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Strength Properties of Cement Concrete Paver Blocks of M35 Grade Using Fly Ash

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Abstract: *Precast cement concrete paver blocks are used for road surfacing. The performance of road surfacing is better than asphalt and rigid concrete pavements. These are made as small elements from plain cement concrete with zero slumps. An attempt has been made to replace OPC by fly ash for manufacture of paver blocks of M35 grade with thickness 60mm and 80mm. Fly ash is a byproduct of thermal power plant which is a waste material. OPC has been replaced by fly ash in varying proportions of 0%, 20%, 30% and 40%. This paper presents the study of compressive strength and flexural strength of paver blocks and it was found that 30% of OPC replacement by fly ash is optimum.*

Keywords: *Compressive strength, flexural strength, fly ash, OPC, paver blocks*

1. Introduction

Cement concrete paver blocks are precast solid products made out of cement concrete [1]. The raw material required for manufacture of products is Portland cement and aggregates which are available locally in every part of the country. In addition to basic raw materials admixture is also used to maintain workability and alter curing time and to increase compressive strength. Paver blocks are manufactured from semi dry mixes of low workability and zero slumps. These are made in different shapes and sizes. Concrete paver blocks were first introduced in Holland in the fifties as replacement of paver bricks which had become scarce due to post war building construction boom [2]. Paver blocks are used for road surfacing. The inter locking paver blocks make up the wearing surface and are a major load spreading component of pavement [3]. These are generally made with M30 to M55 grade concrete with varying thicknesses from 50mm to 120mm. These are used for non-traffic, light traffic, medium traffic, and heavy duty traffic.

2. Materials used for manufacture of paver blocks

2.1 Cement

Ordinary Portland cement (43 grades) has been used for present study confirming to IS: 8112-1989 [4]. OPC whose normal consistency 31%, IST and FST 87min., 201min. respectively, fineness 5, soundness 2.0, specific gravity 3.13, and 28 days 45.2 Mpa was used.

2.2 Aggregates

Aggregates form about 70% to 80% of volume of concrete [5]. Aggregates are classified into two types namely: Fine aggregate and coarse aggregate .The properties of both fine and coarse aggregate such as shape, size, hardness, surface texture, strength, water absorption, pour structure and gradation affect the performance of concrete products.

2.2.1 Fine Aggregates

The aggregate which passes through 4.75mm sieve and lower size limit of 0.07mm are known as fine aggregates. Natural river sand with 4.75mm maximum size procured from Pathankot was used as fine aggregate for the present study. Its physical properties and sieve analysis are given in table 1. Fine aggregate of fineness modulus 2.70, confirming to zone II as per IS: 383-1970 [6] was used to manufacture for paver blocks for the present study.

Table 1: *Physical Properties of Fine Aggregates*

Properties	Observed values
Bulk Density(Loose).kg/m^3	1560
Bulk Density (Compacted).kg/m^3	1690
Specific gravity	2.63
Water Absorption, %	0.90

2.2.2 Coarse Aggregates

Crushed stone with 10mm size were used for the present study procured from Handesra (Punjab). Physical properties and sieve analysis results of coarse aggregate are given in Table. Coarse aggregate of FM 6.86 confirming to IS: 383-1970 [6] has been used for the present study.

Table 2: *Physical properties of Coarse Aggregate*

Properties	Observed values
Bulk Density(Loose).kg/m^3	1450
Bulk Density(Compacted).kg/m^3	1610
Specific gravity	2.63
Water Absorption, %	0.5

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2.3 Chemical Admixture

Concrete paving blocks are manufactured from semi-dry mixtures which possess poor flow properties even under vibration. BASF Master Glenium SKY 8233 chemical admixture has been used for manufacture of paver blocks. Confirming to IS: 9103-1999 [7] specifications.

***Table 3**: Physical properties of BASF Master Glenium SKY 8233*

Aspect	Light brown
Relative Density	1.08 ± 0.01 at 25°
pH	≥ 6
Chloride ion content	< 0.2 %

The recommended dosage of selected admixture is 500ml to 1500ml per 100kg of cementations material.

2.4 Fly Ash

Fly ash is an inorganic non-combustible by product of coal-burning power plants. Fly ash is removed from the flue gas by electrostatic precipitators. Fly ash as per AS TM C618 is classified as class C and class F Fly ash. Class F ashes are produced from bituminous coals and that class C ashes are produced from lignite coals

Today there is a general trend to replace higher levels of OPC with fly ash in concrete. In this study F-type fly ash has been used for manufacture of cement concrete paver blocks using different proportions of fly ash as replacement of OPC which has been procured from D.B.C.R Thermal Plant, Yamuna Nagar. The physical properties of the samples of Fly ash collected from D.B.C.R. Thermal Power Plant, Yamuna Nagar are as per Table-4.

