Experimental Study on the Concrete Using Sugarcane Bagasse Ash with Coal Bottom Ash

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Abstract study primarily deals with the characteristics of concrete, including compressive strength and workability. Moreover, this study also investigates the thermal stability of all concrete mixes at elevated temperature. Twenty five mixes of concrete were prepared at different replacement levels of scba (0%, 5%, 10%, 15% & 20%)) with cement and cba (0%, 10%, 20%, 30% & 40%) with fine aggregates. The water/cement ratio in all the mixes was kept at 0.55. The workability of concrete was tested immediately after preparing the concrete whereas the compressive strength of concrete was tested after 14, 28 and 60 days of curing. Based on the test results, a combination of 10% scba and 10% cba is recommended. This research also indicates that the contribution of scba and cba doesn't change the thermal properties of concrete.

Keywords: compressive strength, coal bottom ash, elevated temperature, sugarcane bagasse ash, workability

I. INTRODUCTION

Agro waste is the waste produced from various agricultural goods. Bagasse from sugarcane, wheat husk and wheat straw from wheat, groundnut shell from groundnut, and rice husk from paddy are the wastes of agriculture. Most of the developing countries produced near about 400 million tons of agricultural waste annually. Nowadays, some of the wastes such as rice husk, bagasse, shell of ground nuts etc. Are partly used as a fuel for power generation. This utilization results into ash which causes the problem of disposal. Moreover, the chemical composition of the ash has diverted these wastes into the useful materials which can be used in concrete construction. Apart from above mentioned agrowaste ashes, some researchers identified that the sugarcane bagasse ash can also be used as pozzolan in concrete.

Sugarcane is one of the major crops grown in over 110 countries. According to food and agriculture organization (fao), india is the second largest producer of sugarcane in the orld. It produces 340 million tons of sugarcane every year. The fibrous matter that remains after crushing and juice extraction of sugarcane is known as bagasse. When this bagasse is burned under controlled temperature, it results into ash. The resulting sugarcane bagasse ash (scba) contains high levels sio_2 and al_2o_3, which can help to enabling its use as a supplementary cementitious material (scm). The use of scba as scm not only reduces the production of cement which is responsible for high energy consumption and carbon emission, but also can improve the compressive strength of cement based materials like concrete and mortar (janjaturaphan and wanson 2010). This improved compressive strength depends on both physical and chemical effects of the scba. The physical effect also called filler effect Which relates to shape, size and texture of the scba particles while the chemical effects relate to the ability of scba to participate in the pozzolanic reaction with calcium hydroxide by providing reactive silicious compounds (srinivasan andsathiya 2010).

II. MATERIAL AND METHODOLOGY

Properties of materials

The aim of studying various properties of material used is to check the conformance with codal requirements and to enable an engineer to design a concrete mix for a particular strength. The following materials were used in the present study.

Properties of cement

In present investigation opc of 43 grades was used. The values are conforming to specifications given in bis: 8112-2013

Properties of aggregates

Properties of coarse aggregates

The coarse aggregates used in present investigation, were a mixture of two locally available crushed stone of 10 mm and 20 mm size in 50:50 proportions. The aggregates were washed to remove dirt, dust and then dried to surface dry condition.

Properties of fine aggregates

Natural sand was used as fine aggregates, collected from chakki river (pathankot). The specific gravity, water absorption and fineness modulus of fine aggregates was determined as 2.71, 1.21 and 2.67 respectively.

Properties of sugarcane bagasse ash

The ash was obtained from the boiler of a sugar mill situated at village budhewal, which falls at a distance of about 4 kms from jandaili on ludhiana-chandigarh road. The ash was ground before it was used as a cement replacement material. After grinding, the fraction of particles retained on 45µm sieve was 15%.

Properties of coal bottom ash

The ash was obtained from guru hargobind thermal plant (ghtp lehra mohabbat) which is located on state highway no. 12, running from bathinda to barnala.

