

An Experimental Study of Pervious Concrete with Partial Replacement of Coarse Aggregate by Pebble Stone

S.Manojkumar¹, S.Manoj Kumar¹, K.Ravikumar¹, Dr.M.Seethapathi²

¹UG Students, ²Head of The Department

Civil Engineering, Tamilnadu college of Engineering, Coimbatore, India

Abstract—Pervious concrete is a type of pavement that allows water to infiltrate through the surface into the ground below. Pervious concrete is designed to manage storm water runoff in urban areas by reducing the amount of runoff that flows into storm drains and ultimately into nearby waterways. This innovative solution offers many benefits, including reduced flooding, improved water quality, reduced heat island effect, improved air quality, and reduced maintenance costs.

Pervious concrete is made up of a porous concrete surface layer that is typically 3 to 6 inches thick. The porous surface allows water to infiltrate into the ground below the pavement. Underneath the surface layer, there is a gravel or crushed stone layer that provides additional storage for storm water. Finally, there is a subbase layer of pebble stone or crushed stone that supports the pavement structure.

The construction of pervious concrete involves careful planning and design to ensure that it is effective in managing storm water runoff. Proper design includes consideration of factors such as soil conditions, drainage patterns, and traffic loads. Additionally, proper maintenance is essential to ensure the long-term effectiveness of pervious concrete. Maintenance may include regular vacuuming to remove debris from the surface, periodic power washing to remove accumulated sediment, and repairs to damaged pavement sections. The strength parameters and permeability parameters met the requirements and pervious concrete made with pebbles as a coarse aggregate can be used for sustainable pavement construction.

Key words — Air voids, compressive strength, permeability, pervious concrete, split tensile strength

I. INTRODUCTION

Pervious concrete is a composite material consisting of Coarse aggregate, Portland cement, and water. It is different from conventional concrete as it contains no fines in the mixture, sometimes fines are introduced during the compaction process. The aggregate

usually consists of a single size and is bonded together at its points of contact by a paste formed by the cement and water. The result is a concrete with a high percentage of interconnected voids when functioning correctly, it permits the rapid percolation of water through the concrete. Unlike conventional concrete, which has a void ratio anywhere from 3-5%, pervious Concrete can have void ratios from 15-40% depending on its application.

Pervious concrete characteristics differ from conventional concrete in several other ways. Compared to conventional concrete, pervious concrete has a lower compressive strength, higher permeability, and a lower unit weight, approximately 70% of conventional concrete.

Pervious concrete is concrete made by eliminating most or all the fine aggregates in the concrete mix, which allow meter connected void spaces to be formed in the hardened product. These interconnected void spaces allow the concrete to transmit water at relatively high rates. Pervious concrete pavement is one of the leading materials used by the concrete industry in effective significant “Green” industry practices and is recognized as a Best Management Practice for providing pollution control storm water management and sustainable development (US Environmental Protection Agency). The increased interest in pervious concrete is due to benefits storm water management and sustainable development.



Fig. 1: Pervious Concrete

II. MATERIALS

2.1 GENERAL

The properties of materials used for making concrete mix are determined in laboratory as per relevant codes of practice. Different materials used in present study were cement, coarse aggregates, pebble stone and water. All the materials are tested to confirm the codal recommendation and to enable an engineer to design a concrete mix for a particular strength.practice. Different materials used in present study were cement, coarse aggregates, pebble stone and water. All the materials are tested to confirm the codal recommendation and to enable an engineer to design a concrete mix for a particular strength.

2.2 MATERIAL USED

Cement: Portland Pozzolana Cement, 53 grade confirming IS 1489(1)-1991

Coarse aggregate: locally available crushed blue granite stories conforming to graded aggregate of nominal size 20 mm as per IS 383-1970

Pebble Stone: locally available sand quarry to graded aggregate of different size, smooth and round shape IS 383-2016

Water: potable water

2.3 MIX DESIGN

To prepare the mix, cement content of 450 kg/m³ and aggregate to cement ratio of 4:1 was maintained. The water cement ratio was maintained as 0.4 for entire study. Natural Coarse aggregates (crushed aggregate metal) are partial replaced with pebble aggregate. Proper care was taken to maintain the workability in pervious concrete for easy and proper mixing.

2.4 MIX PROPORTION

S.NO	MIX	CEMENT (kg/m ³)	AGGREGATE (kg/m ³)		WATER (lit/m ³)
			COARSE AGGREGATE	PEBBLE STONE	
1	M1	450	1970.60	Nil	197
2	M2	450	1773.54	197.06	197
3	M3	450	985.3	985.3	197
4	M4	450	197.06	1773.54	197
5	M5	450	Nil	1970.60	197

TABLE NO.1 MIX PROPORTION OF PERVIOUS CONCRET

III. RESULT AND DISCUSSION

3.1 COMPRESSIVE STRENGTH TEST

GENERAL

The cubes were tested on the universal testing

machine after drying at room temperature according to IS 516-1959. The load was applied continuously without impacts and uniformly Load was continued until the specimen failed and maximum load carried by the specimen was recorded. The compressive strength was obtained by considering the average of five specimens at each age To determine the cube strength of the concrete of given properties

