

**EXPERIMENTAL STUDIES ON PERMEABLE CONCRETE
USING RECYCLED AGGREGATES**

**A
THESIS**

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IN
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*Under supervision
of*

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by

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to



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MAY-2019

STUDENT'S DECLARATION

I hereby declare that the work presented in the Project report entitled “**Experimental Studies on Permeable Concrete Using Recycled Coarse Aggregates**” submitted for partial fulfilment of the requirements for the degree of Master of Technology in Structural Engineering at **Jaypee University of Information Technology, Waknaghat** is an authentic record of my work carried out under the supervision of **Dr. Saurav Assistant Professor**. This work has not been submitted elsewhere for the reward of any other degree/diploma. I am fully responsible for the contents of my project report.

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CERTIFICATE

This is to certify that the work which is being presented in the project report titled **“Experimental Studies on Permeable Concrete Using Recycled Coarse Aggregates”** in partial fulfilment of the requirements for the award of the degree of Master of Technology in Civil Engineering submitted to the Department of Civil Engineering, **Jaypee University of Information Technology, Waknaghat** is an authentic record of work carried out by **Ajay Vikram (172656)** during a period from August, 2018 to May, 2019 under the supervision of **Dr. Saurav**, Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat. The above statement made is correct to the best of my knowledge.

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ABSTRACT

Permeable concrete is also known as porous concrete with excessive water permeability that allows water to flow via without problems via the present interlinked huge pore shape. This study reviews the consequences of an investigation for the improvement of permeable concrete. Figuring out the void content, compressive strength after 7 days and 28 days & water permeability beneath falling head the properties of the permeable concrete has been analysed. Reduction in the most appropriate combination of sizes is 10mm to 5mm and 3mm to 5mm the compressive strength of permeable concrete increases. The relation among porosity and compressive strength of 28 days for permeable concrete was badly influenced because of the usage of recycled aggregate concrete rather than of normal aggregate. Though, the binder substances type, age, combination size and take a look at specimen shape had an average impact on the porosity-strength courting. The outcomes additionally confirmed that the permeable concrete has water permeability is mostly because of the porosity and no longer suffering from the use of recycled aggregate to natural aggregate. Observed inter-relationships evolved among compressive strength, porosity and water permeability is used in the mix proportioning of permeable concrete by natural and recycled coarse aggregate to satisfy the requirements of compressive strength and water permeability.

Keywords: Permeability, Permeable Concrete, Recycled Concrete Aggregate, Porosity, Mix Design and Strength.

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CHAPTER 1

INTRODUCTION

Permeable concrete (additionally referred to as permeable concrete, porous concrete, no porous pavement and excellent concrete) is a unique kind of concrete with a high porosity that can be used for concrete flatwork programs which lets in water from rain and other sources to skip without delay throughout, thus reducing the runoff from the time when a site and permitting groundwater recharge [1]. Permeable concrete has made the usage of huge aggregates with little to no first-rate aggregates. The concrete paste then covers the aggregates and permits the water to skip from the concrete slab. Permeable concrete is historically utilized in parking areas, regions with mild site visitors, greenhouses, pedestrian walkways and residential streets. It is a vital application for the sustainable production and is certainly one of many low effect development strategies utilized by builders to shield water high-quality. Permeable pavement is a composed medium that clears the way of storm water through itself to the latent sub soil, which stocks water underground for the nonce. Surface material for permeable pavement did not undergo optimization to a great extent[2]. Permeable concrete is proportionately porous, providing by the exclusion of fine aggregate and pack most of volume with coarse aggregate thus, permeable concrete acquires more voids in the structure dominant to higher water infiltration and air exchange rates collate to conventional concrete, but the structural strength of it is compromised. Properties of mortar, coarse aggregate and the interface determine the strength of concrete. Being very thin, cement paste in permeable concrete fails to create a binder interface between the aggregate that ultimately results in low compressive strength [11]. Permeable pavement system which is also known as PPS, are also use in commercial, residential and industrial applications. We think that this system is used to light duty and infrequent usage but this is used in wide range also. This can be used where there is any possible emigration of pollutants into ground water. An impermeable membrane must be constructed in a PPS and treated storm water have to eventually ooze into an appropriate drainage system. Permeable pavement system is also used where the contaminated water can invade to the underlying soil [21]. During infiltration dangerous pollutants like hydrocarbons and intense metal have the potential to pregnable the groundwater and soil. For the prevention of sand from wandering to the base of permeable

pavement system geotextile are used. During the design of Permeable pavement system, it is very significant to provide storage capacity, maintenance and surface infiltration to pass sufficient amount of storm water that can be treated. Thus, the infiltration linked to the moisture conditions in the pavers and the volume of water infiltrate and bedding layer. Trickling and percolation represent the flow of water as of the unsaturated zone to the immersed zone of the base layer, and it is the major inflow source to the soaked zone accepting that there is no water trade by the encompassing condition underneath the ground level[8].

1.1.HISTORY

Permeable concrete was firstly, used in 1800s in Europe as pavement and load bearing walls. Cost efficiency was the main cause due to a decreased amount of cement. It became accepted again in the 1920s for two storey houses in England and Scotland. It became increasingly feasible in Europe after World war II due to the lack of cement. It wasn't so popular in the US until 1970s. In India it become popular in 2000[1,3].

1.2. Properties:

Fresh Properties:

The permeable concrete mixture is rigid in comparison with the usual concrete. When we measure slumps the value is generally 20mm. though the slump is so high as 50mm are been used. When the aggregates placed and compressed, they firmly adhere to each other and show the characteristic properties of open medium.



Fig.1.1. Laying of fresh concrete (source: Md. Aminur Rahman et al. [11]).

For exceptional guarantee and nice manipulate, bulk density or unit weight is one of the favoured dimension due to the fact few clean concrete homes like hunch are not as enormous

for permeable concrete. Common or everyday solid-cylinder strength assessments additionally gives small fee, due to the fact the sphere concentration of permeable concrete is not easy to replicate in barrel shaped test specimen, and strength is greatly depending on the void content. Unit weights of permeable mixture to conventional concrete aggregate are 70:1. Concrete running time for it is normally reduced due to permeable concrete mixtures. Normally it's recommended to keep an hour gap between mixing and placing shown in Fig.1.1. Though, this all can be controlled by using hydration stabilizers and retarders that extends the working time by as much as 1hr. 30min., depending upon the quantity [11].

Hardened Properties:

Porosity & Density:

The density of permeable concrete relies upon proportions and home of the materials used, and at the compaction methods which might be use in position. In-vicinity densities lying on the allege of 1601 kg/m³ to 2001 kg/m³ are not remarkable, which can be the part of top variety of lightweight concrete. Pavement of 125mm thick by 20% voids may be successful to store 25mm which can preserve rain in its voids, which cover widespread many of were positioned on a 150mm fat coating of open-graded pebbly or beaten rocks secondary- base, the store potential will increase to as a good deal as 75mm of precipitation [16].

Permeability:

The placing operation and materials were depends on the rate of flow via permeable concrete. 0.2cm/s to 0.54cm/s are the typical flow rate of water by the rate of up to 12cm/s. In the laboratories still larger rates were also measured [15].

Compressive Strength:

The mixtures of permeable concrete, in experimental labs, are evaluated or resolved to built a range of compressive strength between 3.5MPa to 28MPa, this can be appropriate for various application. Typical values are approximately 17MPa. The combination and properties of distinct materials, moreover as function strategies and environmental situations, can dictate the precise in-region electricity, as with any concrete fabric. Though, currently there may be no ASTM take a look at ordinary for compressive power of permeable concrete. Testing variability that is measured the usage of varied draft check approaches has been found to be

high and hence compressive power isn't suggested as an popularity standards.

Flexural Strength:

Flexural strength in permeable concrete typically range amid 1MPa and 3.8MPa. Many elements control the flexile strength, considerably diploma of consolidation, porosity, and additionally the mixture/cement proportions. Though, same old application made with permeable concrete doesn't need the dimension of flexural energy for layout [19].

Shrinkage:

Dry shrinkage of permeable concrete builds faster. Though it's miles without a doubt notable to a huge volume than traditional concrete. Specific values could be depends on the substances used in it and mixtures, but value enjoin to 0.002 have been mentioned, around 1/2 that of traditional concrete combos. Approximately five hundredth to eightieth of shrinkage happens within the preliminary ten days, compared to twenty to half of-hour inside the same term for ordinary concrete. Due to the lesser shrinkage and additionally the surface nature, numerous permeable concrete is created without manipulate joints and allowed to crack arbitrarily [23].

