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PERVIOUS CONCRETE PAVEMENT

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Abstract: - Civilization is the part of human life, and technology which is advancing rapidly from centuries. Many efforts are made so far in developing of new construction materials. In the construction industry, concrete technology is plays a vital role. The usage of supplementary cementitious materials, such as Silica fume, zeolite, polyvinyl alcohol etc. in concrete is a new innovative usage in the technology. The increasing amount of waste is a concerning reality that has across the sustainability issues of the environment. "The production of cement also reasons for the global warming by releasing CO2 in the environment. Therefore, formulation of concrete with different type of industrial waste can help in minimizing the environmental problems. Water reaches earth in the form of rain fall. The use of pavement materials like Bitumen, Asphalt concrete seals the soil surface which restricts the rain water from infiltration & natural ground recharge. The construction of impervious pavements initiates a chain of events which results in change in urban environment thus causing an imbalance in ecosystem. Pervious concrete which is referred as enhancing porous concrete gap graded concrete or no fine concrete is a step forwards minimizing urban flooding. The pervious concrete mix is prepared using aggregates conforming to IS- 383, cement, polyvinyl alcohol (PVA) & silica fume, and zeolite as admixture. Zeolite, silica fumes is used for replacing cement in various percentages. The cement paste binds the aggregates leaving voids, these voids make it possible for rain water to drain out from pavement surface. As the water flows down to underground surface recharges the ground water for sustainable development. In this project the parameters such as compressive strength, flexural strength, drainage conditions of various mix proportions of pervious pavement layer will be studied.
Keywords: - Cement silica fume, zeolite, polyvinyl alcohol (PVA), coarse aggregates and water.

1. INTRODUCTION

While pervious pavements have become very popular in the area of storm water management, the true applicability to the highway environment is still unclear. Local agencies and regulators continue to ask Caltrans to consider pervious pavement on projects. However, until more information is determined related to safety, maintainability, constructability, and improved water quality benefit over other approved storm water best management practices (BMPs) the inclusion of pervious pavement into Caltrans projects needs to be carefully considered. Pervious concrete pavements are a very cost-effective and environmentally friendly solution to support sustainable construction

Pervious concrete is also referred as no-fine concrete, zero slump concrete, porous or permeable concrete. The coarse aggregates are bonded with paste formed from cement and water leaving void spaces which allows water to infiltrate. Unlike conventional concrete pervious concrete has high permeability, lower compressive strength. The percentage of voids in pervious concrete can vary from 15% - 40%.

The pervious concrete mix due to silica fume, zeolite and polyvinyl alcohol. Replacement of cement with silica fume and zeolite was restricted to 10% by weight and PVA was replaced with water for 1.6% and 2%.The main objective of this work is to investigate the effect of compressive and flexural strength characteristics of the pervious concrete.

2. LITERATURE REVIEW

M. Uma Maguesvari and V.L. Narasimha- has worked on the influence of fine aggregate and coarse aggregate quantities on the properties of pervious concrete such as compressive strength and permeability.

Sirile Eathakoti and Navya Gundu- have carried their work trying various C: A mix proportions and determined the change in properties of pervious concrete. The test results were then used to determine the pavement slab thickness.

A. Allahverdi and K. Kianpur investigated – The effect of polyvinyl alcohol on flexural strength of concrete of concrete taking the polymer to cement ratio as 0.4%, 0.8%, 1.6%, 2%

From these results, the usage of 1.6% of p:c ratio obtained the optimum test results. The experimental investigation carried out of compressive and flexural strength of pervious concrete by using cement with silica flume, zeolite, Polyvinyl Alcohol.

3. MATERIAL PROPERTIES

3.1. Cement

In this present work Portland pozzolanic cement confirming to IS 1489.1991 was used. This type of cement is obtained by grounding the Portland cement clinker with fine pozzolanic material and adding possible amount of gypsum. Physical and chemical properties of cement are as shown in below Table 1.

Table 1: Physical and chemical properties of cement

Physical Properties of cement		
S.No.	**Property**	**Value**
1	Specific Gravity	3.15
2	Standard Consistency	37%
3	Initial Setting Time	35minute
4	Soundness	1.5mm
5	Final setting time	355 minute
Chemical Properties of cement		
1	Silicon dioxide (SiO_2)	22.9%
2	Aluminum oxide (Al_2O_3)	4.29%
3	Iron oxide (Fe_2O_3)	2.80%
4	Titanium dioxide (TiO_2)	-
5	Calcium Oxide (CaO)	63.20%
6	Magnesium Oxide (MgO)	1.92%
7	Sodium Oxide (Na_2O)	0.7%
8	Potassium Oxide (K_2O)	0.5%
9	Sulfur trioxide (SO_3)	0.35%
10	Loss on Ignition	1.70%

3.2. Silica Fume

It's a very fine pozzolanic material composed of amorphous silica, which is highly reactive produced from electric arc furnace as by product of production of elemental silica. Silica fume has been recognized as a pozzolanic admixture that is effective in greatly enhancing mechanical properties. Silica fume confirming to specifications as per IS 15388.2003 has been used. Properties of silica flume are shown in Table 2.

