*Orinigal Article*

# Relative Comparison of Fire Resisting Capacity between Stone Aggregate Concrete and Brick Aggregate Concrete

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**Abstract:** The use of concrete as a construction material has become increasingly popular due to its high compressive strength and durability. However, concrete can be affected by fire exposure, which can significantly weaken its strength and structural integrity. Fire resistance is a critical aspect of construction materials, particularly in ensuring the safety and structural integrity of buildings during fire incidents. This study focuses on comparing the fire-resisting capacities of stone aggregate concrete and brick aggregate concrete. Factors such as mix design, material qualities, and the duration and severity of the fire are considered as potential influences on the performance of the concrete. The stone chips (LC stone), brick chips (1st class), Sylhet sand, and Portland Composite Cement (PCC) were collected. Secondly, property tests of all the materials were conducted. After performing all property tests, 21 cylinders for each coarse aggregate were built in the third phase, and they were curing for 28 days. In the fourth phase, after 28 days of curing, the compressive strength test of three specimens of each aggregate at room temperature was conducted. After that, 12 samples of each aggregate were subjected to fire at varying temperatures and for a variety of time periods. Through experimental analysis and comparative study, the research findings indicate that stone aggregate concrete exhibits greater strength retention after exposure to fire compared to brick aggregate concrete. This can be attributed to the better thermal insulation properties of stone aggregates, enabling them to withstand thermal stress more effectively than brick aggregates. This study highlights that stone aggregate concrete provides better fire resistance due to its superior thermal insulation properties compared to brick aggregate concrete. The research outcomes contribute to the understanding of the relative fire-resistant capacities of these materials, enabling informed decision-making in the selection of construction materials for fire-resistant application.

**Keywords:** concrete, fire exposure; strength

## 1. INTRODUCTION

The use of concrete as a construction material has become increasingly popular due to its high compressive strength and durability. However, concrete can be affected by fire exposure, which can significantly weaken its strength and structural integrity. In the field of construction, ensuring the fire safety of structures is of paramount importance (Daware et al., 2021). Fire incidents can lead to catastrophic consequences, endangering human lives, damaging property, and causing significant economic losses. Therefore, the selection of suitable construction materials with high fire-resisting capacity is crucial for the design and construction of fire-resistant buildings (Chakradhara, 2021). In this context, the relative comparison of stone aggregate concrete and brick aggregate concrete strengths before and after being exposed to fire is an important area of research. Aggregate is a key component in the production of concrete, and the choice of aggregate type can impact its strength and resistance to fire. Stone and brick aggregates are commonly used in the production of concrete, and their properties can affect the strength of the resulting concrete under normal conditions and after being exposed to fire (Islam et al., 2021). Understanding the relative fire-resisting capacities of stone aggregate concrete and brick aggregate concrete is essential for selecting the most appropriate material in fire-prone environments. Therefore, a comparative analysis of the strength of concrete made with stone and brick aggregates before and after being exposed to fire can provide insights into the suitability of these materials for use in construction projects in fire-prone areas (Biró, 2021). Such research can inform decisions about the selection of the most appropriate aggregate type and help improve the fire resistance of concrete structures. Fire is one of the greatest threats to concrete. Numerous buildings and structures lose structural integrity due to fire. A greater magnitude or higher temperature for a longer time will inflict the most damage to concrete buildings or perhaps cause their collapse. The fire-related damages to the concrete are (reduction of concrete strength, spalling, net-like cracks, crumbled plasters, bared or visible reinforcement) can be determined (Hachemi, 2023). Reinforced concrete constructions naturally resist fire better than steel and wood structures. Rapid heating of concrete has always presented some degree of danger. The database of data from fire tests and fires upon which our knowledge of the fire resistance of concrete is built includes, to a certain extent, the influence concrete fire strength (Sachin, 2020). Determining the strength of concrete before and after exposure to fire and comparing the two situations on a relative basis can be a new scope for research. Our study will help determine which aggregate concrete may be utilized to withstand fire exposure and achieve greater concrete strength after exposure to fire (Zhang et al., 2024).

