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PARTIAL REPLACEMENT OF FINE AGGREGATE IN CEMENT BRICK WITH RED GYPSUM

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Abstract: Cement, fine aggregate, coarse aggregate and water are the major constituents of cement brick. Aggregate, being an important constituent, is used as a filler material and affects the strength and durability properties of concrete. The extraction process of aggregate from quarry contaminates air and water with sulphur dioxide and other pollutants, putting wildlife and local populations at risk. The use of river sand as fine aggregate leads to exploitation of natural resources like, lowering of water table, sinking of bridge piers and erosion of river bed. Red gypsum is the by-product of titanium dioxide extraction from the ilmenite ore and is an industrial waste. It often consumes a lot of space and its disposal is a hectic process. Recent research has confirmed that red gypsum generally contains low level of radioactive material, well below the permitted level stated in the environmental regulation [4]. This makes it desirably suitable for use in different application especially as a construction material. Control mix for the brick was prepared in the ratio 1: 4.5: 4.5 (cement: fine aggregate: coarse aggregate). Fine aggregate was replaced by red gypsum at 5%, 10%, 15% and 20%. Different tests were carried out on these mixes to investigate its strength and water absorption, hence established the optimum percentage of red gypsum that can be used as a replacement to fine aggregate in cement brick. Cost comparison of control brick and red gypsum incorporated brick was analyzed.

Index Terms **- Red Gypsum, Fine aggregate, Compressive strength, Water absorption, Industrial waste, Cement brick.**

I. INTRODUCTION

Concrete being the major constituent for the manufacturing of cement brick has aggregates making 70% of its volume. Globally, 8 to 12 million tonnes of natural aggregate is being consumed annually. The properties of the cement brick are determined by the proportion and the type of sand used to formulate it. It has significant impact on the workability, durability, strength, weight and the shrinkage of concrete.

Nowadays, the use of regular sand is high because of its large utilisation, so the need of sand is more in growing countries to mitigate the fast infrastructure development. The growing demand of sand results in non-availability of good quality sand especially in India and deposits of natural sand are being exhausted which create an extreme menace to the environment. The fast withdrawal of sand waterway bed creates issues like losing water holding soil strata, extending to the sliding of the bank of river, etc. The extraction of sand from the waterway increases the cost of sand and severely affects the financial viability of the construction industry.

As the industrialisation increases, the amount of waste material product is also increasing, which has turned into an ecological issue that must be managed. The utilisation of waste material product in cement brick causes a reduction in price. Also, reutilisation of waste is considered to be the best ecological option for taking care of the issue of waste disposal. Thus, red gypsum being an industrial waste is used as a replacement material in concrete.

II. LITERATURE REVIEW

[1] **Johnson K, Sreedevi N. K., and Wilferd S.** (2020), focused on the utilization of red gypsum, partially or completely as a sand replacing material in conventional cement bricks. Here, the bricks were manufactured using red gypsum, sand and cement by varying red gypsum to sand ratio. Compressive strength and water absorption rate of dry and wet red gypsum were compared. They also investigated on the properties of Brick for Coastal Area Protection (B-CAP), which is a red gypsum based material and proved that it can be used for the construction of sea wall.

[2] **BTV. Krishnan** (2020), mainly focused on investigation, planning, execution and monitoring of various projects in coastal areas. He introduced red gypsum as an alternative to various challenges like shortage of materials in construction and coastal erosion. Here, he studied the properties of gypsum products and also found out many fields in which red gypsum can be used as the best alternative. In this research paper, it was proved that red gypsum can be used for shore protection works, ground improvement and so on.

[3] **Ansari M. A. M. and Unnikrishnan C.** (2020) focused on manufacturing of red gypsum bricks by replacing sand content in conventional cement bricks using red gypsum and found the optimum sand replacement as 25-30%. They also found the possibilities of utilizing red gypsum in construction sector as an alternative and ensured that the compressive strength of red gypsum bricks was in the range of 6.9 MPa and had a weight of 2.5 kg and water absorption of less than 20% by its weight. Later, red gypsum bricks were compared with class 5 bricks and proved it to be feasible for non-load bearing walls and temporary walls. They also suggested the usage of B-CAP in Kerala State Coastal Area Development Corporation Limited (KSCADC) implemented coastal protection works for a period of 1 year and monitored its efficiency in Vettukadu sea shore.

III. MATERIALS USED

[1] CEMENT: -

Cement being a binder, is a substance used in construction industry to bind materials together by setting, hardening and adhering to them. Based on the 28th day compressive strength of the mortar cube, grades of Ordinary Portland Cement (OPC) can be classified as 33, 43, 53. In this project, OPC of 53 grade conforming to IS 8112-1989 is being used. OPC was chosen instead of Portland pozzolana Cement (PPC) because of the presence of fly-ash in PPC which may affect the properties of concrete containing red gypsum. Also, the early strength attained by PPC will be slightly lower than that of strength attained by OPC. Thus, OPC is used in our project.

