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A Comparative Study of Compressive Strength Characteristics of Partially Replaced Fly Ash-Based Concrete with Nominal Concrete at Elevated Temperature.

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ABSTRACT
Concrete is one of the most extensively used construction materials. Due to growing environmental awareness and increasing interest in the use of fly ash concrete, knowledge of material properties at high temperatures is critical for evaluating the fire response of structures. This paper presents the experimental investigations on the effect of temperature on the compressive strength of fly ash concrete of M30 grade at the ages of 7, 14, and 28 days. Cement is replaced with 10,15, 20, 25 and,30% of fly ash at a temperature ranging from 27 to 200^{0}C with the aim of sustainability development; and compressive strength. Fly ash is a fine powder produced from industrial plants using pulverized coal or lignite as fuel. Experimental results of tests indicate that there is a significant increase in compressive strength at low temperatures and degradation at high temperatures.

I. INTRODUCTION:

Concrete is the most widely used man-made in the world, and is the second after water known to be the most utilized substance on the planet. It is obtained by mixing cementing materials, water, and aggregates, and sometimes admixtures required proportions. During the past few year strength concrete has increased interest among structural budding engineers in compressive strength, tensile strength, modulus of elasticity more stability, decrease in deflection, and improved durability. The use of high-strength concrete for construction, especially for multi-storeyed buildings has become common in developing countries Concrete of strength varying from 45 to 60 MPa has been used in high-rise buildings in Mumbai, Delhi, and other metropolitan cities and also employed in bridges and flyovers. Structural concrete may be exposed to elevated temperatures in the pavement of aircraft, oil wells nuclear reactors actors, fire accidents in buildings, etc. In such a situation, concrete should give better performance. The mixture when placed in forms all allowed to cure, hardens into a rock-like mass known as concrete. The hardening is caused by chemical reactions between cement and water and it continues for along time, consequently, the concrete grows stronger with age. The hardened concrete may also be considered as an artificial stone in which the voids of larger particles (coarse aggregate) are filled with the smaller particles (fine aggregate) and the voids of the fine aggregates are filled with cement. In a concrete mix, the cementing material and water from a paste called cement water paste, which in addition to filling voids of fine aggregate, coats the surface of fine and coarse aggregate and binds them together as it cures, thereby cementing the particles of the aggregate together in a compact mass. The strength, durability, and other characteristics of concrete depend upon the properties of the ingredients, the proportion of mix, the method of compaction, and other controls during placing, compaction, and curing. The popularity of the concrete is due to the fact that from the common ingredients. It is also possible to alsothe properties of Concrete to meet the demands of any particular situation. The images on Plate 2 describe the moldabilityof concrete in architectural forms. The advances in technologyhave proved the way to make the best use of the l0Caly available material by judicious mix proportioning and proper workmanship, so as to produce concrete satisfying performance requirements. The previous study involved studying the performance ofthe Strength of fly ash concrete replacing ordinary Portland cement with various percentages of fly ash when exposed to elevated temperature. Fly ash is a fine, glass-like powder recovered from the gases of coal-fired electricity production. Inexpensive replacement Portland cement improves strength, and segregation and is easy to handle. This paper presents a laboratory study on the strength development of concrete containing fly ash and the optimum use of fly ash in concrete. Fly ash was added according to the partial replacement method in mixtures. A total of 4 mixtures with one mix design were prepared. One of them was prepared as a control mixture with 360 kg/m3 cement. In each group 10% of the fly ash content of the control mixture was removed, resulting in the starting mixturehaving 360 kg/m3 cement content. Fly ash in the amount of approximately 10%. 20% and 30% of the rest of the fly ash content were added as partial fly ash replacement. All specimens were moist-cured for 7, 14, and 28 days before compressive strength testing. The efficiency and the maximum content of fly ash that gives the maximum compressive strength were obtained by using ordinary Portland cement. Hence, the maximum amount of usable fly ash amount with the optimum efficiency was determined. This study showed that strength increases with increasing amount of fly ash up to optimum value, beyond which strength starts to decrease with further addition of fly ash. The optimum value of fly ash for the one test group is ratio is about 10%, 15%, 20%, 25% and 30% important factors determining the efficiency of fly ash. 30% of cement. The fly ash/cement ratio is an important factor determining the efficiency of fly ash. It is well known that changes in temperature can produce stresses in Concrete structures of the order of magnitudes such as dead load and live load. However. The stresses due to temperature are produced only when thermal expansion or contraction is restrained (A Ghali et al., 2002). This will affect the strength of the concrete structures when the fire happens. The tensile strength of concrete in a fire decreases due to dehydration and thermal strain at high temperatures. Moreover, the moisture inside the concrete will evaporate. This combined with the low permeability of the high-strength concrete will produce high pressures. The pressure can be high enough to cause palling. With spalling pieces of concrete are chipped off, and in some cases, concrete members can even explode. When a structure is in fire, it tends to be subjected to higher temperatures until 1000°C. Concrete surfaces exposed to heat are significantly affected at elevated high temperatures or accidental fires. Large quantities of concrete exposed to the fire during the fire may spill off from the surface. This may failthe structure and material itself. t is important to consider the actual or realistic behaviour in the design of the strength of the material used to protect the structure when a fire occurs. Due to many cases of accidentsdue to concrete being subjected to high temperatures, it is seen that analytical, computation, and study are still not enough developed in concrete buildings exposed to high temperatures. Therefore, it is important to take into consideration thatdue to concrete being subjected to high temperatures, it is seen that analytical, computation, and study are still not enough developed in actual or realistic behaviour in the design of the fire protection to make the Structure safe from failure. This research was conducted to study the performance of high-strength difference concrete with two per cent of the fly ash and to determine the spalling and cracking effect due to high temperature.

