USE OF STEEL FIBRE IN NO FINES CONCRETE

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ABSTRACT

No-fines concrete is a form of lightweight porous concrete, obtained by eliminating the sand from the normal concrete mix. The advantages of this type of concrete are lower density, lower cost due to lower cement content, lower thermal conductivity, relatively low drying shrinkage, no segregation and capillary movement of water, better insulating characteristics than conventional concrete because of the presence of large voids.This project presents the results of an investigation to determine the performance characteristics of concrete mixes made without fine aggregates. Single sized course aggregates fraction 10-20 mm and Ordinary Portland cement were used in the experiments. Concrete mixes with different percentages of steel fibres in no fines concrete were prepared to find compressive, flexure and tensile strength of concrete. It was found that the strength of no-fines concrete is lower that that of normal weight concrete, but sufficient enough for structural use. Due to its high ratio of continuous voids, this concrete has high water permeability.

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1. INTRODUCTION

No-fines concrete, also known as porous, pervious, permeable and cellular concrete, is a porous concrete obtained when fine aggregate is omitted. The most widespread applications of no-fines concrete include road paving and surface treatments to permit water drainage. Although no-fines concrete has been used for paving for more than20 years in the U.S.A., few studies have dealt with its durability performance. In relation to this application, the knowledge of the durability ofno-fines concrete has been limited to the study of freezing and thawing, shrinkage, thermal expansion, capacity to percolate water through the cement paste and abrasion resistance. However, the recent emphasison the construction use of non-renewable mineral resources and energy has increased the interest in exploring possible further uses of no-fines concrete. Since sustainability issues have a primary role in the construction, acoustic and/or thermal insulation characteristics and water permeability of no-fines concrete could be considered in a wide range of applications, which could require their use in form of panels.

For instance, in a recent study no-fines concrete has been considered as a suitable choice for dynamic insulation technology. The porous layer of no-fines concrete is located between two ventilated cavities; therefore, a ventilated façade could protect no-fines concrete layer from climatic agents. This technology is based on the passage of ventilation air through porous layers of the walls that could also require steel reinforcement. The extension of the use of no-fines concrete to building components is limited mainly due to the necessity of embedding steel reinforcement.

The most widespread applications of no-fines concrete include road paving, pavement permeable base, pavement edge drains or shoulders. The recent emphasis on sustainability issues in the construction has increased the interest in exploring possible further uses of no-fines concrete. No-fines concrete has a porous structure with relatively large interconnected voids that confers to it acoustic and thermal insulation characteristics, water permeability, and economy in terms of material cost. In addition, no-fines concrete could be also more interesting than an ordinary concrete, considering its environmental impact in terms of reduction of carbon dioxide emission.

2. LITERATURE REVIEW

Malhotra : (1976) found that the density of no-fines concrete is generally about 70 percent of conventional concrete when made with similar constituents. The density of no-fines concrete using conventional aggregates varies from 1602 to 1922 kg/m3. A clinker aggregate was trialled and the no-fines concrete produced a density of 961 kg/m3.

Adequate vibration is imperative for strength of conventional concrete. The use of no-fines concrete is different and is a self-packing product. Malhotra (1976) suggests that the use of mechanical vibrators and ramming is not recommended with no-fines concrete. A light rodding should be adequate and used to ensure that the concrete reaches all sections of the formwork. This is not a problem with conventional concrete since it has greater flow ability than no-fines concrete. The light rodding ensures that the concrete has penetrated all the areas impeded by reinforcing steel.

Ghafoori et al :- (1995) Undertook a considerable amount of laboratory investigation to determine the effectiveness of no-fines concrete as a paving material. The curing types were investigated to determine if there was any difference between wet and sealed curing. There appeared to be only a negligible difference in strength between the different curing methods. It was clear from the test results that the strength development of no-fines concrete was not dependent upon the curing conditions.

The indirect tensile test conducted by Ghafoori et al (1995) found that the sample tests varied between 1.22 and 2.83 MPa. The greater tensile strength was achieved with a lower aggregate-cement ratio. Ghafoori et al (1995) explained the more favourable properties obtained by the lower aggregate-cement ratio by an improved mechanical interlocking behaviour between the aggregate particles.