[2] FINE AGGREGATE: -

Aggregates are inert granular materials. Aggregates used here must be clean, hard and strong particles that are free of absorbed chemicals, clay coatings and other fine materials that could cause concrete to deteriorate. Fine aggregate used for the preparation of cement bricks is Manufactured sand of Zone II conforming to IS 383:2016. Sand grains are angular, shape of grains approximate to spherical form, elongated and flattened grains being present only in very small or negligible quantities.

[3] COARSE AGGREGATE: -

The material which is retained on IS sieve size 4.75 mm is termed as coarse aggregate. The crushed stone is generally used as a coarse aggregate. The nature of work decides the maximum size of the coarse aggregate. Locally available coarse aggregate with a nominal size 6mm is used for the experimentation.

[4] RED GYPSUM:-

Red Gypsum (RG) is the by-product of titanium dioxide manufacturing industry and is abundantly produced in Travancore Titanium Products Ltd. (TTPL), Trivandrum. RG is a reddish-brown solid chunk generated from sulphate process of ilmenite ore which is rich in titanium and iron. The major constituents of RG are hydrated calcium sulphate and iron hydroxide. Solid chunks of RG are shown in Figure 1.

Figure 1: Red gypsum

[5] ADMIXTURE: -

Superplasticizers are substances added to decrease viscosity and plasticity and to increase workability and performance. The superplasticizer used in this study is Fosroc Conplast SP 430. It is a chloride free superplasticizing mixture based on selected sulphonated naphthalene polymers. It is dark brown in colour.

IV. METHODOLOGY

A control mix of 1: 4.5: 4.5 (cement: fine aggregate: coarse aggregate) was adopted as the control mix (RB-0) for our experiment. Further, fine aggregate was replaced using red gypsum at 5%, 10%, 15% and 20% thereby forming RB-5, RB-10, RB-15 and RB-20 mixes respectively. The percentage composition of materials in cement brick is shown in table 1.

The mixes were then casted into specimens having dimensions 210 x 110 x 60 mm. Compressive strength test and water absorption test were performed on it.

Table 1: Percentage composition of materials in cement brick

Mix designation	Cement (%)	6mm downsize-coarse aggregate (%)	Fine aggregate (Zone II) (%)	Red Gypsum (%)	Dosage of admixture per kg of cement used (kg)
RB-0	10	45	45	0	$3.9x10^{-4}$
RB-5	10	45	42.75	2.25	$3.9x10^{-4}$
RB-10	10	45	40.5	4.5	$3.9x10^{-4}$
RB-15	10	45	38.25	6.75	$3.9x10^{-4}$
RB-20	10	45	36	9	$3.9x10^{-4}$

V. RESULTS

TESTING

Compressive Strength Test: -

Compressive strength is the most important of all the physical properties of cement brick. The compressive strength is the ability of the material or structure to withstand the load on its surface without cracking or deflection. Compressive strength test on bricks is carried out to determine the load carrying capacity of bricks under compression with the help of compression testing machine (CTM), as per IS 2185 (Part 1):2005. The test results after 7 and 28 days of curing is shown in table 2. Variation of compressive strength with respect to percentage of red gypsum is shown in Figure 2.

Table 2: Compressive Strength Test

Mix designation	7^{th} day average compressive strength (MPa)	28^{th} day average compressive strength (MPa)
RB-0	12.03	14.35
RB-5	14.21	16.81
RB-10	12.33	15.08
RB-15	11.04	13.49
RB-20	9.16	11.90

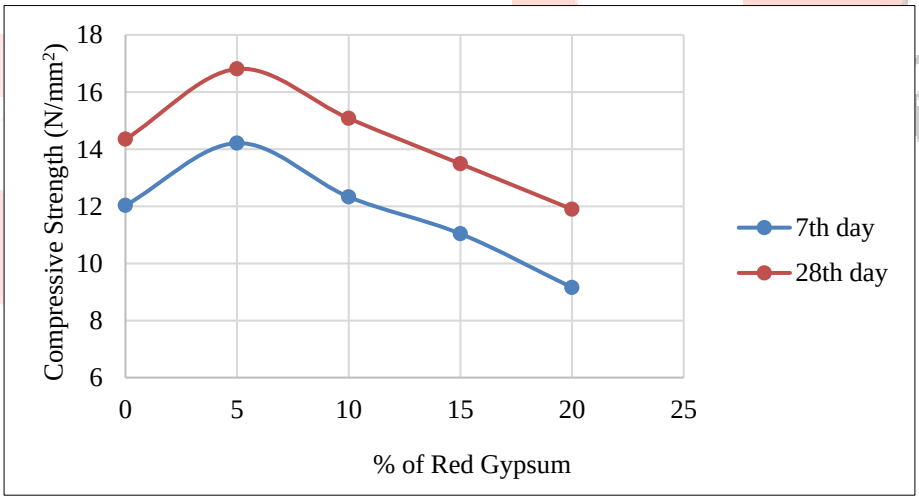

Figure 2: Plot of Compressive strength vs percentage of red gypsum

The ratio of compressive strength of different mixes to that of compressive strength of control mix were calculated and plotted against percentage of red gypsum in Figure 3.

