Experimental Study of Pervious Concrete

Ankit Badriprasad Agrawal[1], Atharva Amol Upasani[2], Hagawane Srushti Vilas[3], Chaitanya Deepak Bharaskar[4], Vijay Ishwar Kotambe[5], Omkar Navanath pasalkar[6]

[1, 2, 3, 4, 5, 6] Dept of Civil Engineering

[1, 2, 3, 4, 5, 6] Zeal Polytechnic, Narhe, Pune-411041

Abstract- *Pervious concrete is a special type of concrete with a high porosity used for concrete flatwork applications that allows water from precipitation and other sources to pass directly through, thereby reducing the runoff from a site and allowing groundwater recharge. It is also called as porous concrete, permeable concrete, no fines concrete and porous pavement. Pervious concrete is made using large aggregates with little to no fine aggregates. The concrete paste then coats the aggregates and allows water to pass through the concrete slab.Pervious concrete also finds its effective application in low loading intensity parking pavements, footpaths, walkways and highways. The pervious concrete is considered as an Environmental Protection Agency (EPA) for providing pollution control, storm management and suitable development. It is a composite material produced by mixing cement, inert matrix of sand and gravel or crushed stone. This concrete has a light color and open-cell structure because of which they do not absorb heat from the sun; they also do not radiate the heat back into the atmosphere, which reduces heating in the environment. Pervious concrete has low installation costs. In addition, it filters the storm water thus reducing the number of pollutants entering the rivers and ponds. Pervious concrete also improves the growth of trees.*

Pervious Concrete pavement is a new technique in Pavement construction. Through this technique we can find a solution for the low ground water level, effective management of storm water runoff, Agricultural problems, etc. Permeable concrete can be introduced in low traffic volume areas, walk ways, sub base for concrete pavements, inter locking material etc. Permeable concrete as a paving material have the ability to allow water to flow through itself to recharge ground water level and minimize surface storm water runoff. This property of porous concrete reviews its applications and engineering properties, including environmental benefits, strength and durability. By replacing a part of cement with conplast SP430, then it results the more strength to the concrete. Hence it acts as an eco-friendly paving material.

Keywords- Pervious concrete, Mix proportion, Permeability, porosity.

I. INTRODUCTION

Concrete is a composite material composed mainly of water, aggregate, and cement. The desired physical properties of the finished material can be achieved by including additives and reinforcements in the mixture. A fluid mass that is easily molded 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 thepantheon is the World's largest unreinforced concrete. After the collapse of Roman

Although high strength concrete is often considered relatively as a new material, 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 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 nomimal-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.

Permeable concrete is nothing but no fines concrete, which is also known as porous, gap graded or permeable concrete mainly consists of normal Portland cement, CA, water. In which FA are not existent or present in very small amount i.e. < 10% by weight of the total aggregates. Permeable concrete pavement is an unique effective means to address the important environmental issues which support green and sustainable growth

II. LITERATURE SURVEY

Nowadays, large amount of plastic bottles are wasted and disposed every day. People are thrown away them without considering that what those plastic bottles can have impact on the humans and/or environment. Andreas Froese,the founder of Eco-Tec Environmental Solution, in searching for finding an inventive solution to junk, established the innovation of building plastic bottle houses

2.1 Permeable Concrete for drainable concrete bases - Journal of Transportation Engineering, Vol. 121, No. 3, May/ June 2004 C. A Rapp[2] Permeable concrete is gaining acceptance for use as a pavement base course. As shown in Figure 1, this material produces a finished base course that is highly porous but stable. These properties produce three benefits: The material's drainable nature protects the primary pavement from harmful effects of surface and subsurface water. Strength and durability of permeable concrete provide a highly protective cover over the aggregate base and a strong working platform for placing concrete pavement. Ease of construction is a significant cost and scheduling factor. The material can also be used for erosion control on side slopes and in paving ditches. In this usage it reduces runoff by allowing water percolation but still prevents soil erosion.

