DEVELOPMENT OF NO FINES CONCRETE AS A CONSTRUCTION MATERIAL IN PARKING AREA

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ABSTRACT*: Considerable research has been conducted on environmentally sustainable development. This has lead to the use of no-fines concrete in place of conventional concrete and asphalt surfaces. This material dramatically reduces environmental degradation and the negative effects association and the negative effects associated with urban sprawl. No-fines concrete has been used as an effective method for treating and reducing negative environmental impacts. Problems plagued the initial development, with the pores becoming clogged and stopping the water from passing through causing ponding and the skid resistance of the road surface. The second problem was concerned with the unsafe perception that this creates. This thesis analyses the effectiveness of no-fines concrete in pavement applications. This was achieved by analyzing the properties and characteristics of no-fines concrete. The analysis was undertaken by conducting a number of standard concrete tests and comparing the characteristics of the no-fines and conventional concrete samples. The tests included both fresh and hardened concrete tests to obtain a complete picture of its properties during the construction and working phase. The Analysis was undertaken by determining the properties of no-fines concrete. For this no-fines concrete cubes with aggregate cement ratio 5:1 with three water cement ratio of 0.35, 0.40 and 0.45 and three size range of aggregates 9.5 mm-13.2 mm, 13.2 mm – 16 mm and 16 mm-20 mm were cast of 150 mm cube size. These were tested for compressive strength, indirect tensile strength, flexural strength and water absorption .The study confirmed that no –fines concrete possesses required flexural strength and higher water absorption, therefore, no-fines concrete can be used in parking lots with confidence. This will have many advantages.

1. INTRODUCTION

The use of light weight concrete (LWC) has been a feature in construction industry for centuries but like other material the expectations of performance have raised and now we are expecting a consistent, reliable material with predictable characteristics. The term no-fines concrete generally means concrete composed of cement and a coarse (9mm - 19 mm) aggregate only (Atleast 95% should pass the 20 mm BS Sieve, not more than 10% should pass the 10 mm BS Sieve and nothing should pass the 5 mm BS sieve) and the product so formed has many uniformly distributed voids throughout its mass. No-fines concrete is mainly used for load bearing, cast in situ external and internal walls, non-load bearing walls and under floor filling for solid ground floors. No-Fines concrete consists of an agglomeration of coarse single sized aggregate covered with a thin layer of cement paste approximately 1.3mm thick. This form of concrete has the ability to allow water to permeate the material which reduces the environmental problems associated with asphalt and conventional concrete pavements. The most common application of no-fines concrete is in low traffic volume areas, for example: parking lots, residential roads, driveways and footpaths.

2. OBJECTIVES

1. Mechanical properties required for the use of no-fines concrete for pavements of parking area.
2. Properties variation with various size of course aggregate.
3. Properties variations with different water cement ratio.

3. EXPERIMENTAL PROGRAM

The investigation of different properties of the aggregates and cement used to make no-fines concrete test samples is done. The test such as Sieve analysis, bulk density of aggregates, consistency, IST,FST and specific gravity of cement were done.
The results of these test are useful to explain the differences in the compressive strength of the no-fines concrete when a different aggregate sample of same size is used.

4.1 Physical characteristics of material used:

Coarse Aggregate:-

Sieve Analysis:

The aggregate with maximum size of 20 mm , 16mm and 13.2 mm are used in each size range the aggregates were homogeneous in nature and roughly cubical in shape and confirmed the requirements of IS383 – 1970

IS Sieve Size (mm)	% retained	cumulative % retained	% passing
20	1.6	1.6	98.9
16	21.9	23.4	78.1
13.2	29.6	53.00	70.6
9.5	39.12	92.55	60.35
Pan	7.45	100	-

Table 1 (Gradation of Coarse aggregates)

Bulk Density of Aggregates:

Capacity of the container	3 liters
Weight of the container, W1	3442 gm
Weight of container + weight of aggregates W2	8195 gm
Weight of container + weight of loose aggregates W3	7560.5 gm
Rodded bulk density (kg/l)	8195-3442/3 = 1.58 kg/l
Rodded bulk density (kg/m^3)	1580 kg/m^3
Loose bulk density	7560.5-3442/3 = 1.37 kg/l = 1370kg/m^3

Table 2 (Density of Bulk Aggregates)

The bulk density of the aggregates used in the concrete sample is 1580 kg/m^3 and loose bulk density 1370 kg/m^3.

