IJETST- Volume||01||Issue||08||Pages 1251-1259||October||ISSN 2348-9480 2014

Open access Journal International Journal of Emerging Trends in Science and Technology

Flexural Strength of ICBPs Utilizing Waste Brick Kiln Dust as a Partial Replacement of Cement adding Waterproofing Superplasticizer as a Admixture

Authors

Sharda Sharma[1], Shiv Kumar Yadav[2]

[1]P.G. Scholar, Department of Civil Engineering, M.M.M.U.T. Gorakhpur

Email id- *sharda.ietstp@gmail.com*

[2]P.G. Scholar, Department of Civil Engineering, M.M.M.U.T. Gorakhpur

Email id- *shivkumaryadav.20@gmail.com*

Abstract-

Now a day's construction of Interlocking concrete block pavements(ICBPs) generally called paver block is going to increase rapidly with very high rate due to having easy laying, consuming less time, easy in installation and mainly due to found in a lot of variety and shapes which gives better surface finishing and attractive look. Demand of ICBPs increasing day by day for different categories like Non-traffic, Light-traffic, Medium-traffic, Heavy-traffic and Very heavy-traffic and applications likes Building premises, monument premises, landscapes, public garden, parks, domestic drives, Pedestrian plazas, shopping complexes ramps, car parks, office driveways, housing colonies, office complexes, rural roads with low volume traffic, City streets, small and medium market roads, low volume roads etc. In this experimental study we considering flexural strength for M-35 grade of paver block with partial replacement of cement with brick kiln dust (B.K.D.) at six different percentages like 5 %, 10 %, 15 %, 20 %, 25 % and 30 % and comparison with conventional mix that is 0 % of replacement of cement also adding 2 % waterproofing superplasticizer by weight of cement added at 7, 14 and 28 days.

Index Terms—*Brick Kiln Dust (B.K.D.), Flexural Strength, OPC 43 grade cement, Superplasticizer.*

INTRODUCTION

Paver block was firstly introduced and manufactured in the Netherlands in 1924 and led to growth of paver block during probably World War II. After that it was introduced in Holland in the fifties as replacement of paver bricks and demanded due to having boom in construction at that time. A research was done by Shackel in seventeen and eighteen on the performance of paver. A hierarchy came when paver block shapes was developed and various shapes and design curves were checked. In India paver block was introduced by Bureau of Indian Standards and research and development work was started by Central Road Research Institute (CRRI) on paver block in the nineties. In this experiment the work is done to find out the flexural strength for paver block in which cement is partially replaced with waste brick kiln dust at different percentages.

EXPERIMANTAL STUDY

This experiment investigate about density variation and flexural strength for paver block as per IS 15658:2006 in which cement is replaced by waste brick kiln dust at various percentage 5 %, 10 %, 15 %, 20 %, 25 % and 30 % and comparison with conventional mix that is 0 % of replacement of cement also adding 2 % waterproofing superplasticizer by weight of cement added at 7, 14 and 28 days.

SELECTION OF MATERIALS AND ITS PHYSICAL PROPERTIES

Cement

As per easily availability of and concerning to IS 8112: 1989 OPC 43 grade cement has been taken in this experimental investigation. Physical properties of OPC 43 grade cement is shown in table 1 below as investigated in lab experiments.

Table 1: Physical Properties of OPC 43 Grade cement

S.N.	Name of Test	Test Result
1	Fineness	6%
2	Consistency	30%
3	Initial Setting Time	80 minutes
4	Final Setting Time	325 minutes
5	Specific Gravity	3.16

Table 2: Compressive Strength of OPC 43 grade Cement

S. NO.	No. of days	As per IS 8112:1989 Compressive Strength of cube in N/mm^2	In laboratory Compressive Strength of cube in N/mm^2
1	3	23	24
2	7	33	34.4
3	28	43	44

Brick Kiln Dust

Brick kiln dust (B.K.D.) locally called "Rubbish" is taken from brick production place near Motiram, Gorakhpur (as shown in fig. 1) was used for partial replacement of cement in all mixes as per design consideration. The physical properties of B.K.D. like fineness, specific gravity and optimum moisture contain and dry density etc were obtained through lab testing and process of finding physical properties as per IS codes. The physical properties of B.K.D. are shown in table 3.