Freezing Thaw Resistance:

Freezing thaw resistance of permeable concrete inside the area seems to be related with the saturation degree of voids inside the concrete all through moment of freeze. In the sphere, plainly the fast draining features of permeable concrete keep away from saturation from occurring. When the massive open voids were waterlogged, absolute freezing may reason rigorous damage in few cycles [20]. Standardized trying out with means of ASTM C 666 can not represent area situations quite, because the big open voids are saved saturated in the take a look at, and because of the fee of freezing and defrosting be fast. It is made known that even once eighty cycles of sluggish freeze and defrosting, permeable concrete combos sustain extra 95% in comparative dynamic modulus, whilst the identical combos showed a lot less than 50% when tested at a extra speedy rate. It became stated that higher performance conjointly is probably predicted in the situation due to the short draining physical

characteristics of receptive concrete. During the usage of air-entraining agent inside the cement paste, setting the permeable concrete on at the least 150mm, and on occasion up to 300mm or even 450mm of a drainable rock base, such as 25mm beaten stone, is normally encouraged in freeze-thaw environment wherein some full-size moisture might be encountered in the course of freezing situations [28].

1.3. ADVANTAGES OF PERMEABLE CONCRETE:

Ease in Installation:

Pervious pavement doesn't need pricey things like concrete or asphalt surfaces do. In favour of an unending installation, the land does not contain any grade and vegetation, the level of rock is out-fitted as a support, just like a concrete or asphalt set up. Then the grids are laid out, and clipped to fit roughly any objects. These grids were pallet-sized and mild sufficient to be used by means of a solo character, make it easier to plow big areas in a shorter period of time. Once grids were placed in their respective location and locked combined, they are packed with gravel or limestone, and compacted right into a robust and durable floor. As grids contain great strength, heavy devices can be used to sell off, spread and compact the fabric with right planning and installation. Once the grids are filled, they are capable to last long to deal with almost any type of small or big vehicle or device [32].

Durable:

In many instances pervious paths are durable like concrete or asphalt surfaces. It can sustain heavy vehicles which include wheel loaders, backhoes, forklifts and 18-wheelers without any issue. Because they consist of floating floor and has joints that make it flexible, which is capable to move because of the soil under it changes and shifts. Asphalt or concrete will generally tend to buckle whilst situations like frost motive upheaval, or if the soil under is compacted or washed away. Pervious path won't crack or break down due to expansion and contraction like concrete and they are less likely to be damaged and form potholes [34] [35].

Sustainable:

The pervious paths grids are composed from surroundings pleasant cast-off materials which

reduce the quantity of waste inside the gadget and decrease the power necessary make or build fresh substances. On the end of their existence, they might be difficult be recycle, simultaneously reduce the carbon footprint [31].

Low Cost:

Concrete and asphalt may be luxurious to use and requires a big quantity of manual labour. Pervious paths are cheap in evaluation and in consistent with rectangular foot and calls for relatively less labour. The fill substances are taken from neighbourhood belongings, reducing its price of transportation and due to the truth that these grids are made from mild- weight plastic, the delivery charges are decreased to its lowest.

Can be Temporary:

Many times businesses want additional parking on a temporary basis, like at some point of the holiday season or at huge carrying occasions. Afterward, the space may want to be reclaimed for other makes use of. Pervious pavement can be used as proper solution for temporary parking. The grids may be organized down over an easy bed of gravel or reasonably flat soil, then stuffed with gravel or sedimentary rock to shape a short parking zone. Afterward, these grids can be easily eliminated without any problem and can be saved for use for some another time, and the filled material can be reused elsewhere or thrown away [22].

Can be used as Lawn Parking:

The grids that are filled, can be used to temporary garden parking for light-weight vehicles and by dividing the burden, the garden reflects less damage and as a result grid can be easily removed and saved for later use. For permanent growth parking at venues like fairgrounds or song venues, the grids may be hooked up with a base of rock, then packed with sod or soil and grass seed to offer a durable parking surface that looks as if a ordinary lawn whilst it is not getting used. It can be maintained with ordinary gardening tools, and not like dirty paths of parking, it won't be a muddy mess after a rain storm. For a permanent use at venues like fair grounds or concert areas, these grids can be installed with a base of rock, then can be filled with soil and grass seed to provide a durable parking floors that look like any another normal garden which is not used [37].

Build Temporary or Short-term Roads:

Weighty gear at oil field or manufacturing sites are the main purpose for harm to encircling soil, compacting it or making roughness that create it hard to apply or traverse, especially after a rain storm. With porous paths, you will be able to create temporary roads in an effort to defend the soil via the construction vicinity, or drill operation. The sites can be restored as new as possible when the roads are eliminated. With a complete location of rocks and gravel stuffed, the permeable course might be able to help the heaviest system and still be smooth to cast off.

Substitution to costly Drainage system:

With a traditional asphalt or concrete surface, the parking places need to have typhoon drains, devices and pipes to control overflowing water during rainy season or flooding. This can drastically be added to the construction charges of the parking region, and if the device is hooked up to a municipal waste water machine, there can be greater expenses and permissions are also required to integrate the drainage system. Pervious paths let in any water that is gathered around drain through the surface and into the floor. This allows preventing flooding and allows any aquifers inside the vicinity to be refilled evidently [36].

Can be used as Erosion Control:

In soil free areas, like the arid southwest or on hills or slopes, pervious paths can be used to preserve soil and stop erosion. Simply vicinity the paving grids over the location that needs safety and fill it with gravel, or for a variety of herbal appearance, soil and grass seed. It can additionally be used for landscaping purposes, to create walkways or enhancing the areas around timber or different structures. Pervious paths in particular versatile paving cloth and may be an exceptional worth in comparison to asphalt or concrete. It creates a strong, strong floor that desires a marginal quantity of maintenance, and it could be used almost anywhere[27].

1.4. FUNCTION OF PERMEABLE CONCRETE:

- Patios
- Lining of walls
- Artificial reefs
- Pavement edge drains
- Driveways and residential roads
- Pathways or sidewalks
- Parking areas
- Low water crossings
- Tennis courts
- Sub-base for the conventional concrete pavement
- Low-volume pavements
- Stabilization of slopes
- Tree grates in sidewalks
- Groins and seawalls
- Hydraulic structures
- Decks of swimming pool
- As Noise barriers
- Walls

CHAPTER 2

LITERATURE REVIEW

2.1. General

This examination is about Permeable concrete. Permeable concrete is a sort of solid that has a low water-bond proportion and contains none or next to no measure of sand. This solid has a light shading and open-cell structure as a result of which they don't assimilate warm from the sun; they additionally don't emanate the warmth over into the climate, which lessens warming in the earth. This examination paper shows the after effects of checking water quality from a few test vehicle stop zones planned and built in Spain with coves made of interlocking solid square asphalt, permeable black-top, polymer-modified permeable concrete and strengthened grass with plastic and solid cells.

2.2. Literature Survey

Evi Aprianti S [1] In this paper the issues of property are of top problems presently as we will be inclined to use extraordinary amount of natural assets for manufacturing materials like concrete. Depletion of herbal sources is one among such sustainability issues which we want to address in an efficient manner. Thus, usage and use of these wastes could reduce the use of herbal sources and it can also serve toward the call for of environment. The gift paper offers a brief reputation of recycled mixture concrete created out of recycled combination summarizes and extensively analyses a number of the maximum important research findings over the last few years concerning the material elements. It moreover attempts to give an explanation for the processes for the higher performances, identifies the gaps within the present facts and underlines the reasons why this promising generation has not become extensively normal by way of the improvement business enterprise. Thus natural resources and raw materials are wished in massive quality used for the production of concrete worldwide.

Chandrappa et al. [2] In this paper the utilization of permeable concrete as an asphalt cloth in low-volume road programs has picked up importance due to its fantastic herbal views.

This paper audits the upgrades what is extra, satisfactory in elegance relevant to permeable strong studies and practices. The examinations on mechanical-hydrological-durability properties of permeable cement finished in one of kind examinations have been evaluated. The tempest water decontamination talent of permeable cement has been recorded. The discipline examinations of few take a look at areas and in-benefit permeable strong asphalts had been talked about. A survey has been made on recuperation tactics to build the water powered productiveness of permeable cement asphalts. A be aware has been made connection with at the lifestyles cycle value research of permeable cement. Due to an expanded utilization of permeable cement inside the asphalt enterprise due to its innumerable advantages, there exists a broad degree for extra research to apprehend the fabric better, which will make it a succesful realistic roadway material in future.

