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Mix Proportion of Materials in Pervious Concrete

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Abstract - These days the concrete industry is looking for supplementary cementitious material with the objective of utilising solid waste, low-cost constructions and disposal problems caused by industries. The rice husk ash, GGBS and Fly ash are among the solid waste produced by rice milling industry, thermal power plant and iron manufacturing industry respectively. In order to overcome this problem, the partial replacement of cement with the above mentioned mineral admixtures can be an economic alternative. And the cement is partially mixed with the mineral admixtures up to 50%. So both the mechanical and physical properties of pervious concrete will be enhanced and it also helps to reduce the consumption of cement which intern helps the reduction in carbon emission to the environment.

Key Words: Pervious Concrete, GGBS, Fly Ash

1. INTRODUCTION

It is the need of an hour to use the other material than natural resources as it is consumed very heavily by rapid urbanization. The ecosystem should be conserved and the natural resources should be preserved. The roads of India face lot of problems like water logging, run off water, etc. If the pervious concrete is used in such areas then the results can be more promising. The cement can be replaced by the byproducts like fly ash and slag then there are many benefits to the environment. The pavements are constructed with the help of pervious concrete in order to capture the rainwater and it can be properly lead in to the ground. But the use of pervious concrete in the pavement has led to the development of lesser strength than the conventional concrete pavement.

The shape of the aggregate is also very important parameter and when used in the previous concrete then the permeability and compressive strength. Hence the shape of aggregate plays a very important role.

1.1 MATERIALS

The demand for the use of fly ash in construction is gaining momentum in India. One instance of the increasing concern to put fly ash to use rather than its disposal, is in the growing list of areas of application. Fly ash has a various application other than construction like agriculture, ceramics, metallurgy etc.... Common areas where fly ash is used are Manufacturing of prefabricated materials like bricks/blocks etc.., land reclamation, soil stabilization, road constructions, embankments, landfills etc. Non-engineering applications are in agriculture, plant nutrients, ceramics, neutralizing soil acidity, metal extraction etc. ASTM has specified two classifications of fly ash, Class C and Class F depending on the type of coal and the resultant chemical analysis.

Class C fly ash contains CaO higher than 10% and has cementitious properties and it is normally formed from the burning of sub bituminous coals. Class F fly ash contains CaO below 10% and has pozzolanic properties. Normally formed from the combustion of an anthracite coal. The pervious concrete consists of OPC or PPC, water and coarse aggregate. The size of coarse aggregate used should be of uniform to minimize the surface area, roughness it is also noted that W/C ratio should be in the range of 0.25 – 0.35.

TABLE 1: Specification for Fly Ash in Cement and Concrete

Name	ASTM C-618	European Specifications			IS 3812 2003 - I
		En-450	En-197-I	En-3892 part-I	
SiO_2 minimum					35
Reactive/soluble SiO_2, min.		25	25		20
$SiO_2+Al_2O_3+Fi_2O_3$ minimum	70				70
MgO, Maximum					70
LOI (1hour) max.	6	5-7	5-7	7	5
Total alkalis, max.	1.5				1.5
SO_3, maximum	5	3		2	3
Free CaO, maximum		1	1		
Total/reactive CaO, maximum		10	10	10	
Fineness, 45	34	40		12	34

micron, maximum					
Blaines fineness m^2 /kg min.					320
Cement activity 28 days	75	75		80	80
Lime reactivity, N/mm^2					4.5
Soundness, Le-Chatelier, mm		10	10	10	10
Autoclave, Percent	0.8				0.8

The GGBS can be replaced for Portland cement in concrete mixes by as much as up to 50% and 28%-33% of fly ash.

2. Mix Design Calculations

2.1 Mix Proportion for M35 Grade of Pervious Concrete

Stipulation for Proportioning:

- Mix Grade: M35
- Type of cement: OPC 43 grade confirming to IS 269:2015
- Maximum nominal size aggregate: 20 mm
- Exposure condition: Severe – very severe
- Minimum cément content: 340 kg/m^3
- Method of concrete placing: Pumping
- Maximum cement content: 450 kg/m^3
- Specific gravity of cement: 3.00
- Specific gravity of coarse aggregate: 2.74
- Condition SSD
- Slump value 150-175 mm
- Specific gravity of fly ash: 3.00

2.1.1 Target Strength for Mix design

From Page-1 of IS 10262: 2009 the target strength is given by

$$F'_{ck} = f_{ck} + 1.65 \times S$$

Where:

F'_{ck} = target mean compressive strength at 28 days in N/mm^2

F_{ck} = characteristic compressive strength at 28 days in N/mm^2

S = standard deviation in N/mm^2

1.65 is tolerance factor

The value of standard deviation can be assumed from Table 8 of IS 456:2000 or from Table 1 of IS 10262:2009

Table 1 Assumed Standard Deviation
(Clauses 3.2.1.2, A-3 and B-3)

