High Strength Permeable Pavement using no Fines Concrete

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ABSTRACT: *In spite of having low Compressive and flexural strength, No-fines concrete has properties capable of being used as rigid pavement for low traffic volume roads. Along with the mix proportions and water content to have sufficient bond between the aggregate particles, it is critical to determine what happens to the water once it penetrates the pavement surface. Different combinations of Cement, GGBS, water and Course aggregate with different maximum size and gradation were adopted for trial mixes to arrive at M20 grade concrete.M20 grade concrete is achieved with a w/c ratio of 0.36, Coarse aggregate of nominal size 20 mm passed and 10 mm retained ,cement is partly replaced with 30% of GGBS and with a cement to Course aggregate ratio of 1:4. Its compressive strength were observed to be 20.4 kN/m3.A perforated pipe can be provided at center of the pavement above sub-base such that it collects the water stored in concrete and drains it to the required treatment plant or a recharge pit.*

Keywords:*No-finesconcrete,GGBS,trial mix design, pavement, low traffic volume roads, runoff*

I. INTRODUCTION

No-Fines concrete is a form of lightweight concrete obtained when fine aggregate is omitted, i.e. consisting of cement, water, and coarse aggregate only. Nofines concrete is thus an agglomeration of coarse aggre gate particles, each surrounded by a coating of cement paste up to about 1.25 mm (0.05 in.) thick. There exist, therefore, large voids within the body of the concrete which is responsible for its light weight structure .

II. OBJECTIVE AND SCOPE

The objective of the present study is to check the performance of no fines concrete on various mixes of aggregates. Due to the absence of fine aggregate in no fines concrete, there is a high percentage of void space which results in high permeability.

The scope of the present work is to carry out a detailed analysis of the following sub systems for the prescribed conditions-

1. Cement: concrete mix by volume is taken as 1:4, 1:6 and1:8.
2. Ordinary Portland cement of 53 grade.
3. Replacement of cement by 20 & 30% of GGBS.
4. Aggregates of sizes 20mm passing and 10mm retained are taken.
5. Water/cement ratios are limited to 0.36 and 0.38.
6. Testing of specimens at the ages of 28 days.
7. Determining the compressive strength of M20 grade mix.

III. METHODOLOGY

The methodology adopted and material characterization and design mix is carried out is presented in the form of flow chart and parameters studied. Also the sequential activities involved in this study are presented in graphical form. Details of experimental study in materials are presented in the sub sequent headings.

COLLECTION OF MATERIALS
PHYSICAL TESTS ON MATERIALS
PREPARATION OF SAMPLES
PREPARATION OF DIFFERENT SAMPLES CHANGING THE PARAMETERS
TESTING OF SAMPLES FOR 28 DAYS
COMPRESSIVE TEST VALUES OF DIFFERENT CEMENT TO AGGREGATE RATIOS,W/C RATIOSAND 20 & 30 % GGBS PARTIAALY REPLACED CEMENT
PAVEMENT SPECIFICATIONS
RESULTS AND CONCLUSIONS

IV. MATERIALS:

A. ***COARSE AGGREGATE:*** The density of no-fines concrete depends primarily on the grading of the aggregate. The usual size is 10 to 20 mm; 5 per cent oversize and 10 per cent undersize are allowed, but no particles should be smaller than 5 mm . Flaky or elongated particles should be avoided. The use of sharp-edged crushed aggregate is not recommended.

B. ***GGBS:*** Ground granulated blast furnace slag is obtained by quenching molten iron slag.GGBS is added to concrete.The normal ratios of aggregates and water to cementitious material in the mix remain unchanged.It is direct replacement of Portland cement.GGBS vary from 20% to 40% for no fine concrete.

Figure 1–shows GGBS

V. PREPARATION OF SAMPLES:

C. MIXING PROCESS

1. Weigh aggregate, cement,GGBS and water for the mix.

2. Moisten the working surface of the wheelbarrow to prevent the materials from sticking to the sides.

3. Add the aggregate to the wheelbarrow and add approximately half the water and mix until all the aggregate is wet.

4. Spread the cement and water uniformly over the surface of the aggregate

5. Mix the concrete until the aggregate is evenly covered with cement paste.

Figure 2– Shows the Hand mixing

A. COMPACTING AND CURING

Rodding was adopted for the compaction of no-fines concrete. The concrete samples were tamped 25 times and split into three layers. This procedure ensures sufficient compaction has been produced.

Figure 3– Compacting the no fines concrete when moulding

Figure 4–No fines concrete after fill in the mould

The curing process starts with the moulds being left in place for 2 or 3 days, to allow sufficient bonding between the aggregate particles. After the specimens were removed from the mould they were placed in the fog room until the time of testing. This process was used to ensure that optimum curing was achieved.

VI. WORKABILITY TEST ON SAMPLES

No-fines concrete is said to have self compacting properties. This will be tested with the compacting factor test. The slump and VEBE tests are not good for testing no-fines concrete due to the low cohesion between the aggregate particles.

B. COMPACTION FACTOR TEST

The compacting factor test is used to determine the extent with which the fresh concrete compacts itself when allowed to fall without the application of any external compaction. The compaction obtained from the free falling is compared with the same sample under standard compaction practices (that is 3 layers, each rodded 25 times).

Compacting factor = $\frac{(m_1)}{(m_2)}$

m_1 = Partially compacted concrete(kg)
m_2 = Fully compacted concrete.(kg)

Figure 5 – shows compaction factor

V.COMPRESSIVE STRENGTH OF CONCRETE

The compressive strength tests are conducted to ensure a minimum strength is achieved by the particular mix. Cylinder and cube testing are methods of determining the compressive strength. The cube test, due to the method by which it is implemented, should give a more stable test specimen than the cylinders. This test will determine the strength of the sample along the entire length of the sample and eliminate problems encountered with the edge aggregate dislodging and failing.

