EXPERIMENTAL STUDY ON THE EFFECT OF GLASS FIBER AND POLYPROPYLENE FIBER ON BITUMEN MIX

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A Thesis Submitted to

Atmiya University in Partial Fulfilment of the Requirements for

The Degree of Master of Technology in [Transportation Engineering]

Month and Year

July – 2021

Civil Engineering,

Faculty of Engineering & Technology

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CERTIFICATE

It is certified that the work contained in this dissertation thesis entitled '**Experimental Study on the Effect of Glass fiber and Polypropylene fiber on Bitumen Mix**' submitted by **Mr. Ajay B. Parmar**, **190041012** studying at Civil Engineering Department, Faculty of Engineering & Technology, for the award of M.Tech (Civil-Transportation Engineering) is absolutely based on his own work carried out under my/our supervision and that this work/thesis has not been submitted elsewhere for any degree/diploma.

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Dedicated

My Beloved

Parents

To,

Who always picked me up on time and

Encouraged me to go on every adventure,

Especially

This one.

AKNOWLEDGEMENT

Research brings about dramatic changes in the traditional lookout of Science & Technology. It has widened our vision, opened newer avenues and lightened the dark obscure facts of mysterious universe. Behind every success there are lot many effects, but efforts are fruitful due to hands making the passage smoother. I express my deep sense of gratitude for hands, people extended to me during my work.

I would like to thank to my guide Mr. Ashraf M. Mathakiya, for initial spark, constant unceasing encouragement, critical evaluation, suggestion, constant untiring guidance and affection during the entire span of my post-graduation study and also thanks to Mr. Prashant H. Lakkad for his direction and consistent support in my work. Thank you sir to illuminate me for my work.

I am very grateful to express sincere thanks to Dr. G. D. Acharya, Principal, Atmiya University, Rajkot and Mr. Hemant Sonkusare, Head of Civil Engineering Department, Atmiya University for giving me an opportunity to undertake this thesis for study.

I would like to express my special thanks to my seniors as well as my classmates who were always stood by me and provided me all the necessary help to complete my work.

At the occasion of this presentation, I would like to thank from the bottom of my heart to all mighty and My Parents and Brother for their endless love, support and encouragement.

Ajay B. Parmar

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EXPERIMENTAL STUDY ON THE EFFECT OF GLASS FIBER AND POLYPROPYLENE FIBER ON BITUMEN MIX

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ABSTRACT

The continuing rapid growth in traffic, along with the rise in allowable axle loads, requires improvement of highway paving materials. In the recent decades, different types of fiber materials are utilized for improving the performance of asphalt mixture. The Bond between fibers and binder and the strengthening mechanism in asphalt concrete is somehow different. Purpose of this research is to improvement performance of pavement and also increases stability and strength of pavement. In this bitumen grade VG-30, two types of additives Glass Fiber & Polypropylene Fiber are used and a systematic laboratory study of physical property of bitumen, aggregate, stripping value test, Marshall Mix design and tensile strength ratio tests are carried out with various percentage of both additives separately for BC grade – II of 4.9%, 5.4% and 5.9% bitumen content. Based on the tests observed effective output is 0.3% of Glass fiber and 0.3% of polypropylene fiber in 4.9%, 5.4% and 5.9% of bitumen content and also from ITS test effective result observed 0.3% of Glass fiber and 0.3% of polypropylene fiber in 4.9%, 5.4% and 5.9% of bitumen content.

Key words:- Bituminous mix, Bitumen concrete grade – II, Glass fiber, Polypropylene fiber, Marshall Stability Test, Indirect tensile strength test, Stripping test.

CHAPTER – 1 INTRODUCTION

1.1 GENERAL

"Transportation is the key infrastructure of a country. Development of a country depends on the connectivity of various places with adequate road network. Roads are important assets for any nation. In India, Highway construction activities have taken a big leap since last decade. Construction of highway involves huge outlay of investment. There are various types of pavements which differ in their suitability in different environments. Each type of pavement has its own merits and demerits. The purpose of highway pavement is to provide smooth surface over which vehicles can move safely from one place to another."

Basically, all road pavements fall into two broad categories namely flexible and rigid. Flexible pavement is that pavement which is surfaced with bitumen material with no reinforcement. Bituminous pavement which is more economical and reliable compared to rigid (concrete) pavements. The ingredients of the mixture include dense grading of coarse aggregates, fine aggregates, fillers and bitumen binder. In India, 98% roads are having flexible pavements which having bituminous layers A precise engineering design of a flexible pavement may save considerable investment; as well as reliable performance of the in-service highway pavement can be achieved. Pavement industry has developed rapidly all over the world during the last few decades, especially in developing countries like India. Following the rapid development and population growth, increased traffic load, higher traffic volume, and insufficient maintenance led to many severe distresses (e.g. rutting and cracking) of road surfaces. And also due to climate change flexible pavement resulting bleeding, rutting, reveling and unevenness which makes the pavement unsuitable for use and leading to failure of pavement.

Bitumen is one of the main reasons for asphalt pavement failure. There are various mechanisms that affect the viscoelastic properties of asphalt mixtures in time, among which age hardening can be considered to be an important one. Age hardening of asphalt mixtures is an irreversible process, which contributes to a reduction of the durability of pavements. Even though bitumen is only one component of asphalt mixtures, the overall performance of the asphalt pavement is largely dictated by the viscoelastic properties of the bitumen.

Recently, large number investigations have demonstrated that bitumen properties (e.g. viscoelasticity and temperature susceptibility) can be improved using an additive or a chemical reaction modification. The quality and durability of bituminous road is influenced by the type and amount of filler material is used. Fillers play an important role in engineering properties of bituminous paving mixes. Various materials such as cement, granite powder, stone dust and fine sand are normally used as filler in bituminous mixes. Cement, granite powder is expensive and used for other purposes more effectively.

Roads can be classified into two types based on the materials and their design approaches.

1) Flexible Pavement

2) Rigid Pavement.

1.2 FLEXIBLE PAVEMENT

Bitumen has been widely used in the road construction of the flexible pavement since vary long time. It is a very simple and most convenient type of the construction. For the single lane flexible pavement varies from 20 to 30 lakh per km in plain area. In however the conventional bitumen performance or application may not be measured satisfactory because of the curtains reasons are given below:

- In summer duration temperature become high, so bitumen become soft and due to this resulting bleeding, rutting and segregation reason for the failure of the flexible pavement.
- In winter duration temperature become low and bitumen become brittle and due to this process cracking, raveling and unevenness is happening and which make reason for the failure of the pavement.
- In rainy duration water enters into the pavement due to this making pot holes or sometime removing the whole layer of flexible pavement.

- In hilly region according sub-zero temperature, the freeze thaw cycle according due to ice melting and freezing this reason ice in bituminous voids are expanding and contracting according into the pavement and its make a reason the failure of the pavement.
- The cost of bitumen has been rising day by day. In future, there will be scarcity of bitumen and it will be become very high costs.

Based on recent investigations and research on bitumen properties (e.g. Viscoelasticity, moisture susceptibility and temperature susceptibility) it is found that moisture resistance can be improving by adding chemical and adhesive for modification of the flexible pavement.

1.3 RIGID PAVEMENT

Rigid pavement, though costly in initial stage and cheap in long duration because of low maintenance costs. There are various merits in the use of rigid pavements are summarized below:

- Besides the easy available of cement, concrete roads have a long life and are practically maintenance-free.
- Another major advantage of concrete roads is the saving in fuel by commercial vehicles to an extent of 14-20%. The fuel savings themselves can support a large program of concreting.
- Cement concrete roads save a substantial quantity of stone aggregates and this factor must be considered when a choice pavement is made.
- Concrete road can resist any weather conditions- wide ranging temperatures, heavy rainfall and water logging.
- Though cement concrete roads costly than a flexible pavement initially, they are economy when whole-life-costing is considered.
- Reduction in the cost of concrete pavements can be brought about by developing semi-self compacting concrete methods and the use of closely spaced thin joints.
- R&D effects should be initiated in this area.

1.4 BITUMINOUS MIX DESIGN

1.4.1 OBJECTIVE OF BITUMINOUS MIX DESIGN

- To obtain a durable pavement, sufficient amount of bitumen is required.
- Adequate strength must be provided to obtain resistance against shear deformation under higher temperatures.
- Additional voids have to be incorporated to facilitate the compaction performed by traffic.
- The placement must be performed with ease which will demand sufficient workability.
- The premature cracking in the bituminous pavement can be avoided by providing sufficient flexibility for bitumen.
- The flexibility must be attained at small temperature so that the shrinkage cracks can be avoided.