Cement:

The cement used was PPC confirming IS 1489:1991

Consistency test:

Quantity of cement taken	400 gm
Time of gauging	4 minutes 25 seconds
Quantity of water observed for normal consistency	36% i.e. 144 gm

Table 3 (Consistency of cement)

Setting Time Test:

Apparatus used	Vicat apparatus with square needle
Quantity of cement used	400gm
Quantity of water used	85% of water required for normal consistency = 0.85*144 = 122.4 gm
Initial setting time observed	162 minutes
Final setting time observed	484 minutes

Table 4 (Setting time test results)

Specific Gravity of Cement:

Weight of empty pycnometer, W1	457.5 gm
Weight of empty pycnometer+ weight of cement, W2	631.5 gm
Weight of empty pycnometer +weight of cement+weight of kerosene,W3	1114.5gm
Weight of empty pycnometer + weight of kerosene, W4	1000.5gm
Weight of empty pycnometer + weight of water, W5	1114gm
Weight of cement w.r.t kerosene = W2-W1	631.5-457.5=174gm
Weight of equal volume of kerosene =(W4-W1)-(W3-W2)	1000.5-457.5)-(1114.5-631.5) =44gm
Specific gravity of cement w.r.t kerosene	174/44=3.95
Weight of kerosene filling bottle	1000-457.5=542.5gm
Weight of equal volume of water	1141-457.5=683.5gm
Specific gravity of kerosene w.r.t water	542.5/683.5= 0.793
Specific gravity of cement w.r.t water	3.95*0.793= 3.135

Table 5 (Specific Gravity test result)

Compressive Strength of Cement:

Quantity of cement taken	200gm
Quantity of standard sand taken	600gm
Quantity of water measured	288 ml
Compressive strength of cement after 7 days	34.163MPa

Table 6 (Compressive strength results)

3.2 Mix Design:-

For this study cubes of 150 mm size were cast with aggregate size of 20-16mm, 16-13.2mm, 13.2-9.5mm and water cement ratio of 0.35, 0.40, 0.45 with 0.996 kg of water used to cast three cubes of no fines concrete.

The details of mix proportions are as under

Sr. No	Mix No.	Size of Aggregates(mm)	Aggregate cement ratio	W:C ratio
1	20C1	20-16	5:1	0.35
2	20C2	20-16	5:1	0.40
3	20C3	20-16	5:1	0.45
4	16C1	16-13.2	5:1	0.35
5	16C2	16-13.2	5:1	0.40
6	16C3	16-13.2	5:1	0.45
7	13.2C1	13.2-9.5	5:1	0.35
8	13.2C2	13.2-9.5	5:1	0.40
9	13.2C3	13.2-9.5	5:1	0.45

Table 7 (Mix proportions)

Testing of cubes:

Cubes were taken out on scheduled date of testing in order to achieve dry saturated surface conditions. The cubes were kept on gunny bags inside the laboratory and were tested at least after 6 hours when being taken out from water.

Compressive Strength:

The compressive strength which will be discussed in the results is the average of at least 3 test samples.

S.No	Mix No.	W:C ratio	Average Compressive Strength (MPa)
1	20C1	0.35	16.29
2	20C2	0.40	13.92
3	20C3	0.45	11.10
4	16C1	0.35	14.81
5	16C2	0.40	18.22
6	16C3	0.45	16.73
7	13.2C1	0.35	9.62
8	13.2C2	0.40	16.88

