ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

MANUFACTURE OF INTERLOCKING CONCRETE PAVING BLOCKS WITH FLY ASH AND GLASS POWDER

Truptimala Pattnaik (Asst Prof)[*1], Nihar Ranjan Mohanta(Asst prof)[2], Niharika Patel[3], Paresh Biswal[4] & Rajat Kamal Moharana[5]
[*1,2,3,4&5]Department of Civil Engineering, G.I.E.T. GUNUPUR,ODISHA

DOI: 10.5281/zenodo.1161697

ABSTRACT
Problems associated with construction site have been known for many years. Construction industry has to support a world of continuing population growth and economic development. Interlocking concrete paving blocks are ideal materials on the footpaths, parking areas, gardens, etc. for easy laying, better look and finish. But now being adopted extensively in different uses where the conventional construction of pavement using hot bituminous mix or cement concrete technology is not feasible or desirable. The rising costs of construction materials and the need to adhere to sustainability, alternative construction techniques and materials are being sought. To increase the applications of concrete paving blocks, greater understanding of products produced with locally available materials and indigenously produced mineral admixtures is essential. In the present investigation, concrete paving blocks may be produced with locally available cement, aggregates, fly ash and waste glass powder as the mineral admixture. Different mix proportions are prepared using cement replaced by equal quantity of fly ash and waste glass powder. The study indicated that fly ash and waste glass powder can effectively be used as cement replacement without substantial change in strength

KEYWORDS: Abrasion Resistance, Concrete Paving Blocks, Fly Ash, Glass Powder, Strength.

I. INTRODUCTION
Interlocking Concrete Paving Blocks (ICPB) has been extensively used in a number of countries for quite some time as a specialized problem-solving technique for providing pavement in areas where conventional types of construction are less durable due to many operational and environmental constraints. Interlocking concrete paving block technology has been introduced in India in construction, a decade ago, for specific requirement viz. footpaths, parking areas, gardens, etc. but now being adopted extensively in different uses where the conventional construction of pavement using hot bituminous mix or cement concrete technology is not feasible or desirable.

Interlocking concrete paving blocks are manufactured from semi-dry mixes. During manufacturing process vibration and pressure is applied to the mix. By this process dense and strong concrete paving blocks can be achieved to form strong and durable paving surfaces. Moreover interlocking behaviour of concrete paving block gives the ability of spreading loads to larger areas. Interlocking concrete paving blocks has several advantages over asphalt and concrete pavements in their structural, aesthetics, construction and maintenance, operational and economical characteristics. Like other pavement surfaces, the design of concrete paving blocks is based upon environmental, traffic, sub grade support and pavement materials conditions and their interactive effect.

II. RESEARCH SIGNIFICANCE
The advancement of concrete technology can reduce the consumption of natural resources and energy sources and lessen the burden of pollutants on environment. Presently large amounts of fly ash are generated in thermal power plants with an important impact on environment and humans. Leaving the waste materials to the environment directly can cause environmental problem. Hence the reuse of waste material has been emphasized. Waste can be used to produce new products or can be used as admixtures so that natural resources are used more efficiently and the environment is protected from waste deposits. In the recent time, the importance and use of fly ash in concrete has grown so much that it has almost become a common ingredient in concrete.

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

Recycling, disposal and decomposing of waste glass possesses major problems for municipalities everywhere, and this problem can be greatly eliminated by re-using waste glass as cement replacement in concrete. Moreover, there is a limit on the availability of natural aggregate and minerals used for making cement, and it is necessary to reduce energy consumption and emission of carbon dioxide resulting from construction processes, solution of this problem are sought thought usages of waste glass a partial replacement of Portland cement. Recycling of waste glass may affect respiratory system if breath in pollutants. Glass is non-biodegradable and do not decompose easily by itself therefore do not have significant environmental and social impact could result in serious impact after disposal. Therefore an experimental investigation in developing concrete containing waste glass powder is very important.