Abadjieva et al :-Determined that the compressive strength of no-fines concrete increases with age at a similar rate to conventional concrete. The no-fines concrete specimens tested had aggregate-cement ratios varying from 6:1 to 10:1. The 28 day compressive strength obtained by these mixes ranged from 1.1 and 8.2 MPa, with the aggregate-cement ratio of 6:1 being the strongest. He concluded that the most plausible explanation for the reduced strength was caused by the increased porosity of the concrete samples. This strength is sufficient for structural load bearing walls and associated applications. Ghafoori et al (1995) produced no-fines concrete with a compressive strength in excess of 20 MPa when using an aggregate-cement ratio of 4:1.

Abadjieva et al investigated the influence of the aggregate-cement ratio on the tensile and flexural strength of no-fines concrete. This study only assessed aggregate-cement ratios ranging from 6:1 to 10:1. The highest strengths were obtained with an aggregate-cement ratio of 7:1 and the strength decreased with an increasing aggregate-cement ratio. He found that the tensile and flexural strengths of no-fines concrete were considerably lower than those obtained from conventional concrete, but he could not explain why the sample with the highest strength had a ratio of 7:1.

Krishna Raju :- A study conducted by Krishna Raju et al (1975) focused on the optimum water content for no-fines concrete. It was determined that for the particular aggregate-cement ratio there is a narrow range for optimum water-cement ratio. This water-cement ratio was imperative to gain the maximum possible compressive strength. A higher than ideal water-cement ratio would cause the cement paste to drain from the aggregate particles. Alternatively, a water-cement ratio too low would stop the cement paste from adhering sufficiently to the aggregate. When the optimum water-cement ratio was not obtained, sufficient compaction could not be achieved, further compounding the loss of compressive strength.

Meininger :- (1988) investigated the effect on the properties of no-fines concrete with the addition of sand. He found that when a small amount of sand was added to the mixture, the compressive strength of the concrete increased from 10.3 MPa to 17.2 MPa. The sand added was between 10 and 20 percent of the aggregate by weight. The increased fines filled some of the voids, reducing the air content from 26 to 17 percent. A decrease in the voids causes the concrete to bond more effectively, thus increasing the compressive strength. With more than 30 percent sand the concrete started to display the properties of conventional concrete and did not have sufficient voids necessary for water flow.

3. METHODOLOGY

3.1. Tests Conducted on Cement:

The cement used in this experimental work is "Ultratech 53 grade Ordinary Portland Cement". All properties of cement are tested by referring IS 12269 - 1987 Specification for 53 Grade Ordinary Portland cement. Test results are presented in Table 1.

Table 1 : Physical Properties of Cement (Confirming to IS 12269 – 1987)

Sr. No.	Description of Test	Results
01.	Fineness of cement (residue on IS sieve 90- micron sieve)	5 %
02.	Standard consistency of cement	30%
03.	Setting time of cement a) Initial setting time b) Final setting time	 74 min. 385 min.
04.	Soundness test of cement (with Le-Chatelier's mould)	1.0 mm

3.2 Test Conducted on Water:

Potable water available in laboratory is used for mixing & curing of concrete.

3.3. Tests Conducted On Coarse Aggregates:

Table 2: Physical Properties of Coarse Aggregate

Sr. No.	Property	Results
01.	Fineness Modulus	6.013
02.	Aggregate crushing value	20%
03.	Specific Gravity	2.70
04.	Water absorption	1.2%
06.	Aggregate Impact Value	14%
07.	Surface moisture	Nil

3.4Physical Properties of Steel Fibres:

3.4.1 Hook Ended Steel fibre:

Dramix steel fibres conforming to ASTM A 820 type-I are used for experimental work. Dramix HK **- 80/60** is high tensile steel cold drawn wire with hooked ends, glued in bundles & specially engineered for use in concrete. Fibres are made available from Shakti Commodities Pvt. Ltd.; New Delhi in the literature is given in Table 3.