Testing of concrete

In this study, the specimens were tested after 14, 28 and 60 days of curing to study the effect of scba and cba in concrete while all the cubes were tested after 28 days of curing to study the effect of different temperature ranges on compressive strength of all mixes. The 24 mixes were prepared other than control mix. The cement was replaced with different replacement levels of scba (0%, 5%, 10%, 15% & 20%) while fine aggregates was replaced with different ranges of cba (0%, 10%, 20%, 30% & 40%). The water/cement (w/c) ratio in all the mixes was kept 0.55. The cubes considered in this study consisted of 225 numbers of 150mm side cubes and same numbers of 100mm side cubes.

Mix design of concrete by BIS recommendations

The present investigation includes design of concrete mix for M20 grade of concrete. The guideline given in codes BIS: 10262-2009 and BIS: 456-2000 has been adopted for mix design of concrete.

Selection of water-cement ratio

Based on experience, adopt water-cement ratio as 0.55 maximum water cement ratio is 0.55, hence o.k.

Selection of water content

Based on experience, adopt 186 litres.

Proportion of volume of coarse aggregate and fine aggregate content

Volume of coarse aggregate corresponding to 20 mm size aggregate and fine aggregate (zone ii) for water-cement ratio of 0.50 is 0.62.

Preparation of trial mixes

Based on the concrete mix design by bis method, four trials mixes were prepared. Two trials mixes were prepared with water cement ratio of 0.55 and other two mixes were prepared with water cement ratio of 0.50. The nine cubes were cast for each mix and were tested at 3, 7 and 28 days.

Table 1: Residual compressive strength of concrete mixes at different temperature range

Mix	SCBA (%)	CBA (%)	Residual compressive strength (n/mm^2) at different temperature ranges			
			Room Temperature	150°c	300°c	600°c
D1	0	0	29.85	26.54	24.45	12.03
D2	5		30.84	28.49	25.46	10.37
D3	10		31.24	28.56	25.7	11.02
D4	15		30.77	26.95	25.3	10.44
D5	20		29.68	26.42	23.84	10.15
D6	0	10	29.14	26.15	23.11	11.86
D7	5		30.56	27.35	23.8	12.8
D8	10		30.92	27.38	25.63	11.57
D9	15		30.03	26.69	24.53	12.07
D10	20		28.99	25.97	22.64	11.34
D11	0	20	28.41	25.71	23.21	10.85
D12	5		29.49	26.57	23.97	10.37
D13	10		30.14	27.34	24.84	11.02
D14	15		29.31	26.95	25.31	10.44

D15	20		28.38	25.35	22.73	11.75
D16	0	30	27.82	24.26	21.73	12.19
D17	5		29.22	25.6	23.05	11.86
D18	10		29.51	25.68	23.43	10.96
D19	15		28.72	25.32	23.48	11.62
D20	20		27.77	24.65	22.66	10.41
D21	0	40	27.04	24.15	21.74	11.74
D22	5		28.54	25.14	22.83	10.96
D23	10		28.46	25.16	23.39	10.78

Table 4.22: Percentage loss in compressive strength at different temperature range

Mix	Scba (%)	Cba (%)	Percentage loss (-) in compressive strength with increase in temperature		
			Room temperature to 150°c	Room temperature to 300°c	Room temperature to 600°c
D1	0	0	11.1	18.1	59.7
D2	5		7.6	17.4	66.4
D3	10		8.6	17.7	64.7
D4	15		12.4	17.8	66.1
D5	20		11	19.4	65.8
D6	0	10	10.3	20.7	59.3
D7	5		10.5	22.1	58.1
D8	10		11.4	17.1	62.6
D9	15		11.9	18.3	59.8
D10	20		10.4	21.9	60.9
D11	0	20	9.5	18.3	61.8
D12	5		9.9	18.7	64.8
D13	10		9.3	17.6	63.4
D14	15		8.1	20.6	64.4
D15	20		10.7	19.9	58.6
D16	0	30	12.8	21.9	56.2
D17	5		12.4	21.1	59.4
D18	10		12.9	20.6	62.9
D19	15		11.8	18.2	59.5
D20	20		11.2	18.4	62.5
D21	0	40	10.7	19.6	56.6
D22	5		11.9	20	61.6
D23	10		11.6	17.8	62.1
D24	15		9.7	20.1	58.1
D25	20		10	19	58.9