2.2 Permeable concrete pavement permitting – Land Development Volume 1 No. 8 August 2005 - M. Offenberg[3] Permeable concrete is one of the hottest topics in the world of land development today. It is not a new technology, but it's a technology that is being embraced in a world of sustainable development and expensive land. If you've never seen it before, it looks like pavement made out of a big, gray Rice Krispies treat. In technical terms, it is a concrete manufactured without fine aggregate. This creates a void structure in the concrete that allows stormwater to pass through at incredibly high rates — on the order of 500 inches per hour. As a developer, you're probably thinking and wondering how many wonderful ways you can use this on your new site.

2.3 Effect of compaction energy of permeable concrete - M.Suleiman J.kevern(2006)[3] This paper summarizes a study performed to investigate the effects of compaction energy on permeable concrete void ratio, compressive strength, tensile strength, unit weight, and freeze- thaw durability. Laboratory results show that compaction energy affects permeable concrete compressive strength, split tensile strength, unit weight and freeze-thaw durability.

2.4 Field performance of permeable concrete - concrete technology forum K.Wang (2016)[4] This paper describes the current state of practice in permeable concrete placement methods

2.5 Porous Pavement – The Overview Porous Pavement Book 2008 B. Ferguson[5]Eight years of research have recently concluded with the first comprehensive review of porous pavement technology and applications resulting in the book, Porous Pavement, authored by Bruce Ferguson. It defines nine families of porous paving material each of which has distinctive costs, maintenance requirements, advantages and disadvantages for different applications, installation methods, sources of standard specifications, and performance levels.

2.6 Clogging in Permeable Concrete – Journal of Environmental Management May2017 M. F. H) [6]On the campus of Auburn University, architecture and construction students are working side by side with university facilities personnel as they learn by building with permeable concrete. Since the fall of 2003, six permeable concrete slab projects have been successfully built including: a sidewalk, a parking lot, a paved picnic area, and colored permeable arboretum walking trails. Each new project has been filled with learning opportunities as students and workers have experimented with the materials and application techniques of permeable concrete.

2.7 Chindaprasirt P., Hatanaka s., "Cement paste characteristics and porous concrete properties", Construction and Building Materails, vol. No. 22, 2008, [7]Improvement in properties of porous concrete using fiber - International Research Permeable concrete is a different type of concrete with highly porous structure used for concrete flatwork applications that allow water from precipitation and other sources to pass directly through, this reducing the runoff from a site and allowing recharging ground water. This porosity is attained by a highly interconnected void content. In previous concrete, the amount of fine aggregate is little or no fine aggregate such as sand, because of that it is referred as "No fine or less fine concrete". The use of permeable concrete is significantly increasing due to reduction of road runoff and absorption of noise. This concrete is being used as paving material in the United States for the construction of parking lots, sidewalks and secondary roads. The production of better quality permeable concrete is necessary to meet specification requirements for the construction of durable permeable concrete pavements.

2.8 Performance and Manufacturing of permeable concrete – International Journal of Modern trends and research 2017 Parvez Choudhary, Dr. Bharat Nagar, Mukesh Chaudhary[8]Permeable concrete which is also called permeable concrete, no fines concrete, and porous flatwork applications that allows water from rainfall and other sources to pass directly through and thereby reducing runoff from a site and allowing groundwater recharge. Permeable concrete is made using large coarse aggregates with little to no fine aggregates. The concrete paste then Coates the aggregates and allow the water to pass though the concrete slab

2.9 Installation of permeable concrete – RMC Research and Education Foundation August2017 - C.Wolfersberger[9]Permeable mixture suppliers must employ high quality control. Permeable mixes contain Portland cement, a nominal 3/8" or larger, Florida lime rock aggregate, admixtures and minimum water as designed. In some locations, granite may be substituted. Almost all fine aggregate is eliminated from the mix to provide the necessary voids to allow the penetration of water. Typically, permeable concrete has about 70% of the density of standard concrete paving mixtures.

