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Assesment of concrete paver blocks with alternative sand material

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ABSTRACT

All over the world the availability of natural sand is in acute shortage due to over exploitation of sand from the river beds so almost all the countries are doing research for alternative sand material for preparation of concrete. In India also the availability of natural sand material is lesser and also most of the states in India were already abandoned for excavation from river beds due to depletion of water table. In the present work crushed sand is used for replacement of natural sand which is crushed in Vertical Shaft Impact crushers (VSI). This crushed sand is termed as Manufactured sand (M-Sand) in the present work. This M-sand is used for making concrete for preparation of concrete paver blocks with replacement of natural sand from 0% to 100% with various proportions at an increment of 10%. The mechanical properties like split tensile strengths, flexural strength, and durability properties such as Abrasion resistance, freez-Thaw showed that it significantly improved compared with control mix concrete. The paver blocks are the new ideology in construction of roads in low traffic, medium traffic and heavy traffic roads. This research is an attempt made for utilizing the M-Sand in commercial production of value added products such as paver blocks. This will be beneficial to the environmentally and ecologically sustainable development of new world towards a greener world since use of natural sand produces the depletion of ground water table in the world as a whole and India in particular.

Key words: *Abrasion resistance, Flexural strength, Freez-Thaw, Paver block, Split tensile strength.*

Introduction

The sustainable developments in infrastructure involves the use of concrete for the construction of buildings, industries etc which need construction materials such as coarse and fine aggregates. The availability of natural sand for the fine aggregates is now a days is scarce and in acute shortage. Due to acute shortage of conventional sand almost all countries are searching for alternative material. In this work manufactured sand which is manufactured in VSI Crushers were used to replace the conventional river sand to compensate the lack of availability of natural resources and find out the ways and means of using this alternative sand material for fine aggregates.

M-sand is a product obtained after crushing the rock boulders in the VSI crushers to a powder form to the sizes varies from 4.23mm- 75 microns and micro fines were washed using water during the process of M-sand production. The gradation of the M-sand is determined using sieve analysis and gives the results that zone II as per the standards and specifications of IS 383. Earlier studies show that use of Used foundry sand in different percentages to replace the conventional river sand. Now in this work M-sand is used to replace the natural sand from o% to 100% in incremental increase of 10% for

the preparation of commercial products such as interlocking paver blocks. This interlocking paver blocks now-a-days are used for the construction of roads in parks, walking paths , markets, petrol bunks, industrial sheds, medium traffic village roads, and heavy traffic roads.

Review of Literature

The feasibility of using waste plastic as partial replacement to fine aggregate in concerted was used experimentally by Zainab *et al.* (2017) and the result showed the strength decreases when increasing the waste plastic percentage is increasing. Supriya kulkararani and Vikhyut Katti (2017) experimentally studied and reported that the properties of paver blocks manufactured with foundry sand the strength increases up to 30% replacements and beyond which the strength reduces and water absorption of paver blocks is increasing with increasing with increase in percentage of foundry sand. Kauswalk Tanit *et al.* (2018) experimentally studied and reported that the foundry sand is used in paver blocks and achieved up to use of 10% used foundry sand gives maximum strength beyond which the strength reduces.

Saling and Prasad (2019) reported that the strength of paver blocks using Used foundry sand increases up to 30% replacements and decreasing beyond 30% replacements level and water absorption up to 20% replacement level of used foundry sand in place of conventional river sand is increasing beyond 20% replacements decreasing. Ashok Kumar and Partheepan (2017) investigated experimentally the flexural strength of Geo polymer concrete in paver blocks and reported that the flexural strength increases t0 13.27% than the conventional sand concrete paver blocks for M35 Grade concrete.

Abdul Rachman *et al.* (2020) studied and reported that the flexural strength and water absorption of concrete paver blocks with processed waste tea ash in concrete flexural strength of M10, M20, M30, M40, and M60 Grade concrete was 5.03%, 17.98%, 26.72%, 37.44% and 53.69% lower than that of conventional sand concrete paver blocks similarly the water absorption values increases to 0.64%, 4.64%, 13.14%, 16.37%, and 20.75% higher than that of conventional sand concrete paver blocks for M10, M20, M30, M40, and M60 Grade concrete. Prasant Udeniyan and Abhay Kumar Jha (2020) evaluated experimentally the properties of paver block using dismantled concrete as aggregate for medium traffic roads and reported that the flexural strength reduced and also the value is more than the specifications reported in IS 15658, hence concrete with demolished concrete waste aggregates is used for preparation of concrete paver blocks for medium traffic roads.

