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An Experimental Investigation on Precast Cement Concrete Paver Blocks using Fly ash

Maninder Singh[1], Pardeep Mehla[2], Professor Ajay Kumar[3]

Abstract- In these days the use of precast cement concrete interlocking paver blocks in road pavement is widely used. Such a time precast cement concrete interlocking paver blocks is better option in road construction as compared to the asphalt and rigid concrete roads which is made by bitumen and gravel in a cost view of point and better suitability. India is a developing country so here the construction of roadway and building plays an important role. These paver blocks are made from semi dry mixes of concrete with zero slump and stone chips lesser in size as compared to conventional concrete. In this thesis I have design paver blocks by using cement concrete mixture of design Mix with M35 grade and M40 grade concrete with water cement ratio 0.45 and 0.40 respectively and with application of super-plasticizer dosage@ 0.5% by weight of cementitious material without pigment, with varying percentages of fly-ash as 0 %,20 %,30 % and 40 % as part replacement of OPC have been manufactured and tested as per IS 15658:2006. The strength test such as compressive strength and flexural strength was performed on each mix at 7 and 28 days .The durability test of water absorption and freeze-thaw resistance were performed at 28 days. The compressive strength is an index of strength of the concrete and the flexural strength represents the bending performance of paver block under traffic load. To suit the Indian climate conditions, for different weathering conditions of temperature and rainy season, water absorption and freeze-thaw resistance were of much importance for study. The main objective of this thesis is to use waste products like fly ash for the production of paver block which will useful in construction.

Keywords: Coarse Aggregate, Fine Aggregate, OPC 43 Grade Cement, Fly Ash, Compressive Strength, Flexural Strength, Paver Block.

I. INTRODUCTION

The concept of using interlocking paver block is very old. The first time road using paver block was constructed in 5000 B.C. by the Minoans. About 2000 years ago, with the help of labour and military group the first time roman constructed pavement roads. Since, this process is continued and culture is followed for constructing pavement roads. Concrete Paving Blocks were first manufactured in the Netherlands in 1924. It was probably World War II that led to the growth of concrete blocks as a paving material. Concrete block pavement (CBP) was introduced in The Netherlands in the early 1950s as a replacement for baked clay brick roads. The general worldwide trend towards beautification of city pavements, the rising cost of bitumen?s as a paving material and the rapid increase in construction and maintenance cost have encouraged designers to alternate paving material such as concrete blocks. The strength, durability and aesthetically pleasing surface of pavers have made CBP ideal for many commercial, municipal and industrial applications. In 1960 German developed high efficiency machinery tools for the construction of interlocking paver block. Manufacturing technology quickly followed by countries like South Africa New Zealand, Australia, Europe and England in the 1970?s.

II. OBJECTIVE AND SCOPE

The objective of this dissertation is given below-

- To evaluate the performance of M35 & M40 grade precast cement concrete interlocking paver blocks using fly ash F-type for road surfacing.
- To evaluate compressive strength and flexural strength of paver blocks using fly ash F-type as partly replacement of OPC in varying percentages of 20%, 30 % and 40 %.
- To evaluate water absorption and freeze-thaw resistance of paver blocks using fly ash F-type as partly replacement of OPC in varying percentages of 20%, 30 % and 40 %.
- To compare the relative suitability of paver block with fly ash over traditional paver blocks without fly ash.

III. NEEDS OF THE RESEARCH

1) To enhances the properties like workability, Compressive Strength, Flexural Strength and also increase its durability and concrete finishing by using Fly Ash in concrete.
2) The aim of this work is to study the use of Fly Ash waste material to produce concrete Paver Blocks.
3) Determine the engineering property of Fly Ash based Paver Block and compare them with conventional Paver Block.
4) To comment on the suitability and limitation of Paver Block in construction of pavements.

