International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 05 Issue: 06 | June - 2021 ISSN: 2582-3930

STUDY OF STRENGTH CHARACTERISTICS OF PERVIOUS CONCRETE CONSTITUTING OF PARTIALLY REPLACED AGGREGATES UTILIZING THE OAT MIX DESIGN METHOD

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ABSTRACT

Pervious concrete have special advantages and limitations over the normal conventional concrete. Using of Pervious concrete as a pavement surface layer for its superior drainage ability characteristic is making pervious concrete mixes a priority indamp regions and regions with high rainfall insities. There has always been a continuous research on recycled aggregates in concrete structures by varying different percentages of recycled aggregates as per the design and use of the structure. This study includes the replacement of aggregates with recycled aggregates partially i.e. 20% and 40% in pervious concrete. Therefore a few laboratory tests are performed on the mix designs and the comparative graphs are plotted for identical overview of recycled aggregates in pervious concrete mix.

Key words: Octagonal Array Test (OAT), MORTH, IRC, Pervious, Partially, recycledaggregates.

CHAPTER 1

INTRODUCTION

1.1 General

Analysts, architects and manufacturers are continually looking fr›r better than ever approaches to secure nature during advancement in the best manners conceivable. One rising innovation is the utilization of permeable materials, for example, pervious concrete as an elective material for surfaces in low rush hour gridlock zones.

Human progress started and created around waterway banks. Things were reasonable at those occasions as people lived in congruity with nature. Industrialization made a huge difference. Toward the finish of the l9th century the modern upset saw the ascent of the universe of customers. Concentrated populace pacltets created at and around mechanical region. Fast Urbanization measure presented numerous difficulties before arranging specialists. Government, neighborhood organization is attempting their level best to give all fundamental pleasantries to this populace. At the same time, one troublesome test before organization is to oversee squander created by this enormous populace. Strong waste age is a ceaselessly developing issue at worldwide, provincial and nearby levels.

Development and destruction squander is created at whatever point any development/destruction activity happens. It comprises generally of latent and non- biodegradable material, for example, solid, mortar, metal, wood, plastics and so forth. An aspect of this waste comes to the civil stream. It is assessed that the development business in India creates around 10-12 million tons of waste yearly. Projections for building material prerequisite of the lodging division show a deficiency of totals to the degree of around 55,000 million cu.m an extra 750 million cu.m totals would be required for accomplishing the objectives of the street segment. Reusing of total material from development and destruction waste may lessen the request supply hole in both these parts.

These squanders are weighty, having high thickness, frequently massive and consume extensive extra room either out and about / public waste compartment. It isn't unprecedented to see enormous heaps of such waste, which is weighty too, stacked on streets particularly in huge tasks, bringing about gridlock and interruption. Squander from little generators like individual house development or destruction, discover its way into the close by city container/tank/squander capacity stations, making the city squander hefty and corrupting its quality for additional treatment like fertilizing the soil or vitality recuperation. Regularly it discovers its way into surface channels, stifling them. It establishes around 10-20 % of the metropolitan strong waste (barring enormous development ventures).

While retrievable things, for example, blocks, wood, metal, titles are reused, the solid and stone work squander, representing over half of the loss from development and destruction exercises, are not being presently reused in India.

Cement and stone work waste can be reused by arranging, smashing and sieving into reused total. This reused total can be utilized to make concrete for street development andbuilding material. Work on reusing of totals has been done at Central Building Research Institute (CBRI), Roorkee, and Central Road Research Institute (CRRI), New Delhi

1.2 Pervious Concrete

Pervious cement is a blend of Portland concrete, uniform coarse aggregate, with both a modest quantity of or without fine aggregate, and water. Fitting measures of water and cementitious material are utilized to make a glue that shapes a slight coat around total particles yet leaves free spaces between them. Accordingly, poresare framed in the pervious materials.

Water/cement proportions somewhere in the range of 0.27 and 0.30 are utilizedregularly with legitimate incorporation of compound admixtures, and those as high as
0.35 to 0.42 have been utilized effectively. The connection among quality and water/cement portion isn't clear for pervious concrete, in light of the fact that dissimilar to ordinary cement, the all out glue content is not exactly the voids content between the totals. New pervious cement is normally firm, with low usefulness contrasted with ordinary cement. Slump values are typically under 20 mm. For quality control and quality confirmation, unit weight or mass thickness is liked.

Pervious solid blend is stiffer when contrasted with ordinary cement. The pores can go from 2 to 8 mm, and the void substance generally goes from 15% to 25% with compressive qualities of 2.8 MPa to 28 MPa. Notwithstanding, qualities of 2.8 MPa to 10 MPa are all the more ordinarily utilized. The depleting pace of pervious concrete will differ with total size and thickness of the blend however will by and large fall inside the scope of 81 to 730 liters/minute/m2. A significant issue of concern is the stopping up of the pores with time. It is suggested that pervious concrete be cleaned normally either through vacuum cleaning or high weight washing. Figure 1.1. gives a photo of pervious concrete and 1.2. shows the pervious cement contrasted and the ordinary cement

Figure 1.1 Pervious concrete

Figure 1.2 Pervious concrete compared with the conventional concrete

1.3 Merits of Using Pervious Concrete

1.3.1 Environmental Benefits

Pervious cement permit the water to revive the underground water flexibly and channel water to tree roots. Storm water is one of the main sources of poisons entering streams. Pervious cement decrease overflow by putting away a huge volume of water inside the pavement until it saturates into the ground. The vast majority of the pollutants are conveyed by the initial 12 to 25 mm of downpour. Since this underlying water is contained inside the pavement it diminishes the amount of contaminated water from arriving at the streams.

Pervious concrete are light in shading, which assists with decreasing the ground level ozone by bringing down the temperatures in and around significant urban communities. This is attainable because of the open cell structure of the solid, which doesn't assimilate and store heat and later transmit it once again into the condition the manner in which black-top surfaces do. The open structure additionally draws on the cooler earth temperatures underneath the pavement to hold the pavement temperatures down. The Pervious concrete permit the water to energize the underground water flexibly and channel water to tree roots.

1.3.2 Economical Benefits

There is lower establishment costs related with the utilization of pervious concrete in light of the fact that the requirement for underground piping and storm water drains are eliminated. No significant earthworks are required since the pavement needn't bother with incline to canals and depletes for satisfactory water control strategies. The framework doesn't need the overhauling of existing storm water sewerframeworks, as there is practically no overflow.

Pervious concrete pavements effectively double as a storm water management system and eliminate the need to buy extra land for maintenance bowls, as the pavement functions as one. This assists engineers with amplifying their benefits and use the land all the more productively.

The underlying expenses of pervious solid pavements are higher than those for traditional solid pavements. This is because of two factors, the materials utilized are marginally more costly and the expanded thickness of the pervious solid pavement contrasted with regular pavements. Be that as it may, in the long haul, pervious solid pavements are more practical.

The pervious cement has another cost sparing advantage regarding the measure of lighting required for the pervious solid pavement. This is because of the light shade of the asphalt, which mirrors light, consequently lessening the establishment and working expenses.

Pervious concrete is a feasible material that has a future like that of customary cement. Effectively developed no-fines pavement ought to have a future of 20 to 40 years and in this manner a lower life-cycle cost, as indicated by the Southern California Mixed Concrete Association.

1.3.3 Other Benefits

Standing water is a typical issue related with solid pavements. This is aggravated by heavy downpour, which makes the pavement surface frictionless . Aquaplaning turns into agenuine risk for vehicles and can make harm to the street clients and public. Pervious concrete doesn't experience the ill effects of these deficiencies since a huge volume of water will be penetrated in a flash into the pavement. The open structure of the pervious pavement causes a distinction in appearance time among immediate and reflected sound waves. This distinction diminishes the commotion level power, making permeable pavements assimilate the sound.

1.4 Limitations of Use of Pervious Concrete

Although pervious concrete is a flexible material ready to be utilized in wideareas, there are times when its utilization is certainly not a feasible decision. Pervious concrete have an unpleasant finished, honeycomb like surface, which comes up short on the high holding quality on the wearing course. Moderate measures of raveling are ordinary with almost no issues except for this turns into a significant issue on profoundly dealtstreets. This problem is being researched with the top 12mm being ground away so the exposed aggregate have stronger bonds with the surrounding material.

Pervious concrete design is of basic significance, as the base of the pavement is needed to hold water until it percolates into the soil without failing. This requires the utilization of storm water the board standards to figure out what happens to thewater once it infiltrates the surface and pervious concrete design standards to plan a pavement structure that is fit for withstanding the inward weights brought about by the water in the pavements.

1.4.1 Clogging of Pervious Concrete Voids

Obstructing of the pervious concrete can happen in zones where water will run from grassed or soil regions and underneath exceptionally vegetated regions. Soil is fit for stopping up the pores and lessening the viability of the concrete. These issues can be decreased or wiped out by right plan and routine support of the pervious concrete.

The support incorporates normal clearing or vacuuming and the expansion of enhancements to help separate natural materials. Pressure washing might be required if the soil has been washed from the surface into the basic material. This system has been appeared to reestablish the concrete to approach new condition.

1.5 Applications of Pervious Concrete

1.5.1 Non-Pavement Applications of Pervious Concrete

Pervious Concrete has various helpful non-pavement applications including structures, tennis courts, depletes and channel tiles, floors in nurseries, yards, incline adjustment, pool decks, zoo zones e.t.c.

Pervious Concrete has been used by European nations in a wide range of building circumstances. It has been utilized for projected set up load-bearing dividers in houses, multi-story and elevated structures, as pre-assembled boards' and steam restored blocks.

A conspicuous utilization of pervious concrete in Europe is in tennis court applications. The main variety from an ordinary blend is the somewhat littler total usedto give a smoother playing surface. The penetrability of the pervious concrete diminishesthe time taken for water to deplete and the surface to be playable.