2.10 Compressive Strength of permeable concrete pavement RMC Research andEducation Foundation August 2017 A.M.Mulligan[10]The permeable concrete system and its corresponding strength are as important as its permeability characteristics. The strength of the system not only relies on the compressive strength of the permeable concrete but also on the strength of the soil beneath it for support. Previous studies indicate that permeable concrete has lower compressive strength capabilities than conventionalconcrete and will only support light traffic loadings. This thesis investigated prior studies on the compressive strength on permeable concrete as it relates to water-cement ratio, aggregate-cement ratio, aggregate size, and compaction and compare those results with results obtained in laboratory experiments conducted on samples of permeable concrete cylinders created for this purpose.

2.11 Studies on characterization of permeable concrete Conference of transportation group of India 2017 M.Uma Maguesvari, V.L. Narasimha[11]This study illustrates angularity number, which influence properties and behavior of permeable concrete with fine aggregate and coarse aggregates. It is observed that the increase in fine aggregate results in reduction of volume of voids which in turn increase of compressive strength, flexural strength and split tensile strength. Angularity number is more for higher size aggregate and which is reduced when size of aggregate reduces.

2.12 Study the effect of silica fumes on permeable concrete – International Journal of Engineering Research and Technology 2020 Himanshi Kashyap, Abhishek Singh Rana , Aditya Tiwari[12]Permeable concrete pavements have been placed successfully on slopes up to 16%. In these cases, trenches have been dug across the slope, lined with 6-mil visqueen, and filled with rock (CCPC 2003). Pipes extending from the trenches carry water traveling down the paved slope out to the adjacent hill side. The high flow rates that can result from water flowing down slope also may wash out sub grade materials, weakening the pavement. Use of soil filter fabric is recommended in these cases.

2.13 Review of permeable pavement systems- Building and Environment 42 (2007) 3830–3836 2006 Miklas Scholz, Piotr Grabowieck[13]The purpose of this review paper is to summaries the wide-range but diffuses literature on predominantly permeable pavement systems (PPS), highlight current trends in research and industry, and to recommend future areas of research and development. The development of PPS as an integral part of sustainable drainage systems is reviewed in the context of traditional and modern urban drainage. Particular emphasize is given to detailed design, maintenance and water quality control aspects. The most important target pollutants are hydrocarbons, heavy metals and nutrients (i.e. nitrogen and phosphorus). The advantages and disadvantages of different PPS are discussed with the help of recent case studies. Thelatest innovations are highlighted and explained, and their potential for further research work is outlined. Recent research on the development of a combined geothermal heating and cooling, water treatment, and recycling pavement system is promising.

2.14 M. Admute, A. V. Gandhi, S. S. Adsul, A. A. Agarkar,(April-2017),"PermeablePavements: New Technique For Construction Of Road Pavements in India"[14]In this paper they summarize literature on permeable pavements, highlight current trends in research and industry, and to recommend future areas of research and development. Permeable pavements have a base and sub base that allow the movement of storm water through the surface and hence reduce runoff, this effectively traps suspended solids and filters pollutants from the water. Permeable pavement control storm water at the source, reduce runoff, reduce cost and improve water quality by filtering pollutants in the substrata layers and increase subsurface water level.

2.15 Jeet Yadu(2016)"Permeable Pavement & its Application- A Case Study"[15]He summarized literature on study of construction and application of such a pavement which is permeable in nature. The problem related to scarcity of water arriving due to increasing area of paved surfaces has been considered. A detailed study has been made in Raipur city and views are focused in the direction of water conservation through enhancing the ground water recharge. It also deals with the advantages and disadvantages of this pavement system. Permeable pavement are not so complex and are easy to install ,they have many advantages like ground water recharging, storm water management and applications of permeable pavement is depends on various aspects such as climate ,area of application, traffic volume and load.