***Table 4:** Physical properties of Fly ash*

Property	Observed value
Specific gravity	2.1
Class	F-type

2.5 Water

Potable tap water was used for casting specimens. The water confirms to the requirements of IS: 456-2000 [8].

3. Mix Design and Proportioning

Mix design is a process of selecting suitable ingredients for concrete determining the proportions which would produce as economically as possible, a concrete that satisfies the requirements of paver blocks. The concrete mixes were designed with cement, water, fine aggregate, coarse aggregate and super plasticizer with varying percentages of fly ash 0%, 20%, 30% and 40% as part replacement of OPC. The paver blocks were manufactured with M35 grade of concrete of thicknesses 60mm and 80mm.

***Table5:** Mix Proportions of M35 grade (SSD** aggregate)*

Mix	Fly Ash kg/m^3	Cement kg/m^3	Water kg/m^3	Fine Aggregate kg/m^3	Coarse Aggregate kg/m^3	Super Plasticizer Kg/m^3	Water/CeMa* Ratio
M35 F.A0	0	360.0	161.41	702.8	1196.8	1.84	0.45
M35 F.A20	79.2	316.8	161.41	679.5	1157.0	1.94	0.41
M35 F.A30	118.8	277.2	161.41	673.4	1146.6	1.94	0.41
M35 F.A40	158.4	237.6	161.41	666.8	1135.3	1.94	0.41

CeMa: Cementitious Material, SSD: Saturated Surface Dry

4. Casting of Specimen

The paver blocks of M35 grade concrete with 0% fly ash, as a reference mix, M35 grade concrete with 20%, 30% and 40% fly ash, were casted with thickness 60mm and 80mm. The casted specimen was cured for 07 days and 28days progressively for observing compressive strength and flexural strength at 07 days and 28 days of age.

5. Strength Properties

5.1 Compressive Strength

Compressive strength of M35 grade paver blocks of 60mm thick and 80mm thick with and without fly ash proportions are tabulated in Tables and shown in figure for 07 days and 28 days and corrected compressive strength after applying correction factor as per IS: 15658-2006 [2].

***Table 6:** 07 days Compressive strength of M35 Grade, 60mm thick paver blocks*

Mix Id	Compressive Strength (MPa) I	II	III	IV	Average Compressive Strength (MPa)	Correction Factor	Corrected Compressive Strength (MPa)
M35 FA0	34.8	35.7	35.9	36.3	35.68	1.06	37.82
M35 FA20	34.5	35.2	34.5	34.4	34.65	1.06	36.73
M35 FA30	31.4	31.8	30.9	32	31.53	1.06	33.42
M35 FA40	25	25.3	24.7	25.2	25.05	1.06	26.55

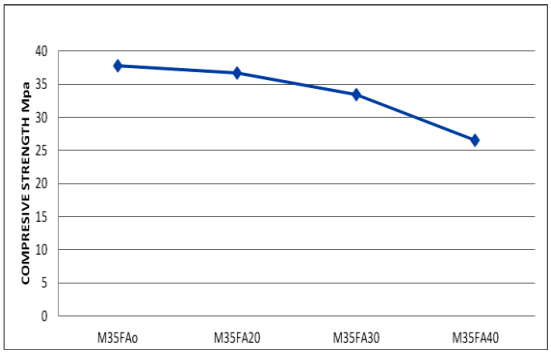

Figure 1: *07 days Compressive strength of M35 Grade, 60mm thick paver blocks*

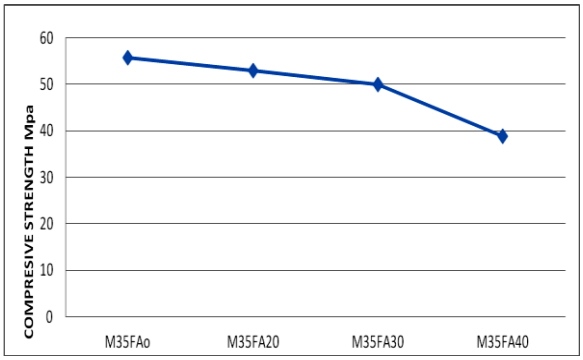

Figure 2*: 28 days Compressive strength of M35 Grade, 60mm thick paver blocks*

Table 7: *28 days Compressive strength of M35 Grade, 60mm thick paver blocks*

Mix Id	Compressive Strength (MPa)				Average Compressive Strength (MPa)	Correction Factor	Corrected Compressive Strength (MPa)
	I	II	III	IV			
M35 FA0	53.2	52.7	52.2	52.1	52.55	1.06	55.7
M35 FA20	50	49.3	48.9	51.7	49.98	1.06	52.97
M35 FA30	48.2	47.6	46.6	46.1	47.13	1.06	49.95
M35 FA40	37.1	35.3	35.7	38.6	36.68	1.06	38.88