## 2. LITERATURE REVIEW

As a result of variables such as higher thermal stability, lower thermal conductivity, denser structure, and lower porosity, stone aggregate concrete is generally in a better position to withstand fire than brick aggregate concrete, according to a study (Singh et al. 2018). This is because stone aggregate concrete has a higher density than brick aggregate concrete. Certain testing involved exposing concrete specimens to elevated temperatures and observing how they reacted when exposed to fire. The purpose of these tests was to determine the fire resistance of stone aggregate concrete and brick aggregate concrete (Li et al. 2019). The ASTM E119 Standard Test Methods for Fire Tests of Building Construction and Materials is a standard that gives instructions for conducting fire tests on building materials, including concrete, in order to evaluate the fire resistance of these materials. In order to determine the thermal conductivity of concrete samples, a thermal conductivity metre was utilized (Islam et al., 2021). Additionally, for finite element analysis (FEA), the following was performed: For the purpose of simulating and analysing the structural reaction of concrete elements that were subjected to fire, finite element analysis (FEA) software was utilised. This allowed for a comparison to be made between stone aggregate concrete and brick aggregate concrete (Li et al., 2019). Stone aggregate concrete was used. Stones such as granite, limestone, basalt, and gravel were used as coarse aggregates in stone aggregate concrete. Crushed bricks or brick chips were used as coarse materials in brick aggregate concrete (Singh et al., 2018). Stone aggregate concrete was more commonly utilised than brick aggregate concrete. Exposure to fire, stone aggregate concrete and brick aggregate concrete both undergo a decrease in compressive strength. This is due to a number of variables, including the loss of moisture, thermal expansion, and chemical changes. When exposed to fire for a longer period of time and at a higher temperature, the intensity of the strength loss, spalling, and cracking behaviour can vary. (Bai et al., 2017). The first condition was for one hour at temperatures of 100, 200, 300, and 400 degrees Celsius, while the second condition was for thirty minutes, sixty minutes, ninety minutes, and one hundred and twenty minutes at a constant temperature of 600 degrees Celsius ) (Wang et al., 2020). One hour at 400 degrees Celsius caused the 1:2:4 concrete mix specimens to lose 16.04% of their strength, while two hours at 600 degrees Celsius caused them to lose 85.96% of their strength. After being heated to 600 degrees Celsius for two hours, the specimens of the 1:3:6 concrete mix saw a maximum decline in strength of 73.61%, while the strength loss from room temperature to 400 degrees Celsius was 19.63% (UK) (Wróblewska & Kowalski, 2020). For the purpose of increasing the fire resistance of concrete, several fibres, including polypropylene, steel, and glass, have been explored as potential additives (Hachemi, 2023). According to Ganesan et al. (2008), the incorporation of fibres can assist in mitigating the loss of strength that originates from fire-induced spalling and cracking. In order to enhance the fire resistance of concrete, fly ash, silica fume, and slag have all been subjected to extensive research and have been utilised. Based on the findings of Wang et al. (2020), the utilisation of these materials results in an enhancement of the pore structure and a reduction in the calcium hydroxide content of concrete, which ultimately leads to an enhanced retention of strength following exposure to fire. For the purpose of enhancing the post-fire strength of concrete, superplasticizers and setting accelerators have been the subject of research (Song et al., 2020). These admixtures have the ability to increase the bonding between aggregates and cement paste, as well as boost workability and minimise porosity. This ultimately leads to improved strength retention (Gu et al., 2015).

## 3. MATERIALS & METHODS

The stone chips (LC stone), brick chips (1st class), Sylhet sand, and Portland Composite Cement (PCC) were collected. Secondly, property tests of all the materials were conducted. After performing all property tests, 21 cylinders for each coarse aggregate were built in the third phase, and they were curing for 28 days. In the fourth phase, after 28 days of curing, the compressive strength test of three specimens of each aggregate at room temperature was conducted. After that, 12 samples of each aggregate were subjected to fire at varying temperatures and for a variety of time periods. Finally, the relative compressive strength of the cylinder specimen before and after fire exposure was determined. In the fifth phase, the tensile split test for three specimens of each coarse aggregate concrete at room temperature was conducted. Then, for each coarse aggregate concrete specimen, three specimens were subjected to fire at the maximum temperature of 250°C for a maximum time of 8 hours, and the tensile split test was performed on those specimens. Finally, the relative tensile strength of the cylinder specimens before and after fire exposure was determined.

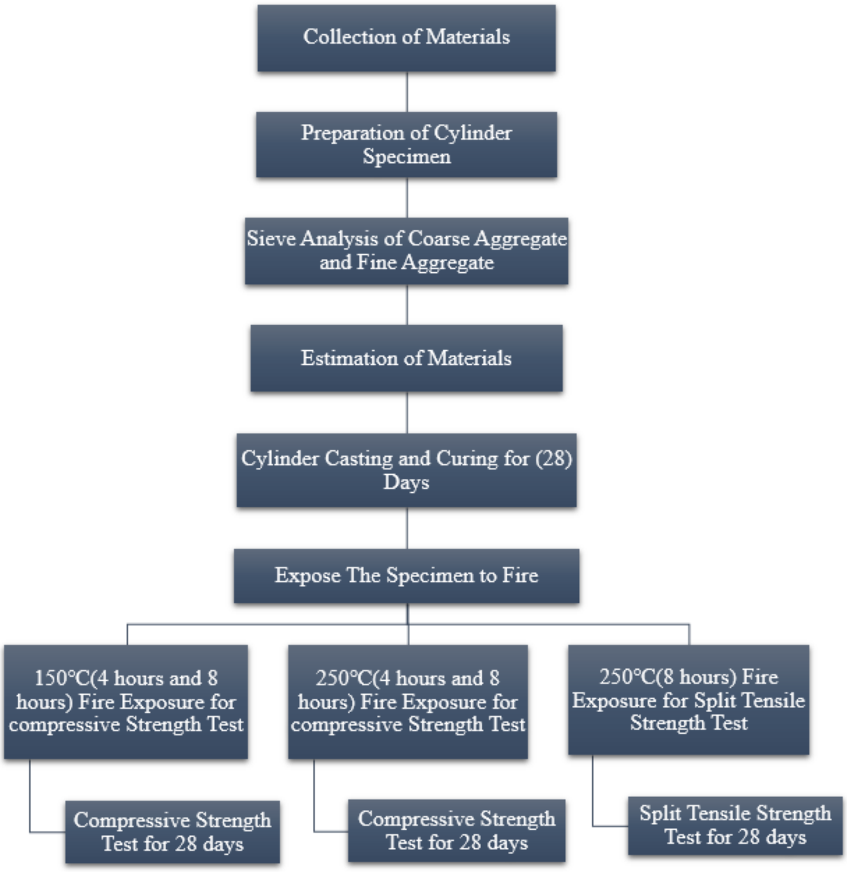


**Figure 01:** Flow chart of activities

First, the fine aggregate was prepared for sieve analysis. In this study, standard test method ASTM C136 was followed for sieve analysis of fine aggregate. Fine aggregates should be passed through a 4.75-mm sieve and retained at a 0.15-mm sieve, according to ASTM C136, and the fineness modulus of fine aggregates ranges from 2.3 to 3.1. A 1000-gram sample was used for this test. After weighting the sieve opening, a 0.15mm, 0.30mm, 0.6mm, 1.2mm, 2.36mm, and 4.75mm sieve were used for the sieve analysis test. When the sieve analysis was conducted, the sieve was shaken properly so that the fine aggregates passed easily. After shaking the sieve, the weight of fine aggregates that were retained in different sieves was measured. The weighed value was then recorded in a notebook. From this test, the FM value for fine aggregates was achieved.