Sl No. (1)	Grade of Concrete (2)	Assumed Standard Deviation N/mm^2 (3)
i) ii)	M 10, M 15	3.5
iii) iv)	M 20, M 25	4.0
v) vi) vii) viii) ix) x)	M 30, M 35, M 40, M 45, M 50, M 55	5.0

$$F'_{ck} = f_{ck} + 1.6\ (S)$$
$$F'_{ck} = 35 + 1.65\ (5)$$
$$F'_{ck} = 43.25\ N/mm^2$$

2.1.2 Determination of water cement ratio

Basically water cement ratio depends upon the exposure conditions From Table 5 of IS-456:2000

Table 5 Minimum Cement Content, Maximum Water-Cement Ratio and Minimum Grade of Concrete for Different Exposures with Normal Weight Aggregates of 20 mm Nominal Maximum Size

(Clauses 6.1.2, 8.2.4.1 and 9.1.2)

Sl No.	Exposure	Plain Concrete			Reinforced Concrete		
		Minimum Cement Content kg/m^3	Maximum Free Water-Cement Ratio	Minimum Grade of Concrete	Minimum Cement Content kg/m^3	Maximum Free Water-Cement Ratio	Minimum Grade of Concrete
1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	Mild	220	0.60	-	300	0.55	M 20
iii)	Moderate	240	0.60	M 15	300	0.50	M 25
iii)	Severe	250	0.50	M 20	320	0.45	M 30
iv)	Very severe	260	0.45	M 20	340	0.45	M 35
v)	Extreme	280	0.40	M 25	360	0.40	M 40

Maximum water/cement ratio is 0.45
Adopt W/C ratio = 0.35

2.1.3 Determination of water content

- Water content depends upon the maximum size of aggregate
- From Table 2 of IS 10262:2009
- Maximum water content for 20 mm size aggregate is **186 liters**
- The obtained 186 liters is for slump value of 25-50 mm (IS 10262:2009 Clause 4.2)

Table 2 Maximum Water Content per Cubic Metre of Concrete for Nominal Maximum Size of Aggregate
(Clauses 4.2, A-5 and B-5)

Sl No.	Nominal Maximum Size of Aggregate	Maximum Water Content [1]
	mm	kg
(1)	(2)	(3)
i)	10	208
ii)	20	186
iii)	40	165

NOTE — These quantities of mixing water are for use in computing cementitious material contents for trial batches.

[1] Water content corresponding to saturated surface dry aggregate.

Target slump is 150-175 mm

As per is 10262:2009 clause 4.2, we can increase 3% of water for every additional 25 mm slump

50-75 = 3 %

75-100 = 3 %

100-125 = 3 %

125-150 = 3 %

150-175 = 3 %

So we have to increase Total of 15% in order to achieve 175mm slump

186 + 15% of 186 = 213.9 liters

2.1.4 Calculation of cement content

As Per **Table 5 IS 456:2000**
For severe exposure condition minimum cement content is 340 Kg/m^3
Water cement ratio = 0.35
Actual water content is 213.9 liters

$$\frac{213.9}{0.35} = 611.14 \text{ Kg/m3}$$

Cement obtained is greater than 450kg/m^3 hence adopt 450kg/m^3

2.1.5 Mix design calculation per unit volume of the concrete

Volume of concrete is 1 m^3

- Volume of cement = $\frac{mass\ of\ cement}{volume\ of\ cement}\ x\ \frac{1}{1000}$

$$\frac{450}{3.00}\ x\ \frac{1}{1000} = 0.150 \text{ m}^3$$

- Volume of water= $\frac{mass\ of\ water}{volume\ of\ water}\ x\ \frac{1}{1000}$

$$\frac{213.9}{1}\ x\ \frac{1}{1000} = 0.2139 \text{ m}^3$$

- Volume of voids assuming (15%)

$$\frac{15}{100} = 0.15 \text{ m}^3$$

- Volume of aggregate

Total volume of conc. - (volume of cement + volume of water + volume of voids)

$$1- (0.15 + 0.2139 + 0.15) = 0.4861 \text{ m}^3$$

- Mass of coarse aggregate

0.4861 x 1 x 2.74 x 1000 = 1331.914

- Mass of Fly Ash aggregate

Replacing 10% of fly ash with cement
Assuming specific gravity of fly ash as 3.00
10% of 450 Kg/m^3 = 45kg

Cement: Fine Aggregate: Coarse Aggregate : Fly Ash 1: 0: 3.32:0.1

3. CONCLUSION

The pervious concrete needs proper mix design. The proportion of cement, fly ash or GGBS, water, coarse aggregate and water-cement ratio have been calculated with the help of Indian standard code (IS: 10262 : 2009). To cast the concrete cubes the mix design is very essential. The testing such as compressive strength, split tensile strength, workability test, etc... can be conducted properly for the pervious concrete. The data obtained in this research paper is very useful for further procedure related to the concreting procedure.

