Review Paper

Different mineral admixtures in concrete: a review

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Abstract
The present work reviews the various mineral admixtures used in concrete which modifies the concrete properties. In this study, cement is partially or completely replaced by different mineral admixtures such as fly ash, silica fume, rice husk ash, Ground Granulated Blast Furnace Slag, palm oil fuel ash and metakaolin. The strength obtained is different for different mineral admixtures by adding these to concrete. Various concrete characteristics like split tensile, compressive and flexural strength, durability, workability are presented.

Keywords GGBS · Fly ash · Metakaolin · Palm oil fuel ash · Silica fume · Rice husk ash

1 Introduction

In developing countries, demand for Portland cement is growing significantly [1]. By using additional materials i.e. mineral admixtures, compressive strength of concrete increases [2]. Waste materials which are produced from industries can be used in concrete by replacing either aggregates or cement [1]. In some studies, aggregates are replaced by palm oil shells which are waste product in agriculture industry and this is used as light weight aggregate [3]. In some studies, different mineral admixtures are used as replacement of cement [4].

Quality of concrete can be improved by adding different mineral admixtures: metakaolin, GGBS, Fly Ash, Rice Husk Ash, Palm Oil Fuel Ash and Silica Fume. Mineral admixtures influence the hardened properties of concrete [5]. By incorporating these admixtures cement content get reduced which minimize environment impact and the properties of concrete also increases [6]. Also problems with disposal may reduce because these admixtures are industrial by-products [7]. Effect on fresh concrete due to mineral admixtures shows variation in mechanical and durability properties compared to conventional concrete [8]. Usage of supplementary cementitious materials in the preparation of concrete can leads to significant energy savings, cost savings and environmental pollution reduction [9].

2 Background study

Firstly, silica fume used in 1969 in Norway but was employed in North America and Europe in early's 1980 [9]. The usage of silica fume has been increased worldwide over recent years which can enhance the permeability, strength and durability [10]. Silica Fume used as a partly or complete substitute of cement which increases the concrete properties [11].

Silica fume is used as an artificial pozzolonic admixture which is also called as micro silica or condensed silica fume [12]. Silica fume is obtained from coal with quartz reduction in an electric arc furnace and is waste bi-product of manufacturing silicon or Ferro silicon alloys [13]. The particle size is which is < 1 micron [14] and has an avg. diameter

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of 0.1 microns. Its chemical composition consists of > 90% of SiO_2 and other constituents are Sulphur, Carbon and aluminium oxides, potassium, Fe, Ca [15]. Adding of silica fume decreases the permeability of concrete to the chloride ions [16]. These protect the steel from corrosion in coastal region. In Tables 1 and 2 physical and chemical properties of silica fume are tabulated.

Metakaolin is a white powder of $Al_2O_3.2SiO_2$ [17] and obtained from the calcinating of pure kaolinite clay at an ambient temperature of 650^0 850 °C [18]. It is high quality pozzolonic material which is effective in increasing strength and reduces the sulphate attack.particle size of metakoalin is smaller compared to cement particles [19].

It is a non-crystalline amorphous and cementitious material. For maintaining the consistency of concrete and to produce high strength concrete, Metakaolin is used as an admixture [20]. In concrete, metakaolin is used as replacement material. For every production of one ton of metakaolin leads to 175 kgs of CO_2 emission, which is very less when compared to Portland clinkers [21]. In Tables 1 and 2 physical and chemical properties of metakaolin are tabulated.

From agro-waste of palm oil, POFA is obtained [22] [23]. Fiber waste and shells of palm kernel are burned in chimneys to produce heat at a temperature of 450 °C [24]. It is estimated that approximately 4 kgs of dry biomass is produced to produce one kg of palm oil [25].The obtained ash is collected, pulverized and passed through IS 90 mm sieve [26]. POFA are used in super structures and long span bridges mainly for precast, pre stressed girders and high raised skyscrapers. In Landfills, the disposal of palm oil fuel is being as a waste, these many cause environmental problems [27]. In Tables 1 and 2 physical and chemical properties of POFA are tabulated.

Fly ash is obtained from electricity generation in thermal power plants coal is combusted, during this process a byproduct fly ash is formed. Fly ash contains majorly calcium oxide, silica, and alumina. Fly ash is categorized into two types C-type, F-type. C-type consists of pozzolonic and cementations properties and it has high calcium content. F-type consists only pozzolonic properties and it has low calcium content [28]. In Tables 1 and 2 physical and chemical properties of fly ash are tabulated.