1.4.2 MAIN CONSTITUENTS OF BITUMEN MIX

- Course and Fine aggregate
- Filler
- Binder

Course aggregate are known for their abrasion resistance and toughness. These aggregate offer compressive and shear strength to the mix. These also facilitate good interlocking properties between aggregates. Fine aggregate fill voids in the mix created by the course aggregate and provide stiffening to the binder. Fillers play the role of filling the voids, help in stiffening the binder and offer higher permeability.

1.4.3 TYPES OF BITUMEN MIXES

Open graded mix, the filler and fine aggregates are absent. These mixes are porous in nature and offer good frictional property. This is lower the strength if the pavement is constructed for a high speed pavement construction. Gap graded bituminous mix, large course aggregates are missing in this types of mix. This has good fatigue property as well as tensile strength. Well graded mix, is a dense mix. These have all ranges of aggregates are sufficiently packed. These facilitate the proper filling of voids in a systematic manner. These types of mix offer good compressive and tensile strength.

1.5 TERMINOLOGY

1.5.1 BITUMEN

Asphalt is also known as bitumen. It is a sticky, black, highly viscous semi-solid or liquid form of petroleum. Bitumen is petroleum product obtaining by the refining of the crude petroleum in the refinery. It is a black or brown in color and also has waterproofing and other adhesive properties. Bitumen is also found as natural deposit or as component of naturally occurring asphalt, in which it is associated with mineral matter.

1.5.2 STONE DUST

Stone dust obtained at last of the crusher unit. It is used as filler material between two aggregate and aggregate sand fill voids. Filler mostly used when flexible pavement construction after filler spread on the road so upper portion of pavement are fill with stone dust.

1.5.3 GLASS FIBER

Glass fiber is a type of inorganic fiber. It is forming element is glass; it is produced from raw materials which has high strength. Glass fiber prevents bleeding and rutting in high temperature as well as glass fiber has a good resistance to cracking. Glass fiber various types available in the market like E-glass, C-glass, A-glass, D-glass, R-glass etc. In mostly C-glass used in more its length between 6 to 10 mm.

1.5.4 POLYPROPYLENE FIBER

Polypropylene fiber is generally superior to polyamide fibers in elasticity and resiliency but lower wear resistance. It displays good heat insulating properties and is highly resistant to acids, alkalies. The fiber is sensitive to heat and light and resistance to these agents is largely determined by the effectiveness of added stabilizers.

1.6 PROBLEM STATEMENT

Currently, majority of the Indian roads are flexible pavements, the ones having bituminous layers because they are provide good durability in paving mixtures. Bituminous materials or asphalts are extensively used for roadway construction, primarily because of their excellent binding characteristics and water proofing properties and relatively low cost. The performance of asphalt pavements is mainly governed by the properties of the bitumen, because bitumen is the continuous matrix and only deformable component. At high temperatures (40 to 600^{0}C), bitumen exhibits a viscoelastic behaviour. Pavement defects, such as rutting at high temperatures, cracking in low temperatures, are not only due to traffic loads but also to the thermal susceptibility of bitumen (Ruan, 2003).so, study shows only bitumen is not a perfect solution of this problem. As an organic matter bitumen is also age harden .when bitumen is hardened, the bitumen mixture will become brittle and its ability to support traffic-generated stresses and strains may significantly reduce which resulting cracking.

1.7 NEED OF STUDY

- To minimize the pavement failure and enhance the pavement performance.
- To improve stability and strength of the pavement.
- Ultimately decrease layer thickness of the pavement.
- Overall cost of the project reduced and environmentally safe.
- Low maintenance costs required.

1.8 OBJECTIVE OF STUDY

Following are the objectives of study:-

- To study the effect of significant changes in characteristics of the bituminous mixes by using Glass fiber and Polypropylene fiber with varying percentage.

1.9 SCOPE OF STUDY

Scope of Study is limited to BC grade II of 4.9%, 5.4% and 5.9% bitumen binder content only and examined following characteristics:

- Physical properties of bitumen VG30.
- Marshall Stability test on normal specimen (without fiber) and fiber added specimen (0.1%, 0.2%, 0.3%. 0.4%.for glass fiber and 0.1%, 0.2%, 0.3%, 0.4% for polypropylene fiber).
- Indirect tensile strength test on normal specimen (without fiber) and fiber added specimen (0.1%, 0.2%, 0.3%. 0.4%.for glass fiber and 0.1%, 0.2%, 0.3%, 0.4% for polypropylene fiber).
- Stripping test on normal specimen (without fiber) and fiber added specimen (0.1%, 0.2%, 0.3%. 0.4%.for glass fiber and 0.1%, 0.2%, 0.3%, 0.4% for polypropylene fiber).

CHAPTER – 2 LITERATURE REVIEW

2.1 GENERAL

This chapter literature review presents the specific our study area and fundamental property of the bitumen materials and finding the principle form the review that are related to the current study of water effect of on the flexible pavement.

The literature reviews illustrate how different material use in the bitumen and shows effect on pavement. The review shows the different effect and help in finding the test and methodology.

2.2 RESEARCH STUDIES

The research papers which are studied for this work are following:

1) A Study on the Performance of Glass fibre modified Bitumen in Dense Bitumen Macadam

Polagani sateesh, Pallati aviansh

Exponential increase in traffic, overloading of commercial vehicles and significant variations in daily and seasonal temperatures have shown some limitations of conventional bitumen performance. It is thought that with the help of additives is one of the approaches to improve performance of flexible pavements. Here fibers have been used to improve the performance of asphalt mixtures against permanent deformation and fatigue cracking, Because of their inherent compatibility with asphalt cement and excellent mechanical properties. In the present study, an attempt has been made to study the effects of use of a mineral fibre called Glass fibre is used as an additive in Dense Bituminous Macadam (DBM). An experimental study is carried out on conventional bitumen and fibre modified binder. Using Marshall Procedure, Optimum Fibre Content (OFC) and Optimum Binder Content (OBC) for DBM are found respectively. The modified bitumen at Different percentages are subjected to different performance tests like Dynamic Shear Rheometer (DSR) and Creep Properties to evaluate the effects of fibre addition on mix performance.

The optimum bitumen content (OBC) of DBM mix based on the marshal test results since, all Marshall Parameters are satisfying the requirement of MORTH specifications, the Optimum Binder Content is fixed as 4.5%. From Marshall Properties it is seen that, 4% of Air voids is obtained at 1.5% Glass fibre content and the stability value is also maximum at this percentage from the above conclusions on, i.e. DSR and Marshall Properties it was observed that 1.5% Glass fibre is the optimum fibre content which gives better results.

2) Effect of adding glass fiber on the properties of asphalt mix

M. S. Eisa, M. E. Basiouny, M. I. Daloob

The continuing rapid growth in traffic, along with the rise in allowable axle loads, requires improvement of highway paving materials. In the recent decades, different types of fiber materials are utilized for improving the performance of asphalt mixture. A laboratory investigation was carried out into the effect of adding Glass Fiber (GF) on some properties of Hot Mix Asphalt (HMA) mixtures. Subsequently, five HMA specimens were prepared using the Marshall Mix design method for wearing surface mix (mix 4C). Marshall Stability (MS) and flow tests were applied to the specimens. Also, MS and flow values were recorded. For the Optimum Asphalt Content (O.A.C) and different GF percentages, the Marshall parameters were calculated. Then, some special tests were conducted to measure the different mix properties, including loss of stability, wheel tracking and indirect tensile strength tests. Results of the study led to important conclusions regarding using of Glass Fiber (GF) to improve most of the properties of HMA mixtures. Finally, this study recommended a proposed mix with 0.25% GF by weight of the total mix. The optimum content of GF is 0.25% by weight of the total mix, producing improved mixtures of hot asphalt, which provide higher stability value by 10%, adjusted flow value by reducing it with 13% and more rutting resistance by reducing rutting value by 19.7% comparing with control asphalt mixture.

