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Study of Compressive Strength of Concrete at Elevated Temperature with Different types of Cement and grades of Concrete

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ABSTRACT
The concrete performance under fire conditions is one of the critical aspects that ensures their structural integrity and safety. This experiment investigates Concrete compressive strength subjected to elevated temperature, considering variations in cement types and concrete grades. The objective is to assess the impact of different types and grades on the fire resistance and other properties of concrete. The experimental program involved preparing concrete specimens using different varieties of cement, here we used Portland Pozzolana Cement (PPC) and Portland Slag Cement (PSC). Additionally, various concrete grades, including M20 and M30, were considered. These combinations provided a comprehensive evaluation of the effects of cement and concrete grade on compressive strength at elevated temperatures. A high-temperature chamber was employed to subject the concrete specimens to controlled thermal conditions. The temperature range chosen for this study was based on typical fire scenarios encountered in real-world situations. Compressive strength tests were conducted before and after the specimens exposed to high temperatures, and the results are compared to evaluate performance of different cement types and concrete grades. Preliminary findings disclosed that the compressive strength of different grades of concrete increased with increase in temperature for all cement types. PSC-based concrete exhibited higher compressive strength compared to PPC-based concrete. The results of this study have important implications for designing fire-resistant concrete structures and selecting appropriate cement types and concrete grades. The findings highlight the potential of incorporating supplementary cementitious materials in concrete formulations to enhance its fire resistance. The research outcomes contribute to improving the understanding of concrete behaviour under elevated temperature conditions and provide valuable guidance for the construction industry in developing fire-resistant structures and this study also helps us to decide type of cement.

1. Introduction

Indeed, concrete has a pivotal role in shaping the world we live in today. Its versatile behaviour and numerous benefits have made it a popular choice in construction over a period. The rediscovery of concrete in the 18th century and the subsequent invention of Portland cement by Joseph Aspdin marked a significant milestone in the development of this material. Since then, concrete has been widely used in various industrial and civil engineering projects, including bridges, dams, highways, buildings, and airports. The ability of concrete to mould into different shapes, sizes and qualities made it to choose over other materials. This flexibility allows for creative and innovative designs, enabling architects and engineers to bring their visions to life. Additionally, concrete has a relatively long lifespan and requires minimal maintenance, making it a cost-effective choice for construction projects. Concrete's strength under compression is another key advantage. It can withstand heavy loads and provides stability and durability to structures. Its non-combustible nature also adds to its appeal, making it a safer option in terms of fire resistance. However, concrete does have some limitations. Its tensile strength is relatively low compared to other building materials, which makes it susceptible to cracking under tension. To overcome this drawback, various techniques have been developed, such as reinforcing concrete with steel bars or fibers to enhance its tensile strength. Concrete also has a lower strength-to-weight ratio compared to some alternative materials, which may impact its use in certain applications where weight is a critical factor. Additionally, its low ductility means that concrete is less capable of undergoing large deformations without failure. Despite these drawbacks, the benefits of concrete have made it an indispensable construction material. Ongoing research and advancements in technology continue to improve its properties and address its limitations, ensuring that concrete remains a versatile and widely used substance in the construction industry.

2. Experimental Methods or Methodology

2.1 Materials

2.1.1 Cement

Cement is a crucial binding agent in concrete, composed mainly of calcium silicates that react with water during hydration. It forms a solid paste that binds aggregates together, creating a dense and cohesive material.

2.1.2 Manufactured Sand

Manufactured sand, also known as M-sand, is a fine aggregate produced by crushing hard rocks or granite. It offers several advantages over traditional river sand in concrete production. Manufactured sand has a specific particle size and shape, providing better interlocking properties in concrete.

2.1.3 Coarse aggregate

Coarse aggregates, which typically have a diameter between 3/8 and 1.5 inches, are defined as any particle larger than 0.19 inches. Gravel makes up the majority of the coarse aggregate used in concrete, and crushed stone comprises the majority of the remaining material. The term "coarse aggregates" refers to particles larger than 4.75mm.

2.1.4 Water

We used potable water that met the standards for water for concreting and curing specimens as specified by IS: 456-2000 and was readily available from local sources.