Naviya and Vengateswara Rao (2014) experimentally investigated on properties of concrete paver block with the natural fibers, the flexural strength and water absorption was examined with fibers at 0.105, to 0.50%, the water absorption is improved and flexural strength is 4.78% to 23.89% more than the concrete paver blocks with conventional river sand. From these above literatures the concrete with M-sand as fine aggregates is used in this present work and reported with different percentages of replacement level.

Materials Used (Saravanan and Jagdeesh, 2016)

Cement

Ordinary Portland cement of Grade 53 confirming to IS:12249. The cement used for this research work was tested in the loboratory for it's physical properties and is presented in Table 1.

Table 1. The physical properties of cement

Sl no	Properties	Values	As per code
1.	Specific gravity	3.15	3.10 .- 3.15
2.	Standard consistency	31%	30.-35
3.	Initial setting time	33	30 (.Min.)
4.	Final setting time	385	600 (Max.)
5.	Compressive strength		
	a) 7 days	43.50MPa	43 MPa
	b) 28 days	57.50MPa	53 MPa
6.	Fineness m^2 / kg	270.80	225
7	Soundness (mm)	1.00	10

Aggregates

Coarse aggregates

The coarse aggregates used in this present research work is crushed stone aggregates of size 12mm , where all these aggregates should passing through 12mm sieve and 100% retaining in 10mm sieve and confirming to IS: 383. The stone material used as coarse aggregates should be free from soft rocks so as to ensure adequate durability of concrete paver

blocks. The Physical properties of coarse aggregates such as specific gravity, Bulk density, water absorption, Crushing strength, Impact strength and sieve analysis of coarse aggregates were determined in accordance with IS: 383 and the values obtained were reported in Table 2.

Fine aggregates

The fine aggregates used in this research work is natural sand and M-Sand. This M-sand is used to replace the natural river sand form 0%to 100% replacements in concrete for manufacturing the concrete paver blocks. The M- sand is produced in Vertical Shaft Impact crushers. The stone boulders were fed into the crushers and is fine grained to the required size from 4.23 mm to 75 microns. The excess fines were properly removed by way of washing. The advantage of using the M-sand is the size and shape of aggregates was properly controlled while in crushers it self but it is not possible in the case of natural sand. The Physical properties such as specific gravity, Bulk density, water absorption, Crushing strength, Impact strength and sieve analysis of fine aggregates were determined in accordance with IS: 383 and the values obtained were reported in the Table 2.

Water

The water is an important ingredient of concrete which is actually reacts with cement. Water used for preparing the concrete and curing the concrete for preparation of concrete paver blocks should be free from oil, acid, alkalinities, clay and organic impurities. Salt free water was used in this research work since the salt water leads to decrease the concrete's strength and durability properties. The water is added to the mixture of coarse aggregates, fine aggregates with cement and the quality of water used to be good and having the pH value of 7. The water is tested for the dissolved solids both organic and inorganic, suspended solids, alkalinity, chlorides and sulphates and pH the values are presented in Table 3 and compared with IS : 456.

Admixtures used in this research work

The chemical admixture used in his work is Naphthalene sulphonate based super plasticizer confirming to IS: 9103. The commercial brand used is CERAPLAST 300RR. The admixtures used in this research work is to improve the strength parameters such as compressive strength of the concrete paver blocks, to reduce the water content for the concrete so as to maintain zero slump. The physical proper-

Table 2. Physical properties of coarse and fine aggregates

Sl No	Properties	Coarse aggregates	Fine aggregates M-sand	Natural sand
1.	Specific gravity	2.70	2.45	2.60
2.	Bulk density	1510	1556	1460
3.	Water Absorption (%)	0.45	1.00	1.15
4.	Moisture constent	0.85	1.15	1.10
5.	Fineness particles Less than 0.075 mm(%)	-	5.30	4.14
6.	Fineness modules	6.72	3.54	3.44
7	Impact value	12.50	-	-
8	Crushing strength	13.50	13.80	
9	Sieve analysis	-	Zone-II	Zone -II

Table 3. Test results on water

Sl No	Properties	Values	As per code
1	pH Value	7.00	Not less than 6.00
2	Dissolved Solids(organic), mg/lit	10	Nottoexceed200
3	Dissolved Solids(in-organic), mg/lit	1084	Not to exceed 3000
4	Suspended solids mg / lit	30	Not to exceed 2000
5	Chlorides as Cl mg / lit	36	Not to exceed 2000for PC and 500 for RCC
6	Sulphates as SO4, mg / lit	64	400
7	Alkalinity as CaCo3, mg / lit	52	250

ties such as Physical state, specific gravity, pH value, relative density, chloride content of the admixture were tested and reported the values in Table 4.