Table 3 : Physical Properties of Steel Fibres (HK-80/60)

Sr. No.	Property	Values
1.	Diameter	0.75 mm
2.	Length of fibre	60 mm
3.	Appearance	Bright in clean wire
4.	Average aspect ratio	80
5.	Deformation	Continuously deformed circular segment
6.	Tensile strength	1050 Mpa
7.	Modulus of Elasticity	200 GPa
8.	Specific Gravity	7.8

Dosages used: 1-2 % at the constant by weight of cement.

3.4.2 Crimped Type Steel Fibre (CR 50/30):

Crimped type steel fibres conforming to ASTM A 820 type-I are used for experimental work. CR 50/30 **is** high tensile steel cold drawn wire with crimped types, glued in bundles & specially engineered for use in concrete. Fibres are made available from Kasturi Composite Pvt. Ltd.; Amravati (Maharashtra) in the literature is given in Table 4.

Table 4: Physical Properties of Steel Fibres (CR 50/30)

Sr. No.	Property	Values
1.	Diameter	0.6 mm
2.	Length of fibre	30 mm
3.	Appearance	Bright in clean wire
4.	Average aspect ratio	50
5.	Deformation	Continuously deformed circular segment
6.	Tensile strength	1025 Mpa
7.	Modulus of Elasticity	200 GPa
8.	Specific Gravity	7.5

Dosages used: 1-2 % at the constant by weight of cement.

4. TEST ON FRESH CONCRETE

4.1 Slump Test:

The slump test is a method of testing the fresh concrete for particular characteristics including workability. It is a simple method of determining if different batches of concrete are the same. This is determined if the same constituents in the same proportions do not vary the characteristics of the concrete sample.

Result of Slump Test:

This test was undertaken on each sample of concrete used for the hardened concrete tests. The slumps obtained on the concrete samples are as follows:

Table 5 – Result of Slump Test

Type of Concrete	Slump (mm)
No Fines Concrete (6:1)	170
Fibered No Fines Concrete (1%)	150
Fibered No fines Concrete (2%)	135

4.2 Compacting 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 tamped 25 times). The sample falls from the initial cone and is captured in a second cone. It is then allowed to fall into a test cylinder with a diameter of 150 mm and height of 300 mm.

Result of Compacting Factor Test:

The results from the compacting factor test conducted on the concrete samplesare found below table

Type of Concrete	Partially Compacted (m_1)	Fully Compacted (m_2)	Compacting Factor
No Fines Concrete (6:1)	10.925	11.435	0.96
Fibered No Fines Concrete(1%)	10.145	11.200	0.90
Fibered No fines Concrete (2%)	13.000	13.450	0.97

5. TESTING OF HARDENED CONCRETE SPECIMENS

5.1 Compressive Strength:

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 cylinder testing is an Australian Standard for testing compressive strength, while cube testing is a British Standard.

Results of Compression Strength:

Table 6– Compressive Strength of Concrete Cubes for 3 Days

Sr. No.	Specimen Type	Force (kN)	Cross Sectional Area (mm^2)	Compressive Strength (MPa)	Average Compressive Strength (MPa)
1	No Fines (6:1)	113	22500	5.02	5.11
2	No Fines (6:1)	117	22500	5.18	
3	No Fines (6:1)	115	22500	5.13	
4	Fibered No Fines (1%)	136	22500	6.04	6.38
5	Fibered No Fines (1%)	150	22500	6.67	
6	Fibered No Fines (1%)	145	22500	6.44	
7	Fibered No fines (2%)	140	22500	6.22	6.76
8	Fibered No fines (2%)	162	22500	7.2	
9	Fibered No fines (2%)	155	22500	6.88	

Table 7– Compressive Strength of Concrete Cubes for 7 Days

Sr. No.	Specimen Type	Force (kN)	Cross Sectional Area (mm^2)	Compressive Strength (MPa)	Average Compressive Strength (MPa)
1	No Fines (6:1)	142	22500	6.30	5.95
2	No Fines (6:1)	154	22500	6.84	
3	No Fines (6:1)	106	22500	4.73	
4	Fibered No Fines (1%)	150	22500	6.67	7.66
5	Fibered No Fines (1%)	175	22500	7.78	
6	Fibered No Fines (1%)	192	22500	8.53	
7	Fibered No fines (2%)	155	22500	6.88	8.10
8	Fibered No fines (2%)	202	22500	8.97	
9	Fibered No fines (2%)	190	22500	8.44	

