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Permeable Technique for Construction of Road Pavement

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***Abstract*: This study represents the experimental work related to permeable pavement feasibility. Now a day's permeable pavement is a new concept introduced worldwide. In India and other countries research is going in positive direction. There are many advantages of permeable pavement. Permeable pavements allow storm water runoff to filter through surface voids into an underlying stone reservoir where it is temporarily stored and/or infiltrated. For this study kasak area of Bharuch city has been selected with the specific road network nearby to the zadeshwar link joining kasak road to Sheetal circle. The above road network has the history of the accumulation of water in the area during the monsoon season for long duration. To study the above objective the rainfall data for the area during the different day, month is collected. The volume data is the other important aspect for identifying the low volume road. The quality of soil sub grade is the other data, which is collected for determining the thickness of permeable asphalt concrete at this road network. The soil quality is also useful in order to identify suitability of disposal of the seepage ground water nearby to the stream/artificial drainage link.**

The main aim of our project is to improve the strength characteristics of pervious concrete. But it can be noted that with that increase in strength the permeability of pervious concrete will be reduced. Hence, the improvement of strength should not affect the permeability property which serves is purpose.

Key words: Permeable base; Porous concrete; Porosity; Effective particle size; compressive Test; Mixture ratio design.

INTRODUCTION

Permeable pavement is a storm water drainage system that allows rainwater and runoff to move through the pavement's surface to a storage layer below, with the water eventually seeping into the underlying soil. Permeable pavement is beneficial to the environment because it can reduce storm water volume, treat storm water quality, and replenish the groundwater supply and lower air temperatures on hot days. Typically, between 15% and 25% voids are achieved in the hardened concrete, and flow rates for water through pervious concrete are typically around 480 in./hr (0.34 cm/s, which is 5 gal/ft²/ min or 200 L/m²/min), although they can be much higher. Due to the increased void ratio, water is conveyed through the surface and allowed to infiltrate, and evaporate, whereas conventional surfaces will not do so. A permeable pavement surface therefore becomes an active participant in the hydrological cycle: rainfall and snowmelt are conveyed back through soils into groundwater.

PERVIOUS CONCRETE TRAPS

Pervious concrete is also a unique and effective mans to address important environment issues and sustainable growth. When it rains pervious concrete automatically acts as a drainage system thereby putting water back where it belongs. Pervious concrete is rough textured and has a honeycombed surface with moderate amount of surface raveling which occurs on heavily travelled roadways. Carefully controlled amount of water and cementitous materials are used to create paste. The paste then forms a thick coating around aggregate particles to prevent the flowing off of the paste during mixing and placing. Using enough paste to coat the particles maintain a system of interconnected voids which allow water and air to pass through. The back of sand in previous concrete results in a very harsh mix that negatively affects mixing delivery and placement. Also due to the high void content pervious concrete is light in weight (about to 2000 Kg/m^3) pervious concrete.

Void structure provides pollutant captures which also add significant structural strength as well. It also results in a very high permeable concrete that drains quickly. Pervious concrete can used in a wide range of applications, although its primary use is in residential roads, alleys and driveways, low volume pavements, low water crossing, sidewalls and pathways, parking areas tennis courts, slope stabilization, sub-base conventional concrete pavements etc.,

BENEFITS OF PERVIOUS CONCRETE

Pervious concrete pavement system provide storm water management tool under the requirements of the EPA storm water phase II final rule phase II regulations provide programs and practices to help control the amount of contaminants in our waterways. Impervious pavement particularly parking lots collect oil, anti-freeze and other automobile fluids that can be washed into streams, lakes and oceans when it rains EPA

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storm water regulations set limits on the levels of pollution in our streams and lakes. To meet these regulations local officials have considered two basic approaches.