3) Experimental and numerical investigation of the properties of the Hot Mix Asphalt Concrete with basalt and glass fiber

Mahmoud Ameri, Mehdi Nemati, Hamid Shaker

In the recent decades, different kinds of fiber materials are used for improving the asphalt mixture performance. Meanwhile, different kinds of fiber are used excessively due to their desirable physical and chemical properties and their easier application. The main purpose of this research is to evaluate the characteristics of the asphalt mixture while using basalt fiber and glass fiber. In order to provide asphalt samples, these two types of fibers are used in different percentages. In this way, 42 samples (with different percentages of fiber and bitumen) were made using Marshal Hammer. In the next step, while constructing 63 asphalt samples using a gyratory device, then mix asphalt conventional tests include the determination of indirect tensile strength, moisture sensitivity test, and resilient modulus and creep tests performed. The results of this research indicate that using these two types of fibers increased the percentage of optimum bitumen and marshal resistance. At best, adding 0.1% glass fiber resulted in 13% increase in marshal resistance. Finally, ANFIS-GUI was used to estimate the experimental result and the feasibility of employing neural fuzzy network to predict the laboratory data have been evaluated.

Generally, when using the fiber in the asphalt mixtures, the increase in the Marshall stability can be seen. At best, adding 0.1% glass fiber resulted in a 13% increase in the Marshall stability. In the case of using fibers, there will be an increase in the flow value. The use of 0.3% basalt fibers resulted in a 10% increase in the flow value.

4) Use of Glass fiber in Recycled Asphalt Pavement

SHREYAS.R.S, Ms. Nandini.K

Exponential increase in traffic, overloading of commercial vehicles and significant variations in daily and seasonal temperatures have shown some limitations of conventional bitumen performance. It is thought, that with the help of additives is one of the approaches to improve performance of Recycled Asphalt Pavements. Here fibers have been used to improve the performance of asphalt mixtures against permanent deformation, Because of their inherent compatibility with asphalt and excellent mechanical properties. In the present study, an attempt has been made to study the effects of use of a mineral fibre called Glass Fibre of

12mm along with the Bitumen is added in the percentages of (0.5, 1, 1.5, 2) to the total weight of the material.

An experimental study like Marshal Stability and Stripping value test is carried out on fibre modified Recycled Asphalt Pavement. The modified pavement at Different percentages are subjected to different performance tests to evaluate the effects of fibre addition on mix performance. Preparing the mix design using Glass fiber and Bitumen, with different percentages i.e. 0.5%, 1%, 1.5%, 2% by the total weight of RAP material.

As the results shows that, the Glass Fiber used in the RAP material gives the more stability compared to all other type of samples. The highest value of stability is obtained at the addition of 1.5% of Glass Fiber and equivalent amount of Bitumen

5) Use of Glass fibre in Bituminous Mixes

Er.Mohammed Ayoub Mirza, Er.Deepak Kumar, Er.Aafaq Ahmad Bhat

Mixture of coarse aggregate, fine aggregate, binder and filler forms a bituminous mixture. A bituminous mixture where all ingredients are mixed, placed and compacted at high temperature is Hot Mix Asphalt. Hot mix Asphalt can be in the form of Dense Graded mixes (DGM) known as Bituminous Concrete (BC) or in the form of gap graded mixes known as Stone Matrix Asphalt (SMA). For the stabilization of Stone Matrix Asphalt additives composed of mineral fibers, cellulose fibers or polymers are required to prevent drain down of the mix. The present study aims to study the effects of use of a naturally and locally available fibre called Glass fibre. Glass fibre is used as stabilizer in Stone Matrix Asphalt as an additive in Bituminous Concrete. Mixes were prepared by grading the aggregates as per Ministry of Road Transport And Highways (MORTH) specification, varying binder content regularly from 4% to 6% and varying fibre content from 0%, 0.3% and 0.6% of total mix. Using Marshall Method tests were conducted and based on results Marshall Graphs were plotted. It was observed that Optimum binder content for both the mixes (Bituminous Concrete and Stone Matrix Asphalt) was 5.5%. Also it was concluded that Optimum fibre content for both the mixes was 0.3%. Then the Bituminous Concrete and Stone Matrix Asphalt mixes prepared at Optimum binder content and Optimum Fibre Content are subjected to different performance tests like Drain Down test, to evaluate the effects of fibre addition on mix performance. It was observed that by the addition of the Glass Fibre the drain down characteristics of mixtures decreases, Drain Down value of Stone Matrix Asphalt is reduced to 0.025% and there is negligible drain down of binder of Bituminous Concrete. It is observed that Stone Matrix Asphalt is better than Bituminous Concrete in respect of creep characteristics.

Here Optimum Binder Content and optimum fibre content is found 5.5% and 0.3% respectively By addition of fibre up to 0.3% Marshall Stability value increases and with further addition of fibre it decreases. But addition of fibre stability value not increased as high as Stone Matrix Asphalt.

6) The Effect of Polypropylene fibers on Asphalt Performance

Serkan Tapkın

Polypropylene fibers are extensively used in civil engineering applications for many years. These fibers are used in concrete as a three dimensional secondary reinforcement. Due to adhesion between polypropylene fibers and bitumen, the strengthening mechanism in asphalt concrete is somehow different. In this study, asphalt concrete specimens with polypropylene fibers were manufactured at the optimum bitumen content. It was observed for fiber-reinforced specimens that the Marshall Stability values increased and flow values decreased in a noticeable manner. The fatigue life of these specimens was also increased. The improvement of the properties of asphalt concrete shows the positive effect of polypropylene fibers. The fiber-reinforced asphalt mixture exhibits good resistance to rutting, prolonged fatigue life and less reflection cracking. Therefore it is concluded that the application of polypropylene fibers alters the characteristics of asphalt mixture in a very beneficial way.

For the given aggregates and bitumen, the optimum bitumen content was found to be 5.5%. When the fatigue life of the specimen is expected to be longer, the production cost is reduced, since it is expected that the optimum bitumen content would be smaller for the specimens with polypropylene fibers. In various experiments carried out, the polypropylene content was ranging from 0.3%, 0.6%, 1%. When the polypropylene fiber content increases, an increase in the Marshall Stability index has been observed reaching 58% for the specimens reinforced with 1% of polypropylene fibers.

7) Contribution of Polypropylene fibers in Modification of VG 30 Bituminous Mix

Disha Rajyaguru, Rohit Kumar, Prof. C. B. Mishra

Road transportation sector plays a pivotal role in accessing the growth of any country. In developing nations like India, where the traffic development and axle loading is developing at logarithmic scale, weakening of roadways is quick before their future on account of adaptable flexible pavement. The researchers and designers are continually attempting to enhance the execution of bituminous mixtures. In this concentrate, at first bituminous mixtures samples were readied at the ideal bitumen content. To the acquired bitumen content polypropylene fibers in extent of 4%, 5% and 6% are added to assess the volumetric properties of Marshall Mix design. It was observed for fiber-reinforced specimens that the Marshall Stability values increased and flow values reduced in a recognizable way. The change of the properties of bituminous mixture shows the constructive outcome of polypropylene fibers. In this manner, it is presumed that the utilization of polypropylene fibers changes the attributes of bituminous mixtures in an exceptionally helpful manner. In this paper, VG 30 bituminous mix design with utilization of 12mm length polypropylene fiber with 4%, 5% and 6% by weight of bituminous binders and without it is concentrated on to decide the result of it as volumetric properties at the best bitumen content. Finally, the study concluded that 5.0% of polypropylene of 12 mm length is better than other percentages used in the experiment, because the air void increased to 17.45% at this percentage.

8) Aggressive Environmental Effect on Polypropylene Fibre Reinforced Hot Mix Asphalt

Niyazi Uğur Koçkal, Sevil Köfteci

Highway transportation is the most preferred transportation system as compared to other modes due to its high accessibility. Flexible highway pavement consists of mainly aggregate and bitumen, besides, in order to improve performance, some organic and/or inorganic additives are also utilized as additional constituents in the hot mix asphalt (HMA). By improving performance, positive characteristics can be gained to the HMA such as high strength, durability, toughness, suitable flexibility and resistance to impact. In this study, an attempt has been made to minimize deterioration due to the damage given by different aggressive environmental conditions. For that purpose, polypropylene fibers were added in varying ratios (0, 5, 7.5 and 10 % by weight of binder) into the HMA, then these mixtures were maintained in the freeze-thaw cycling cabinet, CaCl2, NaCl and Na2SO4 solutions for a certain period. The results showed that stability increased continuously by mixtures with a content of up to 7.5 % of polypropylene fibre, and then a drop was observed by 10 % fibre reinforced mixtures. In addition, exposure to freeze-thaw cycles and Na2SO4 solution was found as the most harmless and harmful conditions, respectively among other environments in the investigation.