Ground granulated blast furnace is extracted when a molten slag is quenched in water or by steam which is obtained from blast furnace, it produces a glassy granular product which is dried and ground into a fine powder known as GGBS. Types of GGBS are granulated slag, pelletized slag, expanded or foamed slag, and air cooled slag. Among these most commonly granulated slag is used as mineral admixture.

GGBS consists of pozzolonic and cementations properties. To hydrate the slag activator is needed. GGBS has characteristics like corrosion resistivity, sulphate attack

Table 1 Chemical Properties of mineral admixtures

	Fly Ash (%) [80]	GGBS (%) [30]	RHA (%) [50]	Silica fume (%) [9]	Metakaolin (%) [52]	POFA (%) [81]
SiO_2	25–60	27–38	85.5–95.5	95.75	52	53.5
Al_2O_3	10–30	13.24	0–2.5	0.35	46	1.9
Fe_2O_3	5–25	0.65	0–1.5	0.21	0.6	1.1
TiO_2	<1	<1	<1	<1	0.65	0.34
CaO	<10	34–43	0.51	0.17	0.09	8.3
MgO	<1	0.15–0.76	0.44	0.09	0.03	4.1
K_2O	<1	0.37	2.91	<1	0.03	6.5
Na_2O	<1	<1	<1	0.51	0.1	
LOI	<1	<1	<1	<1	1	6.19
SO_3	<1	<1	<1	0.42	<1	0.93
MnO	7–15	<1	<1	<1	<1	0.16

Table 2 Physical properties of mineral admixtures

	Fly ash	GGBS	RHA	Silica fume	Metakaolin	POFA
Shape	Spherical [80]	Spherical [30]	Irregular [50]	Spherical [75]	Spherical [82]	
Specific gravity	1.9–2.55 [80]	2.6 [30]	2.3 [50]	2.25 [83]	2.6 [84]	2.22 [85]
Average particle size	0.5–300 µm	4.75 mm down [30]	<45µ [50]	0.1µ	12 µ [21]	
Bulk density (Kg/m$^{3)}$	540–860	1000–1100	20	750–850 [55]	0.4–0.5 [38]	1625 [65]
Surface area		6000 cm^2/g		20000 m^2/kg [69]	4.5–5.5	980 m^2/kg

and water impermeability [29]. GGBS increases heat of hydration, drying shrinkage and reducing creep, reducing bleeding and raising the ultimate compressive strength [30]. In Tables 1 and 2 physical and chemical properties of GGBS are tabulated.

Rice Husk Ash is formed during milling of the paddy and this is used as a fuel and it is formed by burning rice husk. RHA consists of major amount of silica. RHA reduces permeability and improves strength of concrete. RHA also resist sulphate and chloride attacks [31]. In Tables 1 and 2 physical and chemical properties of RHA are tabulated.

3 Properties of mineral admixtures

The properties like physical and chemical are extracted from previous studies and are presented in tables below. The Chemical properties of different mineral admixtures are shown in Table 1 and The physical properties of different mineral admixtures are shown in Table 2. The mineral admixtures are shown in Fig. 1.

4 Workability studies

FRC with steel fibers has maximum compressive strength at 0.3% for 3 days, 28 days and at 0.2% for 7 days. Strength and workability decreases due to partial replacement of fly ash [32]. Compressive strength decreases at 7 days compared to 28 days if fly ash content increases in concrete. Augment in fly ash, improves consistency and workability of cement [33]. Workability decreases when the percentage of GGBS increases. If GGBS is in higher percentage then SCGB beams shows higher ductility [34]. Workability of OPC with partial replacement of GGBS increases depending on the replacement level. Hence, the optimum replacement is 40% for structural purposes [35]. Slump has increased on 20% & 40% replacement of GGBS in cement & marble slurry in fine aggregate respectively. Also Split tensile, Compressive & Flexural potency increases when compare to control concrete at same substitute levels for M25 grade [36]. Addition of GGBS reduces water demand and increases workability. For M25 SCC grade strength obtained is maximum at 50% replacement of GGBS to cement and 50% replacement of CRF to river sand [37].

