Section A-Research paper

A COMPARATIVE STUDY ON THE VARIOUS ALTERNATIVE MATERIALS FOR CEMENT, FINE AGGREGATE AND COARSE AGGREGATE IN CONCRETE

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ABSTRACT

Concrete is being manufactured for a wide range of purposes on the planet today, due to this rapid speed of development. It is critical for the construction of a framework that will allow for the long-term use of concrete. Yet concrete expends a ton of common assets because of which it isn't considered as a domain well disposed specimen. Portland cement is a significant component of solid which creates CO_2 during its creation which skeptically influences the environment. Likewise, sand and coarse aggregates are draining at a quicker rate due to the development of large scale constructions. Because of this, there is a requirement to recognize exchange materials for cement, sand and coarse aggregates. In this investigation, we studied about the various supplementary constituents used, which can generate a concrete without compromising on their properties and might improve some performance if used in optimum. This kind of concrete might be characterized as a Green or Sustainable Concrete.

Keywords:*Sustainable Concrete, supplementary constituents, Alcofine, Copper Slag, Sintered Fly Ash Aggregate.*

1 INTRODUCTION

Since time immemorial, concrete has been the main ingredient for the construction of structures, yet the huge demand of concrete has led to extensive extraction of both sand and stone aggregates which are the main components of concrete. Sustainable Concrete talks about whether the material is economical, eco-friendly and feasible. In this case, we talk about the combination of materials, thus reducing the cement cost and reducing CO_2 emission. Natural riches are strength of our nation. Due of the development of industries, natural resources are being plundered. Sand is one among the natural resources which is used in the erection of buildings and road pavements. It is quarried from the river bed causing depletion of the bed, lowering the water table, and bed worsening. Hence, the growing need is to find an different material equivalence to sand and settling an economical and environmental obligated solution. The growth in the construction industry brings up several concerns regarding availability of natural aggregate resources, as they are being rapidly exhausted. In this project, to identify the Cement, Fine aggregate, Coarse aggregate, and to reduce its amount by replacement with other constituent materials.

2 SUPPLEMENTARY CONSTITUENTS

This section presents the data regarding the supplementary constituents of Cement, Sand and Coarse Aggregate and its optimum utilization. Some essential literatures are studied to attain an extensive knowledge regarding Sustainable Concrete.

2.1 Replacement of Cement by supplementary cementitious Materials

Cement performances as a fastener material in customary concrete yet it includes warmth of hydration, which prompts reduction of concrete along these lines, that we supplant GGBS as a cover material in concrete. It enhances workability and diminish cement usage, excessive resistance to sulphate and other chemical compounds. So, cost will prudent and diminish condition by utilizing contamination of industry squander. Fly ash frequently acts as alternative of Portland cement with the share of zero-30% by means of the total mass of the cement. Fly ash and lime mixture ought to lessen CO_2 emission and it calls for much reduced energy to produce cement results in green concrete and additionally to reduce the price and the heat of hydration [1].

Concrete enterprise has continually accepted the use of diverse business garbage as a substitute to those materials considering that, otherwise such commercial waste needs to be rid off within the shape of landfills inflicting large quantity of land pollution. Substitute of cement by fly ash and lime in concrete mix is reviewed as eco-friendly and inexpensive. It protects the cement demand for the identical power thus redeeming the raw substances together with limestone, coal and so on used for production of cement. Fly ash is pozzolanic material and it enhances compressive strength and durability of the concrete. Because of alkaline nature lime has a better acid resistance. Lime has advantage pozzolanic pastime, this gives cementitious merchandise [2-3].

Metakaolin in concrete as partial alternative of cement. Metakaolin is neither the derivative of an industrial method neither is it absolutely natural. Pozzolanic reactions alter the microstructure of concrete and field of hydration items through annihilating discharged calcium hydroxide (CH) and formation of extra calcium silicate hydrate (C-S-H), conveying results like extended quality and reduced porosity and subsequently enhanced strength and durability [4-9].

Table1: Replacementof cementbysupplementarycementitious materials.

