"Design of Pervious Paved Parking Area to Harness Reusable Rainwater"

A PROJECT

Submitted in partial fulfillment of the requirements for the award of the degree

of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

Under the supervision of
Dr. Ashish Kumar

(Associate Professor)

By

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to

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY
WAKNAGHAT, SOLAN – 173234
HIMACHAL PRADESH, INDIA

May, 2018

CERTIFICATE

This is to certify that the work which is being presented in the project report titled **“Design of pervious paved parking area to harness reusable rainwater”** in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology in Civil Engineering and submitted to the Department of Civil Engineering Jaypee University of Information Technology Waknaghat is an authentic record of work carried out by Ishan Sharma (141263) & Akshit Negi (141656) during a period from July 2017 to May 2018 under the supervision of Dr. Ashish Kumar Associate Professor, Department of Civil Engineering, Jaypee University of Information Technology,Waknaghat.

The above statement made is correct to the best of our knowledge.

Date: - ………………………

Dr. Ashok Kumar Gupta	Dr. Ashish Kumar	External Examiner
Professor & Head of Department	Associate Professor	
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Declaration by the Candidate

We hereby declare that the Project report entitled "**Design of Pervious Paved Parking Area to Harness Reusable Rainwater**" submitted by us to Jaypee University of Information Technology, Waknaghat, Solan in partial fulfillment of the requirement for the award of the degree of B.TECH in CIVIL ENGINEERING DEPARTMENT is a record of bonafide project work carried out by us under the guidance of Dr. Ashish Kumar. We further declare that the work reported in this project has not been submitted and will not be submitted, either in part or in full, for the award of any other degree or diploma in this institute or any other institute or university.

Solan   Signature of the Candidate

Ishan Sharma

Akshit Negi

Date:

Acknowledgement

We take this opportunity to express our profound gratitude and deep regards to "**Dr. Ashish Kumar**" sir for his exemplary guidance, monitoring and constant encouragement throughout the course of this seminar. The blessing, help and guidance given by him time to time shall carry us a long way in the journey of life on which we are about to embark. We extend our gratitude to the lab in-charge, **Mr. Jaswinder Deswal** for his support and direction.

The vision of working in a team with a high level of responsibility fostered a character of teamwork and created a feeling of oneness which thus, extended our range of vision, encouraged us to perform to the best our ability and create a report of the highest quality. We extent our deep appreciation and thanks to the authors of various research article which were helpful in the completion of this project.

Ishan Sharma

Akshit Negi

Abstract

When water is allowed to percolate through the pavement surface, such pavements are called pervious pavements which are applicable in the areas of improper drainage system. General applications includes parking areas, filtering pollutants out of runoff, infiltrating runoff into the ground and maintaining the natural hydrologic function of the site .

Our task includes discovering how the properties of plain bitumen (VG-40) are altered when additives are added. Characteristics such as strength of the pavement, softening point, viscosity, ductility, penetration1 values of the modified bitumen . The main objective of the project is to demonstrate the significant improvement in the properties of the plain bitumen when additives are added which further can be used for casting pervious pavement. Crumb rubber (Mesh-40) is used as an additive, made from tires. The experimentation results explained that properties of bitumen such as porosity, Ductility Softening point and Compressive strength has improved significantly.

It can thus be concluded that CRMB:-

- Increase the adhesive force between the aggregates and bitumen
- Keep the aggregates attached to each other and
- Imparts impact resistance to CRMB pavement.
- Increase in softening point of the bitumen from 47℃ to 62℃.
- Ductility reduction up to 25%

These characteristics in turns improve the porosity and strength properties of the CRMB pavement.

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CHAPTER 1
INTRODUCTION

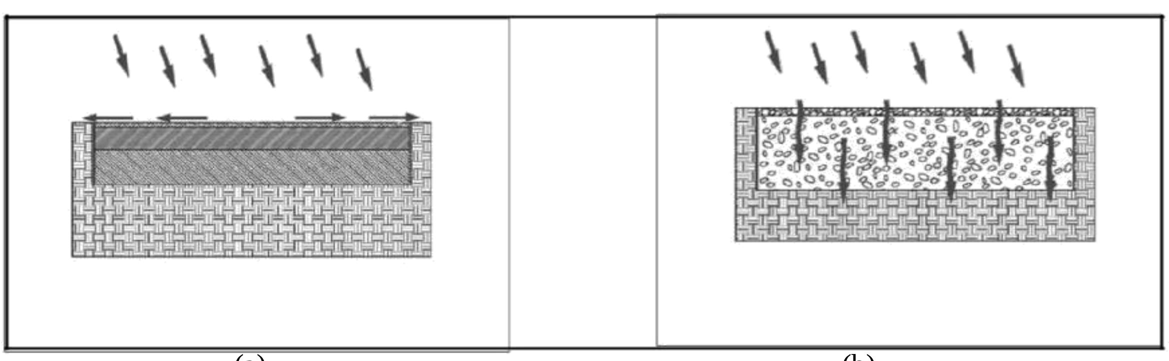
1.1 General:-

The add-on part gives an introduction and groundwork into porous asphalts mainly the solid asphalt structures & to build proficient binding of the pavements. This study hereby gives an insight into the goal, connotation and upcoming scenario of the subject. Study gives the basic skeleton of plan.

1.2 Background:-

In late time specialists and planners are hunting down as good as can be expected ways to verify that earth is secured in the most ideal way accessible. One such growing development is the 'pervious asphalt that allows H2O to percolate surfaces that are generally non porous, for instance, investigated thick asphalts. Penetrable asphalts are of various sorts which consist of porous concrete, pervious asphalt and interlocked concrete block pavers.

Porous asphalts permit major part of precipitation to pervade through asphalt course to the stone reservoir and the remaining water is infiltered to the soil. With perfect layout and foundation, porous asphalt proves to be helpful for storm-water organization systems, which push assault, to elevate water quality. Main function of the pervious asphalt is to oversee over-flow & permit nonstop stream exclusive of H2O logging.



(a) (b)

Figure 1.1:- (a)Rainfall on normal Pavement (b)Rainfall on Permeable Pavement(Yalchinskaya et al. ,2012)

Normal utilizations of Pervious Bitumen Asphalts incorporate side-walks, drain channels, grating course for highway asphalts, inflexible asphalts and low volume roads.

Advantages fuses:- constriction in storm water overflow, including reduction of temperature and stream rate, increase in groundwater incursion & helps to control surge flows. The assembled water can be used for street washing which helps in diminishing the street clean.

Normal utilizations of Pervious Bitumen Pavements incorporate parking areas, side-strolls, channels, grating course for thruway asphalts, inflexible asphalts and low volume streets.

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Permeable black-top comprises of large proportion of inter connected air voids, less than 15%.CRMB upgrade the rutting resistance, flexibility modulus and breaking resistance of the asphaltic blends. This happens generally, because of the adjustment in the property of bituminous side to the level of the consistency, softening point and limit modulus. This distinction emerges because of the thorough activity of elastic particles and their inflammation with bitumen. The adaptable Crumbs retain liquid segment of bitumen and can swell up to 3-5 times. This results in a more prominent level of dark-top in the latch, thusly developing its thickness. CRMB improve the rutting protection and furthermore the condition cordial as Crumb rubber is extracted from the waste tires.

1.3 Purpose:-

With rise in population, number of vehicles/ Km has increased which resulted in road widening. .In urban areas constrained right of way are available, due to which unpaved areas are diminishing (called shoulder of street utilized for waste), which prompts improper seepage and water logging conditions hence there is a want of such a framework which will give proper drainage to storm water without hindering the continuous traffic flow.

The purpose of this examination was to inspect the usage of a developing gale water administration development as it applies to the atmosphere. With extending environmental care and a propelling attitude alter in storm water organization frameworks. This investigation intends to provide guidance to Indian masters & central associations in overseeing porous bitumen as a tempest H2O controlling strategy. Significant goal of this research is to be inclined towards the essential blueprint & proposal for the permeable bitumen blend & effective measures for better storm water administration.

Figure 1.2:- Water logging on Indian street

1.4 Objectives of the study:-

- To design (Theoretical) a pervious paved parking area to harness reusable rain water.
- To design a sample representing the layer wise schematic of the porous pavement.
- To determine the overall efficiency of the pavement.
- Cost Analysis of the parking lot.

1.5 Scope of study:-

1. Assurance of ideal bitumen substance of permeable asphalt by changing Crumb rubber size.
2. Enhancing the quality and porousness of the porous asphalt with the utilization of added substances, for example, crumb rubber (mesh-40).

1.6 Constituents of thesis:-

1. Chapter One:- provides an idea and introduction to the survey performed till date. It gives a general foundation and gives the degree and targets of the project.

2. Chapter Two:- provides a written assessment of the permeable or penetrable asphalt innovation.

3. Chapter Three:- involves the methods and material selection for experimental testing.

4. Chapter Four:- provides the in-depth review of the performance of the pervious pavement.

5. Chapter five:- provides the examination conclusions and degree for future work

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction:-

Extensive variety of information is available regarding matter of crumb rubber addition to the bitumen for regulating storm water management. Likely the most fundamental research papers with respect to crumb rubber modified bitumen and its effects are studied throughout the course of this project.

2.2 Literature Review:-

Porous Pavement Mix design and Testing **(Indian Roads Congress SP 53-2010 & International Journal of Engineering Science Invention Research & Development; Vol.1, 2010).** Marshall mix design for aggregate and determination of optimum bitumen content was achieved. Further testing on aggregates and modified bitumen sample provided results, which were of great use in future scope for use of pervious pavement as a storm water management technique.

Pervious pavement aggregate gradation (**International Journal of Engineering Science Invention Research and Development, September, 2014**).The aggregate gradation consists of 100 percent of 19 mm down sized aggregates but requires less than 15 % of the aggregate fraction passing 4.75 mm, so that the compacted mix becomes permeable and provide adequate permeability.

Use of crumb rubber as a bitumen binder (**Indian Roads Congress SP 53-2010**). Physical properties of plain bitumen like rutting and viscosity enhances, at a temperature of around 136 degree Celsius when higher amount of crumb content is added to the blend. Crumb rubber modified bitumen allows the water to infiltrate through the pavement thus recharging the ground water level.

