Experimental Study of High Strength Concrete By Alccofine and Bagasse Ash

Harshdeep Vani¹, Kaamun², Sahil Arora³
¹er.hd04@gmail.com, ²kaamun008@gmail.com, ³sahilarora.civil@cumail.in
¹Department of civil engineering, Chandigarh University, Mohali, Punjab, 140413, INDIA
²Assistant Professor, Department of civil engineering, Chandigarh University, Mohali, Punjab, 140413, INDIA

Abstract. The use of concrete is increasing day to day very rapidly. The lesser the cross-section higher will be the grade of concrete. High-grade concrete is generally used in the nuclear power plant or precast prestressed concrete. The higher the cement content high will be the occurrence of the defect due to heat of hydration in the concrete. This paper deals with the experimental study of high-strength concrete which can be prepared by using the cement content less than the required quantity by using any other supplementary material. Like Alccofine and bagasse ash. Alccofine is costlier than cement which increases the cost of concrete to adjust that cost of concrete the bagasse ash is been used in the place of fine aggregate.

1 Introduction

Concrete is mainly a man-made material used all over the world and has played an important role in the development of all countries. For the increasing demand in recent years, a lot of research has been done on concrete to make it more durable and resistant. In the 1970s, compressive strength greater than 40 N/mm² was called high strength concrete. Then, compressive strength 60100 N/mm² classified as “High-Performance Concrete” high strength concrete is used for concrete mix with high machinability, high strength, high elastic modulus, High density, high dimensional stability, low permeability, and resistance to chemical attack [1–4],[5]

To obtain greater strength and strength from concrete, high-performance concrete is required. The current process of producing concrete is not sustainable as it not only consumes a large amount of aggregate and water but also consumes a significant amount of Portland cement. The Portland cement production process consumes a lot of energy and emits CO₂, which causes global warming. Currently, global warming is the most serious environmental problem and all economic and political debates are based on the question of sustainability. After researching the environmental impacts of concrete and sustainability as the current driving force in the world, the construction industry must find different ways to reduce the use of Portland cement, natural aggregates, and drinking water. To solve this problem, a sustainable method is to use a large amount of industrial waste as an alternative to aggregates and Portland cement [6–8].
Alccofine 1203 is a highly treated, high glass content, highly reactive slag product obtained through controlled granulation. As a result, the combination of Alccofine 1203 and bagasse ash creates an attractive alternative that can be defined as high-performance, high-strength concrete. Bagasse ash is very similar to the volcanic ash used in hydraulic cement production, the oldest known dating back about 2,300 years [5,9,10]. Pozzolan is a silicon or silicon/aluminous material that, when mixed with lime and water, forms a cohesive compound. The bagasse ash produced thus has both ceramic and pozzolanic properties. When burning shredded coal for heat, the ash contains 80% bagasse ash and 20% tail ash. The exhaust gases are collected at the economizer, the air preheater, and the ESP hopper which carries the ash further. Bottom ash is clinker ash collected in the liquid hopper under the boiler. The newly developed admixture allows for an extremely low water/binder ratio without sacrificing workability. One of the main advantages of mineral admixtures in high-strength concrete is that even if the cement content is reduced, there are economic and environmental benefits, but it also means a decrease in temperature rise when the degree compaction is higher [5,9–13].

On the other hand, bagasse ash is generated during the burning of sugarcane for sugar production in the sugar industry. Bagasse is usually obtained from two different industrial sources. The first source, where the bagasse is taken, comes from the bottom of the storage tanks and it is the dust discharged after combustion. The second SCBA source is directly accessed by smoke from the chimneys. SCBA produces 50% cellulose, 25% hemicellulose, 25% lignin. For each ton of sugarcane, bagasse content is 26% . The main reason to use SCBA as an alternative to cement is due to its pozzolanic properties. This is why many researchers have proposed studies on the pozzolanic properties of ARA. So they can figure out how to use these ashes in the construction industry. This test covers the use of an ARA part in the construction. This test study involves two different types of tests and it is classified as two and that is fresh and hard concrete testing. The cone slump test is the subject of the fresh concrete test, while the compression test, flexural test, carbonation test, and RCPT test are the subject of the hardened concrete test. The cement was replaced by 10%,20%, and 30% from the volume of total Cementous material respectively.

