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LIFE CYCLE ASSESSMENT OF PERVIOUS CONCRETE AND COMPARISON WITH CONVENTIONAL CONCRETE

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Abstract: Pervious concrete is a type of concrete with high permeability. It is used for concrete flatworks application that allow the water to percolate through it, thereby reducing the runoff from a site and allowing ground water recharge. The high porosity is attained by a highly interconnected void content. Typically pervious concrete has water to cementisious material ratio of 0.28 to 0.4. The mixture is composed of cementisious materials, coarse aggregates and water with no fine aggregates. Introducing of a small amount of fine aggregates will basically reduce the void content and increase the strength. Generally porous concrete is used in parking areas, areas with less traffic, residential areas. It is an important application for ground water recharge. The present project works on the study and comparison of mechanical properties, permeability and durability properties of different grades of pervious concrete (M15,M20, M25).

Keywords: Portland cement, Traffic congestion fuel economy, greenhouse gases.

I.INTRODUCTION

Concrete is a composite material composed mainly of water, aggregate, and cement. The physical properties of the finished material can be achieved by having additives and reinforcements in the mixture. A fluid mass that is easily moulded into shape can be formed by mixing these ingredients together in certain proportions. Over the time, a hard matrix formed by cement binds the rest of the ingredients together into a stone-like durable material with many uses such as Famous concrete structures like the Hoover Dam, the Pannama Canal and the Roman Pantheon. The concrete technology was used earlier on large-scale by the ancient Romans, and the concrete was highly used in the Roman Empire. The Colosseum was built largely of concrete in Rome, and the concrete dome of the patheon is the World's largest unreinforced concrete. After the collapse of Roman Empire in the mid-18th century the technology was re-pioneered as the use of concrete has become rare. Today, the widely used man made material is concrete.

HISTORICAL BACKGROUND

Although high strength concrete is often considered relatively as a new materials, its development has been gradual over many years.in the 1950s, USA considered the concrete with a compressive strength of 34mpa as high strength. In 1960's, the concrete with compressive strength 41mpa to 52mpa were used commercially. Within the early 1970', 62mpa concrete was being made. Within the world state of affairs, however, within the last fifteen years, concrete of

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terribly high strength entered the sector of construction of high-rise buildings and long span bridges. In line the compressive strength over 110mpa has been thought-about by IS 456-2000 for the applications in pre-stressed concrete members and cast-in-place buildings. However recently reactive concrete could be a one that having nearly compressive strength of 250mpa. It's fully supported pozzolanic materials. The first distinction between high strength concrete and nominal-strength concrete refers to the relation of utmost resistance offered by compressive strength of the concrete sample for the application of any type of load. Though there's no correct separation between high-strength concrete and normal-strength concrete, the Yankee Concrete Institute defined the compressive strength greater than 42mpa as high strength concrete.

PROPERTIES OF CONCRETE

Generally the Concrete is a material with high compressive strength than to tensile strength. As it has lower tensile stress it is generally reinforced with some materials that are strong in tension such as steel. The elastic behaviour of concrete at low stress levels is relatively constant but at higher stress levels start decreasing as matrix cracking develops. Concrete is a low coefficient of thermal expansion material and it maturity leads to shrinks. Due to the shrinkage and tension all concrete structures crack to some extent. Concrete prone to creep when it is subjected to long-duration forces. For the applications various tests be performed to ensure the properties of concrete correspond to the specifications. Different strengths concrete are attained by different mixes of concrete ingredients, which are measured in psi or MPA. The Different strengths of concrete are used for different purposes. If the concrete must be light weight a very low-strength concrete may be used. The Lightweight concrete is achieved by the addition of lightweight aggregates, air or foams, the side effect is that the strength will get reduced. The concrete with 3000-psi to 4000-psi is oftenly used for routine works. The concrete with 5000-psi although more expensive option is commercially available as a more durable one. For larger civil projects the concrete with 5000-psi is oftenly used. 5000 psi above strength concrete are often used for specific building elements. For example, the high-rise concrete buildings composed of the lower floor columns may use 12,000 psi or more strength concrete, to keep the columns sizes small. Bridges may use 10,000 psi strength concrete in long beams to minimize the number of spans required. The other structural needs may occasionally require high-strength concrete. The concrete of very high strength may be specified. If a structure must be very rigid, even much stronger than required to bear the service loads. For these commercial reasons the concrete of strength as high as 19000-psi have been used.