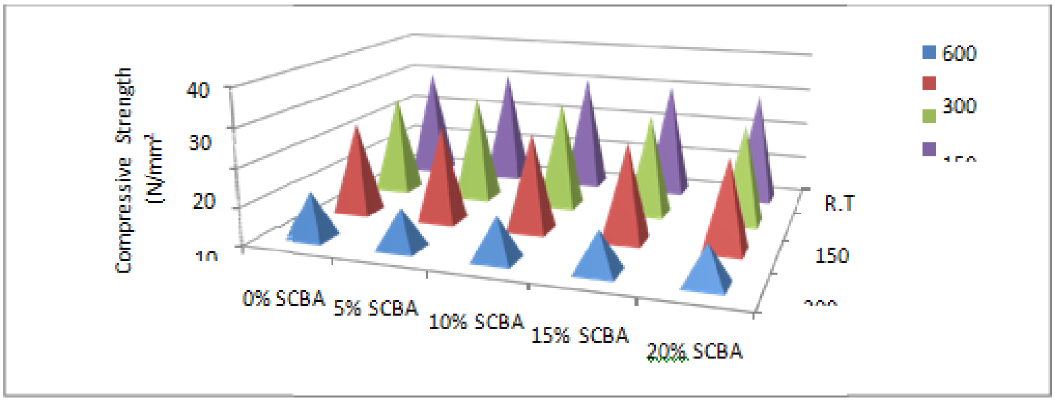

Figure 4.12: Compressive strength of concrete at different temperature ranges with different replacement levels of cement with scba and 0% cba

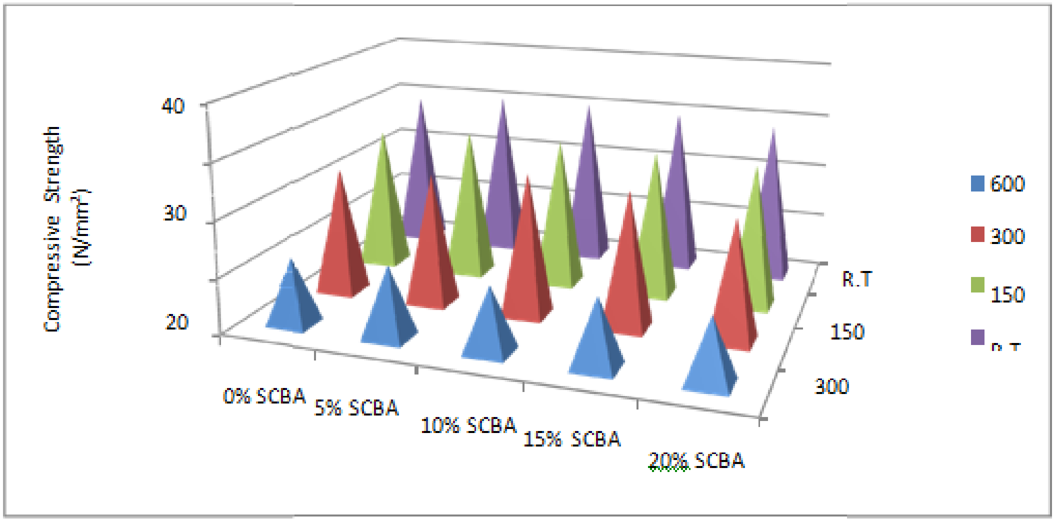

Figure 4.13: Compressive strength of concrete at different temperature ranges with different replacement levels of cement with scba and 10% cba

