# A Review on Sugarcane Bagasse Ash which Enhance Properties of Ultra-High Performance Concrete and Usable for EFUHPC

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## Abstract:-

In this study we discus about sugarcane bagasse ash which improving mechanical properties of concrete, High Performance Concrete (HPC) and suitable for making Eco-friendly Ultra-High Performance Concrete (EFUHPC). Many ecofriendly materials like Sugarcane bagasse ash, Fly Ash, Volcanic Ash, Rice barn Ash are used for improving for properties of concrete and UHPC. Ultra High Performance Concrete (UHPC) is latest material for construction industry which has high strength, durability and other mechanical properties of concrete as compare to Conventional Concrete. According to previous research SBA enhances the mechanical properties of concrete when 5% to 10% amount of SBA used at place of cement.

Key words:- HPC, UHPC, EFUHPC, SBA, fly ash

## 1. Introduction:-

Cement is most significant material for concrete which consume globally third largest energy after aluminum and steel industry and production of cement release large amount of carbon dioxide (CO2) [1,2,3]. At present time of cement production methods approximately 850kg per ton CO2 released in Environment. At present time many cmentitious materials used in concrete place of cement in different amounts which reduce consumption of cement [2,3]. At present time agricultural wastes (AW) are also major problem of environment. From last recent years for consumption of AW frequently used in concrete at place of cement in form of ash like fly ash (FA), Rice Brain Ash (RBA), volcanic ash (VA), and sugarcane Bagasse ash (SBA) [6]. The use of agricultural waste ash (AWA) in concrete make eco-friendly concrete and environmental friendly [1]. SB is by product of agriculture and sugar industry. India and Brazil 46.3% amount of sugarcane produce in 2021 of all world's production [9]. The farm waste residual ash in concrete use made green concrete [3].

The sustainable materials should be used to design for green structures for good features then conventional materials. The sustainable materials are waste materials which used after proper recycling.

Rajasekar el all used bagasse ash in UHPC and found workability and compressive strength enhanced and rate of water absorption decreases at 15% amount of SBA. Treated SBA after heat curing improved properties of UHPC. Abdalla et al used SBA 0-40% and found that mechanical properties were improved at 10% SBA replacement weight of cement. Agwa et all investigated concrete containing 0&, 10%, 20% , 30% and 40% amount of SBA by weight of cement and improves mechanical properties of UHPC at 10% amount of SBA. Partial replacement of SBA as place of cement reduced the quantity of cement in UHPC. Cement production released hug amount of $CO_2$ which affected to environment. Huang et al investigated calcination of SBA at various temperatures (300°C, 600°C, and 900°C) and found lowest workability with consistency of 44mm and fluidity at 191mm at 300°C.

Figure 01 :Sugar-Cane processing Stage [03]

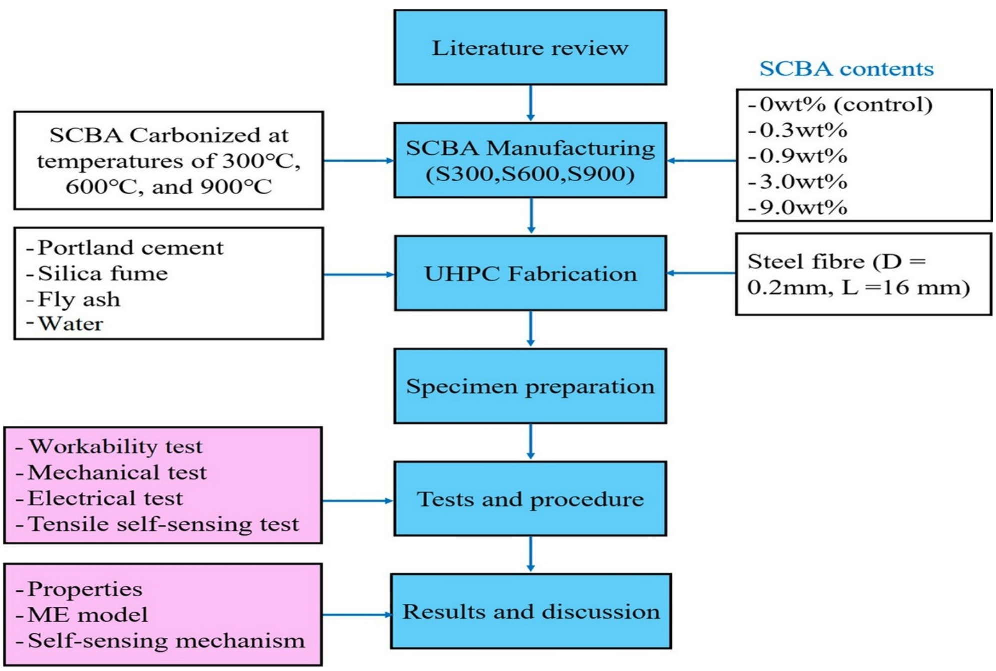


Figure02: Study Roots of UHPC [05]