Table 2: Properties of Silica Flume

S.No.	Property	Value
1	Specific Gravity	2.22
2	SiO2	85-90%

3.3. Zeolite

Zeolite is a rock composed of micro porous alumina silicates, and oxygen. It occurs naturally in several regions of the world where volcanic activity has occurred near water. Since they're underactive and based on naturally occurring minerals, they're not believed to have any harmful environmental impacts. Properties are shown in Table 3.

Table 3: Properties of Zeolite

S.No.	Property	Value
1	Specific Gravity	2.3
2	Porosity	28%
3	Appearance colour	Grayish white

Figure 1 Zeolite

3.4. Coarse Aggregates

Coarse aggregates of sizes ranging from 10mm – 20 mm were used confirming to IS383.1970.the various aggregate properties were tested accordingly and their value are shown below in Table 4

Table 4

S. No.	Test	Value
1	Specific Gravity	2.81
2	Water absorption	0.20%
3	Aggregate impact value	29.33%
4	Aggregate crushing value	3.86%
5	Abrasion value	30%
6	Flakiness index	19.23%
7	Elongation Index	18.14%
8	Bulk density	2kg/litre

3.5. Polyvinyl Alcohol [PVA]

It's a water soluble synthetic polymer [C2H4O] which has high flexibility, tensile strength. 7gm of polyvinyl alcohol was dissolved in 300ml water and was kept aside for 24 hours. The properties of polyvinyl alcohol are shown below in Table 5.

Table 5

S. No.	Property	Value
1	Specific Gravity	1.19-1.26
2	P^H	Natural
3	Melting Point	225°C
4	P^H	5.7

Figure 2 Polyvinyl alcohol

3.4 Water

Ordinary drinking water available locally was used for casting and curing of all specimen of this research. Water is an important ingredient of pervious concrete which is actually participates in the chemical reaction with cement.

4. PREPARATION OF CONCRETE SPECIMEN

The mix proportion of pervious concrete is not same as conventional concrete. There is no codal provision for preparation for mix design. The mix proportion is based on the literature review and guideline given by National ready-mix concrete association (NRMCA).

I. Required quantity of aggregates and cement, polyvinyl alcohol (PVA) & silica fume is taken by correctly weighing.
II. The weighed items are mixed in a tray for certain time until all the aggregates are in contact of cement
III. The amount of water calculated is taken in a measuring jar and it is added to the mix.
IV. The aggregate, cement, water, polyvinyl alcohol (PVA) & silica fume is thoroughly mixed before placing in the mould.
V. Size of mould is taken 150mm x 150mm x 150mm and oil is applied to each inner side of the cube
VI. Mixed concrete is added to mould in three layers and each layer is tamped for 25 times with the help of tamping rod.
VII. Concrete moulds are kept for 24 hrs and it is demoulded, then the cubes are placed in a water tank for certain duration.

5. EXPERIMENTAL RESULTS

The experimental investigation is carried based on volume proportions and the cement content was taken to be 320 kg/m3. Water/cement ratio was taken to be 0.40 from previous studies and from various trial mixes. Mix proportion pertaining to 1:4 and 1:6 cement /aggregate ratio (C: A) is considered to carry out investigation. Aggregate sizes ranging from 10 mm - 20 mm were used to prepare the samples of various mix proportions.

5.1. Compressive Strength

The compressive strength test is carried out as per IS 516:1959 test on hardened concrete. The load is applied without shock and increased continuously at a rate of approximately 140 kg/sq cm/min. In this investigation, 1:4 and 1:6 C/A mix concrete is considered to perform the test by-weight basis with 10% of cement replaced by silica fume , zeolite and 1.6%,2% PVA solution . All the concrete cubes were de-molded within 24 hours after casting. The demoulded test specimens were properly cured in water available in the laboratory at an age of 7 and 28 days. Compression test was conducted on a 2000KN capacity universal testing machine.

5.2. Flexural Strength

The axis of the specimen is carefully aligned with the axis of the loading device. The load shall be applied without shock and increasing continuously at a rate such that the extreme fiber stress increases at approximately 7 kg/sq cm/mm. that is, at a rate of loading of 400 kg/min for the 15•0 cm specimen. In this investigation, 1:4 and 1:6 C/A mix concrete is considered to perform the test by-weight basis with 10% of cement replaced by silica fume , zeolite and 1.6%,2% PVA solution . All the concrete beams were de-molded within 24 hours after casting. The demoulded test specimens were properly cured in water available in the laboratory at an age of 7 and 28 days. Flexural test was conducted on flexural testing machine.