2 Method

2.1 Properties of Material

All the design mix is prepared by the consideration of IS 456 and IS 10262 the properties of the material are listed below table 1

| Table 1 Properties of Constituent Materials |
|-------------------------------------------|
| Material                     | Property         | Value            |
| Cement                       | Specific Gravity | 3.12             |
|                             | Fineness         | 2.3%             |
|                             | Consistency      | 29.5%            |
|                             | Setting time     | 32 min, 588 min  |
|                             | Compressive Strength | 47.25 @ 28Days   |
| Aggregate(fine)              | Specific Gravity | 2.61             |
|                             | Fineness Modulus | 2.99             |
| Aggregate (Coarse)           | Specific Gravity | 22.66            |
|                             | Fineness Modulus | 7.90             |
| Marble powder                | Specific Gravity | 3.05             |
|                             | Fineness Modulus | 99%              |
| Bagasse ash                  | Specific Gravity | 2.65             |
| Alccofine                    | Specific Gravity | 3.5              |
| Superplasticizer (Master Gellium) | Specific Gravity | 2.15             |
2.2 Preparation of mix

For the experimental study, the bagasse ash is been replaced by the fine aggregate and cement with Alccofine 1203 in the high strength concrete which is prepared by the design specifications of IS 10262:2019. The affine aggregate is replaced by bagasse ash in the manner of a single percentage from 1% up to the workability finishes. Alccofine is introduced in concrete on the replacement of the cement up to the negative results is seen, see table 2.

| Ratios | Cement (in Kg) | Sand (in Kg) | Coarse Aggregate (in Kg) | Water (in Kg) | Bagasse Ash (in Kg) | Alccofine (in Kg) | Superplasticizer (in Kg) | Marble Powder (in Kg) |
|--------|---------------|--------------|--------------------------|---------------|---------------------|-----------------|------------------------|----------------------|
| HS1    | 443           | 640          | 1277                     | 141           | 0                   | 0               | 0                      | 4.5                  | 22                   |
| HS2    | 443           | 633.6        | 1277                     | 141           | 1                   | 6.4             | 0                      | 0                    | 4.5                  | 22                   |
| HS3    | 443           | 627.2        | 1277                     | 141           | 2                   | 12.8            | 0                      | 0                    | 4.5                  | 22                   |
| HS4    | 443           | 620.8        | 1277                     | 141           | 3                   | 19.2            | 0                      | 0                    | 4.5                  | 22                   |
| HS5    | 443           | 614.4        | 1277                     | 141           | 4                   | 25.6            | 0                      | 0                    | 4.5                  | 22                   |
| HS6    | 443           | 608          | 1277                     | 141           | 5                   | 32              | 0                      | 0                    | 4.5                  | 22                   |
| HS7    | 443           | 601.6        | 1277                     | 141           | 6                   | 38.4            | 0                      | 0                    | 4.5                  | 22                   |
| HS8    | 443           | 595.2        | 1277                     | 141           | 7                   | 44.8            | 0                      | 0                    | 4.5                  | 22                   |
| HS9    | 438.57        | 588.8        | 1277                     | 141           | 8                   | 51.2            | 1                      | 4.43                 | 4.5                  | 22                   |
| HS10   | 434.14        | 588.8        | 1277                     | 141           | 8                   | 51.2            | 2                      | 8.86                 | 4.5                  | 22                   |
| HS11   | 429.71        | 588.8        | 1277                     | 141           | 8                   | 51.2            | 3                      | 13.29                | 4.5                  | 22                   |
| HS12   | 425.28        | 588.8        | 1277                     | 141           | 8                   | 51.2            | 4                      | 17.72                | 4.5                  | 22                   |
| HS13   | 420.85        | 588.8        | 1277                     | 141           | 8                   | 51.2            | 5                      | 22.15                | 4.5                  | 22                   |
| HS14   | 416.42        | 588.8        | 1277                     | 141           | 8                   | 51.2            | 6                      | 26.58                | 4.5                  | 22                   |
| HS15   | 411.99        | 588.8        | 1277                     | 141           | 8                   | 51.2            | 7                      | 31.01                | 4.5                  | 22                   |
| HS16   | 407.56        | 588.8        | 1277                     | 141           | 8                   | 51.2            | 8                      | 35.44                | 4.5                  | 22                   |
| HS17   | 403.13        | 588.8        | 1277                     | 141           | 8                   | 51.2            | 9                      | 39.87                | 4.5                  | 22                   |
| HS18   | 398.7         | 588.8        | 1277                     | 141           | 8                   | 51.2            | 10                     | 44.3                 | 4.5                  | 22                   |
The cost of concrete is taken in reference to the prices of Mohali district Punjab and SOR by PWD. All prices listed below are the prices that include the transportation cost, this includes only the material cost, see table 3 and figure 1.