After optimum bitumen rate determined, samples containing polypropylene fibre (PF) were prepared at 5%, 7.50 % and 10 % of specified optimum bitumen weight. Polypropylene fibers were added into the mixture during mixing process in the asphalt mixer. The Marshall stability of asphalt samples was seen to increase with the fibre content and reached an optimum value at 7.5% of fibre content and afterwards it got decreased for 10%. The bulk density of asphalt samples was found to increase with the fibre content increase in percentage from 0 to 7.5.

9) Fatigue Behavior of Polypropylene Fiber Reinforced Bituminous Concrete Mix

Abdullah Ahmad, Yassir Nashaat A. Kareem

This Conventional bituminous mixes have performed satisfactorily well on a wide range of roads in the past, but it is seen that bituminous mixes are now exposed to greater stresses because of the increase in magnitude of commercial vehicles and higher tyre pressures. Increasing magnitude of wheel loads and tyre pressures of current traffic, the performance of neat bituminous mixes is generally unsatisfactory for paving applications. The purpose of present work is to study the behaviour of fiber reinforced bituminous concrete mix on fatigue performance. Polypropylene fibers are extensively used in civil engineering applications for many years. Due to adhesion between polypropylene fibers and bitumen, the strengthening mechanism in bituminous concrete is somehow different. In this study, bituminous concrete specimens with polypropylene fibers were manufactured at the optimum bitumen content. It was observed for fiber-reinforced specimens that the Marshall Stability values increased and flow values decreased in a noticeable manner. The fatigue life of these specimens was also increased significantly. The improvement of the properties of bituminous concrete shows the positive effect of polypropylene fibers. The fiber-reinforced bituminous concrete mix exhibits prolonged fatigue life. Therefore it is concluded that the application of polypropylene fibers alters the characteristics of bituminous concrete mix in a very beneficial way.

In this study fiber content taken 0.3%, 0.6%, 0.9%, 1.20%, 1.50%. When the polypropylene fiber content increases, an increase in the Marshall Stability index was observed reaching 27 % for the specimens reinforced with 1.5 % of polypropylene fibers. In this stability value increase with fiber content increase and flow value decrease with increase fiber content.

10) Partial Replacement of Bitumen with Glass fiber in Flexible Pavement

K. Sri Harsha, M. Nikhil, K. Hemantha Raja

The idea of utilizing different fibers to enhance the conduct of pavement is not new in nowadays. The modern developments of fiber fortification began in the mid-1960s. The fiber materials were presented and are ceaselessly being presented in the market as new applications for the pavement for example polyester fiber, asbestos fiber, glass fiber, polypropylene fiber, Carbon fiber, Cellulose fiber, etc. Among these distinctive fiber materials we have picked the glass fiber in light of the fact that the consequence of this review demonstrates that strengthening the bitumen clearing blend with glass fiber upgrades the general execution of the pavement. To study the effect of pavement when it is Partially replaced with glass fiber and how ductility and penetration value is varying by adding 1%,2%,3% glass fiber by replacing bitumen .The stability and flow values should be determined for nominal and modified mix by Marshall method by varying percentage of fibers.

The optimum binder content for addition of glass fiber is 5.4%. The optimum binder content for the nominal mix is 5.6%. The Maximum Marshall Stability value occurred at 5% of bitumen for 3% of glass fiber is 26.03KN. As compared to the nominal mix the stability value increasing. And the flow value is decreasing.

2.3 IS CODE

1) IS 1203-1978 “Method for Testing Tar and Bituminous Materials: Determination of Penetration”

In this IS code covers the methods for the determination of penetration of asphaltic bitumen and native asphalt and blown type bitumen.

2) IS 1205-1978 “Method for Testing Tar and Bituminous Materials: Determination of Softening Point”

This standard covers the method for the determination of softening point of asphaltic bitumen and fluxed native asphalt, road tar, coal tar patch and blown type bitumen.

3) IS 1206-1978 “Method for Testing Tar and Bituminous Materials: Determination of Viscosity”

This standard covers the methods for the determination of viscosity of bitumen, tar and cutback bitumen.

4) IS 73-2013 “Paving Bitumen – Specifications”

This standard prescribes the requirements of various grades of paving bitumen for use as binders in the construction of pavements. Bitumen is graded by viscosity at 60^0C.

5) IS 2386 (Part III) – 1963 “Methods of Test for Aggregates for Concrete” Specific gravity, Density, Voids, Absorption and Buckling”

In this standard covers the methods for the determination of specific gravity, absorption and voids present in the aggregate.

CHAPTER – 3 MATERIAL AND METHODOLOGY

3.1 GENERAL

This chapter deals with the methodology which is used. Also it is deal with material characteristics which is used in bitumen sample. The different properties of bitumen samples are tested before and after aging. The tests carried out are briefly explained.

3.2 METHODOLOGY CHART

The following diagram shows the step by step process of research work.

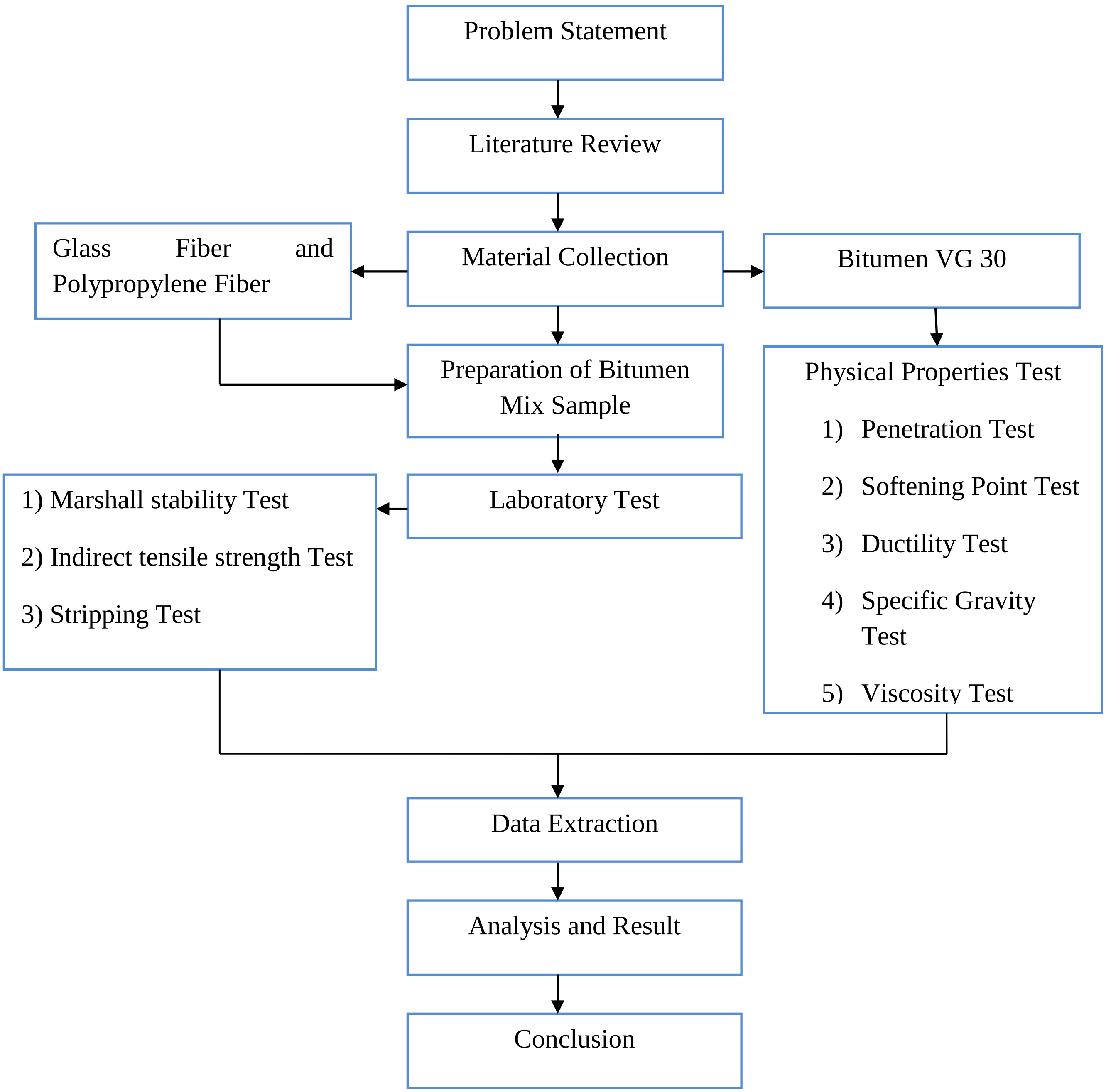


FIGURE 3.1: FLOW CHART OF METHODOLOGY

The process of research work is described above using flow diagram. The neat bitumen of viscosity grade 30 (equivalent to penetration grade 60/70) is used for this research study. Hydrate Lime and concrete dust is used as filler material for this study. Penetration test is conducted to get penetration value of different binders. Ductility Test is carried out on bitumen to test the adhesive property of bitumen and its ability to stretch. The Marshall stability of the bituminous mix specimen is defined as a maximum load carried in kg at standard test temperature of 60 C when load is applied under specified test conditions.