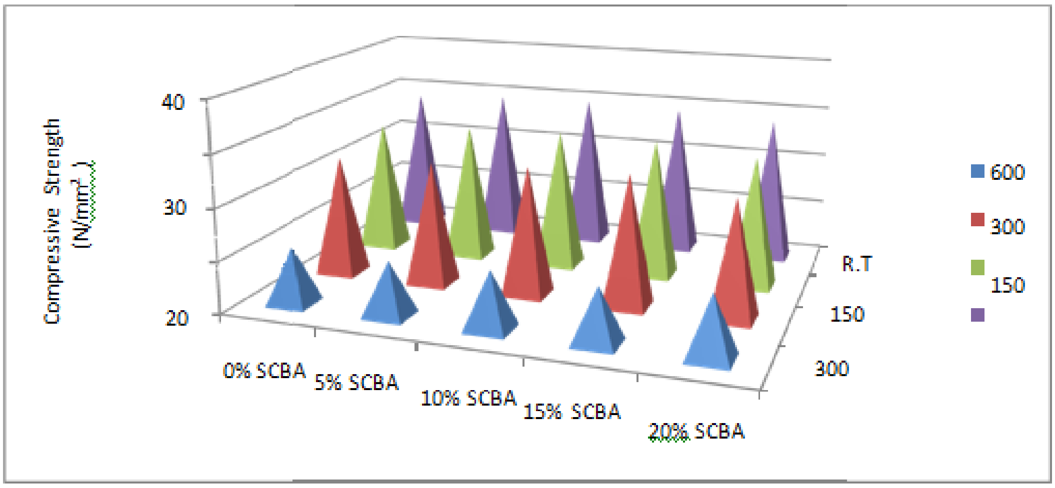

Figure 4.14: Compressive strength of concrete at different temperature ranges with different replacement levels of cement with scba and 20% cba

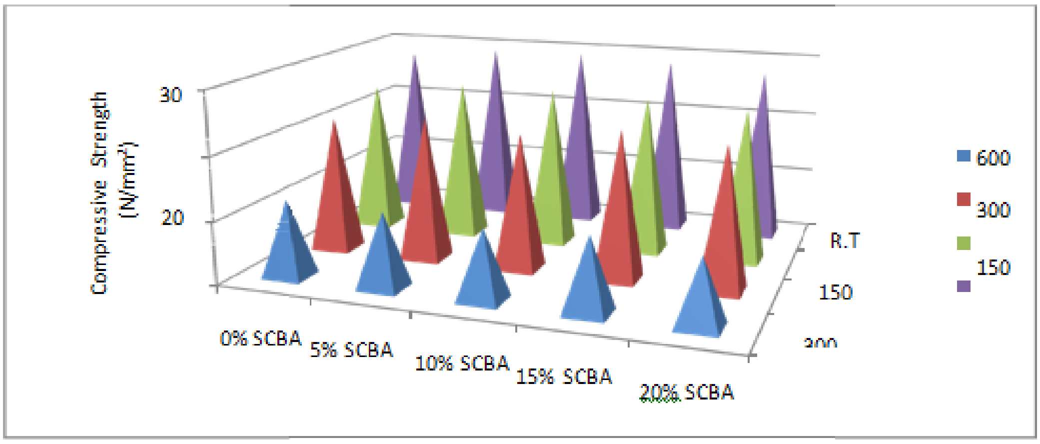

Figure 4.15: Compressive strength of concrete at different temperature ranges with different replacement levels of cement with scba and 30% cba