### Table 3 Cost of Constituent Material

| Material       | Unit       | Rate   |
|----------------|------------|--------|
| Cement         | Per bag    | 400 INR|
| Fine Aggregate | Per m³     | 3550   |
| Coarse aggregate | Per m³ | 2460   |
| Alccofine      | Per kg     | 10     |
| Bagasse ash    | Per quintal| 100 (only Transportation) |

### Table 4 Results of the Experimental Study

| Ratios | Compressive Strength | Flexural capacity | Split tensile strength | Cost of concrete |
|--------|-----------------------|-------------------|------------------------|------------------|
|        | 7 days curing | 28 days curing | 7 days curing | 28 days curing | 7 days curing | 28 days curing | In INR           |
| HS1    | 42.6       | 71             | 5.13       | 7.27          | 4.86       | 5.90          | 6359.22         |
| HS2    | 42.9       | 71.5           | 5.16       | 7.32          | 4.87       | 5.92          | 6352.82         |
| HS3    | 43.38      | 72.3           | 5.22       | 7.40          | 4.90       | 5.95          | 6346.42         |
| HS4    | 43.56      | 72.6           | 5.24       | 7.43          | 4.91       | 5.96          | 6340.02         |
| HS5    | 43.92      | 73.2           | 5.28       | 7.49          | 4.93       | 5.99          | 6333.62         |
| HS6    | 44.16      | 73.6           | 5.31       | 7.53          | 4.95       | 6.01          | 6327.22         |
| HS7    | 44.34      | 73.9           | 5.33       | 7.56          | 4.96       | 6.02          | 6320.82         |
| HS8    | 44.4       | 74             | 5.34       | 7.58          | 4.99       | 6.04          | 6314.42         |
| HS9    | 45         | 75             | 5.41       | 7.68          | 5.03       | 6.11          | 6316.88         |
| HS10   | 45.72      | 76.2           | 5.50       | 7.80          | 5.05       | 6.14          | 6325.74         |
| HS11   | 46.14      | 76.9           | 5.55       | 7.87          | 5.05       | 6.14          | 6334.6          |

### Figure 1 Freshly Concrete preparation

3 RESULTS
The prepared concrete is tested on 2 days i.e., after the curing period of 7 and 14 days. Concrete is tested by three tests compression test flexural test and split tensile test. The cost of concrete is also determined by taking into consideration the Schedule of Rates by the PWD Punjab government. All the rates are taken from the market of Mohali and SOR PWD, see table 4.
The pozzolanic action of bagasse ash and fineness of sugarcane bagasse ash makes a good increment in the strength of the concrete. This increase is due to its size which is finer than the particle of fine aggregate. But ash absorbs more water than the aggregates therefore due to less water available in the concrete there is a restriction to the limit of replacement of ash to fine aggregate, see figure 2.

**Figure 2:** 7 days curing Results
For normal concrete, the ash can replace the fine aggregate up to 20% but for the high strength concrete it only gives the replacement up to 7%. The ash is a burden for the sugar industries, so its cost is only the transportation cost and sometimes the companies themselves provide the transportation facilities, see figure 3 and 4, it reduces the cost of concrete by 6%.

Figure 3: 28 days Curing Results

Figure 4: 7 Days Curing Results
The use of Alccofine is very much appreciable in concrete because of its fineness when compared to any hydraulic material like fly ash slag or any other material. There are two reasons which are responsible for the increment of the strength of the high strength concrete (proposed) first is the fineness of the material which can fill the voids of the concrete which increase the particle packing, second is that the Alccofine does not absorb water which makes the Alccofine replace the cement without disturbing the reaction between the admixtures, see figure 5.