2.16 Stephen.A.Arhin, Rezene, Wasi Khan,(December-2014),"Optimal Mix Design forPrevious Concrete for Urban Area"[16]In this paper they developed and tested five design mixes of previous concrete to identify the appropriate mix which provided the maximum compressive strength with acceptable permeability rate and flexural strength for the district of Colombia. They conducted five designs mixes using three different types of compaction method such as self-consolidating, half ridding, and standard proctor hammer. They concluded that, the standard Proctor Hammer

2.17 Darshan S. Shah, "Water absorbing ConcreteNew Era For Rural Road Pavement"(Issued on 8th, August 2014) [17]The above paper statesstudy on using permeable concrete as road construction material relatively new concept for rural road pavement, with increasing problem in rural areas related to low ground water level, agriculture problem. His report focus on pavement application of concrete which also has been referred on permeable concrete, permeable concrete, no fine concrete , gap graded concrete and enhanced porosity concrete.].

III. RRESEARCH DEVELOPMENT

Permeable concrete pavement is a unique effective means to address the important environmental issues which support green and sustainable growth.In general, for making porous concrete, we will use the aggregates of size which passes through 12.5mm sieve and retained on 10mm sieve. In this project we have taken single size aggregates i.e 12.5mm. the single size aggregates make a good no-fines concrete, which addition to having large voids and hence light in weight, also offers architecturally attractive look.

3.1. MATERIALS

Permeable concrete uses same materials as conventional concrete, except that there are usually No or little fine aggregates. The size of the coarse aggregate used is kept fairly uniform in size (most common is 3/8 inch) to minimize surface roughness and for a better aesthetic, however sizes can vary from ¼ inch to ½ inch. Water to cement ratio should be within 0.27 to 0.34. Ordinary Portland cement and blended cements can be used in permeable concrete. Water reducing admixtures and retarders can be used in permeable concrete.

3.1.1 CEMENT:

Ordinary Portland cement is the most common type of cement in general use around the world as a basic ingredient of concrete, mortar, stucco, and most non-specialty grout. It developed from other types of hydraulic lime in England in mid-19th century and usually originates from limestone. It is a fine powder produced by heating materials to form clinker. After grinding the clinker we will add small amounts of remaining ingredients. Many types of cements are available in market. The colour of OPC is grey colour and by eliminating ferrous oxide during manufacturing process of cement we will get white cement also.
Ordinary Portland Cement of 53 Grade of brand name Ultra Tech Company, available in the local market was used for the investigation. Care has been taken to see that the procurement was made from single batching in air tight containers to prevent it from being effected by atmospheric conditions. The cement thus procured was tested for physical requirements in accordance with IS: 169-1989 and for chemical requirement in accordance IS: 4032-1988. The physical properties of the cement are listed in Table –1

Table-1 Properties of cement

Sr. No	Properties	Test results	IS: 169-1989
1	Normal consistency	0.32	--
2	Initial setting time	60min	Min of 30min
3	Final setting time	320min	Max of 600min
4	Specific gravity	3.14	
5	Compressive strength		
6	3days strength	29.4Mpa	Min of 27Mpa
7	7days strength	44.8Mpa	Min of 40Mpa
8	28days strength	56.53Mpa	Min of 53Mpa

3.1.2FINE AGGREGATES:

Sand is a natural granular material which is mainly composed of finely divided rocky material and mineral particles. The most common constituent of sand is silica(silicon dioxide, or SiO_2), usually in the form of quartz, because of its chemical inertness and considerable hardness, is the most common weathering resistant mineral.Hence It is used as fine aggregate in concrete. River sand locally available in the market was used in the investigation. The aggregate was tested for its physical requirements such as gradation, fineness modulus, specific gravity in accordance with IS: 2386-1963.The sand was surface dried before use.

Table-2 Properties of fine aggregates

Sr. No	Perticulars	Values
1	Fineness modulus	2.4
2	Specific Gravity of fine aggregate	2.55
3	Free moisture	2%

3.1.3COARSE AGGREGATES:

Crushed aggregates of less than 12.5mm size produced from local crushing plants were used. The aggregate exclusively passing through 12.5mm sieve size and retained on 10mm sieve is selected. The aggregates were tested for their physical requirements such as gradation, fineness modulus, specific gravity and bulk density in accordance with IS: 2386- 1963. The individual aggregates were mixed to induce the required combined grading. the particular gravity and water absorption of the mixture are given in table.