Table 8: *07 days Compressive strength of M35 Grade, 80mm thick paver blocks*

Mix Id	Compressive Strength (MPa)				Average Compressive Strength (MPa)	Correction Factor	Corrected Compressive Strength (MPa)
	I	II	III	IV			
M35 FA0	30.4	29.7	29.6	28.4	29.53	1.18	34.84
M35 FA20	29	28.6	28.4	29.8	28.95	1.18	34.16
M35 FA30	27.6	27.3	26.7	26.7	27.08	1.18	31.95
M35 FA40	21.4	21.7	22	22.8	21.98	1.18	25.93

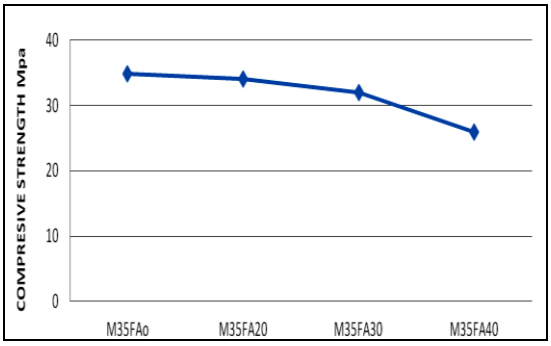

Figure 3: *07 days Compressive strength of M35 Grade, 80mm thick paver blocks*

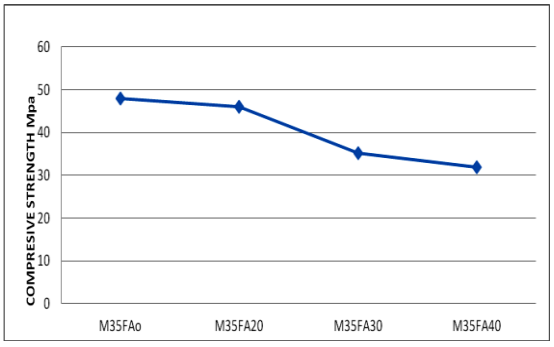

Figure 4: *28 days Compressive strength of M35 Grade, 80mm thick paver blocks*

Table 9: *28 days Compressive strength of M35 Grade, 80mm thick paver blocks*

Mix Id	Compressive Strength (MPa)				Average Compressive Strength (MPa)	Correction Factor	Corrected Compressive Strength (MPa)
	I	II	III	IV			
M35 FA0	40.3	40.8	41.8	39.4	40.58	1.18	47.88
M35 FA20	40.5	39.6	38.9	37.3	39.08	1.18	46.11
M35 FA30	30.3	29	30	30	29.83	1.18	35.19
M35 FA40	25.3	25	28.6	29	26.98	1.18	31.83

5.2 Flexural strength

The breaking load and Flexural strength of M35 grade paver blocks at 07 days and 28 days of age for 60mm and 80mm thickness with and without fly ash proportions are tabulated in Tables and figures.

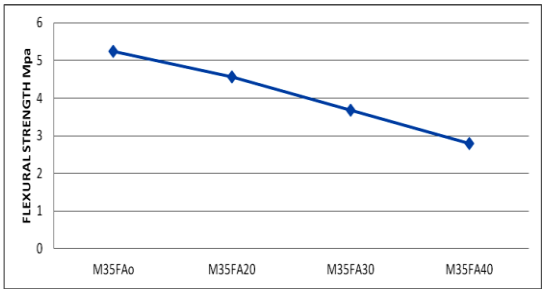

Figure 5: *07 days Flexural strength of M35 Grade, 60mm thick paver blocks*

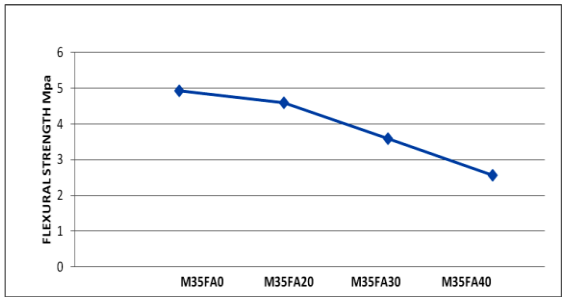

Figure 6: *07 days Flexural strength of M35 Grade, 80mm thick paver blocks*

Table 10*: 07 days Flexural strength of M35 Grade, 60mm thick paver blocks*

Mix Id	Breaking Load (KN)				Flexural Strength (MPa)				Average Flexural Strength (MPa)
	I	II	III	IV	I	II	III	IV	
M35 FA0	11.5	11.5	12	12	5.13	5.13	5.35	5.35	5.24
M35 FA20	10.5	10.5	11	9	4.68	4.68	4.91	4.01	4.57
M35 FA30	8.5	8	8.5	8	3.79	3.57	3.79	3.57	3.68
M35 FA40	6	6	6	7	2.68	2.68	2.68	3.12	2.79