## 2. Physical Properties:

Many researchers found different physical properties of SBA which are specific gravity, density, surface aea, and particle size. Agwa et al [03] shows specific gravity 1.9 to 2.4, density 245.4 kg/m3 – 610.6 kg?m$^3$, mean particle size 4.5 to 30.5 nm and surface area 274-4532 cm$^2$/g.

**Table01: Physical Properties of SBA [03,**

| Reference | Density | Surface area ($cm^2/g$) | Particle size |
|---|---|---|---|
| Agwa et al [03] | 245.5-610kg/$m^3$ | 274-4532 | 4.5-30.5 |
| Ganeshan et al [12] | -------------------- | 953$m^2$/kg | ------------ |

# 3. Chemical Properties:-

Sugarcane bagasse ash chemical properties obtained from previous researchers investigation. Many researchers showed different chemical composition of SBA in previous studies. Some researchers chemical composition of SBA is in Table No. 2

**Table 02: Chemical Composition of SBA**

| Authors | $SiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | CaO | MgO | $SO_3$ | $K_2O$ | $Na_2O$ | LOI |
|---|---|---|---|---|---|---|---|---|---|
| Rajasekar et al [01] | 86.79 | 2.45 | 1.75 | 3.42 | 1.46 | 0.3 | 3.83 | ----- | 7 |
| Abdall et al [02] | 76.18 | 3.62 | 8.71 | 2.88 | ------ | ----- | 5.49 | --- | 5.82 |
| Agwa at al [04] | 78.93 | 4.27 | 5.94 | 4.11 | 0.93 | ---- | 3.09 | ---- | ------ |
| Memon et al [07] | 66.7 | 9.24 | 1.53 | 10.07 | 4.6 | ----- | 2.44 | 1.3 | 1.9 |
| Praveen Kumar et al [08] | 55.49 | 9.92 | 8.29 | 8.74 | 7.96 | ----- | 8.34 | 0.93 | 5.4 |

# 4. Slump test for workability:-

Many researchers showed that slump value enhance and some study showed that decrease slump value after using SBA. Rajasekar et al used Replacement of 0-20 % amount of SBA and slump value enhances up to 13% at 20% amount of SBA[01]. Abdalla et al used 0 to 40% amount of SBA in place of cement and slump value fall from 95 mm to 45mm[2]. Similarly Huang et al[04] used 0 to 80% amount of SBA in place of cement and optimum slump value 245mm found at 40% amount of SBA and after SBA increased then slump value decreased. Lian, Jet al[05] used 0 to 9% amount of SBA in place of cement and consistency fall from 93mm to 31 mm and fluidity fall from 209mm to 138mm respectively.

# 5. Mechanical Properties:-

**5.1 Compressive Strength**:- In earlier studies researchers 0 – 40% amount of SBA and found different results but maximum researchers found 5-10% amount of cement replaced with SBA provide optimum results in compressive strength. Abdalla et all, Agwa et all, Memon et all and found optimum result at 10% amount of SBA. Similarly Rajasekar et al found optimum results at 5%% amount of SBA[ Table no. 03]. According to researchers investigation 10% amount of SBA good for compressive strength at 28days curing tests.

Table03: Compressive Strength of SBA

| Authors | Replacement of Cement (in %) | Results (in MPa) | Optimum amount of SBA | Result at Optimum amount of SBA |
|---|---|---|---|---|
| Rajasekar et al [01] | 0%,5%,10%, 15% & 20% | 193, 254, 287.5 & 254 | 15% | 287.5Mpa |
| Abdalla et al [02] | 0%, 10%, 20%, 30% & 40% | 55, 64, 53, 46 & 25 | 10% | 64Mpa |
| Agwa et al [03] | 0%,5%,10%, 15% , 20%, 25% & 30% | 24, 24.5, 26, 21,20,17.5, 15.5 | 10% | 26Mpa |
| Memon et al [07] | 0%,5%,10%, 15% & 20% | ----------- | 10% | 23.94Mpa |
| Praveen Kumar et al [08] | 0%,5%,10%, 15% & 20% | 65.2, 67.4, 68.5, 59.3& 58.35 | 10% | 68.5Mpa |
| Kiran, and Kishore [19] | 0%,5%,10%, 15%, 20%, 25% | 39.4, 45.5, 42.9, 39.7, 30 and 18.7 | 5% | 45.5Mpa |
| Ganeshan et al [12] | 0%,5%,10%, 15%, 20%, 25% and 30% | 0%,5%,10% , 15%, 20%, 25% and 30% | 10% | 33.9 Mpa |