IV. LITERATURE REVIEW

O. Kayali (2008) [16] studied about Fly ash lightweight aggregates in high performance concrete and obtained that concrete produced using fly ash aggregates is around 22% lighter and at the same time 20% stronger than normal weight aggregate concrete. Drying shrinkage is around 33% less than that of normal weight concrete. Moreover, the aggregates possess high durability characteristics that are required for high performance in structures. There are numerous research and journals which clearly explains behavior of fly ash and its properties in concrete that can help and guide many research areas like addition of fly ash to improve soil fertility and crop yield production which requires proper basic knowledge of fly ash.
Rafat Siddique, (2003) [22] studied the behavior of fly ash by replacing sand and obtained result which says that compressive strength, splitting tensile strength, flexural strength, and modulus of elasticity of fine aggregate (sand) replaced fly ash concrete specimens were higher than the plain concrete (control mix) specimens at all the ages.
Charles Berrymana .et.al., (2005) [6] studied fly ash replacement for cement in reinforced concrete pipe with the water reducing admixtures and the results revealed that the maximum 7 days compressive strength was observed for the replacement of 35% Class C and 25% Class F fly ash. An increase of 15 % in durability and strength tests is observed in the concrete mixes containing 65% replacement of cement by Class C fly ash.

V. MATERIAL USED

A Cement - Ordinary Portland cement (43 grade) has been used for present study confirming to IS 8112:1989. The physical properties of ordinary Portland Cement (OPC) 43 grade are reported in Table 3.2:

Table. Physical Properties Ordinary Portland cement (OPC) 43 grade

Physical property	Results Obtained	IS: 8112-1989 specifications
Normal Consistency	31%	
Initial setting time(minutes)	87	30(minimum)
Final setting time(minutes)	201	600(maximum)
Fineness (retained on 90-micron sieve)%	5.1	10(maximum)
Soundness(mm)	2.2	10(maximum)
Specific gravity	3.13	-----------
Compressive Strength(Mpa) 3-days 7-days 28 days	 24.8 35.4 45.2	 23(minimum) 33(minimum) 43(minimum)

B. Fly Ash

1) Physical properties of Fly ash

Sr. No.	Property	Observed value
1.	Specific gravity	2.1
2.	Class	F-type

2) Chemical properties of fly ash

Sr.No	Chemical composition	Unit	Observed values
1.	Unburnt Carbon	% by mass	0.87
2.	Loss on ignition	% by mass	0.73
3.	Silica as sio_2	% by mass	53.3
4.	Calcium as Ca0	% by mass	1.66
5.	Calcium as Ca	% by mass	0.53
6.	Sulphate as So_4	% by mass	0.35
7.	Alkali Content as NaoH	% by mass	0.39
8.	Iron as Fe_2o_3	% by mass	4.5
9.	Copper as Cu	mg/kg	6.3
10.	Chromium(Total) as Cr	mg/kg	5.44
11.	Zinc as Zn	mg/kg	6.43
12.	Lead as Pb	mg/kg	0.65
13.	Nickel as Ni	mg/kg	7.25
14.	Aluminum as Al_2O_3	% by mass	4.89
15.	Mercury as Hg	mg/kg	0.19

C. Aggregates
1) Fineness modulus of Aggregate

Fineness modulus of Aggregate

Type of Aggregate	Fineness modulus
Coarse	6.856
Fine (sand)	2.697

2) Specific Gravity of Aggregate

Specific Gravity of Aggregate

Type of Aggregate	Size of Aggregate (mm)	Specific Gravity
Coarse	10	2.65
Fine (sand)	-	2.63

3) Water Absorption

Type of Aggregate	Size of Aggregate (mm)	% Age Water Absorption
Coarse	10	0.05
Fine (sand)	-	0.91

D. Water
pH value of water used in mixing with ingredients in practical work is 6.

E. Super Plasticizer
To increase the Compressive Strength, reduced the consumption of water and maintain the slump value a poly carboxylic ether based super plasticizer complying with IS: 9103-1999 were used.

VI. Mix Design

M40 grade concrete were designed for manufacture of and 80 mm thick paver blocks recommended to be used for road surfacing. Mix design for M35 and M40 grade with 0 %, 20%,30 % and 40 % fly ash are reported in this Table.