(**International Journal of the Physical Sciences Vol. 6(4), pp. 684-690**). Effect of crumb rubber concentration on the physical and rheological properties of rubberized bitumen binders are very vital in the design considerations. Various tests were conducted to study crumb rubber's addition on ductility, penetration value and softening point of bitumen. Results obtained are represented in graphical form.

Determined the rates of infiltration through pervious asphalt areas**.(Marty Wanielista & Manoj Chopra, Performance Assessment of Portland Cement Pervious Pavement)**. Testing involved field examination of test cells and laboratory infiltration tests on the sample. Results are further graphically represented. Nevertheless the concept of testing the pervious concrete and the soil as one system proved valuable and lead to the recommendation that a single ring infiltrometer should be placed in the pervious pavement and about 8 inches into the sub-soil during the construction phase and used for testing infiltration rates in the future.

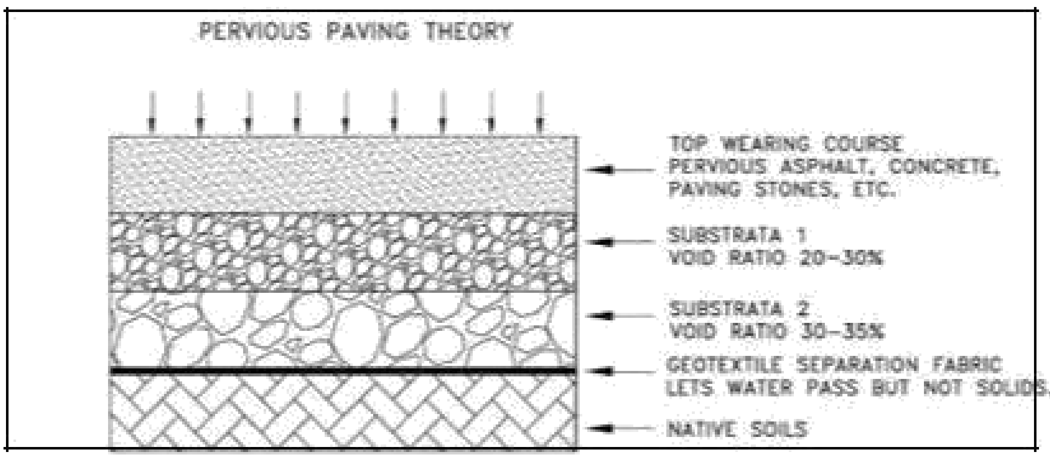

Figure 2.1:- Illustration of a porous asphalt section

Primary permeable asphalts concluded by EPA: porous bitumen and pervious pavement.

2.3 Benefits & advantages:-

The upsides of porous pavements keep running from ecological favorable circumstances to well-being profit. A segment of the benefits linked with the porous asphalt is not compelled to practice of development which would be helpful for storm water management. The ACI has extra preferences as it diminishes the water clogged territories accordingly enhancing the parking areas and making extra lift to the airplane amid departure because of the cooling impact, and permitting air water.

2.3.1 Management of storm water:-

Aspiration of permeable asphalt is improvement and utilization of the natural limit of soil to infiltrate water and recharge groundwater. Traditionally reviewed asphalt, penetrable asphalt is termed as Best Management Practice (BMPs) inside government associations as another training to storm water administration and run-off control.

Porous asphalt offers the probability to possibly coordinate the rate of continuous runoff from different safe surfaces. The EPA in addition says that permeable asphalts can furnish the numerous purposes of regarding tempest water association: diminishment of pollutants in this manner filtering water, diminishing the need for gale sewers, and reestablishes adjacent H2O bodies.

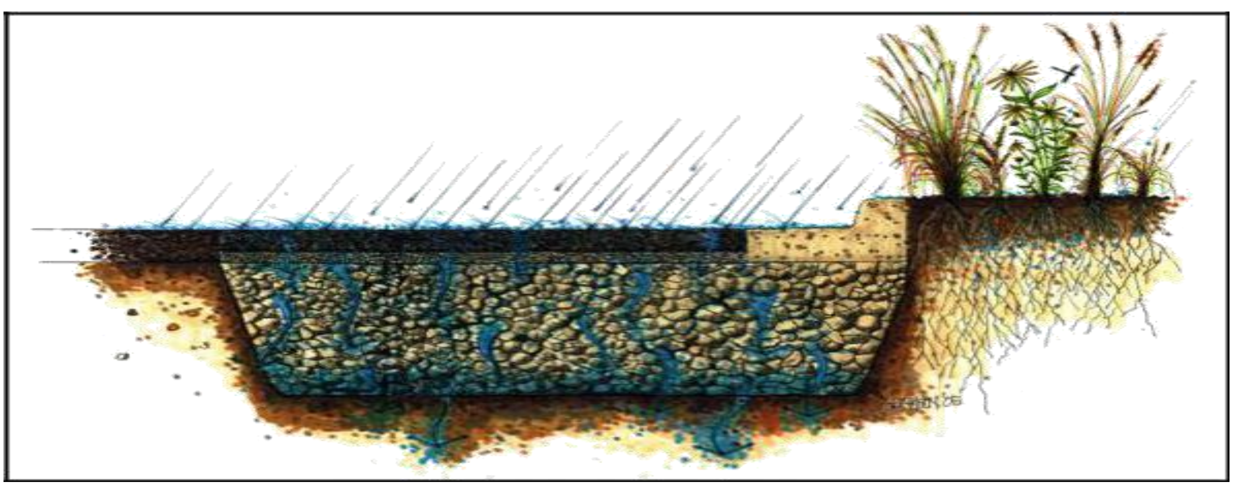

Figure 2.2:-Representation of Storm H2O infiltration.

2.3.2 Safety:-

Porous asphalt proves vital in road protection to both the voyagers, those by walking or in the vehicles as a result of potential for slide protection especially when there are huge downpours. As immobile H_2O is discarded from surface wash and shower is decreased, subsequently brings about improving driver detectable quality. Hydroplaning measures for road way services can be regulated by the use of penetrable bitumen pavements as they exhibit high porosity which allows water to permeate through.

2.3.3 Durability and strength:-

Major problems with penetrable asphalts (particularly top course) is hardness and value properties. In winter season, during snowfall there is chance for blockage which creates a probability of depletion of top layer.

2.4 Disadvantages:-

2.4.1 Aging and stripping:-

Application of top layer over the aggregates which are exposed to O_2, daylight & H_2O which further leads to the execution of bituminous mixes. This results in top layer setting and thinning in a bitumen overall life. Right when bitumen solidifies, aggregates can be stripped off viably from the bitumen mix.

Stripping is a result of water being trapped in bituminous structure under wet conditions.

2.4.2 Shorter Service Life:-

The service life of pervious bitumen surface is shorter than that of traditional thick blend layers. Moreover, it additionally relies upon the filler substance & sort, totals gradation & climatic conditions. Hence for better and longer service life the pavement should be designed in accordance with standard norms.

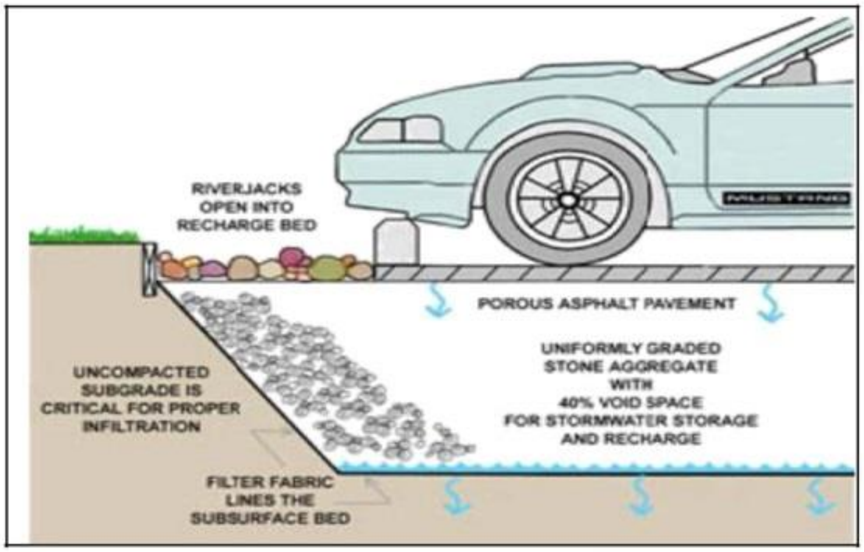

Figure 2.3:- Pervious Asphalt c/s

2.5 Requirements for air void:-

Permeable asphalts are penetrable and have infiltration property of the structure. The porousness of the asphalt is vital for the usefulness of the formation. In customary, asphalt blend designs, set up air void % is 4% to 8.5%,percentage < 3.2% have brought about rutting, percentages> 8% can prompt release of hydrogen ion of the asphalt filler which results in breaking.

2.6 Aggregate gradation:-

Aggregate gradation is done to achieve the correct air voids in the blend grading and properties of the totals utilized as a part of the surface course. With a specific end goal to give a higher air void rate, a more noteworthy extent of coarse aggregates and few fine totals are required.

Table 2.1: National Bitumen Pavement Association's suggested Design gradation for pervious Bitumen Surface Course (After Kumaar et al., 2014)

Sieve Size (mm)	Percentage Passing %
19	100
12.5	85-100
9.5	55-75
4.5	10-25
2.36	5-10
0.075	2-4

Source:- Kumar et al,, 2014

The percent passing on a 0.475 cm sieve varies between 12-36% with a low proportion of fine totals in the blend according to the N.A.P.A.

2.7 Maintenance:-

Avoidance of hindrance caused by debris is the main factor for the proper functioning of the system. The system is vacuumed annually/semi-annually to ensure that void structure is clear of dirt and debris.