II.METHODOLOGY

Materials Production Phase: Includes each step in the materials manufacturing process, from extraction of raw materials (e.g., limestone) to their

Fig 1. Pervious concrete.

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Transformation into a pavement input material (e.g., cement). Also includes any necessary transportation that occurs between facilities.

Construction Phase Processes : In construction phase process, method used in the placement of pavement materials at the project location. It includes onsite construction equipment and traffic delay caused by construction activities. Pavements associate with the environment through many pathways, including albedo, vehicle rolling resistance, carbonation, and lighting.

Maintenance Phase: The preservation, reformation, and reconstruction activities that occur during the life of a pavement. The maintenance phase usually involves its own materials, construction, and use phases.

End-of-Life Phase: Depending on boundary conditions, the end-of-life phase can include demolition, disposal in a landfill, recycling processes, and/or other activities that occur when the pavement is taken out of service.

A pervious solution is typically built with 3 layers; "pervious bitumen mix" as the surface layer, followed by a pervious aggregate sub-base over undisturbed soil. The measurements and structure of

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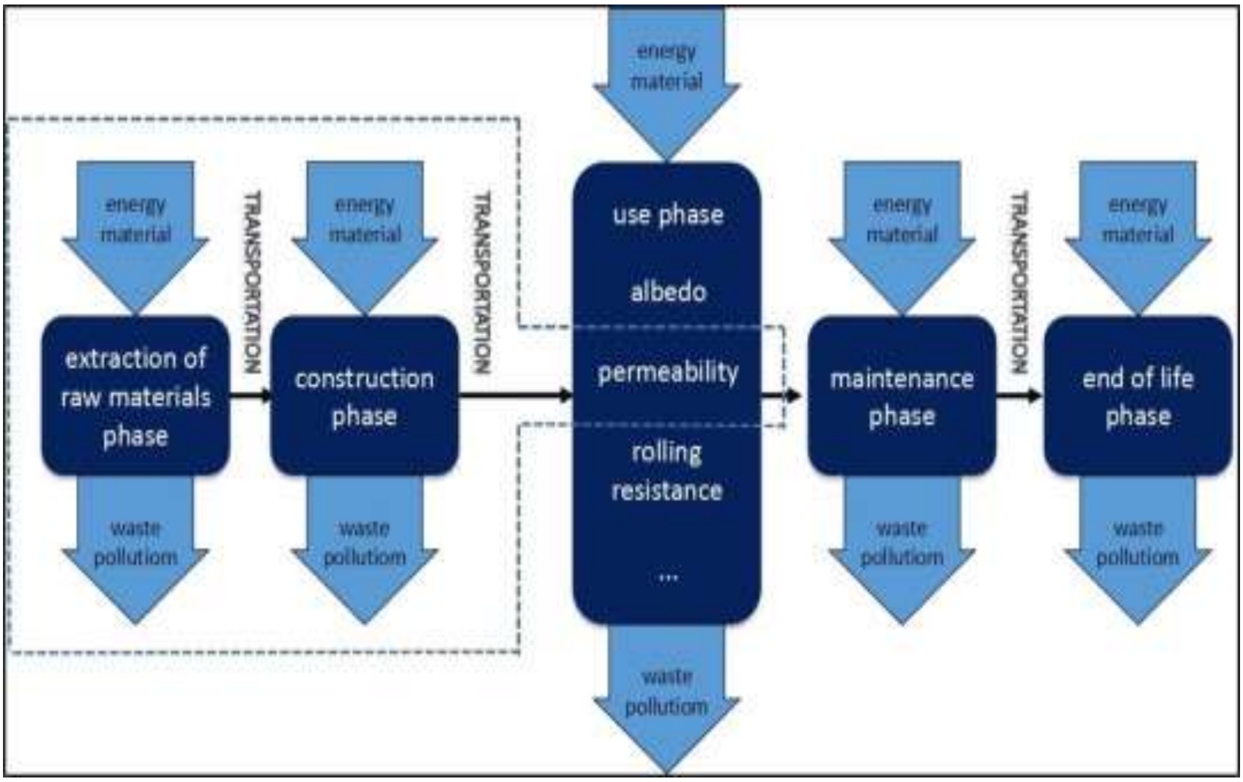