Mix Proportions M40 grade (SSD aggregate)**

Mix	Fly-Ash %age	Fly-Ash Cement Water Fine Coarse Aggregate Aggregate Kg/m^3 Kg/m^3 Kg/m^3 Kg/m^3 Kg/m^3	Super Plasticizer Kg/m^3	S.P % by wt. of CeMa	Water/ CeMa* Ratio
M40 F.A0	0	--- 405.0 : 161.41 : 669.6 : 1190.4	2.03	.5 %	0.4
M40 F.A20	20	89.1 356.4 : 161.41 : 644.0 : 1144.9	2.06	.5 %	0.362
M40 F.A30	30	135.6 311.85 : 161.41 : 638.0 : 1134.3	2.06	.5 %	0.362
M40 F.A40	40	178.2 267.3 : 161.41 : 629.1 : 1119.7	2.06	.5 %	0.362

***CeMa : Cementitious Material , **SSD: Saturated Surface Dry**

VII. EXPERIMENTAL PROCESS

A. Casting

1) The moulds are used for making of concrete Paver Block as per IS: 15658-2006 methods of tests for Strength of concrete.
2) Paver back mould of 200×160×80 mm size.
3) Firstly decide the number of sample to be taken during concreting.
4) Before casting of materials shuttering oils should be used inside the mould properly.
5) Collect the all material in the pan before the mixing properly.
6) Mix the all material in the pan.
7) Use of vibrating machine/table in compacting concrete to a voids formation of air voids in concrete.
8) Submerge the specimen in water at a temperature of 27o C for 7 days, 14 days and 28 days respectively.
9) Finally check its compressive strength as per as IS: 15658-2006

.B. Curing Process

Curing is a process where a concrete specimen or concrete structure is cured under water for different no. of days for different specimen. For example paver block is cured for 15 to 21 days and then its compressive strength will be checked.

C. Testing Procedure

The test was carried out with specimens at different curing ages. The test was initiated at 7 and 28 days of age of the concrete mixes.

VIII. RESULTS AND DISCUSSION

The Paver Block is designed on the basis of IS: 15658 -2006 as per M 40 Grade Designation of-Paver Blocks. The results which are comes out from testing is given below:

A COMPRESSIVE STRENGTH

Table 1: 7 days Compressive strength of M 40 Grade, 80 mm thick paver blocks

SR. NO.	MIX ID	COMPRESSIVE STRENGTH (Mpa)				AV. COMPRESSIVE STRENGTH (Mpa)	CORRECTION FACTOR	CORRECTED COMPRESSIVE STRENGTH (Mpa)
		I	II	III	IV			
1	M40 FA0	29.9	31.7	30	29.6	30.3	1.18	35.75
2	M40 FA20	30.7	29.6	30	30	30.08	1.18	35.49
3	M40 FA30	28.2	27.8	28.6	28.2	28.2	1.18	33.28
4	M40 FA40	20	21.4	19.3	20.7	20.35	1.18	24.01