Table 2.2: Maintenance actions for Permeable Pavement (Lebeans et al, 2012)

Care Actions	Frequency
Removal of debris from pavement area Sanitation of area	Once a month
Seed uncovered upland areas Vacuuming	As required
Inspection of surface decadence	Annually

2.8 Designing of Pavement Theory:-

As per the National Cooperative Highway Research Program (NCHRP), the goal was acquired through the following:

1. Design utilizes existing mechanistic observational innovations in view of finish asphalt configuration step.

2. User-accommodating computational programming and confirmation in light of the Design Guide ways.

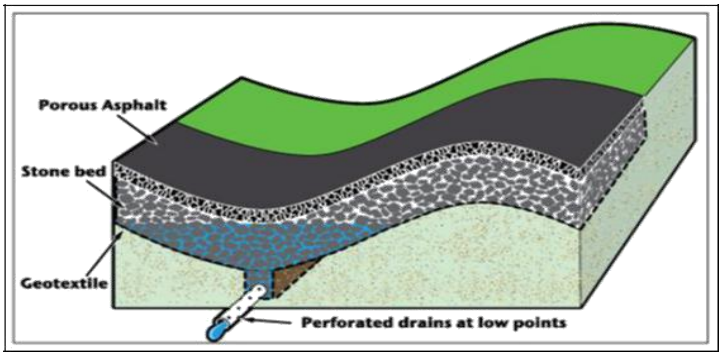

Figure 2.4:- Traditional Permeable Asphalt pavement

2.9 Summary:-

This study consists of a written work review of penetrable porous black-tops concerning bitumen, interlocking pavers and solid black-top structures. These black-tops are planned to permit free draining through the structure. Porous black-tops generally are proposed for avenues with low traffic movements. By empowering liquids to seep through the structure, runoff is controlled or regulated from the contiguous areas. Such black-tops help in diminishing the measure of contaminations reaching the ground water by isolating the overflow. Some more advantages may include noise reduction, enhanced security for voyagers.

Permeable bitumen asphalt pavements incorporate permeable bitumen course, repository course both put on the sub grade material. Customarily thick graded bitumen blend plans have air void rate in the vicinity of 3.5% and 9%. The end part outlines with a concise finish of the speculations related with asphalt configuration including background based, and experimental Pavement Design.

Figure 2.5:- Permeable Pavement Vs Normal Asphalts

Table 2.3:- Normal Pavement Vs Porous Pavement

Normal Pavement	**CRMB Pavement**
Poor in quality	Good quality
Elevated abrasion property	Declined abrasion property
Low maintenance required	High maintenance required
Lesser resistance against freezing & thawing	Higher resistance against freezing & thawing
Unable to control floods, surge flows	Able to control floods
No storage profits	Storage advantages and applications
Greater volume of blend	Mix volume requirement is reduced
Lesser skid resistance offered	Higher resistance to skid phenomena

CHAPTER 3
MATERIALS AND METHODS

3.1. General:-

This chapter introduces the exploration techniques utilized in this study. The test technique for this exploration was partitioned into three sections.

- Part 1: mostly managed the adjustment of the characteristics of asphalt by using CRMB-40.
- Part 2: Marshall Stability Test was performed for analysis after the determination of suitable blend for permeable asphalt.
- Part 3: involved determination of permeability of permeable asphalt.

3.2. Material Selection:-

3.2.1 CRMB Mesh-40:-

Physical properties of plain bitumen like rutting and viscosity enhances, at a temperature of around 136 degree Celsius when higher amount of crumb content is added to the blend. Physical properties of the porous pavements are highly dependent on the affiliation/binding b/w the bitumen and crumb rubber.

Modified bitumen asphalts exhibits following advantages:-

- Lower defenselessness to day to day and occasional temperature varieties.
- High resistance against deformation.
- Enhanced age protection properties.
- Improved attachment between binder and aggregates.
- Overall upgraded execution in extraordinary climatic conditions and overwhelming traffic conditions

3.2.2 Crumb Rubber- Environment friendly product:-

Well used and waste tires are intense biological threat to a great extent to countries. Bituminous properties of the asphalts in terms of storm water infiltration are largely dependent on the crumb rubber and bitumen blends. Generous use of the additive from squander tires in asphalt proves out to be more helpful choice to the building construction applications and environmental idea. Changed bitumen black-tops can bound natural effect and lift the security of general resources.

Figure 3.1:- Crumb Rubber mesh - 40

The capacity of crumb rubber to enhance the black top execution is dependent on factors that incorporates the blending techniques, response duration and magnitude of rubber. Two unique procedures of blending crumb rubber with asphalt are, a dry procedure and a wet procedure.

Wet procedure includes blending of finer crumb rubber with asphalt at high temperature (185˚C-225˚C). In dry process, the crumb rubber is united with the aggregates prior the formation of asphalt. Amid dry process, the compound reaction between crumb rubber and bitumen is exceptionally constrained. Crumb rubber of mesh 40 size is measure is used throughout the examination..

3.2.3 Mixing of CRUMB Rubber with Bitumen:-

255 g of asphalt was heated to 185˚c, to liquid state in a one Lt. compartment. Black top is warmed to a temp. (185 °C - 225˚C) & after which crumb rubber was added. For each mix (6-22%) of crumb rubber by wt. of different volume were utilized. Blending of the mix involved conventional stirrer. The blend was then warmed to 155-185 °C and the entire mass was mixed utilizing a conventional stirrer for around 55 min to 65 min.

Figure 3.2:- Mixing of crumb rubber with bitumen

3.3. Testing on Modified Bitumen:-

3.3.1 Ductility Test:-

- CRMB is heated till fluid state is reached and then poured in a mould having a brass plate.
- Mercury coating is applied over the surface of the mould.
- Place is kept in water shower at 28°C for 55 min.
- Fixed the sample in ductility testing machine and adjust pointer to 0.
- Machine was started and pulled cuts on a level plane at 5.2 cm/min. Note down the separation at which the sample breaks.

Figure 3.3:- Ductility Test

3.3.2 Softening Point of Bitumen:-

- Sample is heated for 12-16 min till fluid state is reached.
- Rings & plates are greased with glycerin and dextrin.
- Modified asphalt is poured in form and kept in cooler place it for 35 minutes. The rings, thermometer and balls are arranged properly. Measuring glass containing water is heated until the point when material softens and the ball is gone through the ring. Temperature at which the ball touches base is nothing but the softening point.

Figure 3.4:- Softening point test

3.3.3. Penetration Test:-

Level of hardness or consistency of asphalt is known as the penetration value. Procedure is as follows:-

- Modified asphalt is poured in the mould and cooled for 30 minutes.
- 65 minutes H2O shower is provided to the mould.
- Holder is placed and needle is set to reach the surface of the sample.
- Needle is released after five seconds and the observation is recorded.

Figure 3.5: Penetration test

3.4 Marshall mix design:-

3.4.1. Overview:-

Marshall Stability Test determines the Optimum bitumen content.

3.4.2. Marshall mix design:-

Marshall stability and flow test gives the measure of execution to the Marshall Mix plan method. The stability of the test measures the load passed on by the compacted test sample at a stacking rate of 5.7 cm/minute.

Load is associated with the sample till failure, and the most extreme load is called as stability. Deformation at most extreme load is calculated by the electrical check in the flow value.

Specimen Preparation:-

About 1200mg of aggregate totals are warmed to a temperature of (150 -180) degree celcius.

- Modified Bitumen is warmed to a temperature of (122–127) degree Celsius with the fundamental trial rate bitumen (say 4% weight of the totals.
- The warmed aggregates and bitumen are together mixed at temperature of (154-166) degree Celsius.
- The mix placed in a preheated form and compacted by a rammer with 75 blows on either side.
- Keep the mix in the mould for 24 hours and after the expel the from the form with the assistance of test extractor.
- Weight of the sample is measured both in air and water.
- Keep the sample in water shower at 65 degree Celsius for 35 minutes.
- The weight of mixed totals taken for the making of the sample may be sensibly changed to get a compacted thickness of 62.5+/-3 mm.

Loading Machine:- Digital meter is connected with the loading frame that gives the flow values and stability values. The load jack produces a regualr vertical moment of 5cm per minute.

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3.5 Crushing test:-

One of the model in which pavement material can compound is by pounding under the compressive anxiety. A test is institutionalized by **IS: 2386 SECTION IV** and used to decide the devastating quality of totals. The total squashing gives a relative measure of imperviousness to pulverizing under bit connected pounding load.

The test comprises of subjecting the example of aggregate in standard from to pressure test under standard load condition. Dry aggregates going through 12.5mm screen and held 10 mm strainers are filled in a barrel cylinder shaped measure f 11.5 mm breadth and 18 cm height in three layers. Each layer is pressed together 25 times with at standard tamping rod. The test is weighted and put in the test chamber in three layers each being stuffed once more. The specimen is subjected to a compressive load of 40 tons step by step connected at the rate of 4 tons/minute. At the point squashed aggregates are then sieved through 2.36 mm screen and Wright of passing material (W2) s expressed as percentage of the weight f the total sample (W1) which is the sum of crushing value.

Aggregate crushing value = (W1/W2)*100

Results are shown in (Annexure A)

3.6 Abrasion test:-

Abrasion test is helped out through the hardness property of aggregates and to choose whether they are reasonable for various asphalt development works. Los Angeles abrasion test is a favored one for doing the hardness property and has been instituonalized in India **(IS: 2386 PART- IV).** The standard of Los Angeles abrasion test is to discover the rate wear because of relative rubbing activity between the aggregate and steel balls utilized as grating charge.

Los Angeles machine comprises of around drum of inner diameter 700 mm and length 520 mm continues even prior empowering it to be turned. A grating charge comprising of cast iron round chunks of 48 mm diameters and weight 340-445 g is set in the barrel along side the aggregates. The quantity of the grating circles shifts as per the evaluating of the example. The amount of aggregates that will be utilized relies on the degree of taking after aggregates and as a rule ranges from 5-10 kg. The chamber is then bolted and pivoted at the speed of 30-33 rpm for a sum of 500-1000 transformations relying on the degree of aggregates.

After number of decided gyrations, the material is sieved through 0.17 cm strainer and passed part is dealt with as the rate total weight of the sample. This value is known as Los Angeles abrasion esteem.