3.3 MATERIAL SELECTION

3.3.1 Types of bitumen

Bitumen or bituminous binder available in India is mainly of the following types:

I. Penetration grade

- **Bitumen 80/100:** The characteristics of this grade confirm to that of S 90 grade of IS-73-1992.This is the softest of all grades available in India. This is suitable for low volume roads and is still widely used in the country.
- **Bitumen 60/70:** This grade is harder than 80/100 and can withstand higher traffic loads. The characteristics of this grade confirm to that of S 65 grade of IS- 73-1992. It is presently used mainly in construction of National Highways & State Highways.
- **Bitumen 30/40:** This is the hardest of all the grades and can withstand very heavy traffic loads. The characteristics of this grade confirm to that of S 35 grade of IS-73-1992. Bitumen 30/40 is used in specialized applications like airport runways and also in very heavy traffic volume roads in coastal cities in the country

II. Viscous Grade Bitumen

Paving grade bitumen is the bitumen obtained from refineries and conforms to IS 73. Recently, the third revision of Indian Standards for Paving Bitumen Specifications IS 73:2006 has been released by Bureau of Indian Standards. Three grades of Bitumen confirming to IS 73: 1992 are manufactured in India. In this third revision grading of Bitumen is changed from penetration grade to viscosity grade. To improve the quality of Bitumen, BIS revised IS-73-1992

Specifications based on viscosity grade (viscosity @ 60 deg. C) in July 2006. As per the Specifications, there are four grades VG-10, VG-20, VG-30 & VG-40.

The new method of grading the product has now rested on the viscosity of the Bitumen (at 60 ºC and 135 ºC). The new grades have thus evolved with nomenclature:

TABLE 3.1 STANDARD PHYSICAL PROPERTIES OF BITUMEN

CHARACTERISTICS	Paving Grades or Viscosity Grade Bitumen Requirements			
	VG-10	VG-20	VG-30	VG-40
Absolute viscosity at 60^0C, Poises, Min	800	1600	2400	3200
Kinematic viscosity at 135^0C, cSt, Min	250	300	350	400
Penetration at 25^0C	80-100	60-80	50-70	40-60
Softening point, ^{0}C, Min	40	45	47	50

- Viscosity Grade -30 Bitumen is used for the present study.

3.3.2 Rheological Properties of Bitumen

Rheology is the study of deformation and flow of materials. It is the science knowledge that is related to all aspects of deformation of material under the influence of external stresses. Bitumen behaves in a unique manner depending upon both the load applied and the rate of loading. Temperature additionally is a factor that could be correlated with the rate of loading. At elevated temperatures, or slow rates of loading, bitumen becomes a viscous material. At decreased temperatures or higher rates of loading, bitumen becomes a highly elastic material.. The study of bitumen rheology is an important phenomenon to characterize the dynamic mechanical behaviour of binders. Pavement deformation is closely related to asphalt binder rheology.

3.3.3 Properties of fiber material

TABLE 3.2 MECHANICAL PROPERTIES OF GLASS FIBER

Density	2.59 g/m^3
Tensile strength	1370-2070 Mpa
Color	White
Specific gravity	2.57
Tensile modulus	72.45

TABLE 3.3 MECHANICAL PROPERTIES OF POLYPROPYLENE FIBER

Color	White
Density	0.91 gm/cm^3
Elongation at break	10 – 45%
Melting point	170^0 C
Modulus of elasticity	8.48 GPa

3.4 EXPERIMENT CHART

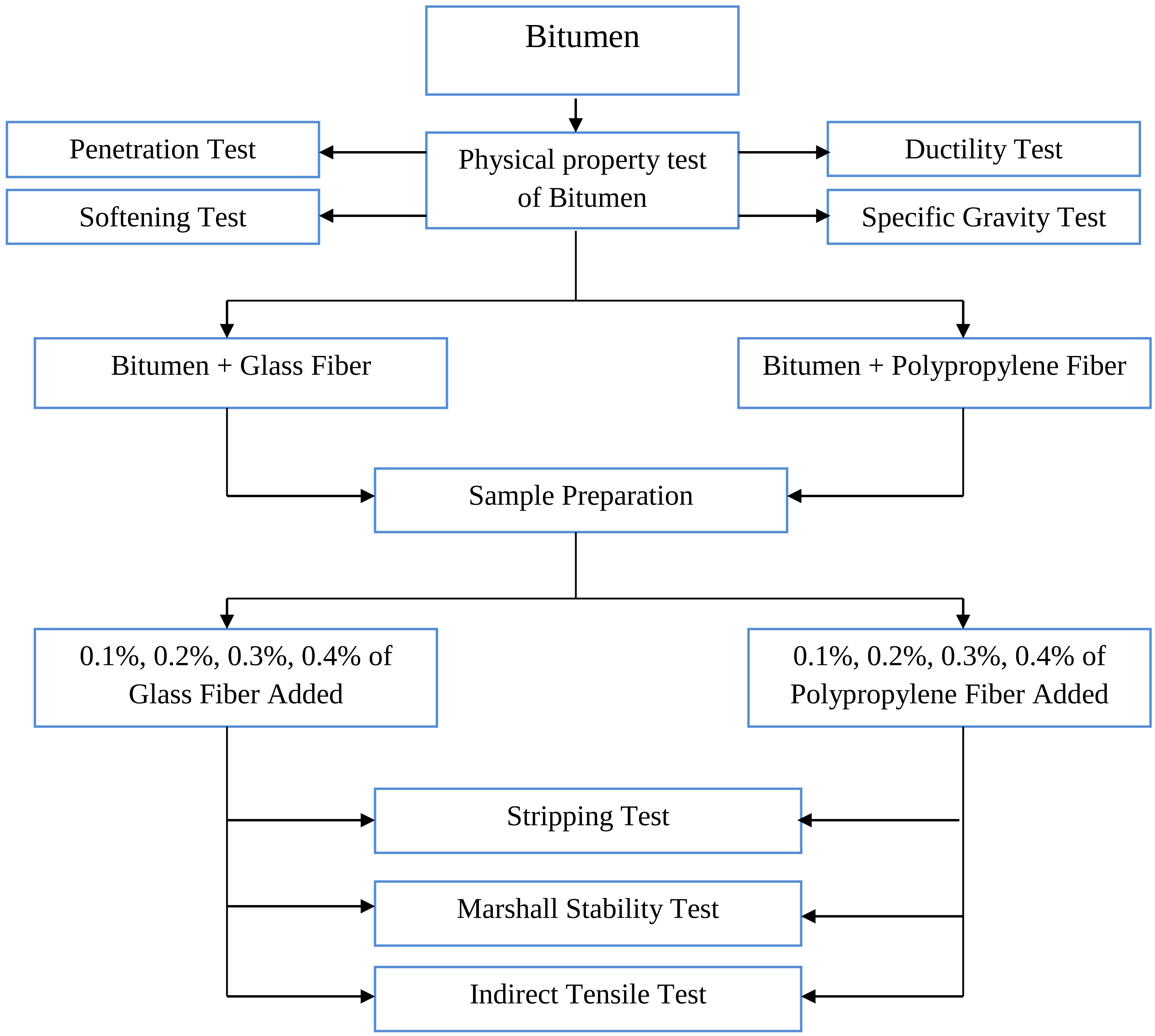


FIGURE 3.2: EXPERIMENTAL CHART

3.5 BASIC TEST ON BITUMEN

Different types of standard tests conducted on it are briefly described below. The physical properties of bitumen can be obtained using these tests.