Table 6 Compressive strength for 7 & 28 days for various mix proportions

S. No	Proportion (Cement: Aggregates)	Water cement ratio	Percentage of cement replaced with	Density kN/m^3	Compressive strength at 7 days(MPa)	Compressive strength at 28 days(MPa)
1	1:4	0.4	0%	18.51	5.81	8.51
2	1:4	0.4	10% SF	18.49	4.69	7.59
3	1:4	0.4	10% SF+1.6%PVA Sol.	17.96	4.12	6.41
4	1:4	0.4	10% SF+2%PVA Sol.	18.19	4.11	6.19
5	1:4	0.4	10% Zeolite		6.87	9.17
6	1:6	0.4	0%	18.21	4.11	6.19
7	1:6	0.4	10% SF	18.00	3.39	5.61
8	1:6	0.4	10% SF+1.6%PVA Sol.	18.02	3.41	5.33
9	1:6	0.4	10% SF+2%PVA Sol.	18.02	3.29	5.12
10	1:6	0.4	10% Zeolite	18.63	4.59	6.19

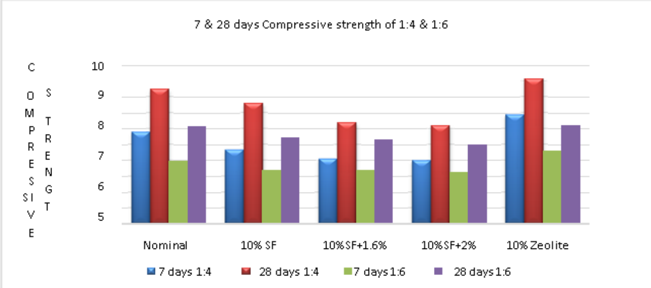

Figure 4 Comparing Compressive Strength of mix design when replacement of Cement by SF, PVA, Zeolite

Figure 5 Pervious concrete

Table 7 Flexural strength for 7 and 28 days for various mix proportions

S.No	Proportion (Cement: Aggregates)	w/c ratio	Percentage of cement replaced with	Flexure strength at 7 days(MPa)	Flexure strength at 28 days(Mpa)
1	1:4	0.4	0%	1.67	2.65
2	1:4	0.4	10% SF	1.20	1.86
3	1:4	0.4	10% SF+1.6%PVA Sol.	1.17	1.77
4	1:4	0.4	10% SF+2%PVA Sol.	1.12	1.73
5	1:4	0.4	10% Zeolite	1.79	2.66
6	1:6	0.4	0%	1.11	1.69
7	1:6	0.4	10% SF	1.07	1.61
8	1:6	0.4	10% SF+1.6%PVA Sol.	1.05	1.60
9	1:6	0.4	10% SF+2%PVA Sol.	1.02	1.58
10	1:6	0.4	10% Zeolite	1.49	1.79

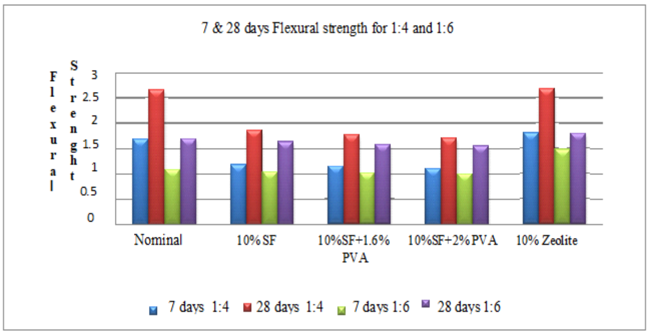

Figure 6 Comparing flexure Strength of mix design when replacement of Cement by SF ,PVA , Zeolit

Figure 7 Compressive and flexure strength test

6. PAVEMENT SLAB THICKNESS DETAILS

The pervious concrete pavement thickness mainly is dependent on the volume of traffic expected on the pavement surface. The following details on pervious pavement categories have been opted from California Department of Transportation for pervious concrete

Table 8

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
B	Parking lots, park & ride areas, maintenance access roads, scenic overview areas, sidewalks and bike paths (with maintenance/vehicular access), maintenance vehicle pullout	Few heavy loads	Low speed (less than 30 mph)	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

For pervious concrete use the following minimum thicknesses for the Class 4 AB layer:

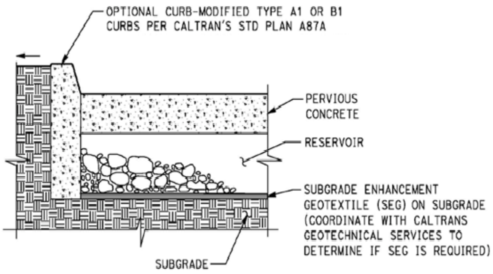

Figure 8 Typical PCP Section

- 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 15cm 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.