RHA is replaced in OPC at 25% has no effect on workability and strength. 10% replacement of RHA was good for structural concrete [38]. RHA is highly porous material due to this concrete requires increase in water cement ratio. Workability of concrete gets decreased when RHA content is increased [15]. Maximum compressive strength was obtained 10% SF + 30% QD. Workability has decreased by adding quarry dust and silica fume. An RCPT value shows that permeability of ions reduces with addition of Silica Fume [39]. Max. strength was obtained at 15% of replacement with Silica fume. Workability decreases with increment of silica fume percentage [40]. He justifies that slump decreases as the percentage of metakaolin content

Fig. 1 Different mineral admixtures

increases. The maximum strength obtained by both combination of metakaolin and silica fume at 6% and 15% at 7 and 28 days of curing [41]. Highest Compressive strength obtained at 15% of replacement at 28 days of curing. Workability decreases with increase in cement replacement [42].

5 Strength studies

W/C ratio played a important role in determination flexural and compressive strength. At 35, 45, 55% replacements, compressive strength of concrete is maximum for 0.4 W/C ratio [43]. The optimum percent replacement is 15% fly ash and 15% metakaolin in cement increases compressiveness & split tensile strength [8]. It has observed that 10% replacement increases strength and 30% replacement decreases concrete strength on comparision with control concrete [13]. Increase in fly ash content in concrete decreases compressive strength in ECC mixes but for FA/C = 1 strength of 25 MPa was achieved. Tensile properties get increased at 1% addition of fibers for FA/C ratio of 0.25 [44]. For M40 grade compressive strength of concrete is less at 50% replacement and more at 60% replacement compared to plain concrete. For M40 and M30 grades at 60% replacement resistance to chloride ion penetration is more. [45]. Fly ash fiber reinforced concrete has highest compressive strength at 20% replacement. It has observed on adding fly ash in cement with steel fibers increases the strength [46]. At 20% and 4% replacement level of GGBS and Nano Silica increases concrete compressive strength. Increase in compressive strength is 37% when compared to conventional mix [47].

The strength is 10 to 20% of cement content in concrete of M30 to M40 grade concrete for 80 to 90% replacement of cement with GGBS. It is found that 40% of replacement will yield better results for split tensile strength [48]. It was found that at 0% GGBS replacement with cement and 30% steel slag with fine aggregate, concrete achieves highest compressive strength. concrete has optimum strength at 15% GGBS replacement with cement and 30% steel slag with fine aggregate [26]. Cement is replaced by 5% GGBs and 15% fly ash which increase flexural, split tensile & compressiveness of concrete. Durability of concrete also increased at 5%, 15% GGBS, fly ash respectively. [49]. RHA in cement increases Compressive strength of pervious concrete beyond that, it get decreased.RHA is replaced by 10% in cement which improves Flexural strength of Pervious concrete beyond that, it get decreased [50].

If replacement is increased above 10% compressive strength get decreased with increased exposure conditions. Hence 10% replacement is optimum for concrete to resist sulfate environment [8]. At 28 days modified mixture is prepared by replacement of cement with 10% RHA and 100% replacement of aggregates with recycled aggregates gave 2.11% more compressive strength, 3.88% more tensile strength compared to conventional concrete [51]. Concrete has higher compressive strength at OPC + 0.25%CF + 10%RHA compared to all other systems. At 0.25% replacement of coir fiber highest compressive strength has achieved [22]. At 10% replacement of RHA, 0.25% glass fibers shows a optimum compressive, sp;lit tensile and flexural potency of M40 grade concrete at the age of 7 days [52]. RHA is replace by cement results in showing the graph increasing compressive strength at 7.5% and decreasing at 10%, hence the optimum percent of RHA is to be replaced with cement is 7.5% [53]. Cement was replaced by silica fume with percentages of 0, 5, 7.5, and 10%. Compressive, flexural and split tensile potency obtained maximum at 10% substitute of cement with silica fume when compare to normal concrete [54]. Partially replaced silica fume in concrete which has durability, strength characteristics for mixes with partial replacement of 5, 10, 15% of silica fume. Results show that compressive strength and split tensile strength of cube gains max. at 10% of replacement of silica fume for 7,14 and 28 days [55].

