

# Study of Impact of Elevated Temperature on the Characteristic Strength of M30 Grade Concrete Based On Plasticizer

Nandita Suman<sup>1</sup>, Krishna Murari<sup>2</sup>

M.Tech, Department of Civil Engineering, B.I.T Sindri, Dhanbad, India<sup>1</sup>

Assistant Professor, Department of Civil Engineering, B.I.T Sindri, Dhanbad, India<sup>2</sup>

**ABSTRACT:** In this experimental study several steps of work has been included. Concrete cubes were made with plasticizer and without plasticizer are exposed to heat for 12 hours and as a result, undergo physical changes or spalling. This causes reduction of strength of concrete. Two concrete mixes were prepared one mix is with 2% plasticizer (sikament<sup>®</sup> 581) of cementitious material and another mix is without plasticizer and cubes were prepared in moulds. After 24 hours cubes were demoulded and they were put for curing for 7 days and 28 days. After required period of curing, residual compressive strength of concrete cubes without plasticizer were checked after exposure to heat in muffle furnace and the similar process is done with plasticizer also. The results show that rate of reduction of residual strength of concrete cubes with plasticizer after exposure to heat is less than that of the residual strength of concrete without plasticizer after exposure to heat. Therefore, this study has been carried out to generate experimental data on standard grade of concrete M30 and residual compressive strength of Concrete with and without Plasticizer after exposed to elevated temperature at 200°C, 400°C, 600°C, 800°C for 12 hours.

**KEYWORDS:** Super Plasticizer, Mix Proportioning, Slump Loss, Compressive Strength, Elevated Temperature.

## I. INTRODUCTION

In a limit heat is good but when the amount of heat increases in high it causes injury; damage the property, also its cause of death. In construction world of civil heat safety is necessary to taken in mind and mesures include those that are planned during the construction of a building or put in structures that are already constructed, and those that are tough to occupants of the building.

Under normal conditions, most concrete structures are subjected to a range of temperature no more severe than that imposed by ambient environmental conditions. But there are important cases where these structures may be exposed too much higher temperatures for example fire buildings, chemical and metallurgical industrial application in which the concrete is in close.

Concrete's thermal properties are most complex than for most material because not only is the concrete a composite material whose constituents have different properties, but its properties also depend on moisture and porosity. Exposure of concrete to elevated temperature affects its mechanical & physical properties. Elements could spall distort and displace, and, under certain conditions, the concrete surface could spall due to the buildup of steam pressure. Because thermally induced dimensional changes, loss of structural integrity, and release of moisture and gases resulting from the migration of free water could adversely affect plant operations and safety, a complete understanding of the behavior of concrete under long-term elevated-temperature exposure as well as both during and after the thermal excursion resulting from a postulated design basis accident condition is essential for reliable design evaluations and assessments. Because the properties of concrete change with respect to time and the environment to which it is exposed, an assessment of the effects of concrete aging is also important in performing safety evaluations. Presented in the following sections of this report is a review of the effects of elevated-temperature on concrete material, concrete

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materials for elevated-temperature service, code and design considerations for reinforced concrete structures exposed to elevated temperature, and the performance of selected structural members subjected to elevated temperature.

Generally, concrete structures have a very good heat resistance. Although damage to the concrete gradually appears with increasing temperature, it is possible to repair the structure after an adequate assessment. To do this in systematic way, knowledge is necessary concerning residual material properties, methods to assess the strength and calculation techniques.

## Residual Strength:

The remaining compressive strength after a heat is influenced by different parameters. First of all, the heating conditions, such as heating rate, duration at target temperature and the presence of an external load are of importance.