Sr. No	Perticulars	Values
1	Specific Gravity of coarse aggregate	2.6
2	Water absorption	1%

3.1.4 WATER :

Water plays a vital role in achieving the strength of concrete. For complete hydration it requires about 3/10 th of its weight of water. It is practically proved that minimum water-cement ratio 0.35 is required for conventional concrete. Water participates in chemical reaction with cement and cement paste is formed and binds with coarse aggregate and fine aggregates. If more water is used, segregation and bleeding takes place, so that the concrete becomes weak, but most of the water will absorb by the fibers. Hence it may avoid bleeding. If water content exceeds permissible limits it may cause bleeding. If less water is used, the required workability is not achieved. Potable water fit for drinking is required to be used in the concrete and it should have pH value ranges between 6 to 9.

3.1.5 ADMIXTURES:

Admixtures means a material, apart from cement, water Associate in Nursingd aggregates that's used as an ingredient of concrete and is extra to the batch straight off before or throughout mix. Additive is a material which is added at the time of grinding cement clinker at the cement factory.For modifying the mix properties the chemicals that are added to the concrete mix. These should never be considered as a substitute for good mix design, for workmanship, or use of good materials.

IV. METHODOLOGY

This chapter deals with the various mix proportions adopted in carrying out the experiments and experimental results obtained with respect to their workability, permeability, compressive strength, split tensile strength , flexural strength and durability test.

4.1 MIX DESIGN OF CONCRETE

The strength is mainly influenced by water cement ratio, and is almost independent of the other parameters the properties of concrete compressive strength is influenced by the properties of aggregate in addition to that of water cement ratio. To obtain good strength, it is necessary to use the lowest possible w/c ratio which affects the workability of the mix. In the present state of art, concrete which has a desired 28days compressive strength of minimum 15Mpa, 20Mpa, 25Mpa can be made by suitable proportion of the ingredients using normal methods for compacting the mixes?

Table 4.1 Stipulations for Proportioning

Maximumsizeof aggregate	12.5mm
Specificgravityofcement	3.14
Specificgravityoffine aggregates	2.55
Specificgravityofcoarseaggregates	2.6
Finessemodulusof fine aggregates	2.4
Waterabsorptionofcoarseaggregates	1%
Freemoisturein coarseandfineaggregates	Niland2%
Typeofcement	OPC53grade

Table 4.2 Mix Design for M20 Grade Concrete

Sr. No	Ingredients	Weight kg/m3	Absolute volume(cm^{3})	
1	Cement	380	(380/3.14) x10^{3}	=120.6x10^{3}
2	Water	190	(190/1)x10^{3}	=190x10^{3}
3	Coarse Aggregates	1125.6	(1125.6/2.6) x10^{3}	=432.92x10^{3}
4	Air	4	(4/100) x10^{6}	= 40 x103

4.2CASTING PROCEDURE

4.2.1Mixing:

- Mix the cement and coarse aggregate on a water tight none-absorbent platform until the mixture is thoroughly blended and is of uniform color
- Add the conplast SP430 in water and stir properly and pour into cement and coarse aggregate mixture.

- Mix it until the concrete appears to be homogeneous and of the desired consistency.

Fig. 4.2.1 Concrete Mixing.

4.2.2Casting/Sampling:

- Clean the mounds and apply grease.
- Fill the concrete in the moulds in 3 equal layers
- Compact each layer with not less than 35strokes per layer using a tamping rod (steel bar 16mmdiameter and 60cm long, bullet pointed at lower end)
- Level the top surface and smoothen it with a trowel compaction of permeable concrete with tamping rod.

Fig. 4.2.2 Casting and Sampling

4.2.3. Curing of Specimens:-

The test specimens are stored in moist air for 24hours and after this period the specimens are marked and removed from the moulds and kept submerged in clear fresh water until taken out prior to test.