Water and Power Resources Services in America effectively tried the utilization of channels and channel tiles built from pervious concrete underneath pressure driven structures. This application made it conceivable to lessen the inspire pressureon the structures and to empty ground water out of underneath framework like sewer pipes.

Analysts at Rutgers University utilized pervious concrete as a story surface in a plastic nursery as a major aspect of a sunlight based warming framework. This application gave an appropriate hard surface fit for withstanding the development of hefty gear, while keeping water from ponding on a superficial level and disheartening weed development.

1.5.2 Pavement Applications of Pervious Concrete

Most of pervious concrete applications are parking areas, walkways, pathways, parks, shoulders, channels, commotion obstructions, contact course for interstate pavements, penetrable based under a typical concrete pavement, and low volume streets.

Pervious concrete pavements were created after some accomplishment with openevaluated black-top and their applications in parking areas and administration streets. Open reviewed black-top is a blend of even evaluated total, modest quantities of fines and a bituminous material. This street surfacing has a generally high void proportion, ordinarily running somewhere in the range of 18and 25 percent.

Parking garages are another application for pervious concrete, made utilizing a pervious concrete wearing course and a few fundamental permeable layers. The fundamental permeable layers comprise of three layers changing from a sandy material to a 37 mm total. The essential assignment of the apparent multitude of permeable layers is to go about as a supply for holding water until it pervades into the dirt. This is a compelling technique for controlling water spillover in circumstances where blaze flooding as often as possible happens. The decreased overflow takes out the issues of downstream flooding brought about by conventional impenetrable concretesurfaces.

The utilization of pervious concrete as an edge channel or permeable hard shoulders has been attempted widely in France. Unnecessary elevate pressures created in concrete pavements lead to the improvement of strategies to quickly empty water out of the pavement base.

1.6Other Aspects Pertaining to the Use of Pervious Concrete

Pervious concrete has been as of late brought into the pavement applications. Like any new item there are challenges or vulnerabilities looked by the provider regarding the right circumstances it tends to be applied in and the right laying and compacting methodology. The advantages of pervious solid pavements are not known by the more extensive network and its future isn't completely perceived.

1.6.1 Lack of Experience

The absence of experience existing with the utilization of pervious concrete pavements comes from it being a generally new item. The contrast between the properties of pervious concrete and traditional concrete expects it to be set and compacted in an alternate manner.The low functionality and self-compacting nature of the pervious solid outcomes in just an insignificant measure of rodding and compaction and no vibrating.

The diverse situation and compaction strategies required are not broadly perceived. At the point when these significant methodology are not accurately attempted it can detrimentally affect the quality, appearance and adequacy of the pavement. This can influence the water saturating limit of the pavement , lessening the natural advantagesrelated with its utilization.

1.6.2 Lack of Public Awareness

Before an item is acknowledged and executed by general society, there must be an attention to its advantages. The ecological and financial advantages of the pervious concrete are not yet broadly perceived. Regarding nature, this item can possibly kill the negative effects on the earth related with the utilization of traditional concrete. Pervious concrete can make driving conditions more secure by taking out standing water and the issues relatedwith the absence of hold or grip on streets. In monetary terms, the absence of need of broad earthworks and the redesign of existing sewer frameworks implies setting aside time and cash yet this advantage isn't generally perceived. Designers and mortgage holders would all the more promptly utilize this item if its advantages were announced.

In a general public with an accentuation on supporting nature, greener items ought to be empowered and potentially implemented by the legislature trying to lessen the negative effects related with never-ending complications.

1.7Need for the Study

Eventhough pervious concrete was first utilized in the 19thcentury, it has as of late expanded in prominence. As metropolitan zones grow, the issues related with overflow the board have gotten additionally testing. The attention on the negative ecological impacts related with pavement runoff has likewise expanded. These two issues have prodded the ongoing enthusiasm for pervious solid pavements.

Furthermore, Pervious concrete fulfills the utilitarian prerequisites of pavements and can possibly be utilized as a wearing course. In any case, the low and medium compressive and flexural quality of pervious concrete because of open void structure has limited its basic applications. Henceforth there is a need to methodically consider the expected uses of pervious concrete as an auxiliary component as very few investigations are done in India for nearby conditions and furthermore utilizing neighborhood materials.

1.8Project Objective

The primary target of this examination is to discover quality and penetrability attributes of the pervious solid when ordinary coarse totals are supplanted with reused total (Aggregates held from destruction squander which is squashed to get normal coarse aggregate shape and size).

The targets of the current investigation are:

- To obtain the best result's in trial examinations conducted.
- To set up the connection between compressive quality sections distinctive level ofaggregate (Recycled aggregate) substituted for various blend extents.
- To build up the connection between porousness sections versus diverse level of aggregateswapped for various blend extents.

1.9 Project Scope

The extension is restricted to the utilization of materials picked for the analyses, which are:

- Ordinary Portland concrete 53 grade.
- Locally accessible crushed angular coarse aggregates of most extreme size 20 mm.
- Locally accessible structure destruction waste.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The Orthogonal Array Testing Strategy (OATS) is an orderly, factual method of testing pair- wise connections. It gives agent (consistently appropriated) inclusion of all factor pair blends. This makes the procedure especially valuable for mix testing of programming segments. **Dr. Genichi Taguchi** was one of the primary defenders of symmetrical clusters in test plan. His strategies, known as **Taguchi Methods**, have been a backbone in exploratory planning producing fields for a considerable length of time. Symmetrical clusters are two dimensional varieties of numbers which have the fascinating qualit that by picking any two segments in the exhibit you get an even appropriation of all the pair-wise mixes of qualities in the exhibit. Here is some wording for working with symmetrical exhibits followed by a model cluster in Figure 1 [Sloane2001]:

Will be produced by the OATS procedure.

Runs: the quantity of columns in the cluster. This straight forwardly means the quantity ofexperiments that

Elements: The number orthogonal arrays exhibits were initially found as a mathematical interest bymonks [Copeland2001].The of segments in array

Levels: The greatest number of qualities that can be taken on by any single factor. Aorthogonal array will contain values from 0 to Levels-1.

Strength: the number of columns it takes to see each of the Levels Strength possibilitiesequallyoften. Orthogonal arrays are most often named following the pattern $L_{Runs}(Levels^{Factors})$.

Figure 1: An $L_9(3^4)$ orthogonal array with 9 runs, 4 factors, 3 levels, and strength of 2.

	Factors			
Runs	0	0	0	0
	0	1	1	2
	0	2	2	1
	1	0	1	1
	1	1	2	0
	1	2	0	2
	2	0	2	2
	2	1	0	1
	2	2	1	0

Why use this technique?

Experiment determination represents an intriguing issue with regards to the designing proficient. Testing can just show the presence of deformities and never their nonappearance, and that thorough testing rapidly gets outlandish even in little frameworks. Be that as it may, testing is essential. Being smart about which experiments you pick can have a significant effect between

OATS gives a way to choose a test set that: Guarantees testing the pair-wise mixes of the apparent multitude of chose factors. Makes a proficient and succinct test set with numerous less experiments than testing all blends everything being equal. Makes a test set that has an even circulation of all pair- wise blends. Activities a portion of the perplexing blends of all the variables.2Is less complex to produce and less blunder inclined than test sets made by hand. To act as an illustration of the advantage of utilizing the OATS procedure over a test set that thoroughly tests each mix everything being equal, consider a framework that has four choices, every one of which can have three qualities. The thorough test set would require 81 experiments (3 x 3 x 3 x 3 or the Cartesian result of the choices). The test set made by OATS (utilizing the symmetrical exhibit in Figure 1) has just nine experiments, yet tests the entirety of the pair-wise mixes. The OATS test set is just 11% as huge at thecomprehensive set and will reveal the vast majority of the connection bugs. It covers 100% (9 of 9) ofthe pair-wise mixes, 33% (9 of 27) of the three-way mixes, and 11% (9 of 81) of the four-way blends. The test set could undoubtedly be increased if there were especially dubious three-and four-way blends that ought to be tried.

How to utilize this method?

The OATS method is basic and direct.The means are illustrated underneath.

1. Choose what number of independent factors will be tried for collaboration. This will guide to the Factors of the exhibit.

2. Choose the most extreme number of qualities that every autonomous variable will take on. This will guide to the Levels of the exhibit.

3. Locate an appropriate symmetrical exhibit with the most modest number of Runs.3 A reasonable cluster is one that has at any rate the same number of Factors varying from Step 1 and has at any rate the same number of levels for every one of those elements as chosen in Step 2.

4. Guide the Factors and values in an array.

5. Pick values for any "left over" Levels.

6. Transcribe the stipulations into experiments, including any particularly suspicious combinations that aren't produced.

Examples

A Simple Example

1. There are three independent factors (the areas of the page).

2. Every factor can take on 2 values (covered up / obvious).

3. A $L^4(2^3)$ orthogonal array will work - two levels for the qualities and three components for the factors. Note that the number of runs isn't important to pick a suitable array.

4. Planning the values onto the array would look like Figure 2 where Hidden=0 and Visible=1:

OA before mapping factors			
	Factor 1	**Factor 2**	**Factor 3**
Run 1	0	0	0
Run 2	0	1	1
Run 3	1	0	1
Run 4	1	1	0
OA after mapping factors			
	Top	**Middle**	**Bottom**
Test 1	Hidden	Hidden	Hidden
Test 2	Hidden	Visible	Visible
Test 3	Visible	Hidden	Visible
Test 4	Visible	Visible	Hidden

5. There are no "left over" Levels. As such, there is a worth planned to each level inthe array.

6. Stepping through the test case values from each stipulations, four experiments will be accessible. This is expected to test the entirety of the pair-wise communications among the three factors. The experiments may transcribe.