Substitution of M30 grade with 0,25,30,40 and 50% silica fume. The Compressive strength and split tensile strength increased at 25% of replacement with cement [56]. He has replaced silica fume by 0%,2.5%,5%7.5%, 10%12.5%,15%,20%,25%,30% with M20,M25 and M30 grade of concrete.. Strength obtained maximum at 10% of replacement [10]. Compressive strength was obtained maximum at 7.5% of replacement of cement. Percentage increment in silica fume decrease tensile and shear potency [57]. CSA was replaced at 5%,10% and 15% and silica fume at 5% and 10% of substitute by cement of M50 grade of concrete. Maximum strength was obtained at (10% + 10%) SF + CSA [58]. Here, Cement replace by SF and fly ash with a percentages of 5, 10,15%. The result obtained has very low Split tensile and compressive strength, so it can't be used for structural applications [59]. Cement replaced by metakaolin with percentages of 5, 10, 15, 20% of M30 grade. Flexural, compressive and split tensile strength obtained maximum at 15% of replacement [60]. The mix shows the maximum compressive strength gained at 10% partial replacement. With increase in replacement dosage, the strength found to be decreasing [61]. Here, cement replaced by fly ash with 20% of replacement and metakaolin with percentages of 5, 10, 15% at 7, 28, 90 days. Maximum Flexural, compressive and split tensile potency gained at 10% of substitute with cement in comparison with normal concrete [62]. Tensile and compressive strength was obtained maximum at 15% of replacement. Flexural strength gained max. at 10% of replacement when compared to conventional concrete [25].

RHA was replaced by 0, 5, 10, 15 and 20% and metakaolin was replaced by 2.5 and 5%. Split tensile and compressive strength of RHA was obtained at 10% and 5% of metakaolin. Combination of both achieved at 10% of RHA and 5% of metakaolin [19]. Cement was replaced by fly ash with 5, 10, 15, 20, 25 and 30% and metakaolin by 5,10,15 and 20% with M40 grade of concrete for 7 and 28 days. Split tensile and compressive strength gives best results at 30% fly ash and 15% of metakaolin [21]. The concrete strength augment as the percentage of metakaolin content increase up to 15% of replacement with its cement weight.Metakaolin increases the strength of concrete in comparision with normal concrete [63]. Conventional mix with 15% of replacement with cement achieved maximum strength. Flexural, Compressive, Split tensile strength was obtained at 15% of metakaolin and 50% robo sand at all ages [12]. This paper involves the replacement of cement with POFA at percentages of 10%, 20% and 30% at the age of 7, 21, 28 days. The compressive strength seems to be increasing with increment in age of concrete and decreases with increment in POFA content [64]. Flexural, Compressive, Split tensile strength were studied at 7, 14 and 28 days and obtained max. strength at 20% of replacement when compare to conventional concrete [65]. Compressive potency obtained maximum at 12.5% replacement. Split tensile potency is highest at 7.5%. By usage of POFA cost of concrete will be reduced [66].

This work involves the partial replacement of cement in concrete by POFA with percentages of 5, 10, 15, 20% of M40 grade of concrete. Split tensile, compressive, flexural strength conducted on the blended concrete and achieved maximum strength at 10% of replacement [67]. Concrete mechanical properties are determined with a replacement of 5, 10% POFA for 3, 7, 28 days. Maximum split tensile and compressive strengths are obtained at 5% replacement [68]. Compressive strength was maximum and split tensile potency was highest at 2.5% of replacement with POFA. Later on potency decreases when POFA percentage increase [69]. POFA replaced with cement at 0, 10, 30 and 50% for 7 and 28 days. Compressive & Flexural potency obtained maximum at 30% replacement of POFA when compared to normal concrete [24]. Egg shell powder replaced by 10,8,6,4,2% and palm oil fuel ash by 0,2,4,6,8,10%. Results shows that 6% POFA and 4% egg shell powder has the highest strength of all mix percentages [70]. The replacement of coarse aggregates with Palm oil shells and the binding material with palm oil shells is up to 30% is recommended to achieve the light weight concrete [71]. Demand of construction materials are increased now days. In order to bring down this problem, we are searching for new alternate materials. In the present study, POFA , and Gypsum (SCC) has been used as an admixture to cement in concrete manufacturing and its collection and properties has been studied in phase I [72].