Lei Gu and Togay Ozbakkaloglu [3] In this paper plastics have emerge as an crucial part of our modern-day way of life, & worldwide production of plastic has increased hugely. This paper summarizes this written literature till 2015, discuss the material residences & recycling techniques of additionally the affect of plastic substances to the properties of concrete. To offer a complete evaluation, a whole of eighty 4 research were thought-approximately, and they have been classify in sub lessons based on no longer or now not they treated. Furthermore, the morphology of concrete containing plastic substances is represented at some stage in this paper to make clear they have an impact. The residences of concretes containing virgin plastic substances were additionally reviewed to check their similarities and variations with concrete containing recycled plastics.

Aditya Ranaa et al. [4] In this paper the Portland cement development system is a chief contributor to greenhouse fuel emission and lack of herbal sources. The partial substitute of cement by way of commercial waste likes fly ash, silica fume, stone waste and so on. Now not entirely make a contribution to belongings development. Though conjointly complements the sturdiness of concrete. Among the numerous wastes investigated within the past, the result of marble suspension on sturdiness of concrete has no longer been studied. Cutting, grinding and sprucing maneuvers in marble dispensation plant life generate a big amount of slurry, which adversely impacts the surroundings and people. The present examines the feasibleness of the use of marble deferral in concrete manufacturing, as partial alternative of Portland cement. Six concrete mixes, containing marble slurry (up to 25%) in area of

Portland cement have been set and evaluated for energy, morphology, permeability, resistance to chloride migration porosity, carbonation and corrosion.

Joshaghani et al. [5] In this paper permeable cement is a feasible asphalt with high penetrability. The reason for this investigation is to assess mechanical and physical properties of the permeable cement including thickness, quality, porosity, and penetrability. Taguchi structure of trials was utilized to advance the execution of these qualities. The connection between properties subject to coarse total size. As the most extreme size of the coarse total increments, both the porosness and porosity grows up. Likewise, it results in a noteworthy abatement in compressive quality. There is an exchange off among quality and porosness which ought to be considered to meet the base prerequisites for the permeable cement.

Fontaneda et al. [6] In this paper permeable asphalts have become out to be a standout amongst the most utilized affordable city waste framework (SUDS) tactics in car parks. This exam paper displays the outcomes of checking water first-rate from some exploratory vehicle prevent regions planned and developed in Spain with straights made from interlocking strong rectangular asphalt, permeable black-pinnacle, polymer-modified permeable concrete and bolstered grass with plastic and stable cells. Also, unique sub-base materials were applied (limestone totals and critical oxygen heater slag). This investigation on this manner envelops maximum of the materials applied as porous surfaces and sub-base layers anywhere throughout the world. Effluent from the check sounds became determined for disintegrated oxygen, pH, electric powered conductivity, add as much as suspended solids, turbidity and mixture oil hydrocarbons with the stop intention to interrupt down the conduct seemed by means of each mix of surface and sub-base substances. What's more, penetrability checks had been attempted in all vehicle parks utilizing the 'Laboratories Caminos Santander' permeameter and the Cantabrian Portable Infiltrrometer. All consequences are given collectively the influence of floor and sub-construct materials with admire to water best markers utilizing bivariate connection measurable investigation at a confidence size of 95%. The polymer-modified permeable strong floor route in mixture with limestone overall sub base exhibited the pleasant execution.

K . Cosic et al. [7] In this paper they have an effect on of mixture kind and length on the houses of permeable concrete. Five unique concrete mixtures had been organized, which include a popular dense concrete mixture and 4 permeable concrete combinations with

numerous combination sorts (dolomite or metal slag) and differing proportions of 4–8 mm to eight–sixteen mm mixture fractions (30:60 or 60:30). The outcomes propose that a better quantity of small mixture fractions (four–eight mm) yielded better density concrete combinations and extra flexural energy. Though, connected porosity is the principle parameter for estimating permeable concrete performance becomes enormously prompted more with the aid of the aggregate type than the dimensions.

Monalisa Behera et al. [8] In this paper the issues of property are of top problems presently as we will be inclined to use extraordinary amount of herbal assets for manufacturing materials like concrete. Depletion of herbal sources is one among such sustainability issues which we want to address in an efficient manner. Thus, usage and use of these wastes could reduce the use of herbal sources and it can also serve toward the call for of environment. The gift paper offers a brief reputation of recycled mixture concrete created out of recycled combination summarizes and extensively analyses a number of the maximum important research findings over the last few years concerning the material elements. It moreover attempts to give an explanation for the processes for the higher performances, identifies the gaps within the present facts and underlines the reasons why this promising generation has not become extensively normal by way of the improvement business enterprise.

H.M. Imran et al. [9] In this paper uncontrolled storm water runoff not solely creates drain issues and flash flood Though additionally present a substantial danger to water quality and therefore the surroundings. These issues will, to an outsized quantity, be decreased by means of a sort of typhoon water management method using permeable pavement systems (PPS) in urban, business and business regions, anyplace common issues are as a result of severe undrained hurricane water. PPS may be accomplice competitively priced resolution for assets drain systems, and management water security similarly as renewable strength in certain instances. Considerable research has been carried out at the function of PPS and their enhancement to ensure sustainable drainage structures and water best. This paper affords a evaluate of the usage of permeable pavement for numerous features. The paper focuses on drainage structures and storm water runoff best from roads, driveways, rooftops and parking masses. PPS are extraordinarily powerful for hurricane water control and water recycle. Moreover, geotextile gave extra centers to decrease the pollution from penetrate runoff into the ground, developing a appropriate environment for the biodegradation method.

Furthermore, recently, floor supply heat pumps and PPS are determined to be a super combination for property renewable electricity.

Wen-Ten Kuo et al. [10] In this paper strong municipal waste incinerator bed ash was carried out to the test instead for ordinary aggregate in permeable concrete. The blend mix of the concrete had been 1st resolute the use of a vertical glide test. Other exams, which incorporates compressive power, permeability, bending and break up tensile strength assessments, had been additionally completed. The check consequences show that the unit weight of the modern permeable concrete created with MSWIBA modified into near 1653–2080kg/m³ and extra ideal to the ratio of cement paste filling.

Md. Aminur Rahman et al. [11] In this paper pervious pavements are regularly greater used as urban storm water manage structures. Pervious pavement structures permit hurricane water to penetrate through the pavement surface and into the clear out layer. Three not unusual recycled creation and demolition substances, recycled concrete combination, beaten brick and reclaimed asphalt pavement had been assessed in mixture with nonwoven geotextile to evaluate their suitability as clean out substances in permeable pavements. As in dangerous situation, storm water mixtures were organized in the experimental labs with a little better than the average pollutant ratio in storm water runoff events taking location in town areas. Constant head permeability exams were finished to examine the storm water filtration ability and clogging behavior of recycled creation and demolition substances. This research placed that the geotextile cover will increase pollutant deletion efficiency of the recycled creation and demolition substances; though it has capacity to cause extra clogging because of non-prevent accumulations of sediments in a protracted length. The Model for Urban Storm water Improvement Conceptualization modified into moreover hired to expect the pollutant elimination efficiency of the recycled creation and demolition substances and the expected consequences have been confirmed with the laboratory experiments.

C. Thomas et al. [12] This paper gives the most of the evaluation administered to observe the bodily, mechanical and sturdiness houses of concrete incorporate recycled combination. One of the major unknown factors of recycled mixture concretes is stated to sturdiness in insistent environments. Also the majority of the outcomes determined within the text aren't equivalent because of the heterogeneousness of the water/cement ratios, recycled aggregates and sorts of cement used. In this analysis, recycled aggregate concrete with limited and

ordinary coarse mixture alternative and reference concretes with 24 w/c ratio had been cast to have a look at their bodily and mechanical homes, behavior underneath stepped forward permeation, oxygen and water permeability. The durability of the concretes created with recycled mixture is worse because of the intrinsic porousness of them. These variations decrease for low w/c ratios, as in this case the maximum influential element is the low porosity received inside the new stepped forward cement paste.