1. Reduce the overall runoff from an area
2. Reduce the level of pollution contained in runoff

Efforts to reduce runoff include zoning ordinances and regulations that reduce the amount of impervious surfaces in new developments (including parking and roof areas) increased green space requirement and implementation of "storm water utility districts" that levy an impact fee on a property owner based on the amount of impervious area. Efforts to reduce the level of pollution from storm water include requirements for developers to provide system that collect the "first flush" of rainfall usually about 25mm and "treat" the pollution prior to release. Pervious concrete pavement reduces or eliminates runoff and permits "treatments" of pollution two studies conducted on the lone-team pollutant removal in permeable pavements suggest high pollutant removal rates. By capturing the first flush of rainfall and allowing it to percolate into the ground soil chemistry and biology are allowed to "treat" the polluted water naturally. Thus, storm water retention areas may be reduced or eliminated allowing increased land use. Furthermore by collecting rainfall and allowing it to infiltrate groundwater and aquifer recharge is increased peak water flow through drainage channel is reduced and flooding in minimized. In fact the EPA named pervious pavements as a BMP for storm water pollution prevention (EPA 1999) because they allow fluids to percolate into the soil. Another important factor leading to renewed interest in pervious concrete is an increasing emphasis on sustainable construction. Because of its benefits in controlling storm water runoff and pollution prevention pervious concrete has the potential to help earn a credit point in the U.S. green building council's leadership in energy & environment Design (LEED) green building rating system increasing the chance to obtain LEED project citification. This credit is in addition to other LEED credits that may be earned through the use of concrete for its other environmental benefits. Such as reducing heat island effects recycled content and regional materials. The light colour of concrete pavements absorbs less heat from solar radiation then darker pavements and the relatively open pore structure of pervious concrete stores less heat helping to lower heat island effects in urban area. Tress planted in parking lots and city sidewalls offer shade and produce a cooling effect in the area further reducing heat island effects. Pervious concrete pavement is ideal for protecting trees in a paved environment (many pants have difficulty growing in areas covered by impervious pavements sidewalls and landscaping because air and water have difficulty getting to the roots) pervious concrete pavements are not a typical use for pervious concrete, concrete surfaces also can improve safety during rainstorms by eliminating ponding (and glare at night) spraying and risk of hydroplaning.

MAJOR APPLICATION OF PERVIOUS CONCRETE

- Low-volume pavements
- Residential roads, alleys and driveways
- Sidewalks and pathways
- Parking area
- Low water crossings
- Tennis courts
- Sub base for conventional concrete pavements
- Slope stabilization
- Well linings
- Hydraulics structures
- Swimming pool decks
- Groins and seawalls
- Noise barriers
- Walls(including load –bearing)

LITERATURE REVIEW

Through researching pervious concrete for this research, it was found that there has only been a limited amount of work completed on this topic. There is some information relating to no-fines or pervious concrete in general but very little relating to its use in pavement applications. Nonetheless, the different applications do not significantly affect the properties of no-fines concrete. The following sections give a brief review on fabrication, properties and application of no-fines concrete or pervious concrete.

Ibrahim H.A and Razak H.A on properties of pervious concrete.

Parmar Manisha, & Dr. A. M. Jain, M.E. Scholar, L.D. College of Engineering, SVIT VASAD (2014 IJEDR) Feasibility of PERMABLE Pavement: A Case Study at Hatkeshwar Area of Ahmedabad City.

Jain A.K and Chouhan J.S et al. (2012) have studied the effect of shape of aggregate on compressive strength and permeability properties of pervious concrete.

AREA OF STUDY

Bharuch city is the small city of Gujarat, which attracts people from the different place of Gujarat for different activities. Kasak area of the Bharuch is one of the prime locations. The total population of Kasak area is about 15,000 people it is the most waterlogged area in Bharuch city during the high rainfall. Main spots in this area where the most water logging occurs are kasak circle, Pritam society, Out of which kasak circle is selected as the study area. The rainfall data kasak area from the Bharuch Nagarpalika is collected. The traffic volume count survey is carried out for the purpose of identifying the area having low traffic volume. The traffic survey is conducted in the kasak road of the kasak area.