## Spalling:

Spalling is a physical process of the breakdown of surface layers of masonry (typically concrete) which crumble into small pebble-like pieces in response to high temperatures and/or mechanical pressure. The physical appearance of spalling may also include striated lines, discoloration of the masonry and pitting or rough texture to the concrete that remains attached to the slab. Spalling is caused by heating, mechanical pressure, or both. This heat and/or pressure cause uneven expansion of the materials that make up the concrete (such as sand and gravel), the reinforcing steel and concrete mix, or the surface and subsurface layers of the concrete. Alternatively, the heat may release the water in the concrete. Pressure created by rapid changes in temperature, such as application of cold water to the heated concrete surface during firefighting operations, can also cause spalling. These processes break the bond that holds the solids together and thus cause the concrete to crumble.

## Type of spalling:

There are mainly three type of spalling:-

Explosive spalling- This type of spalling occurs during the early part of a fire, usually within the first 30 minutes or so of a standard furnace test.

Surface spalling- This type of spalling is associated with local removal of surface material including, pitting and blistering. Surface spalling may result in exposure of the reinforcement.

Post cooling spalling- This is a non-violent process with no sound and is caused by carbonate aggregates in limestone expanding on re-hydration during the cooling phase of fire.

## Plasticizer:

The earliest known published reference to the use of small amount of organic material to increase the fluidity of cement contains composition was made in 1932 where polymerized naphthalene formaldehyde sulphonate salts, were claimed as useful in this role. This was followed during the mide 1930s to early 1940s by numerous disclosures regarding the use of lignosulphonate and improved composition. In recent years, construction agencies in North America, Great Britain and other countries have evinced great interest in the use of super plasticizers, super fluidifiers, and sipper water reducers. The super plasticizer are referred to as high range water reducing admixture by ASTM C 494, which mainly disperser the water in concrete matrix. This property is some time called as dispersion- fluidification property of concrete admixture. According to the United Nations, there will be at least 20 megacities of more than 10 millions habitants in the years 2025. These cities will require large amount of construction material for buildings and municipal infrastructures as well as for facilities necessary to food, drinking water and sewage.

A good plasticizer fluidizes the mortar or concrete in a manner different from that of the air-entraining agents. Many of the plasticizer, while improving the workability, also entrains some air. A good plasticizer is the one, which does not entrain air more than 1% to 2%.

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## II. LITRATURE REVIEW

Effect of Plasticizer and fire or heating effect on the strength of concrete:

**Dr. Salahaldeen Alsadey et al** has outlined an experimental study that measures the effects of super plasticizer on proprieties of M30 grade concrete. However, Super plasticizers are the most important admixtures enhancing concrete performance. Hence, an experimental investigation was conducted to determine the optimum dosage for the admixtures and to study the effect of over dosage of the mentioned. Concrete mixes with SP dosages of 600, 800, 1000 and 1200 ml/100kg of cement were prepared, together with one control mixes. After casting, normal curing was carried out on the concrete samples. Properties such as compressive strength were determined, besides determining the workability of the fresh concrete. However, compressive strength is improved by dosage 1.0 % of SP after 28 days curing is 55 N/mm<sup>2</sup>, which is higher than that of control concrete, the optimum amount of admixture must be 1 %. Over dosage of SP found to deteriorate the properties of concrete with indication of lower compressive strength. However, if the dosage levels are lower than the optimum dosage, increase in admixture dosage help to enhance the concrete characteristics

**Roshan Tamrakar et al (2013)** has investigated the research program on three different families of super plasticizers. Rheobuild 1125(Sulphonated naphthalene polymer based) Glenium 140 (Polycarboxylic ether polymers) Pozzolith 225 (Modified lignosulphate) Two design ratios of M20 and M40 grade were used for mix proportioning of concrete constitute by weight. The water cement ratio were maintained as 0.55, 0.40, to study the effect of these super plasticizer on various properties of concrete. The dosages of super plasticizer were adopted as 0.25% by weight of cement. To study the effect of super plasticizer the experiment has been divided into four series namely workability series, water reduction series and cement saving series, compressive strength.