III. MATERIALS AND METHODS

1. Experimental Investigation

The purpose of this investigation was to evaluate the effect of partial replacement of cement by fly ash and waste glass powder on strength of interlocking concrete paving block specimens. The experimental parameters and their levels were chosen according

TABLE 1: PHYSICAL PROPERTIES OF CEMENTING MATERIALS

Properties	Cement	Fly Ash	Glass powder
Fineness % passing (sieve size)	97.50 (45 μm)	98.20 (45 μm)	82.00 (45 μm)
Fineness by Blaine's air permeability test (Specific Surface Area S m^2/kg)	275 2750 cm^2/gm	310 3100 cm^2/gm	-
Specific Gravity	3.11	1.97	2.29

TABLE 2: CHEMICAL COMPOSITION OF CEMENTING MATERIALS

Composition (% by mass)/ property	Cement	Fly Ash	Glass powder
Silica (SiO_2)	18.97	42.29	71.68
Alumina (Al_2O_3)	3.93	24.71	1.04
Iron oxide (Fe_2O_3)	3.79	4.61	0.11
Calcium oxide (CaO)	66.68	2.53	7.68
Magnesium oxide (MgO)	2.91	0.74	3.74
Sodium oxide (Na_2O)	0.11	0.49	13.34
Potassium oxide (K_2O)	2.46	0.58	0.186
Sulphur trioxide (SO_3)	1.15	0.26	-
Loss on Ignition (%)	1.80	1.10	0.30