3.4.1 Penetration Test (IS: 1203-1978)

3.4.2 Softening Point Test (IS: 1205-1978)

3.4.3 Viscosity Test (IS: 1206-1978)

3.4.4 Ductility Test (IS: 1208-1978)

3.4.5 Specific Gravity (IS: 1202-1978)

3.4.6 Stripping Test (IS: 6241-1971)

3.4.7 Marshall Stability Test (AASHTO T245)

3.4.8 Indirect Tensile Test (AASHTO T283)

[1] Stripping Test (IS: 6241-1971):-

Procedure:-

1. 200 g of clean and dry aggregate passing 20 mm IS sieve and retained on 12.5 mm sieve are heated up to 150°C when these are to be mixed with bitumen.
2. Bitumen binder amounting to five percent by weight of aggregate is heated to 160°C.
3. The aggregate and binder are mixed thoroughly till they are completely coated and mixture is transferred to the beaker and allowed to cool at room temperature for about 2 hours.
4. Distilled water is then added to immerse the coated aggregates.
5. The beaker is covered and kept in a water bath maintained at 40°C, for 24 hours.
6. After 24 hours, the beaker is taken out, cooled at room temperature and the extent of stripping is estimated visually while the specimen is still under water.
7. Indian Road Congress (IRC) has specified the maximum stripping value as 5 percent for aggregates to be used in bituminous construction like surface dressing penetration macadam, bituminous macadam and carpet.

[2] Marshall Stability Test (AASHTO T245):-

Bituminous concrete mix is commonly designed by Marshall Method. This test is extensively used in routine test program for the paving jobs.

The method is to live the conflict of the compressed cylindrical kind of the asphalt mixture with the plastic bending once the sample is loaded within the diametrical direction at the deformation rate 50.8 mm/minute. The stability of the mix is defined as a maximum load carried by a compacted specimen at a standard test temperature of 60^0C. The flow is measured as the deformation in units of 0.25 mm between no load and maximum load carried by the specimen during stability test (flow value may also be measured by deformation units of 0.1 mm). This test attempts to get the optimum binder content for the aggregate mix type and traffic intensity. This is the test which helps us to draw Marshall Stability vs. % bitumen.

Procedure of Sample Preparation:-

The course aggregate, fine aggregate, and the filler material should be proportioned so as to fulfill the requirement of the relevant standards. The bituminous mix specimen's thickness is 63.5 mm. 1200 gm of aggregates are heated 175^0 to 190^0 C. The bitumen is heated 121^0 to 138^0 C. Then both are mixed. The Bituminous mix is placed in a mould and number of blows compacted accordingly specified.

Specimen Testing:-

The sample was submerged in water at $60^0 \pm 1^0$ C for 30 minutes. It was then placed in a Marshall Stability test set and a deformation rate of 50.8 mm / min was applied until the mould failed. Under the maximum load, the mould failure is considered to be Marshall Stability in kN. The stability result thus obtained is corrected. The total amount of deformation occurring at the maximum load is 0.25 mm and is recorded as the flow rate value. Remove the sample from the bath and complete the test for no more than 30 second.

Marshall Method's Various Parameters:-

Following analysis will be performed and obtained data from the experiments.

1) Theoretical Specific gravity of the mix (Gt)

Specific gravity Gt is the specific gravity of that specimen and it consider without air voids, and is given by:

$$G_t = \frac{W_1 + W_2 + W_3 + W_b}{\frac{W_1}{G_1} + \frac{W_2}{G_2} + \frac{W_3}{G_3} + \frac{W_b}{G_b}}$$

Where, W1, W2, W3 and Gb are the weight of course aggregates, fine aggregates, weight of filler and Wb is the weight of bitumen, accordingly. G1, G2, G3 and Gb are the obvious specific gravity of course aggregate, obvious specific gravity of fine aggregate, obvious specific gravity of filler and obvious specific gravity of bitumen accordingly.

2) Bulk specific gravity of mix (Gm)

The actual specific gravity mix Gm is found out by following equation:

$$G_m = \frac{W_m}{W_m - W_w}$$

Where, Wm and Ww are the weight of mix in air and the weight of mix in water accordingly.

Wm-Ww is the volume of the mix.

3) Air voids percent (Vv)

The percent of air voids by volume in the specimen is found by following equation:

$$V_v = \frac{(G_t - G_m)100}{G_t}$$

Where, Gt and Gm are the theoretical specific gravity of the mix and the bulk or actual specific gravity of the mix accordingly.

4) Quantity of bitumen (Vb)

The percent of volume is found following equation:

$$V_b = \frac{\frac{W_b}{G_b}}{\frac{W_1+W_2+W_3+W_b}{G_m}}$$

Where, W1, W2, W3, Wb are the weight of course aggregate, the weight of fine aggregate, the weight of filler and the weight of bitumen, accordingly. Gb and Gm are the apparent specific gravity of bitumen and the bulk specific gravity of mix, accordingly.

5) Voids in mineral aggregate (VMA)

Voids in mineral aggregate are calculated from following equation:

$$VMA = V_v + V_b$$

Where, Vv and Vb are the % air voids and the percent bitumen in the mix, accordingly.

6) Voids filled with bitumen (VFB)

Voids filled with bitumen VFB is calculated from following equation:

$$VFB = \frac{V_b \times 100}{VMA}$$

Where, Vb and VMA are percent bitumen content in mix and the percent voids in the mineral aggregate, accordingly.

7) Determine optimum bitumen content

In order to determine the optimum binder content for the mixed design, the average is the following three asphalt contents. Use the Marshall Mix design to check the stability values, flow values, and VFB specifications table as table. The maximum stability of the adhesive content. The maximum packing specific gravity (Gm) of the binder content. In the mixture, the designed air porosity percentage (Vv) is the median of the bitumen.

TABLE 3.4 REQUIREMENTS FOR BITUMINOUS CONCRETE

Properties	Viscosity Modified bitumen grade paving Bitumen			Test method
Compaction Level	75 blows on each face of the Marshall specimen			
Minimum stability (KN at 600 C)	9	12	10	AASHTO T245
Flow (mm)	2 - 4	2.5 - 4	3.5 - 5	AASHTO T245
Marshall Quotient (Stability/Flow)	2 - 5	2.5 - 5		MS – 2 and ASTM D2041
% air voids	3 – 5			
% voids Filled with Bitumen (VFB)	65 – 75			
Coating of aggregate particle	95 % minimum			IS:6241
Tensile Strength Ratio	80 % minimum			AASTHO T245

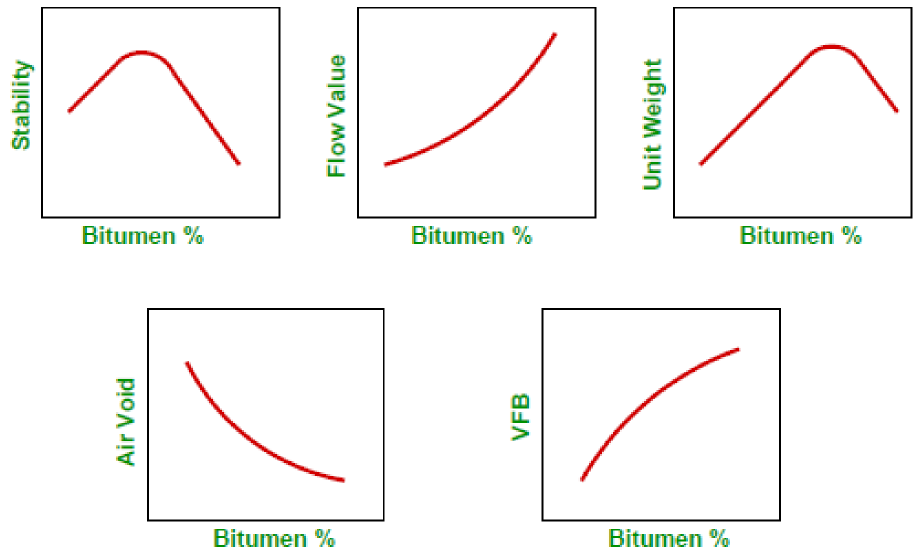


FIGURE 3.3 MARSHALL GRAPHICAL PLOTS

[3] Indirect Tensile Test (AASHTO T283):-

This test has been conducted according to standards of ASTM D6931-07. The IDT strength of Bituminous mixtures id performed by loading a cylindrical specimen across its vertical diametric plane at a specified rate of deformation and test temperature. The highest load at failure is recorded and used to calculate the IDT strength. IDT strength values are helpful to estimate the resistance against fatigue and rutting. The following equation is used for calculating the indirect tensile strength of specimen.