Figure 1: B.K.D. for Partial Replacement of Cement

Table 3: Physical Properties of B.K.D

S. No.	Physical Properties	Results
1	Fineness modulus	3.67
2	Specific gravity	2.35
3	Maximum dry density	1.444
4	Optimum moisture content	17
5	Shear Angle (Ø)	19.19°
6	Liquid Limit	No
7	Plastic Limit	No

Coarse aggregate

As per given in "IS 15658: 2006 Precast concrete blocks for paving-specification" maximum size of coarse aggregate in paver block should be 12 mm nominal size. So in this study we consider only 12 mm nominal aggregate & its testing. The results of tests are shown in table 4.

Table 4: Physical Properties of Coarse Aggregate

S. No.	Lab Experiments	Result
1	F.M.	6.27 %
2	Specific gravity	2.85
3	% age of water absorption	0.7
4	Crushing value	22.33

Fine Aggregate

As per IS 15658: 2000 the fine aggregate both river /quarry sand and stone dust meeting the requirement can be used in the production of concrete block pavements. In this experimental study fine sand was used. Its result of lab tests is shown in table 5.

Table 5: Physical Properties of Fine Aggregate

S. No.	Lab Experiments	Result
1	F.M.	3.19
2	Specific gravity	2.56
3	% age of water absorption	0.82

Superplasticizer

Superplasticizer Waterproofing Chemical which reduces the ratio of water and cement and confirming to IS 9103 has been taken in this experimental study. Its properties are shown in table 6.

Table 6: Physical Properties of Superplasticizer

S. No.	From Manuals	Result
1	Appearance	brownish liquid
2	specify gravity	1.18-0.05
3	pH value	8.00 to 9.00
4	Normally Dose	As per concrete mix design

Water

Portable water is generally considered satisfactory for mixing concrete used in this analysis. It has pH value between7 to 8 tested at paper indicator as shown in figure 2 below.

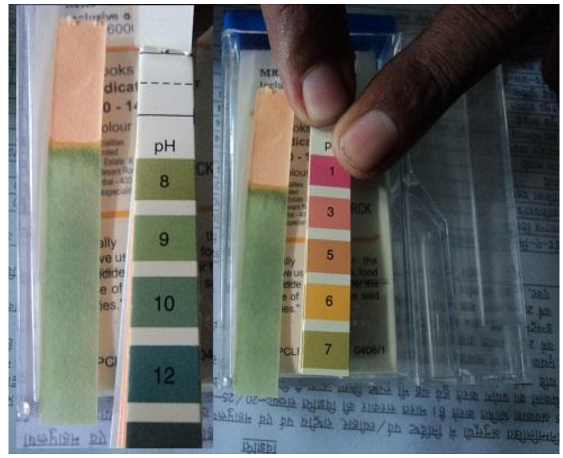

Figure 2: Water pH Test Through pH Indicator Paper Test

Mix proportion

In this experimental study mix design is prepared for M-35 grade designation of paver block as per IS 10262: 2009 to find out the trail proportion of materials like cement, water, fine aggregate and coarse aggregate, superplasticizer and B.K.D. which was partially replaced by cement by weight. Trail mix proportion ratio for M-35 grade designation for paver block is shown in table 7 as below.

Table 7: Mix Proportion for Trials

S. No.	Materials	Contents	Ratios
1	Cement	372.5 kg/m^3	1.00
2	Water	149 kg/m^3	0.40
3	Fine aggregate	1062.02 kg/m^3	2.85
4	Coarse aggregate	921.06 kg/m^3	2.47
5	Chemical admixture	8.3 kg/m^3	0.02
6	Water-cement ratio	-	0.40

CASTING AND TESTING

ICBPs are used for masonry; paving blocks must be dense. Equipment must be capable of a high degree of compaction and satisfactory output. A combination of vibration and pressure is the most effective way of achieving compaction. There was used mould of size 100x100x500 mm^3 for production of prism. Vibrating table was used to achieve the compaction to satisfactory samples unless more cement is used. After moulding the prism of sample with different variation, samples of prism were kept in the water for curing for flexural strength test. Testing of flexural strength is done as per concerning to IS 15658:2006 and recommended as flexural test is done as per IS 516-1959 Methods of tests of strength of concrete.

