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Design of Improved Drainage System using Pervious Concrete

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Abstract - *Pervious concrete is a relatively new concept for rural road pavement, with increase into the problems in rural areas related to the low ground water level, agricultural problem. Pervious concrete has introduced in rural road as a road pavement material. Pervious concrete as a paving material has seen renewed interest due to its ability to allow water to flow through itself to minimize storm water runoff. In rural area cost consideration is the primary factor which must be kept in mind. So that in rural areas costly storm water management practices is not applicable. Pervious concrete pavement is unique and effective means to meet growing environmental demands. By capturing rainwater and allowing it to seep into the ground. This pavement technology creates more efficient land use by eliminating the need for retention ponds, swell, and other costly storm water management devices. Pervious concrete can be used for a number of applications, but its primary use is in road pavement such as in rural areas. In rural areas larger amount of rainwater ends up falling on impervious surfaces such as parking lots, driveways, sidewalks, and streets rather than soaking into the soil. This creates an imbalance in the natural ecosystem and leads to a host of problems. Kavilpad is one of those place where there is no sufficient space for proper drainage hence it is the site that we selected for the implementation of our project.*

Key Words*: *Pervious concrete, drainage, rural

1. INTRODUCTION

Pervious concrete can be used for a number of applications, but its primary use is in road pavement such as in rural areas. Pervious concrete is also referred to as porous concrete, permeable concrete, no-fines concrete, gap-graded concrete, and enhanced-porosity concrete. Pervious concrete contains little or no fine aggregates such as sand, it is sometimes referred to as "no-fines" concrete. Pervious concrete pavement in rural areas is a unique and effective means to achieve a proper drainage. In rural areas larger amount of rainwater ends up falling on impervious surfaces such as parking lots, driveways, sidewalks, and streets rather than soaking into the soil. This water either flows away or it just cease to move. As the latter creates many severe problems in the habitat, the rainwater rushing across pavement surfaces picks up everything from oil and grease spills to chemical fertilizers. Kavilpad is one of those places with poor drainage system which induced a spark to take this project.

2. AIM AND OBJECTIVE

The main aim is to improve the drainage system using pervious concrete.

The objectives are as follows:

- Review the different geological conditions encountered in the area.
- Evaluate the current road drainage design systems.
- Develop better design for drainage systems that can be used in rural roads.

3. METHODOLOGY

1. Surveying
2. CBR Test
3. Test On Pervious Concrete
4. Comparison With Ordinary Concrete
5. Design Of Pavement
6. Design Of Drainage System

4. RECONNAISSANCE AND SURVEYING

Reconnaissance survey is done to examine the general character of the area for the purpose of determining the most feasible route or routes for the further more detailed investigations.

Profile and cross section leveling was done.