Fig 2. Product life cycle flowchart.

Each layer is dependent on application, preponderating site conditions and performance requirements.

Permeable bitumen mix allows surface water to freely seep through the wearing surface to the underlying ground (or drainage system) with the ability to act as a reservoir during periods of high downfall. During these times this characteristic can support in delaying the discharge of surface water into water courses or drainage systems reducing the risk of overwhelming systems and causing flash flooding. Collection of water in the system can also have a advantageous effect in reducing the heat island effect. During times of increasing temperatures and heavy rainfall, water collected within the system evaporates creating a cooling effect reducing surface temperatures.

III. CONCLUSION

In the Life cycle Assessment (LCA) comparison of different paving material of the initial construction phase, the results illustrate that mix designs of the pavement surface course greatly influence the LCA comparison results. Porous concrete pavement with slag cement requires less energy consumption than conventional concrete.

- Pervious concrete has less strength than conventional concrete by 18.2% for M15, 14.5% for M20 and 12.6% for M25.

- Similarly the tensile and flexural strength values are also comparatively lower than the conventional concrete by 30%.

- Though the pervious concrete has low compressive, tensile and flexural strength it has high coefficient of permeability hence the following conclusions are drawn based on the permeability, environmental effects and economical aspects.

- It is evident from the project that no fines concrete has more coefficient of permeability. Hence, it is capable of capturing storm water and recharging the ground water. As a result, it can be ideally used at parking areas and at residential areas where the movement of vehicles is very moderate.

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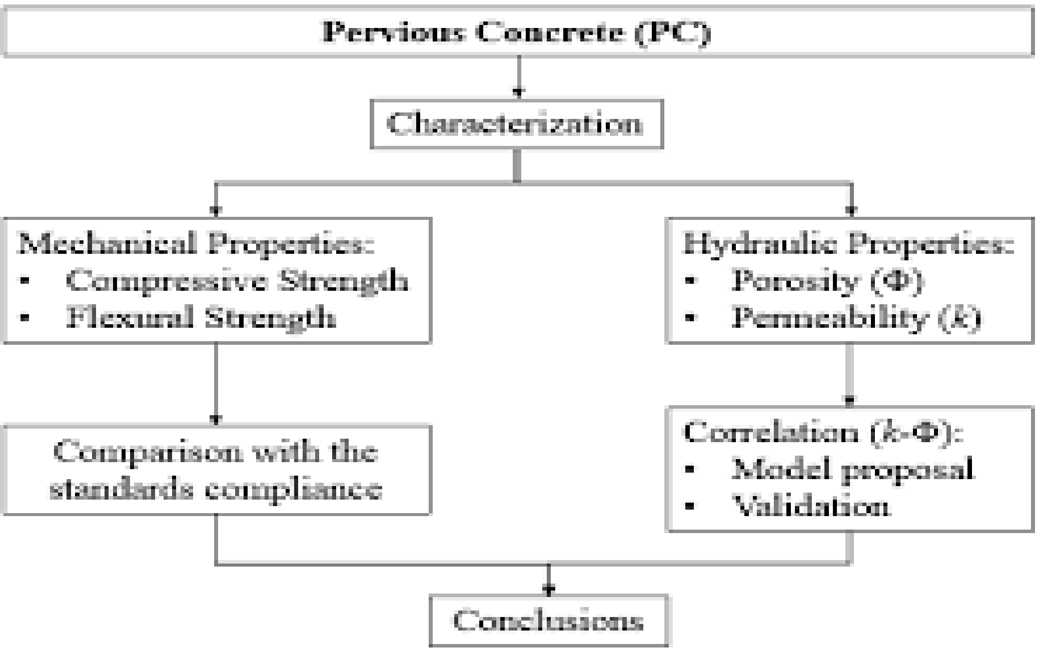