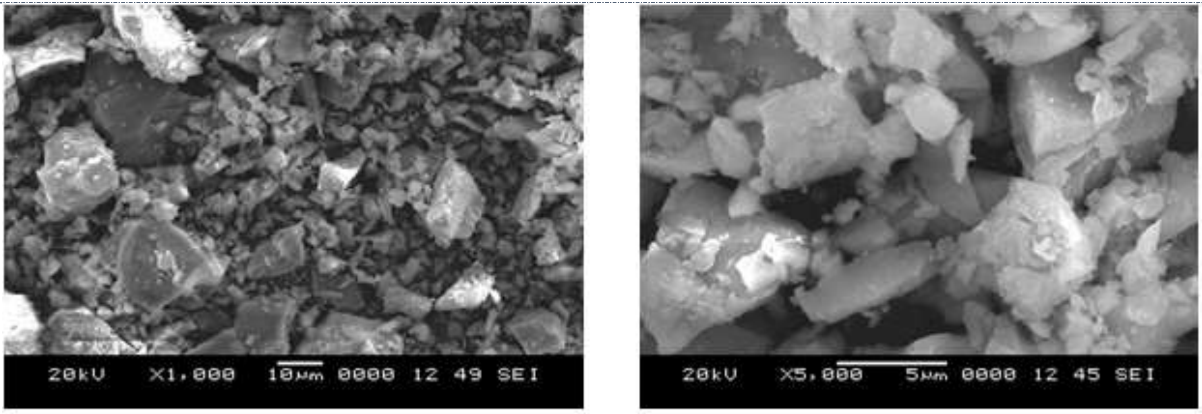

Figure 1: SEM Microphotographs of cement under different magnification

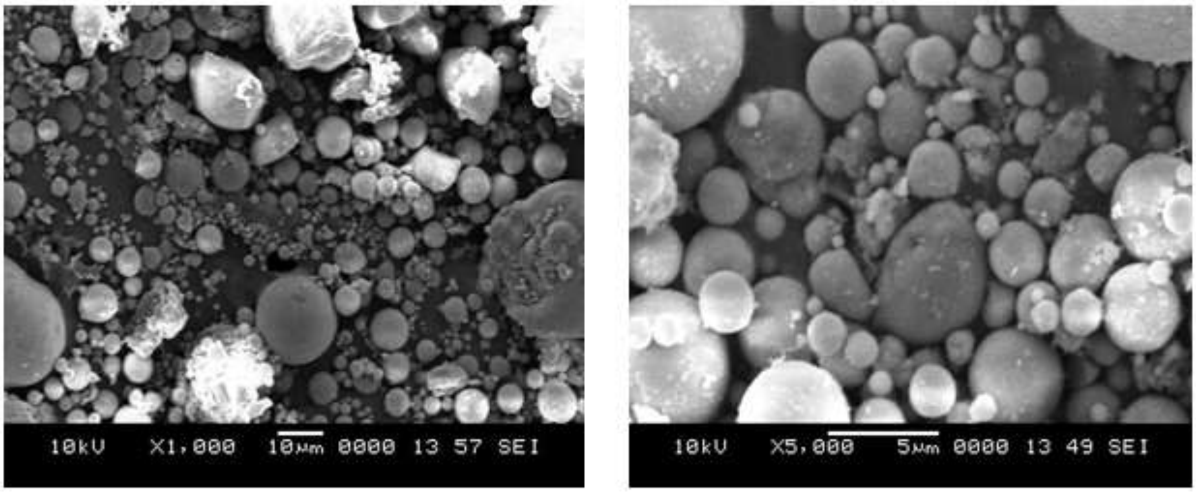

Figure 2: SEM Microphotographs of fly ash under different magnification

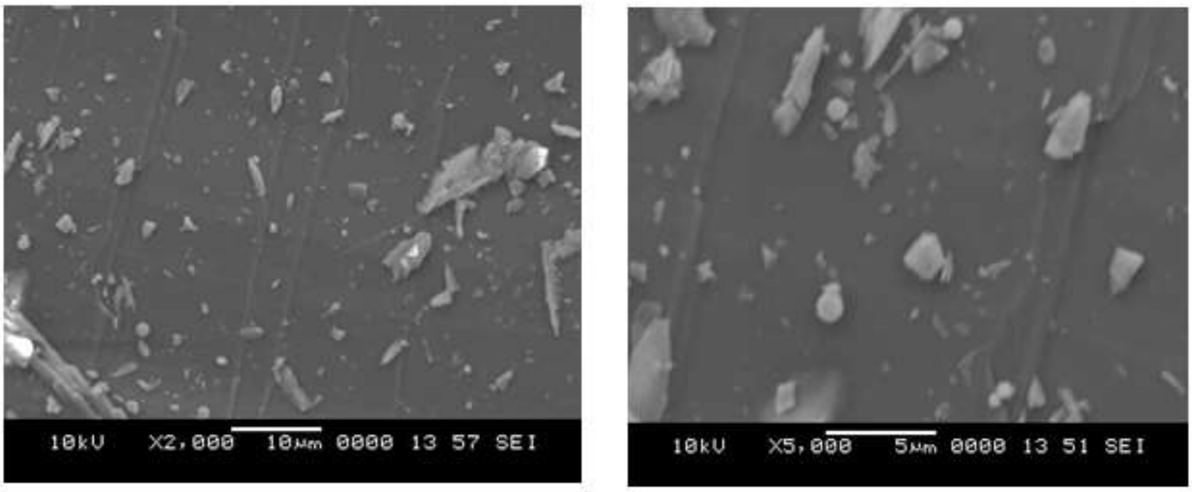

Figure 3: SEM Microphotographs of glass powder under different magnification

2. Constituent Materials

Cement

The cement available in the local market Ordinary Portland Cement (OPC) 43 grade conforming to IS 8112: 2009 is used.

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

Aggregate

Coarse aggregate of size varying from 6 mm to 12 mm are used depending on the thickness of interlock pavers. The natural river sand available in the local market is used as a fine aggregate. The fine and coarse aggregates shall consist of crushed or uncrushed materials, which apart from the grading requirements comply with IS 383:1970. The fine aggregate (Sand) belongs to grading Zone II as per IS: 383-1970. Fineness Modulus of sand is 2.935. The specific gravity of fine aggregate is 2.55. Fineness Modulus of coarse aggregate is 5.732. The specific gravity of coarse aggregate is 2.69.

Water

The water shall be clean and free from deleterious matter. It shall meet the requirements stipulated in IS 456:2000.

Other Additives

Under special circumstances, plasticizers or super plasticizers at around 0.4 per cent of cement by weight is added for high early strength.

Supplementary Cementitious Materials

The class F Fly Ash is collected from LANCO, Udupi Power Corporation Limited (UPCL),
Karnataka. It is a coal- based thermal power plant in Yelluru, Udupi district of Karnataka state in the coastal region of India with total capacity of 1200 MW. Fly ash conforms to IS: 3812: 1999. The glass powder is obtained by crushing waste glass pieces in an abrasion testing machine. The 600 micron passing fraction is used for the experimentation

Figure 4: Collection and crushing of waste glass pieces and making powder (passing 600 micron sieve size)

3. Mix Proportions and Experimental Factors

The commonly used processes for the manufacture of pre-cast cement concrete paving units require dry, low slump mixes. Mix design is carried out to form M40 grade of concrete by using IS 10262: 2009 and specification given by IRC: SP: 63: 2004 and IS 15658: 2006 which provided a mix proportion of 1:2:3 with water cement ratio of 0.40. Five different mixes are prepared using cement replaced by equal quantity of fly ash and waste glass powder at varying percentage of 0, 10, 20, 30, and 40.