Fig. 4.2.3 Curing of Specimens

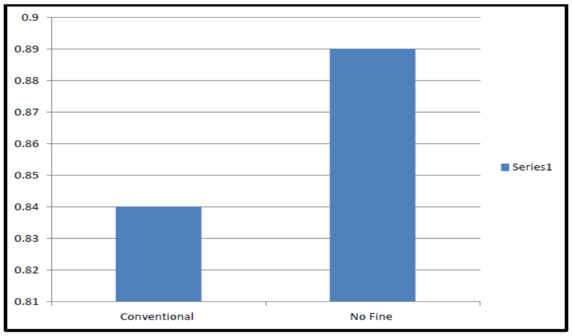
V. TEST RESULTS AND DISCUSSION

5.1 WORKABILTY:

Results obtained from compaction factor test showing that the workability of concrete.

Table-5.1.1 Compaction factor for conventional concrete and No fines concrete

Grades Of Concrete	Compaction Factor	
	Conv. Concrete	No Fines Concrete
M20	0.84	0.89



Fig–5.1 Workability variation of conventional and Pervious concrete for different grades

5.2 COMPRESSIVE STRENGTH:

Grades of Concrete	Compressive Strength(N/Mm)			
	Cured In Water		Cured In Mgso4	
	7 Days	28 Days	7 Days	28 Days
M20	14.98	20.79	12.82	18.74

Table-5.2.1 Compression strength of No fines concrete cubes cured in water

Grades of Concrete	Compressive Strength(N/Mm)			
	Cured In Water		Cured In Mgso4	
	7 Days	28 Days	7 Days	28 Days
M20	17.26	25.44	15.6	24.03

Table-5.2.2 Compression strength of conventional concrete cubes cured in water

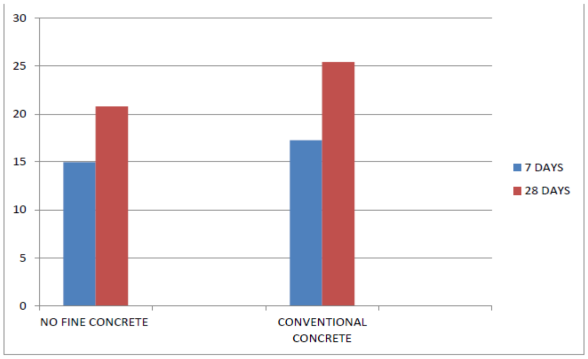


Fig 5.2 Seven and twenty eight days split tensile strength variation of conventional And No fines concrete cured in water.

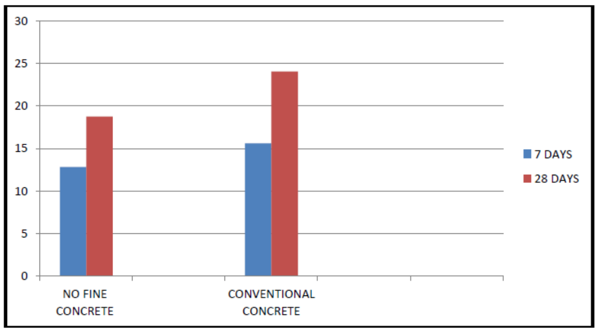


Fig. 5.3 Seven and Twenty eight days compressive strength variation of conventional And No fines concrete cured in MgSo4.

5.3 TENSILE STRENGTH:

Grades of Concrete	Split TensileStrength(N/Mm)			
	Cured In Water		Cured In Mgso4	
	7 Days	28 Days	7 Days	28 Days
M20	1.17	1.57	1.04	1.39

Table-5.3.1 Split tensile strength of No fines concrete cubes cured in water and cured in MgSo4.