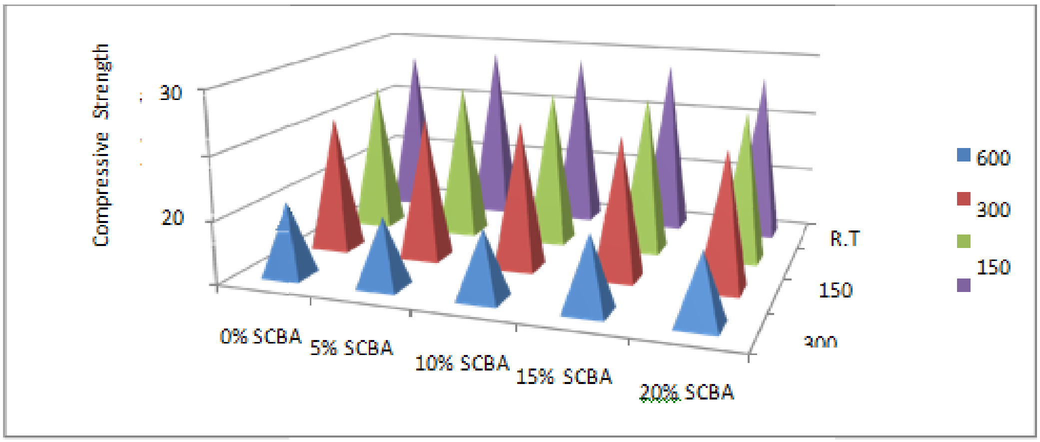

Figure 4.16: Compressive strength of concrete at different temperature ranges with different replacement levels of cement with scba and 40% cba

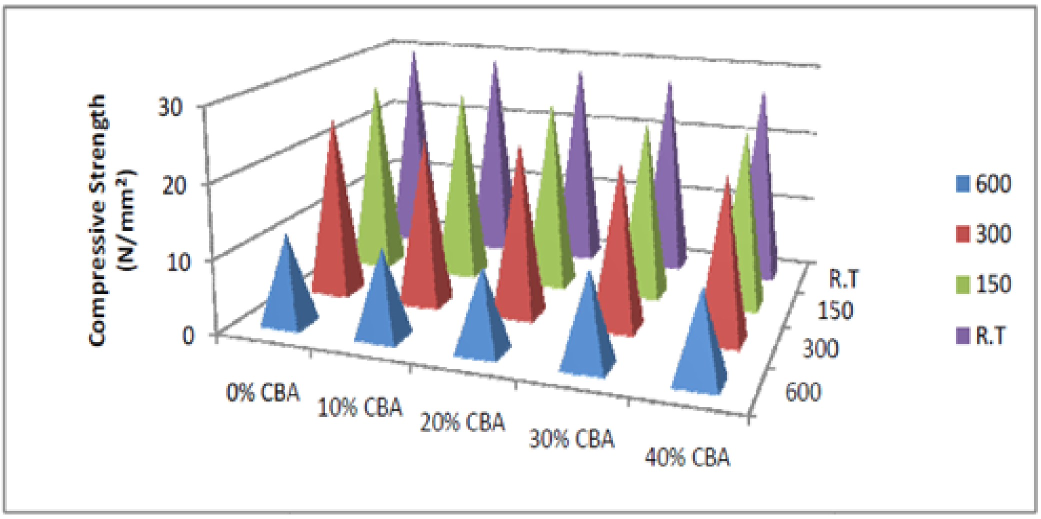

Figure 4.17: Compressive strength of concrete at different temperature ranges with Different replacement levels of fine aggregates with CBA and 0% SCBA

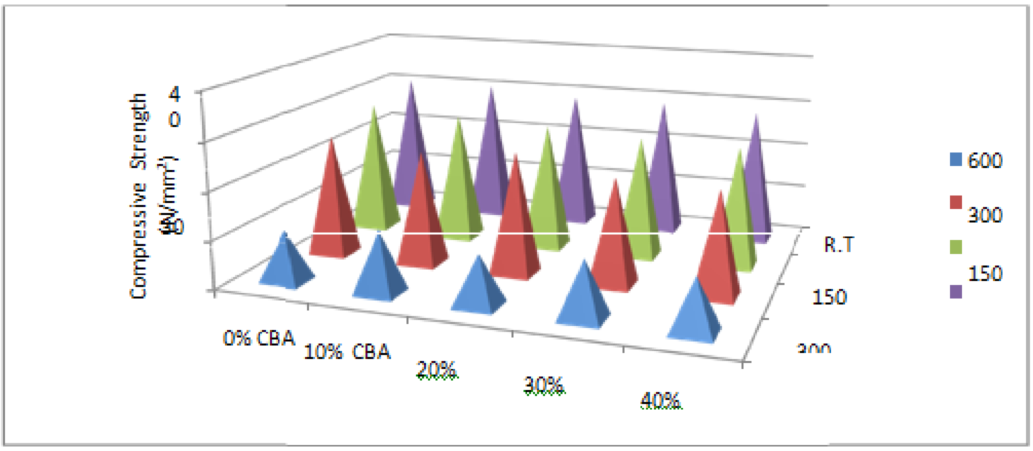

Figure 4.18: Compressive strength of concrete at different temperature ranges with different replacement levels of fine aggregates with cba and 5% scba

