EXPERIMENTAL STUDY ON MECHANICAL PROPERTIES OF MODIFIED PERVIOUS CONCRETE AS A RIGID PAVEMENT FOR LOW VOLUME TRAFFIC

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Abstract:-

The previous concrete which is also known as No-fines concrete is a mixture of cement, water and a particular sized coarse aggregate combined to form a porous structural material. Application of pervious concrete in pavements mainly focuses on storm water control mostly in urban areas where scarcity of land is high. Permeable pavement allows water from precipitation and other sources to pass through it and therefore reduces the runoff from a site, which results in the recharge of ground water and increases the level. In this view it is necessary to study the behavior of pervious concrete by enhancing its mechanical properties by maintaining required permeability.

The main objective of this investigation is to develop a strong pervious concrete mix using with waste tyre rubber powder. In addition, it is also aimed to compare the mechanical properties of these modified mixes with pervious concrete. The properties such as compressive strength, indirect tensile strength, flexural strength and permeability tests are performed to determine the suitability. From the study it is concluded that using of fine aggregate and waste tyre rubber powder as partial replacement material in coarse aggregate shows significant improvement in the mechanical properties (i.e. compressive strength, indirect tensile strength and flexural strength) with maintaining required permeability. Among all the considered modified mixes, MPC-4 (i.e. 10% waste tyre rubber powder as partial replacement material in coarse aggregate) performs better.

1. INTRODUCTION:-

1.0.Objective:-

1. As urbanization increases in India and many parts of the world the problem of water logging and requirement of drainage is also increase. This is partly due to impervious nature of the bituminous and concrete pavements.
2. Pervious concrete which has an open cell helps significantly to provide high permeability due to its interconnected pores. Pervious concrete (also called porous concrete, permeable concrete and no fines concrete).
3. Pervious concrete has been used in the united state for over 30 years.
4. Pervious concrete was first used in the 1800s in Europe as pavement surface and load bearing walls.
5. Cost efficiency was the main motive due to a decreased amount of sand.
6. Pervious concrete if adopted for construction of pavements, platform/walkways, parking lots designed for lighter load.
7. To bind masonry blocks like stones, bricks and to plaster slabs and walls.

1.1 Advantages of pervious concrete:

- Decreasing flooding possibilities, especially in the urban areas.
- Recharging the ground water level.
- Improving water quality through percolation.
- Sound absorption
- Heat absorption.
- Supporting vegetation growth
- It allows more efficient land development opening stoved with forge and
- Reduce temperature.

1.2 Disadvantages of pervious concrete:

- Many engineers and contractors lack expertise with pervious concrete technology.
- Low strength due to high porosity.
- High maintenance requirement
- Limited use as a load bearing unit due to its low strength.
- Porous pavement has a high rate of failure.

1.3 Applications of pervious concrete:

- Pervious pavement for parking lots
- Green house floors
- Pavements, walls and floors where better acoustic absorption characteristics are desired.
- Swimming pool decks
- Bridge embankments
- Tennis courts
- Sub base for conventional concrete pavements
- Sidewalks and pathways

1.4 Pervious Concrete in India:

Pervious concrete can be successfully used in India in applications such as parking lots, driveways, sidewalks, road platforms, etc. Over the next 15 years there is expected to be a significant amount of housing construction in India.

1.5 Current status of pervious concrete:

Although there is a very little documented use of no-fines concrete in Australia, it was first utilized as early as 1946. No-fines concrete was used in the construction of a residential house in Ryde, new south wales.

1.6 Objectives of the investigation:

Following are the objectives of the present study.

- To determine the optimum pervious concrete mix.
- To determine the mechanical properties of modified pervious concrete by partial replacement of coarse aggregate by 5% and 10% of fine aggregate.
- To determine the mechanical properties of modified pervious concrete by partial replacement of coarse aggregate by 5% and 10% of waste tire rubber powder.

1.7 Scope of investigation:

- The present investigation addressed the strength and permeability aspects of pervious concrete mixes.
- Aggregate to cement ratio of 4:1 used for this study.
- Studied compressive strength, split tensile strength, flexural strength and permeability of pervious concrete and modified pervious concrete.

- 5% and 10% of coarse aggregate of pervious concrete is partially replaced by waste tyre rubber powder as one case study.
- 5% and 10% of coarse aggregate of pervious concrete is partially replaced by fine aggregate as another case study.