4.1 LONGITUDINAL SECTION OF ROAD

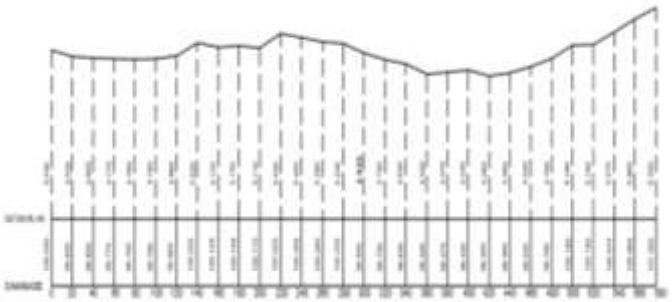


Fig 4.1 Longitudinal section of road

CROSS SECTIONING OF ROADS

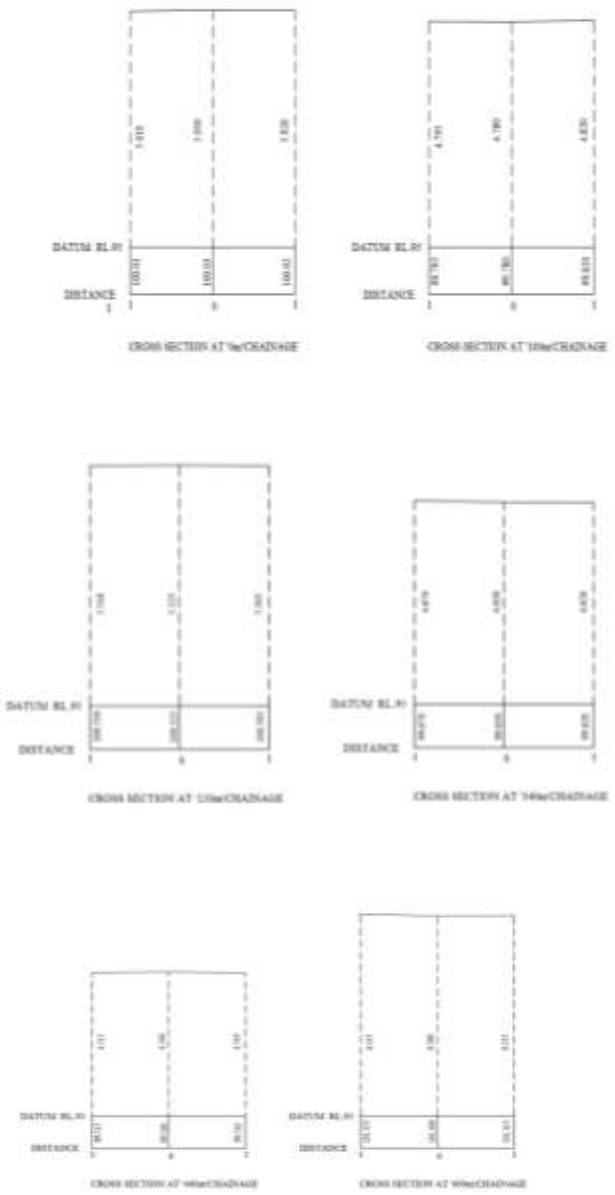


Fig 4.2 Cross Section of roads

5. TEST CONDUCTED ON SOIL

CALIFORNIA BEARING TEST

The soil samples of non-stabilized and stabilized soil for CBR test were prepared as per standard procedure.

C.B.R. = (Test load/Standard load) x 100

Since it is an already existing road the CBR value of that road is given below

Standard load at 2.5mm penetration=1370kg

Standard load at 5mm penetration=2055kg

CBR at 2.5mm penetration=(load at 2.5mm penetration/std load)x100

CBR=(70/1370)X100

=5.109

For 5mm penetration=(105/2055)x100

CBR=5.11

5.1 STABILISATION OF SUBGRADE

Since the bearing capacity of the soil in the site is very low, it is necessary to stabilise it .The sub grade is essentially black cotton soil. RHA and $CaCl_2$ cannot be used alone for stabilization as they lack cementing agent for increased strength and are difficult to pulverize soil at low water content respectively. Thus Optimization of above 2 combinations can be an effective method for soil stabilization and it is Found at 10% RHA and 1.5% $CaCl_2$. Reinforcing the soil with Coir Fiber can improve the strength characteristics of the soil and the optimum performing subgrade is obtained with the application of 10% RHA, 1.5% $CaCl_2$ and 0.5% Coir Fiber.

6. TEST ON PERVIOUS CONCRETE

6.1 MATERIALS FOR MAKING PERVIOUS CONCRETE:-

Cement, Water, Coarse aggregate, Cementitious materials

CEMENTITIOUS MATERIALS:- Silica fume, Ground granulated blast-furnace slag, Fly ash

6.2 MIX DESIGN OF PERVIOUS CONCRETE

Mix design can be defined as the process of selecting suitable ingredients of concrete and determining their relative proportions with the object of producing concrete of certain minimum strength and durability as economically as possible.