**Table 01:** Grading of fine aggregates

| Sieve No | Sieve Opening (mm) | Material Retain (gm) | Material % Retain | Cumulative % Retain | Passing % | ASTM C33 Finer Upper Limit | ASTM C33 Finer Lower Limit | FM |
|---|---|---|---|---|---|---|---|---|
| #4 | 4.75 | 45 | 4.52 | 4.52 | 95.48 | 100 | 95 | |
| #8 | 2.36 | 84 | 8.43 | 12.95 | 87.05 | 100 | 80 | |
| #16 | 1.19 | 233 | 23.39 | 36.35 | 63.65 | 85 | 50 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| #30 | 0.6 | 285 | 28.61 | 64.96 | 35.04 | 60 | 25 | 2.97 |
| #50 | 0.3 | 138 | 13.86 | 78.82 | 21.18 | 30 | 5 | |
| #100 | 0.15 | 209 | 20.98 | 99.8 | 0.2 | 10 | 0 | |
| Pan | | 2 | | | | 3 | 0 | |
| | | Total=996 | | Total=297.40 | | | | |

At first, the coarse aggregate was collected for sieve analysis. In this study, sieve analysis of coarse aggregate was conducted in accordance with ASTM C136. According to ASTM C136, coarse aggregates should be passed through a 37.5-mm sieve and retained in a 4.75-mm sieve, and the coarse aggregate fineness modulus ranges from 5.5 to 8. A 2000-gram sample was collected for this test. After weighting the sieve opening, a 0.15mm, 0.30mm, 0.6mm, 1.2mm, 2.36mm, 4.75mm, 6.3mm, 9.5mm, 19mm, and 37.5mm sieve were used for conducting the sieve analysis test. While doing the sieve analysis, the sieve was properly shaken so that the coarse aggregates passed easily. After shaking the sieve, the weight of coarse aggregates that were retained in different sieves was taken. The weighted value was then recorded in a notebook. The FM values for stone and brick were obtained from this test.

**Table 02:** Grading of Coarse aggregates (Stone)

| Sieve No | Sieve Opening (mm) | Material Retain (gm) | Material % Retain | Cumulative % Retain | Passing % | ASTM C33 Coarser Upper Limit | ASTM C33 Coarser Lower Limit |
|---|---|---|---|---|---|---|---|
| #1.5 | 37.5 | 0 | 0 | 0 | 100 | 100 | 95 |
| #3/4 | 19 | 989 | 49.45 | 49.45 | 50.55 | 70 | 35 |
| #3/8 | 9.5 | 790 | 39.5 | 88.95 | 11.05 | 30 | 10 |
| #4 | 4.75 | 204 | 10.2 | 99.15 | 0.85 | 5 | 0 |
| #8 | 2.36 | 17 | 0.85 | 100 | 0 | 0 | 0 |
| #16 | 1.19 | 0 | 0 | 100 | 0 | 0 | 0 |
| #30 | 0.6 | 0 | 0 | 100 | 0 | 0 | 0 |
| #50 | 0.3 | 0 | 0 | 100 | 0 | 0 | 0 |
| #100 | 0.15 | 0 | 0 | 100 | 0 | 0 | 0 |
| Pan | | 0 | 0 | | 0 | | |
| | | Total=2000 | | Total=717.60 | | | |

**Table 03:** Grading of Coarse aggregates (Brick)

| Sieve No | Sieve Opening (mm) | Material Retain (gm) | Material % Retain | Cumulative % Retain | Passing % | ASTM C33 Finer Upper Limit | ASTM C33 Finer Lower Limit |
|---|---|---|---|---|---|---|---|
| #1.5 | 37.5 | 0 | 0 | 0 | 100 | 100 | 95 |
| #3/4 | 19 | 1158 | 57.9 | 57.9 | 42.1 | 70 | 35 |
| #3/8 | 9.5 | 535 | 26.75 | 84.65 | 15.35 | 30 | 10 |
| #4 | 4.75 | 298 | 14.9 | 99.55 | 0.45 | 5 | 0 |
| #8 | 2.36 | 9 | 0.45 | 100 | 0 | 0 | 0 |
| #16 | 1.19 | 0 | 0 | 100 | 0 | 0 | 0 |
| #30 | 0.6 | 0 | 0 | 100 | 0 | 0 | 0 |
| #50 | 0.3 | 0 | 0 | 100 | 0 | 0 | 0 |
| #100 | 0.15 | 0 | 0 | 100 | 0 | 0 | 0 |
| Pan | | 0 | 0 | | 0 | | |
| | | Total=2000 | | Total= 742.1 | | | |

A major element of concrete is water. Cement paste is created when water and a cementing substance are combined during the process of hydration. In concrete, cement serves as a binding material. It has an important role in concrete. There are numerous types of cement on the market. Portland Composite Cement was used in this study, where there is clinker (70-70%), slag, fly ash, limestone (21-25%), and gypsum (0-05%). M-25 grade concrete was used with a 1:1:2 mixing ratio in this study. The water-cement ratio is 0.45. Sylhet sand was used as fine aggregate and stone chips and brick chips were used as coarse aggregate.