S.NO	MIX	7 DAYS (N/mm ²)
1	MI	8.28
2	M2	8.07
3	M3	7.75
4	M4	7.64
5	M5	7.56

TABLE NO.2 COMPERSIVE STRENGTH TEST

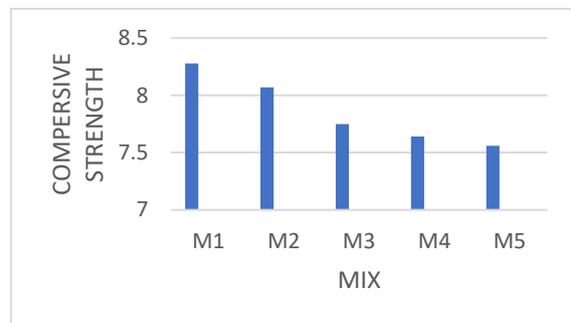


FIG NO.2 COMPARISION OF COMPRESSIVE STRENGTH TEST

3.2 SPLIT TENSILE STRENGTH TEST

To determine the split tensile strength of concrete of given mix proportions. Compression testing machine weighing machine mixer, tamping rods. The tensile strength is one of the basic and important properties of the concrete. The concrete is not usually expected to resist the direct tension because of its low tensile strength and brittle nature However, the determination of tensile strength of concrete is necessary to determine the load at which the concrete members may crack. The cracking is a form of tension failure

S.NO	MIX	7 DAYS (N/mm ²)
1	MI	1.28
2	M2	1.10
3	M3	0.96

TABLE NO.3 SPLIT TENSILE STRENGTH TEST

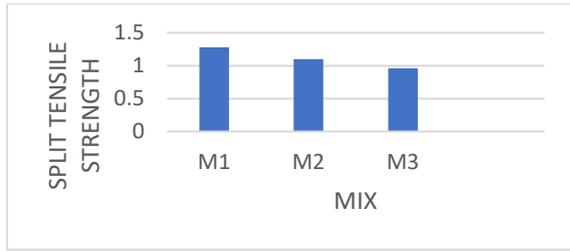


FIG NO.3 COMPARISION OF SPLIT TENSILE STRENGTH

3.3 PERMRABILITY TEST

The cube is fixed in the feet of height of simply supported condition and the water is made to flow through of cube and collected at bottom of cube are infiltrate to the water to collect in the bucket. For the cube of Mix MI, water is applied until the percolation is fulfilled water start to runoff on the surface of the cube. This floor rate is set constant for testing permeability of all other mixes. The time required to fill the 20-litre capacity bucket for all the five cube various mixes are observed and the flow through cube was determined in lit/sec.

S.NO	MIX	RATE OF FLOW THROUGH SLAB (lit/sec)
1	M1	1.27
2	M2	1.63
3	M3	1.89
4	M4	2.17
5	M5	2.56

TABLE NO.4 PERMEABILITY TEST

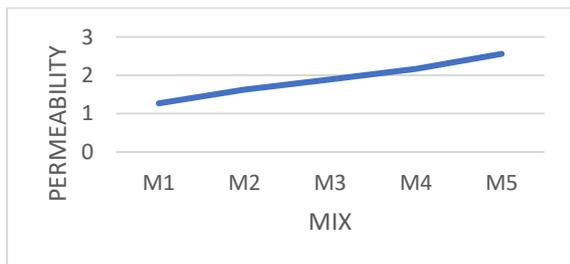


FIG NO.4 COMPARISION OF PERMEABILITY

3.4 PERCENTAGE OF VOID TEST

Percentage of voids is found by following procedure. The test was carried out by immersing the pervious concrete cube to the bucket of water filled to the top level of bucket and the volume of expelled water is collected in another tray. Now volume of water is measure it can be calculated to m3.

S.NO	MIX	PERCENTAGE OF VOIDS (%)
1	M1	26.09

2	M2	26.33
3	M3	26.56
4	M4	27.42
5	M5	28.02

TABLE NO.5 VOID TEST

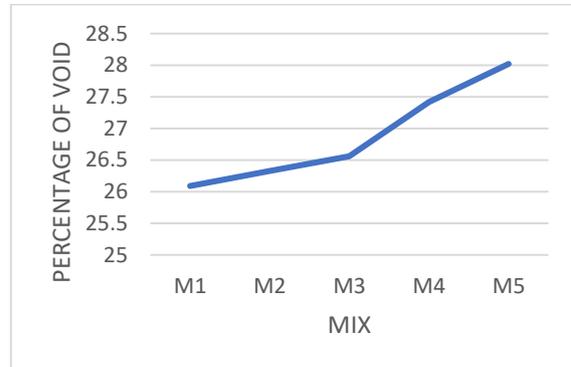


FIG NO.5 COMPARISION OF VOID TEST

IV. CONCLUSION

The following conclusions are made from the experimental investigation in present thesis:

The mechanical properties of pervious concrete such as compressive strength, split tensile and flexural strength reduces with an increasing partial replacement of coarse aggregate by pebble stone. Particularly compressive strength of mix M1, M2, M3, M4 and M5 are the values 8.28 N/mm², 8.07 N/mm², 7.75 N/mm², 7.64 N/mm², 7.56 N/mm² respectively.

M5 results (100% replacement) maximum reduction in strength up to 41% when compared with M1 mix (0% replacement).

Percentage of voids found that to be increased with increasing coarse aggregate.

Permeability is increasing with increase in replacement. M5 (100% replacement) mix gives maximum permeability which is 61% higher than M1 mix (0% replacement).

Hence, we are recommending to replace the conventional coarse aggregate with the pebble stone from 30% to 40% since it gives tolerable reduction in compressive strength when compared with M5 Mix and also results considerable increase in permeability.

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