Nguyen et al. [13] In this paper seashell by Products (SBP) are delivered in a critical amount in France and are consider as waste. This paper examines their utilization as a fractional substitution of totals in permeable solid pavers considered as a naturally well disposed building material. In the wake of structuring the control permeable solid pavers by researching the vitality and the weight compaction, the coarse total portion were halfway (20% or then again 40% by mass) supplanted by SBP got from the *Crepidula* shell. The squashed *Crepidula* seashell of 2/ 4 mm and 4/6.3 mm were utilized to make new seashell side-effects based pavers. In this paper, the mechanical and hydrologic properties of both permeable solid pavers were resolved. Results appear that the seashell results can possibly be utilized as total. The blend configuration permits accomplishing both a compressive quality of 16 and 15Mpa for separately the control permeable solid pavers and the seashell side-effects based pavers and a porosness coefficient in the scope of 3– 8mms⁻¹.

Kevern and Farney [14] This paper shows the after effects of an exploration undertaking to examine lessening the requirement for relieving permeable cement under plastic by consolidating a superabsorbent polymer (SAP) ordinarily expected for inner restoring. Permeable solid examples were delivered with and without the SAP alongside extra relieving water. Compressive quality, unit weight, voids, and porosness testing were performed on solidified barrels. Shrinkage was resolved on bars for aggregate and autogenously distortion with controlled ring testing. Dampness misfortune was resolved with an altered form of the standard used to assess restoring mixes, trailed by rotating shaper surface scraped area. Field test areas were put and relieved under plastic or left open. The outcomes demonstrate that blends containing the SAP would be advised to usefulness and were more grounded at equivalent void substance. The blend containing the SAP had diminished shrinkage, dampness misfortune, and scraped area. After winter, the unprotected SAP field blend had execution equivalent to the control blend restored under plastic. Albeit starter, the outcomes

demonstrate that SAP can possibly lessen restoring necessities for permeable cement under numerous natural conditions.

Kayhanian et al. [15] This paper depicts an examination that utilized penetrability estimation alongside physical and hydrological attributes of 20 permeable solid asphalts in parking areas all through California. The porosness was estimated at five areas: the primary passage, a territory with no activity, and three discrete estimations inside a parking spot at each parking garage. Hydrological and physical site attributes for example, movement stream, disintegration, vegetation cover, dregs amassing, support practice, nearness of breaking, precipitation, and temperature information were likewise gathered for each parking area. These information were utilized to perform itemized factual examination to decide factors impacting changes in porosness and thus surveying conceivable reason for stopping up. Likewise, seven delegate centre examples were gotten from four distinctive parking garages with porosness going from low to high. Porosity profiles created from CT checking were utilized to survey the conceivable nature and degree of stopping up. Results demonstrated that there is an extensive variety in porosness inside each parking area and between distinctive parking garages. All in all, the age of the parking area is the transcendent factor impacting the porosness. Factual examination uncovered that fine dregs (particles fewer than 38 mm) mass is additionally an vital affecting variable. Other affecting components with lower hugeness included number of days with a temperature more noteworthy than 30 C and the measure of vegetation alongside the parking area. The consolidated examined picture examination and porosity profile of the centres demonstrated that most obstructing happens close to the surface of the asphalt. While bring down porosity for the most part had all the earmarks of being restricted to the upper 25mm, in some centre examples proof of low porosity was found up to 100mm underneath the surface.

Mukesh Limbachiya et al. [16] In this paper the main minimizing the environmental effect of concrete manufacturing with the aid of substituting virgin mineral substances with the aid of recycled ones similarly as decreasing the worldwide CO₂ emissions. The approach followed right here includes an outsized substitution of herbal coarse aggregates (NA) with the aid of recycled concrete aggregates (RCA) received from overwhelmed concrete dirt, similarly because using 30% ash (FA) as a partial substitute of Portland cement for solfa syllable concrete manufacturing. Previous have a look at via the authors has located the

ability of victimization coarse RCA to supply concrete with an identical 28-day fashion electricity thereto obtained as soon as victimization natural aggregates. This paper discusses the end result of every partial and full replacement of herbal coarse aggregates by means of coarse RCA during a ash concrete. Engineering residences and sturdiness overall performance are tested on each concrete sorts (Portland cement and fly ash) for mixes designed with severe proportions of the RCA (zero%, 30%, 50% and one hundred%) through mass. The outcomes received confirmed that while embed high amount of the RCA ought to minor resistance to chloride penetration and carbonation of concrete nonetheless similar layout energy to that of the control mix is probably achieved.

Gin Lee et al. [17] In this paper permeable solid asphalt is water and air penetrable, the dirt below can be kept damp and water may rapidly channel into ground, permit groundwater assets to recharge in time. Permeable cement additionally has numerous other favourable circumstances including sound retention and slide obstruction and is thusly appropriate in Taiwan's stormy and moist condition. Be that as it may, the predominance of air voids result into low quality, so permeable cement is not appropriate to use in surface streets with overwhelming activity loadings. In this investigation they tried to decide the reasonable blend of bond, silica rage, super plasticizer, steel fibre, course total, etc for permeable solid asphalt sufficient for street surfacing. The outcomes appeared that the pressure quality of one permeable solid centre example from the reproduced field site was up to 275.7kg/cm^2 furthermore, surpassed the common cement structure detail. The flexural quality of one permeable cement sawed example from the re-enacted field site was up to 48.11kg/cm^2 what's more, surpasses the interstate inflexible asphalt detail (45 kg/cm^2). Water infiltration was great with field penetrability test appearing about $1100\text{ml}/15\text{sec}$. This investigation of the recreated field permeable cement asphalt will be significant for roadway plan and development.

Haselbach et al. [18] In this paper explained the expanded urban temperatures negatively affect the regular and human condition by creating expanded vitality use and exhaust cloud arrangement. Permeable solid asphalt is one innovation that may help alleviate expanded urban temperatures. Temperature information from an instrumented site in Iowa and warmth stockpiling marvels for different climate designs are displayed. The site contains both permeable solid asphalt with a sun based reflectance file of 14 and customary solid asphalt

with a SRI of 37. Initiative in Energy and Environmental Design acknowledged a high SRI (>29) as one technique to portray a cool surface. Warmth limits of the two frameworks were considered alongside an affectability examination of the information sources. The assessment underpins the end that despite the fact that permeable cement may have a much lower SRI than customary cement made with comparable materials, it tends to be viewed as a cool asphalt alternative. Also, daytime rainfalls joined with the inside high surface region result in significantly more expulsion of put away warmth from the framework, with a more fast moderation of UHI effects and decrease in the potential for warm stun from tightly packed surface spill over.

Amor Ben Fraj et al. [19] This paper observes the mechanical homes and the sturdiness parameters of lightweight mixture. In this they have an effect on of each the growing inclusion of PUR foam waste and also the occurrence of super plasticizer to the compressive power, bulk density, workability, dynamic modulus of elasticity, mass loss, fuel permeability, chloride diffusion coefficient and general porosity of the different concrete to the comparison of usual weight concrete(made without foam waste). The decrease in density is replaced with the growth of total porosity in between the lightweight concrete. The durability of concrete is being lowered by the bad consequences of cementitious medium Compressive strength of lightweight concrete ranges from 8MPa to 16MPa and among ten nd fifteen criterion for the dynamic modulus of elasticity.

H. Hebhouh et al. [20] In this paper the experimental investigation became achieved by different series of concrete combinations: sand substitution aggregate, gravel substitution combination and a mixture of both aggregates (sand and gravel). The concrete formulations were made with a persevering with water/cement significance relation. The results deduced shows that the mechanical properties of concrete specimens made victimization the marble wastes had been located to conform to the concrete manufacture requirements and therefore the replacement of natural aggregates via waste marble aggregates as much as seventy fifth of any system is useful for the concrete resistance.

Schaefer et al. [21] In this paper, Portland cement permeable concrete has demonstrated splendid capability to decrease road noise, beautify splash and spray, and advance friction as a surface carrying route. A look at Iowa State University and the National Concrete Pavement Technology Centre to increase mixture designs and approaches for Portland

Cement Pervious Concrete used for highway applications. A file is produced on the development and typical overall performance of a Portland cement pervious concrete overlay built on the Minnesota Road Research Project low-amount roadway take a look at feature to determine the efficiency of permeable concrete as an path. Issues associated with creation of the path are defined, as are outcomes of field assessments to signify the scenario of the pavement seven months following production, to decide flow developments of the superimpose, and to represent the tire–pavement noise of the path. Results of this research display that powerful Portland cement pervious concrete path can be designed for exhausting direction packages.