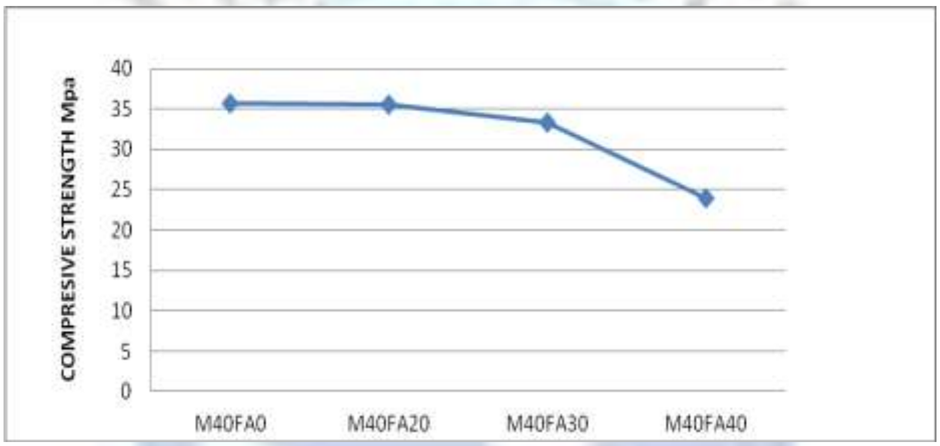

Figure 1: 7 days Compressive strength of M 40 Grade, 80 mm thick paver blocks

Table 2: 28 days Compressive strength of M 40 Grade, 80 mm thick paver blocks

SR. NO.	MIX ID	COMPRESSIVE STRENGTH (Mpa)				AV. COMPRESSIVE STRENGTH (Mpa)	CORRECTION FACTOR	CORRECTED COMPRESSIVE STRENGTH (Mpa)
		I	II	III	IV			
1	M40 FA0	42.3	42.3	43.8	43.7	43.03	1.18	50.77
2	M40 FA20	42.8	41.8	40	40	41.15	1.18	48.56
3	M40 FA30	36.4	34	35.3	38.6	36.08	1.18	42.57
4	M40 FA40	30	27.1	29.3	29.3	28.93	1.18	34.13

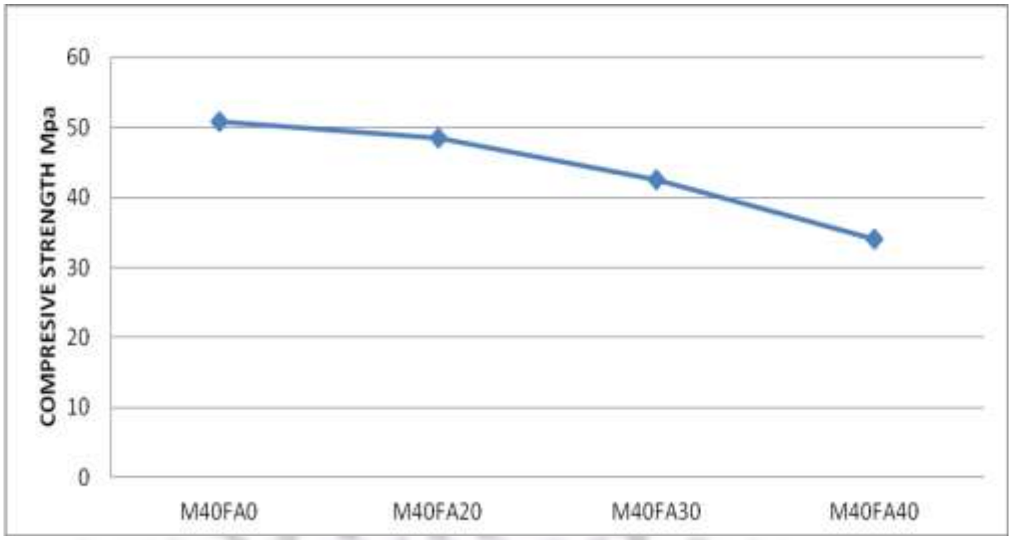

Figure 2: 28 days Compressive strength of M 40 Grade, 80 mm thick paver blocks

B. Flexural strength

Table 3: 7 days Flexural strength of M 40 Grade, 80 mm thick paver blocks

SR. NO.	MIX ID	BREAKING LOAD (KN)				FLEXURAL STRENGTH (Mpa)				AV. FLEXURAL STRENGTH (Mpa)
		I	II	III	IV	I	II	III	IV	
1	M40 FA0	18.5	20	20.5	19.5	4.63	5.00	5.13	4.88	4.91
2	M40 FA20	20	19	18	18.5	5.00	4.75	4.50	4.63	4.72
3	M40 FA30	14	15	14.5	14	3.50	3.75	3.63	3.50	3.59
4	M40 FA40	10	11	11	12.5	2.50	2.75	2.75	3.13	2.78