EXPERIMANTAL INVESTIGATION

Experimental study was done on prism manufactured in concrete laboratory of size 100 x 100 x 500 mm^3 in which cement was replaced by brick kiln dust at 5 %, 10 %, 15 %, 20 %, 25 % and 30 % by weight and comparison with 0 % that means conventional mix (CM) to examine density variation due to change of percentage of cement and effect on flexural strength. There was manufactured total 63 prisms for testing as per IS 15658:2006 and some samples of prism size 100 x 100 x 500 mm^3 are shown in figure 3 as below which were examined for density variation and flexural strength as per IS code recommended.

Figure 3: Samples of Prism size 100 x 100 x 500 mm^3

Density Variation

Density variations were examined in this experiment on prism of size 100 x 100 x 500 mm^3 after casting at 7, 14and 28 days in which firstly weight of each prism at every percentage of change of cement with brick kiln dust taken and counted average value for density variation in kg/m^3 as shown in table 7 as below. As we know density is defined as "mass per unit volume" that means how much amount of mixture concrete is there per cubic meter volume.

$$\text{Density}= \frac{Mass}{Volume}$$

Where,

Mass is in Kg and Volume in m^3.

There is also shown average density variation of prism for each percentage of change in cement in table 7.

Table 7: Density Variation of Prism

% of Cement Replaced	Density at 7 Days	Density at 14 Days	Density at 28 Days	Average Density Variation
CM	234.20	235.00	236.00	235.067
5%	233.20	234.20	234.80	234.067
10%	238.40	239.40	240.00	239.267
15%	237.40	235.00	235.40	235.933
20%	228.00	229.20	229.80	229.000
25%	229.80	230.60	231.00	230.467
30%	228.20	228.60	228.80	228.533

Flexural Strength/Breaking Load of Test Specimens

As per concerning IS 15658: 2006 precast concrete blocks for paving flexural strength is consider by taking beam size of 100x100x500 mm^3 .The flexural test is done as per IS 516-1959 Methods of tests of strength of concrete. The load is applied from top on the beam loading through a roller placed midway between the supporting rollers as such applied in the Figure 4. Actual loading of beam is shown in Figure 5.

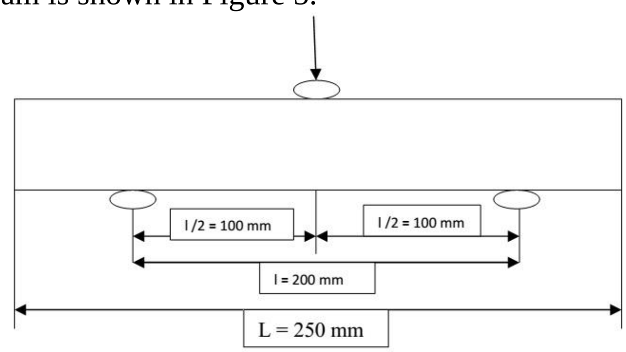

Figure 4: Method of Loading Test Specimen for Flexural Strength

Where,
L = overall length of the beam parallel to the longitudinal axis (mm)
l = overall length 50 mm
P = Load applied to the beam.

The load was applied on the beam without shock and continuously uniform increased at the rate of 6 KN /mm^2. The load was applied until the beam braked and the maximum applied loads were noted down as shown in indicator of the test machine.

Figure 5: Actual Flexural Loading

Flexural Load
Flexural load for Paver Block at different percentage of replacement with OPC 43 grade cement with waste brick kiln dust 0 %, 5%, 10%, 15%, 20%, 25%, 30 % at 7,14 and 28 days are listed below in table 8 and flexural strength in table 9. Numbers of prism taken were 3 for each percentage at each day of testing's of flexural load as per recommended in IS 15658-2006 .The maximum flexural load P was shown as breaking load in nearest to 1 N.