Lian and Zhuge [22] In this paper penetrable bitumen, because of its large porosity and penetrability, is careful as an choice in evaluation to normal tightly packed tough bitumen is controlled for the water storm which is properly and sparing manner. Porous cement regularly made of single-sized overall sure collectively by means of Portland relationship, utilizing restrictedly as an bitumen material, suitable to its missing auxiliary great. Distinctive mixture structures have been endeavored and their impacts at the compressive quality and penetrability which is consider for porous cement were tested in this exploration. The perfect general and mix segments sample were cautioned for progressed pervious cement.

Park et al. [23] In this paper researched and broke down the physical and mechanical properties and additionally the seawater purging qualities of water-porous solid utilizing reused total, granular fake zeolite, silica smoke and glass fiber with the end goal to show successful use of waste solid total also, infer a technique to enhance the execution and seawater decontamination qualities of water permeable concrete. The quality test outcome demonstrated that the quality expanded as the blending proportion of the reused total was expanded. Be that as it may, it showed the attributes of more noteworthy compressive quality and flexural quality than plain cement by 50 and 75%, individually. The aftereffect of estimation for the broken up oxygen utilization sum and in addition T-N (add up to nitrogen) and T-P (add up to phosphorous) after the water-penetrable cement was submerged in the counterfeit water channel shown that as the target void proportion was more prominent, the seawater purging execution was more magnificent. Furthermore, it was discovered that the blending of the granular fake zeolite is compelling for seawater cleansing. Consequently, it

was found that despite the fact that the total was supplanted with reused total when making water-penetrable cement for seawater sanitization, if a suitable measure of admixture was blended; the reused total was successful for the physical and mechanical properties and additionally the seawater filtration qualities. It was suspected that the suitable blending proportion of the reused total was roughly half when the objective void proportion was set to 20%.

Neithalath et al. [24] In this paper techniques for describing the pore structure includes in a concrete based material with open pore structure, called permeable cement, and the utilization of these pore structure includes in porosness expectation is the focal point of this paper. Porosity of a few permeable cement blends is resolved utilizing volumetric and territory portion strategies while stereology and mathematical morphology based techniques are utilized to extricate the trademark pore sizes. The trademark pore sizes decided utilizing a few strategies relate well to one another. A Weibull likelihood circulation work is found to sufficiently demonstrate the pore measure appropriation in permeable cements. The estimations of porosity and the morphologically decided pore sizes, alongside the pore stage network spoke to utilizing an electrical conductivity proportion are utilized in a Katz–Thompson type relationship to foresee the penetrability of permeable cements. It is appeared in this paper augmentation of water transport conduct of permeable cements is best accomplished by expanding the pore availability factor.

M.L. Berndt [25] In this paper the suitability of exploitation more property concrete for turbine foundations and alternative applications related to great portions of concrete became investigated. The method taken becomes to form textile substitutions in order that the environmental, energy and CO₂-effect of concrete may be decreased. Five simple concrete mixes were taken into consideration. These had been (a) conventional blend with no cloth substitutions, (b) 50% substitute of cement with fly ash, (c) 50% replacement of cement with blast furnace slag, (d) 70% replacement of cement with blast furnace scoria and (e) 25% replacement of cement with ash and twenty fifth alternatives with chamber/furnace scoria. It comes to be determined that the mixes containing 50% slag gave the first-class widely widespread overall performance. Though, values remained best for durable concrete and the chloride diffusion coefficient turn out to be progressed via incorporation of slag within the blend.

Voldera et al. [26] In this paper the advancement of parking garages and person on foot regions, develop trees are regularly expelled from the site and supplanted with saplings after improvement is finished. This examination expects to ponder the likelihood of utilizing permeable permeable concrete as elective asphalt that may continue existing full grown trees, and every one of the advantages they can give, alive after site advancement. Three diverse asphalt medicines: no asphalt, impenetrable widespread cement and permeable permeable cement had been contrasted extra than 2 years with test their capability to alter improvement and leaf gas change of existing 15– 18-yr-old American sweetgum (*Liquidambar styraciflua*) trees. Soil water and temperature elements of the permeable plots were firmly connected with the ones in the control plots. Plots treated with permeable cement had extra prominent soil water content than plots with standard cement within the greater profound soil layers in some seasons, yet now not amid the mid year. Tree dimension relative development prices have been similar over the three asphalt kinds. There turned into no effect of the drugs on leaf water ability or leaf fuel alternate. The information added on this paper endorse that permeable permeable cement does no longer deliver more benefits in making sure development and survival of preceding increase timber in new city improvements.

Haselbach et al. [27] In this paper permeable cement is a novel clearing material with macropores that guide in keeping up normal hydrologic penetration rates on created properties. There is a worry that the pores in the permeable cement may stop up because of long haul affidavit of fine materials in spillover, or due to a disastrous events, for example, the disappointment of upstream disintegration control measures or flooding. This exploration centers around these extraordinary occasions and introduces a research center technique mirroring a progression of calamitous stopping up cycles with earth loaded overflow. It is anticipated that the earth materials would will in general stay close to the surface of permeable solid frameworks since most arrangements have a vertical porosity dispersion with the littler pores close to the best. The centers utilized were from genuine field arrangements and the outcomes show that extraordinary occasions with generous affidavit of dirt on a permeable solid asphalt will significantly lessen its administration ability, even incidentally completely "obstructing" the asphalt. Be that as it may, the greater part of the mud stays on or close to the surface and the invasion limit of the permeable cement was

reestablished to satisfactory, despite the fact that lower, levels with straightforward upkeep, for example, surface clearing, and consequent flushing like ensuing precipitation occasions.

Kevern et al.[28]In this paper permeable cement is ending up more typical as a temperate water the executives device in stop defrost atmospheres. One of the primary concerns or hindrances keeping a more across the board application is the part of stop defrost sturdiness, regardless of whether saw or genuine. This research work portray a progression of tests intended to decide the particular job coarse total has on the stop defrost toughness of permeable solid utilizing the ASTM C666A strategy. Seventeen diverse coarse total examples were acquired from areas over the United States and Canada. Permeable solid blends were set utilizing a blend extent recently decided as stop defrost strong. The scope of solid total degrees unmistakably characterized a degree detail and recommendations are made for streamlining the degree with a little bit of sand. Blends with brilliant stop defrost execution contained either stone or very strong waterway rock. The effect of total precision on blend extents and extreme yield is additionally examined.

Lucka et al. [29]In this paper spillover from rural exercises can antagonistically influence the earth; in any case, close to nothing inquire about has been directed to decide the execution of permeable cement for use in horticulture. Permeable cement, with its exceptional invasion properties, could be useful at the point when utilized as a strong/fluid partition material for creature encouraging cushions, compost, or compost stockpiling cushions. Lab tests were directed on reproduced tests of permeable concrete produced using two total sources (waterway rock and limestone) with two size portions from each total. Water was sifted through treated the soil hamburger cows compost what's more, sheet material (compost) that was set over the permeable solid examples. T-tests shown that the mass of fertilizer held on the surface of the permeable cement examples was essentially more noteworthy when littler total sizes (#8 stream rock) were utilized ($p \leq 0.012$). Supplement investigations were directed on the gushing from the manure on permeable cement and contrasted with qualities from an indistinguishable test performed by separating water through fertilizer on a 80 review wire work screen. Sifting the fertilizer emanating through permeable cement brought about noteworthy decreases in absolute nitrogen, dissolvable phosphorus, and aggregate phosphorus contrasted with the wire screen; be that as it may, no reliably critical contrasts were found as for alternate analytes (e.g. broken down natural

carbon, ammonium, nitrate, and nitrite). The utilization of various total sorts (waterway rock or on the other hand limestone) or diverse added substances (fly fiery debris or filaments) did not have any huge impact on analyte levels. This proposes blends of these materials in permeable cement blends won't influence the execution of permeable cement in this kind of use.