Alccofine increases the price of concrete by 1.3% because earlier it is been decreased by the bagasse ash. For better reach, one should use the Alccofine and bagasse ash for the increment in strength purposes. This proposed concrete can be used where the grade of concrete is restricted by the cost of the concrete.

4 Conclusion
1. the high strength can be prepared by the use of marble powder in place fly ash or silica fume in the mix design of the concrete.
2. for the grade of M70 for the particular mix design the bagasse ash can replace Fine aggregate only up to 8%. This is due to water scarcity in concrete after 8% workability reduces to 0
3. Alccofine is much finer than cement which fills the voids in the concrete and provides greater strength
4. Alccofine can replace cement up to 8% because after that the quantity of cement in concrete becomes very less and binder scarcity occurs due to less w/c ratio in high strength concrete
5. The combination of bagasse ash and Alccofine can increase the strength of compression by 13% and decrease the cost of concrete by 1.3%
References

[1] Mittal M, Verma A, Kaur I, Kaur B, Sharma M, Goyal L M, Roy S and Kim T-H 2019 An efficient edge detection approach to provide better edge connectivity for image analysis IEEE Access 7 33240–55

[2] Abbas A T, Gupta M K, Soliman M S, Mia M, Hegab H, Luqman M and Pimenov D Y 2019 Sustainability assessment associated with surface roughness and power consumption characteristics in nano-fluid MQL-assisted turning of AISI 1045 steel Int. J. Adv. Manuf. Technol. 105 1311–27

[3] Kumar R, Chohan J S, Goyal R and Chauhan P 2020 Impact of process parameters of resistance spot welding on mechanical properties and micro hardness of stainless steel 304 weldments Int. J. Struct. Integr. ahead-of-p

[4] Ramteke D D, Balakrishna A, Kumar V and Swart H C 2017 Luminescence dynamics and investigation of Judd-Olfelt intensity parameters of Sm3+ ion containing glasses Opt. Mater. (Amst.) 64 171–8

[5] Kalyana Chakravarthy P R and Rathan Raj R 2017 Analysis on compressive strength of concrete with partial replacement of cement with alccofine ARPN J. Eng. Appl. Sci. 12 2392–5

[6] Singla N, Singla S, Thind P S, Singh S, Chohan J S, Kumar R, Sharma S, Chattopadhyaya S, Dwivedi S P, Saxena A, Issakhov A and Khalilpoor N 2021 Assessing the Applicability of Photocatalytic-Concrete Blocks in Reducing the Concentration of Ambient NO2of Chandigarh, India, Using Box-Behnken Response Surface Design Technique: A Holistic Sustainable Development Approach J. Chem. 2021

[7] Sidhu B S, Sharda R and Singh S 2021 Spatio-temporal assessment of groundwater depletion in Punjab, India Groundw. Sustain. Dev. 12

[8] Khairandish M I, Chopra A, Singh S, Chohan J S and Kumar R 2021 Effect of Gradation and Morphological Characteristics of Aggregates on Mechanical Properties of Bituminous Concrete and Dense Bituminous Macadam Iran. J. Sci. Technol. - Trans. Civ. Eng.

[9] Srinivasan G 2020 Study on alccofine based high performance concrete IOP Conference Series: Materials Science and Engineering vol 993, ed A P Harikrishnan S. (IOP Publishing Ltd)

[10] Hashim M and Tantray M 2021 Developing and optimizing foam concrete using industrial waste materials Innov. Infrastruct. Solut. 6

[11] Babu B.S. Kumar K. K S S P B A 2021 2nd International Conference on Manufacturing, Material Science and Engineering 2020, ICMMSE 2020 AIP Conference Proceedings vol 2358 (American Institute of Physics Inc.)

[12] Ramesh V and Koniki S 2021 Comparison of mechanical properties of flyash-GGBS based GPC and flyash-alccofine based GPC with different concentrations of alkaline activators AIP Conference Proceedings vol 2358, ed K S S P B A Babu B.S. Kumar K. (American Institute of Physics Inc.)

[13] Ashwini K and Srinivasa Rao P 2021 Behavior of concrete using alccofine and nano-silica under elevated temperature Int. J. Adv. Technol. Eng. Explor. 8 600–18