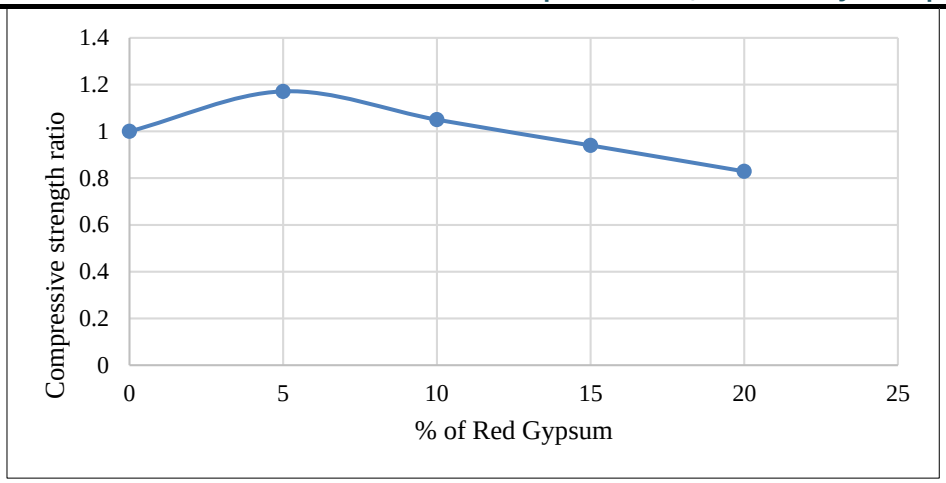

Figure 3: Plot of compressive strength ratio vs percentage of red gypsum

Water Absorption Test: -

Water absorption test on bricks was conducted to determine durability property of bricks such as quality and behaviour of bricks in weathering. The results of water absorption are shown in table 3. Variation of percentage of water absorption with respect to percentage of red gypsum is shown in Figure 4.

Table 3: Water absorption test results

Mix designation	Water Absorption value (%)
RB-0	5.54
RB-5	6.29
RB-10	7.17
RB-15	7.53
RB-20	9.09

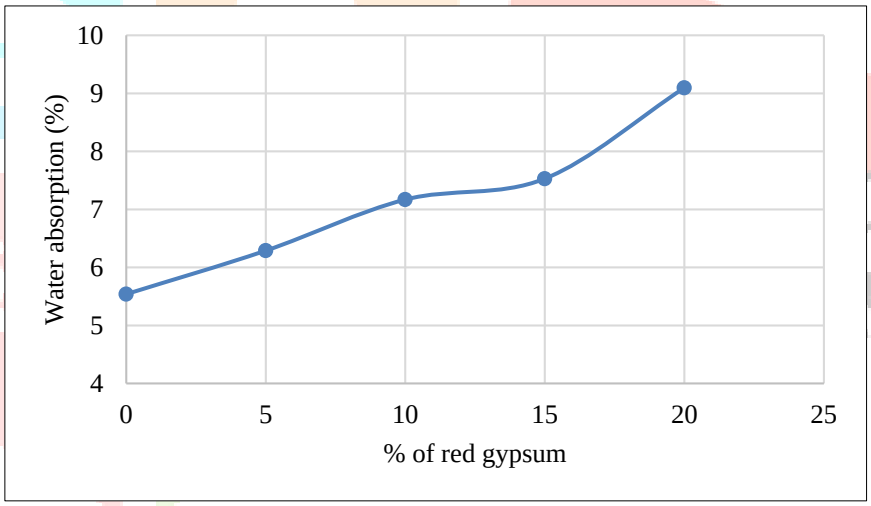

Figure 4: Plot of water absorption vs percentage of red gypsum

VI. Conclusion

- For both 7th and 28th day, it shows an increase in compressive strength upto 5% replacement, then afterwards it was found to gradually decrease. The increase in strength might be due to pozzolanic reactions, while the gradual decrease in strength might be due to the increase in fineness content of red gypsum.
- There is an increase in water absorption as the percentage replacement of red gypsum increases.

VII. Inferences

- The optimum percentage of replacement was found to be 5%. At this point, the compressive strength increased by a percentage of 17.14.
- From the test results, the strength of all mixes (RB-0, RB-5, RB-10, RB-15 and RB-20) attained a minimum compressive strength as per IS 2185 (Part 1)-2005 and all conforms to grade C.

VIII. REFERENCES

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