Table 8: Flexural Load in N

S. No.	% of Cement Replaced	Flexural load in N at 7 days	Flexural load in N at 14 days	Flexural load in N at 28 days
1	0% (CM)	16	20	23
2	5%	14	19	20
3	10%	13	17	19
4	15%	13	19	21
5	20%	11	16	17
6	25%	8	13	15
7	30%	6	8	11

Calculation of Flexural Strength
The flexural strength of the specimen calculated as follows

$$F_b = \frac{3Pl}{2bd^2}$$

Where,
P = maximum load, in N
1 = distance between central lines of supporting rollers, in mm;
b = average width of block, measured from both Faces of the specimen, in mm; and
d = average thickness, measured from both ends of the fracture line, in mm.
$F_{b} =$ flexural strength, in N/mm^2.

Table 9: Flexural Strength in N/mm^2

S. No.	% of Cement Replaced	Flexural strength at 7 days	Flexural strength at 14 days	Flexural strength at 28 days
1	0% (CM)	4.8	6	6.9
2	5%	4.2	5.7	6.3
3	10%	4.2	5.4	6.3
4	15%	4.5	5.7	6.6
5	20%	3.3	4.8	5.4
6	25%	2.4	3.9	4.5
7	30%	1.8	2.4	3.3

RESULT AND DISCUSSIONS

Density Variation
For prism of size 100 x 100 x 500 mm^3 manufactured in concrete laboratory at M-35 grade
(i). The maximum density 238.40 kg/m^3 was attained at the replacement of 10%, while the minimum density of 228.20 kg/m^3 was attained at 30% replacement at 7 days of testing as shown in figure 6.
(ii). The maximum density 239.40 kg/m^3 was attained at the replacement of 10%, while the minimum density of 228.60 kg/m^3 was attained at 30% replacement at 14 days of testing as shown in figure 7.

(iii). The maximum density 240.00 kg/m^3 was attained at the replacement of 10%, while the minimum density of 228.80 kg/m^3 was attained at 30% replacement at 28 days of testing as shown in figure 8.

(iv). Comparisons of density at 7, 14 and 28 days is shown in figure 9 and it is showing that density is varying and it attained maximum at 28 days for each varying of percentages of cement with brick kiln dust.

(v). Average density variation is shown in figure 10 where the maximum density 239.267 kg/m^3 was attained at the replacement of 10%, while the minimum density of 228.533 kg/m^3 was attained at 30% replacement.