2.2 History of Pervious Concrete

The underlying utilization of pervious concrete was in the UK in 1852 with the development of two private houses and a sea groyne. After that it was once again introduced into the United Kingdom in the year 1923 from Holand. The utilization of pervious concrete turned out to be more significant after the finish of WorldWar II with the related material deficiencies (Malhotra., 1976). Since pervious concrete utilize less binder than regular concrete and cement was alarm around then, it appeared to be that pervious concrete was thebest material for that period.

After WorldWar II, the utilization of pervious solid spread everywhere on over the world to European countries, African countries, Venezula, the Middle East, and Australia. Pervious concrete for the most part doesn't need as much concrete glue contrasted and customary solid, inspiring its expanded utilization (Wanielista M., and Chopra M., 2007).

The pervious concrete turned out to be wide spread for applications, for example, projected set up load-bearing walls of single and multi-story houses and, in certain occurrences in tall structures, pre- assembled boards, and stem-relieved squares and furthermore applications incorporate dividers for two-story houses, load bearing walls for elevated structures (up to 10 stories) and infill boards for elevated structures (Tenni P.D. et al., 2004). Regardless of the upsides of the pervious cement, the quantity of structures and houses using pervious concrete in North America was genuinely confined **(ACI 522 Pervious Concrete, 2006)** on account of the material impediments.

The interest for no-fines concrete for pavement applications kept on expanding and a foundation called 'Portland Cement Pervious Institute' was framed in 1991 to proceed with the examination. (Ghafoori et al., 1995) records the improvement of porous base materials fit for putting away a more prominent volume of water until it disperses into the encompassing soil.

As of late, pervious concreteuse in the U.S. has started to increment. Specifically, certain states, for example, Florida, Utah, and New Mexico have been needed to diminish uncontrolled tempest water spillover. California, Illinois, Oklahoma, and Wisconsin have applied pervious cement for penetrable base and edge channels (Mathis., 1990). The utilization of pervious concrete addresses the issues of Best Management Practice (BMP) of the Environmental Protection Agency (EPA), which will prompt extra development in pervious concrete application.

Pervious concrete has been latently utilized as a drainable base, or sub-base material. What's more, pervious concrete has been executed for a street surface or grating coarse (ACI 522 Pervious Concrete, 2006), principally for the low clamor delivery and high-water ingestion (Sandberg and Ejsmont 2002; Beeldens et al., 2003; Nakahara et al., 2004) of such a surface layer. Since a flimsy surface layer of pervious cement has preferred protection from rutting over permeable black-top, pervious concrete has been used instead of permeable black-top surface courses in Japan to improve wellbeing and ride quality (Nakahara et al., 2004).

2.3 Summary

In view of the writing survey a concise synopsis is given beneath;

1. The building properties of pervious concrete announced in the writing demonstrate high porosity, low quality, and satisfactory coefficient of porousness. It is accepted tha these constraints have delayed the utilization of pervious concrete.

2. The standard consistency trial of new concrete; the slump test and Kelly ball test are not appropriate for the estimation of the consistency of pervious concrete. Visual review to guarantee that coarse aggregate are uniformly covered with the concrete glue is the most agreeable methodology in getting a legitimate consistency.

3. The benefits of pervious concrete incorporate improving slide obstruction by eliminating water during precipitation occasions, lessening commotion, limiting the warmth island impact in enormous urban areas, saving local environments.

4. The constraints of pervious concrete are connected to quality, durability and maintainance.

5. Studies have demonstrated that pervious concrete can treat water, both precisely and organically.

6. There is no revealed research on the utilization of metropolitan strong waste in particular structure destruction squander (Recycled aggregate) as substituting material for total in Portland concrete pervious cement.

7. Obstructing materials like trash and soil fill the pore organization with the end goal that pervious concrete doesn't deplete appropriately. These obstructing materials influences coefficient of porousness as well as strength.

8. The connection between compression strength and water/cement proportion isn't clear for Pervious concrete.

9. There is no announced exploration on the rational mix design methodology for Pervious concrete.

CHAPTER 3

PRESENT STUDY: MATERIAL PROPERTIES,TEST METHODS AND EXPERIMENTAL PROGRAM

3.1 Introduction

This part manages the description of materials utilized their properties and researchapproach embraced in this study.

3.2 Materials

3.2.1 Cement

The majority of the concrete conforming to Indian Standards is reasonable for making pervious concrete. The decision of the sort of concrete and its substance relies upon quality and penetrability prerequisites of the mix. However, the concrete utilized needs to have a similarity with different fixings utilized. Common Portland concrete of 53grade adjusting to the necessities of IS 12269-1987 was utilized in this investigation. The amount of concrete required for the tests was gathered from one single source and the packs were put away in almost impenetrable holder. The Table 3.1 and Table 3.2 shows the concoction and physical properties of the concrete utilized.

Table 3.1 Chemical properties of cement (OPC, 53Grade)

Sl.No	Particulars	Values as given by manufacturer	Requirement as per IS: 12269-1987
1	Lime (%)	63.56	---
2	Soluble Silica (%)	20.8	---
3	Alumina (%)	5.2	---
4	Iron Oxide (%)	4.2	---
5	Magnesia (%)	0.7	Not more than 6
6	Insoluble Residue (%)	1.26	Not more than 3
7	Sulphur Calculated as SO3	1.76	Not more than 2.5
8	Total Loss on Ignition (%)	2.06	Not more than 4
9	Total Chloride Content (%)	0.022	Not more than 0.1
10	Proportion of Lime to Silica, Alumina & Iron Oxide (%)	0.93	Between 0.80-1.0
11	Proportion of Alumina to Iron Oxide (%)	1.27	Not less than 0.66

Table 3.2 Physical properties of cement (OPC, 53Grade)

Sl.No	Particulars	Results	As per IS: 12269-1987
1	Normal Consistency (%)	31	---
2	Specific Gravity	3.07	---
3	Initial setting Time (Min)	122	Should not be less than 30 < 300
	Final setting Time (Min)	406	
4	Fineness by Air Blaine Apparatus ($m^{2/}kg$)	256	> 225
5	Compressive Strength (Mpa)		
	3 Days	28.34	27
	7 Days	37.67	37
	28 Days	53.67	53

3.2.2 Coarse Aggregate

Pervious concrete can be produced using typical cementing aggregates. Aggregates compose the bulk of concrete mix and give dimensional dependability to concrete. Level of Coarse aggregate substance is more in pervious solid when contrasted with fine aggregates. Squashed igneous rock stone with a greatest size of 20 mm was embraced as the coarse aggregate. An evaluating of coarse aggregate was consolidated in this investigation is coarse aggregate going through 20 mm and held on 10 mm IS sieve. The

tests on coarse aggregate were directed as per IS 2386 and IS 383: 1970. The physical properties of coarse aggregate and Sieve investigation consequence of coarse aggregateare introduced in Table 3.3 and Table 3.4 individually.

Table 3.3 Physical properties of coarse aggregate

Sl .No	Name of the experiment	Result	Permissible value as per IS code
1	Specific gravity	2.65	---
2	Water absorption (%)	0.15	---
3	Bulk density (Kg/m^3)	1480	---
4	Crushing value (%)	27	< 30
5	Impact value (%)	18	< 30
6	Abrasion value (%)	12.2	< 30
7	Flakiness index	11.92	< 30
8	Elongation index	29.7	---

Table 3.4 Sieve analysis result of coarse aggregates

Sl No	IS Sieve size	Weight of aggregate retained	Cumulative weight of aggregate retained	Cumulative percentage of aggregate retained (%)	Percentage of aggregate passing (%)
1	20mm	0	0	0	100
2	16mm	240	240	24	76
3	10mm	727	967	96.7	3.3
4	5mm	33	1000	100	0
			Total	220.7	
Fineness modulus= 220.7/100=**2.27**					

3.2.3 Recycled Aggregate

In the current investigation, reused aggregate acquired from building destruction waste is utilized as substitute aggregate in pervious concrete. A reviewing of reused aggregate which is consolidated in this investigation is aggregate going through 20 mm and held on 10 mm IS sieve. Because of high water retention, reused aggregate was kept in water for 24 hours before mixing to keep steady the water-cement proportion of mix extent for pervious concrete.


Figure 3.1 Recycled Aggregate

The nature of pervious concrete with reused aggregate is reliant on the nature of the reused material utilized. The high dense steel or mild steel and other inserted materials, assuming any, must be eliminated and care must be taken to prevent contamination by different materials. So it is important to utilize reused aggregate with less contamination to deliver pervious concrete with worthy quality and porousness. The tests on reused aggregate were led as per IS 2386 and IS 383:1970. The physical properties of reused aggregates and Sieve investigation after effect of reused aggregates are introduced in Table 3.5.

Table 3.5 Physical Properties of Recycled Aggregate

Sl No	Name of the experiment	Result
1	Specific gravity	2.51
2	Water absorption (%)	4.54
3	Bulk density (Kg/m^3)	1281
4	Crushing value (%)	34.8
5	Impact value (%)	29.3
6	Abrasion value (%)	30.5

3.2.4 Water

This is the most affordable and also most significant element of concrete. The water, which is utilized for making pervious concrete, sought to be perfect and liberatedfrom destructive polluting influences, for example, oil, soluble bases, acids etc., in general, the water which is good for drinking ought to be utilized for making concrete. Convenient tap water was utilized for the preparations and curing ofspecimens.

Inadequate water brings about irregularity in the mix and helpless bond quality between aggregates particles. Nonetheless, high water content outcomes in the decrease ofpores or wiping out the void structure required for porosity.

3.3 Test Methods

The test method are detailed below

3.3.1 Test on Fresh Pervious Concrete

3.3.1.1 Slump Test (IS: 1199-1959)

Slump test is the most generally utilized strategy for estimatingworkability of concrete which can be utilized either in lab or at site of work. A concise system to lead slumptest is directed by IS: 1199-1959.

The inner surface of the slump cone is completely cleaned and liberated from dampness and afterward form is filled in four layers of pervious cement. Each layer is packed multiple times by the packing bar. After the top layer has been tamped, theconcrete is hit off level with a trowel and packing rod. The shape is taken out from the concrete quickly by raising it gradually and cautiously vertical way. This permitsconcrete to collapse. This difference in height is known as Slump of concrete.

