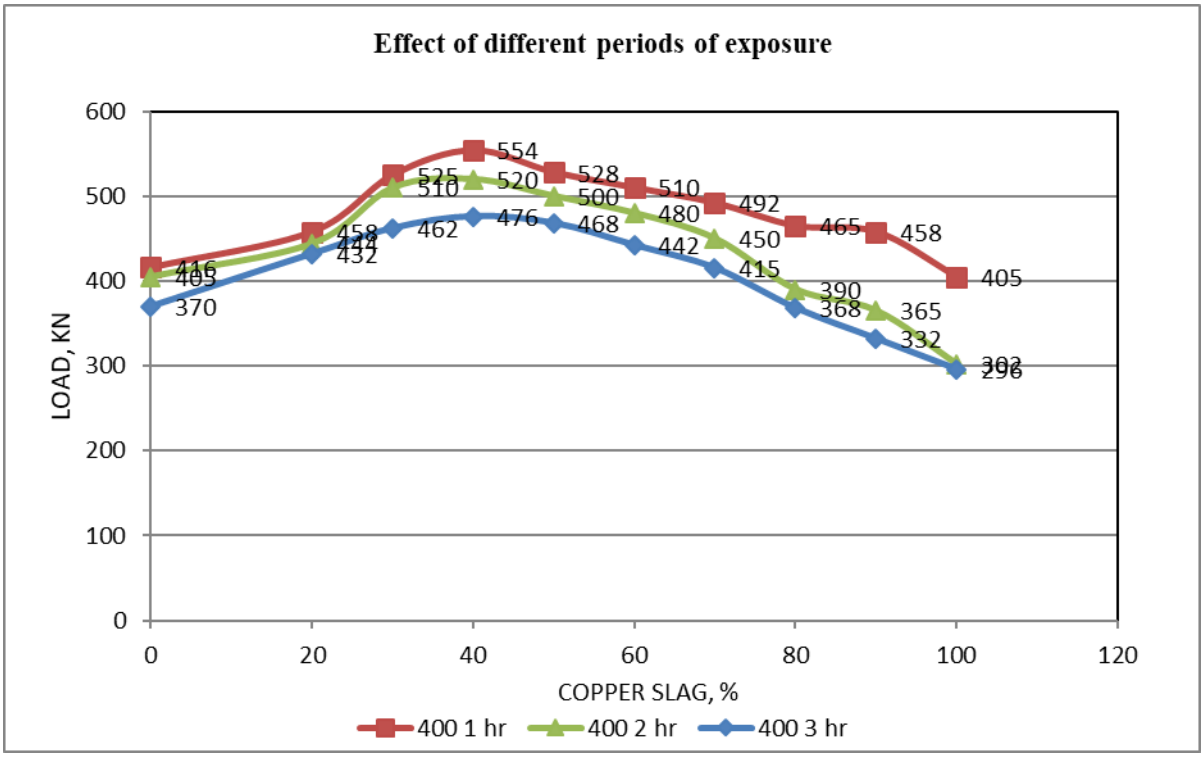

Figure 15 Behaviour of Copper slag concrete at 400° C when exposed for different periods

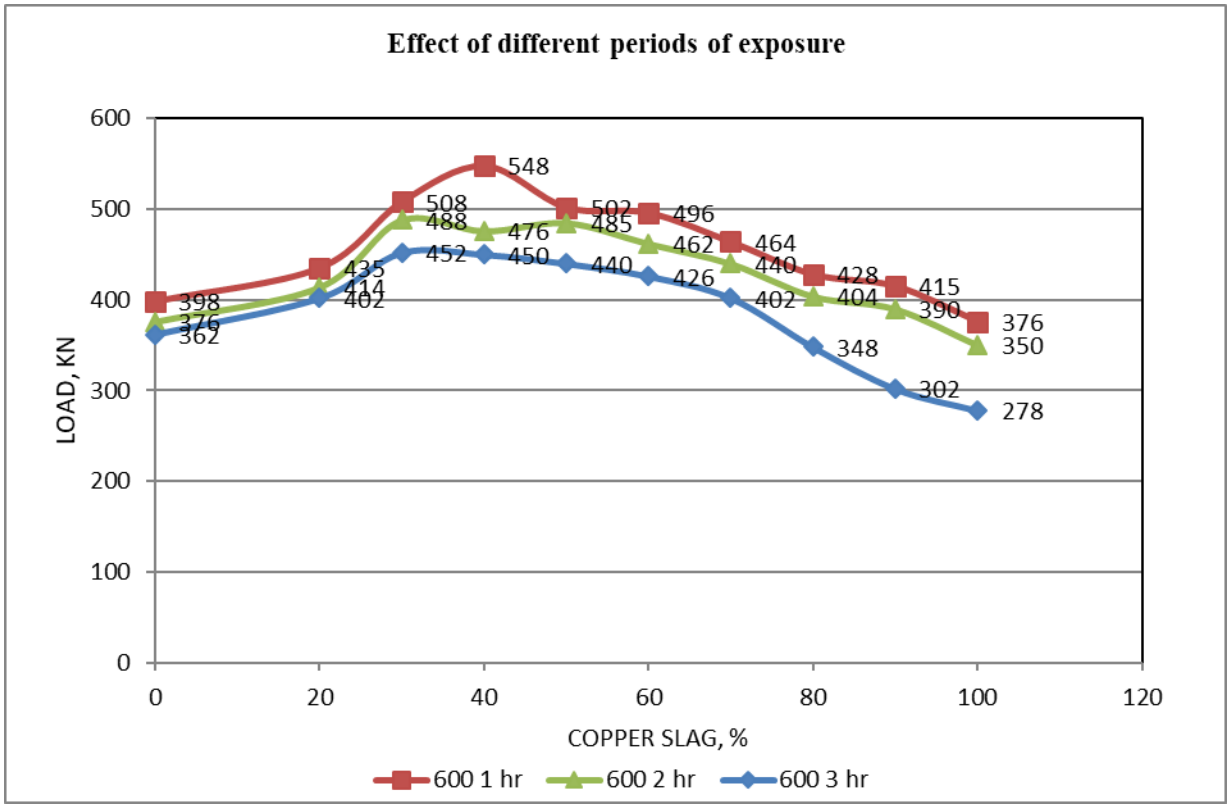

Figure 16 Behaviour of Copper slag concrete at 600º C when exposed for different periods

CONCLUSIONS

The loss of strength due to deterioration of concrete on exposure to high temperature is measured by testing the specimens for their compressive strength. The changes in the strength of concrete are studied, analysed and the results are presented. Concrete mix generated with 40% copper slag content exhibited maximum strength post which a decline in the strength parameter was observed. Hence slag inclusion shall be restricted to not more than 40% for producing slag infiltrated concrete that will yield better results than the conventional mix.

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