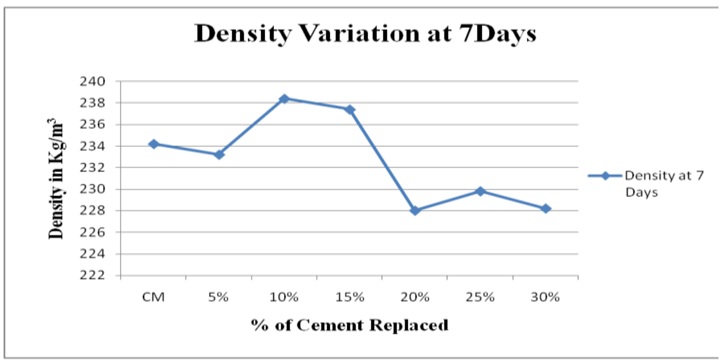

Figure 6: Density Variation at 7 days

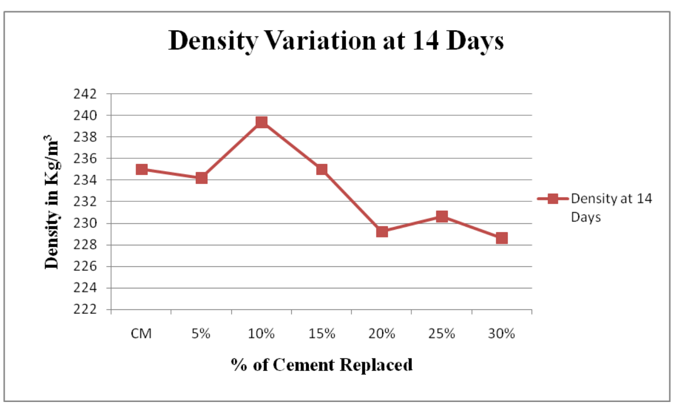

Figure 7: Density Variation at 14 days

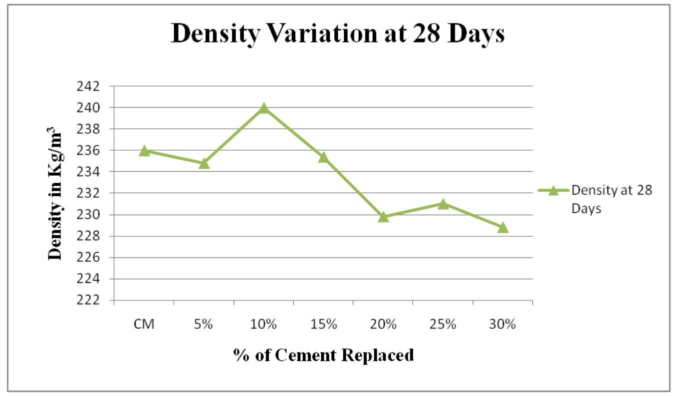

Figure 8: Density Variation at 28 days

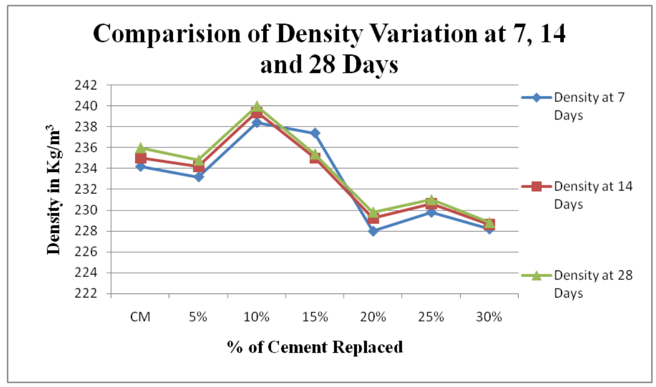

Figure 9: Comparison of Density Variation at 7, 14 and 28 days

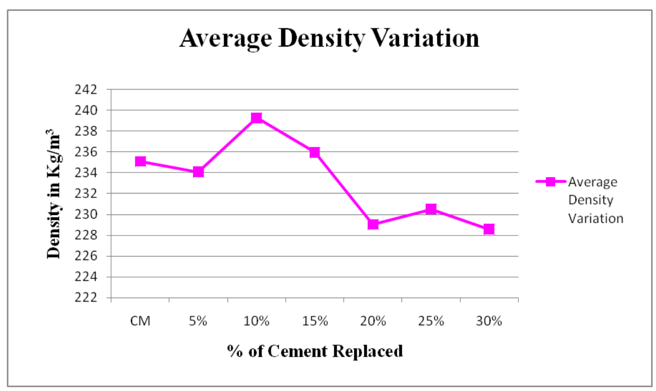

Figure 10: Average Density Variation

Flexural Load

Figure 11 is showing the comparison of flexural load of prism at 7, 14 and 28 days with different partial replacement of the cement with brick kiln dust. From the Figure 11 it can be concluded that the addition of brick kiln dust as partial replacement of the cement with 15 % is giving the slightly same result as conventional mix that is 0 % at 28 days.

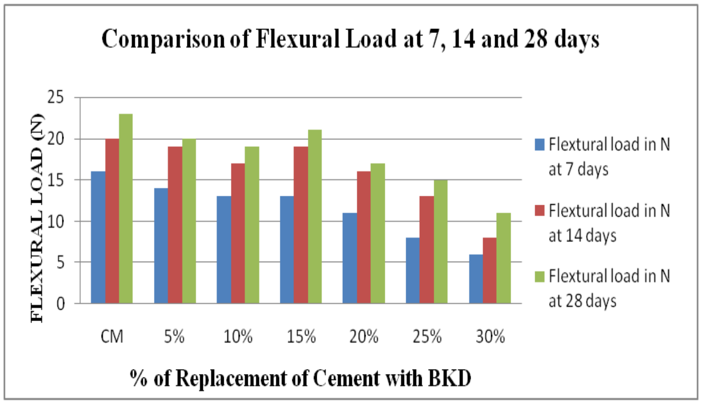

Figure 11: Comparison of Flexural Load at 7, 14 and 28 days

Flexural strength

As per IS 15658:2006 precast concrete blocks for paving flexural strength required for M-35 grade should be minimum 5 N/mm^2 and flexural strength of prism of size 100 x 100 x 500 mm^3 manufactured in concrete laboratory at M-35 grade has following results

(i). After 7 days of testing, flexural strength of prism at 0 % that is conventional mix (CM) near to attained required strength but not attained strength of 5 N/mm^2 at any percent as shown in figure 12.