Table 4. Specification of Super plasticizer

Sl. No	Property	Value
1	Physical state	Brown in colour
2	Specific gravity	1.18
3	pH	6.50
4	Relative density	1.10
5	Chloride content	0.002

Grades Requirements and Design of Concrete Paver Block Pavements

The requirements for the different category of the traffic ,the following Table 5 shows the Grade designations of paver blocks, traffic category, recommended minimum thickness of paver block for different category of roads are given as per the IS:15658-2006, Table 1.

Sampling

The paver blocks selected for testing should be the representative of the consignment. The number of concrete blocks to be sampled from each batches for each tests shall be as per Table 4 of IS : 15658. The samples shall be taken for the different strength and durability tests shall be marked for future reference. The following Table 6 shows the details of number of samples to be tested for each Grade of concrete paver blocks.

Methods Used for Strength and Durability Tests

Split Tensile Strength

Split tensile strength of concrete paver blocks were conducted as per IS : 15658-2006. Annexure F. The paver blocks were immersed in water for 48 Hours@ 25 °C the samples were removed from the water curing tank then the samples were wiped off using cloths then the tests were carried out as per the procedure in the specifications. The test samples were properly positioned with packing piece at the top and bottom of the sample as per standards and as per code. Then the test was carried out along the centers of the breadth of the concrete paver block parallel to the longer edges. The split tensile strength of the concrete paver block for the Grades of M30, M40 and M50 was then calculated as per IS.: 15658-2006 and BS EN 1338-2003 and the results obtained experimentally was presented in Figure 1. And were discussed in detailed.

$$T = \frac{0.637kP}{S} \quad \text{.. (1)}$$

Where,
P = Failure Load in N,
k= this value obtained from BS EN 1338-2003,
S = l x t where l =average failure length in 'mm'
t= average thickness of the specimen in 'mm'
S = average area in 'mm^2'

Flexural Strength or Wet Transverse Test on Concrete Blocks

This flexural strength of concrete paver block is determined as per annexure G of IS 15658- 2000 and IS 1237-1980 Annexure E. The breaking load and the flexural strength of concrete paver blocks were carried out on the Universal Testing Machine (UTM) where the bottom rollers supports at 150 mm apart. The ply wood of thickness 3 mm and 200 mm wide

Table 5. Recommended Grades of concrete Paver Blocks

Sl. No	Grade Designation of Paver Blocks	Traffic Category	Minimum thickness of Paver Blocks	Traffic Examples of Application
1	M30	Non-Traffic	50mm	Building premises, monument premises. Public gardens, parks, pathways, embankment slopes etc
2	M40	Medium- Traffic	80mm	City streets, small and medium market roads, low volume roads, utility cuts on arterial roads etc
3	M50	Heavy-Traffic	100mm	Bus terminals, industrial complexes, factory floors, roads on expensive soil pavements, and service stations, Industrial roads etc

