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ECONOMICAL AND ENVIRONMENTAL CONSERVE CONCRETE

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ABSTRACT

Now a day's construction work is increasing day by day and concrete is an important material which is required in large quantity for construction. Cost of concrete depends on ingredients used for making concrete such as cement, river sand and coarse aggregate. If the cost of these ingredients is reduced by alternate materials then cost of concrete reduces which ultimately results in reduction in the cost of construction.In the present project work an attempt has been made to use alternate materials so that cost of concrete will reduce. Stone dust has been replaced with river sand, and fly ash with cement in varying quantity. With the replacement of these materials in making concrete a comparable results has been obtained. The use of such waste or by-product materials not only results in economical and sustainable concrete but also it conserves the natural resources and maintain the good environmental conditions.

Keywords : Cement, Fly Ash, Stone Dust, River Sand.

I. INTRODUCTION

One major challenge before the infrastructure industry is to execute projects in harmony with nature. Nature has imposed limitations over the resources. The days of availability of natural resources in abundance has gone. Now, one has to work with number of constraints in respect of natural resources. One such limitation is the availability of natural river sand for making concrete. Day by day this resource is depleting at a faster rate with the ever faster rate of increasing construction activity. Similarly the manufacturing of cement emits equal amount of carbon-dioxide in environment. One has to look all such aspects while using these materials. Now the days has come to look upon seriously at the concept of sustainable development involving the use of high performance, environment friendly materials produced at reasonable cost. The three fundamental elements for supporting an environment friendly concrete technology for sustainable development are the conservation of primary materials, the enhancement of the durability of concrete structures, and a holistic approach to the

technology. Regarding the conservation of primary materials, reductions in the consumption of cement, aggregates and water, along with the use of waste materials and industrial by-products, are the principal actions to be taken in order to reduce the utilization of non-renewable resources and the negative impact on the environment. In the present project work an attempt has been made to use crushed stone dust and fly ash as part replacement of natural sand and cement, respectively. Part replacement of natural sand to the artificial sand (i.e. stone dust) and cement with fly ash can be used for making good concrete. It helps in conservation of natural sand, and causes less environmental pollution due to less amount of cement use. Finally, a cost comparison was carried out to find the cost benefits of using such alternate materials.

Due to rapid industrialization and civilization the need of cement is increasing day by day. Due to this demand of raw material required for manufacturing of cement has also increased. For coping up to this demand a large amount of calcareous and argillaceous material is being excavated from quarry which ultimately increases the soil pollution. Also during the manufacturing of Portland cement huge amount of carbon dioxide is released which causes air pollution. Manufacture of cement is high-energy intensive industry. In manufacturing of one tonne of cement, 350 Kg of coal is required which leads to emission of about 1 tonne of CO_2 in atmosphere. By using alternate materials to cement it is possible to save coal and reduce the adverse effect on environment. Less requirement of cement means less emission of CO_2 which result in reduction in greenhouse gas emission. A large amount of $CO_{2\ is}$ released in environment every year and out of which 5% is released only because of cement factory. Due to the increase in the production of cement, the percentage of CO_2 emission increases day by day, which causes increase in air pollution. As like to the cement, aggregate is another ingredient material use for making concrete. Generally there are two type of aggregates namely fine aggregate and coarse aggregate which are used for making concrete. This classification is based on the size of aggregate. The aggregate having size less than 4.75 mm is called fine aggregate and aggregate having size more than 4.75 mm is called coarse aggregate.Coarse aggregate gives body to the concrete and fine aggregate is used to fill the voids in the concrete. Proper quality of aggregate is very much important for concrete making. The strength, durability, workability and other properties are also depend on the quality of aggregate used in making concrete. River sand is generally used as fine aggregate in concrete. Due to large consumption of concrete the requirement of river sand is ultimately increasing day by day, which result in excessive extraction of river sand from rivers. Due to this the available sources of river sand are getting exhausted at a faster rate. Good quality sand may have to be transported from long distance, which adds to the cost of construction. In some cases, natural sand may not be of good quality and it effect on quality of concrete. Due to these adverse effects, many researchers are busy in finding the alternatives of the concrete materials. So it is necessity to find alternative solution for cement and fine aggregate to reduce at least some percent of pollution.

II. MATERIALS AND METHODS

2.1 Conventional ingredients

2.1.1 Cement

Cement is one of the important materials in concrete. It is used in concrete as a binding material. Cement is used in almost all the important elements of building construction such as, roof, slab, beam, column, lintel, brick work, etc. As it ages, it gains more strength and make the building component strong. In India, cement is manufactured by dry process and wet process. There are many grades of cement available in market, viz. 33, 43, 53 grade cements. These grades denote the strength of cement which will attain when mixed with standard sand and water, casted, cured for 28 days and tested in a standard manner. Presently 53 grade is the high strength cement available in India. For this work 53 grade ordinary Portland cement was used.