Table 8 – Compressive Strength of Concrete Cubes for 28 Days

Sr. No.	Specimen Type	Force (kN)	Cross Sectional Area (mm^2)	Compressive Strength (MPa)	Average Compressive Strength (MPa)
1	No Fines (6:1)	330	22500	14.69	12.71
2	No Fines (6:1)	219	22500	9.73	
3	No Fines (6:1)	308	22500	13.71	
4	Fibered No Fines (1%)	330	22500	14.67	14.67
5	Fibered No Fines (1%)	280	22500	12.44	
6	Fibered No Fines (1%)	380	22500	16.89	
7	Fibered No fines (2%)	355	22500	15.78	16.44
8	Fibered No fines (2%)	405	22500	18	
9	Fibered No fines (2%)	350	22500	15.55	

5.2Indirect Tensile Strength Test:

The tensile strength of concrete cannot be measured directly. This leads to theneed to determine the tensile strength through indirect methods. The indirect tensile test is also referred to as the 'Brazil' or splitting test, where a cylinder is placed on its side and broken in the compression machine. This test can also be used to determine the modulus of elasticity of the concrete sample.

Results of Indirect Tensile Strength Test:

Table 9 – The Results of Indirect Tensile Strength Test on Concrete Cylinders of Different Mixes

Sr. No.	Specimen Type	Force, P (kN)	Length, L (mm)	Diameter, D (mm)	Indirect Tensile Strength, T (MPa)	Average Tensile Strength (MPa)
1	No Fines (6:1)	74	300	150	1.05	1.20
2	No Fines (6:1)	80	300	150	1.13	
3	No Fines (6:1)	102	300	150	1.44	
4	Fibered No Fines (1%)	120	300	150	1.70	1.88
5	Fibered No Fines (1%)	131	300	150	1.85	
6	Fibered No Fines (1%)	147	300	150	2.09	
7	Fibered No fines (2%)	140	300	150	1.98	2.07
8	Fibered No fines (2%)	148	300	150	2.09	
9	Fibered No fines (2%)	152	300	150	2.15	

5.3 Modulus of Rupture:

The modulus of rupture is a flexural test that uses a symmetrical four-point loading on a plain, un-reinforced concrete beam. The beams are tested on their side when the concrete is unsegregated as it is representative of the true modulus of rupture. The maximum tensile stress in the bottom fibres of the test beam is known as the modulus of rupture.

Results of Modulus of Rupture Test:

The results from the modulus of rupture test determined for the no-fines and conventional concrete is found in Table 10.

Table 10 – The Results of Modulus of Rupture Test on Concrete Beams of Different Mixes

Sr. No.	Specimen Type	Force P (kN)	Length L (mm)	Depth D (mm)	Width B (mm)	Modulus of Rupture f_{cf} (MPa)	Average Modulus of Rupture (MPa)
1	No Fines (6:1)	9.75	700	150	150	2.02	2.02
2	No Fines (6:1)	9.16	700	150	150	1.9	
3	No Fines (6:1)	10.31	700	150	150	2.14	
4	Fibered No Fines (1%)	8.5	700	150	150	1.76	2.59
5	Fibered No Fines (1%)	15.25	700	150	150	3.16	
6	Fibered No Fines (1%)	13.78	700	150	150	2.86	
7	Fibered No fines (2%)	10.50	700	150	150	2.17	2.76
8	Fibered No fines (2%)	14.50	700	150	150	3.0	
9	Fibered No fines (2%)	15	700	150	150	3.11	

6.0 CONCLUSION

1. The strength of No fines concrete is lower, then also this concrete is used for road pavement.
2. The compressive strength of Plain No fines concrete is smaller than the fibered no fines concrete.
3. The Indirect tensile strength of Plain No fines concrete is smaller than the fibered no fines concrete.
4. The Flexural strength of plain No fines concrete is smaller than the fibered no fines concrete.
5. The workability of plain No fines concrete is higher than Fibered no fines concrete.

6. The cost of No fines concrete is less than conventional concrete, because of omitting the fine aggregate from concrete.

7. No fines concrete is environmental friendly due to absence of river sand.

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