Table 11: *07 days Flexural strength of M35 Grade, 80mm thick paver blocks*

Mix Id	Breaking Load (KN)				Flexural Strength (MPa)				Average Flexural Strength (MPa)
	I	II	III	IV	I	II	III	IV	
M35 FA0	18.5	20	20.5	20	4.63	5.00	5.13	5.00	4.94
M35 FA20	19	19	18	17.5	4.75	4.75	4.50	4.38	4.59
M35 FA30	14.5	15	14	14	3.63	3.75	3.50	3.50	3.59
M35 FA40	10	11	10	10	2.50	2.75	2.50	2.50	2.56

Table 12*: 28 days Flexural strength of M35 Grade, 60mm thick paver blocks*

Mix Id	Breaking Load (KN)				Flexural Strength (MPa)				Average Flexural Strength (MPa)
	I	II	III	IV	I	II	III	IV	
M35 FA0	14	15	14	14	6.24	6.69	6.24	6.24	6.36
M35 FA20	13	14	13	14	5.80	6.24	5.80	6.24	6.02
M35 FA30	12	11.5	12	12.5	5.35	5.13	5.35	5.58	5.35
M35 FA40	10	10.5	9	11.5	4.46	4.68	4.01	5.13	4.57

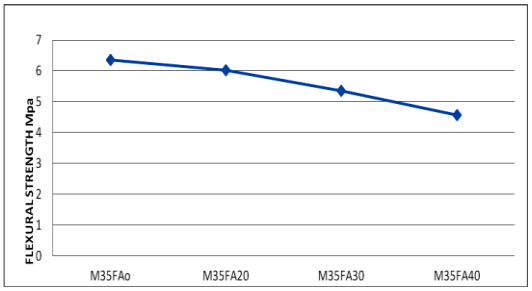

Figure 7: *28 days Flexural strength of M35 Grade, 60mm thick paver blocks*

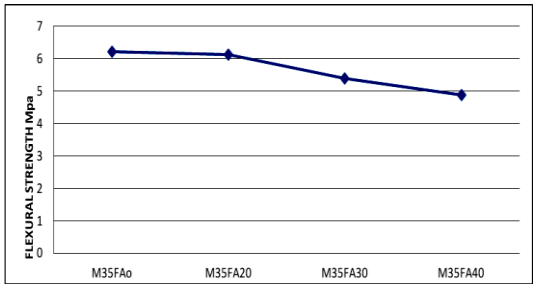

Figure 8: *28 days Flexural strength of M35 Grade, 80mm thick paver blocks*

Table 13: *28 days Flexural strength of M35 Grade, 80mm thick paver blocks*

Mix Id	Breaking Load (KN)				Flexural Strength (MPa)				Average Flexural Strength (MPa)
	I	II	III	IV	I	II	III	IV	
M35 FA0	25	24	24.5	26	6.25	6.00	6.13	6.50	6.22
M35 FA20	24	25	24	25	6.00	6.25	6.00	6.25	6.13
M35 FA30	22	20	22	22	5.50	5.00	5.50	5.50	5.38
M35 FA40	19	20	19	20	4.75	5.00	4.75	5.00	4.88

6. Conclusions

The compressive strength was found to decrease at early age for all mixes with increase in percentage of fly ash. The results show that it is feasible to use up to 30% fly ash for M35 grade, 60mm thick paver blocks as the target strength is achieved. It is technically

feasible to use fly ash in the production of paver blocks used for road surfacing. It will be a great help for environmental protection against greenhouse gases and also provide financial benefits to the construction industry. The flexural strength of all the mixes with varying proportions of fly ash was found to decrease with age. However the rate of decrease of flexural strength for fly ash mixes up to 28 days follows the same trend as that of compressive strength. As fly ash in mixes increased the flexural strength has increased considerably between 07 days to 28 days as compared to reference. The study shows that the minimum breaking load requirement for paver blocks as per IS: 15658-2006 has been met even with 40% fly ash for both the mixes. Hence fly ash can also be suitably used for manufacture of paver blocks to be used for road surfacing from flexural strength point of view.

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