2.1.2 Aggregate

Aggregates are the important constituents in concrete. They give body to the concrete, reduce shrinkage and effect economy. To produce good concrete only good quality of cement alone is not sufficient. Aggregate and sand should be good, well graded, and free from harmful impurities. Aggregate shall be angular and hard. The aggregates occupy 70–80 percent of the volume of concrete. Without the study of the aggregate in depth and range, the study of the concrete is incomplete. As mentioned earlier based on the size of aggregates they are classified in two types, namely fine and coarse aggregates. The following paragraphs give brief details of the properties of these aggregates:

I) Fine Aggregate

Aggregate whose size is 4.75 mm and less was considered as fine aggregate. The main function of fine aggregate is filling the voids in concrete. The fine aggregate do not contribute to the strength of concrete but it increases its workability which directly affects the strength and other properties of concrete. River sand is chemically inert material and hence used as a fine aggregate. In the present work, river sand is collected from a local river near to Mahad city.

II) Coarse Aggregate

The size of aggregate bigger than 4.75 mm is considered as coarse aggregate. But, as per the concern of spacing of reinforcement size of coarse aggregate should be provided within the limits specified by the various codes. The size, shape, texture, soundness and strength are some of the important points which are considered at the time of selecting the coarse aggregate. The angular aggregate gives high strength and durability as compare to rounded and flaky aggregate. Almost all natural aggregates originates from bed rocks, they can be manufacture either in crusher or manually. For this work, coarse aggregates are obtained from “Isane Stone Crusher” which is located in Mahad. In the work presented two different sizes of coarse aggregates were used viz. 10 mm aggregates and 20 mm aggregates.

2.1.3 Water

Water is used for two purposes viz. mixing and for curing. Water used for mixing shall be clean and free from impurities. Generally, water which can be used for drinking is good enough for use in mixing in concrete. It actively participates in the chemical reaction with cement. It helps to form the strength giving cement gel. The

quantity and quality of water is required to be looked very carefully for making good quality concrete. During the concrete operation, often a great control on properties of cement and aggregate is exercised, but the control on the quality of water is often neglected. Since quality of water affects the strength, it is necessary to look into the purity and quality of water. Normally the PH value of water in between 6.5 to 7 was used for making concrete. The water used for the work was potable and it was free from organic matter.

2.2 Alternative ingredients

2.2.1 Fly ash

Fly ash is a finely divided residue resulting from the combustion of powdered coal and transported by the flue gases and collected by electrostatic precipitator. It is a waste product of coal burnt in power plants. The use of fly ash as concrete admixture not only extends technical advantages to the properties of concrete but also contributes to the environmental pollution control. In India alone, we produce about 100 million tons of fly ash per year, the disposal of which has become a serious environmental problem. The effective utilization of fly ash in concrete making is, therefore, attracting serious considerations of concrete technologists and government departments. The chemical composition of fly ash which contain SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, Na_2O, K_2O, SO_3etc which is near about same as cement, because of this fly ash is used in making concrete and many researchers are busy in their research related to the fly ash. When fly ash is used with cement it is usually presumed that the reaction produces a gel in addition to the gel produced through the hydration of cement. In this work fly ash is substituted for cement because of it provides various properties cement concrete such as, it increases the workability, durability, it can reduce the permeability and corrosion, and it reduces the heat of hydration which helpful in mass construction to reduce sulphate attack and alkali aggregate reaction.

2.2.2 Crushed stone dust.

Stone dust is a byproduct which is obtained from stone crusher. In district like Raigad there is large number of stone crushers which produces coarse aggregates. About 20 % of stone dust is produced in every batch of stone crusher while producing coarse aggregate. This stone dust produced cannot be used directly as a coarse aggregate in making concrete. Stone dust is normally used in construction of road pavements, but the requirement of such stone dust in making road pavements is much less than the available quantity from the stone crushers. This ultimately results in a huge disposal problem. In stone dust and river sand the mother material is same that the stone. So, in this work, an attempt has been made to check the possibility of replacing the river sand with stone dust. To cope up with the shortage of river sand, now a day's sand making machines are also available in market to produce artificial sand from stones which can be used for making concrete. Stone dust used in concrete not only to reduce the soil pollution but also helps in reducing the overall cost of concrete, and helps in some extent in relaxation in use of river sand.

III RESULT AND DISCUSSION

In the present work fly ash has been replaced with cement and stone dust with river sand by varying the percentage of replacements.