REFERENCES

1. C. Manoj Kumar, U. K. Mark Vivin Raj and D. Mahadevan,(2015), "Effect of titanium di-oxide in pervious concrete", International journal of ChemTech Research, vol. 8, issue 8, pp 183-187.
2. C. Lian and Y. Zhuge,(2010), "Investigation of the effect of aggregate on the performance concrete, Challenges, Opportunities and solutions in structural engineering and construction", taylor and francis group, pp 505-510.
3. Hassan Tajik Ghashghaei and AbolfazlHassani, (February 2016), "Investigating the relationship between porosity and permeability coefficient for pervious concrete pavement by statistical modeling", Journal of material science and applications, vol 7, pp 101-107.
4. Hwang-Hee Kim, Chun-Soo Kim, Ji-Hong Jeon and Chan-Gi Park,(2016), "Effects on the physical and mechanical properties of porous concrete for plant growth of blast furnace slag, natural jute fiber and styrene butadiene latex using dry mixing manufacturing process", Journal of materials, vol. 9, issue 84.
5. Ramadhansyah P. J., Mohd Ibrahim M. Y., MohdRosliHainin, M. Naquiddin M. Warid and Wan Ibrahim M. H., (2014), "Porous concrete pavement containing nano-silica: pre-review", advanced materials research, vol. 911, pp 454-458.
6. Norbert Delatte and Stuart S. Schwartz, (June 2010), "Sustainability benefits of pervious concrete pavement", 2nd International conference on sustainable construction materials and

technologies, universita polytechnic dellemarche, Italy.

7. MulianZheng, Shuanfa Chen and Binggang Wang, (March 2012), "Mix design method for permeable base of porous concrete", International journal of pavement research and technology, vol. 5, no. 2, pp 102-107.
8. An Cheng, Hui-Mi Hsu, Sao-Jeng Chao and Kae-Long Lin, (March 2011), "Experimental study on properties of pervious concrete made with recycled aggregate", International journal of pavement research and technology, vol. 4, issue 2.
9. Sriravindrarajah, Rasiah, Wang, Neo Derek Huai, Ervin and Lai Jian Wen, (2012), "Mix design for pervious recycled aggregate concrete", International journals of concrete structure and materials, vol. 6, issue 4, pp 239-246.
10. Stephen A. Arhin and RezeneMadhi and Mr. Wasi Khan, (December 2014), "Optimal mix designs for pervious concrete for an urban area", international journal of engineering research and technology, vol. 3, issue 12, pp 42-50.
11. George N. McCain and Mandar M. Dewoolkar,(2009),"Strength and permeability characteristics of porous concrete pavements", TRB annual meeting.
12. R. E. Neal, (April 2007), "Mix design development for pervious concrete in cold weather climates", A review of national concrete pavement technology centre, Iowa state university.
13. M. HarshavarthanBalaji, M. R. Amarnaath, R. A. kavin and S. Jaya Pradeep, (February 2015), "Design of eco-friendly pervious concrete", International journal of civil engineering and technology,vol. 6, issue 2, pp 22-29.
14. GordanaToplicic-Curcic, DusanGrdic, NenadRistic and ZoranGrdic, (April 2015), "Pervious concrete in sustainable pavement design", 41th International conference on contemporary achievements in civil engineering, Subotica, Serbia.
15. Mary Vancura, Lev Khazanovich and Kevin MacDonald, (January 2011), "Structural analysis of pervious concrete pavement", Transportation research board 90th Annual meeting
16. ThusharaPriyadarshana, ThilakJayathunga and RanjithDissanayake, (2011),Pervious concrete - A sustainable choice in civil engineering and construction.
17. Husain N Hamdulay, Roshni J John and D. R. Suroshe, (August 2015), "Effect of aggregate grading and cementitious byproduct on the performance of pervious concrete", International journal of Innovative research in science, engineering and technology, vol. 4, issue 8, pp 6890-6897.
18. Mr. V. R. Patil, Prof. A. K. Gupta and Prof. D. B. Desai, (2010),"Use of pervious concrete in construction of pavement for improving their performance", Second international conference on emerging trends in engineering,pp 54-56.
19. Dania M. Abdel-Aziz, Duaa O. Al-Maani and Wael Al-Azhari, (April 2015), "Using pervious concrete for managing storm water run-off in urban neighborhood: A case of Amman", American International journal of contemporary research, vol. 5, issue 2.
20. Maniarasan S. K., Nandhini V., Kavin G. and Kavin Kumar T. R., (April 2015), "Study on characterization of pervious concrete for pavement", International journal of research in engineering and applied science, vol. 5, issue 4, pp 81-81-97.
21. A.K. Jain and Dr. J. S. Chouhan, (2011)," Effect of shape of aggregate on compressive strength and permeability properties of pervious concrete", International journal of advanced engineering research and studies, vol. 1, issue 1, pp 120-126.
22. IS 10262:2009 guideline for concrete mix design proportioning
23. IS 456:2000 Indian Standard for Plain and Reinforced Concrete-Code of Practice
24. IS 269:2015 Indian Standard Ordinary Portland cement — Specification.