Test Procedure:-

Make at least 6 compacted specimens for each mixture, 3 to be tested dry and 3 to be tested after partial saturation and moisture conditioning with a freeze-thaw cycle.

Compact the 6 specimens with a Marshall compactor so that the compacted specimens have air voids 7 percents. This level of higher air voids can be obtained by adjusting the number of Marshall blows applied on each side of the specimens by trial and error.

Separate the 6 specimens into 2 subsets so that the average air voids of the two subsets are approximately equal.

One set will be tested dry. Keep it at room temperature and then place in a 25^{0}C water bath for 2 hours prior to determining their indirect tensile strength.

The other set will be conditioned as follows:

Wrap a plastic film around each specimen and place the wrapped specimen in a plastic bag containing 10 ml of water and seal the plastic bag. Place a plastic bag in a freezer at temperature of -18^{0}C for a minimum of 16 hours. Remove the specimens from the freezer.

Place the specimens in a water bath maintained at 60^{0}C for 24 hours. Remove the plastic bag and the plastic film from each specimen after placing the specimens under water.

Remove the specimens from hot water bath and place in a water bath maintained at 25^{0}C for 2 hours.

Remove the conditioned specimens and test for indirect tensile strength.

Calculate the tensile strength of each specimen as follows:

$$St = 2000\ P/\ \pi\ t\ d$$

Where,

St = tensile strength, kPa

P = maximum load, N

t = specimen thickness, mm

d = specimen diameter, mm

Calculate the tensile strength ratio (TSR) as follow:

Tensile strength ratio (TSR) = $\mathbf{S_2 / S_1}$

S1 = average tensile strength of the dry subset

S2 = average tensile strength of the conditioned subset

TABLE 3.5 NUMBER OF SPECIMENS CASTING SCHEDULE FOR MARSHALL STABILITY AND ITS

SCHEDULE FOR MARSHALL STABILITY TEST

Bitumen Content	Normal Specimen	Glass Fiber Content (%)				Polypropylene Finer Content (%)			
		0.1	0.2	0.3	0.4	0.1	0.2	0.3	0.4
4.9	3	3	3	3	3	3	3	3	3
5.4	3	3	3	3	3	3	3	3	3
5.9	3	3	3	3	3	3	3	3	3
	9	9	9	9	9	9	9	9	9
Total Number of Specimens = 81									

SCHEDULE FOR INDIRECT TENSILE TEST

Bitumen Content	Normal Specimen	Glass Fiber Content (%)				Polypropylene Finer Content (%)			
		0.1	**0.2**	**0.3**	**0.4**	**0.1**	**0.2**	**0.3**	**0.4**
4.9	6	6	6	6	6	6	6	6	6
5.4	6	6	6	6	6	6	6	6	6
5.9	6	6	6	6	6	6	6	6	6
	18	18	18	18	18	18	18	18	18
Total Number of Specimens = 162									

Indirect Tensile Strength test make 6 compacted specimens for each mixture, 3 specimen tested for Unconditional and 3 specimen tested for Conditional.

CHAPTER – 4 TEST RESULT AND ANALYSIS

4.1 GENERAL

This chapter includes all test results obtained by testing of bitumen and bitumen mix design for the additives. The Marshall test, stripping test and indirect tensile test with the editing the additives like Glass fiber and Polypropylene fiber.

4.2 SIEVE ANALYSIS

The screening analysis test was used to determine the aggregate size of the collected quarry sample. Through this screening test, the ratio of course aggregate, fine aggregate and filler is determined to ensure that the aggregate is well mixed within the specified level of bitumen grade MORTH. The results of the screening analysis test are listed in the table.

4.3 AGGREGATE RESULT

The aggregate performance tests were performed on the various specified properties, and the resulting test results were computed with the allowable values in the MORTH specification, as shown in the table.

TABLE 4.1 TEST RESULTS OF THE AGGREGATES

PROPERTY	RESULTS	SPECIFICATION
Aggregate Impact Value, %	10.29 %	24% maximum
Water Absorption,%	0.45 %	2% maximum
Specific gravity	2.74	2 – 3
Abrasion value%	27	35% maximum

4.4 BITUMEN TEST RESULTS

Bituminous binders used in pavement construction works include both bitumen and tar. Bitumen is a petroleum product obtained by the distillation of petroleum crude where as road tar is obtained by the destructive distillation of wood or coal. Bitumen is available in variety of types. The grade of bitumen used in this research is VG 30. The obtained physical properties of VG-30 such as penetration, ductility, softening point, viscosity and specific gravity and their requirements as per specifications given in IS 73:2006.

TABLE 4.2 TEST RESULTS OF BITUMEN SAMPLE

PROPERTY	TEST RESULTS	SPECIFICATION LIMITS AS PER IS
Penetration at 25^0 C /100 gm / 5 sec, mm	64	60 – 70
Ductility, cm	81.02	75 cm minimum
Softening point	50^0C	40^0C to 55^0C
Viscosity at 60C, Poise	1057	1000$\pm$200
Specific gravity	1.01	0.97 to 1.03

4.5 GRADATION FOR BC GRADE-II MIX DESIGN

The aggregate gradation is mainly based on the Ministry of Road Transport & Highways (MoRT&H) 2013 specifications. The MoRTH gradation i.e. the Indian gradation having nominal maximum size of aggregate 19 mm and minimum size is 0.075 mm given in MoRTH specification. This size of aggregate used only for Bituminous Grade – II only.

TABLE 4.3 GRADATION OF BITUMENOUS CONCRETE GRADE-II

Sieve	Actual % passing			Stone Dust	% Passing proposed mix design				Total Passing %	Limit as per
Size	20 mm	10 mm	6 mm		20 mm	10 mm	6 mm	Stone dust		MORTH
	DN	DN	DN		DN	DN	DN			Table – 500/18
Mm	-	-	-		15%	19%	18%	48%	100.0%	Grading 2
19	100	100	100	100	15	19	18	48	100	100
13.2	39.5	100	100	100	5.925	19	18	48	90.9	79-100
9.5	10.9	72.4	100	100	1.635	13.756	18	48	81.4	70-88
4.75	2.1	0.68	73.18	100	0.315	0.129	13.17	48	61.6	53-71
2.36	2.1	0	35.58	100	0.315	0	6.404	48	54.7	42-58
1.18	0	0	4.88	85	0	0	0.878	40.8	41.7	34-48
0.6	0	0	0.81	61.15	0	0	0.146	29.35	29.5	26-38
0.3	0	0	0.38	39.75	0	0	0.068	19.08	19.1	18-28
0.15	0	0	0.28	26.79	0	0	0.050	12.86	12.9	12-20
0.075	0	0	0.23	19.35	0	0	0.041	9.29	9.3	4-10

Aggregate gradation process carried out then mix design proportion obtained for Bituminous Concrete grade – II has been described in Table 4.4.