2.3 Replacement of cement is by varying quantity of fly ash and river sand with stone dust by a fixed quantity i.e. 20%. (E.g. 20% - 20%, 30% - 20%, 40% - 20%).The table shows the results of compressive strength and tensile strength of concrete made by keeping stone dust constant (20 %) and by varying percentage of fly ash:

Table 1: Compressive and tensile strength of concrete (stone dust 20 % and varying percentage of fly ash)

Fly ash (%)	Stone dust (%)	Slump (mm)	Comp. Strength (N/mm^2)		Tens. Strength (N/mm^2)	
20	20	87	27.4	27.47	2.5	2.38
			28.78		2.36	
			25.72		2.29	
30	20	92	21.58	23.40	2.22	2.17
			24.42		2.08	
			24.2		2.22	
40	20	105	20.93	20.10	2.22	1.95
			20.5		1.81	
			18.75		1.81	

2.4 Replacement of cement is by varying quantity of fly ash and river sand with stone dust by a fixed quantity i.e. 30%. (E.g. 20% - 30%, 30% - 30%, 40% - 30%).The table shows the results of compressive strength and tensile strength of concrete made by keeping stone dust constant (30 %) and by varying percentage of fly ash:

Table 2: Compressive and tensile strength of concrete (stone dust 30 % and varying percentage of fly ash)

Fly ash (%)	Stone dust (%)	Slump (mm)	Comp. Strength (N/mm^2)		Tens. Strength (N/mm^2)	
20	30	76	24.42	26.89	1.15	2.06
			25.29		1.94	
			27.47		2.08	
30	30	84	20.06	22.38	1.94	2.08
			22.67		2.08	
			24.42		2.22	
40	30	91	20.55	21.38	1.8	1.8
			22.67		1.94	
			24.42		1.67	

2.5 Replacement of cement is by varying quantity of fly ash and river sand with stone dust by a fixed quantity i.e. 40%. (E.g. 20% - 40%, 30% - 40%, 40% - 40%).The table shows the results of compressive strength and tensile strength of concrete made by keeping stone dust constant (40 %) and by varying percentage of fly ash:

Table 3: Compressive and tensile strength of concrete (stone dust 40 % and varying percentage of fly ash)

Fly ash (%)	Stone dust (%)	Slump (mm)	Comp. Strength (N/mm^2)		Tens. Strength (N/mm^2)	
20	40	66	27.9	26.60	1.94	2.38
			23.54		1.81	
			27.47		2.15	
30	40	71	23.55	22.38	1.94	2.17
			22.67		2.08	
			20.43		1.94	
40	40	74	17.9	19.33	1.94	1.95
			20.92		1.53	

			19.18		1.24	

2.6 Replacement of river sand is by varying quantity of stone dust and cement with fly ash by a fixed quantity i.e. 20%. (E.g. 20% - 20%, 30% - 20%, 40% - 20%).The table shows the results of compressive strength and tensile strength of concrete made by keeping fly ash constant (20 %) and by varying percentage of stone dust:

Table 4: Compressive and tensile strength of concrete (fly ash 20 % and varying percentage of stone dust)

Stone dust (%)	Fly ash (%)	Slump (mm)	Comp. Strength (N/mm^2)		Tens. Strength (N/mm^2)	
20	20	87	27.4	27.47	2.5	2.38
			28.78		2.36	
			25.72		2.29	
30	20	76	24.42	26.89	1.15	2.06
			25.29		1.94	
			27.47		2.08	
40	20	66	27.9	26.60	1.94	1.96
			23.55		1.81	
			27.47		2.15	

2.7 Replacement of river sand is by varying quantity of stone dust and cement with fly ash by a fixed quantity i.e. 30%. (E.g. 20% - 30%, 30% - 30%, 40% - 30%).The table shows the results of compressive strength and tensile strength of concrete made by keeping fly ash constant (30 %) and by varying percentage of stone dust

Table 5: Compressive and tensile strength of concrete (fly ash 30 % and varying percentage of stone dust)

Stone dust (%)	Fly ash (%)	Slump (mm)	Comp. Strength (N/mm^2)		Tens. Strength (N/mm^2)	
20	30	92	21.58	23.40	2.22	2.17
			24.42		2.08	
			24.2		2.22	
30	30	84	20.06	22.38	1.94	2.08
			22.67		2.08	
			24.42		2.22	
40	30	71	23.55	22.38	1.94	1.99
			22.67		2.08	
			20.93		1.94	

2.8 Replacement of river sand is by varying quantity of stone dust and cement with fly ash by a fixed quantity i.e. 40%. (E.g. 20% - 40%, 30% - 40%, 40% - 40%).The table shows the results of compressive strength and tensile strength of concrete made by keeping fly ash constant (40 %) and by varying percentage of stone dust:

Table 6: Compressive and tensile strength of concrete (fly ash 40 % and varying percentage of stone dust)

Stone dust (%)	Fly ash (%)	Slump (mm)	Comp. Strength (N/mm^2)		Tens. Strength (N/mm^2)	
20	40	105	20.93	20.10	2.22	1.95
			20.5		1.81	
			18.75		1.81	
30	40	91	20.55	21.38	1.8	1.81
			22.67		1.94	
			20.93		1.67	
40	40	74	17.9	19.33	1.94	1.54
			20.92		1.53	
			19.18		1.24	

2.9 Strength comparison of ordinary concrete and concrete made with alternative materials such as stone dust and fly ash. The table shows that the results of slump and strength (compressive and tensile strength) ordinary concrete and concrete made with varying percentage of alternative material (stone dust and fly ash).