2.0 LITERATURE REVIEW :-

Jain and Chouhan (2011):
conducted experimental work on shape of aggregate used in manufacturing of pervious concrete have remarkable bearing on compressive strength and permeability of pervious concrete. The magnitude of this effect is determined by conducting laboratory experiments on mixes of pervious concrete prepared using aggregates of different shape with varying water cement ratio.

Uma Maguesvaria and Narasimhan [8] (2013):studied about the influence of fine aggregate and coarse aggregate quantities on the properties of pervious concrete. Materials used are OPC Type I, fine aggregate corresponding to grading II and four sizes of coarse aggregate namely, 4.75mm to 9mm to 12.5mm, 12.5mm to 16mm, 16mm to 19.5mm. Mixes were prepared with the water cement ratio of 0.34, cement content of 400kg/m3 and maintaining the aggregate cement ratio as 4.75:1. Fine aggregate was replaced with coarse aggregate in the range of 50 - 100 % by weight. Various mechanical properties of the mixes were evaluated.

Rui Liu[1] (2013):
studied about the reuse potential of tire chips as coarse aggregates in pavement concrete was examined in this research by investigating the effects of low- and high-volume tire chipson fresh and hardened concrete properties. One concrete control mixture was designed, which well exceeds CDOT Class P concrete requirements.

Patil and Gupta [16] (2013):
developed a strong and durable pervious cement concrete (PCC) mix using different types of fine aggregates with varying the quantity of fine aggregates. In addition, it is also aimed to compare the properties of these PCC mixes. In the present investigation, two types of fine aggregates are used viz., Crushed Stone (CS) and River Sand (RS) are used. The percentage of fine aggregates used in PCC mix is 15 per cent. The properties of PCC mixes investigated are compressive strength, flexural strength, abrasion resistance.

Iftekar Alam et al (2014):
done the work on effect of various types of aggregate and cement on the properties of pervious concrete. In this study Performance of pervious concrete was evaluated in terms of air void, absorption, compressive strength, tensile strength and water permeability. Ninety six cylinders of 4x8 sizes were investigated. The porosity varies from 0.17 to 0.30.The water permeability varies from 5.5 mm/s to 13.2 mm/s.

Praveenkumar Patil and Santosh Murnal (2014):
performed a study on M20 pervious concrete is designed by ACI522R -10 design code. The effect of w/c ratio and aggregate size on the strength of pervious concrete are studied. The property of pervious concrete by replacing cement by fly ash is also studied. It is revealed that the compressive strength increases as the water/cement ratio decreases up to optimum w/c ratio and with increase in volume of paste.

Harish Nayak et al (2015): developed a strong and durable pervious cement concrete (PCC) mix using Polyester Fiber. In addition it is also aimed to compare the properties of these PCC mixes to lay concrete pavers. The properties such as compressive strength, flexural strength, and Tensile strength tests were performed. Compressive strength of specimens for 1:3 ratio with Glass fiber and polyester fiber increased by 17.17% & 4.65% at 28 days when compared with control specimens.

Abid Alam & Shagufta Naz (2015): considered 3 batches of no-fine concrete mixes each with two different sizes of aggregate were prepared to find the mix that generated high compressive strength and study the effect of percentage of fine aggregate on the compressive strength of no- fine concrete.

3. CHARACTERIZATION OF MATERIALS:-

- Cement
- Coarse aggregate
- Water
- Waste tyre rubber

3.1 Cement :

The most common cement used in construction is ordinary Portland cement conforming to IS: 12269-1987.This type of cement is typically used in construction and is readily available from a variety of sources. The cement is fresh and uniform colour. The cement is free from lumps and foreign matter.

The fineness is used to quantify the surface area of cement. The surface area provides a direct of the cement fineness. The typical fineness of cement ranges from 350 to 500 kg. A size-reduced, recycled rubber which is known as Ground and crumb rubber, can be used in both paving type projects and in mould able products. These types of paving are: Rubber Modified Asphalt (RMA), Rubber Modified Concrete, and as a substitution for an aggregate.

4.2 MIX DESIGN:

Pervious concrete uses the same material as in the case of conventional concrete, except that there is usually no or little fine aggregate. The size of the coarse aggregate used to keep fairly uniform in size to minimize surface roughness and for a better aesthetic water to cement ratio Should be within 0.3 to 0.45 ordinary Portland cement and blended cement can be used in pervious concrete. Admixtures can be used in pervious concrete.