II. MATERIAL:

2.1 Cement

Ordinary Portland Cement (OPC) is widely used in construction and building projects. To conduct this experimental study OPC 53 conforms to the Indian Bureau of Standards (BSI) specifications IS 12269-1987.The details specification of used cement is mentioned below in Table 1.

Table 1: Properties of OPC 53

Sl NO	Properties	Value
1	Fineness	98%
2	Specific gravity	3.146
3	Normal Consistency	32%
4	Initial setting time	141 min
5	Final setting time	204 min

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2.2 Fine aggregate

Fine aggregate is a crucial component in concrete. Fine aggregates generally help to fill the voids in concrete and create a compact dense mixture. Sand also helps to maintain the proper workability of concrete. There are various types of fine aggregate available in the market like natural sand and manufactured sand. To conduct this experiment natural river sand is used. The details properties of sand are listed below in Table 2.

Table 2: Properties of Fine Aggregate

Sl No	Properties	Value
1	Zone	ii
2	Specific gravity	2.69
3	Water absorption	0.8 %
4	Free surface moisture	0.2%

2.3 Coarse aggregate

Coarse aggregate consists of naturally occurring materials such as gravel, or resulting from the crushing of parent rock, including natural rocks, slag, expanded clays and shales (lightweight aggregates) and other approved inert materials with similar characteristics, having hard, strong, durable particles, conforming to the specific requirements of this section. Coarse aggregate is used in non-structural concrete applications or hot bituminous mixtures may also consist of reclaimed Portland cement concrete meeting the requirements. In this experimental work, natural granite stones are used as coarse aggregate and the details specifications are mentioned below in Table 3.

Table 3: Properties of CoarseAggregate

Sl No	Properties	value
1	Specific gravity	2.78
2	Water absorption	0.4%
3	Free surface moisture	Nil