4. Casting of Interlocking Concrete Paving Blocks

The interlocking concrete block specimens of plan area 31,250 mm2 and thickness of 80 mm are cast according to mix proportion in a rubber mould of zigzag shape (Unipaver).

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

5. Curing of Specimens

To find the effect of partial replacements of cement by fly ash and glass powder, the specimen were air cured for 7, 28 and 56 days.

Figure 5: 80 mm thick rubber mould (Unipaver)

Figure 6: Concrete paving blocks

6. Testing

Compressive strength of paving blocks are determined in accordance to IS: 2185 (Part1): 2005 as well as IS 15658: 2006. As per IRC: SP: 63: 2004 minimum compressive strength of a single block should be above 30 MPa. Recommended grades of paver blocks for different traffic categories are specified by IS 15658: 2006.

Flexural strength of paving blocks are determined and can be expressed in terms of flexural stress or in the form of breaking load specified by IS 15658: 2006. It is suggested that minimum flexural strength of a single block should be above 4.5 MPa.

Tensile Strength of paving blocks are determined by testing according to IS 15658: 2006. The characteristic tensile splitting strength shall not be less than 3.6 Mpa. None of the individual results shall be less than 2.9 Mpa.

Abrasion Resistance test of paving blocks were done in accordance to IS: 15658: 2006. The abrasion resistance of specimen is tested by Tile abrasion testing machine or Bohme disc abrader. The test specimen for abrasion is cut from the whole concrete paving block. The test specimens shall be square in shape and of size 7.06 x 7.06 cm (i.e., 50 cm^2 in area). As per IS: 15658: 2006 the wearing depth should not exceed 3.5 mm of concrete block used for general purpose and should not exceed 2 mm for heavy traffic. The abrasion resistance of the concrete blocks, when tested as per IS: 15658: 2006 shall not have volume loss greater than 15 cm^3 per 50 cm^2.

Water absorption of concrete paving block is determined as per IS: 15658: 2006. As per IS: 15658: 2006 water absorption of individual concrete paving block should be less than 7% or maximum 6% by mass (i.e., Average of 3 units).

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

IV. TEST RESULTS

Test results are presented graphically and in tabular forms and have been discussed under different categories.

1. Compressive Strength

Compressive strength of paving blocks are determined in accordance to IS: 2185 (Part1): 2005 as well as IS 15658: 2006. The apparent compressive strength of individual specimen shall be calculated by dividing the maximum load (in N) by the plan area (in mm^2). The corrected compressive strength shall be calculated by multiplying the apparent compressive strength by the appropriate correction factor given in Table 5 of IS 15658: 2006. Correction factor for 80 mm thick chamfered block is 1.18.

Results for compressive strength of concrete paving blocks M_{FG} (0), M_{FG} (10), M_{FG} (20), M_{FG} (30), and M_{FG} (40) at 7, 28 and 56 days are shown in table 3 and figure 7

Table 3: Overall results of development of compressive strength in paving blocks

Age, Days	Compressive Strength, MPa (N/mm^2)				
	Variation of fly ash and glass powder replacement with cement				
	$M_{FG(0)}$	$M_{FG(10)}$	$M_{FG(20)}$	$M_{FG(30)}$	$M_{FG(40)}$
7	40.28	40.40	41.41	41.03	38.58
28	48.08	49.34	51.98	50.47	50.09
56	48.23	49.65	52.32	50.77	50.24