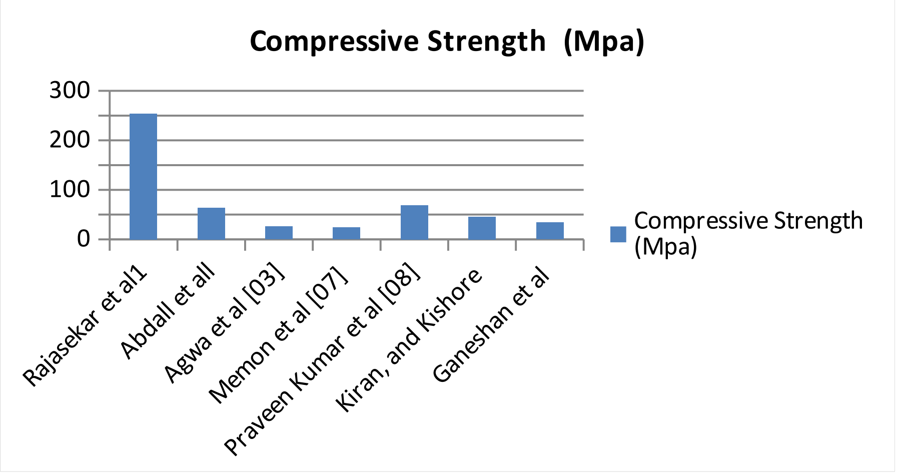


Figure 03: Compressive strength at 10% SBA replacement of Cement

**5.2 Flexural Strength**:- Researcher used 0 – 40% amount of SBA and found different results but maximum flexural strength found at 15% amount of cement replaced with SBA. Kiran and Kishore used 0%, 5%, 10%, 15%, 20% and 25% amount of SBA and after

28days curing results found 3.92,4.38,4.12,4,2.86 and 2Mpa respectively, as result at 5% SBA gain maximum flexural strength. Similarly Srinivasan and Sathiya used 0% - 25% amount SBA and result founds 3.46, 3.74, 3.56, 3.38, 3.18 and 3.02 Mpa And optimum results found at 5% amount of SBA. Praveen Kumar et al [08] used 0%, 5%, 10%, 15% and 20% amount of SBA and after 28days curing results found 8.12, 8.29, 8.37, 7.52 & 7.30Mpa respectively, as result at 10% SBA gain maximum flexural strength.

Table 04: Flexural Strength of SBA

| Authors | Replacement of Cement (in %) | Results (in MPa) | Optimum amount of SBA | Result at Optimum amount of SBA |
|---|---|---|---|---|
| Abdalla et al [02] | 0%,5%,10%, 15% & 20% | 6.4, 6.9, 6, 5 & 4.8 | 10% | 6.9Mpa |
| Praveen Kumar et al [08] | 0%,5%,10%, 15% & 20% | 8.12, 8.29, 8.37, 7.52 & 7.30 | 10% | 8.37Mpa |
| Kiran, and Kishore [09] | 0%,5%,10%, 15%, 20%, 25% | 3.92, 4.38, 4.12, 4, 2.86 and 2 | 5% | 4.38Mpa |

**5.3 Split tensile strength:-** Split tensile strength at 28 days results obtained in previous studies investigators taken 0 to 25% amount of cement replaced with SBA and optimum results observed at 10% replacement. Kiran and Kishore[09] was observed 1.37 Mpa respectively at 5% amount of SBA, similarly Praveen Kumar et al [08] l used 5%,10%, 15% & 20% amount of SBA and found split tensile strength 12.92% enhanced at 5% and 25.17% enhanced at 10% after that reduced SPT 2.04% at 15% and 14.73% at amount of 20% SBA and 5.52 Mpa at optimum amount of SBA.