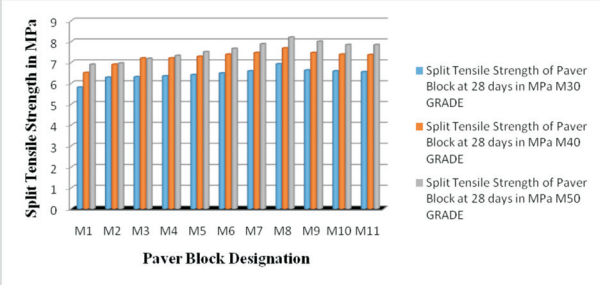

Fig. 1. Split tensile strength VS Paver block Designations

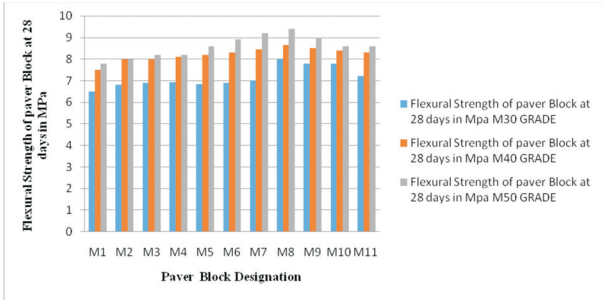

Fig. 3. Flexural strength VS Paver block Designations

should be placed between the tiles and each of the supports and steel rods between the blocks and each of the supports between the paver block and the steel rod. The load is applied continuously with increments of loads and shock free up to collapse of the paver block sample. The load at which the sample collapses of the paver blocks sample was recorded in 'N' as breaking load and is recorded in Table 7 and thus the flexural strength of concrete paver block was then calculated as per the equation (2) and the methods specified in the annexure G of the code, the flexural strength of concrete paver block is recorded in Table 8 for the concrete Paver blocks of Grades M30, M40 and M50.The thickness (d) shall be the average measurements taken using dial caliper pistal type at the average of two measurements at the location of the fracture 50 mm from each edge as per IS 1237-1980 Annexure E.

$$fb = \frac{3Pl}{2bd2} \quad .. (2)$$

Where,

$f_{b=}$ flexural strength in ' $mm^{2'}$

P = maximum cracking load in 'N'

l = length between the central line of the supporting roller in ' mm'

b = average width of concrete paver block in 'mm'

d = average thickness of concrete paver block in 'mm'

The flexural strength of concrete paver blocks for M30, M40 and M50 Grades of concrete paver blocks were then calculated and presented in Figure 2. The detailed discussion of the flexural strength of concrete paver blocks were presented in detail.

Abrasion Test or Test on Resistance to Wear

The abrasion resistance or resistance to wear is an important factor for road pavements, airfields, industrial floors, ware houses, dock yards, etc. This test has been conducted as per IS: 15658-2006, Annexure E and Annexure F of IS : 1237-1980. The square shaped specimen of size 71mm shall be cut from the concrete paver block specimens so selected for the test. The contact face and opposite face of the specimen shall be parallel and flat. The reduction in thickness shall be measured using the following formula (3). The average wear and the wear on individual specimen shall be reported for the samples and the abrasion resistance value so obtained should be specified the limits as per the specifications. The test was conducted and the results swere reported in Figure 4.

$$t = \frac{(W1-W2)V}{W1A} \quad .. (3)$$

Where, t = reduction in thickness after 16 cycles in 'mm''

w_1 = initial mass of the paver block specimen in 'g'

w_2 = Final mass of the specimen after 16 cycles in 'g'

v = Initial volume of the specimen in '$mm^{3'}$

A = Surface area of the specimen in '$mm^{2'}$

Freez- Thaw Durability Test

This test is part of durability of the concrete paver blocks and was conducted as per the Annexure-H of IS:15658. This test covers the determination of the resistance of concrete paver blocks to repeated cycles of freezing and thawing when the paver blocks were fully immersed in 3% sodium chloride (Nacl) solution. The loss of weight is calculated to nearest 0.01%. The sample is submerged in 3% sodium chloride (Nacl) solution for 24 hours saturation period, after 10 cycles one cycle should be 16 hours of freezing followed by 8 hours of thawing. After each cycle the specimen shall be washed with 3% sodium chloride solution to remove the loose particles. These loose particles collected at the bottom of the container shall be washed and dried to

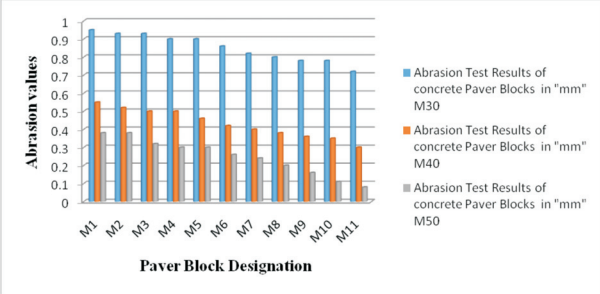

Fig. 4. Abrasion Test results VS Paver block Designations

constant weight, this residue shall be the loss of weight. The weight shall be determined to the nearest 0.01 kg.