2.4 Fly ash

Fly ash also known as flue ash, is one of the residues generated, in combustion, and comprises the fine particles that rise with the flue gases. Fly ash is a powdery substance obtained from dust collectors, whether they are electrical precipitators or bag houses, in electrical power plants that use ground coal or fuel. Two parameters determine the reactivity of fly ash, one is the mineralogy, and the second is the particle characteristics. The particles of fly ash range in size from 1-100 microns. Ash that falls to the bottom of the boiler's combustion chamber (commonly called a firebox) is called bottom ash. In modern coal-fired power plants, fly ash is generally captured by electrostatic precipitators or other particle filtration equipment before the flue gases reach the chimneys. Together with bottom ash removed from the bottom of the boiler, it is known as coal ash. Depending upon the source and composition of the coal being burned, the components of fly ash vary considerably, but all fly ash includes substantial amounts of silicon dioxide (Si02) (both amorphous and crystalline), aluminium oxide (Al203) and calcium oxide (Ca0), the main mineral compounds in coal-bearing rock strata.The minor constituents of fly ash depend upon the specific coal bed composition but may include one or more of the following elements or compounds found in trace concentrations (up to hundreds ppm): arsenic, beryllium, boron, cadmium, chromium, hexavalent chromium, cobalt, lead, manganese, mercury, molybdenum, selenium, strontium, thallium, and vanadium, along with very small concentrations of dioxins and PAH compounds. It also has unborn carbon. Fly ash material solidifies while suspended in the exhaust gases and is collected by electrostatic precipitators or filter bags. Since the particles solidify rapidly while suspended in the exhaust gases, fly ash particles are generally spherical in shape and range in size from 0.5 µm to 300 µm. The properties of fly ash used in this experimental work are mentioned below in Table 4.

Table 4: Properties of fly ash

Sl No	Properties	value
1	Colour	Grey
2	Bulk density	0.994
3	Specific gravity	2.2

2.5 Water

The water content and the minerals and chemicals dissolved in it are crucial to achieving quality concrete. Water is an inorganic, transparent, tasteless, odourless, and nearly colourless chemical substance, which is the main constituent of Earth's hydrosphere and the fluids of all known living organisms (in which it acts as a solvent). The water used in this experimental work hasa pH value of 6 to 8.

2.6 Super-plasticizer

The superplasticizerhas intrinsic high workability and modest strength requirements, and accelerators are not universally added to foamed concrete. However, they have been used to improve the workability of a foamed concrete mix or to achieve the same workability at a reduced w/c ratio. Little is known about the detailed effects of plasticizers, or indeed any other admixture, on the properties of the foamed concrete so dosage should be based on information from the manufacturer and the confirmation from trial mixes. They have very low w/c ratios used in LFC and are only possible because of the fluidizing power of high-quality third-generation super plasticizing agents. Plasticizers help up in increasing the workability of concrete without the addition of water. The lower water-cement ratio can be achieved without reducing the workability at the same cement content by using a plasticizer. It works as a dispersion agent releasing the water trapped in the flocks resulting in workability. Plasticizers are used for a moderate increase of workability and super plasticizers are used where a very large increase in workability is required. In practice, plasticizers are used in dosages for generating higher workability and better slump retention. On the retention of Sika, Sika pastorate super was selected as the most suitable for use. This is described as an aqueous modified carboxylate, designed specifically for ultra-high water reduction applications such as Self-compacting concrete.

2.7 Methods

This experimental work mainly focused on examining the compressive strength of concrete at an elevated temperature by replacing the cement with Fla ash. Generally, three combinations of the mixture of concrete were prepared by introducing fly ash with the replacing levels 10%,15% 20%,25% and 30% (FAC_{10},FAC_{15},FAC_{20},FAC_{25},FAC_{30}). The compressive strength of these concrete mixtures was tested at a high elevated temperature of 100^0 C and $200^0$with the help of a furnace.The test specimens of size (150 x 150 x 150) mm were prepared by confirming the code IS 516:1959. The mix design of concrete was prepared as per the guidelines set by IS 10262:2009 and IS 456:2000. The details of the mix proportions are given in Table 5.

Table 5 Mix details of FAC per m^3

Mix	Cement (kg)	FA (kg)	Sand (kg)	Water (kg)	Aggregate (kg)	
					20 mm	10 mm
PC	413	-	698	186	776	400
FAC_{10}	371	42	698	186	776	400
FAC_{15}	351	62	698	186	776	400
FAC_{20}	330.4	82.6	698	186	776	400
FAC25	309.75	103.5	698	186	776	400
FAC_{30}	289	124	698	186	776	400