*Cylinder volume= πr2h=π× (2/12)2× (8/12) =0.0581 cft*

*Total number of specimens =21*

*Total dry volume= 0.0581×21=1.2201 cft*

*Total wet volume=1.2201 ×1.5=1.8302 cft*

*Sum of the ratio=1+1+2=4*

*Cement=1.8302 /4×1×0.8*

*=0.366 bags*

*=0.366 ×50=18.30 kg*

*Sand=1.8302 /4×1=0.458 ×45.34=20.76kg [As per PWD 2022 we can get, unit weight of sand chips=1600kg/m3]*

*Stone Chips=1.8302 /4×2=.9151×46=42kg [As per PWD 2022 we can get, unit weight of stone chips=1600kg/m3]*

*Brick Chips=1.8302 /4×2=.9151×36.27=33.19kg [As per PWD 2022 we can get, unit weight of Brick chips=1280 kg/m3]*

*Water Required*

*0.45 = W/C*

*=> W= 0.45 × 18.30 = 8.24 liters≅8.5 liters*

In this study, the ASTM C39 and AASHTO T-22 methods were followed. During casting time, some apparatus like a hammer, cylinder mold, compaction rod (16 mm diameter), tray, digital balance, plain sheet, mixture machine, bucket, wire brush, range, and a slum cone was used. The size of the cylinder mold was 4 x 8 inches. After cleaning the mold with a wire brush, mobiles were used as a lubricant to easily remove the hardened concrete. The range was used to tie up all the loose ends. After preparing all the apparatus, all the materials were measured as an estimation. The mixer machine was then installed, and turned it on and started adding stone chips, then sand, cement, and water.

**Table 04:** Cylinder preparation, casting and curing of the specimen

| | Compressive Strength (28 days) | | | | | Sample | Split tensile strength (28 days) | | |
|---|---|---|---|---|---|---|---|---|---|
| Sample | Room Temp. | Fire Exposure Time (hr) | | Fire Exposure Temp.(°C) | | | Room Temp. | Fire Exposure Time (hr) | Fire Exposure Temp. (°C) |
| | | 150°C (4hr) | 250°C (8hr) | 250°C (4hr) | 250°C (8hr) | | | 250°C (8hr) | |
| Stone Agg. | 3 | 3 | 3 | 3 | 3 | Stone | 3 | 3 | |
| Brick Agg. | 3 | 3 | 3 | 3 | 3 | Brick | 3 | 3 | |

After adding water, waited for a few minutes so that ingredients could mix uniformly. When mixing was finished, the mixer machine was unloaded. Then the slum value had been tested. After taking the slum value, began filling the cylinder mold with three layers, each of which was compacted with 25 blows with a tempting rod. Following this procedure, 21 cylinders were created for both stone and brick chips. After filling the mold, hammered out the sides of the cylinder gently to prevent air bubbles from condensing inside the mold. When filling was finished, all the cylinder molds were stored in a less crowded area for 24 hours. After 24 hours, the cylinder mold had been opened, and it was kept in the water for 28 days. In this research, the ACI 216 methodology was followed. It was kept at room temperature for 24 hours after curing for 28 days. After that, six groups of cylinders were constructed, with three cylinders in each groups using stone chips as coarse aggregate. Two groups of cylinders were exposed to fire continuously in an oven at 150 °C for four and eight hours. Three further set of cylinders were exposed to fire continuously in an oven at 250 °C for four and eight hours. In the same manner, another four set of cylinders were constructed, each containing three cylinders containing brick chips as coarse aggregate. Two groups of cylinders were exposure to fire continuously in an oven at 150 °C for four and eight hours. Three further sets of cylinders were exposed to fire continuously in an oven at 250°C for four and eight hours. After heating these samples, they were removed from the oven and allowed to cool naturally in the open air for 24 hours.

**Table 05:** Fire Exposure of the Specimen

| **Sample** | **Room Temperature** | **Fire Exposure Time (hr)** | | **Fire Exposure Temp.(°C)** |
|---|---|---|---|---|
| Stone Agg. | 25°C | 4 | 8 | 150° |
| Brick Agg. | 25°C | 4 | 8 | 150° |

Compressive strength test conducted by Universal Testing Machine after completing 28 days of curing by following ASTM C39. To begin, a group of three cylinders were created that was not exposed to fire. Tested specimens were placed in the testing machine on the base plate and maintained in the center of the machine. The load was gradually increased on the specimen (below 2KN/S), and when it failed, it was unloaded and the value recorded. Then another set of cylinders were made, which were exposed to fire for 4 hours at 150 °C and 250 °C, and the testing machine applied a load when the specimens were crushed, and the crush load had been noted. Similarly, provide a load that was exposed to fire at 150 °C and 250 °C for 8 hours. The split tensile strength test was carried out using a Universal Testing Machine as per the ASTM E399 guidelines after completing a 28-day curing period. A set of three cylinders were prepared for the first round of testing which were not exposed to fire. The specimens were clamped at the ends and pulled in opposite directions until they fractured. Once the specimens failed, the values were recorded after unloading. Later, another set of cylinders were created, and these were exposed to fire for 8-hours at 250 °C before testing. The testing machine pulled the specimens up to crush, and the crush load was recorded. The same procedure was followed for both stone chips aggregate concrete specimens and brick chips aggregate concrete specimens.