Results are shown in (Annexure A)

3.7 Testing of aggregates:-

3.7.1 Impact test:-

The aggregate impact test is done to assess the imperviousness to impact of aggregates. Aggregate passing 12.5 mm strainer and held on 10 mm sifter is filled in a round and hollow steel measure (cylinder) of inward width 10.2 mm and profundity 5 cm which is joined to a metal base of impact testing machine. The material is filler in 3 layers where each layer is packed for 25 quantities of blows. Metal sledge of weight 13.5 to 14 Kg is arranged to drop with a free fall of 35.0 cm by vertical aides and the test specimen is subjected to 15 quantities of blows. The crushed aggregate is permitted to go through 2.36 mm IS strainer. Also, the impact esteem is measured as rate of aggregates passing sifter **(W2)** to the aggregate weight of the example **(W1).**

Aggregate impact value = (W1/W2)*100

Aggregates to be used **for wearing course**, the impact value **shouldn't exceed 30 percent**. For **bituminous macadam** the **maximum** permissible value is **35 percent**. For **Water bound macadam** base courses the maximum permissible value defined by IRC is **40 percent**.

Results are shown in (Annexure A)

3.7.2. Specific gravity:-

The specific gravity and water adsorption are essential properties that are required for the design of concrete and bituminous mix. The specific gravity of a strong is the proportion of its mass to that of an equivalent volume of refined water at a predefined temperature. Since the aggregates may contain water pervious voids, so two measures of specific of aggregates are utilized:-

1. Apparent Specific Gravity.
2. Bulk Specific Gravity.

Apparent Specific Gravity, " Gapp, is given by

Gapp = [(Md/Vn)]/W

Where,

Md = Dry mass of the aggregates.

Vn= Net Volume of aggregates excluding the volume of absorbed matter.

W = Density of water.

Bulk Specific Gravity "(Gbulk,) is given by

Gbulk = [(Md/Vb)]/W

Chapter 4

Performance Assessment & Cost Analysis

4.1 Introduction:-

Storm water management techniques promote infiltration & reduce the negative effects of soil use by reducing and attenuating surface runoff. Porous pavements prove to be effective in terms of storm water regulation and ground water level. Open–graded structure of pervious pavements consists of boundary values of aggregates, H2O and bitumen binder with admixtures.

In any case, an absence of information, especially as for long term performance execution, prompts vulnerability in utilizing porous asphalt as an adequate option for storm water management. This research involved determining the rates of infiltration through pervious asphalt areas .Testing involved field examination of test cells and laboratory infiltration tests on the sample.

The ascent in number of impervious areas contrarily influences the earth by modifying the natural water cycle. Natural process of infiltration through the soil is blocked by these areas resulting in runoff after storm events. This runoff brings about after three primary issues:

(1) Decrement in groundwater recharge because of absence of penetration.

(2) Drainage basin flow pattern are altered or are modified.

(3) Movement of pollutants deposited on impenetrable areas.

Consequently, the introduction of impenetrable regions modifies both surface and subsurface water amount and quality.

4.2 Approach to problem:-

Approach to the problem will include Laboratory Tests and Field Investigations on pervious pavement and sub-grade soil respectively.

1. The first step will be to construct the test cells.
2. Test cells are impermeable on all sides excluding the surface layer.
3. A “box” having dimension (100x75) cm and (30) cm deep from the surface.

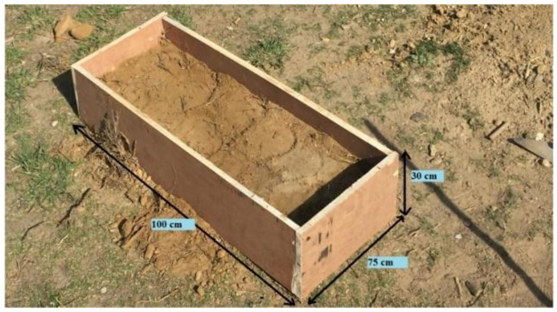

Figure 5.1: Schematic of Test Cell

4. Plywood is used to construct test cells & lining is done with an impermeable rubber line
5. Test cells will be used to conduct single-ring infiltration studies.
6. Laboratory Tests will include the use of a single ring infiltrometer over the pavement surface and carry out infiltration tests.

4.3 Methodology:-

Field Investigation:-

1. The fill used in the cells was natural and uncompacted soil taken from H.P.P.W.D Store, Tara Devi (same soil used in the schematic sample).
2. The soil is compacted evenly with the help of Standard Proctor.
3. Primary evaluation of various in-situ tests is done with the help of test cell.
4. Testing incorporated single ring infiltration tests that proved effective in the determination of flow rates.

Figure 5.2: Standard Proctor Test

Figure 5.3:- Single Ring Infiltrometer embedded in Test cell.

Figure 5.4:- Water poured in the apparatus.

Figure 5.5:- Water level at initial stage.

Figure 5.6:- Water level at final stage.

Laboratory Investigations:-

A standardized procedure will be followed in the lab to determine the infiltration rates of the pervious pavement. The step by step procedure is outlined below:-

1. porous pavement surface is cored using a 10cm diameter.
2.After drilling in-situ infilteration testing is done on core.
3. Irregularities formed during the coring process are removed by grinding the sides which allow the single-ring infiltrometer to fit around the core.
4. Downward force is applied with the assistance of a tamper for infiltrometer embedment
5. Value of infiltration rate in determined by embedded Single-ring infiltrometer Test .

Figure 5.7:- Single Ring Infiltrometer embedded over top course.

Figure 5.8:- Marked Water Level inside the apparatus.

Figure 5.5:- Water level at Initial stage.

Figure 5.5:- Water level at Final stage**.**

4.4 Cost Analysis:-

A cost estimation is approximation of the cost of a program, project, or operation. The cost estimates the product of the cost estimating process.

Cost Analysis is a technique evaluating the obvious cost of a venture before its maturity. Final cost of a task is figured after the completion of project. Cost examination is performed based on the data accessible amid the duration of the project investigation at different stages through the term of a task.

Cost Analysis upholds a critical task which is accomplished before evaluating every item of work, known as amount take-off. Contract reports assists the construction firm for determining the aggregate cost of the task which further comprises of images & every single unique archive.

The totals undertaking capital consists of following :

1. **Direct Costs**:- incorporates cost of materials, hardware and work related with every item of work and cost of materials, and furthermore incorporates cost of subcontracted works.
2. **Indirect Costs**:- are the capital which is not linked with each item of task rather this capital is ascertained for total accomplishment of work, possibility that is cost of any profit. Generally for any project , following three gatherings are required :

- Owner.
- Design experts.
- Construction experts.

Assumptions:-

Project size: 4500 sq. feet.

Type: Porous asphalt parking lot (50 – 55 parking spaces).

Benefits: All (modern development, CSS metropolis)

Life expectancy: 15 year.

Cost (1):- Operating + Maintenance

Table 5.1: Operating & Maintenance Costs

Cot of vacuuming per unit (₹ per square feet)	**4**
Vacuuming regularity (times per year)	**2**
Vacuuming cost of the project (₹ per year)	**36,000**
Examination (₹ per year)	**5000**
Operating and maintenance cost (₹ per year)	**46,000**

Cost (2):- Installation Costs

Table 5.2: Installation Costs

Cost per unit (₹ per square feet)	**300**
Installation cost of project (₹)	**1,35,000**

Cost (3):- Material Cost

Material	Rate(₹/m^3)	Quantity(m^3)	Amount(₹)
Aggregates(10 mm)	1281	21	**26900**
Aggregates(20 mm)	1276	29.4	**37500**
Aggregates(40 mm)	1069	63	**67400**

Cost (4):- Cost of admixture

Additive used is crumb rubber size mesh-40.

Quantity of crumb rubber required = 0.5 tonnes.

Rate = 22 ₹/kg.

Therefore, cost of admixture (₹) = 11000.

Cost (5):- Cost of bitumen

Cost of bitumen (₹/MT) = 37565

Quantity of bitumen used (m^3) = 1 m^3

Therefore, Estimated cost of bitumen (₹) = 90531 /-

CHAPTER 5

RESULTS AND DISCUSSION

5.1 Crumb Rubber Modified Bitumen:-

5.1.1 Effect of Crumb rubber on Ductility:-

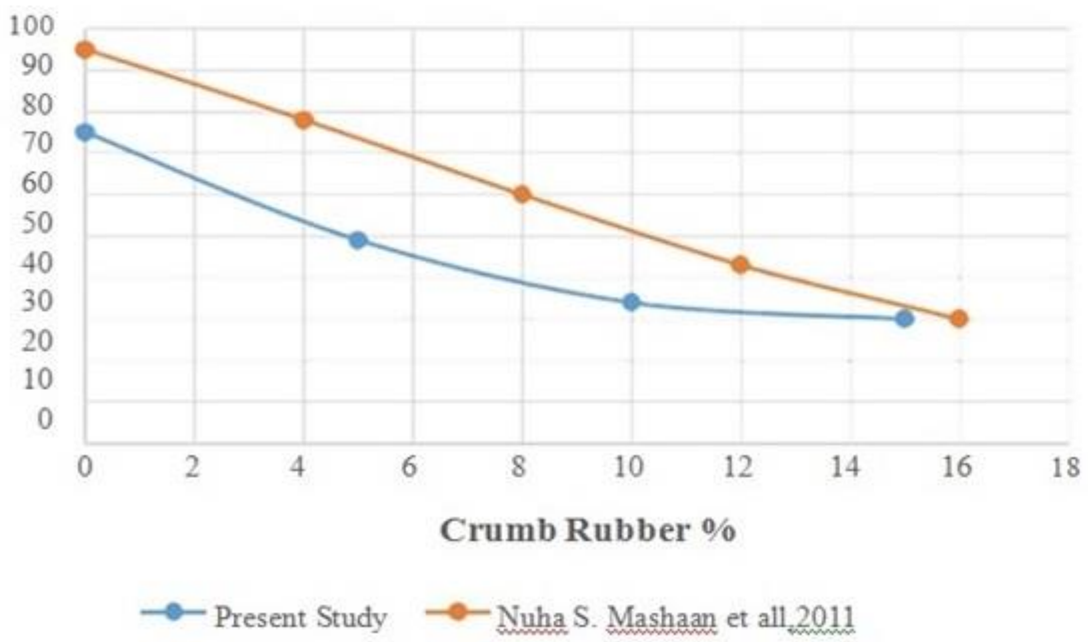

Figure5.1:- Effect of crumb rubber on Ductility.

From the fig 5.1, the decrease in ductility of modified bitumen samples compared with unmodified bitumen were about (35 and 60) % for crumb rubber content of 5 % and 15 % respectively.