The difference in level between the actual size of the cone and that of the most noteworthy height after the collapse of the concrete after lifting of the cone is estimated.

3.3.2 Tests on Hardened Pervious Concrete

3.3.2.1 Compression Test (IS: 516 – 1959)

Compressive test is the most widely recognized test directed on hardened and cured concrete, since it is simple to perform and the greater part of the required characteristic properties of concrete are subjectively identified with its compressive strength.

The compressive strength test was done on 150 x 150 x 150 mm cubes. According to IS 516-1959, All cubes were wet restored up to the day of testing. The cubes were exposed to axial compressive load until failure. The load required for crushing by the surface area of the cubes gives the compressive stress of the concrete which it can withstand without failure or rupture. This indicates the measure of compressive strength and its confirmation with required criteria.

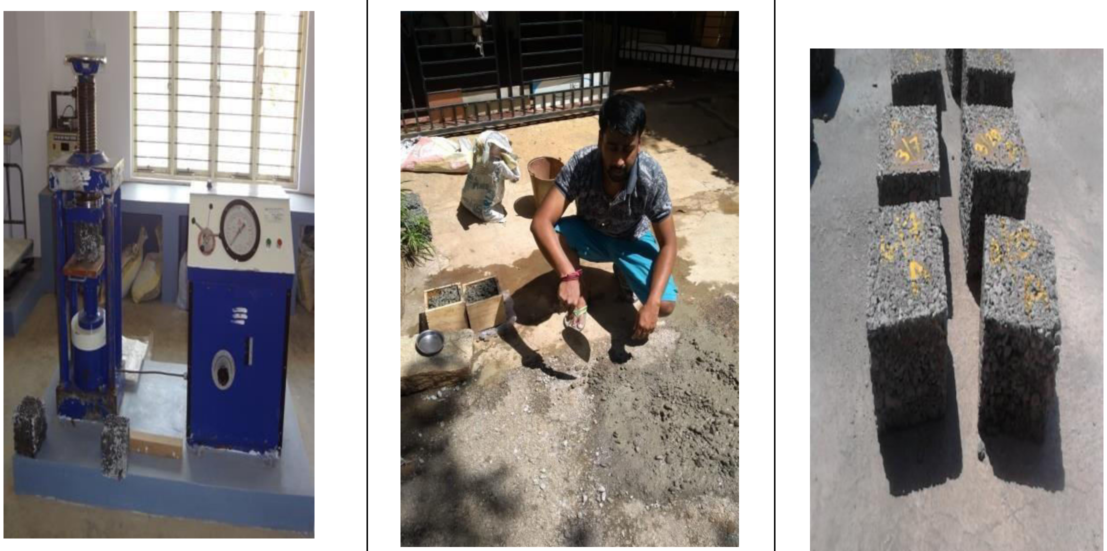

Figure 3.2 Compression testing on pervious concrete cube

3.3.2.2 Split Tensile Test (IS: 5816 – 1999)

The tensile strength of concrete can't be estimated legitimately. This prompts the need to calculate the tensile strength through backhanded strategies. The indirecttensile test is likewise alluded to as the 'Brazil' or splitting test, where a cylinder is set onits side and broken in the compression testing machine.

Splitting tensile test is done according procedure referenced in IS: 5816-1970. The pervious concrete is filled in the standard mould in 3 or 4 layers of measurement 150 mm in width and 300 mm deep. Each layer is tamped well or vibrated to accomplish appropriate compaction. The mounds are kept in dampness for 24 hours. The test cylinders of concrete are taken out from mould and are soaked in water. The tests are conducted after following 28 days curing.Dimension lines are drawn on the two ends of the specimen by utilizing any reasonable methodology.The specimen is mounted on the testing platform of compression testing machine. Two packing segments of steel plates will be given. The pace of loading will be uniform. The load is produced until failure. Least 3 cylinders are tested and the mean value is taken as its strength.

The splitting tensile strength (N/mm2) of concrete cylijnder is determinedutilizing formula,

Splitting tensile strength: $t_{spl} = \left(\frac{2 \times p}{\Pi \times d \times l} \right)$

Where,

p = Failure load in N.

d = diameter of the cylinder in mm.l = length of the cylinder in mm.

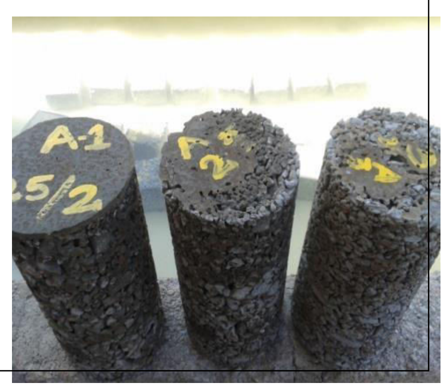

Figure 3.3 Split tensile testing on pervious concrete cylinders

3.3.2.3 Permeability Test

To determine the rate of flow of water through the pervious concrete, with theavailable literature we have chosen constant head permeability test.

Co-efficient of Permeability:

The rate of flow under laminar flow conditions through a unit cross sectionalzone of permeable medium under unit hydraulic gradient is characterized as Co-efficient of permeability. It can be determined utilizing the given formulae below

$$k = \frac{(Q \times L)}{(T \times H \times A)}$$

Where,

k = Co-efficient of permeability in cm/sec.

Q = Total quantity of flow in a time interval **T**

L = Length of the specimen in cm.

T = Time taken by the known amount of flow in sec.

H = Difference in the water levels of the overhead and bottom tanks in mm.A = Total cross sectional area of sample in cm^2.

The permeability test carried out with constant head method with unidirectionalflow. The apparatus setup is as shown in figure3.3.

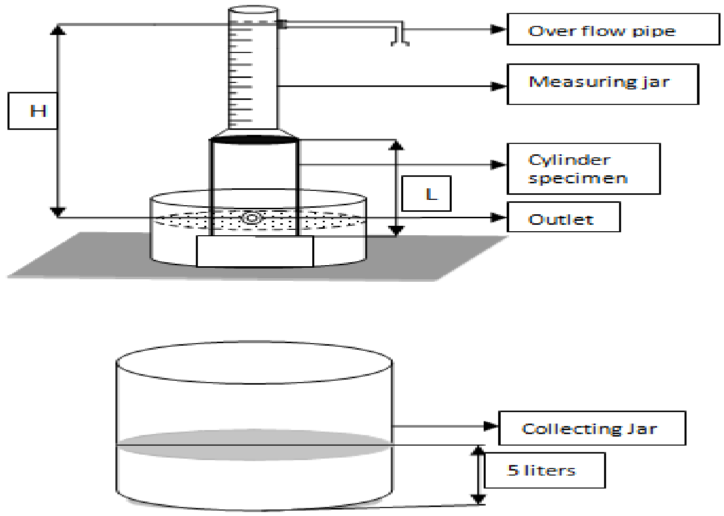

Figure 3.4 Sketch of permeability apparatus

The cylindrical specimens cured at 28 days were utilized for directing the test. The flow was kept up unidirectional by covering the external surface of the cylinder specimen with a sealing agent. Upon the cylinder an estimating container of limit 1000ml was fixed guaranteeing no spillages. A constant head was kept up at the top of the cylinder by nonstop flow of water and gathering container at the bottom of more than 5 liters limit was utilized to gather the water which percolated through the cylinder. A inlet pipe was utilized with a flood outlet to guarantee the constant amount of 1000ml of water provided to the specimen consistently. The total amount of water gathered is kept consistent at 5 liters with the outcome being average of 5 readings.

The gathering container was kept at the base and the stop watch was begun when the flow began and the time recorded in seconds to fill precisely 5 liters of water was noted down. Average of 5 trial readings is taken as the time flow.

Figure 3.5 Constant head permeability test apparatus

3.4. Mix Proportions for Experimental Program

Due to a wide scope of variability of mechanical properties for the reused concrete coarse/fine aggregates, it is typically important to deliberately design a experimental design strategy for getting of feasible mixture of concrete made with those aggregates and evaluating their effect on the mechanical conduct of the subsequent concrete. Ordinarily, a progression of tests wherein intentional changes were made to the factors of the concrete mixture was then directed, so that valid and objective determination can be acquired dependent on the subsequent test information. Expect a designing trial requires n control components and two control levels for each control factor to understand the impact and association of its input details on the yield results. By utilizing a conventional trial measure, typically at least all the viable 2n tests require to be carefully conducted and completed before an ideal presentation can be concluded. The number of tests can get very large really quick. To diminish the number of such tedious and exorbitant tests yet have the option to keep up a knowledge into the general impacts ofthe input factors on the yield, a procedure dependent on the design of experiments that upgrades the Process having controllable input sources and measurable yields should be thought of. In this technique, just a few number of tests that efficiently pickcertain combination of values of those control factors are required, yet it is conceivable to isolate their individual impacts. The hypothesis behind this method, which needs to consider both the way toward designing the trial and the method of analyzing statisticall the trial data of response, depends on the utilization of the orthogonal array. In this investigation, based on test results from some preliminary experimental runs, 5 control factors, i.e., (1) water/cement proportion, (2) cement aggregate ratio,(3)recycled aggregate, (4) sand, and (5) grade of aggregate, which were named as A, B, C, D, and E, individually, and two control levels for each control factor were taken, as shown. To decrease the number of tests, a L_{16} (2^{15}) orthogonal array in the Taguchi technique that lone needs 16 experimental runs to improve the concrete mixture was embraced. Its linear graph and typical tabular form are appeared in Fig. Respectively the columns of orthogonal array correspond to the level of control factors and the orthogonal rows to each trial. That is, a particular arrangement of factor levels to be tested. Hence, the subscript of this orthogonal array indicates sixteen runs and the amount in enclosures indicates 15 two- level experimental conditions associated with a full experimental design. Thetotal degrees of freedom required is 5 _ (2 _1) +10 _ (2 _1) _ (2 _1) = 15. Hence, an L_{16} (2^{15}) orthogonal array, which has 15 degrees of freedom, is a good choice.