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SATELLITE GOOGLE KASAK MAP

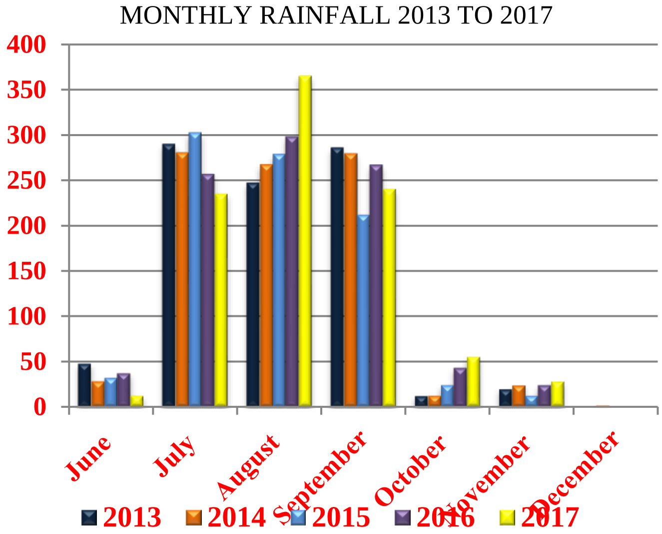
HEAVY RAINS IN KASAK AT BHARUCH

DATA COLLECTION AND ANALYSIS

Infrastructure development in major cities of the country is getting covered with high buildings and road pavements. Traditional pavements cannot absorb the water through the pavement surface during the rainy season, which leads to problems like surface runoff and water logging on the site. Because of this the feasibility of permeable pavement is carried out in internal area of Bharuch. For permeable pavement application in this area the following data are collected which consists of

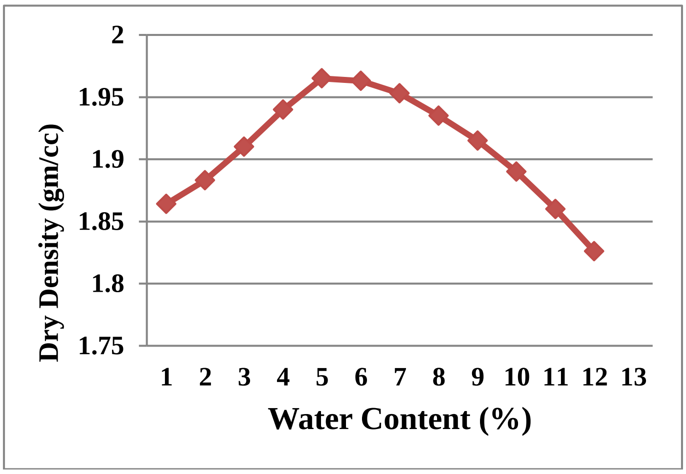
RAINFALL DATA OF THE AREA

MONTHLY SUMMARY					
Month	**2013**	**2014**	**2015**	**2016**	**2017**
January	0.0	0.0	0.0	0.0	0.0
February	0.0	0.0	0.0	0.0	0.0
March	0.0	0.0	0.0	0.0	0.0
April	0.0	0.0	0.0	0.0	0.0
May	0.0	0.0	0.0	0.0	0.0
June	47.4.	28.2	32.0	36.9	12.0
July	290.5	280.5	302.4	256.7	234.8
August	247.5	267.3	278.7	298.0	365.0
September	286.5	279.3	211.5	267.0	240.0
October	11.8	12.1	23.7	43.0	55.0
November	19.3	23.6	12.0	23.8	27.8
December	0.0	1.0	0.0	0.0	0.0
Total	903.0	892.0	860.3	925.4	934.6



SOIL SAMPLE AND CBR TEST

For this study the soil sample is collected from the under construction road site at kasak area. After the collection of soil sample, the California bearing ratio test is carried out to design the different layer of pavement for the conventional pavement.



Dry Density vs. Water Content

PROBLEM IDENTIFICATION

In this research we show the effect of on the properties of concrete, which has been investigated in laboratory and result obtained. So we present it graphically and discussed about it. The study has been carried out by preparing concrete cubes for M20 grade of nominal mix and tested after 7, 14 and 28 days of curing. To study slump loss and workability of concrete slump cone test has been performed.