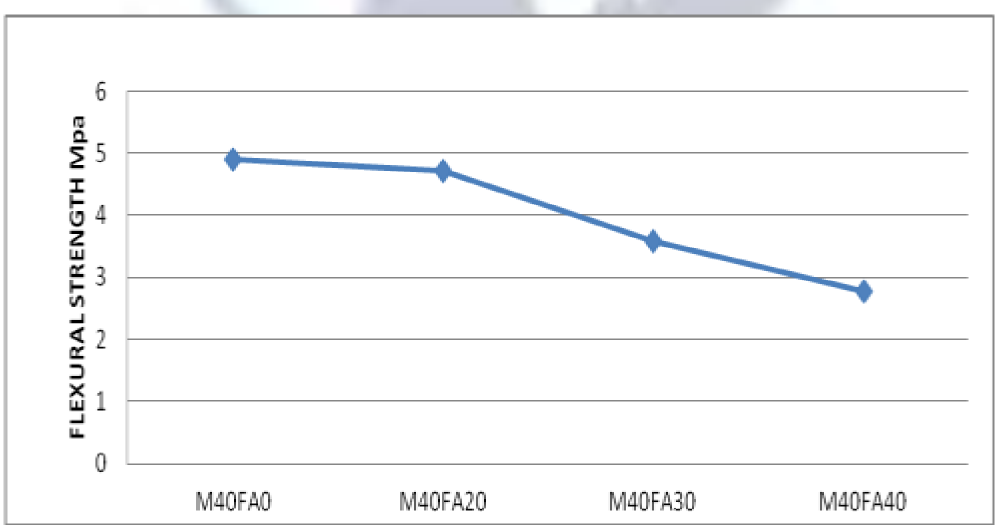

Figure 3: 7 days Flexural strength of M 40 Grade, 80 mm thick paver blocks

Table 4: 28 days Flexural strength of M 40 Grade, 80 mm thick paver blocks

SR. NO.	MIX ID	BREAKING LOAD (KN)				FLEXURAL STRENGTH (Mpa)				AV. FLEXURAL STRENGTH (Mpa)
		I	II	III	IV	I	II	III	IV	
1	M40 FA0	25	25	27	27	6.25	6.25	6.75	6.75	6.50
2	M40 FA20	25	24	24.5	25.5	6.25	6.00	6.13	6.38	6.19
3	M40 FA30	23.5	23.5	23	22	5.88	5.88	5.75	5.50	5.75
4	M40 FA40	22	22	20	20	5.50	5.50	5.00	5.00	5.25

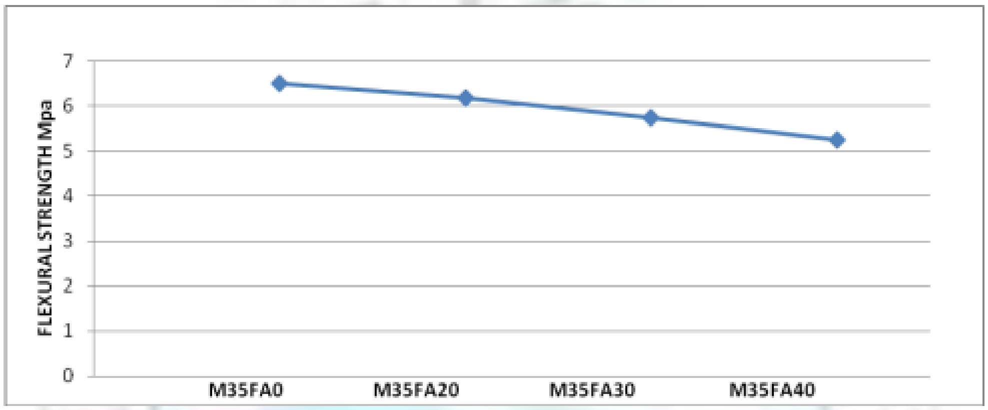

Figure 4: 28 days Flexural strength of M 40 Grade, 80 mm thick paver blocks

Table 5: Water absorption results of paver blocks M 40 grade 80 mm thick

SR. NO.	MIX ID	SATURATED AV. WT. (Kg) Ws	AV. DRY WT. Wd	(Ws-Wd)*100/Wd
1	M40 FA0	5.373	5.201	3.31
2	M40 FA20	5.347	5.193	2.97
3	M40 FA30	5.2	5.053	2.91
4	M40 FA40	5.207	5.073	2.64