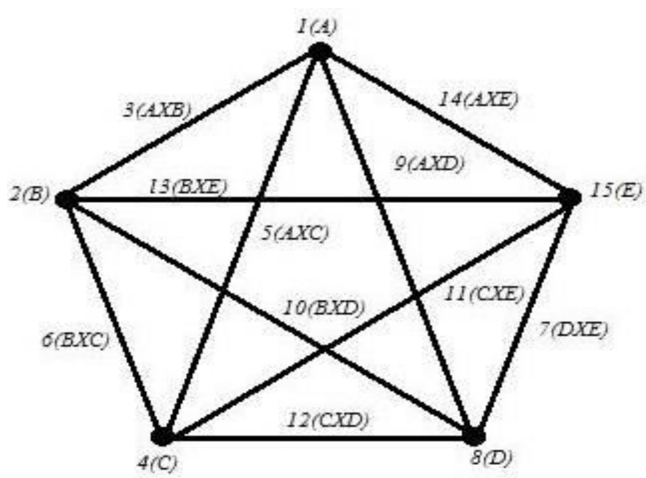

Fig 3.6. A linear graph of an L_{16} (2^{15}) orthogonal array

Table 3.6 Orthogonal array L16 (2^{15}) with factor assignment for the experiments

Mixes number	A	B	AXB	C	AXC	BXC	DXE	D	AXD	BXD	CXE	CXD	BXE	AXE	E	Designation of mixture
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	A1B1C1D1E1
2	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	A1B1C1D2E2
3	1	1	1	2	2	2	2	1	1	1	1	2	2	2	2	A1B1C2D1E2
4	1	1	1	2	2	2	2	2	2	2	2	1	1	1	1	A1B1C2D2E1
5	1	2	2	1	1	2	2	1	1	2	2	1	1	2	2	A1B2C1D1E2
6	1	2	2	1	1	2	2	2	2	1	1	2	2	1	1	A1B2C1D2E1
7	1	2	2	2	2	1	1	1	1	2	2	2	2	1	1	A1B2C2D1E1
8	1	2	2	2	2	1	1	2	2	1	1	1	1	2	2	A1B2C2D2E2
9	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	A2B1C1D1E2
10	2	1	2	1	2	1	2	2	1	2	1	2	1	2	1	A2B1C1D2E1
11	2	1	2	2	1	2	1	1	2	1	2	2	1	2	1	A2B1C2D1E1
12	2	1	2	2	1	2	1	2	1	2	1	1	2	1	2	A2B1C2D2E2
13	2	2	1	1	2	2	1	1	2	2	1	1	2	2	1	A2B2C1D1E1
14	2	2	1	1	2	2	1	2	1	1	2	2	1	1	2	A2B2C1D2E2
15	2	2	1	2	1	1	2	1	2	2	1	2	1	1	2	A2B2C2D1E2
16	2	2	1	2	1	1	2	2	1	1	2	1	2	2	1	A2B2C2D2E1

In the Present Study the Cement Content used is 350kg/M^3 and Water Content LowestAs 0.35 And Maximum of 0.42 Maximum according to **Is Codes**.as shown in table 3.7

Table 3.7. Mix Proportions Obtained By Using Orthogonal Array

Mixes	Designation of mixture	Cement (kg)	Coarse aggregate	Recycled aggregate	Sand	Water content	Water (lt)
1	A1B1C1D1E1	350	2240	560	-	0.35	122.5
2	A1B1C1D2E2	350	1540	560	140	0.35	122.5
3	A1B1C2D1E2	350	2800	_		0.35	122.5
4	A1B1C2D2E1	350	2600	_	140	0.35	122.5
5	A1B2C1D1E2	350	3080	770	-	0.35	122.5
6	A1B2C1D2E1	350	2887.5	770	192.5	0.35	122.5
7	A1B2C2D1E1	350	3845	_		0.35	122.5
8	A1B2C2D2E2	350	2887.5	_	192.5	0.35	122.5
9	A2B1C1D1E2	350	2240	560	-	O.42	147
10	A2B1C1D2E1	350	1540	560	140	0.42	147
11	A2B1C2D1E1	350	2800	_		0.42	147
12	A2B1C2D2E2	350	1540	_	140	0.42	147
13	A2B2C1D1E1	350	3080	770	-	0.42	147
14	A2B2C1D2E2	350	2887.5	770	192.5	0.42	147
15	A2B2C2D1E2	350	3850	_	_	0.42	147
16	A2B2C2D2E1	350	3657.5	_	192.5	0.42	147

The Mix Proportion Which are No Containg Reused Aggregate are Limted. Experiment are Conducted by Taking 8 mixtures.Hence The Following 8 Mixes are Used For The Present Study.as shown in table 3.8

Table 3.8. Mix Proportions Obtained By Using Orthogonal Array

Mixes	Designation of mixture	Cement (kg)	Coarse aggregate	Recycled aggregate	Sand	Water content	Water (lt)
1	A1B1C1D1E1	350	2240	560	-	0.35	122.5
2	A1B1C1D2E2	350	1540	560	140	0.35	122.5
3	A1B2C1D1E2	350	3080	770	-	0.35	122.5
4	A1B2C1D2E1	350	2887.5	770	192.5	0.35	122.5
5	A2B1C1D1E2	350	2240	560	-	O.42	147
6	A2B1C1D2E1	350	1540	560	140	0.42	147
7	A2B2C1D1E1	350	3080	770	-	0.42	147
8	A2B2C1D1E2	350	2887.5	770	192.5	0.42	147

MIX PROPORTION

The mix proportion pervious concrete utilizing reused aggregate is acquired from the following steps given beneath

a) Cement content 350kg/m^3 is fixed dependent on the IS code.

b) C/A proportion is chosen dependent on the literature review of pervious concrete withreused aggregates, In which cement to aggregate proportion is given as 1/8, 1/11 for grade 1 and grade 2 aggregates. As we know cement content the aggregate contentis calculated as underneath.

Ex. C/An is 1/8 C=350 kg/m^3 350/total = 1/8

Aggregate content = 2800 kg

c) W/C is determined based on the literature of pervious concrete utilizing reused aggregate given in which W/C proportion 0.35 and 0.42 is given for grade 1 and grade 2 totals. The Water content is figured by W/C proportion.

Ex. W/C = 0.35

Where C= 350kg/m^3 350/water content = 0.35

We get water content as 122.5 litres

Cement	CA	RA	Sand		W/C	Water
	80%	20%	0%	5%		
350kg	(1/8)2240	560			0.35	122.5
	(1/11)3080	770			0.35	122.5
350kg	(1/8)1540	560		140	0.42	147
	(1/11)2887.5	770	_	192.5	0.42	147

Table 3.9 Sieve size of grade 1 and grade 2 recycled aggregate

Sieve	grade1	grade2
20mm	75-85	90-100
16mm	-	-
10mm	0-5	20-55
5mm	-	0-10
2.5mm	-	0-5

Table 3.10. Main control factors a d factor levels (20% Recycled aggregate)

DESIGNATION	CONTROL FACTOR	LEVEL 1	LEVEL 2
A	Water cement ratio	0.35	0.42
B	Cement aggregate ratio	(1/8)	(1/11)
C	Recycled aggregate	20%	0%
D	Sand	0%	5%
E	Grade of aggregate	G1	G2

Table.3.11 Mix Proportion Obtained By Using Orthogonal Array

Mixes	Designation of mixture	Mix proportion CEMENT:FA:RA:CA	Cement (kg)	Coarse aggregate	Recycled aggregate	Sand	Water content	Water (lt)
1	A1B1C1D1E1	1:0:3.2:4.8	350	1680	1120	-	0.35	122.5
2	A1B1C1D2E2	1:0.4:3.2:4.4	350	1540	1120	140	0.35	122.5
3	A1B2C1D1E2	1:0:4.4:6.4	350	2310	1540	-	0.35	122.5
4	A1B2C1D2E1	1:0.55:4.4:6.4	350	2117.5	1540	192.5	0.35	122.5
5	A2B1C1D1E2	1:0:3.2:4.8	350	1680	1120	-	O.42	147
6	A2B1C1D2E1	1:0.4:3.2:4.4	350	1540	1120	140	0.42	147
7	A2B2C1D1E1	1:0:4.4:6.4	350	2310		-	0.42	147
8	A2B2C1D1E2	1:0.55:4.4:6.4	350	2117.5	1540	192.5	0.42	147

3.14. Main control factors and factor levels (40% Recycled aggregate)

` DESIGNATION	CONTROL FACTOR	LEVEL 1	LEVEL 2
A	Water cement ratio	0.35	0.42
B	Cement aggregate ratio	(1/8)	(1/11)

C	Recycled aggregate	40%	0%

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D	Sand	0%	5%
E	Grade of aggregate	G1	G2

Table.3.15. Mix Proportions Obtained By Using Orthogonal Array

Mixes	Designation of mixture	Mix proportion CEMENT:FA:RA:CA	Cement (kg)	Coarse aggregate	Recycled aggregate	Sand	Water content	Water (lt)
1	A1B1C1D1 E1	1:0:3.2:4.8	350	1680	1120	-	0.35	122.5
2	A1B1C1D2 E2	1:0.4:3.2:4.4	350	1540	1120	140	0.35	122.5
3	A1B2C1D1 E2	1:0:4.4:6.4	350	2310	1540	-	0.35	122.5
4	A1B2C1D2 E1	1:0.55:4.4:6.4	350	2117.5	1540	192.5	0.35	122.5
5	A2B1C1D1 E2	1:0:3.2:4.8	350	1680	1120	-	O.42	147
6	A2B1C1D2 E1	1:0.4:3.2:4.4	350	1540	1120	140	0.42	147
7	A2B2C1D1 E1	1:0:4.4:6.4	350	2310		-	0.42	147
8	A2B2C1D1 E2	1:0.55:4.4:6.4	350	2117.5	1540	192.5	0.42	147

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

This section manages the outcomes and discussions for the tests led in this examination. As discussed in experimental procedure taken (section 3.4) the concrete mixes considered in thisexamination incorporates pervious concrete mixes without any substitution of reused aggregates and pervious concrete mixes in with substitution of reused aggregate in the order of 20%, , 40%and. The new and hardened properties of pervious concrete explored in this examination are discusseduin detail in the accompanying sections.