(ii). After 14 days of testing, flexural strength of prism at 0 %, 5%, 10 % and 15% attained more strength than required that is 5 N/mm^2 and 20 %, 25 % and 30 % not attained strength of 5 N/mm^2 as shown in figure 13.

(iii). After 28 days of testing, flexural strength of prism at 0 %, 5%, 10 %, 15 % and 20 % attained more strength than required that is 5 N/mm^2 and 25 % and 30 % not attained strength of 5 N/mm^2 as shown in figure 14.

(iv). In figure 15 comparison of flexural strength at 7, 14 and 28 days are shown. At 28 days of testing maximum flexural strength was found near to 7 N/mm^2 at 0 % and 15 %.

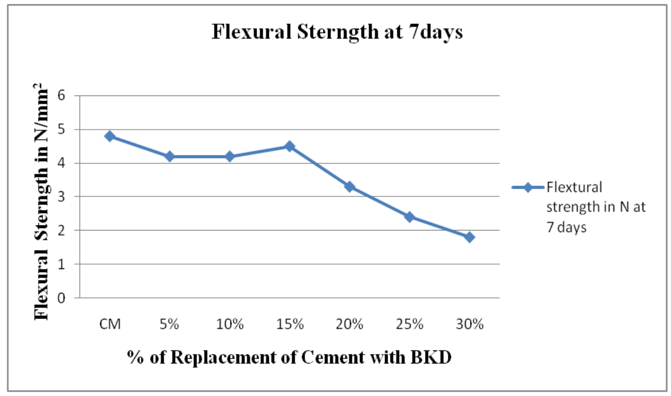

Figure 12: Flexural Strength at 7 days

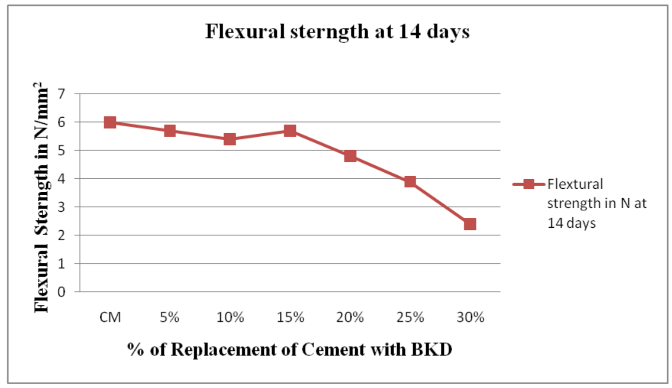

Figure 13: Flexural Strength at 14 days

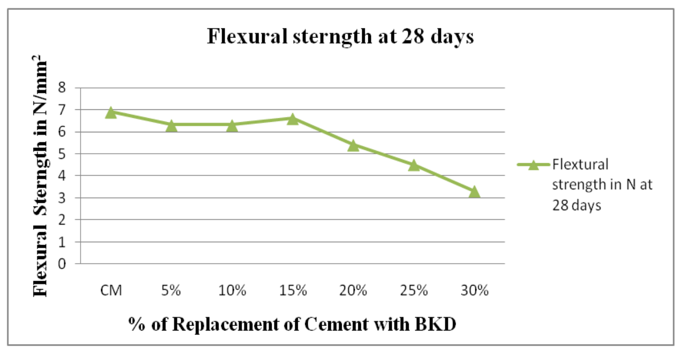

Figure 14: Flexural Strength at 28 days

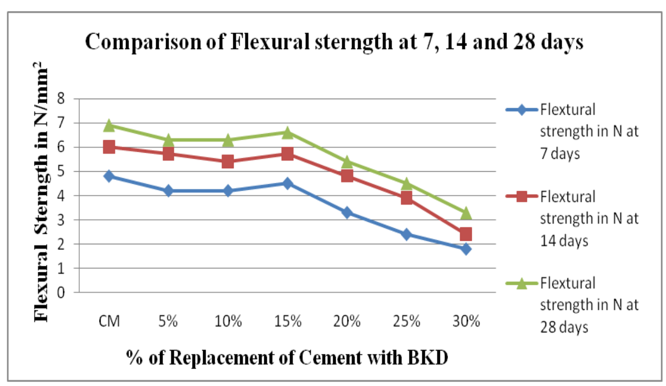

Figure 15: Comparison of Flexural Strength at 7, 14 and 28 days

CONCLUSIONS

(a). From above table 7, figure 9 and 10 and result of density it has been concluded that maximum density variation occurred at 10 % and minimum density variation occurred at 30 % at 28 days of testing.

(b). From above table 9, figure 15 and result of flexural strength it has been concluded that using till 20 % of brick kiln dust as a partial replacement of cement give the useful result and use of cement can be controlled.

(c). From above table 9, figure 15 and result of flexural strength it has been also concluded that using 15 % of brick kiln dust give nearly the same result as conventional mix.

REFERENCES

1. Benítez- et.-al "Implementation of the flexural strength test for concrete pavers" 9th. International Conference on Concrete Block Paving. Buenos Aires, Argentina, 2009/10/18-21.
2. Raman,S. N- et.-al "Influence of quarry dust & fly ash on the concrete compressive strength development". Proc. AEESEAP Int. Conf. 2005.
3. Hameed-et.-al. "Properties of green concrete containing quarry rock dust and Marble sludge powder as fine aggregates", ARPN journal of Engineering and applied Science, Vol. 4(4), pp 8389.
4. Barber, S.D., and Knapton, J. (1976) "An experimental investigation of the behaviour of a concrete block pavement". Cement Concrete Association, U.K.