S. No.	Supplementary materials	Maximumpercentageofreplacement	Optimumpercentageofreplacement	PercentageIncrementin (compressive strength)	PercentageIncrement(splitting Tensile strength)	PercentageIncrement (flexural strength)
1	FlyAsh	60	40	14	8	-
2	GGBFS	30	30	58.45	-	-
3	Lime	15	15	14.58	15.63	3.80
4	Metakaolin	20	10	19.14	5.88	8.33
5	Aluminium Slag	30	25	3.47	6	2.97
6	Alccofine	25	15	18.20	28.71	12.71
7	Silicafume	35	5	18.18	-	-
8	Granite dust Powder	20	15	44.18	-	-
9	RiceHuskAsh	20	10	8.51	10.52	19.90
10	Quarrydust	35	25	39.94	141.66	-

Because of its small particles, large surface zone, and high SiO_2 concentration, Silica Fume has a high responsive pozzolanic property and is used in concrete. Silica fume is a highly refined form of separated silica obtained as a byproduct of industry. The silica fume significantly improves the workability and strength of concrete. Interventions like water absorption, permeability,

sulphate and chloride infiltration opposition are higher if there should be an occurrence of concrete mixed with silica fume when contrasted with ordinary OPC concrete[5,18].

Alccofine is a particularly developed product made from slag with high glass content and high reactivity obtained using the technique of controlled granulation. It increases the hydration manner because of evident hydraulic behaviour and pozzolanic reactivity. Packing density of concrete will increase because of addition of alccofine which will then reduce the quantity of water and admixture [6, 13].

Several analysts looked into granite dust powder, which comes from granite handling processing plant, to see if it might be used as sand or cement substitute in concrete and mortar production. The bulk of the studies revealed positive outcomes and benefits. Anyway, as the side-effect for example the powder varies synthetically relying upon the parent stone rocks which relies upon the territory, level of trans- formative nature and different elements; and furthermore, as the physical qualities of the side-effect relies upon the cleaning work, it is important to direct comparative exploration in our nation to consolidate it is used in the production of concrete and cement to reduce environmental pollution and ensure the long-term use of natural resources [7,29].

India is one of the world's leading rice producers. Rice paddy of roughly 600 million tonnes is harvested on a regular basis all over the world, representing a yearly production of 120 million tonnes Rice Husk. In the vast majority of cases, the husk provided during rice processing is either singed or discarded as garbage. Responsive silica is found in 90 percent to 95 percent of rice husk debris. The use of rice husk waste in concrete as a substitute for cement can reduce greenhouse gas emissions to a greater extent, hence expanding the potential for increasing the number of carbon credits[8-9][31-32].

Quarry dust squander is produced during the devastating procedure of rock and typical waste product that is invented from stone smashing sector which is bounteously attainable to the degree of 200 million tons per annul the waste can cause land removal, well being and ecological issue[9, 32].

2.2 Replacement of Fine Aggregate by Supplementary Materials

Sand has several other options for its replacement, which majorly comprises of industrial wastes and it’s by- products. Industrial wastes and by-merchandise are first-rate issue since these

materials are unsafe for the environmental surrounding and human well-being. These subtances are utilized in creation for their accurate usage and such risky materials can lessen their effects on humans and surrounding environment. Fly ash as a limited alternative for sand and is taken into consideration to be a withered product or spinoff acquired from the technology of energy which differs in line with the source. It brings a good amount of silicon dioxide, as available naturally in amorphous and crystalline shape [2, 11].