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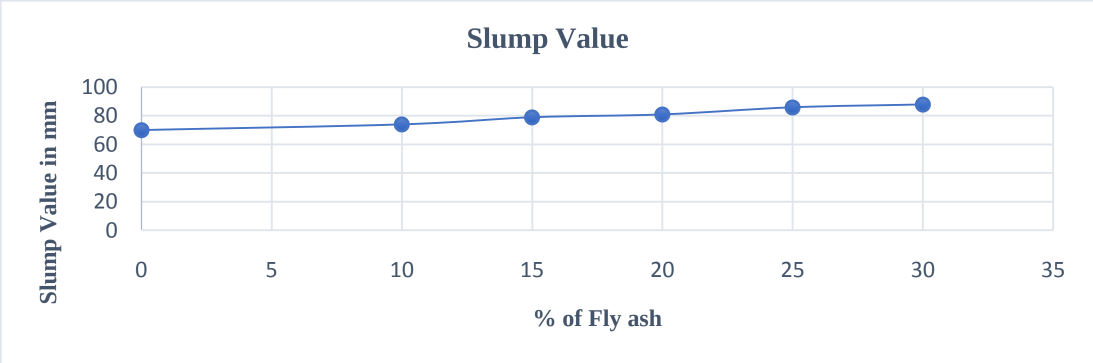
III. RESULTS AND DISCUSSION

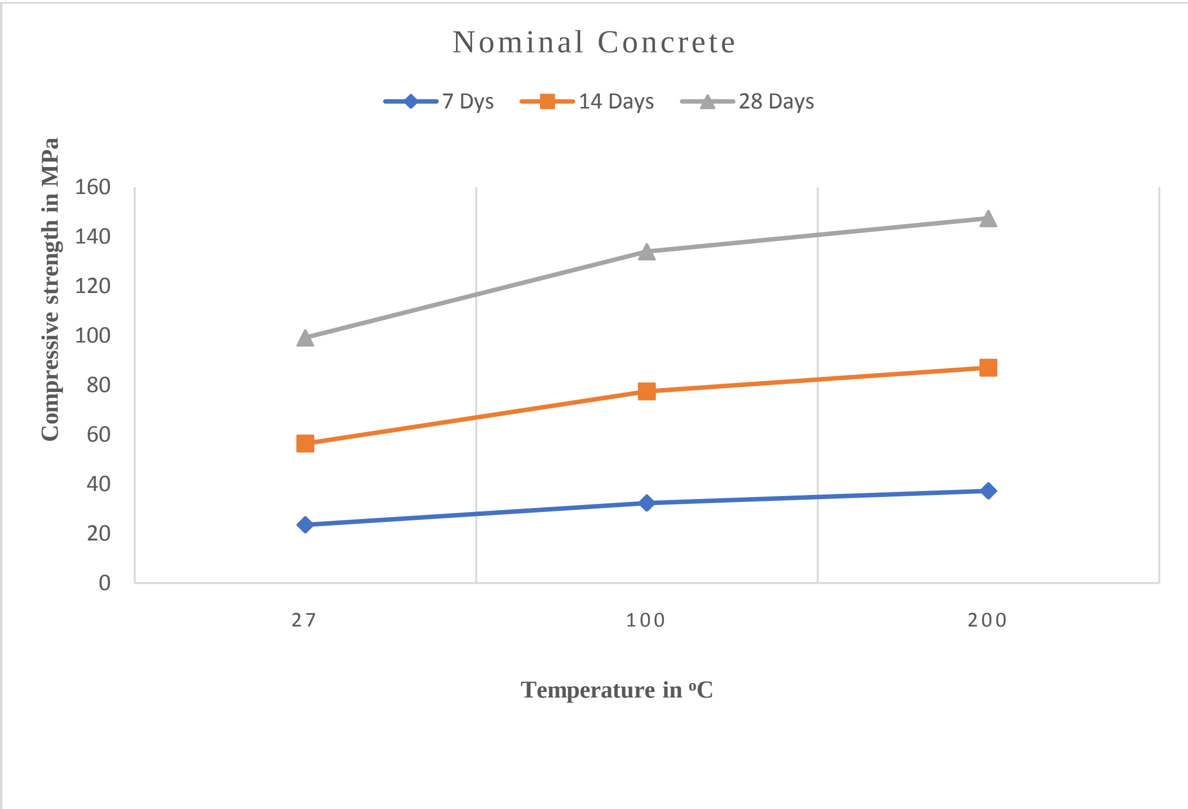
3.1 Slump Test:



The results show that the slump value increases with an increase in the percentage of fly ash content in the concrete.