**Venu Malagavelli and Neelkanteswara Rao Paturu (2012)** has investigation on M30 grade concrete is used as a control mixture with four different super plasticizers namely SNP (Sulphonated Naphthalene Polymer) 1, SNP 2, SNP 3 and SNP 4. Strength of modified concrete is compared with the normal concrete i.e. without super plasticizer. The results show that the significant improvement in the strength and workability of modified concrete.

**Rathan Raj et al (2007)** suggested that High-Reactivity Metakaolin and Alumina Red Mud in dry densified form can be used for the partial replacement of cement and super plasticizer. Platy shaped HRM and ARM in small percentage improved the mechanical and durability characteristics of concrete. Super plasticizer improved the workability of concrete and made possible to get sufficient workable concrete of lower water cement ratio. They reported that, out of the various percentages of HRM and ARM as super plasticizer, the concrete with 8 % replacement of cement with super plasticizer gives better results. Based upon the experimental investigation carried out, the following conclusions were drawn.

- Concrete with 8% replacement of HRM and ARM behaved better than the concrete without any super plasticizer
- Addition of HRM and ARM replaced cement in concrete improved the corrosion resistance of the concrete without any reduction in compressive strength.

**Ramazan Demirbog and Rustem Gul (2007)** investigated the use of Blast furnace slag aggregates (BFSA) to produce high-strength concretes (HSC). These concretes were made with total cementitious material content of 460–610 kg/m<sup>3</sup>. Different water/cement ratios (0.30, 0.35, 0.40, 0.45 and 0.50) were used to carry out 7- and 28-day compressive strength and other properties. Silica fume and super plasticizer were used to improve BFSA 20 concretes. Slump was kept constant throughout this study. Ten percent silica fume was added as a replacement for ordinary Portland cement (OPC) in order to obtain HSC. Results showed that compressive strength of BFSA concretes were approximately 60–80% higher than traditional (control) concretes for different water cement ratios. These concretes also had low absorption and high splitting tensile strength values. Therefore, it was concluded that BFSA, in combination with other supplementary cementitious materials, can be utilized in making high strength concretes.

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**M.Potha Raju et al** carried out a study aimed to study the effect of elevated temperatures ranging from 50 to 2500C on the compressive strength of high-strength concrete (HSC) of M60 grade made with ordinary Portland cement (OPC) and pozollana Portland cement (PPC). Tests were conducted on 100 mm cube specimens. The specimens were heated to different temperatures of 50,100,150,200 and 2500C for three different exposure durations of 1, 2 and 3 h at each temperature. The rate of heating was maintained as per ISO-834 temperature-time curve for standard fire. After the heat treatment, the specimens were tested for compressive strengths. Test results were analysed and the effects of elevated temperatures on PPC concrete were compared with OPC concrete. The PPC concrete exhibited better performance than OPC concrete.

### III. EXPERIMENTAL DETAILS

Material used:

Cement: Portland Pozzolana cement was used of IS 1489.

Fine Aggregate: Fine Aggregate consisting of natural sand obtained from nearest river of B.I.T Sindri.

Coarse Aggregate: Locally available coarse aggregate obtained from nearest quarry. Consisting naturally crushed rock of nominal maximum size 20mm

Step 1: Design of grade M30 mix prepared in the lab as per IS 10262:2009 with plasticizer and without plasticizer.

Step 2: To investigate the effect of Super plasticizers on workability slump tests were carried out and to check the slump loss within time is observed.

Step 3: To investigate impact of elevated temperature on compressive strength cubes [15×15×15] with and without plasticizer were tested at the ages of 7, 28 days. The results are shown in Table.

### IV. RESULT AND ANALYSIS

In this experimental work to find impact of elevated temperature on the characteristic strength with (2% sikament<sup>®</sup>581 of the weight of cementitious material) and without plasticizer of concrete with the help of compression testing machine after exposure to different fixed heat 200°C, 400°C, 600°C, 800°C in muffle furnace. This result also shows that strength reduction between 0°C to 200°C is very less, but after that temperature strength gradually reduced.