COMPRESSIVE STRENGTH = $\frac{\text{FORCE}}{\text{AREA}}$

C. No Fines Concrete Without Ggbs

When the no fines concrete without GGBS,

CEMENT/ AGGREGATE RATIO	W/C RATIO	COMPACTING FACTOR	AVERAGE DENSITY OF SPECIMEN (kg/m^3)	AVERAGE COMPRESSIVE STRENGTH (N/mm^2) (28thday)
1:4	0.36	0.93	1897.44	16.3
	0.38	0.92	1904.67	14.99
1:6	0.36	0.92	1861.016	15.94
	0.38	0.88	1866.073	14.27
1:8	0.36	0.86	1840.78	12.23
	0.38	0.87	1844.727	9.96

its compressive strength becomes very low shown in table 1

D.No Fines Concrete With Ggbs

Figure 6–No fines concrete after 28 days curing

Table 1:shows the cube compressive strength of the test specimen without GGBS

CEMENT/AGGREGATE RATIO	W/C RATIO	GGBS %	AVERAGE COMPRESSIVE STRENGTH (N/mm^2) (28^{th}day)
1:4	0.36	20	18.4
		30	20.4
	0.38	20	16.5
		30	18.5
1:6	0.36	20	15.2
		30	16.8
	0.38	20	12.9
		30	14.3
1:8	0.36	20	9.2
		30	11.5
	0.38	20	8.5
		30	10.1

Table 2 – Shows the cube compressive strength of the test specimens with GGBS.

Figure 7–Compressive test machine when no fines concrete cube testing

VI.VOIDS RATIO AND PERMEABILITY:

The void ratio was determined by measuring the mass of water the mould was capable of holding and determining the mass of water with the concrete sample in place.The volume of voids was calculated to be 32 percent of the mould.

The no-fines concrete slab has a reasonably good permeability with about half of the water being poured onto the concrete passing directly down while the remaining water spread out further until it was able to pass through.permeable rate is 125 lit/ m^3.

Figure 8–Shows permeable of water

VII.PAVEMENT SPECIFICATIONS

No-fines concrete pavements are a form of rigid pavement but differ substantially due to materials used during construction. The no fines concrete pavement consists of a concrete slab over a clean aggregate sub base, a filter fabric and a permeable sub grade. The sub grade material is important, as it is required to be permeable to allow the water in the sub base to penetrate the soil. The sub grade material has to contain a set of favorable properties relating to permeability, support and moisture content while the sub base requires a homogeneous materials with set of properties. The permeability of sub grade is important as it dictates the effectiveness of no fines concrete pavement. Prior to the place of no fines concrete pavement the sub grade has to be tested for rate of permeability with a suitable sub grade permeability test. The minimum percolation rate acceptable for no fines concrete pavement is 2.5 mm per hour. The organic material in sub grade is required to be scarified to a minimum depth of 75 mm. This material requires a proof roll to identify any weak or wet areas that may cause premature pavement failures.

The following figure has been used in the construction of footpaths and bikeways.It consists of 200 mm of clean aggregate and a 60 mm thick no-fines concrete surface. This large amount of sub-base material probably makes this design uneconomical since it will be considerably more expensive than conventional footpaths .

M20 grade of pervious concrete with 12 - 15% voids and can be used for the construction of rigid pavement for low volume traffic roads .The porous concrete allows storage of water up to 125liters per cubic meter of concrete pavement giving time for infiltration thereby reducing the runoff and recharging the ground water.

VIII.CONCLUSION

Based on the study conducted within the scope of the research, the following specific and general concluiosn can be drawn.

1. M20 grade no fines concrete with a density of about 21 kN/m3 can be obtained bythe following mix proportions.

Cement : Course aggregate : 1 : 4

Course aggregate: 20 mm passed and 10 mm retained size aggregate

Water to cement ratio: 0.36

2. The physical properties of the individual components and the no-fines concrete as a whole are extremely important and should be explored further. The rheology of the concrete and the individual materials determine properties like the strength, void ratio, durability and the chemical properties. All these properties need to be known and assessed to make the most appropriate choice for a particular application.

3. The mix proportions for no-fines concrete depends predominantly on the final application. In building applications, the aggregate-cement ratio used is leaner, usually ranging from 6:1 to 10:1 where strengths ranging from 5 MPa to 15 MPa are obtained. This leaner mix ensures that the void ratio is high and prevents capillary transport of water. However, in pavement applications the concrete strength is more critical and aggregate-cement mixes as low as 4:1 has to be used. This lower ratio ensures an adequate amount of bonding between the aggregate and cement to withstand the higher loads.

4. The void content is dependent upon the aggregate-cement ratio and thus varies greatly. The air content of no-fines concrete ranges from 13 to 28 % for aggregate-cement ratio 4:1 .

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X.CODE OF PRACTICE

1.IS 12727-1989:No fines vast insitu cement concrete..

2. IS 383 (1970): Specifications for Coarse and Fine Aggregates from Natural Source of Concrete

3. IS 9377 (1979):Specification for Apparatus for Aggregate Crushing Value .

4.IS 4031 (1996b): Part-3, Methods of Physical Tests for Hydraulic Cement: Determination of Soundness

5. IRC SP 62:2014:Guidelines for design and construction of cement concrete pavements for low volume roads .

6. IS 4031 (1988b) Part-5: Methods of Physical Tests for Hydraulic Cement: Determination of Initial and Final Setting Time.

7.IS 4031 (1996) Part-1: Methods of Physical Tests for Hydraulic Cement: Determination of Fineness by Dry Sieving.