3.2 Compressive Strength

Compressive strength achieved by concrete at 7 days is about 65% and at 14 days is about 90% of the target strength. Casting gains strength with time after casting. The rate of gain of concrete compressive strength is higher during the first 28 days of concrete. The comparative result of the compressive strength of different mixes with different fly ash amountsis shown in the below figures.



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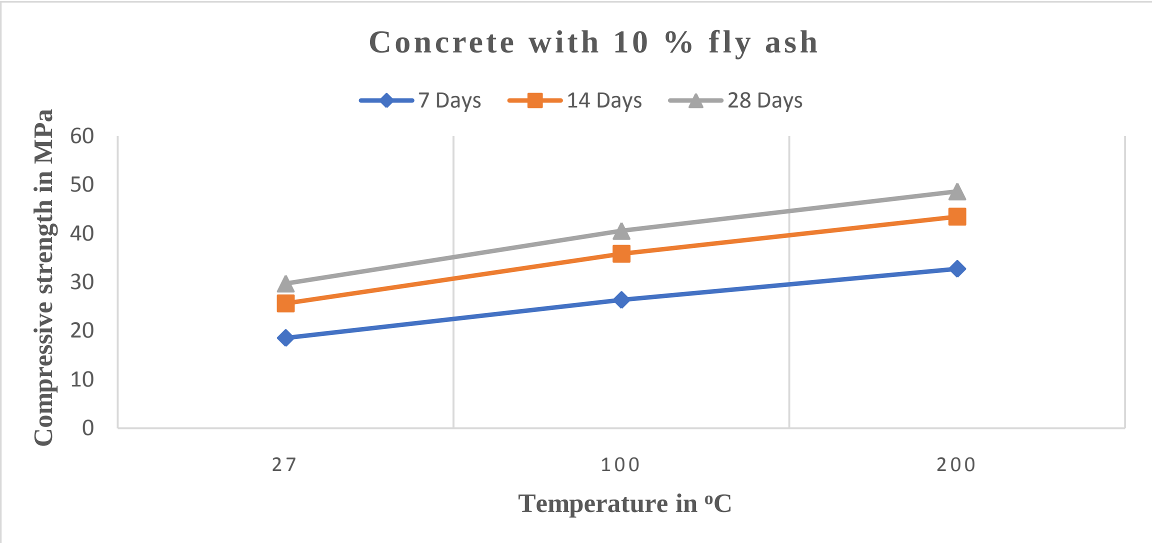