Table 2: Replacement of fine aggregate by supplementary materials,

S.No.	Supplementary Materials	Maximumpercentageofreplacement	Optimumpercentageofreplacement	PercentageIncrementinCompressive Strength	Percentage Increment(IncaseofSplittingtensile)	Percentage Increment (In case ofFlexural Strength)
1	FlyAsh	30	30	58.45	-	-
2	BottomAsh	100	40	20.71	10.86	25.84
3	Copperslag	100	40	8.11		7.58
4	Foundrysand	50	30	19.35	12.36	0.63
5	GlassFiberwith Papercrete	14	12	5.34	40	12.78
6	Crumbrubber	20	20	-0.69	-2.55	-
7	Robosand	100	50	14.43	7.46	32.78
8	GGBFS	60	40	20.13	116.93	-
9	Demolished waste	30	10	-5.26	-	-
10	MarblePowder	40	20	1.34	-	-
11	Quarrydust	30	25	11.68	17.35	-
12	MarblePowder	30	25	11.68	17.35	-
13	Copperslag	100	50	44.63	-	-
14	Papercrete	15	5	4.19	-9.74	-27.77

The utilization of copper slag in the concrete world as a substitution for sand can have the advantage of decreasing the expenses of removal and help in ensuring the environment. Another alternative of reusing copper slag is by utilizing it as a fractional substitution of concrete, it will be conceivable to reuse a squander result material usefully. A lot of copper slag can be used by utilizing it as fine and coarse aggregates in concrete since over 75% volume of concrete is involved by aggregates [5, 7, 12].

Foundry sand is a type of silica sand which has constant physical qualities and by result of ferrous and non-ferrousmetal dumping industry. It is demonstrated that foundry sand utilized as fine aggregate will upgrade the quality of concrete to a more noteworthy expand [10, 14].

The idea of utilizing Quarry dust as fine aggregate is featured these days on the grounds that the interest of river sand is exceptionally high. For substitution of sand, we required a solid material with either same expense or less expense. Since Quarry dust gives the better outcome and cost effectiveness, it very well may be utilized as another option. The non-affected workability is gotten on 20% substitution of sand yet it invigorates equivalent to standard concrete. For higher substitution estimation of sand, workability will most likely be influenced [15-16].

When we add crumb rubber in concrete, there is a decrease of the mechanical behavior, but durability increases. As the amount of crumb rubber increases, the splitting tensile strength, compressive strength, axial compressive strength and the elasticity modulus decreases. Also, sulfate and freezing thawing resistance were upgraded [17 - 18].

River sand is mostly exchanged with substances like Robo sand, which acts as an substitute to fine aggregate in concrete. Since natural river sand is of a huge demand, it has come to a complete exhaustion and rapid depletion of the resources. Robo sand is the key for this issue, since it possesses consistent gradation and zero impurity [18-19].

GGBFS is a by-product of iron and steel industry. During the exchange of GGBS with sand, the strength of concrete gradually increases up to a particular limit then it slowly decreases. The initial strength gain in concrete is high when the partial replacement of GGBS with sand up to 20%[19 - 20].

Demolished waste is mostly generated from a concrete structure, consisting of lumber, dirt, steel, woods, plastics etc. Thus, it is concluded that recycled aggregate concrete maybe an alternative to the conventional concrete. Optimum substitute level of Fine aggregate with recycled aggregates is 10% [20 - 21].

Marble powder is a by-product of marble producing industries. From this result, it is seen that the compressive strength of concrete increases when the marble powder increases up to 20%. Further increase of marble powder waste decreases the compressive strength. Therefore, waste marble powder can be completely used as partial substitute of fine aggregate in Concrete manufacturing. Thereby, reducing the problems of marble disposal and thus, reducing environmental degradation [21, 30].

2.3 Replacement of Coarse Aggregate by Supplementary Materials

Recycled aggregates were commonly utilized as a coarse aggregate substitute. Invented and most commonly used building material in the world is concrete. Mostly acquired by mixing cement, coarse aggregates, fine aggregates, admixtures, water, etc. [2, 24].

In this study, we test concrete which has partial replacement of coarse aggregate by Polystyrene, M20 grade is used and the tests are done for various proportions of Polystyrene with coarse aggregate 5%, 10%, 15%, 20%, 25%. The obtained outcomes were compared with those of conventional concrete. It is observed that compared to the control mix, the polystyrene basedconcrete showed a decrease in the density upto 10%. The highest strength obtained was 25.04 Mpa and the corresponding strength for control concrete was 23.56 Mpa.[8, 25].