Grades of Concrete	Split Tensile Strength(N/Mm)			
	Cured In Water		Cured In Mgso4	
	7 Days	28 Days	7 Days	28 Days
M20	3.19	4.7	2.93	3.99

Table-5.3.2 Split tensile strength of conventional concrete cubes cured in water and cured in MgSo4

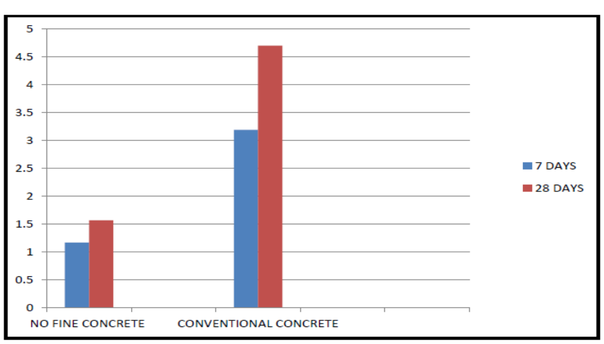


Fig-5.3.1 Seven and Twenty Eight Days split tensile strength variation of conventional and No fines concrete cured in water

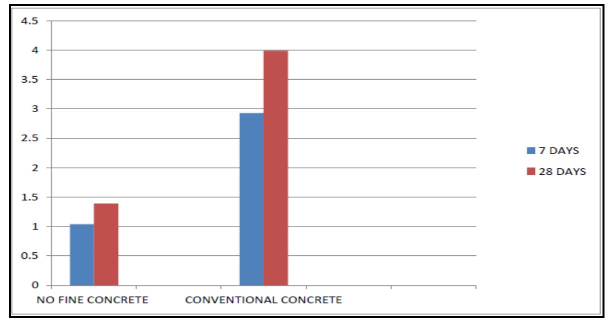


Fig-5.3.2 Seven and Twenty eight days split tensile strength variation of conventional And No fines concrete cured in MgSo4

5.4FLEXURALSTRENGTH:

Grades of Concrete	Flexural Strength(N/Mm)			
	Cured In Water		Cured In Mgso4	
	7 Days	28 Days	7 Days	28 Days
M20	6.68	7.36	6.09	7.06

Table-5.4.1 Split tensile strength of No fines concrete cubes cured in water and cured in MgSo4.

Grades of Concrete	Flexural Strength(N/Mm)			
	Cured In Water		Cured In Mgso4	
	7 Days	28 Days	7 Days	28 Days
M20	8.44	10.12	7.32	9.55

Table-5.4.2 Split tensile strength of conventional concrete cubes cured in water and cured in MgSo4

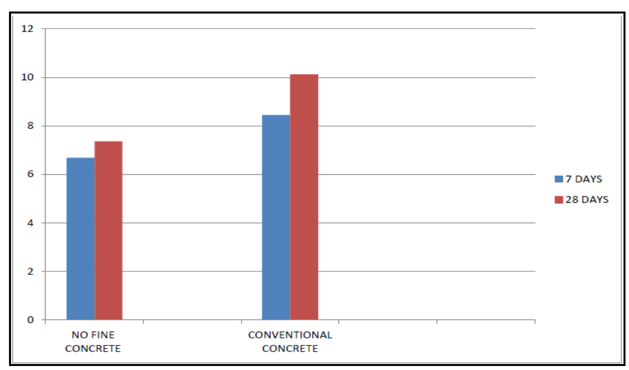


Fig-5.4.1 Seven days and Twenty Eight days flextural strength variation of conventional And No fines concrete cured in water

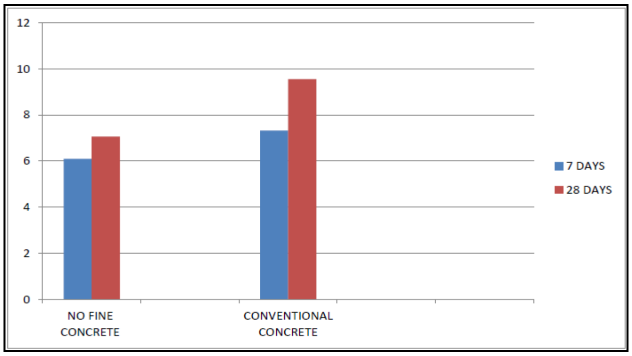


Fig-4.5.2 Seven and Twenty eight days flextural strength variation of conventional And No fines concrete cured in MgSo4