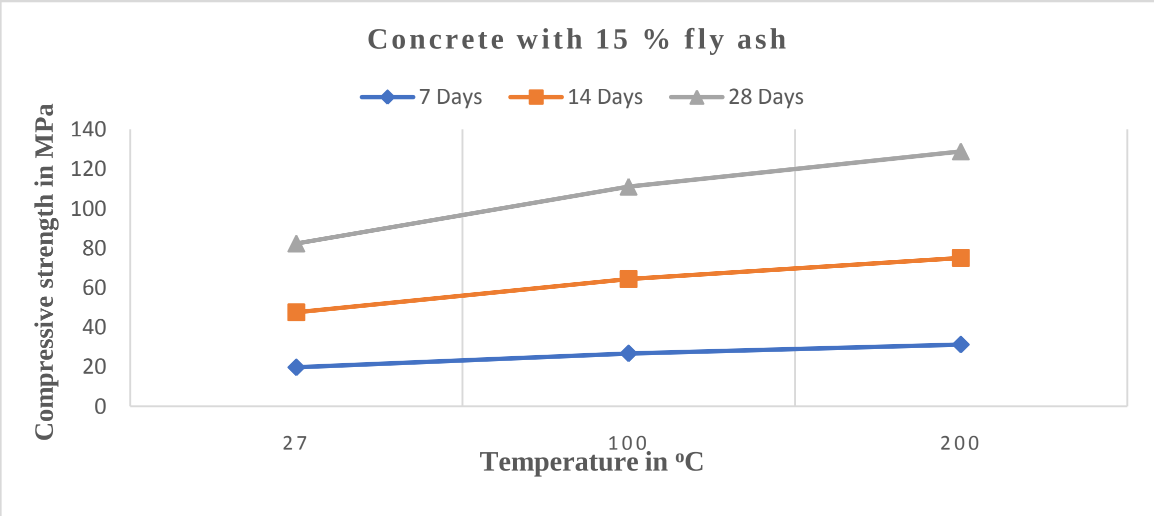

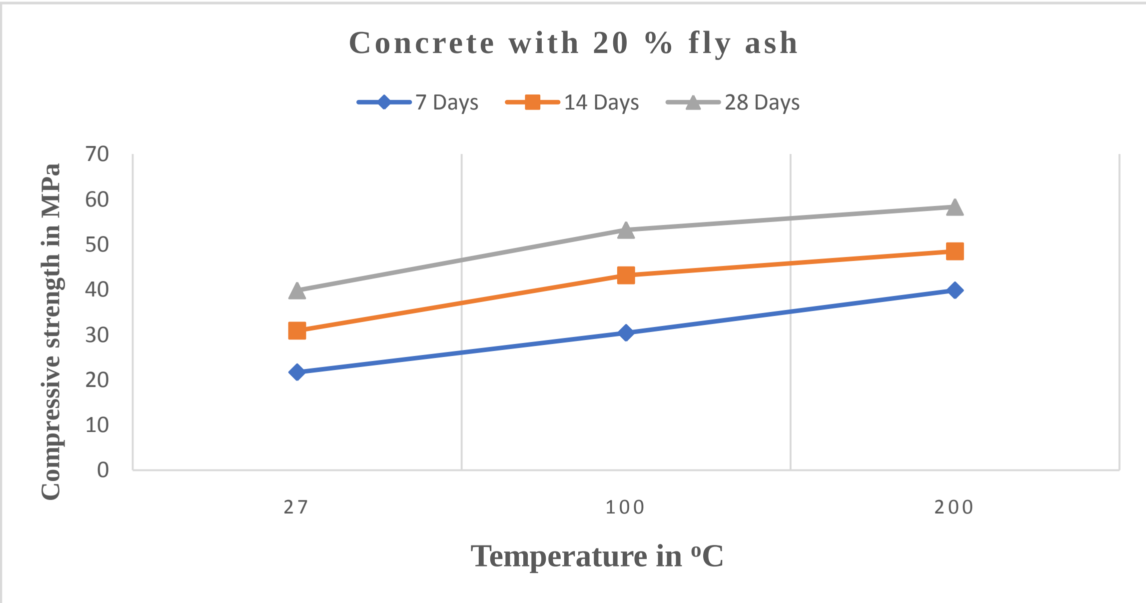

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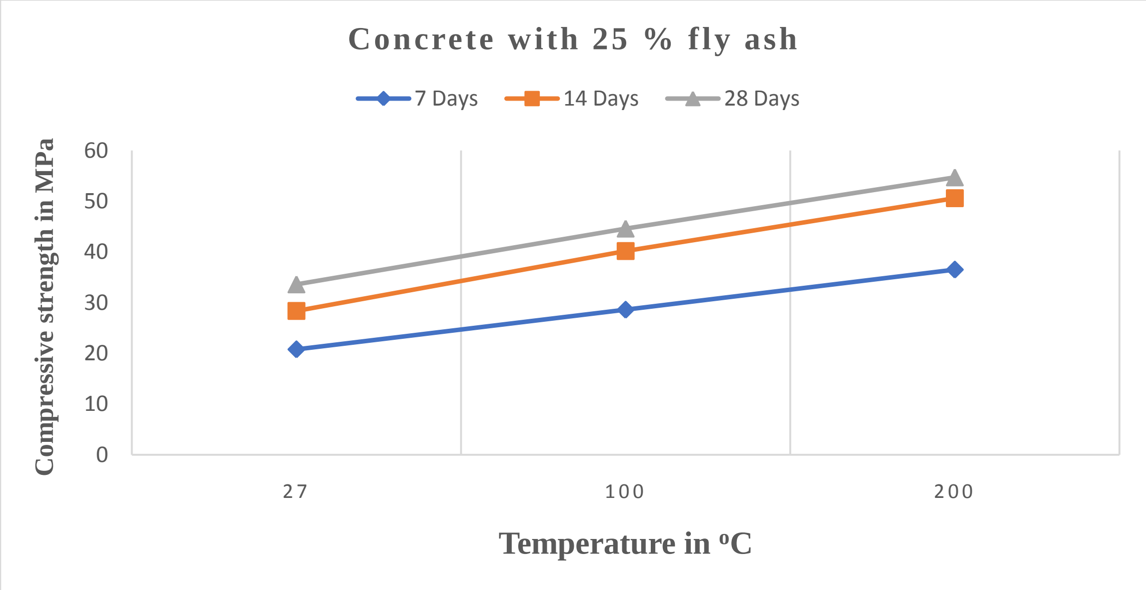