## 4. RESULTS & DISCUSSION

To determine the impact of fire exposure on concrete strength, laboratory experiments on engineering materials in cylinder specimens were performed in this chapter. While performing these laboratory tests, ASTM, AASHTO, and BS standards were followed. After the property test, the sieve analysis, compressive strength test (before fire exposure), split tensile strength test (before fire exposure), compressive strength test (after fire exposure), and split tensile strength test (after fire exposure) were performed. In this chapter, the compressive strength test results (before and after fire exposure of these brick chip aggregate concrete specimens and stone chip aggregate concrete specimens) and the split tensile strength (before and after fire exposure of these brick chip aggregate concrete specimens and stone chip aggregate concrete specimens) are discussed. Based on the results, some tables and graphs were prepared, and those graphs show the comparison between stone aggregate concrete and brick aggregate concrete strength at different stages.

**Table 06:** Compressive strength of stone and brick aggregate concrete at 4 hours fire exposure

| Cylinder Aggregate Type | Duration of Fire Exposure (hrs.) | Temperature | Spacemen No | Compressive Strength (KN) | Compressive Strength (Psi) | Average Value (Psi) |
|---|---|---|---|---|---|---|
| Stone Aggregate | 0 | Room Temp. | 1 | 149.17 | 2666.81 | 3849.24 |
| | | | 2 | 247.59 | 4426.33 | |
| | | | 3 | 249.17 | 4454.58 | |
| | 4 | 150°C | 1 | 216.54 | 3871.23 | 3364.4 |
| | | | 2 | 200.45 | 3583.58 | |
| | | | 3 | 147.58 | 2638.39 | |
| | 4 | 250°C | 1 | 193.41 | 3457.721 | 3216.55 |
| | | | 2 | 157.05 | 2807.68 | |
| | | | 3 | 189.30 | 3384.24 | |
| Brick Aggregate | 0 | Room Temp. | 1 | 125 | 2234.70 | 2542.80 |
| | | | 2 | 183.05 | 3272.50 | |
| | | | 3 | 118.65 | 2121.18 | |
| | 4 | 150°C | 1 | 103.12 | 1843.54 | 2186.43 |
| | | | 2 | 153.24 | 2739.57 | |
| | | | 3 | 110.54 | 1976.19 | |
| | 4 | 250°C | 1 | 157.68 | 2818.95 | 1980.06 |
| | | | 2 | 91.57 | 1637.05 | |
| | | | 3 | 83.02 | 1484.20 | |

Compressive Strength of stone aggregate concrete and brick aggregate concrete at Room Temperature, Compressive Strength at 150°C after 4-hour fire exposure, and Compressive Strength at 250°C after 4-hour fire exposure, respectively, are used to build table 06. Three different specimens were taken for each test. The three results for every segment were averaged after each specimen's compressive strength calculation. And for further comparison, the averaged value used.

**Table 07:** Compressive strength of stone and brick aggregate concrete at 8 hours fire exposure

| Cylinder Aggregate Type | Duration of Fire Exposure (hrs.) | Temperature | Spacemen No | Compressive Strength (KN) | Compressive Strength (Psi) | Average Value (Psi) |
|---|---|---|---|---|---|---|
| Stone Aggregate | 0 | Room Temp. | 1 | 149.17 | 2666.81 | 3849.24 |
| | | | 2 | 247.59 | 4426.33 | |
| | | | 3 | 249.17 | 4454.58 | |
| | 8 | 150°C | 1 | 147.00 | 2628.018 | 2922.22 |
| | | | 2 | 181.11 | 3237.825 | |
| | | | 3 | 162.26 | 2901.01 | |
| | 8 | 250°C | 1 | 139.70 | 2497.511 | 2788.20 |
| | | | 2 | 163.81 | 2928.541 | |

 

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | 3 | 164.37 | 2938.533 | |
| Brick Aggregate | 0 | Room Temp. | 1 | 125 | 2234.709 | 2542.80 |
| | | | 2 | 183.05 | 3272.508 | |
| | | | 3 | 118.65 | 2121.186 | |
| | 8 | 150°C | 1 | 104.00 | 1859.278 | 2065.82 |
| | | | 2 | 129.00 | 2306.22 | |
| | | | 3 | 113.66 | 2031.976 | |
| | 8 | 250°C | 1 | 97.00 | 2806.795 | 1774.00 |
| | | | 2 | 103.00 | 1841.4 | |
| | | | 3 | 97.69 | 1746.47 | |

Compressive strengths of stone aggregate concrete and brick aggregate concrete at room temperature, at 150°C, and at 250°C, respectively, after 8-hour fire exposure are used to build table 7. Three different specimens were taken for each test. The three results for every segment were averaged after each specimen's compressive strength calculation. And for further comparison, the averaged value was used.