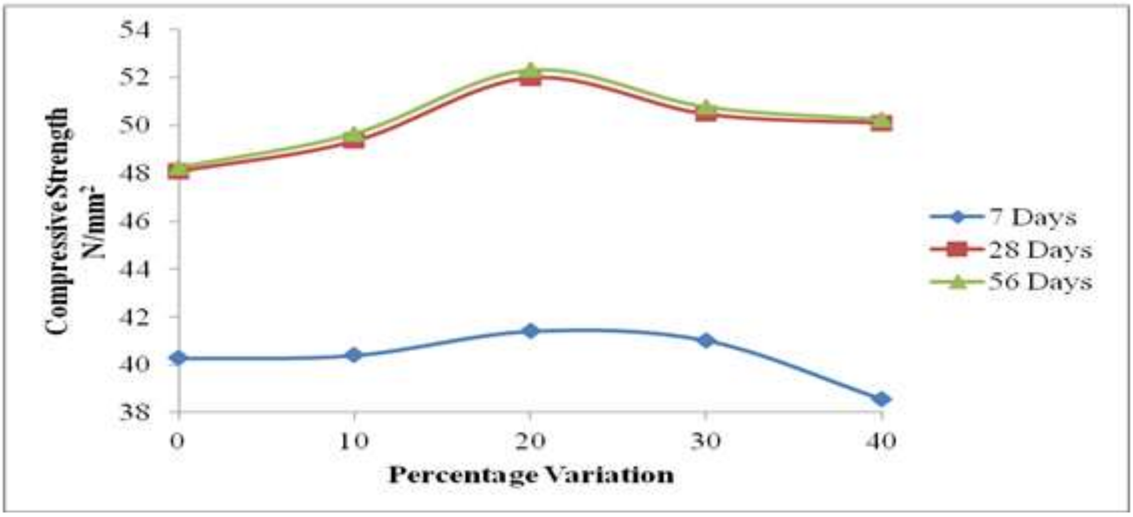

Figure 7: Graph showing variation of compressive strength development

2. Flexural Strength

Results for flexural strength of concrete paving blocks M_{FG} (0), M_{FG} (10), M_{FG} (20), M_{FG} (30), and M_{FG} (40) at 7, 28 and 56 days are shown in table 4 and figure 8

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

Table 4: Overall results of development of flexural strength in paving blocks					
Age, Days	Flexural Strength, MPa (N/mm^2)				
	Variation of fly ash and glass powder replacement with cement				
	$M_{FG(0)}$	$M_{FG(10)}$	$M_{FG(20)}$	$M_{FG(30)}$	$M_{FG(40)}$
7	3.02	3.07	3.64	3.43	2.93
28	5.50	5.58	5.61	5.59	5.38
56	5.59	5.62	5.66	5.61	5.43

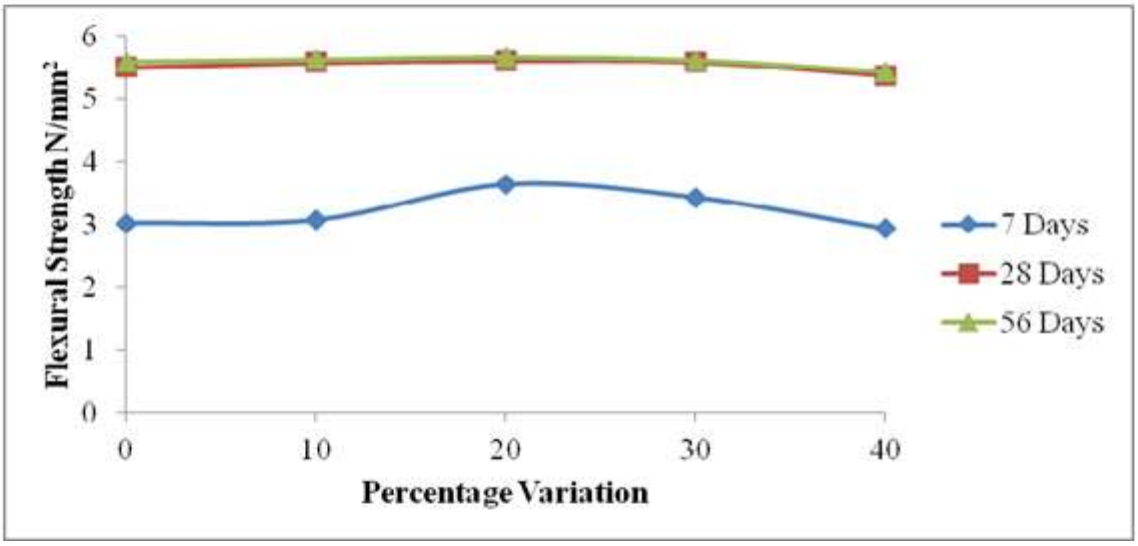

Figure 8: Graph showing variation of flexural strength development

3. Tensile Splitting Strength

Results for tensile splitting strength of concrete paving blocks M_{FG} (0), M_{FG} (10), M_{FG} (20), M_{FG} (30), and M_{FG} (40) at 7, 28 and 56 days are shown in table 5.