Debieb and Said [30] In this paper preservation of natural sources and recycling and reutilization of constructing rubble suggests interesting scope for the monetary growth. This study examines the probability of exploitation weighed down brick as coarse and quality mixture to a new concrete. Crushed brick aggregate are used as a substitute for herbal sand, coarse aggregates. Flexural and compressive strengths up to ninety days of age had been compare with the ones of concrete prepared with the natural aggregates. Water absorption, porosity, shrinkage and water permeability had been also calculated. The results may imply that it is workable to fabricate concrete contain firmed bricks (coarse and satisfactory) with traits type of those of natural aggregates concrete as long as the proportion of recycled aggregates is restrained to twenty-five% and fifty% for the coarse aggregates.

Kwiatkowski et al. [31] In this paper permeable solid infiltration bowl was introduced on the grounds of Villanova University in August 2002. An examination was attempted to figure out what contaminants, assuming any, were acquainted with the dirt's fundamental the site because of this best administration practice (BMP). The normal infiltration rate at the site is around 10)4 cm/s. The waste zone (5,208 m²) comprises of verdant surfaces (36%), standard solid black-top (30%), and rooftop surfaces (30%) that specifically associate with the infiltration beds by means of downspouts and tempest sewers. Composite examples of infiltrated stormwater were gathered from the vadose zone utilizing soil dampness suction gadgets. Discrete examples were gathered from a port inside an infiltration quaint little inn downspout from a rooftop surface. Tests from 17 storms were dissected for pH, conductivity, and centralizations of suspended solids, broken down solids, chloride, copper, and aggregate nitrogen. Copper and chloride were the two constituents of worry at this site. Copper was acquainted with the framework from the roof top, while chloride was presented from choosing rehearses. Copper was not found in pore water underneath 0.3 m and the chloride was not significantly enough to affect the ground water. This exploration demonstrates that with appropriate sitting, an infiltration BMP won't antagonistically affect the ground water.

Miklas Scholz and Piotr Grabowiecki [32] In this paper the motivation behind this survey paper is to condense the wide-run Though diffuse writing on transcendently porous asphalt frameworks (PPS), feature momentum drifts in industries and research, to prescribe future territories of innovative work. The advancement of PPS as a basic piece of feasible waste frameworks specific underline is given to point by point structure. The major imperative target poisons are overwhelming metals, hydrocarbons and supplements (i.e. phosphorus and nitrogen). The points of interest and hindrances of various PPS are talked about with the assistance of ongoing contextual investigations. The most recent developments are featured and clarified, and their promising for further investigate work is laid out. Giving the ongoing examination on the advancement of a joined for cooling capability.

Ya-Mei Zhang et al. [33] according to their paper gives the different outcomes show that rubber debris from waste tires ar useful to reduction of dry shrinkage of cement mortars thanks to their tender characteristics. The addition of rubber powder in cement concrete will substantially enhance frost resistance of concrete. Though, coarse rubber particles (three~four millimeter in diameter) appear to personal little or no high quality end. The totaling of accurate quantity of rubber in concrete will cut back porousness of concrete, though excessive rubber could have negative end result.

K. Ganesan et al. [34] In this paper the usage of waste materials in concrete manufacture offers a quality approach to a number of the environmental issues and issues associated with waste management. Agro wastes which includes rice husk ash, wheat straw ash, hazel nutshell and sugarcane bagasse ash are used as pozzolanic materials for the improvement of blended cements. Few studies are reportable at the utilization of pulp. In this study, the results of BA content material as partial substitute of cement on physical and mechanical homes of hardened concrete vicinity unit reportable. The residences of concrete investigated embrace compressive power, splitting tensile power, water absorption, and permeability traits. The check results suggest that BA is a good mineral admixture, with two hundredth as first-class replacement magnitude relation of cement.

Haselbach et al. [35] In this paper permeable concrete is an change concrete floor which can be wont to lessen the nonpoint supply pollutants consequences of storm water overflow from made-up surfaces like parking and roadway thousands via allowing a number of precipitation to saturate into the bottom beneath. This penetration price is likewise adversely entire of

obstructive of the device, in particular clogging or protective through sand in coastal areas. The experimental consequences were associated with theoretical designed permeableness of receptive concrete device for receptive concrete system truly lined with sand surface. Two special slopes had been utilized. Rainfall fees were replicated for the mixture of direct rainfall and for added storm water runoff from adjoining regions. A fashionable receptive concrete block can permit water to satisfy up with at float costs larger than 0.2cm/s and an average greater excellent sand should have about 0.02cm/s permeability. The restrict of the tool with complete sand coverage led to an green system permeableness of about 0.004cm/s that is just like the rainfall amount of a thirty min duration, 100-365 days frequency occasion within the south eastern United States.

Liv M. Haselbach and Robert M. Freeman [36] In this paper permeable cement is an non-obligatory clearing fabric that could lighten a huge range of the ecological problems caused by urban overflow from created areas. Extra studies is vital through the goal that permeable cement may be superior indicate and all the greater viably applied. A critical assets of permeable cement is porosity, so that it will impact the hydrological and pleasant houses of the material. This exam demonstrates that there is a vertical flow of porosity in chunks positioned with positive function strategies. The vertical type of porosity can have an effect on the best disseminations .These examinations show that for sections around 15 cm (6 in.) in stature and set with an around 10% floor compaction device, the porosity increments altogether from nice to base. A development of vertical porosity conveyance situations had been produced to viably show this utilizing the percentage compaction what's extra, ordinary cored porosities.

L. Goodson et al 37] In this paper a mobile drainage shape is fashioned of a predetermined extent of a settable, water permeable, mobile concrete product. A concrete blend is shaped of a uniformly graded combination in the length variety from /16 inch to 2 inches and in a amount corresponding to the predetermined quantity; a cementitious factor in the amount range from 141 to 658 kilos per cubic backyard of product; water in amount sufficient to create a water-to-cement ratio in the approximate range from zero.30 to 0.55 and sufficient to wet the aggregate. Establishing a cementitious-factor-and water matrix of determinable quantity; a pre-fashioned surfacetant foam, generated from an aqueous surfactant mixture at a dilution of from approximately 3 to twenty-five grams in step with liter of surfactant in

water, wherein the pre-formed foam is inside the density variety of from 2.0 to a few.0 pcf, and the froth is introduced in the quantity range of 5% to 30% of the extent of the cementitious-issue-and-water matrix. Finally, the mix consists of an aqueous flocculent solution at a dilution of from 5 to thirty grams in keeping with liter of water and introduced to the combination in the amount variety of 54 to 2.394 grams in line with cubic yard of product.

M. A. Aziz et al. [38] In this paper the effects of tests conceded out lying on light-weight concrete by way of cork granule are stated. The checks said are for the compressive, tensile and bond strengths, density, permeability, thermal conductivity and shrinkage. Even though the cork light-weight concrete has obstacles its own, the versions which is probably viable by using the use of changing the aggregate proportions, degree of compaction, and so on., deliver upward thrust to a number of beneficial programs. In comparison to mild-weight concretes comprised of different organic aggregates like rice-husk, sawdust, timber-chippings, jute-stick, coconut fibers and debris, the cork light-weight concrete seems to be more succesful for its diverse predictable and unique programs.

2.3. Research Gaps:

1. Most of the works concerning permeable concrete have been performed without using concrete waste. Detailed analysis using concrete waste has not been performed yet.
2. No experimental validations have been performed till now without sand.
3. Previously only few experiments were performed using concrete waste to determine its mechanical properties without sand.

2.4. Research Objectives:

1. To design M25 grade of permeable concrete.
2. To find the mechanical properties of permeable concrete including flexural and compressive strength.

CHAPTER 3

EXPERIMENTAL INVESTIGATION

3.1. Materials used: The materials which are used in this study are meant to obtain the strength of permeable concrete.

3.1.1. PPC: Portland Pozzolana Cement as shown in Fig.3.1. It was used and manufactured at Ambuja Cement Ltd. Darlaghat, Himachal Pradesh confirming to IS 1489(Part 1):1991



Fig.3.1. Portland pozzolana cement.

3.1.2. Recycled coarse aggregate: Recycled coarse aggregate was used in place of normal aggregate. It was obtained by crushing the concrete cubes as shown in Fig.3.2.



Fig.3.2. Recycled coarse aggregate.

3.1.3. Silica fume: It is an artificial pozzolanic admixture as shown in Fig.3.3. It is obtained during manufacture of silicon or ferrosilicon alloys.



Fig.3.3. Silica fumes.

3.1.4. Super plasticizer: In Fig.3.4, it is a chemical admixture used where well-dispersed particle suspension is required, and it is also known as high range water reducer.