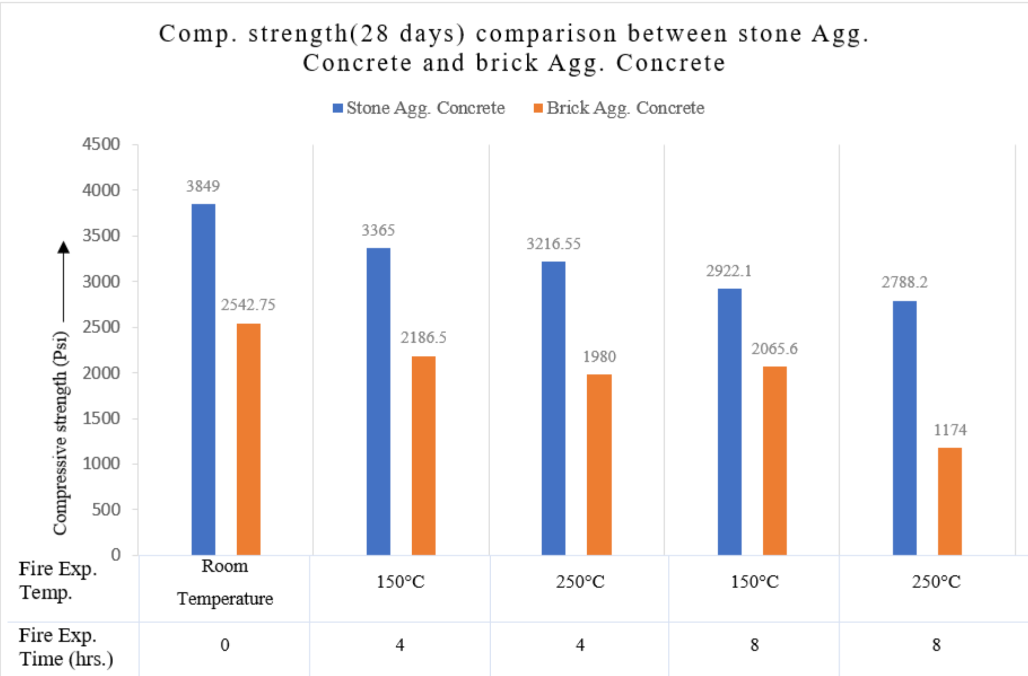


**Figure 02:** Compressive Strength comparison between stone Agg.

The comparison of compressive strengths between stone aggregate concrete and brick aggregate concrete at different stages. At room temperature, the compressive strength of stone aggregate concrete is 3849 Psi, while brick aggregate concrete has a compressive strength of 2542.75 Psi, indicating a difference of 1306.25 Psi. Following a four-hour fire exposure at 150°C, the compressive strength of stone aggregate concrete decreases by nearly 500 Psi to 3365 Psi. Similarly, brick aggregate concrete experiences a reduction of almost 350 Psi, resulting in a compressive strength of 2186.5 Psi. After a four-hour fire exposure at 250°C, stone aggregate concrete's compressive strength decreases by approximately 630 Psi from the reference value, reaching 3221.55 Psi. Similarly, brick aggregate concrete's compressive strength decreased by nearly 560 Psi and reached 2186.5 Psi. Following an eight-hour fire exposure at 150°C, stone aggregate concrete's compressive strength decreases by around 925 Psi to 2922.1 Psi. In comparison, brick aggregate concrete experiences a reduction of roughly 470 Psi, resulting in a compressive strength of 2065.6 Psi. Lastly, after an eight-hour fire exposure at 250°C, stone aggregate concrete's compressive strength decreases by approximately 1060 Psi from the reference value, reaching 2788.2 Psi. In contrast, brick aggregate concrete experiences a substantial reduction of nearly 1360 Psi, resulting in a compressive strength of 1174 Psi. The graph demonstrates that brick aggregate concrete consistently exhibits lower compressive strength compared to stone aggregate concrete. Additionally, fire exposure further diminishes the compressive strength of both types of concrete.

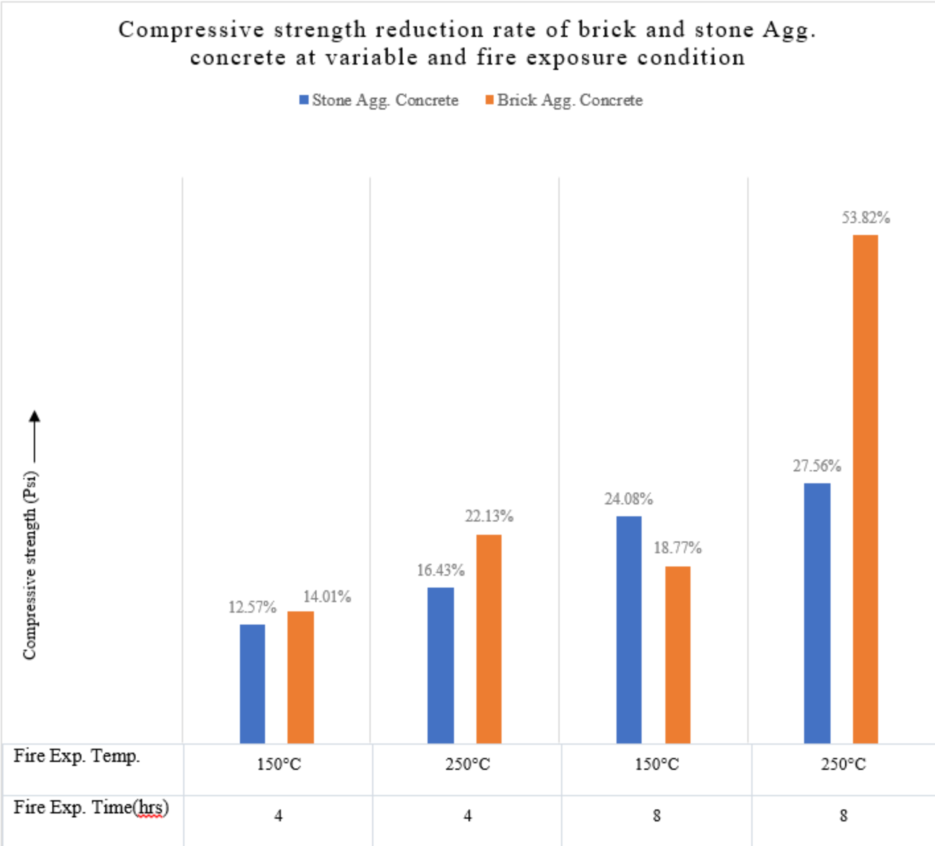


**Figure 03:** Compressive strength reduction rate of brick and stone Agg.

It show the compressive strength reduction rate due to fire exposure at different temperature variance and time variance and compared between stone and brick aggregate concrete. For every segment the compressive strength reduction rate of brick aggregate concrete is higher than stone aggregate concrete but at 150℃-8hour fire exposure brick aggregate concrete shows the strength reduction rate is less than stone aggregate concrete.