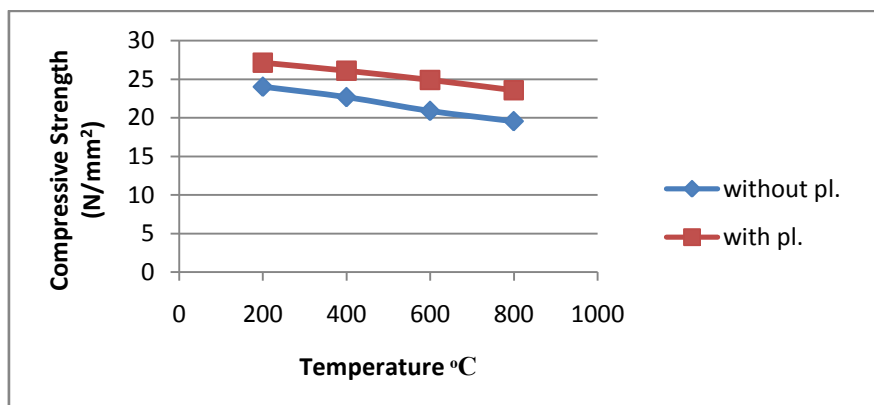


Table 1: Residual strength of concrete without plasticizer and with plasticizer after 7 days after exposure to heat for 12 hrs. This table shows that after exposure to heat concrete with plasticizer having less strength reduction then concrete with plasticizer.

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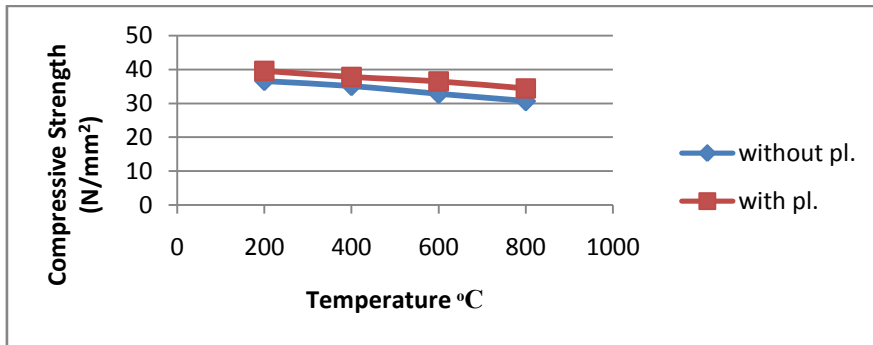


Table 2: Residual strength of concrete without plasticizer and with plasticizer after 28 days after exposure to heat for 12 hrs. This table shows that after exposure to heat concrete with plasticizer having less strength reduction then concrete with plasticizer.

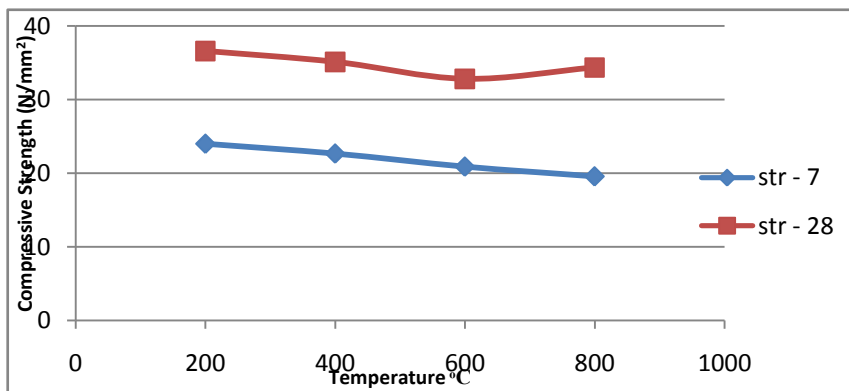


Table 3: Residual strength of concrete without using plasticizer after exposure to heat for 12 hrs. (After 7 days 28 days). This table shows that impact of elevated temperature on characteristic strength of concrete at 7 days having more reduction of strength as compared to 28 days.