DESIGN A CONCRETE MIX USING FLY ASH

Design a concrete mix for M-20 grade using 30% Fly Ash with Following Data

We have used M20 grade of concrete with the ratio 1:1.5.3 (i.e. 1 part of cement with fly ash, 1.5 part of fine aggregate and 3 part of coarse aggregate)

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Following are the materials Used

- Type of cement : 53 grade of OPC
- Type of mineral admixture : Fly ash confirming to IS 3812 (Part-1)
- Maximum nominal size of aggregate : 20 mm
- Minimum cement content : 320 kg/m^3
- Maximum water-cement ratio : 0.45 (Potable water)
- Workability : 100 mm Slump
- Exposure condition :Severe (for RCC)
- Degree of supervision : Good
- Type of aggregate : Crushed angular aggregate
- Maximum cement content : 450 Kg/m^3
- Specific gravity of cement : 3.15
- Specific gravity of fly ash : 2.20
- Specific gravity of C.A. : 2.74
- Specific gravity of F.A. : 2.74
- Water absorption
  - Coarse aggregate : 0.5%
  - Find aggregate : Nil
- Free surface moisture
  - Coarse aggregate : Nil
  - Find aggregate : 1.5%

  Grading of C. A. Conforming to Table-2 of IS : 383

  Grading of C. A. Conforming Zone –I of Table -4 of IS : 383

Target Mean Strength f̕ck

f̕ck = fck + 1.65 s

Therefore target strength = 20 + (1.65×4) = 26.60 N/mm^2

(From Table 6.4 for M 20concretestandard deviation S = 5 N/mm^2)

Selection of Water Cement Ratio

From Table 5 of IS: 456-2000, maximum water cement ratio = 0.45 (Mild exposure) Based on experience adopt water cement ratio as 0.40

0.40 < 0.45, hence ok……..

Selection of Water Content

From Table-2, maximum water content = 186 liters (for 25mm – 50mm slump range and for 20 mm aggregates)

Estimated water content for 100 mm slump = 186 $+\left(\frac{6}{100}\right)$ x186 = 197 litre

Calculation of Cement + Fly Ash Content

w/c ratio = 0.40

Water used = 197 litre

∴ Cement + fly ash content,

w/c = 0.40

$c = \frac{197}{0.40} = 492.5$ Kg/m^3

As per IS: 456- 200, Table -5, minimum cement content for 'severe' exposure condition

= 320Kg/m^3

492.5 Kg/m^3 >320Kg/m^3 . . . . O.K.

Since fly ash is not as active as that of cement, it is usual to increase the cementations material by some percentage, an increase of 30% is considered.

∴Cementations material (cement + fly ash) content = 492.5 × 1.30 = 640.25Kg/m^3.

w/c ratio = $\frac{197}{493}$ =0 .399

Let us the Percentage of Fly Ash 30%

∴ Fly ash content = 640.25 × 0.30 = 192.075 Kg/m^3

Cement content = 640.25 – 192.075 = 448.175 Kg/m^3

Therefore, saving of cement while using fly ash = 492.5 - 448.175 = 44.325 Kg/m^3

Course Aggregate and Fine Aggregate Content

From table -6.8, volume of coarse aggregate corresponding to 20 mm maximum size of aggregate and fine aggregate (Zone-I) for water cement ratio 0.50 = 0.60.

In the present case w/c = 0.40 i.e. less by 0.10 as the w/c ratio is reduce it is desirable to increase the C. A. content to decrease F.A. content.

For every decrease of w/c ratio is less by 0.10 the C. A. volume is increased by 0.02.

∴ Corrected proportion of volume of C.A. = .60 + 0.02 = 0.62

∴ Final volume of C. A. = 0.62 m^3

∴ Final volume of F. A. = 1- 0.62 = 0.38 m^3

Calculation of Mix Proportions

(1) Consider volume of concrete =1m^3

(2) Volume of cement = $\frac{\textit{Mass of Cement}}{\textit{Specific Gravity of Cement}} \times \frac{1}{1000} = \frac{448.175}{3.15} \times \frac{1}{1000}$