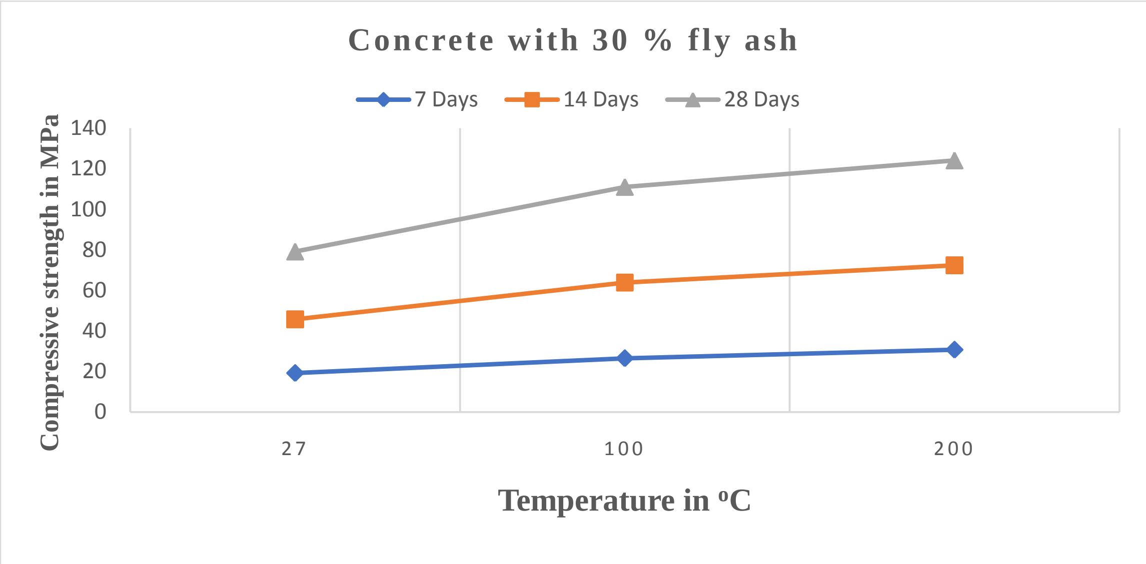

The Results show that, in the case of nominal concrete the compressive strength increased with increased with the temperature. The 7-day strength of concrete increased by 40 % when the temperature increased from 27^0 C to 100^0 C and increased by 30 % when the temperature rose from 100^0 C to 200^0 C. The same trend was observed for 14 and 28-day strength values. By adding 10 % (FAC_{10}) fly ash, the strength of the concrete is initially reduced as compared to the nominal concrete irrespective of the Temperature. Further, with increases in the fly ash content, the strength increased by 20 % as compared to the FAC_{10} mix concrete.FAC_{20} mix gives higher strength as compared to the other fly ash mix. The strength of the FAC_{20} mix is very close to the strength of the nominal mix concrete.

IV. CONCLUSION:

The following conclusion is drawn from the present experimental investigation on the behaviour of the impact of fly ash on the temperature and strength characteristics of concrete.The amount of fly ash directly affects the workability of the concrete. The strength of concreteincreases with an increase in temperature,but the rate of increase of strength is reduced with a rise in temperature. The addition of fly ash to the concrete reduced the strength and affected the water-cement ratio of the concrete. The FAC_{20} mix concrete with a fly ash content of 20% results in approximately a very close value of compressive strength as compared to nominal concrete. The present study recommends a 20% replacement of cement with fly ash gives satisfactory resultsin elevated temperatures. It also recommended that the rate of gain of strength decreases with elevated temperature, so this experiment can also be conducted at higher temperatures more than 200^0 C to check the temperature from which the strength of concrete starts falling.

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