Fig.3.4.Super plasticizer (source: Amor Ben Fraj et al. [19])

3.2. Methodology:

The methodology used in this project started with the problem identification that was carried out by reading various research papers and review papers. After identifying the problem I started collecting materials and performed all the necessary testing. In this phase I will be discussing and showing all the test results calculated from the experiments performed.

3.2.1. Compressive strength measured with 5-10mm size of aggregates.

We prepared M25 concrete mix with 5-10 mm aggregate size. After 28 days of leaving it

undisturbed we checked the compressive strength of the block prepared. Although it gives the appropriate permeability but the compressive strength value didn't reach to the mark.

3.2.2. Compressive strength measured with 3-5mm size of aggregates.

When we prepared the mix with 3-5 mm sized aggregates, the value of compressive strength comes appropriate but it gave the value for permeability less than that of the mix prepared with 5-10 mm sized aggregates.

3.2.3 Silica fume and Super plasticizer mix proportion.

We prepared M 25 concrete mix proportion adding silica fume and super plasticizer in amount 5% & 0.6%, respectively with aggregate size 5-10mm. Then, I do not get appropriate results. So, I increased the percentage or amount of Silica fume and super plasticizer with 3-5mm size of aggregate up to 6% & 0.8%, respectively.

3.3. Tests Performed:

3.3.1. Normal consistency test:



Fig.3.5. Vicat's apparatus

Procedure:

1. Take 400gm of cement in a tray.
2. Assume normal consistency of water as 28%.
3. Add same quantity of water in cement and mix properly.
4. Mix paste thoroughly for 3-5min.
5. Put the paste within the mould.
6. Place mould on glass plate and spot that the plunger touches the paste surface lightly.
7. Release plunger and let it sink in the paste as shown in Fig.3.5.
8. Note down the reading of the plunger from the lowest.
9. Repeat this system again until the penetration of plunger reach between five-7mm.

3.3.2 Initial and Final setting time:



Fig.3.6. Vicat's apparatus

Procedure:

Preparation of Sample:

1. Take 400 g of cement and prepare a neat cement paste with 0.85P of water by weight of cement.
2. Keep gauge time b/w 3 to 5 minutes. When the water is added to the cement, Start the stop watch. Record this time (t_1).
3. Fill up the mould, resting on a glass plate, with the cement paste. Fill up the mould fully and level the surface of the paste.

B. Initial setting time:

1. Place the mould under the rod bearing the needle.
2. Then, let the needle touch the surface of paste lightly as shown in Fig.3.6 and drop the needle into the paste for penetration.
3. In starting the needle totally pierces the test sample. Repeat this procedure after every 2 minutes till the needle fails to pierce the sample for about 5mm. Note this time (t_2).

C. Final setting time:

1. To determining the final setting time, replace the needle by an annular attachment.
2. The cement is consider set when we apply the final setting needle lightly to the surface of the sample; the needle makes an impression, whereas the attachment fails to do so. Record this time (t_3).

3.3.3. Specific gravity test:



Fig.3.7. Specific gravity bottle (source: Global Gilson)

Procedure:

1. Weigh the empty flask (W₁) as shown in Fig.3.7. The flask should be totally dry.
2. Then, take the flask and fill it with cement about 50gm and Measure the weight (W₂).
3. Then, fill the flask fully with kerosene oil and mix the cement and kerosene oil properly to remove air bubble. Weigh the flask with cement and kerosene (W₃).
4. Now, empty the flask and fill it fully again with kerosene only. Weigh the flask (W₄).

$$\text{Specific gravity (S}_g\text{)} = (w_2 - w_1) / (w_2 - w_1) - (w_3 - w_4) * 0.79$$

3.3.4. Fineness test:



Fig.3.8. 90 micron sieve

Procedure:

1. Take the cement sample and rub the cement with hands. The sample should be free from lumps.

2. Now, Take cement about 100gm note it as W1.
3. Put the amount of cement in 90 μ m sieve as shown in Fig.3.8 and close it.
4. Now shake the sieve with your hands by for 15 minutes.
5. Then, weight the retained cement on the 90 μ m sieve and note it as W2.
6. Now, calculate the percentage of Weight retained on Sieve.
7. Repeat the experiment with different samples of cement and take the average of the reading.

3.3.5. Crushing Test:



Fig.3.9. Crushing test apparatus (source: indiamart.com)

Procedure:

1. The aggregates are oven-dried at a temperature of 100 to 110°C for 3 to 4hrs which are first passed through 12.5mm and retained on 10mm sieve.
2. The cylinder as shown in Fig.3.9 is then packed in three layers, every layer is tamped using tamping rod with 25 strokes.
3. Then weight the aggregate and note it as (Weight 'A').
4. Then level the surface of aggregate and insert the plunger. Then placed the apparatus in compression machine and compressed with a uniform speed to get 40tonn load in 10 min. And then, we release the load.
5. Then the sample is sieved through a 2.36mm sieve and the fraction passing through the sieve is weighted as (Weight 'B').

Crushing value = $(B/A) \times 100\%$.

3.3.6. Impact value or Toughness test:



Fig.3.10. Falling drop hammer

A. Preparation of samples:

1. The test sample should follow the given grading:

- Firstly passing through 12.5mm IS sieve should be done.
- Then it should be retended on 10mm sieve.

2. The sample should be dried in oven for 4hrs. At a temperature of 100 to 110°C.

3. Then mould should be filled with the prepared aggregates to about 1/3 and tamping is done of tamping rod with 25 blows.

The mould should finally fill to overflow, compress 25 times and the extra aggregates strike off, using a tamping rod as a straight boundary. The aggregate net weight is (Weight 'A').

B. Determining the Impact value:

i) Always remember to fix the mould of impact testing machine tightly on the base of the machine and sample placed in it and compressed by 25 strokes.

ii) The hammer is raised to 380mm above and allowed to fall freely onto the aggregates as shown in Fig.3.10. The test sample should be subjected to total 15 blows

C. Reporting the results:

i) The sample is sieved through a 2.36mm sieve. The amount that is being passed should be weighted (Weight 'B'). The amount on the sieve that is retained should be weighted as Weight 'C' and if the total weight B+C is less than the initial weight A by more than 1g, the result should be rejected and a new test should be performed and the process is repeated.

ii) The ratio of the weight of the fines formed to the whole sample weight ought to be expressed as a percentage.

Aggregate impact price = $(B/A) \times \text{a hundred}\%$

iii) Two such exams should be achieved and the mean of the results have to be suggested.

3.3.7. Abrasion test:



Fig.3.11. Abrasion testing machine (source: pavementinteractive.org)

Procedure:

1. Choose the grading which is used in the test such that it conform to the grading to be used in construction, for the maximum extent possible.
2. Take 5kg of tests sample for grading A, B, C & D &10 kg for E, F & G.
3. Place aggregates in the abrasion testing machine.
4. Set up the machine for 30 to 33 revolutions per minute. The no. of revolutions for the grading A, B, C & D are 500 and for E, F, G and H grading are 1000.
5. Then, stop the machine after the revolution and take out the sample from the machine as shown in Fig.3.11.
6. Then, the sample is sieved from 1.70mm sieve
7. The sample coarser than 1.7mm size is weighed correct to 1gm.

3.3.8. Specific gravity And Water absorption test:



Fig.3.12. Pycnometer

Procedure:

There are 3 methods of testing to determining the specific gravity of aggregates, according to their sizes greater than 10mm, 40mm and smaller than 10mm. For Samples smaller than 10 mm Pycnometer test is done as shown in Fig.3.12.

3.3.9. Compressive strength test:



Fig.3.13. Compression testing machine

Procedure:

A. Specimen:

- 6 cubes of 15x15x15cm size.

B. Sampling of Cubes:

1. Apply oil to the moulds.
2. Then, put the concrete sample in the mould.
3. Tamp the concrete sample with the tamping rod.
4. Smooth the top surface of the sample with the trowel.

C. Curing of Cubes:

The curing of cubes are done after 24hrs. Then, the cubes put in the water for 7days, 14days and 28 days.

D. Procedure for testing concrete cube:

1. Take out the cube after specified time of curing and dry it.
2. Then, put the cube in compression testing machine.
3. Then, fix the test cube by the upper rotating lever from the top surface of the cube.
7. Then, apply the load steadily with no jerk at the rate of $140 \text{ kg/cm}^2/\text{min}$ as shown in Fig.3.13.Until the specimen fails.
8. Note the reading at which cube fails.