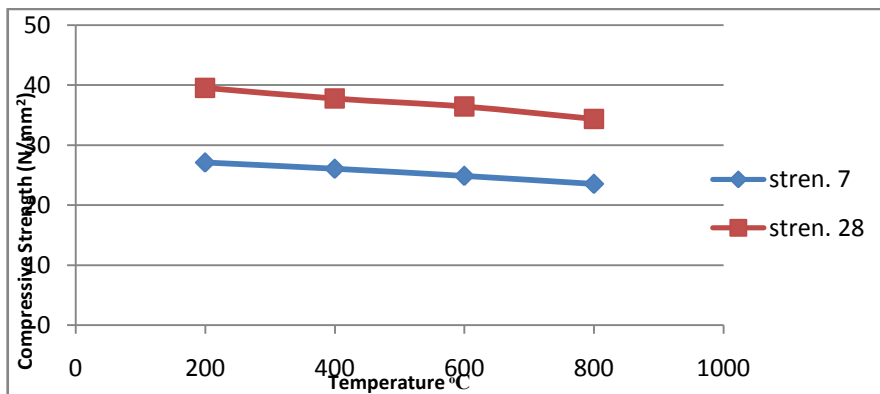


Table 4: Residual strength of concrete with plasticizer after exposure to heat for 12 hrs. (After 7 Days and 28 days). This table shows that impact of elevated temperature on characteristic strength of concrete at 7 days having more reduction of strength as compared to 28 days.

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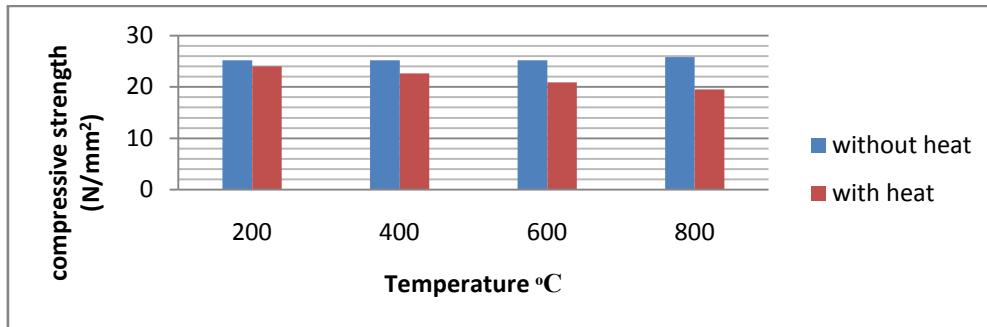


Table 5: Comparison of strength of concrete with exposure to heat and without exposure to heat after 7 days without plasticizer. This table shows that as we increase the temperature strength of concrete decreases gradually.

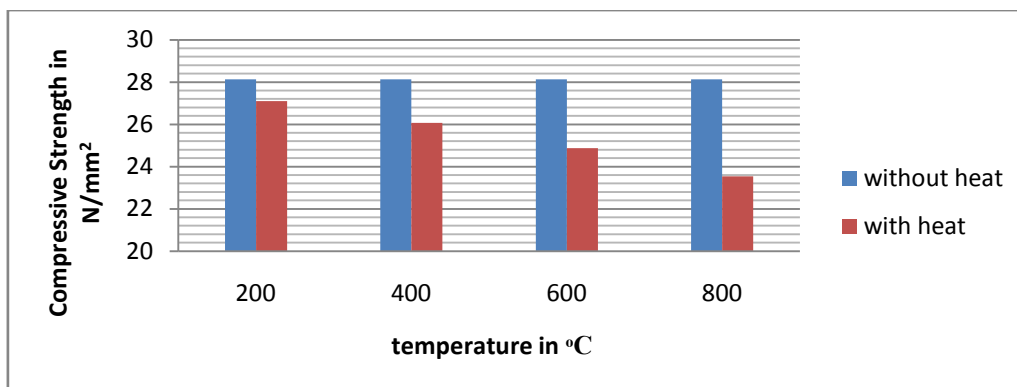


Table 6: Comparison of Strength of Concrete Before and After Exposure to heat after 7 Days with Plasticizer. This table shows that as we increase the temperature strength of concrete decreases gradually.