4.2 Fresh Pervious Concrete Properties

4.2.1 Slump Test

Slump test was undertaken on each sample of concrete used for the hardenedconcrete tests. The slumps obtained on the concrete mix are shown in Table 4.1.

Table 4.1 Slump for 20% Recycled aggregate

Mixes	Designation of mixture	Cement (kg)	Coarse aggregate(CA)	Recycled aggregate(RA)	Sand(FA)	Water content	Water (lt)	Slump (mm)
1	A1B1C1D1E1	350	2240	560	-	0.35	122.5	192
2	A1B1C1D2E2	350	1540	560	140	0.35	122.5	210
3	A1B2C1D1E2	350	3080	770	-	0.35	122.5	216
4	A1B2C1D2E1	350	2887.5	770	192.5	0.35	122.5	185
5	A2B1C1D1E2	350	2240	560	-	O.42	147	176
6	A2B1C1D2E1	350	1540	560	140	0.42	147	170
7	A2B2C1D1E1	350	3080	770	-	0.42	147	210
8	A2B2C1D1E2	350	2887.5	770	192.5	0.42	147	174

Table 4.2 Slump for 40% Recycled aggregate

Mixes	Designation of mixture	Cement (kg)	Coarse aggregate(CA)	Recycled aggregate(RA)	Sand(FA)	Water content	Water (lt)	Slump (mm)
1	A1B1C1D1E1	350	1680	1120	-	0.35	122.5	200
2	A1B1C1D2E2	350	1540	1120	140	0.35	122.5	205
3	A1B2C1D1E2	350	2310	1540	-	0.35	122.5	205
4	A1B2C1D2E1	350	2117.5	1540	192.5	0.35	122.5	185
5	A2B1C1D1E2	350	1680	1120	-	O.42	147	170
6	A2B1C1D2E1	350	1540	1120	140	0.42	147	160
7	A2B2C1D1E1	350	2310		-	0.42	147	160
8	A2B2C1D1E2	350	2117.5	1540	192.5	0.42	147	190

The pervious concrete had a higher slump caused by the low amount of cohesionbetween the aggregate particles. This particular workability test appears to be of little use from the table 4.1 and 4.2it can be seen that slump value varies from one mix proportion to other depending on the replacement of recycled aggregate this is due to low amount of cohesion between the aggregate particles.

4.2.1.1 Graph of Slump Test of All Adopted Mix Proportions

The slump value is less for mix proportion mix 5 without FA and mix6 with FA when compared to other proportion. Since our aim in this project is to make use of recycled aggregates we are going for 50% recycled aggregates replacement for mix proportion. From the above result we get to know as slump value decreases as the percentage of recycled aggregate increases. It is also seen that as the percentage replacement of recycled aggregate increases there is reduction in slump value.

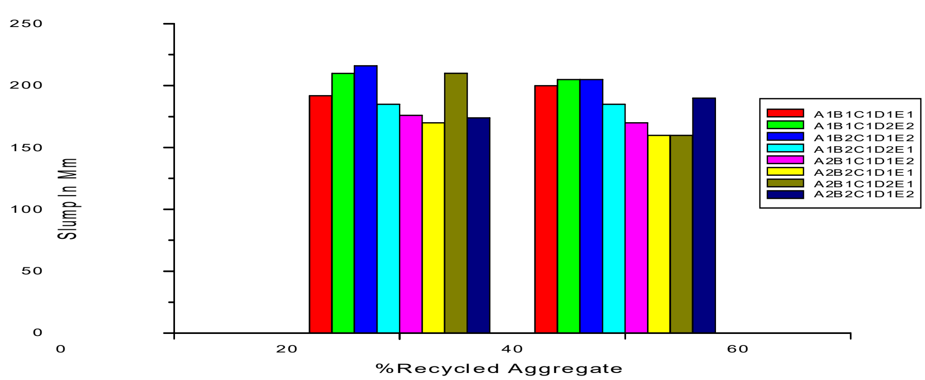

Figure 4.1 % of Recycled Aggregate Vs Slump in mm

4.2.1.2 Graph of Slump Test of All Adopted Mix Proportions

From 4.2.1.1. Graph among eight mixes in 20% replacement of recycled aggregatemix 5 without FA and mix6 with FA had less slump compared to rest of other mixes.

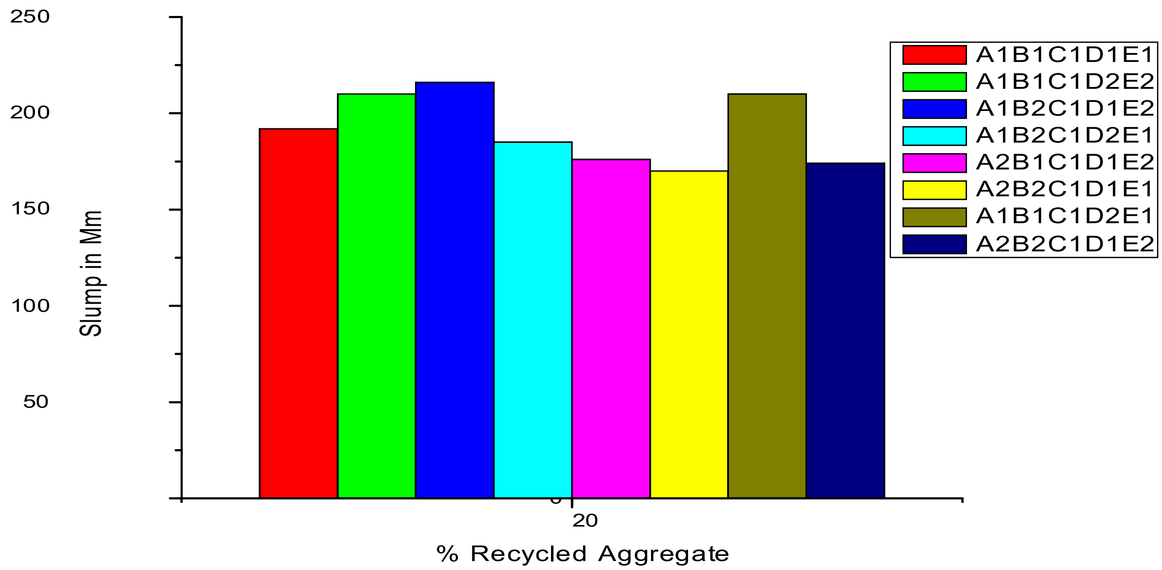

Figure 4.2 % of Recycled Aggregate Vs Slump in mm

4.2.1.3 Graph of Slump Test of All Adopted Mix Proportions

From 4.2.1.2 graph among eight mixes in 40% replacement of recycled aggregate mix 5without FA and mix6 with FA had l ess slump compared to rest of other mixes

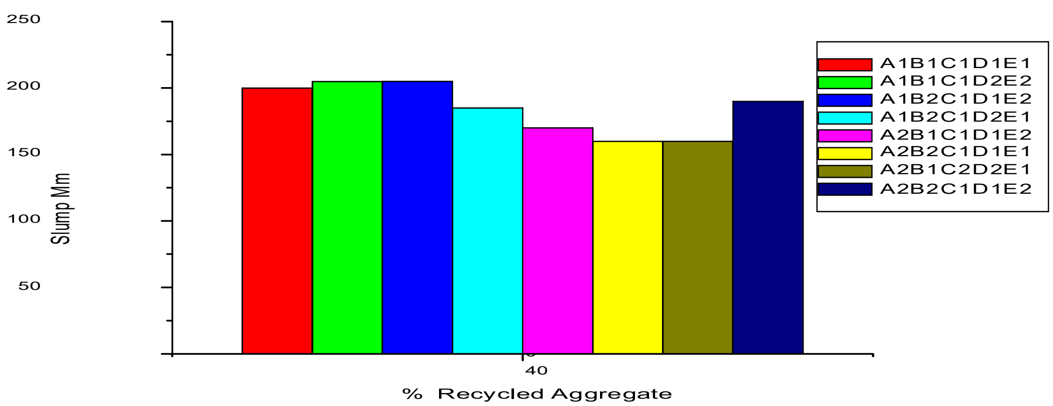

Figure 4.3 % of Recycled Aggregate Vs Slump in mm

4.3 Hardened Pervious Concrete Properties

4.3.1 Discussions on Compressive Strength

The Table 4.5, 4.6, 4.7, 4.8 shows the 7 and 28 days compressive strength results for different mix proportions and different percentage of recycled aggregate which isused in this present work.