2.2 Methodology

A total of 24 cubes were casted. Out of which 6 were of M20 grade Portland Pozzolana Cement (PPC) cement, 6 were of M20 grade Portland slag cement (PSC), 6 were of M30 grade PPC and 6 were of M30 grade PSC. The mould of the beam was 150*150*150 mm. After casting the cubes are placed for 28 days of curing in curing tank. After curing 3 cubes of each grade and each type of cement are kept aside as specimen at room temperature. The rest of them are then placed in oven at 100 degrees Celsius for duration of time of 2 hours. Cubes are then placed in Compression testing machine and appropriate load is applied. The load is applied in such a manner that cube fails and the corresponding data is noted**.**

2.2.1 Weighing materials

The required quantity of materials for M20 and M30 grade concrete of both PPC and PSC are weighed according to the respective mix design.

2.2.2 Mixing of Concrete

According to the mix proportions obtained from the mix design, the calculated quantity of aggregates is taken. The mixing is done in a clean, non-absorbent and water tight platform by means of a trowel. Firstly, coarse aggregates are placed in the tray i.e., platform, thereafter the fine aggregates and cement have been placed into the platform. The dry mix is done thoroughly and at last the calculated

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weight of water as referred from water cement ratio is added to the mix and mixed continuously to achieve a uniform mix within 5 minutes.

2.2.3 Tests on fresh concrete

2.2.3.1. Slump Test

The objective of this test is to measure the workability of concrete mix of given proportions. It gives a hint as to the concrete mixture's fluidity and flowability, which is the essential for identifying whether the concrete is adequate for placing and reaching the desired construction specification. Slump values were within the range of 25 mm to 75 mm.

2.2.4 Mould preparation and Casting

The cube moulds need to be properly lubricated and thoroughly cleaned. To avoid any concrete mix leaking from the sides, it is crucial to make sure the mould fits tightly. The cube mould has dimensions of 150 mm by 150 mm by 150 mm.

Three equal layers of the concrete mixture are poured into the mould. A tamping rod with a 16 mm diameter, 0.6 m length, and bullet-pointed bottom end is used to compact each layer. The cross-section of the mould is evenly covered by the rod's stroke. For each layer, there are 25 strokes used in the compaction process. The following scoop of concrete is deposited, and the identical compaction process is then performed. The top layer is completed and vibrated at the end. Once the slurry covers the top surface of the specimen mould, the vibrating machine is turned off. The first 24 hours of room temperature storage are given to the moulds after casting in the steel mould. Following this time, the moulds are carefully demoulded to protect the edges before being placed in a curing tank at room temperature for a further 28 days of curing.

2.2.5. Curing of specimens

After casting of specimens, the specimen is placed in curing tank. The curing duration for 28 days. After curing for 28 days, cubes are then removed from the tank and exposed to 100˚C temperature for 2-hour duration. 24 cubes in total were casted, 6 each of M20 andM30 of both PPC and PSC, in which 3 of each grade were tested at ambient temperature and the rest 3 cubes kept at 100˚C for 2 hours in the oven and then removed from the oven and let them for air cooling for 24 hours.

2.2.6 Testing of specimens under Compression Testing Machine

The cubes are then removed from the oven and air-cooled at room temperature for a duration of 24 hours. 3 cubes of each grade and type of cement were tested for compressive strength at ambient temperature. And 3 specimens of each grade and type of cement were exposed to elevated temperature and then compressive strength test is conducted. The compressive strength of cubes subjected to high temperature is compared with the compressive strength of cubes at ambient temperature.

3. Results and Discussions

3.1 Failure load and compression strength of specimen tested under UTM

Table 3.1 Failure loads of M20 grade cubes tested under UTM(PPC)

	Failure loads(kN)	
Specimen	Room temperature	2 hrs (100°C)
1	650	695
2	665	685
3	650	725
Average	**655**	**701.6**

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Table 3.2 Failure loads of M20 grade cubes tested under UTM(PSC)

	Failure loads(kN)	
Specimen	Room temperature	2 hrs (100°C)
1	825	865
2	825	850
3	810	870
Average	**821.6**	**861.6**

Table 3.3 Failure loads of M30 grade cubes tested under UTM(PPC)

	Failure loads(kN)	
Specimen	Room temperature	2 hrs (100°C)
1	925	960
2	910	950
3	915	965
Average	**916.6**	**958.3**

Table 3.4 Failure loads of M30 grade cubes tested under UTM(PSC)

	Failure loads(kN)	
Specimen	Room temperature	2 hrs (100°C)
1	1090	1200
2	1075	1155
3	1090	1175
Average	**1085**	**1176.6**

Table 3.5 Compressive Strength of M20 grade cubes (PPC)

	Compressive Strength (MPa)	
Specimen	Room temperature	2 hrs. (100°C)
1	28.8	30.8
2	29.5	30.4
3	28.8	32.2
Average	**29.03**	**31.13**

Table 3.6 Compressive Strength of M20 grade cubes (PSC)