3.2 Coarse Aggregate :

The aggregate of size 10-12mm is desirable for structures having congested reinforcement Wherever possible, aggregates of size higher than 20mm could also be used Well-graded cubical or rounded aggregates are desirable Aggregates should be of uniform quality with respect to shape and grading The crushed coarse aggregate of maximum size 16 mm, 60% of t passing through 16 mm IS sieve and retaining on 12.5 mm IS sieve and 40% of this passing through 12.5 mm Is sieve and retaining on 4.15 mm IS sieve size obtained from the local crushing plant, is n the present study

3.3 Water :

This is the least expensive but most important ingredient of concrete. The water, which is used for making concrete, should be clean and free from harmful impurities such as oil, alkali. acid etc, In general, the water, which is fit for drinking, should be used for making concrete

3.4 Waste tyre rubber :

Disposal of waste tyre rubber has become a major environmental issue in all parts of the world representing a very serious threat to the ecology. One of the possible solutions for the use of scrap tyre rubber is to incorporate it into concrete, to replace some of the natural aggregate. An estimated 1000 million tyres reach the end of their useful lives every year and 5000 millions more are expected to be discarded in a regular basis by the year 2030. Up to now a small part is recycled and millions of tyres are just stockpiled, land filled or buried. The volume of polymeric wastes like tyre rubber and polyethylene tetra phthalate bottles (PET) is increasing at a fast rate.

A size-reduced, recycled rubber which is known as Ground and crumb rubber, can be used in both paving type projects and in mould able products. These types of paving are: Rubber Modified Asphalt (RMA), Rubber Modified Concrete, and as a substitution for an aggregate.

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4. Mechanical properties of Control Pervious Concrete mix (CPC):

4.1 Compressive strength:

The compressive strength results of control pervious concrete of aggregate to cement ratio 4:1 with different water/cement ratio of 0.3, 0.35 and 0.4 at 7 days and 28 days curing period. Refer fig. 5.1 for compressive strength Vs curing period with different WC ratios.

Curing period (Days)	water/cement ratio	Compressive strength (N/mm^2)
7	0.3	7.2
	0.35	7.47
	0.4	7.6
28	0.3	14.12
	0.35	14.5
	0.4	14.87

4.2 Indirect tensile strength:

The indirect tensile strength results of control pervious concrete of aggregate to cement ratio 4:1 with different water/cement ratio of 0.3, 0.35 and 0.4 at 7 days 28 days and curing period.

Curing period (Days)	water/cement ratio	Indirect Tensile strength (N/mm^2)
7	0.3	2.1
	0.35	2.28
	0.4	2.3
28	0.3	3.2
	0.35	3.48
	0.4	3.5

4.3 Flexural strength:

The Flexural strength results of control pervious concrete of aggregate to cement ratio 4:1 with different water/cement ratio of 0.3, 0.35 and 0.4 at 7 days and 28 days curing period. Refer fig. 5.3 for Flexural strength Vs curing period with different W/C ratios.

Curing period (Days)	water/cement ratio	Flexural strength (N/mm^2)
7	0.3	3.18
	0.35	3.4
	0.4	3.6
28	0.3	5.8
	0.35	6.1
	0.4	6.4

4.4 Permeability test:

The permeability test results of control pervious concrete of aggregate to cement ratio 4:1 with different water/cement ratio of 0.3, 0.35 and 0.4. Refer fig. 5.4 for permeability Vs different W/C ratios.

Water cement ratio	Permeability mm/hr
0.3	2032
0.35	1939
0.4	1880

Page 5

4.5 Compressive strength:

The compressive strength results of modified pervious concrete with replacement of 5% fine aggregate to coarse aggregate of aggregate to cement ratio 4:1 with different water/cement ratio of 0.3, 0.35 and 0.4 at 7 days and 28 days curing period. Refer fig. 5.5 for compressive strength Vs curing period with different W/C ratios.