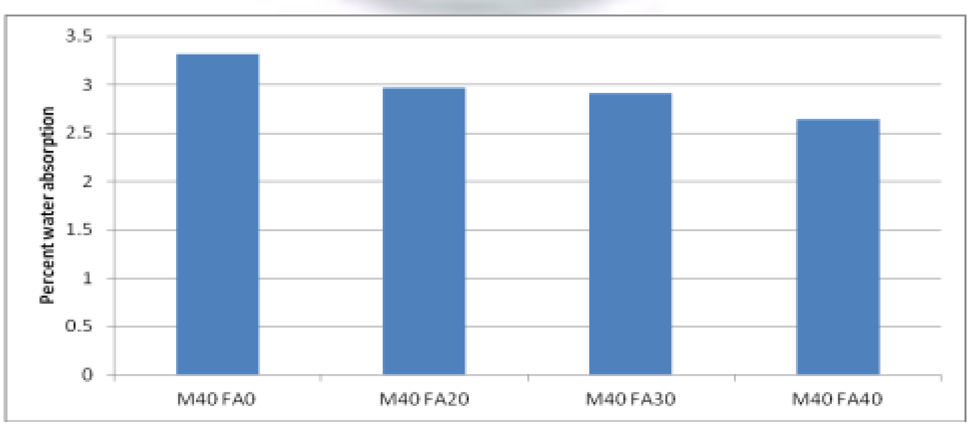

Figure 5: Percent water absorption for various M 40 Grade, 80 mm thick paver blocks

Table 6: Freeze-thaw results of M 40 grade, paver blocks 80 mm thick

SR. NO.	MIX ID	INITIAL DRY WEIGHT (Kg)	NO. OF CYCLES	AV. WT. LOSS (gm)	%AGE WT. LOSS
1	M40 FA0	5.20	10	0.27	0.005
2	M40 FA20	5.19	10	0.43	0.008
3	M40 FA30	5.14	10	0.50	0.010
4	M40 FA40	5.08	10	0.60	0.012

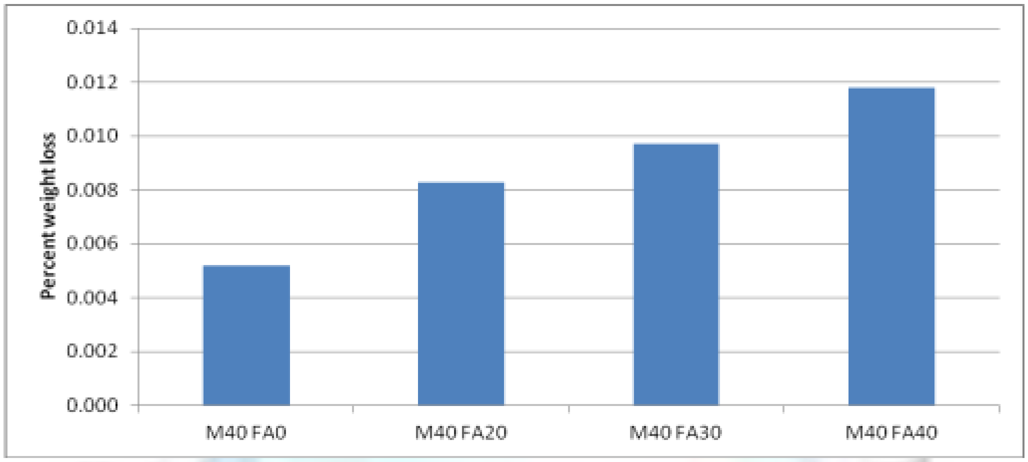

Figure 6: percentage loss of water

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