Size of the cube a=15cm

Volume of the cube a (15X10^-2)^3

= 3.375X10^-3 m

Mix proportion = 1:2:4 (M15)

Weight of concrete = 24000X3.375X10^-3

= 81N

Mass of concrete = 81/9.81

=8.2568 kg

For pervious concrete to acquire full strength 75% of the total weight will be aggregate and remaining 25% will be cement.

Weight of the cement= (25/100)X8.2568

=2.0642 kg

About 8% of the cement is replaced by silica fume, 6% by fly ash, and 12% by GGBS.

Therefore weight of silica fume=0.1651 kg

Weight of fly ash=0.1238 kg

Weight of GGBS=0.2477 kg

Water cement ratio=0.36

6.3 COMPRESSION TEST

The result after conducting compression test are as follows

Compressive strength of conventional concrete (7 days)

= 27.50 N/mm²

Compressive strength of pervious concrete (7 days)

= 24.30 N/mm²

7. RESULTS AND DISCUSSION

Fig 7.1 structure of conventional and pervious concrete

Strength:- From the test conducted we got,

Compressive strength of ordinary concrete (7 days)= 27.50 N/mm²

Compressive strength of pervious concrete(7 days)= 24.30 N/mm²

Durability:- As the water seeps out quickly through the pervious concrete as compared to the conventional concrete. Hence the formation of pot holes reduced.

Permeability:- The flow rate through the pervious concrete is more than conventional concrete due to more voids

7.1 PROPERTIES OF PERVIOUS CONCRETE

- Deformation in the sub grade is not transferred to subsequent layers
- Design is based on flexural strength or slab action
- Have high flexural strength
- Have low repair cost but completion cost is high
- Life span is more when compared to the rigid pavements (low maintenance cost)
- Surfacing can be directly laid on the sub grade
- Thermal stresses are more vulnerable to be induced as the ability to contract and expand is very less in concrete. That's why expansion joints are needed.
- Strength of the road is less dependent on the strength of the sub grade.
- Rolling of the surfacing is not needed.
- Road cannot be used until 14 days of curing.
- Force of friction is high.
- No damage by oils and greases.

8. DESIGN OF PERVIOUS PAVEMENT

PERVIOUS PAVEMENT CATEGORIES

For the cross-section of pervious concrete pavement we have to adopt the following details from California Department of Transportation, for pervious concrete we use the following criteria.

Minimum thicknesses for the Class 4 AB layer:

Category	Examples	Loading	Speed	Risk
A	Landscaped areas, sidewalks and bike paths (with no vehicular access), miscellaneous pavement to accept run-on from adjacent impervious areas (e.g. roofs)	No vehicular loads	N/A	Low risk
B	Parking lots, park & ride areas, maintenance access roads, scenic overview areas, sidewalks and bike paths (with maintenance/vehicular)	Few heavy loads	Low speed(less than 30mph)	Low
C	Rest areas , maintenance stations	Moderate heavy loads	Low speed	Low
D	Shoulders, some low volume roads, areas in front of noise barriers (beyond the traveled way)	Moderate heavy loads	High speed	Medium
E	Highways, weigh stations	High heavy loads	High speed	High

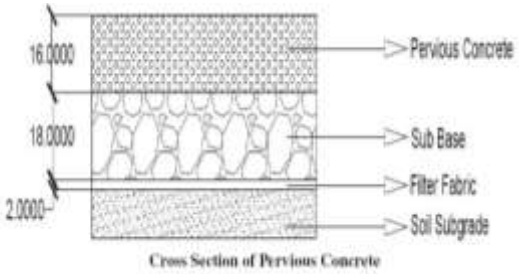
Table 8.1 Pervious pavement categories

From the above table we have;

- Zero for Category A (non-auto locations)
- 0.50 feet for Category B auto areas
- 0.70 feet for Category B truck areas
- 0.70 feet for Category C truck areas

Hence we have to **use 0.50 feet depth of pervious concrete** layer that means 16cm in which it will give higher amount of porosity that allows water to percolate in to ground water and also it can withstand the load given by the parking vehicles.