= ***0.142 m^3***

(3) Volume of fly ash = $\frac{\textit{Mass of Fly ash}}{\textit{Specific Gravity of Fly ash}} \times \frac{1}{1000} = \frac{192.075}{2.20} \times \frac{1}{1000}$ = ***0.0873 m^3***

(4) Volume of water = $\frac{\textit{Mass of Water}}{\textit{Specific Gravity of Water}} \times \frac{1}{1000} = \frac{197.00}{1} \times \frac{1}{1000}$

= ***0.197 m^3***

∴ Absolute volume of all the materials except total aggregate = 0.142 + 0.0873 + 0.197 = 0.4263 m^3

∴ Absolute volume of total aggregate = 1 - 0.4263 = Va = 0.573m^3

∴ Mass of coarse aggregate = Va × volume of C.A. × Sp. Gravity of C. A. × 1000 = 0.573 × 0.62 × 2.74× 1000 = **973.34 Kg say 975 kg**

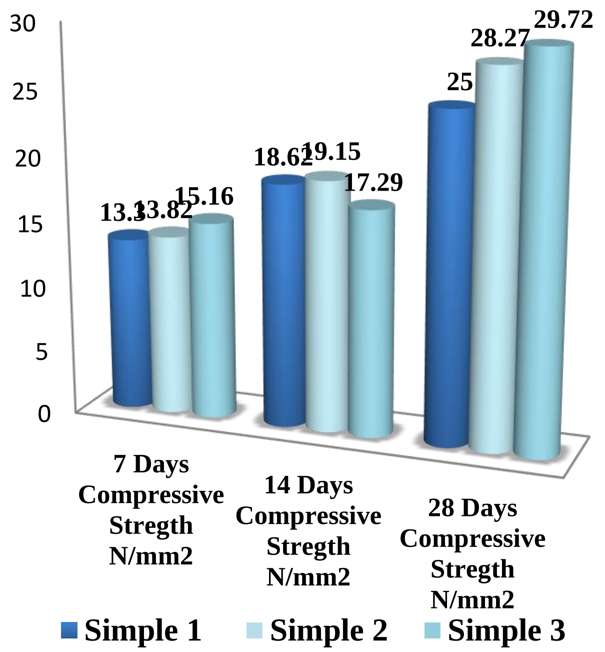
∴ Mass of fine aggregate = Va × volume of F.A. × Sp. Gravity of F. A. × 1000 = 0.573 × 0.38 × 2.74× 1000 = **596.60 Kg say 600 kg**

Mix Proportion (by Mass)

Water	Cement + Fly ash (30%)	F.A.	C.A.
197.00	448.175 + 192.075 = 640.25 Kg	596.60 kg	973.34 kg
0.40	1	0.93	1.52

TESTING DETAILS

Compressive strength test was conducted to evaluate the strength development of cement concrete normal mix, containing 30% of the fly ash at the age of 28 days respectively. Cubes were made of standard size (150mmx150mmx150mm) 9 cubes, IS: 516-1964 is casted after 24 hours the moulds were de-mounded and subjected to water curing. Before testing the cubes were air dried for 2 hours. Crushing loads were noted and average of 3 specimens was determined at 7, 14, and 28 days. The results are tabulated below.



(Compressive Strength for 30% Fly ash Concrete)

Casting Permeable Concrete Pavement Model

CONCLUSION

In this project an attempt is made for assessment of compressive strength of Fly ash cement concrete. Concrete mixes M20, is designed as per the Indian standard code (IS-10262-82) by adding, normal mix design, 30% of fly ash. Concrete cubes of size 150mm X 150mm X150 mm are casted and tested for compressive strength at 7 days , 14 days, and 28 days for all mixes and comparing the results of the cubes containing fly ash and the pure concrete. The compressive strength of all mixes is tabulated. The compressive strength of fly ash cement concrete is assessed for concrete mixes M20 grade concrete with normal mix design and 30% of fly ash. It is found that there is a decrease in compressive strength for M20 grade concrete with increase in the percentage of fly ash.

The pervious concrete needs proper mix design. The mix designs for the replacement of the cement in the concrete by fly ash few percentages. The proportion of cement, fly ash, 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 project is very useful for further procedure related to the concreting procedure.

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