7. CONCLUSION

- Uses of the pervious concrete pavements are a very cost-effective and environmentally friendly.
- Ability of pervious concrete to capture storm water and recharge ground water while reducing storm water runoff enables pervious concrete to play a significant role.
- Pervious concrete is an ideal solution to control storm water, re-charging of ground water, flood control at downstream and sustainable land management
- The compressive and flexure strength of previous concrete decreased with the addition of 10% silica fume ,silica fume and PVA sol. of different proportions
- The compressive and flexure strength of previous concrete increased with addition of 10% zeolite and these can be used at places where moderate compressive strength is required.
- From the above test results it is observed that replacement of cement with 10% zeolite has a drastic increase in compressive strength for 1:4 C:A ratio whereas the increase in flexural strength is very small.
- These can also be used as sound absorbing walls in classrooms, auditorium etc. This can also be used at railway platforms. This will help in reducing water accumulation on railway tracks and also absorbs co2 in air as it contains zeolite

8. SCOPE FOR FURTHER STUDY

The compressive and flexural strength characteristics of previous concrete can be further studies by taking into account following parameters:

- By using the Fly ash, replacing the some quantity of cement.
- By using the metakaolin.
- By varying the water cement ratio.
- By varying the amount of silica fume and also addition of super plasticizers.
- By using some amount of fine aggregates.
- By using recycled coarse aggregates in the concrete mix as replacement of coarse aggregates.
- Using the super plasticizers in the mixes only by removing silica fume.
- Using different aggregates size and mix ratio

REFERENCES

[1] Research Report – Laboratory Testing and Modeling for Structural Performance of Fully Permeable Pavements Under Heavy Traffic: Final Report, dated November 30, 2010, U.C. Davis, Department of Civil and Environmental Engineering (CTSW-RT-10-249.04)

[2] S.O. Ajamu, A.A. Jimoh, J.R. Oluremi-Evaluation of Structural Performance of Pervious Concrete in Construction, International Journal of Engineering and Technology. Volume 2 No. 5, May, 2012.

[3] M. Harshavarthana Balaji, M.R. Amarnaath, R.A.Kavin, S. Jaya Pradeep-Design of Eco friendly

Pervious Concrete. IJCIET Volume 6, Issue 2, February (2015), pp. 22-29.

[4] Infiltration Basins Design Guidance, dated February 2011, California Department of Transportation, Division of Design, Office of Storm Water Management.

[5] Darshan S. Shah, Prof. Jayeshkumar Pitroda, Prof. J.J. Bhavsar-Pervious Concrete: New Era For Rural Road Pavement, International Journal of Engineering Trends and Technology (IJETT) – Volume 4 Issue 8- August 2013.

[6] Praveenkumar Patil, Santosh M Murnal-Study on the Properties of Pervious Concrete, International Journal of Engineering Research & Technology (IJERT) ISSN: 2278- 0181Vol. 3 Issue 5, May – 201

[7] A. Allahverdi, K. Kianpur and M. R. Moghbeli-Effect of polyvinyl alcohol on flexural strength and some important physical properties of Portland cement paste, Iranian Journal of Materials Science & Engineering Vol. 7, Number 1, Winter 2010

[8] Sirile Eathakoti1, Navya Gundu, Markandeya Raju Ponnada-An Innovative No-Fines Concrete Pavement Model (IOSR-JMCE) e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 12, Issue 5 Ver. III (Sep. - Oct. 2015), PP 34-44.

[9] Giannetto G.P., Rendón A.M., Fuentes G.R. Zeolitas: Características, Propiedades y Aplicaciones Industriales. 1st ed. Editorial Innovación Tecnológica; Caracas, Venezuela: 1990. pp. 57–60, 114–118.

[10] T. Divya Bhavana and S. Koushik, International Journal of Civil Engineering and Technology (IJCIET) Volume 8, Issue 4, April 2017, pp. 413–421.

[11] IS 516-1959, Methods of Tests for Strength of Concrete, Bureau of Indian Standards, New Delhi.

[12] M S Shetty, “Concrete Technology”, S.Chand & company ltd, New Delhi.

[13] IS 516-1959, Methods of Tests for Strength of Concrete, Bureau of Indian Standards, New Delhi.

[14] IS 10262-1982, Recommended Guidelines for Concrete Mix Design, Bureau of Indian Standards, New Delhi.

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