Nowadays, misused plastic materials are created in sizeable amount and disposal has become a problem. Hence, usage of waste plastics as a coarse aggregate can help recycle and reuse plastic. In this research, for creating concrete, High-density polyethylene (HDPE) wastes are utilized as coarse aggregates. For generating durable polymer concrete, plastic aggregates and alcofines are used. As a result, concrete containing alcofine and HDPE has a satisfactory strength for an 8 percent exchange of plastic aggregate and 15% alcofine. The concrete materials have passed flexural and split tensile strength tests, demonstrating their high value. In comparison to natural coarse aggregate, plastic aggregate and alcofine used in concrete can avoid tension and rupture. Finally, as the percentage of exchange level is increased, the density of HDPE in the number of concrete specimens decreases. Capillary rise and water absorption were cut down by introducing plastic aggregates.[13, 26].

In this research, Expanded Polystyrene Beadshave had been used as a replacement for coarse aggregate, to use alternative resources in order to achieve long-term sustainability The findings revealed that the amount of Polystyrene beads used in concrete has an impact on the qualities of hardened concrete. When compared to concrete with EPS case, the compressive strength of 0 percent, 10%, 20%, and 25% EPS comprised concrete strengths of 100 percent, 96.2 percent, 62.3 percent, and 45 percent accordingly at 28 days.[14, 27].

Disposal of demolished concrete has become problematic; hence we reuse and recycle it to replace coarse aggregate. For this study, 3-, 7- and 28-days compressive strengths were recorded. Destroyed concrete aggregate of 10%, 20%, 40%, 60%, 80% by weight of the conventional

coarse aggregate and the concrete cubes were casted by that destroyed concrete aggregate then further tests conducted such as workability, compressive strength for that DAC (demolished aggregate concrete). It was observed that the maximum compressive strength was obtained by replacing natural coarse aggregate by 60% artificial aggregate [22, 28].

As we know, disposal of demolished waste has become a major problem, as it requires more land. Hence, it is better to recycle it and reuse it. Demolished building waste with crushed concrete (WCC), has been used as a coarse aggregate replacement from 20%, 30%, 40% (WCC), 3% of crushed coarse aggregate (lathe waste) to reduce the production of demolition waste. It is thus observed that recycled aggregates are viewed to possess a relatively low bulk density, higher crushing and impact values and higher water absorption as compared to natural aggregate[23,29] .

Table 3: Replacement of coarse aggregate by supplementary materials.

S. No.	SupplementaryMaterials	Maximumpercentage ofreplacement	Optimumpercentageofreplacement	PercentageIncrement inCompressive Strength	Percentage Increment(In case ofSplitting tensile)	Percentage Increment(In case ofFlexural Strength)
1	RecycledAggregate	30	20	58.45		
2	Polystyrene	25	5	6.28	1.12	1.05
3	HighDensityPolyethylene	32	8	-	-	-
4	ExpandedPolystyreneBeads	25	10	-2.71	-51.11	-
5	Demolishedconcreteaggregate	80	60	8.41	-	-
6	DemolishedBuildingWastewith Crushed Concrete	40	20	41.5	38.02	10.62
7	Coconutshell	100	25	-5.07	-	-
8	Plastic	20	20	-2.18	-38.12	-8.20
9	Glass	50	10	4.48	-	-
10	CrumbRubber	20	5	-7.79	-	-
11	E-Waste	20	15	18.47	22.62	-
12	SteelSlag	80	40	27.02	-	-
13	LimeStone	100	25	-12.68	-	-
14	SinteredFlyAshAggregates	50	30	27.44	-	183.04

Coconut is grown in huge quantities all around the world. India is considered the third largest cultivation area of coconut. Here, coconut shell has been used as a coarse aggregate replacement. At 28 days, the highest compressive strength of the control mix is 21.28 N/mm^2, while the minimum strength is 14.23 N/mm^2. When a result, as the amount of coconut shell increases, compressive strength drops. As a result, coconut shell can be used to make light-weight concrete [24, 30].