Accordingly , an increase in binder mass could make the binder more elastic stiff and highly resistant to pavement rutting. Meanwhile, the decrease in ductility value could be attributed to the oily part of the bitumen absorbed into the rubber powder and increase in mass of the rubber particles. In effect, the modified binder became thicker compared with the unmodified bitumen samples.

5.1.2 Effect of Crumb Rubber on Penetration:-

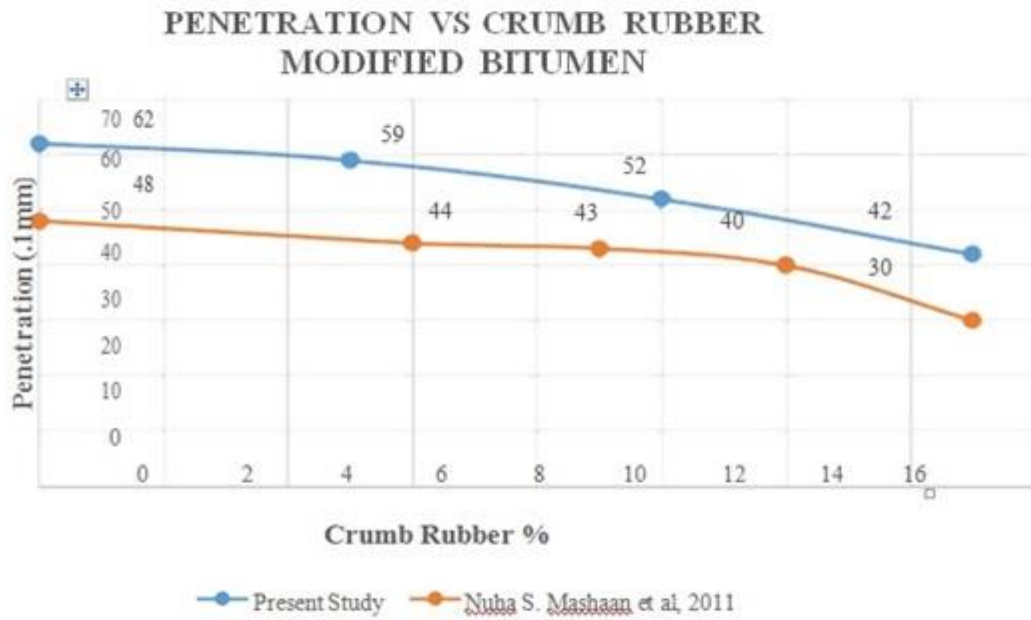

Figure5.2:- Effect of crumb rubber on Penetration.

From fig.5.2 , the penetration decreased as the amount of crumb rubber incrases. It shows that crmb content has significant effect on pentration value. The crumb rubber content has a strong effect on reducing the penetration value by increasing the stifness of crumb, thus, would make the binder less temprature susceptible and lead to high resitance to permeant deformation. Like rutting as mentioned by (Liu et al., 2009). The average reduction in penetration value of modified binder was between 5 and 32 % for crumb rubber content ranginf between 5-15 %.

This is beacause the added crumb rubber makes bitumen more viscous. This was due to the swelling of the rubber particle into the bitumen during the blending process, which led to the decrease in penetration of rubberized bitumen. Thus, indicate the rubberized bitumen binder will be less susceptible to high temprature change and more resistance to rutting .

5.1.3 Effect of Crumb Rubber on Softening Point:-

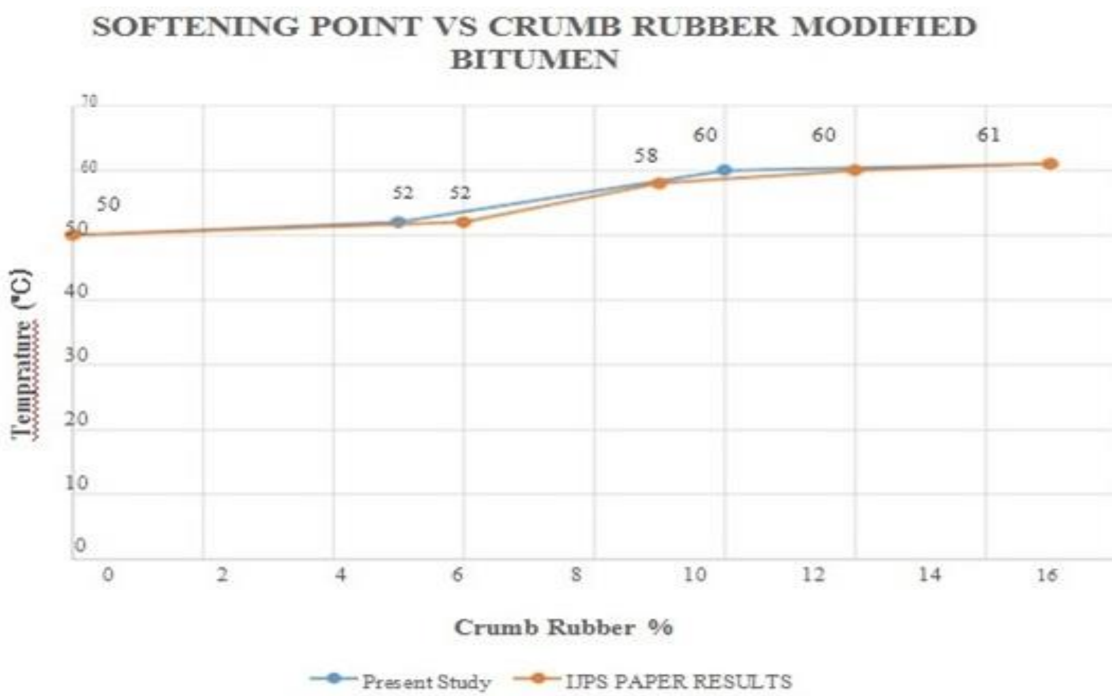

Figure 5.3:- Effect of crumb rubber on softening point.

From the fig. 5.3, with the increase in crumb rubber content softening point of bitumen increases. It shows that crumb rubber content has significant effect on softening point by increasing the viscosity. The average increase in softening value of modified bitumen binder was between 14 % and 22% for crumb rubber content ranging between 5% and 15% respectively. This behavior is justified because bitumen with higher viscosity will generally have a higher failure temperature and therefore have a longer service life due to higher temperature stability.

5.2 Infiltration Rate of Test Cell and Concrete Core:-

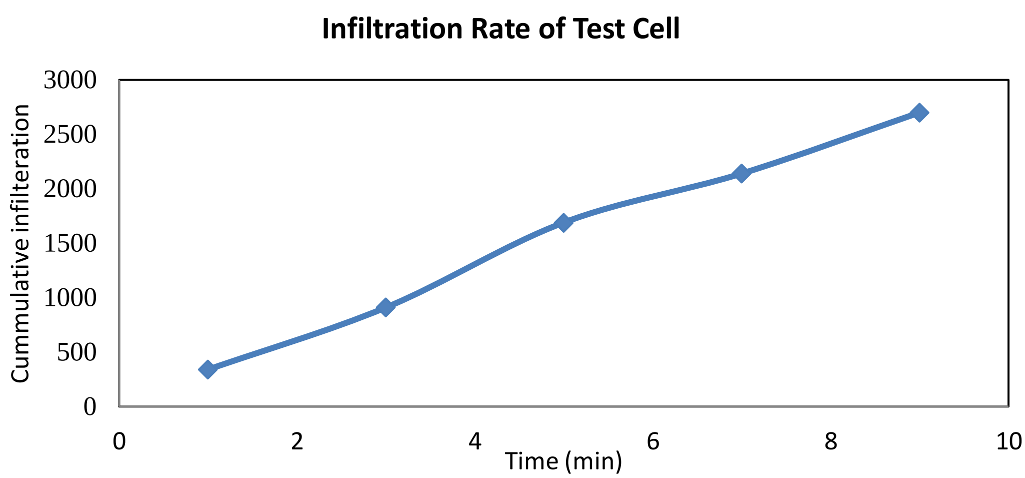

Figure 5.4:- Infiltration rate of test cell.

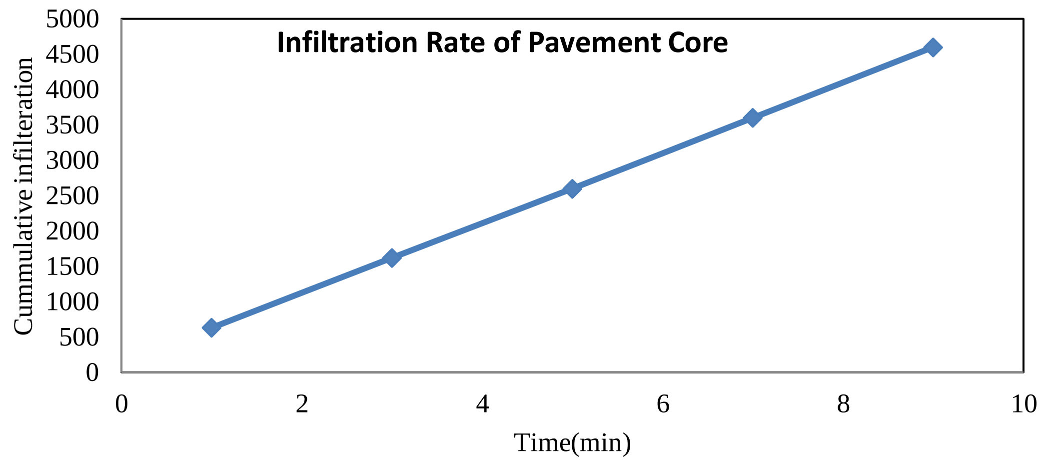

Figure 5.5:- Infiltration rate of pavement core.

The single ring infiltrometer for existing site was used. The test was applied for pervious pavement infiltration estimates while opening of the sub soil and facilitating the extraction of pavement core. Additionally, the field Test of existing pavement is labor intensive and destructive as it requires drilling cores to the pervious pavements in the system being tested. Never the less the concept of testing the pervious pavement and the soil as one system proved valuable and led to the recommendation that single rinfg infiltrometer should be placed in the pervious pavement and about 8 inches into the sub soil during the construction phase and used for testing infiltration rate in the future. Embedding the infiltrometer and filling it with filler will prevent side wall effects that may cause leakage if the ring were embedded after construction. .