6 Durability studies

30% GGBS is replaced in cement then there will be maximum increase of load carrying capacity of compressive potency of concrete. Corrosion resistance of fiber content increase with 30% of GGBS where by increasing GGBS content, compressive strength decreases in acid attack. [73]. Cement gets maximum compressive strength of 55.82 N/mm2 at 50% replacement of GGBS. Static load showed an increase in 18% fatigueless in HPC compared with conventional concrete [74]. Activator ratio increases as 1:2, 1:2.5 and 1:3 split tensile, flexural & compressive strength also increases. Increase in strengths of flexural, split tensile and compression of concrete for ratios of 1:2, 1:2.5 and 1:3 [1]. HVFAHSSCC has high self compacting ability, better segregation resistance, and high fluidity. Due to added steel fibers for HVFASSCC flexural, compressive strengths increases [75].

This paper studies of M35 concrete mix with silica fume as a partial replacement of 0, 5,9,12 and 15% by cement weight. The values shows usage of silica fume increases durability and strength characteristics at all ages compared to conventional concrete [76]. This paper studies of silica fume considering the optimum replacement of cement i.e., 13% replacement with grades of M20, M25, M30, M35 and M40. Percentage increase of silica fume to concrete micro-structure as micro pores are filled. So, density of pore structure becomes higher [77]. At 28 days compressive strength shows better results at 15% replacement of metakaolin for 0.5% & 1% HCl and H_2SO_4 of potency. Effect of HCL is lesser than effect of H_2SO_4 on potency when metakaolin used as replacement in concrete [78]. Compressive strength decrease up to 20% and starts increase at 25% of replacement. Water absorption percentage decrease with increase in POFA at 30% of replacement [79].

7 Summary of the all mineral admixtures

All the mineral admixtures of optimum percentage of replacement with cement with desired conclusions/remarks and Grade of the concrete which is used in the research are listed in Table 3.

Table 3 All Mineral Admixtures Summary

Mineral Admixture	Author	Grade of concrete	Optimum REPLACEMNT	Concluson
Fly ash	Shiv Kumar et al.	M30	35%	Maximum compressive & flexural strength is achieved at w/c-0.4
	Vinay Kumar et al.	M30	30%	Workability increases & strength decreases with increase of replacement level
	Sri Bhavana et al.	M30	10%	Strength is more with & without bacteria compared to conventional concrete
	Krishna Teja & Kameshwara Rao	M30 & M40	60%	Resistance to chloride ion penetration is more in M30 & M40 grade concrete
	Priyanka singh & Niraj	M25	20%	Compressive, Flexural, Split tensile strength increases with added steel fibers
	Surendra & Rajendra	M40	15% Fly ash + 15% Metakaolin	Increase in compressive & Split tensile strength of concrete
GGBS	Lokeshwaran et al.	M30	30%	Workability decreases with increase of GGBS percent. SCGB beams shows higher ductility at higher percentage
	Rakesh Kumar et al.	M35	40%	Compressive, Split tensile, Flexural strength increases
	Anand et al.	M30 & M40	40%	Split tensile strength yields better results at 40% replacement
	Naveena & Chaitanya Kumar	M30	30%	Corrosion resistance of fiber increases but compressive strength decreases due to acid attack
	Mallesh & Suresh	M20	15% GGBS + 30% Steel Slag	15% GGBS is replaced in cement & 30% steel slag replaced in fine aggregate increases compressiveness of concrete
	Arvind Singh Gaur et al.	M25	20% GGBS + 40% Marble Slurry	Replacing marble slurry in fine aggregate & GGBS in cement, slump, split tensile, flexural strength increases
	Mani Deep & Jazeb	M60	5% GGBS + 15% Fly ash	Strength & durability of concrete increases
	Nagendra et al.	M20	20% GGBS + 4% Nano Silica	Increase in compressive strength of 37% compared to conventional concrete
	Manjula & Flexikala	M25	50% GGBS + 50% CRF	Water demand is reduced, workability increased & strength is maximum
RHA	Godwin et al.	M20	10%	Has no effect in workability & strength but flexural, split tensile strength slightly increases
	Talsania et al.	M30-M40	10%	Compressive & flexural strength increases by 10% replacement, beyond that decreases
	Salim Khoso et al.	M15	10%	Compressive, tensile strength increases at 10% RHA & 100% recycled aggregate replacement
	Swathika et al.	M20	0.25% Coir Fiber + 10% RHA	Compressive & Split tensile strength increases

Table 3 (continued)