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	Compressive Strength (MPa)	
Specimen	Room temperature	2 hrs (100°C)
1	36.7	38.4
2	36.7	37.8
3	36	38.7
Average	**36.46**	**38.3**

Table 3.7 Compressive Strength of M30 grade cubes (PPC)

	Compressive Strength (MPa)	
Specimen	Room temperature	2 hrs (100°C)
1	41.1	42.7
2	40.4	42.2
3	40.7	42.9
Average	**40.73**	**42.6**

Table 3.8 Compressive Strength of M30 grade cubes (PSC)

	Compressive Strength (MPa)	
Specimen	Room temperature	2 hrs (100°C)
1	48.4	53.3
2	47.8	51.3
3	48.4	52.2
Average	**48.2**	**52.26**

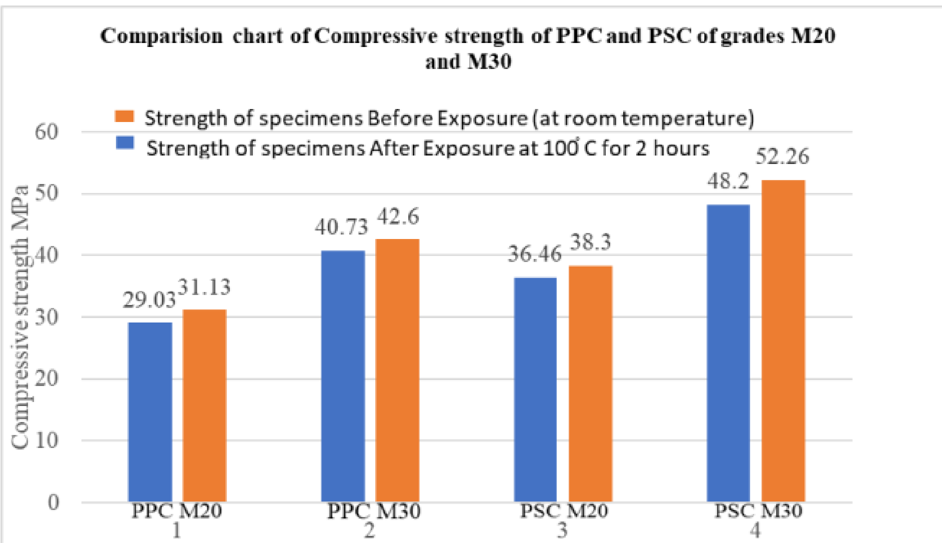

Fig.3.1. Comparision chart of Compressive Strength of PPC and PSC of grades M20 and M30.

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CONCLUSION

Based on the observations from the project performed, the compressive strength of concrete at increase in temperature is slightly increasing while compared to the compressive strength of concrete at room temperature. The increase in compressive strength when exposed to high temperature is because of rehydration process. Since temperature rise slightly more than room temperature concrete gains strength through the rehydration process of cement. However, the rate of hydration will be higher at very high temperature when exposed too long duration then the final strength will be reduced.

The compressive strength obtained from M20 grade of Portland Pozzolana Cement cubes are as follows:

• Strength of cubes subjected to 2 hours exposure at 100℃ was found to be increased by 7.23% compared to that of room temperature.

The compressive strength obtained from M20 grade of Portland Slag Cement cubes are as follows:

• Strength of cubes subjected to 2 hours exposure at 100℃ was found to be increased by 5.04% compared to that of room temperature.

The compressive strength obtained from M30 grade of Portland Pozzolana Cement cubes are as follows:

• Strength of cubes subjected to 2 hours exposure at 100℃ was found to be increased by 4.59% compared to that of room temperature.

The compressive strength obtained from M30 grade of Portland Slag Cement cubes are as follows:

• Strength of cubes subjected to 2 hours exposure at 100℃ was found to be increased by 8.42% compared to that of room temperature.

Since the percentage change in the compression strength at high temperature is less than 15% of the compressive strength of concrete at normal temperature, the variation can be ignored and considered as there is no variation in the compression strength of concrete at temperature of 100℃ when compared with the room temperature. Although there can be variations when concrete is exposed to extremely high temperature for a longer duration. This article concentrates on the DOS flood vulnerability in the infrastructure by employing an on-line infringement identification strategy where a specific DOS intrusion like SYN flood is regarded and the technique of scanning and filtration of system packets for the threat is implemented. Subsequently, the significant correlation between Processor utilization and used resources is presented where the excessive cumulative use of energy generated by a CPU-based DOS invasion decides the cyber hazard.

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