Table 4.3 Shows Compressive Strength (20% Recycled Aggregate)

Mixes	Designation of mixture	Cement (kg)	Coarse aggregate(CA)	Recycled aggregate(RA)	Sand(FA)	Water content	Water (lt)	Compressive strength	
								7 days	28 days
1	A1B1C1D1E1	350	2240	560	-	0.35	122.5	2.22	2.66
2	A1B1C1D2E2	350	1540	560	140	0.35	122.5	3.11	1.77
3	A1B2C1D1E2	350	3080	770	-	0.35	122.5	2.22	1.33
4	A1B2C1D2E1	350	2887.5	770	192.5	0.35	122.5	4.44	3.55
5	A2B1C1D1E2	350	2240	560	-	O.42	147	6.22	4.22
6	A2B1C1D2E1	350	1540	560	140	0.42	147	2.22	5.33
7	A2B2C1D1E1	350	3080	770	-	0.42	147	2.22	1.33
8	A2B2C1D1E2	350	2887.5	770	192.5	0.42	147	0.88	4.44

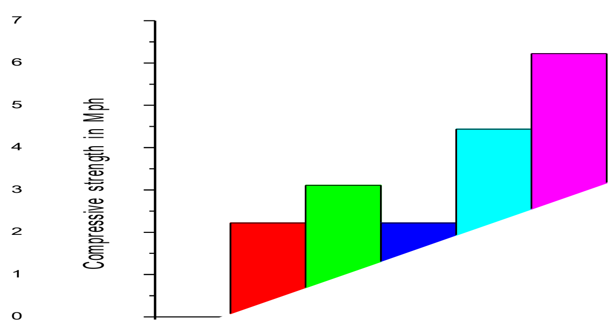

Figure 4.4 Days Vs Compressive Strength

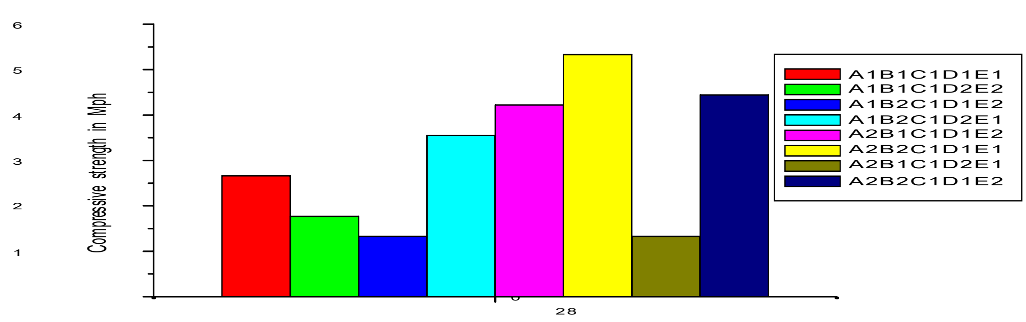

Figure 4.5 Days Vs Compressive Strength

Table 4.4 Shows Compressive Strength Results (40% Recycled Aggregate)

Mixes	Designation of mixture	Cement (kg)	Coarse aggregate(CA)	Recycled aggregate(RA)	Sand(FA)	Water content	Water (lt)	Compressive strength	
								7 days	28 days
1	A1B1C1D1E1	350	1680	1120	-	0.35	122.5	2.26	2.66
2	A1B1C1D2E2	350	1540	1120	140	0.35	122.5	1.14	1.55
3	A1B2C1D1E2	350	2310	1540	-	0.35	122.5	0.55	1
4	A1B2C1D2E1	350	2117.5	1540	192.5	0.35	122.5	2.68	3.77
5	A2B1C1D1E2	350	1680	1120	-	O.42	147	3.86	4.66
6	A2B1C1D2E1	350	1540	1120	140	0.42	147	3.24	6.88
7	A2B2C1D1E1	350	2310		-	0.42	147	4.82	6.11
8	A2B2C1D1E2	350	2117.5	1540	192.5	0.42	147	1.85	2.66

4.3.1.1Graph for Compressive Strength Results Of All Adopted Mix Proportions V/S Recycled Aggregate. (7 Day Results)

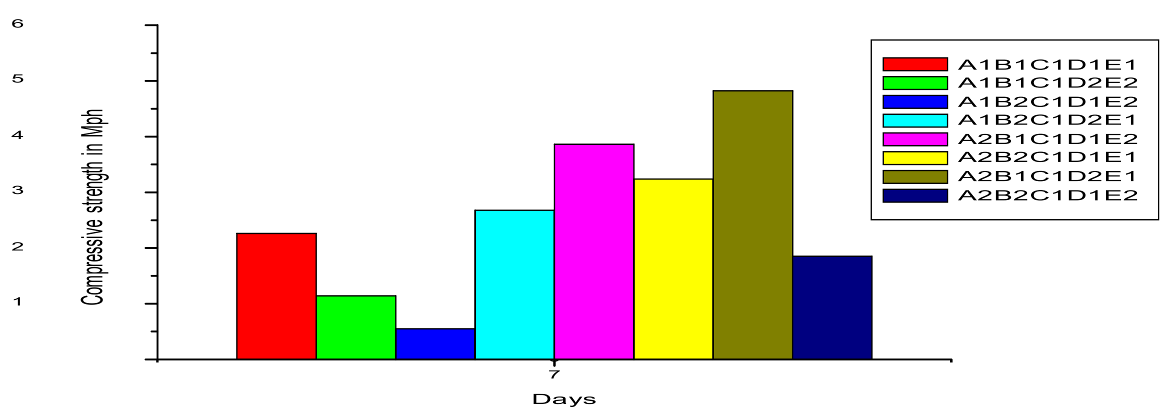

Figure 4.6 Days Vs Compressive Strength

International Journal of Scientific Research in Engineering and Management (IJSREM)
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4.3.1.2 Graph for Compressive Strength Results of All Adopted Mix Proportions V/S Recycled Aggregate (28 Days)

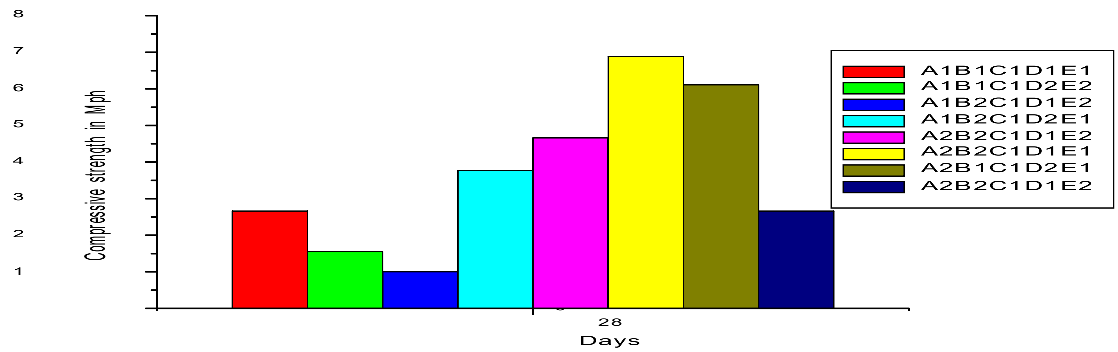

Figure 4.7 Days Vs Compressive Strength

In general the compressive strength of pervious concrete without recycled aggregates is significantly high compared to pervious concrete mix with recycled aggregate. Among all 8 mixes proportion the compressive strength corresponding to 50% replacing of recycled aggregates for mix proportion mix5 and mix6 shows a better result. From the graph 4.3.1 and 4.3.2 shows the variation of compressive strength for different mix proportions.Compressive strength increases as the age of specimen increases

4.3.1.3 Compressive Strength V/S% of Recycled Aggregate. (7&28 Day Results)

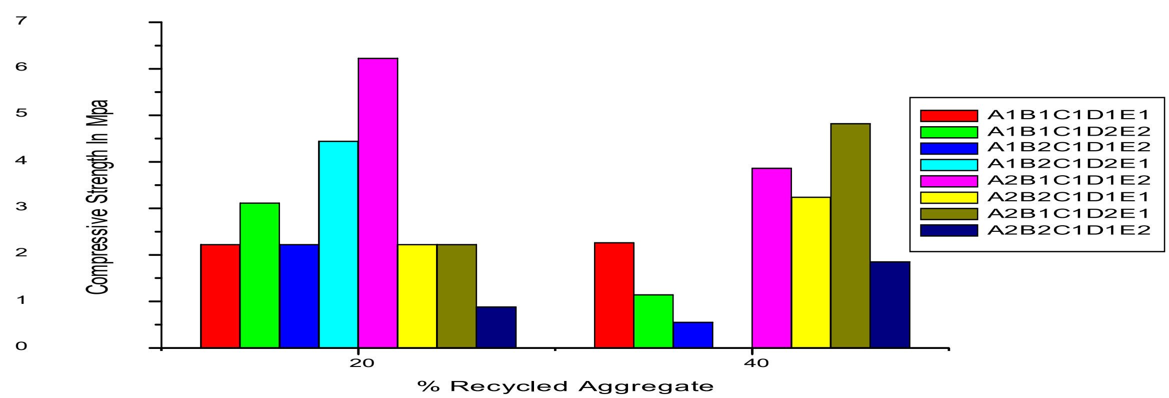

Figure 4.8 % Recycled Aggregate Vs Compressive Strength

International Journal of Scientific Research in Engineering and Management (IJSREM)
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4.3.1.4 Compressive Strength V/S %of Recycled Aggregate. (7&28 Day Results)

Figure 4.9 % Recycled Aggregate Vs Compressive Strength

4.3.1.5 Compressive StrengthV/S % of Recycled Aggregate. (7&28 Day Results)

From 4.3.1.1 to 4.3.1.2 graphs of each replacement shows variation of compressivestrength with number of days for different mixes. The trend in the result clearly indicates that in all mixes. mix 5 without FA and mix6 with FA shows on an average comparatively higher compressive strength also compressive strength increases as the age of specimen increases

4.3.4 Split Tensile Strength

Split tenile test is conducted for different percentage of recycled aggregate for differentproportion and the result are presented in Table 4.9, 4.10

Table 4.5 split tensile results for 28 days (20% of recycled aggregate).