8.1 DETAILED DRAWING



Cross Section of Pervious Concrete

9. PIPE SYSTEM

PIPE DESIGN:- Generally for pervious pavements pipes consisting of 100mm to 200mm diameter can be provided. therefore here we are adopting 150 mm diameter pipes. The pipes are made of PVC(Poly vinyl chloride).

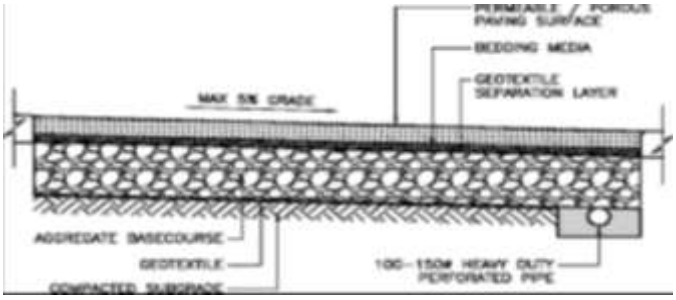


Fig 6.1 Pipe Design

DRAINAGE SYSTEM:- A French drain or weeping tile is a trench filled with gravel or rock or containing a perforated pipe that redirects surface water and groundwater away from an area.

SLOPE REQUIREMENTS:- The trench bottom should be sloped about 1 inch for every 8 feet in the direction of the flow. That is the slope at which the pipe should be laid 1 vertical to 1057 horizontal for maximum efficiency.

FILTER FABRICS:- Geotextiles are permeable fabrics. When used in soil, they serve generally five different functions: Separate, Filter, Reinforce, Protect, Drain

9.1 MAINTENANCE

The majority of pervious concrete pavements function well with little or no maintenance. However, after repeated water flows, debris and residue may lodge within the top 1" to 1 ¼" of the void structure. Maintenance of pervious concrete pavement consists primarily of removing this debris and residue from the void structure to rejuvenate some of its original permeability. In preparing the site prior to construction, drainage of surrounding landscaping should be designed to prevent flow of materials onto pavement surfaces. Soil, rocks, leaves, and other debris may infiltrate the voids and hinder the flow of water, decreasing the utility of the pavement. Landscaping materials such as mulch, sand, and topsoil should not be on the concrete, even temporarily.

A specific frequency for maintenance cannot be stated because of differences in site conditions, water flow and traffic. One recommendation is to evaluate the permeability of the pavement immediately after construction using ASTM C1701 – Standard Test Method for Infiltration Rate of In-Place Pervious Concrete. Perform the test in several locations to establish a benchmark, and re-test at similar locations after a period of service to evaluate the rate of clogging of the pavement with time. This can be used as a basis to set a pavement maintenance schedule for that site.

Vacuuming annually or more often may be necessary to remove debris from the surface of the pavements. For best results over a large area, a regenerative vacuum sweeper should be used. Other cleaning options may include power blowing and pressure washing. Research has shown that using any of these methods to clean a clogged pervious concrete pavement can restore 80% to 90% of the original permeability in some cases.

10. CONCLUSIONS

Pervious concrete pavements are a very cost-effective and environmentally friendly solution to support sustainable construction. Its ability to capture storm water and recharge ground water while reducing storm water runoff enables pervious concrete to play a significant role. Pervious concrete is a smart sustainable option with very high potential. Pervious concrete is an ideal solution to control storm water, re-charging of ground water, flood control at downstream and sustainable land management. Knowledge on pervious concrete is very well received by the Specifies/ Architects / Engineers. Comparing it with conventional concrete it is very much compatible with the conventional concrete. The region where we are going to cast this road is requires the pervious nature because it is a marshy area. Even the cost considerations are very much economical than the conventional concrete road. Thus we conclude that the pervious concrete road is compatible and very apt for our area under considerations.

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