.

Table 5: Overall results of development of tensile splitting strength in paving blocks					
Age, Days	Tensile Splitting Strength, MPa (N/mm^2)				
	Variation of fly ash and glass powder replacement with cement				
	$M_{FG(0)}$	$M_{FG(10)}$	$M_{FG(20)}$	$M_{FG(30)}$	$M_{FG(40)}$
7	3.10	3.10	3.12	3.12	3.11
28	3.71	3.70	3.71	3.71	3.69
56	3.73	3.72	3.75	3.73	3.73

4. Abrasion Resistance Test

Results for abrasion resistance of concrete paving blocks M_{FG} (0), M_{FG} (10), M_{FG} (20), M_{FG} (30), and M_{FG} (40) at 28 and 56 days are shown in table 6 and figure 9

ISSN: 2277-9655
[Pattnaik * *et al.*, 7(1): January, 2018] Impact Factor: 5.164
IC™ Value: 3.00 CODEN: IJESS7

Table 6: Overall results of development of abrasion value in paving blocks

Age, Days	Abrasion Value, mm				
	Variation of fly ash and glass powder replacement with cement				
	MFG(0)	MFG(10)	MFG(20)	MFG(30)	MFG(40)
28	1.58	1.54	1.53	1.51	1.63
56	1.58	1.55	1.53	1.51	1.68

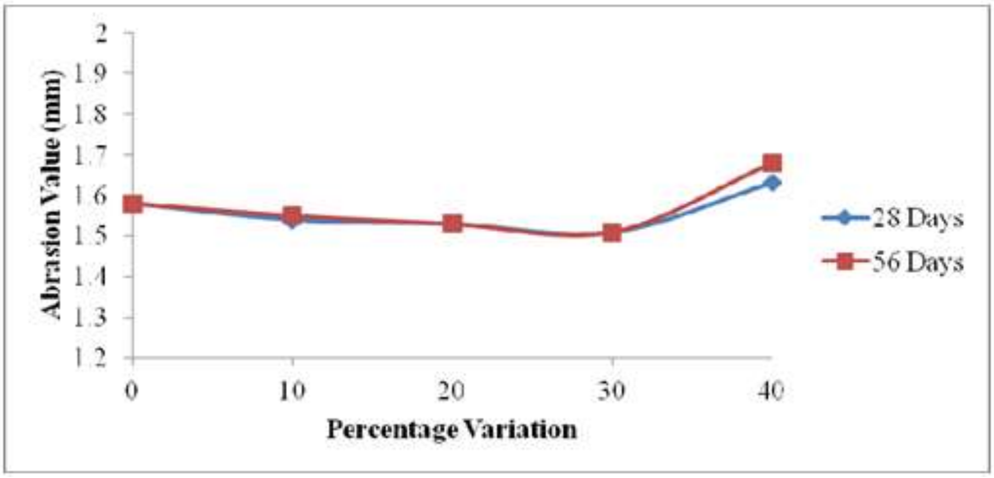

Figure 9: Graph showing variation of abrasion resistance

Figure 10: Abrasion resistance test on concrete paving blocks

5. Water Absorption

Water absorption of concrete paving block is determined as per IS: 15658: 2006. As per IS: 15658: 2006 water absorption of individual concrete paving block should be less than 7% or maximum 6% by mass (i.e., Average of 3 units). But maximum water absorption among all groups was found to be 2.58% in MFG (40) which is much less than the permissible.

V. CONCLUSION

Based on experimental observations, the following conclusions are drawn:

1. Higher compressive strength and flexural strength was achieved when 20% cement was replaced by equal proportion of fly ash and glass powder.
2. The characteristic tensile splitting strength are seems to be satisfactory.