Mixes	Designation of mixture	Cement (kg)	Coarse aggregate(CA)	Recycled aggregate(RA)	Sand(FA)	Water content	Water (lt)	Split-tensile strength 28days
1	A1B1C1D1E1	350	2240	560	-	0.35	122.5	1.13
2	A1B1C1D2E2	350	1540	560	140	0.35	122.5	0.5658
3	A1B2C1D1E2	350	3080	770	-	0.35	122.5	0.707
4	A1B2C1D2E1	350	2887.5	770	192.5	0.35	122.5	0.414
5	A2B1C1D1E2	350	2240	560	-	O.42	147	0.7073
6	A2B1C1D2E1	350	1540	560	140	0.42	147	0.4244
7	A2B2C1D1E1	350	3080	770	-	0.42	147	0.5658
8	A2B2C1D1E2	350	2887.5	770	192.5	0.42	147	0.6366

Table 4.6 split tensile results for 28 days (40% of recycled aggregate).

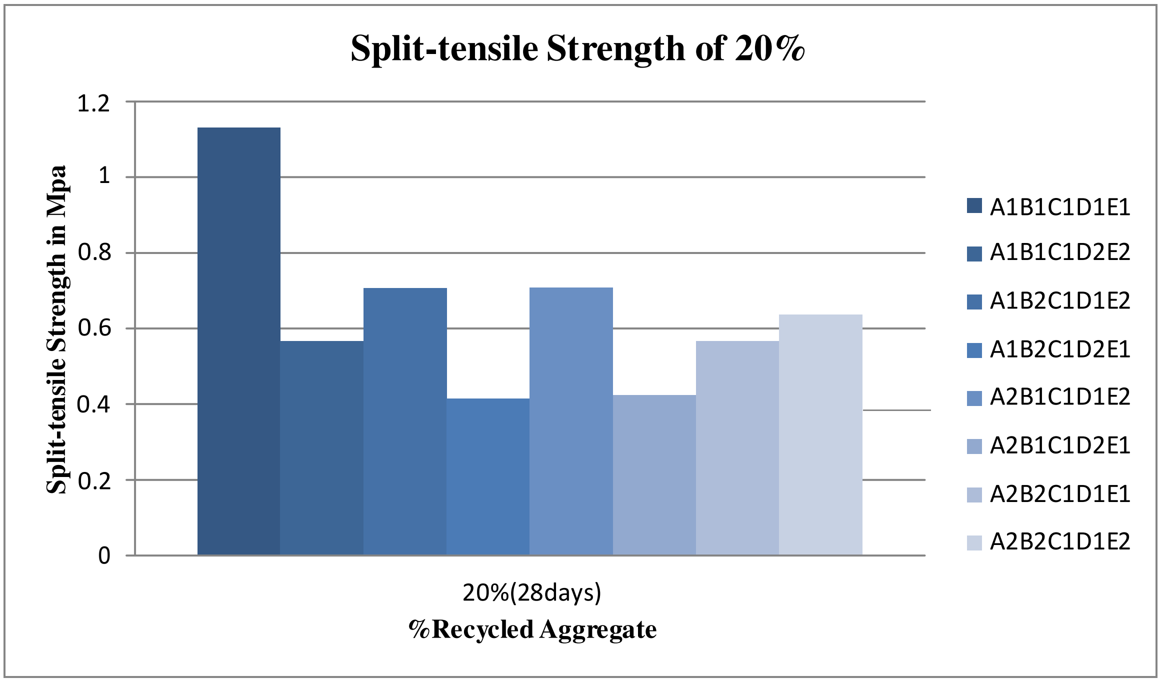
Mixes	Designation of mixture	Cement (kg)	Coarse aggregate(CA)	Recycled aggregate(RA)	Sand(FA)	Water content	Water (lt)	Split-tensile strength 28days
1	A1B1C1D1E1	350	2240	560	-	0.35	122.5	0.212
2	A1B1C1D2E2	350	1540	560	140	0.35	122.5	0.565
3	A1B2C1D1E2	350	3080	770	-	0.35	122.5	0.498
4	A1B2C1D2E1	350	2887.5	770	192.5	0.35	122.5	0.848
5	A2B1C1D1E2	350	2240	560	-	O.42	147	0.707
6	A2B1C1D2E1	350	1540	560	140	0.42	147	0.568
7	A2B2C1D1E1	350	3080	770	-	0.42	147	0.565
8	A2B2C1D1E2	350	2887.5	770	192.5	0.42	147	0.565

The tensile strength for 30% replacement of recycled aggregates of mix proportion mix 5 without FA and mix6 with FA shows a better strength from the graph 4.3.5 shows the variation of tensile strength for different mix proportion. Tensile strength was average in strength with the age of the specimen, but decreased with percentage of recycled aggregate increased.

4.3.4.1 Graph for Split Tensile Results of All Adopted Mix Proportions V/SRecycled Aggregate

4.3.4.1 2 28 Days Split Tensile V/S % of Recycled Aggregate

From 4.3.4.1 graph among eight mixes in 20% replacement of recycled aggregate mix 5 without FA and mix6 with FA had average split tensile value compared to rest of othermixes



Split Tensile Strength In Mpa

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Figure 4.10 Days Vs Split -Tensile Strength

4.3.4.3 28days Split Tensile V/S % of Recycled Aggregate

From 4.3.4.3 graph among eight mixes in 40% replacement of recycled aggregate mix 5without FA and mix6 with FA had average split-tensile compared to rest of othe mixes

4.3.5 Discussions on Co-efficient of Permeability

The permeability is a measure of the ease by which the fluid may flow through the material under a pressure gradient.Permeability is a very important parameter in pervious concrete which differentiates pervious concrete from conventional concreteand helps in sustainable development.

Table 4.17, 4.18, 4.19, 4.20 shows the results of co-efficient of permeability for different mix proportions with different percentage of recycled aggregate which is used in this study

Table 4.7 Co-efficient of permeability results when 20% of recycled aggregate isused

Mixes	Designation of mixture	Cement (kg)	Coarse aggregate(CA)	Recycled aggregate(RA)	Sand(FA)	Water content	Water (lt)	Time in sec to fill 5 litres	Co-efficient of permeability (cm/s)
1	A1B1C1D1E1	350	2240	560	-	0.35	122.5	93	0.3890
2	A1B1C1D2E2	350	1540	560	140	0.35	122.5	105	0.3440
3	A1B2C1D1E2	350	3080	770	-	0.35	122.5	100	0.3620
4	A1B2C1D2E1	350	2887.5	770	192.5	0.35	122.5	90	0.4023
5	A2B1C1D1E2	350	2240	560	-	O.42	147	70	0.5172
6	A2B2C1D1E1	350	1540	560	140	0.42	147	68	0.5325
7	A2B2C1D1E1	350	3080	770	-	0.42	147	110	0.3292
8	A2B2C1D1E2	350	2887.5	770	192.5	0.42	147	115	0.3148

Table 4.8 Co-efficient of permeability results when 40% of recycled aggregate isused

Mixes	Designation of mixture	Cement (kg)	Coarse aggregate(CA)	Recycled aggregate(RA)	Sand(FA)	Water content	Water (lt)	Time in sec to fill 5 litres	Co-efficient of permeability (cm/s)
1	A1B1C1D1E1	350	1680	1120	-	0.35	122.5	103	0.3515
2	A1B1C1D2E2	350	1540	1120	140	0.35	122.5	107	0.3384
3	A1B2C1D1E2	350	2310	1540	-	0.35	122.5	90	0.4023
4	A1B2C1D2E1	350	2117.5	1540	192.5	0.35	122.5	90	0.4023
5	A2B1C1D1E2	350	1680	1120	-	0.42	147	60	0.6035
6	A2B2C1D1E1	350	1540	1120	140	0.42	147	70	0.5173

7	A2B2C1D1E1	350	2310		-	0.42	147	125	0.2897
8	A2B2C1D1E2	350	2117.5	1540	192.5	0.42	147	140	0.2586

4.3.5.1Graph of co-efficient permeability v/s recycledaggregate

As we can see permeability is higher for 20% of recycled aggregate than the value compared to 20 and 40% of recycled aggregate. So we tell, permeability is higher of pcpcwith less recycled aggregate.

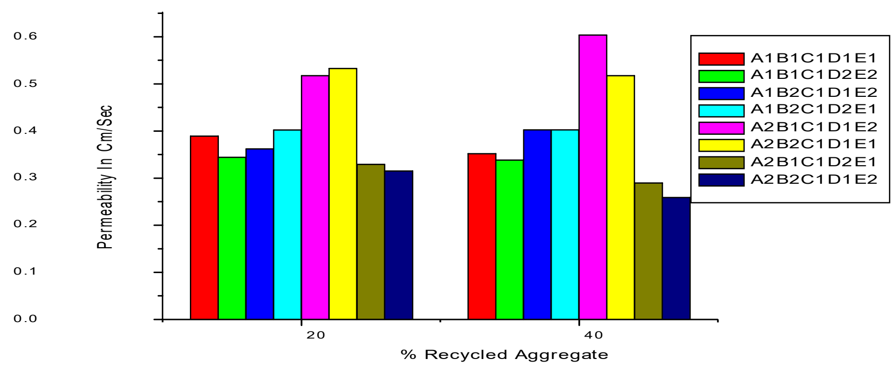

Figure 4.12 % Recycled Aggregate Vs permeability

Conclusion and Future scope

As per the various tests conducted on the various concrete mix designs it is found thatthe mix ratio of all the constitutents such as (1) water/cement proportion, (2) cement aggregate ratio,(3)recycled aggregate, (4) sand, and (5) grade of aggregate all play a major role in each of the characteristic of fresh and hardened concrete.

It is found that the slump value for the mixes having 20% recycled aggregate and lesserwater content has best slump values than other mixes and 40% recycled aggregates.

Coming to the hardened form of the concrete, the compressive strength and split tensile strength of the 40% recycled aggregates concrete cubes are higher than that of 20% recycled aggregates. Therefore a future scope for the study where the compressivestrength of the cubes drops as the percentage of recycled aggregates is increased can bedetermined and an optimum percentage of recycled aggregate to be mixed for better results.

Permeability of the 40% recycled aggregate mixes are also higher than that of the 20%recycled aggregate mixes. Therefore superior drainage ability is obtained in 40 % recycled aggregates.