Mineral Admixture	Author	Grade of concrete	Optimum REPLACEMNT	Concluson
	Nambirajan & Satishbabu	M40	10% RHA + 0.25% Glass fibers	Concrete compressive,split tensile, flexural potencies increases
	Akshay Tandon & Jawalkar	M30, M40, M60	7.5%	Graph shows augment in compressive potency at 7.5% substitution
	Harish et al.	M20	10%	To resist sulfate attack 10% is optimum at all ages of curing
Silica fume	Dilip et al.	M20,M25	10%	High early strength, good quality control
	Arjun kumar	M30	10%	Strength increase up to 10% and starts decreasing
	Kumar & Dhaka	M35	12%	Compressive, flexural strength increases at 12%,split tensile at 9%
	Sesikumar & Tamilvanan	M30	25%	Graph shows increment of strength at 25%
	Akshay suryavanshi	M20,M25,M30	10%	Workability decreases as silica fume increases
	Guru deep Singh	M25	10%SF + 30%QD	SF + QD increases strength due good bond formation
	Joe Paulson	M20, M25, M30, M35 and M40	13%	Addition of silica fume improves pore structure,density becomes higher
	Ali M Mansor		7.5%	Use of SF in HPC decreases the tensile and shear strength
	Prabhulal chouhan	M25	15%	Workability decreases with addition of silica fume content
	R.Umamaheswari	M50	10%SF + 10%CSA	Partially replaced with CSA %SF has significant increase
	V.Prakash	M35	Low strength	Pervious concrete has low compressive strength and flexural strength
Metakaolin	CH Jyothi Nikhila	M70	15%	Effect of HCl is lower than effect of H_2SO_4 on strength when metakaolin is used
	Bindu Biju	M70	10%	With increase in replacement dosage, strength seems to be decreasing
	N.Narmatha		15%	Use of metakaolin increases strength in HPC
	Sunny A. Jagtap	M35	15%	Metakaolin increases the compressive strength,flexural strength
	K.Anantha Lakshmi	M25	10%	Graphs shoes increment up to 10% and then decreases
	O.Hemanth Rama Raju	M35	15%MK + 50% robo sand	Metakaolin and robo sand decreases the effect of acid
	K.Madhu	M30	10%RHA + 5%MK	Workability decreases because of increased water absorption and strength decreases
	V.Subbamma	M40	30%fly ash + 15%MK	Slightly increase in strength by using both combination
	Nova John	M30	15%	Use of metakaolin has faster early age strength
	Srivastava		6%SF + 15%MK	Slump decreases with increase in metakaolin content

Table 3 (continued)

Mineral Admixture	Author	Grade of concrete	Optimum REPLACEMNT	Concluson
POFA	Shamed	M25	7.5%	By usage of POFA cost will be reduced
	Sidek	M30	5%	Using liquidation and powder technique gives optimum percentage of POFA
	Jonida pone		5%	Workability decreases with increase in POFA content
	Liyana Ahmad		30%	POFA concrete relative density was lower when compared to control concrete.
	Ahmad	M40	15%	Optimum increase up to 15% of replacement
	Subhashini	M30	20%	Use of POFA will reduce environmental problems
	Oyejobi		Low strength	Strength decreases as POFA content increases

8 Conclusion

From the above literature Reviews, we have studied the different admixtures used in concrete are as a follows: (1) Silica fume (2) Metakaolin (3) POFA (4) RHA (5) GGBS (6) Fly Ash.

- Every admixture is partially replaced with cement at different proportions on various grades of concrete. If the percentage limit is high, then it impacts on strength properties like compressive, split and flexural strength of concrete and durability properties
- From the above literature reviews, it is shown that the optimal percentage of silica fume and RHA varies from 5 to 15%. Mostly, silica fume and metakaolin increases the heat of hydration and others decreases.
- Metakaolin concrete effectively increases the strength properties when compared to normal concrete. Workability get decreased as percentage of metakaolin increased.
- POFA used as a substitute for cement which enable the comprehensive waste product uses. Usage of POFA as concrete products in the construction industry would reduce the environmental problems associated with landfill disposal.
- Replacement fly ash in cement increases characteristic properties of concrete and also it resist chemical attack on concrete when compared to conventional concrete.
- GGBS replacement in cement increases concrete split tensile, flexural potency. When GGBS is partially replaced in cement, fine aggregate also partially replaced by other materials increases mechanical properties of concrete.
- All the mineral admixtures minimize the bleeding in concrete by using the materials in acceptable proportion. Mineral admixtures of higher specific area and smaller size are mostly preferable to manufacture high dense and impervious concrete.

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