CHAPTER 6

CONCLUSION

6.1. General:-

CRMB upgraded the properties of bitumen binder such as the most part the thickness, softening point, entrance esteem. This enhances the rutting protection, versatility, and improves exhaustion breaking protection of bitumen blends. To get ideal CRMB in accordance with the variations in temperature, factors, for example, blending time, temp, bitumen must be thoroughly considered since these are the variables that administers the execution and usefulness of bitumen blends.

Blend of pervious bitumen asphalt consists of total's gradation with max size to be 1.2 cm and 90% of the totals held on 0.475 cm strainer. Keeping in mind the end goal to enhance bonding between totals and enhance rutting protection of asphalt, CRMB had demonstrated huge outcomes.

Information gathered and introduced through the span of this investigation gave evidence that permeable asphalt holds an infiltrative limit, provided appropriate establishment, even after a long time.

6.2 Conclusions:-

In light of the perceptions of different tests comes about, the accompanying finishing up comments might be inferred:-

1. Crumb rubber addition to bitumen shows extensive variations in the properties primarily lowering of ductility, entrance esteem & increment in soften worth. % adjustment in estimation of properties of bitumen comes out to be 17% - 26% .

2. Totals gradation comprises of 99 % of 1.9 cm down measured totals & also under 9 % of the total division passing 0.475 cm, such that the compacted blend winds up penetrable and give adequate porousness.

3. In request to advance the quality of Permeable Bitumen Pavements, CRMB has appeared to be able to advance the rutting protection of asphalts and totals holding. % expansion in quality of CRMB permeable Pavement and traditional bitumen pervious asphalt is 18% - 28%.

4. Air voids content should be greater than 17% for an asphalt to be penetrable.

5. Permeability of permeable asphalt fluctuates from 0.25 cm/s to 0.20 cm/s with the expansion in the asphalt content.

6. Potency of permeable asphalt fluctuates with differing Crumb rubber amount. Greatest quality of asphalt was achieved at 5% Crumb rubber amount by weight of bitumen took after by 10% Crumb elastic substance and afterward Normal asphalt.

7. Testing was done with the help of single ring infiltrometer to determine various penetration values

8. Testing the framework demonstrated supportive and prompt the suggestion that a solitary ring infiltrometer ought to set in porous asphalt & that too around 9 inches.

9. Standard profundities were utilized as a part of testing, for example, 3 inches for research center tests and 9 inches for field tests.

6.3 Applications:-

- Results in low volume activity streets.
- Parking parts asphalts.
- Pedestrian walk-ways
- Shoulders of run-ways. .

6.4 Benefits:-

- Management of storm H2O.
- Decrease in noise pollution
- Use of pervious pavements shows an increment in ground water level.
- Superior skid protection

6.5 Scope:-

• Further execution examination should proceed on pervious bitumen including versatile modulus, shaft weariness, and solidifying defrosting testing.

• More the porostiy lesser will be the blockage. On the off chance that pores of the asphalt get blocked then the entire framework won't work up to the score and overabundance spillover might be gathered at first glance which will be unsafe for the driver.

• Hydrological plan of pervious asphalt chiefly outline of under cleared drain pipes and storage tanks.

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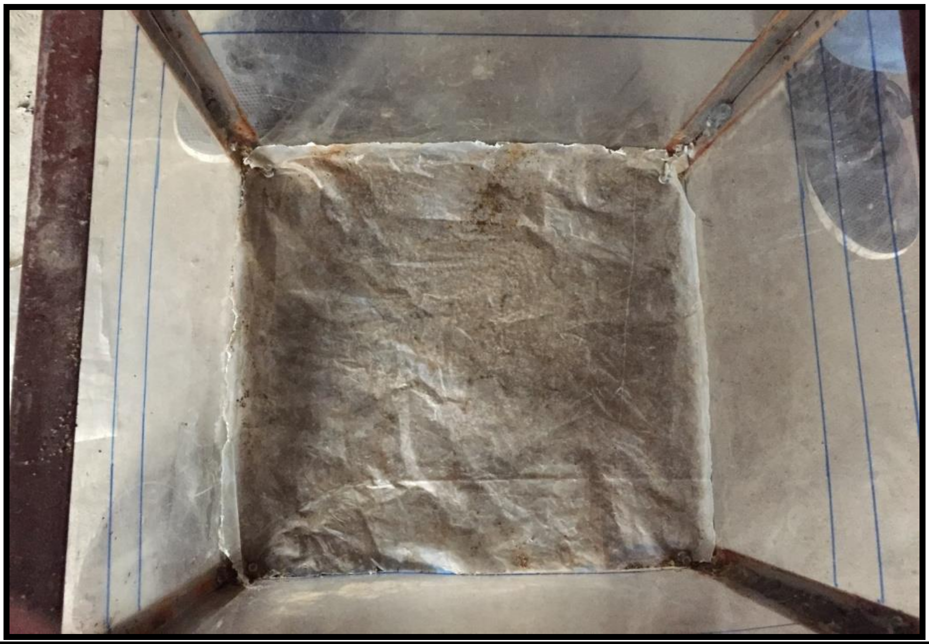
Photos from Lab Work.

Sieve analysis of aggregates

Different size aggregates

CRMB Sample

Filling of Uncompacted Soil Layer



Uncompacted soil layer with water percolating sheet

Stone reservoir with water outlet pipe

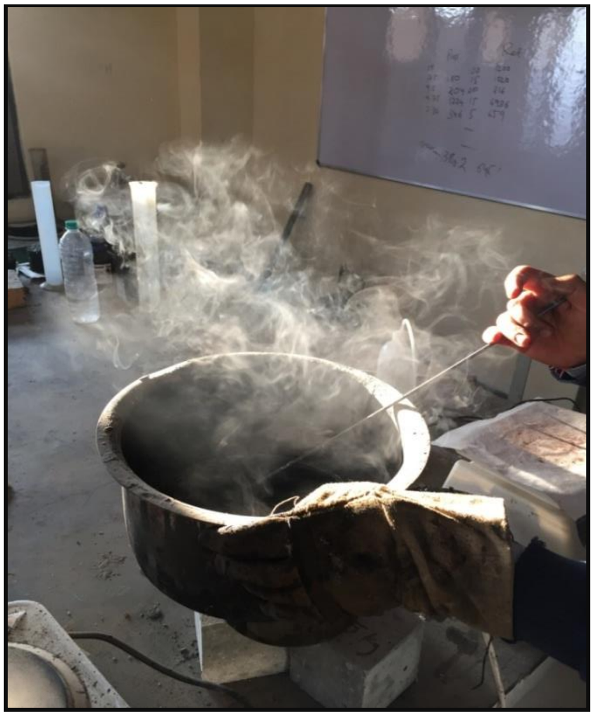


Fig:4.11 Heating of bitumen

Fig:4.12 Mixing of Crumb Rubber(mesh 40) with bitumen

Fig:4.14 Schematic view of Pervious Pavement

Annexure A

Mix Design Calculations	**Various Tests-** Crushing, Abrasion, Impact, Specific Gravity	**A**

A.1 Aggregate Test results

Table A.1 Aggregate Test Results

Test	Paper value	Present value
Crushing Value Test	<30%	26%
Abrasion Test	<35%	33%
Impact Test	25-35%	30%
Specific Gravity	2.12-2.65	2.2-2.62

A.2 Porous pavement gradation

Table A.2 Porous pavement Gradation

Sieve Size (mm)	NAPA recommendations (% passing)	Present Value (%passing)	Present Value (%Retained)	Composition of 1kg mix (g)
19	100	100	0	0
12.5	85-100	90	10	100
9.5	55-75	70	25	250
4.75	10-25	20	44	440
2.36	05-10	7	14	140
0.075	02-04	3	7	70

Annexure B

CRMB Rubber Modified bitumen	B
Test: Penetration, Ductility, Softening	
B1.1-B1.3 Effect of Crumb rubber on properties of bitumen	