9	13.2C3	0.45	17.03

Table 8 Compressive strength results

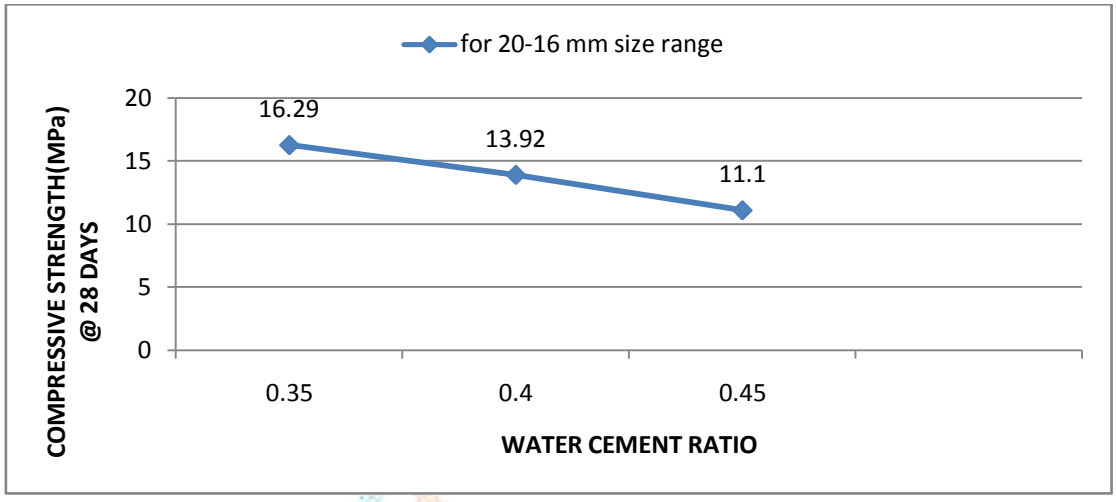

Figure No.1 Plot of compressive strength(MPa) with w/c ratio for 20-16mm size range

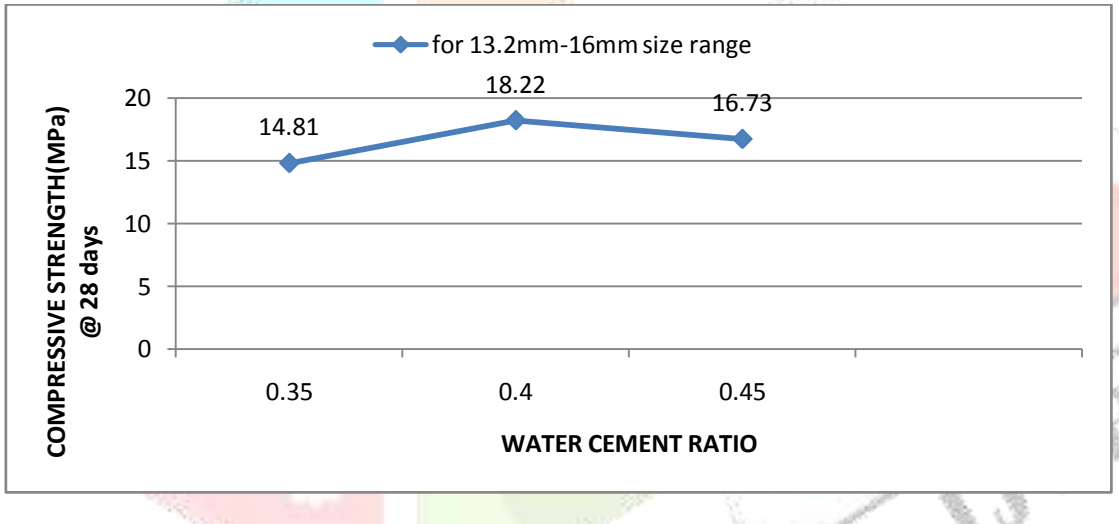

Figure No.2 Plot of compressive strength with w/c ratio for 13.2-16mm size aggregates

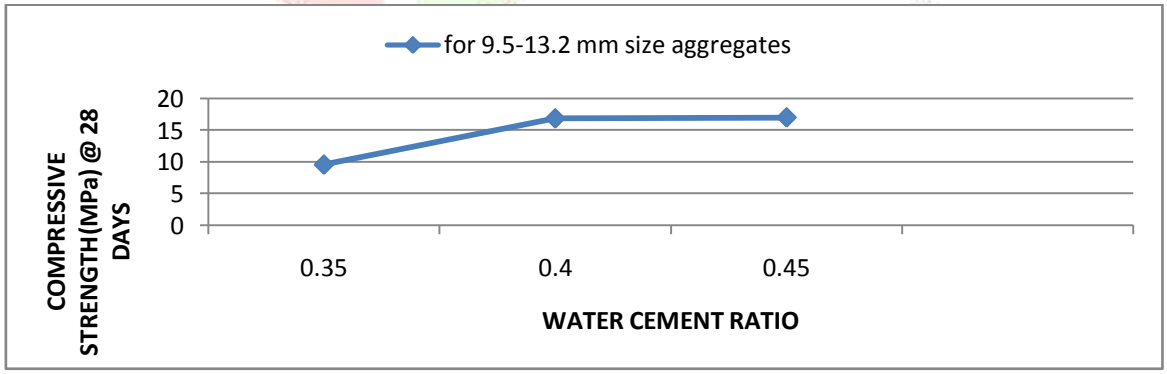

Figure No.3 Plot of compressive strength with w/c ratio for 9.5-13.2 mm size aggregates