Results and Discussion

The Split tensile strength of concrete paver blocks at 28 days for M30 Grade concrete with M-Sand concrete at 70% level of replacements is 19.30% more than the natural sand concrete and 12.76% more for 100% replacement level of concrete than natural sand concrete. The Split tensile strength of concrete paver blocks at 28 days for M40 Grade concrete with M-Sand concrete at 70% level of replacements is 18.15% more than the natural sand concrete and 13.23% more for 100% replacement level of concrete than natural sand concrete. The Split tensile strength of concrete paver blocks at 28 days for M50 Grade concrete with M-Sand concrete at 70% level of replacements is 18.85% more than the natural sand concrete and 13.62% more for 100% replacement level of concrete than natural sand concrete. Similarly,

The flexural strength of concrete paver blocks at 28 days for M30 Grade concrete with M-Sand concrete at 70% level of replacements is 23.08% more than the natural sand concrete and 10.77% more for 100% replacement level of concrete than natural sand concrete. The flexural strength of concrete paver blocks at 28 days for M40 Grade concrete with M-Sand concrete at 70% level of replacements is 15.33% more than the natural sand concrete and 10.67% more for 100% replacement level of concrete than natural sand concrete. The flexural strength of concrete paver blocks at 28 days for M50 Grade concrete with M-Sand concrete at 70% level of replacements is 18.85% more than the natural sand concrete and 13.62% more for 100% replacement level of concrete than natural sand concrete.

The abrasion resistance of concrete paver blocks with M-sand for M30 Grade concrete is 24.21% more than the natural sand concrete paver blocks. The abrasion resistance of concrete paver blocks with M-sand for M40 Grade concrete is 45.45% more than the natural sand concrete paver blocks.

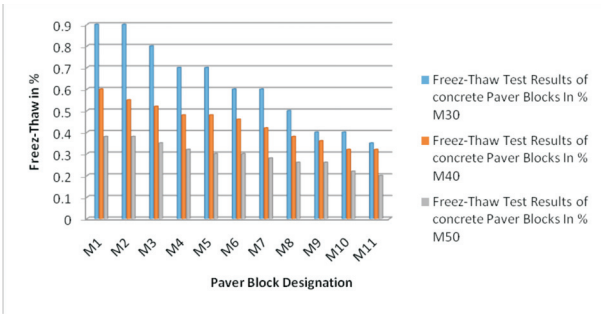

Fig. 5. Freeze- Thaw Test Results VS Paver block Designations

Table 6. Number of test specimen for different Tests

Sl. No.	Paver Block Mix Designation	Number of samples for each Mix Grades				
		Split Tensile Strength	Flexural Strength	Abrasion Test	Freeze-Thaw Test	Total
1	M1	8	8	8	3	27
2	M2	8	8	8	3	27
3	M3	8	8	8	3	27
4	M4	8	8	8	3	27
5	M5	8	8	8	3	27
6	M6	8	8	8	3	27
7	M7	8	8	8	3	27
8	M8	8	8	8	3	27
9	M9	8	8	8	3	27
10	M10	8	8	8	3	27
11	M11	8	8	8	3	27
	Total	88	88	88	33	297

The abrasion resistance of concrete paver blocks with M-sand for M50 Grade concrete is 78.95% more than the natural sand concrete paver blocks. From these results it was observed that concrete with higher grades with M-sand concrete paver blocks are more resistance than natural sand concrete paver blocks which is due to the M-sand provides more density than natural sand concrete blocks. Similarly,

Freez- Thaw test conducted for all Grades of concrete for all mix proportions of concrete with natural sand and observed that very light scaling and no coarse aggregate are visible for all Grades of concrete.

Conclusion

The various tests for strength and durability conducted for concrete paver block of Grades M30, M40 and M50 with M- Sand and reported as follows.

- The split tensile strength of concrete paver blocks with M-sand for concretes of Grades M30, M40 and M50 incorporating M-sand is more for all replacements level of concrete paver blocks than natural river sand concrete paver block,
- Flexural strength of concrete paver blocks with M-sand for concretes of Grades M30, M40 and M50 incorporating M-sand is more for all replacements level of concrete paver blocks than natural river sand concrete paver block, Similarly
- Abrasion resistance for all Grades of concrete paver blocks were tested and the concrete paver blocks with M-sand is more resistance than the concrete paver blocks with natural sand concrete paver blocks.
- Freez-Thaw test conducted for all grades of concrete paver blocks with M-sand and natural sand concrete From these results it was observed that very light scaling was observed for all Grades of concrete paver blocks with M-sand and no course aggregate is visible after the test.
- From these results it was observed that M-sand is used for manufacturing of Paver blocks of Grades M30, M40 and M50.

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