3. It was found that wearing depth decreases with increasing replacement of cement with fly ash and glass powder up to 30%. Hence abrasion resistance are seems to be satisfactory.
4. Water absorption is well below the permissible limit.
5. All the samples satisfies the requirement given in IS 15658: 2006 for concrete paving blocks to be used in non traffic, light traffic and medium-heavy traffic areas.
6. There is a saving in cost of cement if cement is replaced by fly ash and glass powder. The percentage of saving is highly beneficial for mass production of paving blocks. This also reduces the burden of dumping fly ash and waste glass on earth which is eco-friendly.
7. It is concluded that the use of fly ash and glass powder in concrete paving blocks as partial cement replacement is possible.

The increase in strength up to 20% replacement of cement by fly ash and glass powder may be due to pozzolanic reaction of fly ash and glass powder. Fly ash increases in strength over time, continuing to combine with free lime. Increased density and long term pozzolanic action of fly ash, which ties up free lime, results in fewer bleed channels and decreases permeability. Fly ash combines with alkalis from cement that might otherwise combine with silica from aggregates, thereby preventing destructive expansion. The ball-bearing effect of fly ash in concrete creates lubricating action when concrete is in its plastic state. Waste glass when ground to a very fine powder, SiO2 react chemically with alkalis in cement and form cementations product that help contribute to the strength development. Thus it can be concluded that 20% was the optimum level for replacement of cement with fly ash and glass powder

VI. ACKNOWLEDGEMENT

The valuable suggestions and timely help extended by Dr. Bhavani Shankar Rao, Professor, Department of Civil Engineering, NMAMIT Nitte, Udupi, are gratefully acknowledged. Sincere gratitude is extended to all the authors whose publications provided us directional information from time to time. The cooperation and help received from the technical staff of concrete laboratory are gratefully acknowledged.

VII. REFERENCES

[1] Dhanaraj Mohan Patil1, Dr. Keshav K. Sangle, “Experimental investigation of waste glass powder as partial replacement of cement in concrete”, International Journal of Advanced Technology in Civil Engineering, Volume-2, Issue-1, 2013, pp112-117.

[2] Dr. G. Vijayakumar, Ms H. Vishaliny, Dr. D. Govindarajulu, 2013, “Studies on glass powder as partial replacement of cement in concrete production”, International Journal of Emerging Technology and Advanced Engineering, Volume 3, Issue 2, February 2013, pp 153-157.

[3] Fly ash for cement concrete- “Resource for High Strength and Durability of Structures at Lower Cost”, Ash Utilization Division, NTPC Limited (A Govt. of India Enterprise).

[4] IRC: SP: 63-2004 "Guidelines for Use of Interlocking Concrete Block Pavement" Indian Roads Congress.

[5] IS: 15658:2006 on "Precast Concrete Blocks for Paving – Specification," Bureau of Indian Standards.

[6] M.N. Bajad, C.D. Modhera and A.K. Desai., 2012, “ Higher strength concrete using glass powder”, Journal of Structural Engineering, Vol. 39, No. 3, August- September 2012, pp.380-383.

[7] Radhikesh P. Nanda, Amiya K. Das, Moharana. N.C., 2010, “Stone crusher dust as a fine aggregate in concrete for paving blocks”, International Journal of Civil and Structural Engineering, Vol-1, No 3, 2010.

[8] S.D. Sharma, Interlocking Concrete Paver Blocks: An Easy Approach for Road Construction, CRRI, New Delhi, India.

[9] M.N.Bajad, C.D.Modhera, A.K.Desai “Influence of A Fine Glass Powder on Strength of Concrete Subjected To Chloride Attack” International Journal of Civil Engineering & Technology (IJCIET), Volume 2, Issue 2, 2011, pp. 1-12, ISSN Print: 0976 – 6308, ISSN Online: 0976 – 6316.

[10] Vinod B Shikhare and L. G. Kalurkar, “Effect of Different Types of Steel Fibers With Metakaolin & Fly Ash on Mechanical Properties of High Strength Concrete” International Journal of Civil Engineering & Technology (IJCIET), Volume 4, Issue 3, 2013, pp. 73 - 79, ISSN Print: 0976 – 6308, ISSN Online: 0976 – 6316

CITE AN ARTICLE

Pattnaik , T., Mohanta, N. R., Patel, N., Biswal, P., & Moharana, R. K. (n.d.). MANUFACTURE OF INTERLOCKING CONCRETE PAVING BLOCKS WITH FLY ASH AND GLASS POWDER. *INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY*, *7*(1), 604-612.