Effect of water cement ratio and size of aggregates on compressive strength:

Water cement ratio is an important factor which affects the strength of concrete. It is a general trend that compressive strength decreases with increase in water cement ratio of a conventional concrete.

Indirect Tensile Strength:

Indirect tensile strength is not determined from the test rather it is obtained from equation given in IS 12727 : 2009.

Tensile strength = 0.12 fc

S NO.	Mix No.	Size of Aggregates(mm)	W:C Ratio	Average tensile Strength (MPa)
1	20C1	20-16	0.35	1.95
2	20C2	20-16	0.40	1.85
3	20C3	20-16	0.45	1.46
4	16C1	16-13.2	0.35	1.77
5	16C2	16-13.2	0.40	2.18
6	16C3	16.13.2	0.45	2.00
7	13.2C1	13.2-9.5	0.35	1.15
8	13.2C2	13.2-9.5	0.40	2.02
9	13.2C3	13.2-9.5	0.45	2.04

Table 9 Indirect tensile strength results of No fines concrete (MPa)

Effect of size of aggregates on tensile Strength of Concrete:

The tensile strength of No-fines Concrete does not vary much with the size of aggregates. Therefore tensile strength has lower variation in case of No-fines Concrete when the size of aggregates is taken into account.

Flexural Strength of No-fines concrete:-

The flexural strength of no-fines concrete pavement is determined as per IS 12727:2009.

Flexural strength = 0.23 fc

The Flexural strength of all 27 cubes are given in table:-

MIX NO.	SIZE OF AGGREGATES (mm)	WATER CEMENT RATIO	AVERAGE OF FLEXEUAL STRENGTH (MPa)
20C1	16-20 mm	0.35	3.74
20C2	16-20 mm	0.40	3.20
20C3	16-20 mm	0.45	2.55
16C1	13.2-16mm	0.35	3.40
16C2	13.2-16 mm	0.40	4.19
16C3	9.5 – 13.2mm	0.45	3.84
13.2C1	9.5 – 13.2mm	0.35	2.21
13.2C2	9.5 – 13.2mm	0.40	3.88
13.2C3	9.5 – 13.2mm	0.45	3.91

Table 10 Flexural strength of No fines concrete(MPa)

Water Absorption Test of Concrete:-

Cubes were taken out on scheduled date of testing after being dipped in water for 7 days and the weight is measured for each cube. The cubes are then put in oven for 48 hours and again their weight is measured after above mentioned time and water absorption is determined.

RESULTS :-

SIZE OF AGGREAGTS	WATER CEMENT RATIO	WET WEIGHT OF CUBES (kg)	DRY WEIGHT OF CUBES (kg)	% OF WATER ABSORBTION	AVERAGE WATER ABSORPTION (%)
16-20mm	0.35	6.24 6.73 6.45	6.03 6.57 6.23	3.46 3.21 3.59	3.42
16-20 mm	0.40	6.29 6.38 6.34	6.06 6.16 6.13	3.72 3.50 3.40	3.54
16-20 mm	0.45	6.41 6.40 6.48	6.18 6.16 6.25	3.70 3.96 3.67	3.77
13.2-16mm	0.35	6.11 6.01 6.06	5.89 5.81 5.84	3.69 3.52 3.67	3.62
13.2-16mm	0.40	6.36 6.20 6.39	6.10 5.98 6.18	4.20 3.77 3.42	3.79
13.2-16 mm	0.45	6.51 6.54 6.35	6.25 6.27 6.09	4.17 4.28 4.33	4.26
9.5 -13.2 mm	0.35	5.91 5.99 5.74	5.68 5.74 5.49	4.01 4.21 4.51	4.24
9.5-13.2 mm	0.40	6.10 5.93 5.93	5.84 5.69 5.70	4.43 4.24 4.10	4.25
9.5-13.2 mm	0.45	6.11 6.28 6.00	5.82 6.01 5.83	4.48 4.40 3.94	4.32