Table 05: Split Tensile Strength of SBA

| Authors | Replacement of Cement (in %) | Results (in MPa) | Optimum amount of SBA | Result at Optimum amount of SBA |
|---|---|---|---|---|
| Praveen Kumar et al [08] | 0%,5%,10%, 15% & 20% | 4.41, 4.98, 5.52, 4.32 & 3.76 | 10% | 5.52Mpa |
| Kiran, and Kishore [09] | 0%,5%,10%, 15%, 20%, 25% | 1.31, 1.37, 1.34, 1.32, 1.05 and 0.86 | 5% | 1.37Mpa |

## 6. Water absorption and porosity:-

D.-H. Le et al. [11] and T.D. Garrett et al. [12] conducted studies on the influence of incorporating sugarcane bagasse ash (SCBA) as a partial substitute for cement on the water absorption attribute of concrete. Their experimental investigations involved exchanging cement with SCBA in varying proportions ranging from 10% to 30%. The results demonstrated that water absorption enhanced proportionally with the SCBA replacement level, with the maximum absorption observed at a 30% substitution rate. Ganesan et al. [10] reported that increasing the SCBA content in concrete mixtures led to a corresponding rise in water absorption. Their study presented the saturated water absorption values for SCBA replacement levels of 0%, 5%, 10%, 15%, 20%, 25%, and 30% as 4.71%, 4.78%, 4.86%, 4.90%, 5.16%, 5.56%, and 6.08%, respectively. This trend was attributed to the increase in total pore volume within the concrete matrix, as also noted by Garrett et al. [12]. Summer and Prinya [24] reported elevated porosity levels in concrete containing SCBA compared to the control mix. At 28 days of curing, the porosity values for mixtures with 0%, 10%, 20%, and 30% SCBA were 7.20%, 7.22%, 8.31%, and 8.50%, respectively, indicating a significant rise in porosity with increasing SCBA content.

# 7. Economical Aspect of the Study:

The economical aspect of the proposed research work can be understand by considering following parameters –

Table 06: Economical Comparison of UHPC and Eco-friendly UHPC

| **UHPC** | | | | |
|---|---|---|---|---|
| S. No. | Materials | Quantity | Price Per Kg | Material Cost |
| 1. | Cement | 900 kg | Rs 7/- per Kg | 6300/- |
| 2. | Fine | 1005 kg | Rs 2/-per kg | 2010/ |
| 3. | Silica | 220 kg | Rs 40/- per kg | 8800 |
| 4. | Steel | 157 kg | Rs 100/- per kg | 15700 |
| 5. | Super plasticizer | 40kg | Rs 50/- per kg | 2000 |
| 6. | Water | 163 kg | Rs 1/- per kg | 163 |
| Total | | 2485kg | Cost per Cubic Meter | 34973/- |
| **UHPC Cost @ 34973/- per cubic meter (Costly)** | | | | |
| **Eco-friendly UHPC** | | | | |
| S. No. | Materials | Quantity | Price Per Kg | Material Cost |
| 1. | Cement | 630 kg | Rs 7/- per Kg | 4410/ |
| 2. | SBA | 270 kg | Rs 2/-per Kg | 540/- |
| 3. | Fine | 1005 kg | Rs 2/-per kg | 2010/ |
| 4. | Silica | 220 kg | Rs 40/- per kg | 8800 |
| 5. | Steel | 157 kg | Rs 100/- per kg | 15700 |
| 6. | Super plasticizer | 40kg | Rs 50/- | 2000 |
| 7. | Water | 163 kg | Rs 1/- per kg | 163 |

| | | | |
|---|---|---|---|
| Total | 2485kg | Cost per Cubic Meter | 33623/- |
| **Eco- friendly UHPC Cost @ 33623/- per cubic meter (Low cost )** | | | |

Above comparison shows that our proposed proportion is cheaper UHPC and all materials cost taken from local market in Rajasthan.

## 8. Research Gap:-

According to previous research SBA required more study in some fields like
Few studies have focused on the performance of agro-industrial and by-product, such as sugarcane bagasse ash as replacement with cement in UHPC.
The study on cost comparison of use of cement and sugarcane bagasse ash in UHPC has not been done.

## 9. EXPECTED OUTCOME OF THE STUDY:

From availability of a new material like SBA, it is possible that the cost of Ecofriendly UHPC can be reduced, due to which we can get cheap UHPC.
We add new material like SBA, so it is possible that mechanical properties will enhance.
We use some ecofriendly material like Sugarcane bagasse ash so we will get new results in this study.

## 10. Conclusion:-

For sustainable development enhance utilization of SBA in concrete which essential for environment, society.
Past studies point out to utilization of agricultural waste/ Sugar industry waste in concrete industry.
5% - 10% replacement of cement from SBA enhances mechanical properties.
EFUHPC Cost effective as compare to UHPC.

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