Curing period (Days)	water/cement ratio	Compressive strength (N/mm^2)
7	0.3	7.3
	0.35	7.76
	0.4	7.82
28	0.3	14.8
	0.35	15.2
	0.4	15.87

4.6 Indirect tensile strength:

The indirect tensile strength results of modified pervious concrete with placement of 5% fine the relate to coarse aggregate of aggregate to cement ratio del with 5.6 for indirect tensile strength Vs curing period with different W/C ratios. Different water/cement rate, 0.35 and 0.4 at 7 days and 28 days curing period. Refer fig. 5.6 for indirect tensile strength Vs curing period with different W/C ratios.

Curing period (Days)	water/cement ratio	Indirect Tensile strength (N/mm^2)
7	0.3	2.22
	0.35	2.28
	0.4	2.32
28	0.3	3.38
	0.35	3.48
	0.4	3.51

4.7 Flexural strength:

the Flexural strength results of modified pervious concrete with replacement of 5% fine aggregate to coarse aggregate to cement ratio 4:1with different water/cement ratio of 0.3,0.35 and 0.4 at 7 days and 28 days curing period refer fig. 5.7 for flexural strength Vs curing period with different w/c ratio.

Curing period (Days)	water/cement ratio	Flexural strength (N/mm^2)
7	0.3	3.23
	0.35	3.41
	0.4	3.72
28	0.3	5.83
	0.35	6.23
	0.4	6.45

4.8 Permeability test:

The permeability results of modified pervious concrete with replacement of 5% fine aggregate to coarse aggregate of aggregate to cement ratio 4:1 with different water/cement ratio of 0.3, 0.35 and 0.4. Refer fig. 5.8 for permeability Vs different W/C ratios.

Water cement ratio	Permeability mm/hr
0.3	1985
0.35	1896
0.4	1792

• **Results for test conducting the samples:**

Curing period (Days)	Compressive strength				
	CPC	MPC-1	MPC-2	MPC-3	MPC-4
7	7.6	7.82	7.88	7.93	7.97
28	14.87	15.87	16.02	16.17	16.23

Curing period (Days)	Indirect Tensile strength				
	CPC	MPC-1	MPC-2	MPC-3	MPC-4
7	2.3	2.32	2.36	2.38	2.4
28	3.5	3.504	3.57	3.61	3.71

Curing period (Days)	Flexural strength				
	CPC	MPC-1	MPC-2	MPC-3	MPC-4
7	3.6	3.72	3.75	3.8	3.94
28	6.4	6.45	6.54	6.66	6.72

Mix	Permiability (mm/hr)				
	CPC	MPC-1	MPC-2	MPC-3	MPC-4
1:04	1884	1792	1689	1732	1686

5. CONCLUSION :-

1. A water cement ratio of 0.4 is found to be optimum in strength point of view for control pervious concrete mix and modified pervious concrete mixes.

2. Among all the considerable w/c ratios, the w/c ratio increased, the degree of lubrication in the pervious concrete mix increased, which help in better densification of the mix and hence resulted in lower permeability.

3.Compressive Strength increased by 2.89%, 3.62%, 4.34% and 4.86% for MPC-1, MPC-2, MPC-3 and MPC-4 respectively when compared to CPC at 7 days curing period. For 28 days curing period, observed an increase in compressive strength by 6.72%, 7.73%, 8.74% and 9.14% for MPC-1, MPC-2, MPC-3 and MPC-4 respectively when compared to CPC.

4. Indirect tensile strength increased by 1%, 2.6%, 3.47% and 4.34% for MPC-1, MPC-2, MPC-3 and MPC-4 respectively when compared to CPC at 7 days curing period. For 28 days curing period, observed an increase in indirect tensile strength by 1.2%, 2.8%, 3.5% and 6% for MPC-1, MPC-2, MPC-3 and MPC-4 respectively when compared to CPC.

5. Flexural strength increased by 3.33%, 4.1%, 5.55% and 9.44% for MPC-1, MPC-2, MPC- 3 and MPC-4 respectively when compared to CPC at 7 days curing period. For 28 days curing period, observed an increase in flexural strength by 1%, 2.1%, 4.06% and 5% for MPC-1, MPC-2, MPC-3 and MPC-4 respectively when compared to CPC.

6. Permeability decreased by 5.1%, 11.54%, 8.77% and 11.74% for MPC-1, MPC-2, MPC-3 and MPC-4 respectively when compared to CPC.

7. Compressive strength, tensile strength and flexural strength properties of modified Pervious concrete are increased due to the presence of fines. As the fine percentage increases, strength properties increases and permeability decreases.

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