5. Clark A.J. (1987), "Block paving research and development". Concrete, July, 24-25.
6. ASTM C-936. "Standard specification for solid concrete interlocking paving units".
7. ICPI "Design guidelines for Interlocking concrete block pavement". (Part 1 to Part 10).
8. Lakshmi Singh, A.and Md. S. Asgher. 2005. "Impact of brick kilns on land use/land covers changes around Aligarh city, India." Habitat International 29 (2005) 591–602.
9. Brick Kilns Performance Assessment & a Roadmap for Cleaner Brick Production in India, Greentech Knowledge Solutions Pvt Ltd, February 2012.
10. Damle Anand, 2007, Present Status of the Brick Industry in India – Raw Materials, Process Technology and Market. Tile and Brick International.
11. Environmental cost of using top-soil for brick making – A case study from India. 'Livelihood and social security issues of brick kiln workers' held at Mahtama Gandhi Labour Institute, Ahmedabad on 25th August 2009.
12. Development Alternatives, 2005: Environmental and Social Report for VSBK - A Guidance document for Entrepreneurs and Project Auditors.
13. IS 15658:2006, Precast concrete blocks for paving block, Bureau of Indian Standard, New Delhi.
14. IS: 8112-1989, 43 grade ordinary Portland cement, Bureau of Indian Standard, and New Delhi.
15. IS: 383-1970 Specification for coarse and fine aggregate from natural sources for concrete (Second Revision), Bureau of Indian Standard, New Delhi.
16. IS:516-1959 "Methods of tests of concrete "Bureau of Indian Standards, New Delhi
17. IS 456-2000, Plain and reinforced concrete – code for practice (Fourth Revision), Bureau of Indian Standard, New Delhi.
18. Concrete Block Paving Book 1: Introduction Published by the Concrete Manufacturers Association.
19. Concrete Block Paving Book 3: Specification and Installation Published by the Concrete Manufacturers Association.

Author Profile

[1]**Sharda Sharma** accomplished B. Tech in Mechanical Engineering from I.E.T. Sitapur in 2010. Presently pursuing M. Tech (IInd year) in Civil Engineering Department specialization in structural engineering from MMMUT Gorakhpur.

[2]**Shiv Kumar Yadav** accomplished B. Tech in Mechanical Engineering from LDC ITs Allahabad in 2012. Presently pursuing M. Tech (IInd year) in Civil Engineering Department specialization in structural engineering from MMMUT Gorakhpur.