**Table 08:** Split tensile strength of Stone and Brick aggregate concrete at maximum 250℃ after 8-hours fire exposure

| Cylinder Aggregate Type | Duration of Fire Exposure (Hrs.) | Temperature | Spacemen No | Split Tensile Strength (KN) | Split Tensile Strength (Psi) | Average Value (Psi) |
|---|---|---|---|---|---|---|
| Stone Aggregate | 0 | Room Temp. | 1 | 68 | 1215.682 | 1066.70 |
| | | | 2 | 61 | 1090.538 | |
| | | | 3 | 59 | 893.883 | |
| | 8 | 250°C | 1 | 46.96 | 839.535 | 910.33 |
| | | | 2 | 51.08 | 913.191 | |
| | | | 3 | 54.72 | 978.662 | |
| Brick Aggregate | 0 | Room Temp. | 1 | 61.64 | 1101.98 | 1059.49 |
| | | | 2 | 59.04 | 1055.498 | |
| | | | 3 | 57.11 | 1020.994 | |
| | 8 | 250°C | 1 | 53.97 | 964.858 | 835.30 |
| | | | 2 | 50.22 | 897.816 | |
| | | | 3 | 35.98 | 643.238 | |

Split tensile Strength of brick aggregate concrete at Room Temperature, and Split tensile Strength of brick aggregate concrete after 8-hour at 250°C fire exposure is used to build Tables 4.3 Three different specimens were taken for each test. The three results for every segment were averaged after each specimen's split tensile Strength calculation. And for further comparison, the averaged value was used.

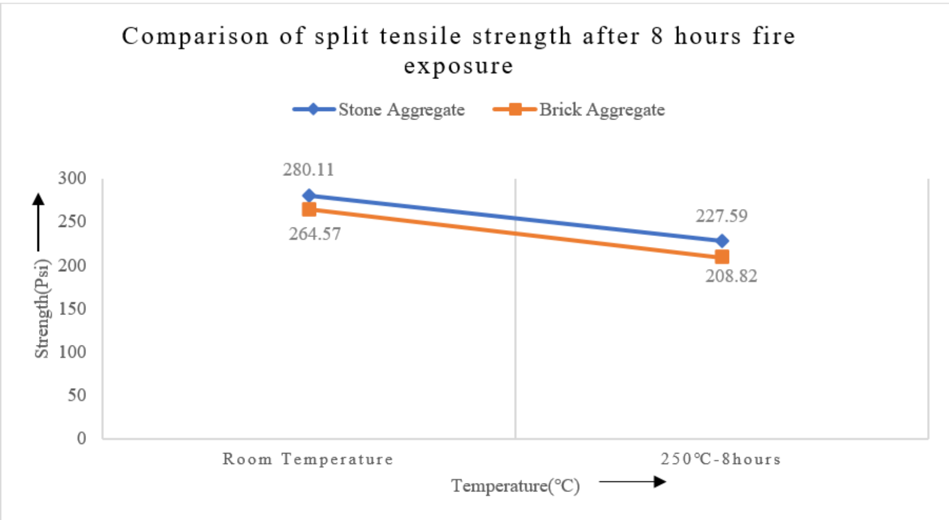


**Figure 04:** Comparison of split tensile strength after 8 hours fire exposure

This graph contain the average split tensile strengths of stone aggregate concrete and brick aggregate concrete at room temperature, and at 250 °C fire exposure. This graph shows the comparison between the split tensile strength at room temperature and the split tensile strength at a maximum temperature of 250 °C after 8 hours. The blue line shows that at room temperature, the split tensile strength of stone aggregate concrete is 280.11 Psi, but after 250 °C, the strength decreases 53 Psi than split tensile strength in room temperature and resulting 227.59 Psi. The orange line indicates that at room temperature, the split tensile strength of brick aggregate concrete is 264.57 Psi, which is reduced to 55.75 Psi after 8 hours of maximum 250 °C fire exposure, and the split tensile strength is 208.82 Psi. So, the graphs show that the split tensile strength is also affected by fire exposure, and brick aggregate concrete is more affected than stone aggregate concrete after fire exposure at high maximum temperatures.