3.3.10. Flexural strength test:



Fig.3.14. Flexural Testing Machine

Procedure:

1. Specimen is prepared into the mould in 3 layers approximately similar thickness by filling concrete in it. Compress layers 35 times using the tamping rod.
2. Surfaces of the supporting and loading rollers are cleaned, and surface of the specimen is also cleaned properly for extra sand.
3. Steel rollers having cross section of dia. 38mm to be used for providing support and loading points. Length must be 10 mm more than the width of the specimen. Four rollers are used there; three out of them must be capable of rotating along their own axis.
4. After removing specimen from water it is tested immediately, while they are still wet.
5. Put the specimen in the machine as shown in Fig.3.14.
6. Then apply the load at the rate of 400 kg/min for the 15cm specimens and for 10 Specimens apply load at a rate of 180kg/min.

3.4. PPC Testing:

Table.3.1: Various test results obtained on PPC:

Material	Normal consistency	Initial setting time	Final setting time	Fineness	Specific gravity
PPC	31.5%	140 min	256 min	98%	2.99

3.5. Recycled coarse aggregate testing:

Table.3.2: Various test results obtained on recycled coarse aggregate:

Aggregate size (mm)	Crushing test	Toughness or Impact value	Abrasion	Specific gravity & Water absorption
5-10	22.46%	11.33%	33.7	2.85 & 4.4%
3-5	18.3%	14.63%	29.6	2.04 & 8.2%

3.6. Experimental Variables:

The experiments to be performed in this project work should firmly be done with proper procedure and accurate parameters.

Following table shows the list of experiment performed and their respective procedures:

List of Materials and Experiments IS Codes

- Portland pozzolana cement IS 1489(Part 1):1991
- Test for aggregate IS 2386(Part 1,2,3,4,5,6,7):1963
- Compression test IS 14858:2000
- Flexural test IS 9399:1979
- Slump test apparatus IS 7320:1974
- Chemical admixtures IS 9103:1999

3.7. Mix design of M25 grade of permeable concrete:

Table.3.3 (a), shows the provisions for proportioning or steps which is to be followed for the preparation of mix design. Table.3.3 (b) shows the test results of the materials which are used in mix design process. And, Table.3.3(c) shows the mix calculations.

Table.3.3 (a): Provision for proportioning:

1.	Type of cement	PPC
2.	Maximum size of aggregate	20mm
3.	Minimum content of cement	310kg/m ³
4.	Max. water/cement ratio	0.45
5.	Workability	50-70mm
6.	Exposure conditions	Normal
7.	Aggregate type	Crushed angular
8.	Maximum content of cement	540kg/m ³
9.	Admixtures	Super plasticizer

Table.3.3 (b): Test data:

1.	Specific gravity of cement	2.99
2.	Specific gravity of water	1.0
3.	Chemical admixture	Conmix SP 1030
4.	Specific gravity of coarse aggregate	2.04
5.	Specific gravity of fine aggregate	0
6.	Water absorption	8.2%
7.	Adopted water/cement ratio	0.22
8.	Super plasticizer used	0.8% by weight of cement
9.	Cement content	627.27kg/m ³

Table.3.3(c): Mix calculations:

1.	Cement mass	627.27 kg/m ³
2.	Mass of water	138 kg/m ³
3.	Coarse aggregate mass	1356 kg/m ³
4.	Mass of admixture	3.68 kg/m ³
5.	Ratio of Water/Cement	0.22

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1. Variation in the properties of permeable concrete via using different size of aggregate:

Table.4.1, shows that we use two different sizes of aggregate in permeable concrete. The apparent density, water permeability coefficient & strength of the concrete were calculated. It is clear that permeable concrete strength is relatively low due to its high porosity. When the mixture's proportion and the apparent density are roughly same, by reducing the aggregate size result's in the increase of the concrete strength. This may indicate that the use of smaller size of aggregate may enhance the strength of the coherence between the cement paste and aggregate.

4.2. Effects of Super plasticizer and Silica fume on permeable concrete:

Table.4.2 represents the result of effects. A small aggregate of 5-10mm and 3-5mm size were used for the experiment, to examine the effects of silica fume and super plasticizers upon the strength and water permeability of permeable concrete. The mixture M3 uses an aggregate of the dia. 3-5mm. When 6% silica fume was mixed with 0.8% super plasticizer, the strength achieved was higher in comparison with the mixture M2. It shows that by using both silica fume and super plasticizer can achieve great effects. The result indicates that the high strength and good water permeability of permeable concrete can be produced by the use of smaller aggregates, silica fume and super plasticizer.

Table.4.1: Mix details

Mix	Aggregate's size (mm)	Fine aggregate (%)	Water/cement ratio	Silica fume (%)	Super plasticizer (%)	Unit wt. (kg/m ³)
M1	5-10	0	0.28	5	0.6	2100
M2	5-10	0	0.22	6	0.8	2050
M3	3-5	0	0.22	6	0.8	2125

Table.4.2: Test results on permeable concrete

Mix	Aggregate's size(mm)	Water/cement ratio	Compressive strength (MPa)		Flexural strength (MPa)	Permeability (mm/s)
			7 days	28 days		
M1	5-10	0.28	6.6	14.2	1.9	7.82
M2	5-10	0.22	12.2	19.8	2.6	7.64
M3	3-5	0.22	16	24.7	3.2	5.78

4.3. Variation in Compressive Strength for different Mix:

As shown in Fig.4.1, different mixtures M1, M2, M3 are taken and in them, different size of aggregate are taken and for different proportion of super plasticizer and silica fume, the compressive strength is calculated.

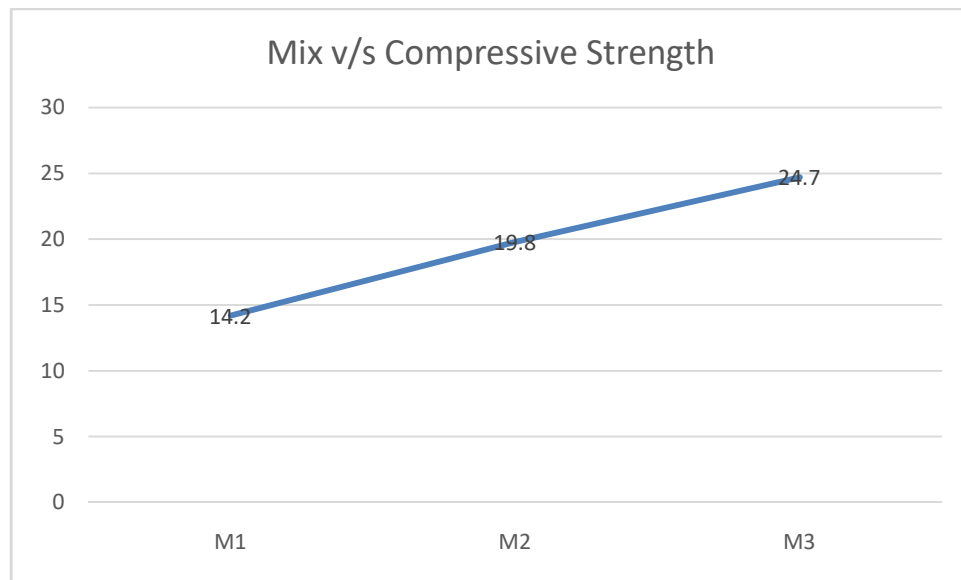


Fig.4.1. Varying Compressive Strength for different Mix

CHAPTER 5

CONCLUSION

Following conclusions are deduced from the results obtained:

1. As there are voids in permeable concrete it's hard to achieve high strength materials using the proportion of the mixtures and common material.
2. Use of small size of aggregates can be useful in enhancing the strength of permeable concrete and the cement quality can be adjusted according to the requirement.
3. The use of silica fume and super plasticizers can improve the strength of permeable concrete by a great amount.
4. Permeable pavement materials are made of a base layer and a surface layer. The compressive strength of the mixture can be reached up to 25MPa and flexural strength up to 3.2MPa, without the use of sand in the mixture.

FUTURE SCOPE:

In India there is a great need of pervious concrete because in urban cities such as Mumbai, Delhi, etc. There we know that the flood comes in the monsoons because there is no proper discharge facility of rain water. So, the pervious concrete will drain the rain water and prevent the cities from floods. And it is also useful in the parking lots, pedestrians and in the green houses.

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