B1.1

EFFECT OF CRMB RUBBER ON PENETRATION OF BITUMEN

Table B.1 Effect of Crumb rubber on Penetration

CRUMB RUBBER CONTENT	PENETRATION	REFRENCE
0	62	48
5	59	--
6	--	44
9	--	43
10	52	--
12	--	40
15	42	30

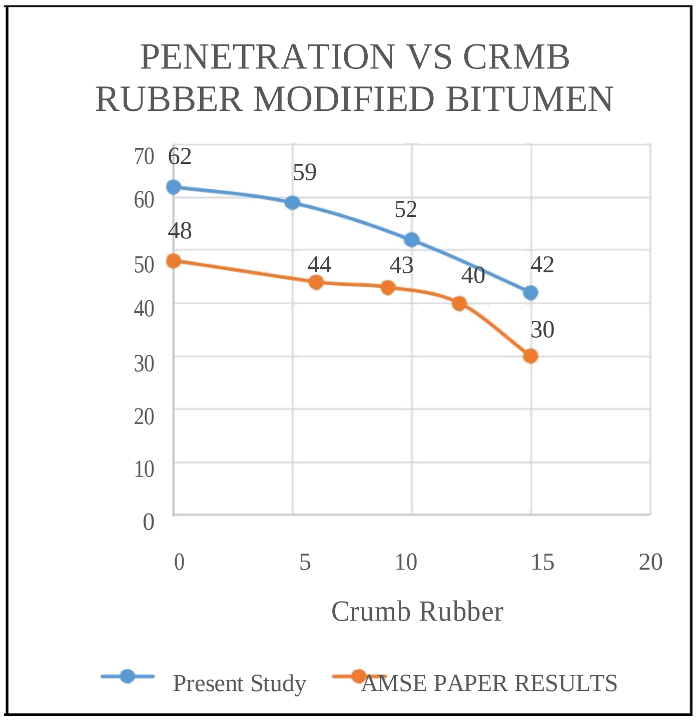


Figure B.1

B1.2

EFFECT OF CRMB RUBBER ON DUCTILITY OF BITUMEN

Table B.2 Effect of Crumb rubber on Ductility of Bitumen

CRMB	DUCTILITY	REFRENCE
0	75	95
4	---	78
5	49	---
8	---	60
10	34	---
12	---	43
15	30	---
16	---	30

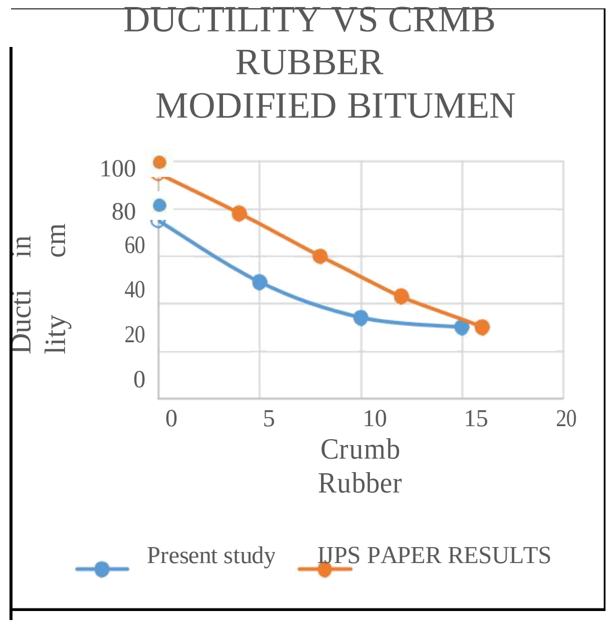


Figure B.2

B1.3

EFFECT OF CRMB RUBBER ON SOFTENING POINT OF BITUMEN

Table B.3 Effect of Crumb Rubber on Softening point of bitumen

CRMB	SOFTENING	REFFRAL
0	50	50
5	52	--
9	--	58
6	--	52
10	60	--
12	--	60
15	61	61

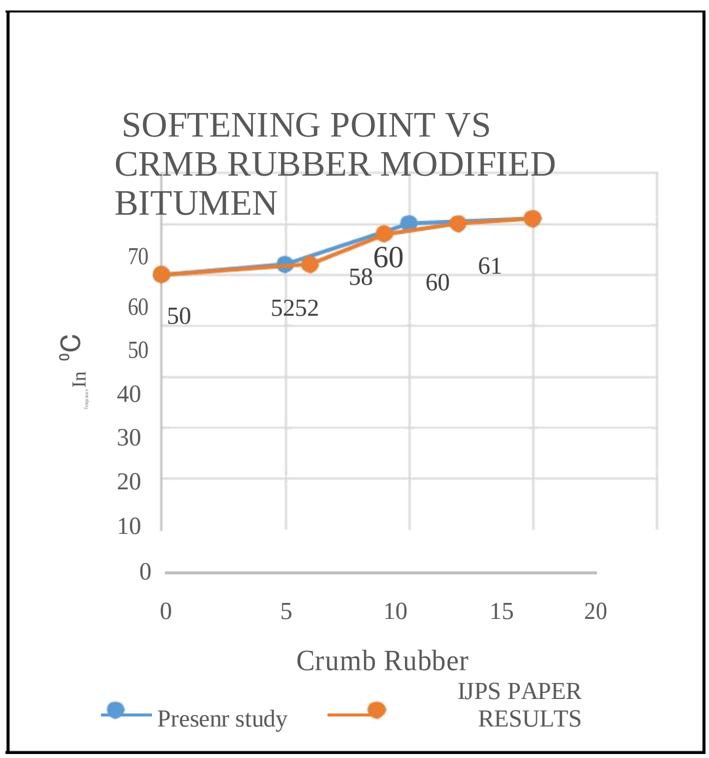


Figure B.3

Annexure C

Test Name: MARHSALL STABILITY	Normal Mix	C1
M1.1-M1.3 Mix design Calculations	CRMB @5%	
M2.1-M2.5 Marshall Mix Graphs	CRMB @10%	

Mix Design Calculation of Normal Bitumen

Table C.1 Mix Design Calculation of Normal Bitumen

Bitumen content (%)	Weight in Air (g)	Weight in Water (g)	Volume Of Sample cm^3	Theoretical Specific Gravity	Mass Specific Gravity
4	1082	580	545	2.49	2.33
4.5	1065	572	550	2.45	2.31
5	1039	570	525	2.44	2.28
5.5	1035	572	532	2.41	2.24
6	1029	565	560	2.4	2.17

Mix Design Calculations CRMB @5%

Table C.2 Mix Design Calculations CRMB @5%

Bitumen content (%)	Weight in Air (g)	Weight in Water (g)	Volume Of Sample cm^3	Theoretical Specific Gravity	Mass Specific Gravity
4	1032	610	532	2.49	2.24
4.5	1022	590	545	2.45	2.23
5	1015	590	532	2.44	2.23
5.5	1035	595	550	2.41	2.18
6	1044	615	562	2.4	2.131

Mix Design Calculations CRMB@10%

Table C.3 Mix Design Calculations CRMB@10%

Bitumen content (%)	Weight in Air (g)	Weight in Water (g)	Volume Of Sample cm^3	Theoretical Specific Gravity	Mass Specific Gravity
4	1087	630	550	2.457	2.37
4.5	1089	595	550	2.44	2.34
5	1044	575	532	2.42	2.32
5.5	1091	598	550	2.4	2.29
6	1097	610	560	2.392	2.26

Table C.4 Stability Values of Marshall Test

BITUMEN CONTENT	STABILITY NORMAL	STABILITY @CRMB 5%	STABILITY @CRMB10%
4	7.5	11.5	9.1
4.5	9.1	13.4	10.2
5	9.7	15.7	11.6
5.5	11.7	14.8	11.2
6	10.4	14.3	10.6

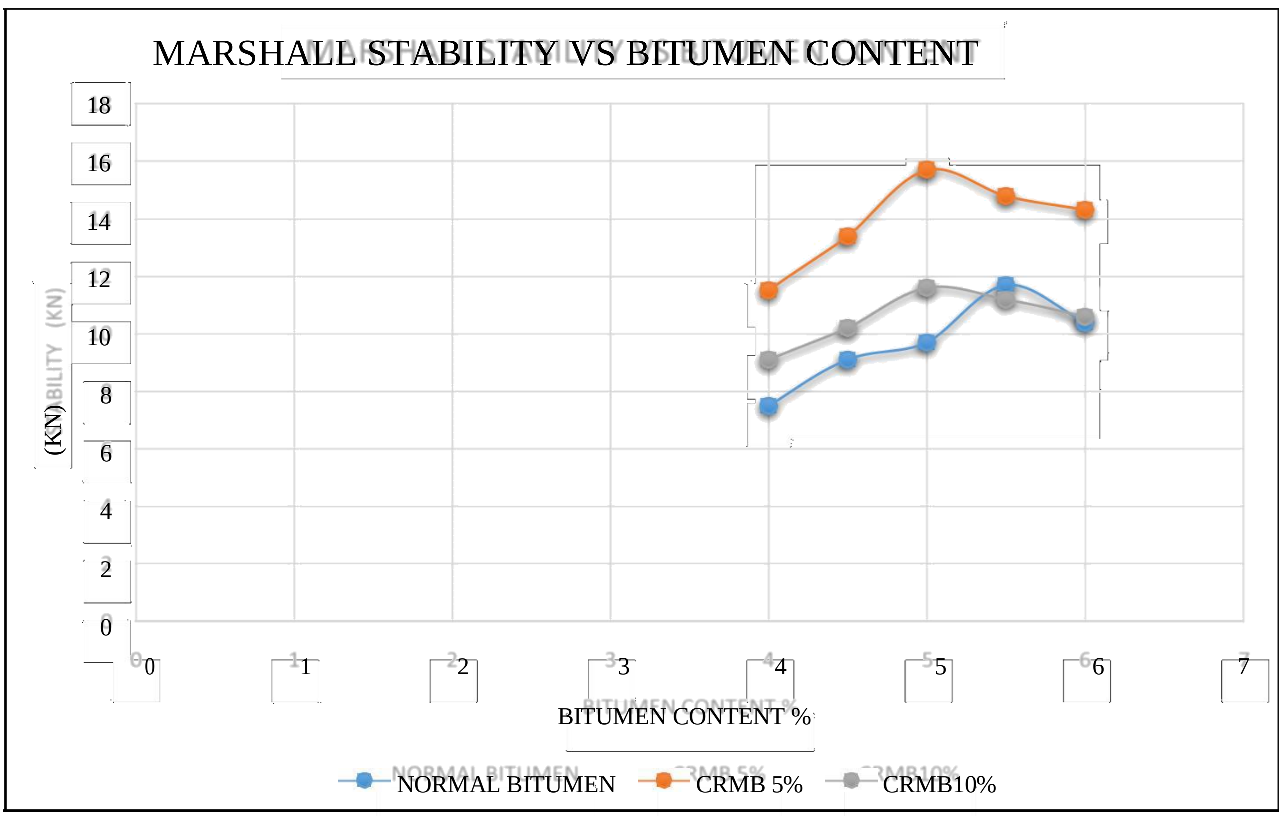


Figure C.1 Marshall Stability Vs Bitumen Content

Table C.5 Flow Value Values of Marshall Test

BITUMEN CONTENT	**FLOW VALUE NORMAL**	**FLOW VALUE @CRMB 5%**	**FLOW VALUE @10%**
4	15.1	8.1	8.8
4.5	15.8	9.4	10.1
5	16.6	10.6	11.3
5.5	17.8	11.8	13.8
6	19.5	14.2	16