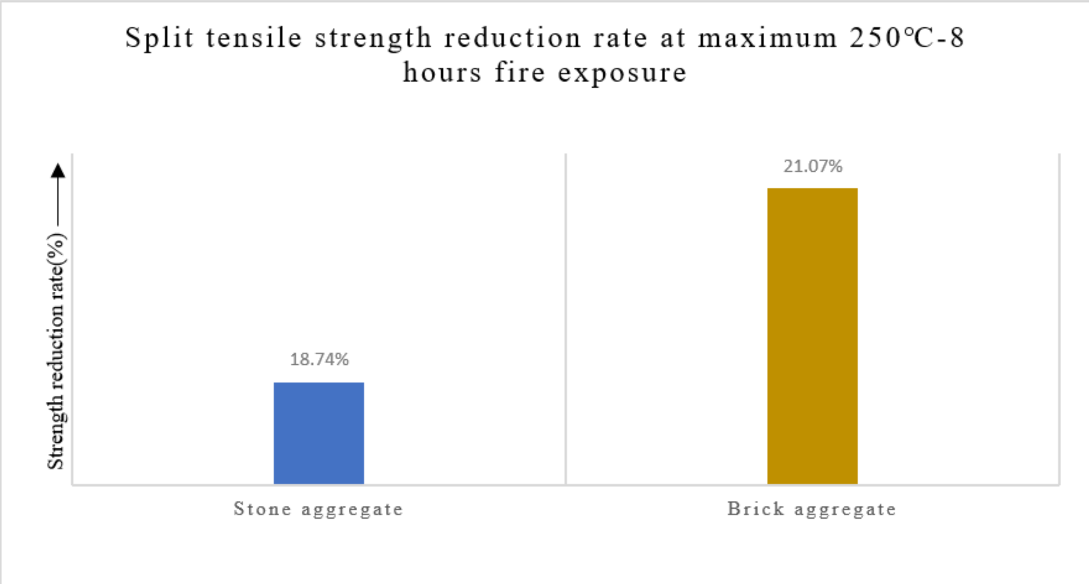


**Figure 05:** Split tensile strength reduction rate at maximum 250℃-8 hours fire exposure

For split tensile strength when stone chips aggregate specimens are exposed to the fire at 250℃ temperature and period is 8 hours the strength decreases 53 Psi than split tensile strength in room temperature and resulting 227.59 Psi and strength reduction rate is 18.74% with respect to the normal temperature. In contrast, for bricks chips aggregate specimens when it is exposed to the fire at 250℃ temperature for 8 hours the split tensile strength is 208.82 Psi and the strength reduction rate is 21.07% which is less fire resisting capacity rather than stone chips aggregate. Based on the aforementioned results, the strength of stone aggregate concrete and brick aggregate concrete is higher before fire exposure. Due to fire stone aggregate concrete and brick aggregate concrete losses their strength. When brick aggregate concrete and stone aggregate concrete are exposed to fire for 4 hours at the temperature of 150°C and 250°C both types of concrete lose their strength in a gradual manner. Stone aggregate concrete strength reduction rate is less with compare to the brick aggregate concrete. Stone aggregate concrete lose strength in a gradual manner, in contrast brick aggregate concrete lose their strength significantly at 8 hours fire exposure when temperature is 150°C and 250°C. In this situation response of brick aggregate concrete is higher than stone aggregate concrete. At the temperature 150°C and time duration is 4 hours and 8 hours stone aggregate concrete lose strength gradual manner. In contrast brick aggregate concrete at the same temperature and same time duration lose less strength with compare to the stone aggregate concrete. Brick aggregate concrete lose its strength significantly at the temperature of 250°C and time durations are 4 hours and 8 hours fire exposure but stone aggregate concrete lose strength in a gradual manner with this same temperature and time duration.

 

## 5. CONCLUSION

There are several factors that could influence the performance of concrete following exposure to fire, including mix design, material qualities, and the length and severity of the fire. The high-temperature qualities of the aggregate used in the concrete have an important impact on determining the performance of the concrete following exposure to fire. Based on the findings of several studies, it can be concluded that stone aggregate concrete has more strength after exposure to fire than brick aggregate concrete due to the better thermal insulation properties of stone aggregates and the resulting ability to resist thermal stress better than brick aggregates. Before fire exposure, both stone aggregate concrete and brick aggregate concrete exhibit higher strength compared to their respective strengths after being subjected to fire. This implies that fire has a detrimental effect on the strength of both types of concrete. When exposed to fire for 4 hours at temperatures of 150°C and 250°C, both stone aggregate concrete and brick aggregate concrete experience a gradual reduction in strength. However, the rate of strength reduction is lower for stone aggregate concrete compared to brick aggregate concrete. This suggests that stone aggregate concrete has a relatively better fire resisting capacity in terms of strength retention during the initial 4 hours of fire exposure. Stone aggregate concrete shows a gradual loss of strength over time, even after 4 hours of fire exposure. In contrast, brick aggregate concrete exhibits a significant reduction in strength only after 8 hours of fire exposure at temperatures of 150°C and 250°C. This indicates that brick aggregate concrete has a higher vulnerability to losing its strength over a longer duration of fire exposure compared to stone aggregate concrete. Therefore, in situations where fire exposure extends beyond 4 hours, brick aggregate concrete may have a lower fire resisting capacity in terms of maintaining strength. At a temperature of 150°C and time durations of 4 hours and 8 hours, stone aggregate concrete experiences a gradual loss of strength. In contrast, brick aggregate concrete loses less strength compared to stone aggregate concrete under the same temperature and time durations. This implies that brick aggregate concrete has a relatively better fire resisting capacity than stone aggregate concrete at a temperature of 150°C. When exposed to a temperature of 250°C for 4 hours and 8 hours of fire exposure, brick aggregate concrete shows a significant loss of strength. In contrast, stone aggregate concrete experiences a gradual reduction in strength under the same temperature and time durations. This indicates that stone aggregate concrete has a better fire resisting capacity compared to brick aggregate concrete at a higher temperature of 250°C. In conclusion, when comparing the fire resisting capacity between stone aggregate concrete and brick aggregate concrete, it can be observed that stone aggregate concrete generally exhibits a better fire resisting capacity in terms of maintaining strength during the initial 4 hours of fire exposure, as well as at higher temperatures. However, brick aggregate concrete may have a relatively better fire resisting capacity in situations where fire exposure extends beyond 4 hours to 8 hours at temperatures of 150°C, as it shows a lesser reduction in strength compared to stone aggregate concrete. In this study only M25 grade of concrete was used for determining relative fire resisting capacity before and after exposure to fire but in future study concrete grade may less than M25 grade. In this study any kinds of fiber did not use in the concrete in future study fiber can be used in the concrete. Only compressive strength test and split tensile test were conducted, but flexural test may be conducted in the future study.

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