Table 7: Compressive and tensile strength of concrete

Fly ash (%)	Stone dust (%)	Slump (mm)	Comp. Strength (N/mm^2)		Tens. Strength (N/mm^2)	
0	0	79	28.34	30.52	2.77	2.86
			32.26		2.63	
			30.96		3.19	
20	20	87	27.4	27.47	2.5	2.38
			28.78		2.36	
			25.72		2.29	
30	20	92	21.58	23.40	2.22	2.17
			24.42		2.08	
			24.2		2.22	
40	20	105	20.93	20.1	2.22	1.95
			20.5		1.81	
			18.75		1.81	
20	30	76	24.42	26.89	1.15	2.06
			25.29		1.94	
			27.47		2.08	
30	30	84	20.06	22.38	1.94	2.08
			22.67		2.08	
			24.42		2.22	
40	30	91	20.55	21.38	1.8	1.81
			22.67		1.94	
			20.93		1.67	
20	40	66	27.9	26.60	1.94	1.96
			23.54		1.18	
			27.47		2.15	
30	40	71	23.55	22.38	1.94	1.99
			22.67		2.08	
			20.93		1.94	
40	40	74	17.9	19.33	1.94	1.54
			20.92		1.53	
			19.18		1.24	

From the above result it is observed that as the percentage of fly ash and stone dust increase strength decreases. Decrease in strength when percentage of stone dust increases with keeping constant percentage of fly ash is less as compare with decrease in strength when percentage of fly ash increases with keeping constant percentage of stone dust. The result also shows that as the percentage of fly ash increases the workability of concrete increases. From above result it shows 20 % - 20 % replacement of fly ash and stone dust with cement and river sand gives approximately same strength with ordinary concrete and increases its workability. But as concern with economy and strength 20 % - 40 % replacement of fly ash and stone dust with cement and river sand is best suited combination for this result but decrease it's workability with ordinary concrete.

2.10COST COMPARISON OF CONCRETES

A cost comparison of 1m^3 ordinary concrete and concrete with stone dust (40%) & fly ash (30%) was done. The details are as follows:

Table 8: Cost comparison of different concretes

Material	Quantity (Kg)		Rate (Rs.)	Amount (Rs.)	
	Without replacing	With replacing		Without replacing	With replacing
Cement	438.13	306.69	350/50 Kg bag	3,067.00	2,147.00
Fly ash	_	131.44	-	-	00.00
River sand	667.8	400.68	7000 / brass	556.0	334.00
Stone dust	_	267.12	1000 / brass	-	43.00
Coarse agg.	1116.7	1116.7	3000 / brass	441.0	441.00
Total Amount				4,064.00	2,965.00

III CONCLUSIONS

The workability of the concrete is increased by increasing percentage of fly ash. The workability of the concrete is decreased by increasing percentage of stone dust. Cement and river sand is more costly compare to fly ash and stone dust, so by using fly ash and stone dust instead of cement and river sand, decrease the cost of concrete. Fly ash is a totally waste material of thermal power plant; hence it gets free of cost and concrete make more economical. The confined effect of addition of stone dust and fly ash makes the concrete more cohesive and dense, thereby reducing the permeability without much affecting the durability of concrete. The shrinkage of the concrete is reduces due this alternative material. The replacement of 20 % fly ash to cement and 40% stone dust to river sand is best combination with respect to strength and economy which gives maximum strength 26.6 N/mm^2.By replacing 40 % fly ash to cement and 20% stone dust to river give maximum slump which is 105 mm.Variation of compressive and tensile strength of concrete made with varying percentage replacement of stone dust while keeping percentage replacement of fly ash constant is very less.Variation of compressive and tensile strength of concrete made with varying percentage replacement of fly ash while keeping percentage replacement of stone dust constant is comparable.For per 1 m^3 concrete, 25.75 % cost can be saved by replacing 20 % fly ash to cement and 40 % stone dust to river sand.

Partial replacement of fly ash with cement increases strength and workability of concrete.Maximum workability has been obtained for 30% replacement of fly ash to cement.Maximum strength has been obtained for 30% replacement of fly ash to cement and 30% replacement of stone dust to river sand. Replacement of fly ash (30%) and stone dust (40%) results in approx. 27% saving in cost. Replacement of fly ash and stone dust results in economical, sustainable, and environment friendly concrete.

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