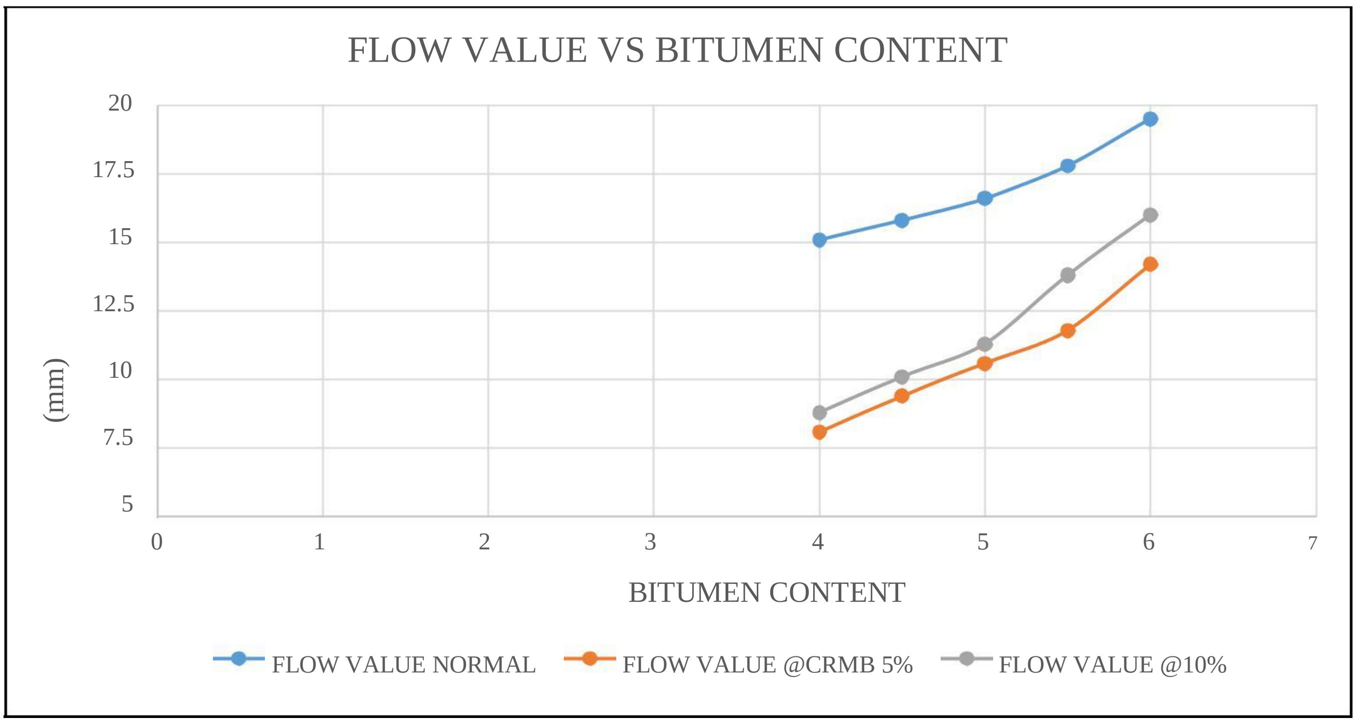


Figure C.2 Flow Value VS Bitumen Content

Table C.6 Value of Air Voids in Marshall Test

BITUMEN CONTENT	AIR VOIDS NORMAL	AIR VOIDS @CRMB 5%	AIR VOIDS @10%
4	11.6	10.5	10.2
4.5	10.7	8.7	8.4
5	10.12	7.7	7.2
5.5	9.62	6.92	6.74
6	8.74	6.8	6.4

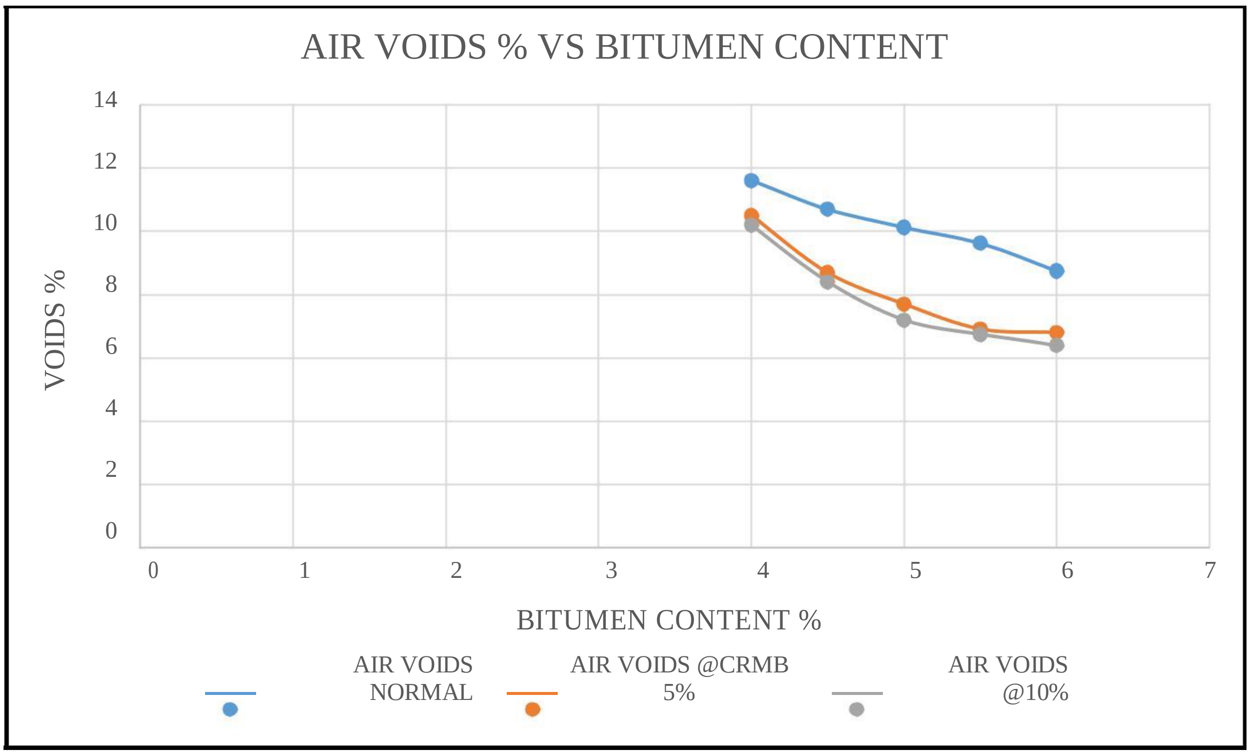


Figure C.3 Air Voids VS Bitumen Content

Annexure D

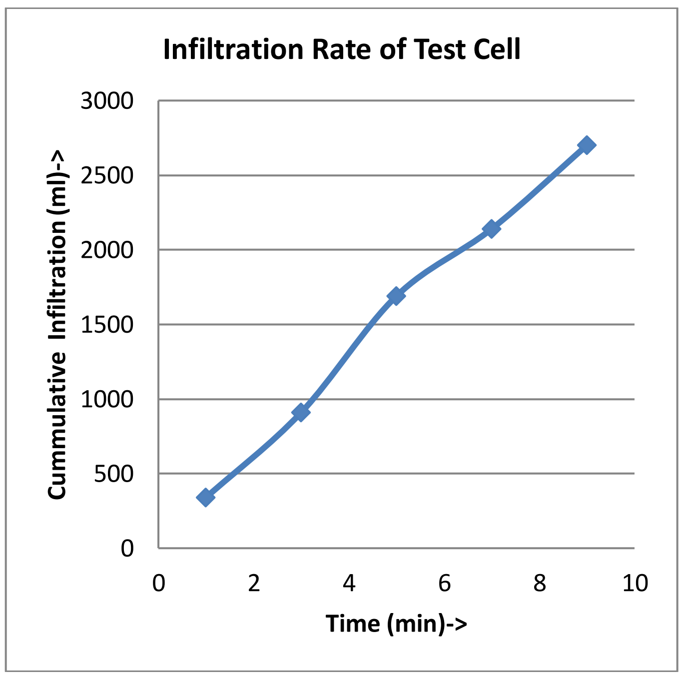
Infiltration Rates	D
Test: Single Ring Infiltrometer	
D1.1-D1.2:- Infiltration Rate of pervious pavement & soil	

D1.1

Infiltration Rate of Test Cell

Table D.1 Infiltration Rate of Test Cell

Time (min)	Volume Remaining (ml)	Of (ml)	Volume Added (ml)	Cummulative Volume Added (ml)
1	660	1000	340	340
3	430	1000	570	910
5	220	1000	780	1690
7	550	1000	450	2140
9	440	1000	560	2700
11	430	1000	570	3270
13	380	1000	620	3890
15	340	1000	660	4550
20	470	2000	1530	6080
25	450	2000	1550	7630
30	430	2000	1570	9200



304.236   10.10714

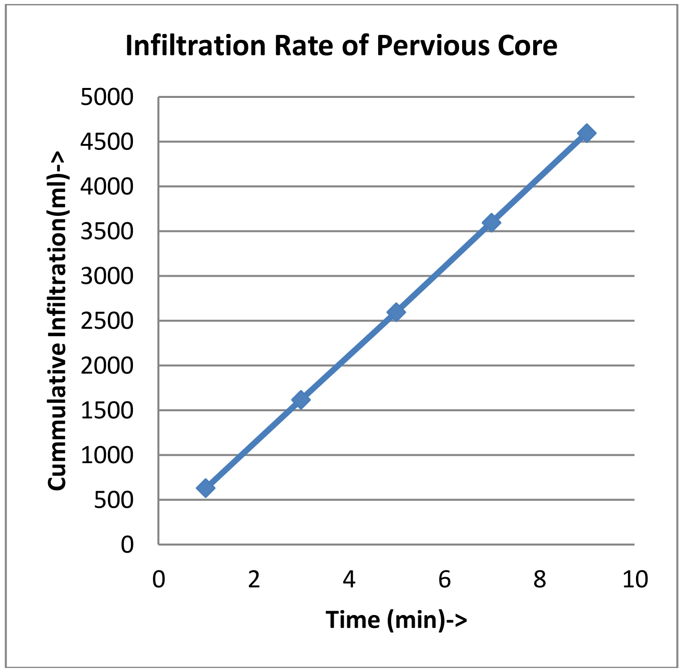
Diameter:- 11.63 in
Area:- 106.14 in sq.
Vol. Rate:- 304.24 cm^3 /min
18.57 in^3 /min

D1.2

Infiltration Rate of Pervious Core

Table D.1 Infiltration Rate of Concrete Core

Time (min)	Volume Remaining (ml)	Of (ml)	Volume Added (ml)	Cummulative Volume Added (ml)
1	370	1000	630	630
3	10	1000	990	1620
5	20	1000	980	2600
7	0	1000	980	3600
9	0	1000	1000	4600
11	785	2000	1215	5815
13	0	1000	1000	6815
15	10	1000	990	7805
20	380	3000	2620	10425
25	550	3000	2450	12875
30	420	3000	2580	15455



513.702 75.9535

Diameter:- 11.63 in
Area:- 106.14 in sq.
Vol. Rate:- 513.70 cm^3 /min
31.35 in^3 /min