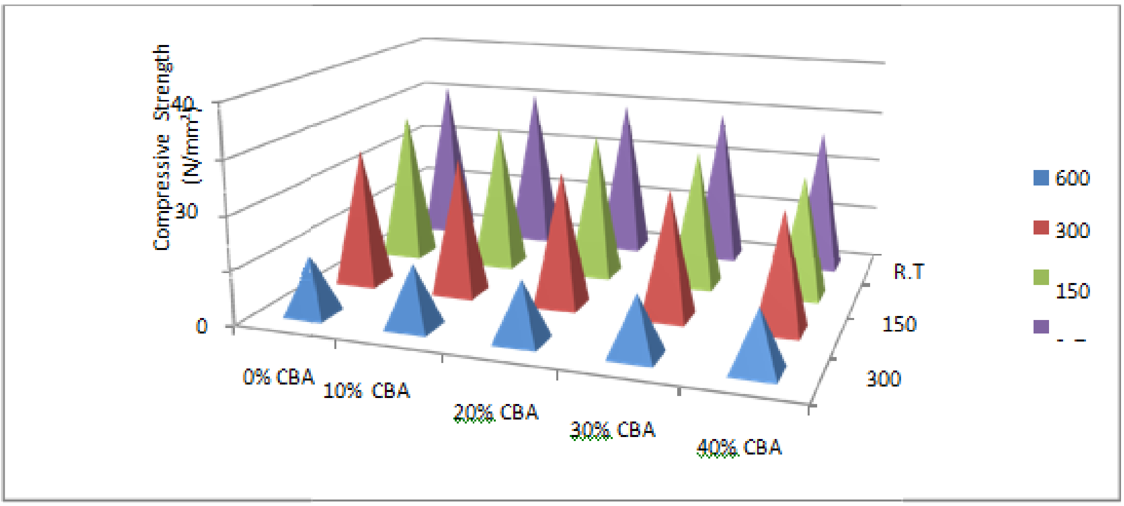

Figure 4.19: Compressive strength of concrete at different temperature ranges with different replacement levels of fine aggregates with cba and 10% scba