Table 11 (% of water absorption)

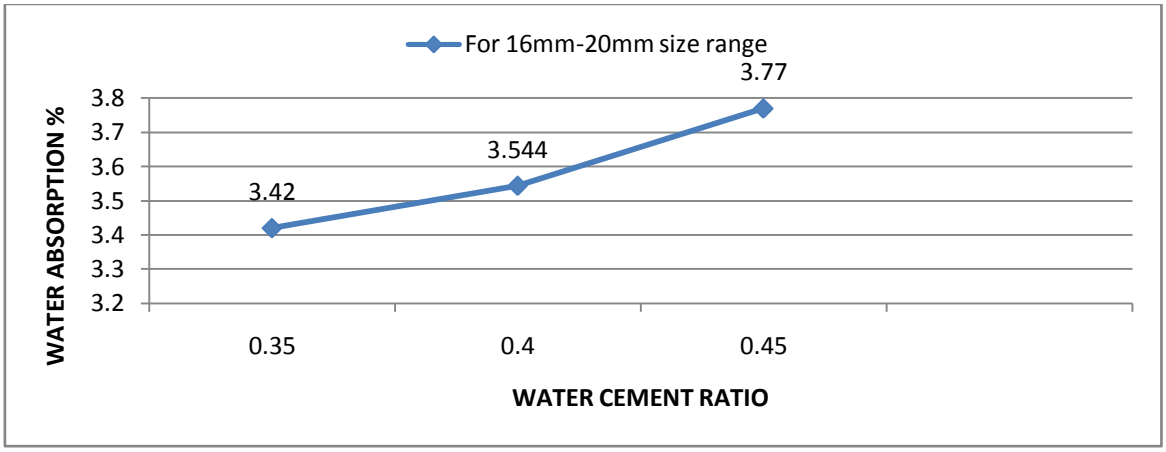

Figure 4 water absorption % with W/C ratio for 16mm-20mm size of aggregates

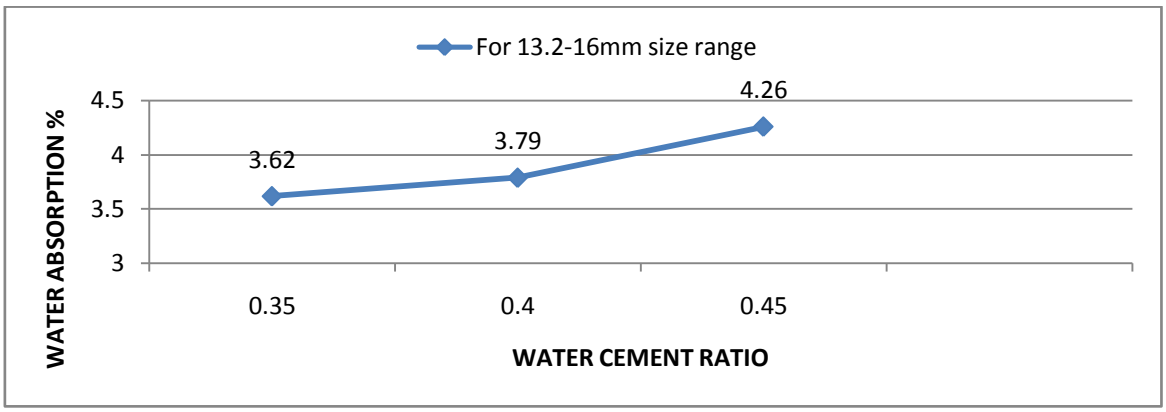

Figure 5 water absorption % with W/C ratio for 13.2-16mm size of aggregates

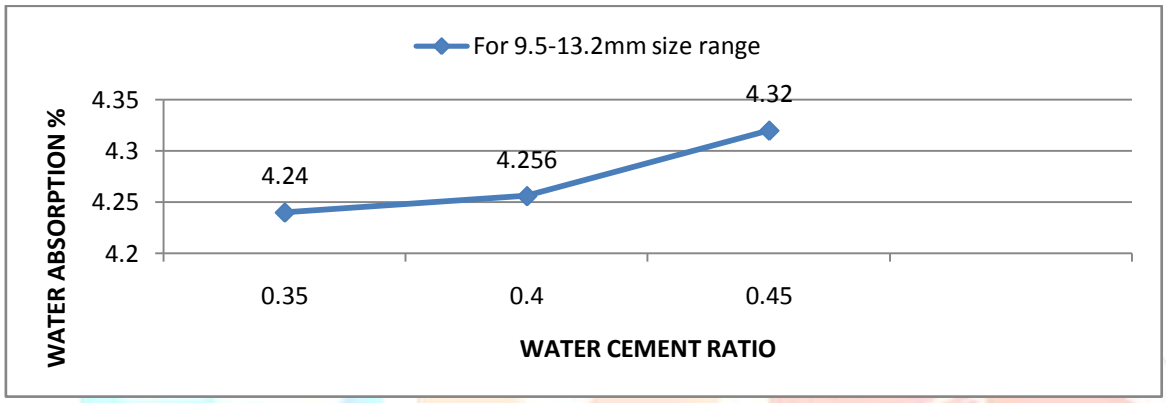

Figure 6 water absorption % with W/C ratio for 9.5-13.2mm size of aggregates

It can be seen from the figure 4 that for the size range of 16-20mm, the water absorption increases from 3.42% to 3.77% with increase in water cement ratio which may be due to availability of more water as water cement ratio increases. Figure 5 and figure 6 also shows that the increase in water absorption with increase in water cement ratio which may due to increase in specific surface area due to reduction in size of aggregates which increases the absorption sites for small size of aggregates. Therefore, more water absorption is observed for smaller size of aggregates.

5. Discussion of Results

1. 13.2mm-16mm size of aggregates gives more compressive strength than the other two sizes. The maximum strength obtained is 18.22 MPa at 0.40 water cement ratio.

2. The effect of water cement ratio have greater influence on compressive strength as 0.40 water cement ratio gives more strength than other water cement ratios used in this investigation.

3. The use of water cement ratio more than 0.45 causes the cement to flow to bottom of the specimen and hence reduces the strength which is being reflected in Figure No. 1 for 16mm-20mm size range of aggregates.

4. The use of aggregate between the size range of 16-20mm causes large size of voids inside the concrete thereby reduction in strength is observed.

5. The compressive strength of no fines concrete generally varies between 9MPa to 16MPa but the above study shows that it can goes upto 18.22 MPa for 13.2mm-16mm and for 5:1 mix proportions. The possibility of achieving compressive strength >=15MPa occurs for following mix proportions:

Size of aggregates→ Water cement ratio ↓	**9.5mm-13.2mm**	**13.2mm-16mm**	**16mm-20mm**
0.35	Not possible	Not possible	Possible
0.40	Possible	Possible	Not possible
0.45	Possible	Possible	Not possible

Table 12 Possibility of achieving of Compressive strength >= 15Mpa

6. The indirect tensile strength varies from 1.22 MPa to 2.83 MPa as per Ghafoori et al[5] and from the above study it lies between 1.15 MPa to 2.18 MPa which is in the above mentioned range.

7. The flexural strength varies between 2.55 MPa to 4.19 MPa.

The possibility of achieving flexural strength >= 3.5 MPa occurs for following mixes:

Size of aggregates→ Water cement ratio ↓	**9.5mm-13.2mm**	**13.2mm-16mm**	**16mm-20mm**
0.35	Not possible	Not possible	Possible
0.40	Possible	Possible	Not possible
0.45	Possible	Possible	Not possible

Table 13 Possibility of achieving of Flexural strength >= 3.5MPa

8. The water absorption values for no fines concrete are found in the range of 3.42% to 4.32% with highest for the aggregate size of 9.5mm-13.2mm.

6. Conclusions

The following conclusions can be drawn from the present experimental study:

1. The compressive strength varies with size of aggregates and water cement ratio considerably .The maximum strength obtained for 13.2mm-16mm size aggregates and for 0.40 water cement ratio. Therefore, for achieving maximum strength gradation of aggregates should be proper and the proportion of oversized and undersized material should be as low as possible.

2. The indirect tensile strength and flexural strength depended on the cube strength of concrete.

3. The water absorption values for no fines concrete cubes is found to be greater than interlocking blocks which makes it a better surfacing material that eliminates the problem of water logging on the pavements and it also allows water to pass through it which helps in improving the groundwater recharge.

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