VI. CONCLUSION

The following conclusions are drawn based on the experimental investigations on compressive strength, split tensile, flexural, durability, permeability considering the environmental aspects‖ also:

- Pervious concrete has less strength than conventional concrete by14.5% for M20.
- 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.
- Further, no fines concrete is an environmental friendly solution to support sustainable construction. In this project, fine aggregates as an ingredient has not been used. Presently, there is an acute shortage of natural sand all around. By making use of FA in concrete, indirectly we may have been creating environmental problems. Elimination of fines correspondingly decreases environment related problems.
- In many cities diversion of runoff by proper means is complex task. Use of this
- concrete can effectively control the run off as well as saving the finances invested on the construction of drainage system. Hence, it can be established that no fines concrete is very cost effective apart from being efficient.

VII. ACKNOLEDGEMENT

We express our deep sense of admiration and gratitude to our project guide Prof. Ankit B. Agrawal, Lecturer, Department if Civil Engineering, Zeal Polytechnic, Narhe, Pune, for his invaluable encouragement, helpful suggestions and supervision throughout the course of this work. His willingness, patience and optimistic attitude could lead to completion of this research work. We are also thankful to Prof.Prashant L. Jadhav (H.O.D, Civil Engineering Department) for his moral support.

I also express my thankfulness to the encouragement from Prof. A. A. Tamboli (Principal, Zeal Polytechnic, Narhe, Pune faculty members of Zeal Polytechnic, Narhe, Pune , for their valuable suggestions from time to time.

I am thankful to the Liberians of Zeal Polytechnic, Narhe, Pune for their cooperation in the initial phase of our project. Among the supporters, and all teaching and non-teaching staff deserves special thanks. The experimental work would not have been possible without their kind cooperation.

Lastly but not the least, I do acknowledge the loving support, cooperation that came from family members, relatives to see the completion of this work.

REFERENCES

[1] Permeable Concrete for drainable concrete bases - Journal of Transportation Engineering, Vol. 121, No. 3, May/ June 2004 C. A Rapp

[2] Pervious concrete pavement permitting – Land Development Volume 1 No. 8 August 2005 - M. Offenberg

[3] Effect of compaction energy of pervious concrete - M.Suleiman J.kevern(2006)

[4] Field performance of pervious concrete - concrete technology forum K.Wang (2016)

[5] Porous Pavement – The Overview Porous Pavement Book 2008 B. Ferguson

[6] Clogging in Permeable Concrete – Journal of Environmental Management May 2017 M. F. Hein

[7] Li X, Xu Q, Chen S. An experimental and numerical study on water permeability of concrete [J].Construction & Building Materials, 2016, 105:503-510.

[8] Performance and Manufacturing of pervious concrete – International Journal of Modern trends and research 2017 Parvez Choudhary , Dr. Bharat Nagar and Mukesh Chaudhary

[9] Installation of pervious concrete – RMC Research and Education Foundation August 2017 - C.Wolfersberger Pervious mixture suppliers
[10] Compressive Strength of pervious concrete pavement RMC Research and Education Foundation August 2017 A.M.Mulligan
[11] Studies on characterization of pervious concrete Conference of transportation group of India 2017 M.Uma Maguesvari, V.L. Narasimha
[12] Study the effect of silica fumes on pervious concrete – International Journal ofEngineering Research and Technology 2020 Himanshi Kashyap , Abhishek Singh Rana , Aditya Tiwari
[13] Review of permeable pavement systems- Building and Environment 42 (2007) 3830–3836 2006 Miklas Scholz, Piotr Grabowieck
[14] M. Admute, A. V. Gandhi, S. S. Adsul, A. A. Agarkar,(April-2017),"Permeable Pavements: New Technique For Construction Of Road Pavements in India"
[15] Jeet Yadu(2016)"Permeable Pavement & its Application- A Case Study"
[16] Stephen.A.Arhin, Rezene, Wasi Khan,(December-2014),"Optimal Mix Design for Previous Concrete for Urban Area"
[17] Darshan S. Shah, "Water absorbing Concrete