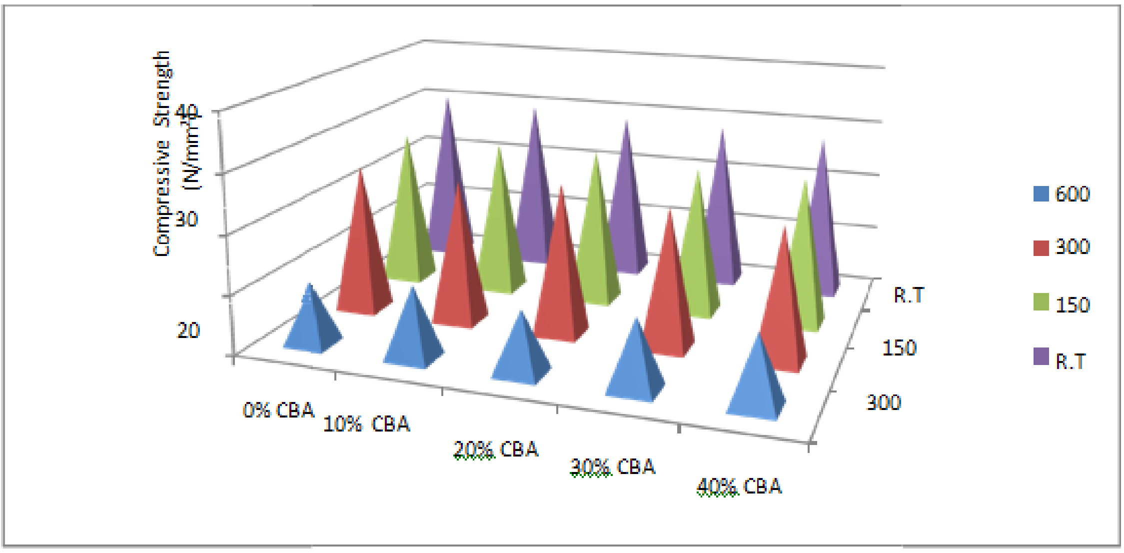

Figure 4.20: Compressive strength of concrete at different temperature ranges with

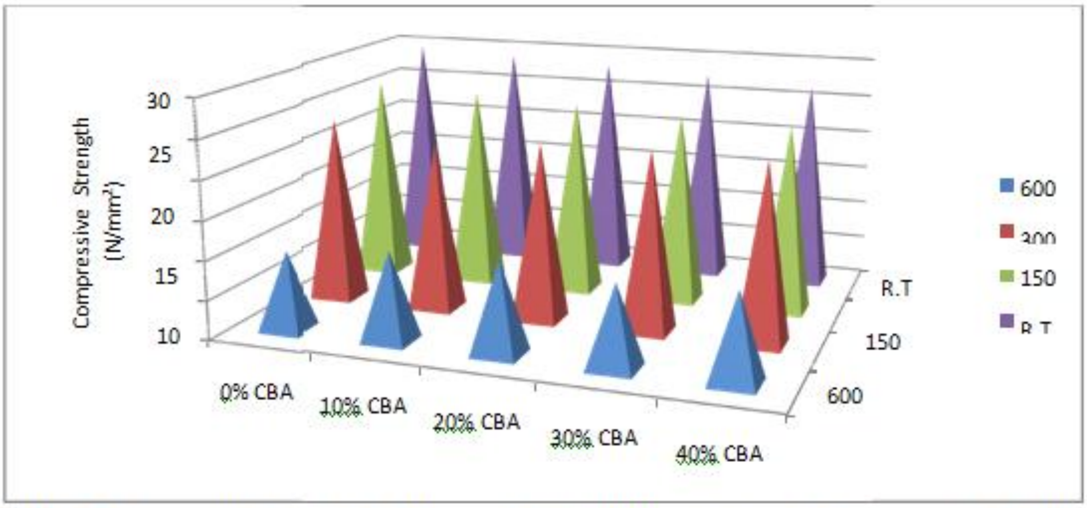

Figure 4.21: Compressive strength of concrete at different temperature ranges with different replacement levels of fine aggregates with cba and 20% scba

III. CONCLUSION

i) The workability of concrete decreases as scba and cba content increases. The slump value decreased from 110 mm to 45 mm with the inclusion of 40% cba and 20% scba.

ii) The compressive strength of concrete increases as scba content increases for all curing ages. The maximum improvement in compressive strength is at 10% of scba but beyond 10% replacement of scba, strength starts reducing. There is a significant reduction in compressive strength at 20% replacement of scba.

iii) The addition of cba decreases the compressive strength of concrete for all curing ages.

iv) As combination, cement can be replaced with scba up to 15% while fine aggregates can be replaced with cba up to 10% without any loss in strength of concrete. The combination of 10% scba and 10% cba is recommended to obtain higher strength and acceptable workability.

v) The contribution of scba and cba doesn't change the strength properties of concrete during heating. All concrete mixes reduce their strength when heated at higher temperature.

vi) The loss in strength is minor up to 150°c. The strength reduces between 7.1-12.9% whereas at 300°c, the reduction in strength is 22%.

vii) The serious deterioration has been found at 600°c. The concrete looses almost half of its original strength.

viii) Statistical analysis shows that the addition of scba and cba significantly affects the 14, 28 and 60 days compressive strength.

ix) On the basis of cost analysis, it is recommended to use these waste materials in concrete which provides potential environmental as well as economic benefits for concrete industries

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