COMPACTION FACTOR:

GRADES OF CONCRETE	COMPACTION FACTOR	
	CONVENTIONAL CONCRETE	NO FINES CONCRETE
M15	0.8	0.85
M20	0.84	0.89
M25	0.87	0.92

COMPRESSIVE STRENGHT:
(PERVIOUS CONCRETE)

GRADES OF CONCRETE	COMPRESSIVE STRENGTH(N/mm^2)			
	CURED IN WATER		CURED IN $MgSo_4$	
	7 DAYS	28 DAYS	7 DAYS	28 DAYS
M15	11.02	16.32	8.96	15.1
M20	14.98	20.79	12.82	18.74
M25	19.86	24.4	17.2	25.53

(CONVENTIONAL CONCRETE)

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GRADES OF CONCRETE	COMPRESSIVE STRENGTH(N/MM^2)			
	CURED IN WATER		CURED IN $MgSo_4$	
	7 DAYS	28 DAYS	7 DAYS	28 DAYS
M15	14.6	19.1	13.03	18.8
M20	17.26	25.44	15.6	24.03
M25	21.3	30.88	19.3	28.87

FLEXURAL STRENGHT (PERVIOUS CONCRETE)

GRADES OF CONCRETE	FLEXURAL STRENGTH(N/mm^2)			
	CURED IN WATER		CURED IN $MgSo_4$	
	7 DAYS	28 DAYS	7 DAYS	28 DAYS
M15	3.79	5.18	3.13	4.91
M20	6.68	7.36	6.09	7.06
M25	8.89	10.28	8.26	9.92

(CONVENTIONAL CONCRETE)

GRADES OF CONCRETE	FLEXURAL STRENGTH(N/mm^2)			
	CURED IN WATER		CURED IN $MgSo_4$	
	7 DAYS	28 DAYS	7 DAYS	28 DAYS
M15	5.43	7.1	4.51	6.37
M20	8.44	10.12	7.32	9.55
M25	10.37	12.57	9.03	11.12

DENSITY:

GRADE OF CONCRETE	DENSITY OF CONCRETE (kg/m^3)	
	CONVENTIONAL CONCRETE	NO FINES CONCRETE
M15	2340	1612
M20	2375	1656
M25	2394	1685

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PERMEABILITY:

PRESSURE DIFFERENCE (Pa)	PERMEABILITY OF CONVENTIONAL CONCRETE(cm/sec)			PERMEABILITY OF NO FINES CONCRETE(cm/sec)		
	M15	M20	M25	M15	M20	M25
5	$5.6X10^{-14}$	$3.2X10^{-14}$	$1.39\ X10^{-14}$	$6.6\ X10^{-3}$	$1.01X10^{-3}$	$9.42\ X10^{-4}$
10	$1.8X10^{-14}$	$9.48\ X10^{-15}$	$7.47\ X10^{-15}$	$1.2\ X10^{-3}$	$8.2\ X10^{-4}$	$6.01\ X10^{-4}$
15	$8.6X10^{-15}$	$6.23\ X10^{-15}$	$3.25\ X10^{-15}$	$8.9\ X10^{-4}$	$5.4\ X10^{-4}$	$2.9\ X10^{-4}$

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