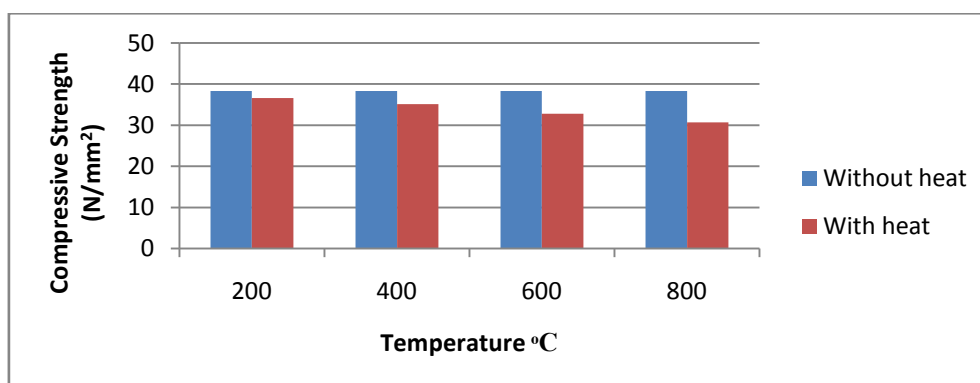


Table 7: Comparison of Compressive Strength of Concrete Before and After Exposure to Heat at 28 Days without Plasticizer. This table shows that as we increase the temperature strength of concrete decreases gradually.

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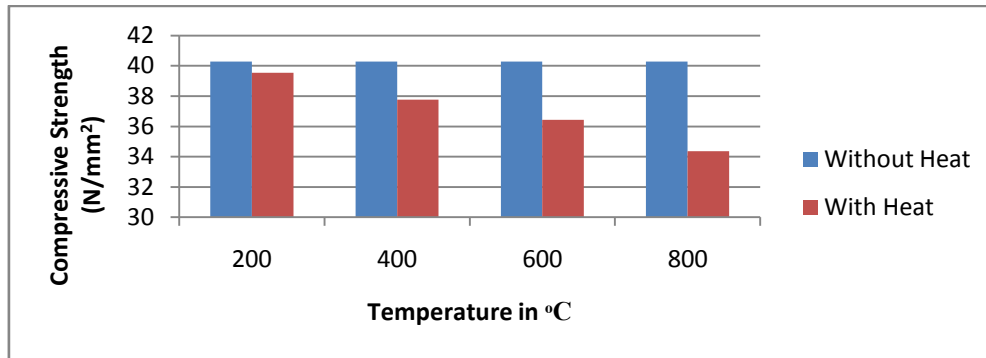


Table 8: Comparison of Compressive Strength Before and After Exposure to Heat at 28 days With Plasticizer. This table shows that as we increase the temperature strength of concrete decreases gradually.

### V. CONCLUSION

On the basis of previous results and discussions following conclusions can be drawn. In general the compressive strength of concrete cubes with plasticizer and without plasticizer reduced substantially when heated to elevated temperature. These results indicate that the residual strength of concrete may be hazardous to sustain the initial design loads.

Following conclusions are given below:

1. The reduction in strength of concrete cubes after exposure to heat is going to decrease.
2. The cubes made without using plasticizer show greater reduction in strength than that of the cubes which are made with plasticizer.
3. From above result, it is clear that concrete cubes which are made with plasticizer are most effective to resist the exposure to heat. Reduction of compressive strength after exposure to heat is less. So, concrete made with plasticizer resist the heat more than that of concrete made without plasticizer.

It is expected that the results will be helpful for the design engineers when designing for heat resistance of concrete structures.

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