Plastic has become a very popular material due to its amazing properties, however excessive use of plastic materials due to the rise in population has degraded the environment and also caused problems for the human health. This research has found that if one replaces 20% of natural aggregates with plastic ones, the compressive strength is nearly equal, but as the percentage of natural coarse aggregate increases, strength of concrete decreases. 84.5 kg of plastic wastes can be used for optimum percentage replacement of 15% of unit volume of concrete [25 - 26, 31].

Glass is made up of Silica, Fly ash and CaCO3 and comes in many different shapes and sizes such as like container glass, flat glass, such as windows, bulbs etc. Replacing aggregates with waste glasses is possible but its uses are limited since the expansion inside the concrete is dangerous, it is due to ASR between cement paste pore water which is highly alkaline and the silica inside waste glasses .10% is the normal amount of replacement of coarse aggregate using waste glass, The increase in 28-day strength is observed to be upto 20% when coarse aggregate is exchanged a with thrown away glass [27, 32].

One of the strongest by product materials that can be part of concrete is crumb rubber. In this research, crumb rubber replaces coarse aggregate. Various tests had been conducted for fresh concrete (compaction factor test, flow test, slump test). Thus, it is observed that substituting the coarse aggregate by rubber leads to actually lowering the aggregate impact value. When the rubber content is increased, water absorption capacity of the aggregates increase as well. It has also been experimentally seen that substitution of coarse aggregates with rubber aggregates lowers the compressive strength of the concrete. Optimum replacement is upto 15% [28, 33].

Cost of concrete and construction materials have undoubtedly soared higher. Thus, it is advisable to reuse and recycle used materials. E-waste, which consists of electronics like TVs, Radios etc can be used as coarse aggregates. 15% replacement with E-wastes is found to obtain optimum Compressive strength [34-35].

Due to the growing population, there has been a demand for utilization of resources. Thus, producing more waste. In this research, we study the usage of steel waste, for example Steel slag. The optimum amount of steel slag to be replaced is known by conducting a compressive strength experiment of 28 days. This is done on cubes having size 150mm x 150mm x 150mm .The amount of steel slag replacing coarse aggregates are, 20%, 40%, 60%, 80%. Depending on shape and size, the structure of steel slag can change. It is due to the difference in shape, texture, surface area of the steel slag that it increases the strength when replacing the coarse aggregate [35-36].

Since time immemorial, concrete has been the main ingredient for the construction of structures, yet the huge demand of concrete has been the main reason for extensive extraction of both sand and stone aggregates which are the main components of concrete. It was found in a study that by adding steel fibres it enhances the strength by 10-20% and strength also increases due to replacement of normal stone aggregate with the limestone aggregates. For 25 - 100% replacement there is a decrease in strength and compressive strength. Up to 75% replacement usage of limestone is beneficial and workability also increases compared to granite aggregates [36 - 37].

Cement of OPC 43 is selected and aggregates of sintered fly ash are prepared when sintered fly ash is taken and cement and water are added into the mix. It is found that when 30% of sintered fly ash is mixed in the concrete, the Compressive strength is maximum at 43.12 N/mm^2, and when 50% sintered fly ash is mixed in the concrete, the Compressive strength is minimum at 26.24 N/mm^2[37 - 38].

3 CONCLUSIONS

The huge demand of concrete has led to an extensive extraction of both sand and coarse aggregates, thereby reducing the natural resources. Cement being major component in concrete has been extensively used which produces a large quantity of CO_2 emission. A solution for such problem is by reusing the waste materials, selecting new materials and creating new concrete combinations. Based on various studies the optimum percentage replacement of new materials like Replacement of Cement can be done by three materials, namely Alcofine, Metakaolin and GGBFS at a optimum content of 15%, 10% and 30%. Replacement of Fine Aggregate can be done by two materials, namely Copper Slag at 50% replacement, Foundry Sand at 30%

replacement. Replacement of Coarse Aggregate can be done by two materials, namely Recycled Aggregate at 20% replacement, Sintered Fly Ash Aggregate at 30% replacement.

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