TABLE 4.4 MIX DESIGN PROPORTION OF AGGREGATE FOR BC GRADE-II

Aggregate Size	20 mm	10 mm	6 mm	Stone Dust
Proportions	15%	19%	18%	48%

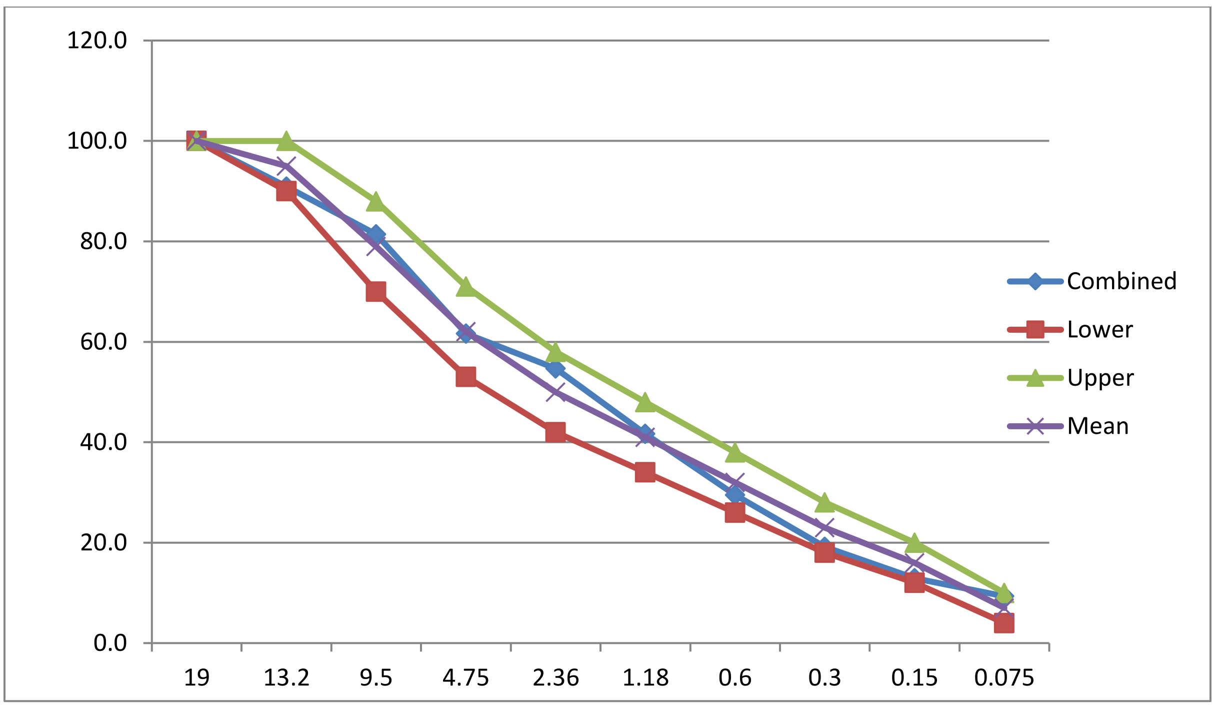


FIGURE 4.1 GRADATION CHART

4.6 MARSHALL MIX DESIGN RESULTS OF BC GRADE-II WITHOUT ADDITIVES

TABLE 4.5 MARSHALL MIX DESIGN RESULTS OF BC GRADE-II WITHOUT ADDITIVES

Bitumen Content	Height of Specimen (mm)	Corrected Stability	Flow (mm)
4.9%	68.7	1048.6	3.8
5.4%	70.3	1106.5	3.5
5.9%	67.3	1344.6	3.6

TABLE 4.6 MARSHALL VAROIUS PARAMETERS RESULTS

Weight in air (Wa) Gm	Weight in Water (Ww) gm	Theoretical specific gravity Gt	Bulk specific gravity Gm	Air voids %Vv	% Volume of bitumen (Vb)	Voids in mineral agg. (VMA)	Voids field with Bitumen (VFB)
1248	705.67	2.422	2.302	4.968	10.645	15.613	68.672
1249.3	699.67	2.406	2.273	5.537	11.529	17.067	67.633
1258.6	699	2.390	2.250	5.869	12.412	18.281	67.413

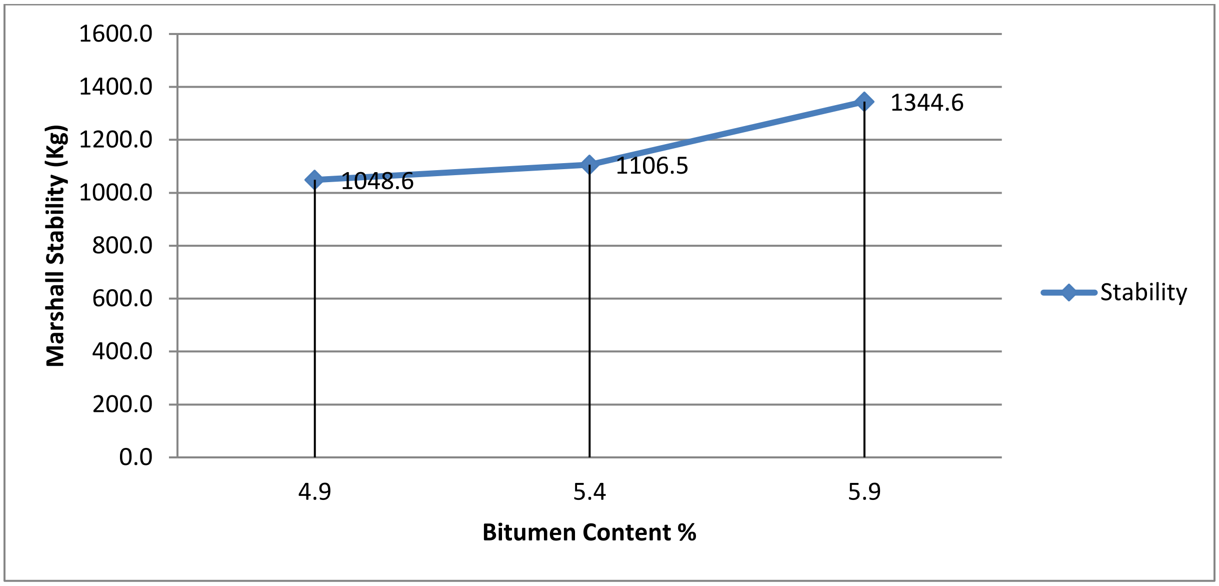


FIGURE 4.2 BITUMEN CONTENT v/s MARSHALL STABILITY

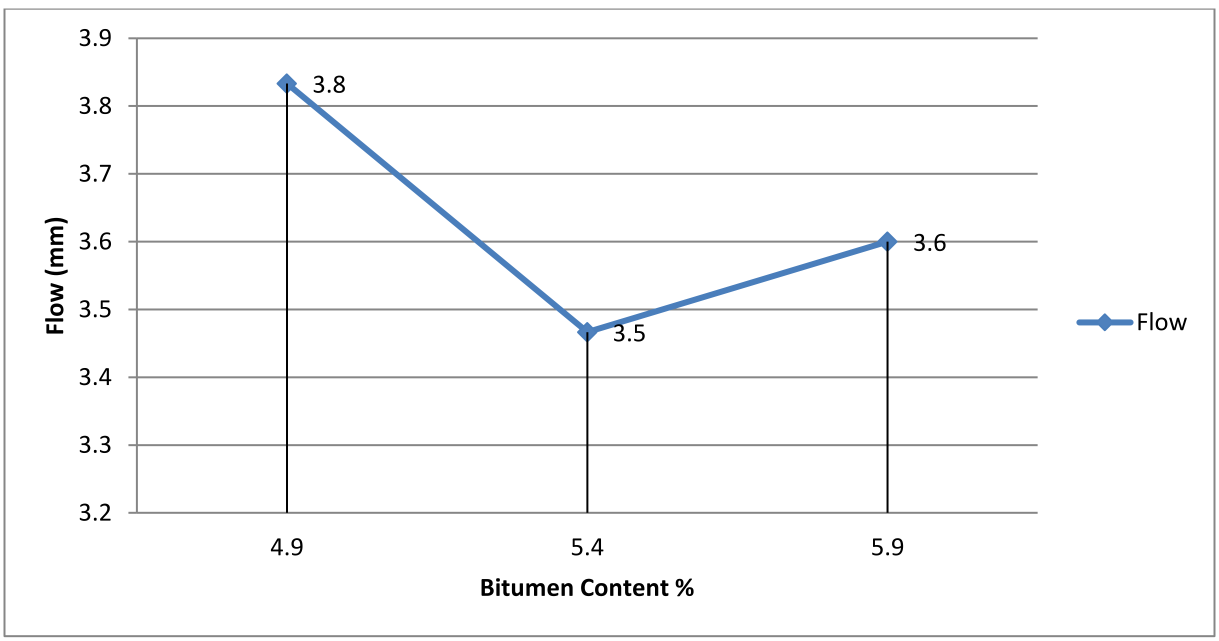


FIGURE 4.3 BITUMEN CONTENT v/s FLOW

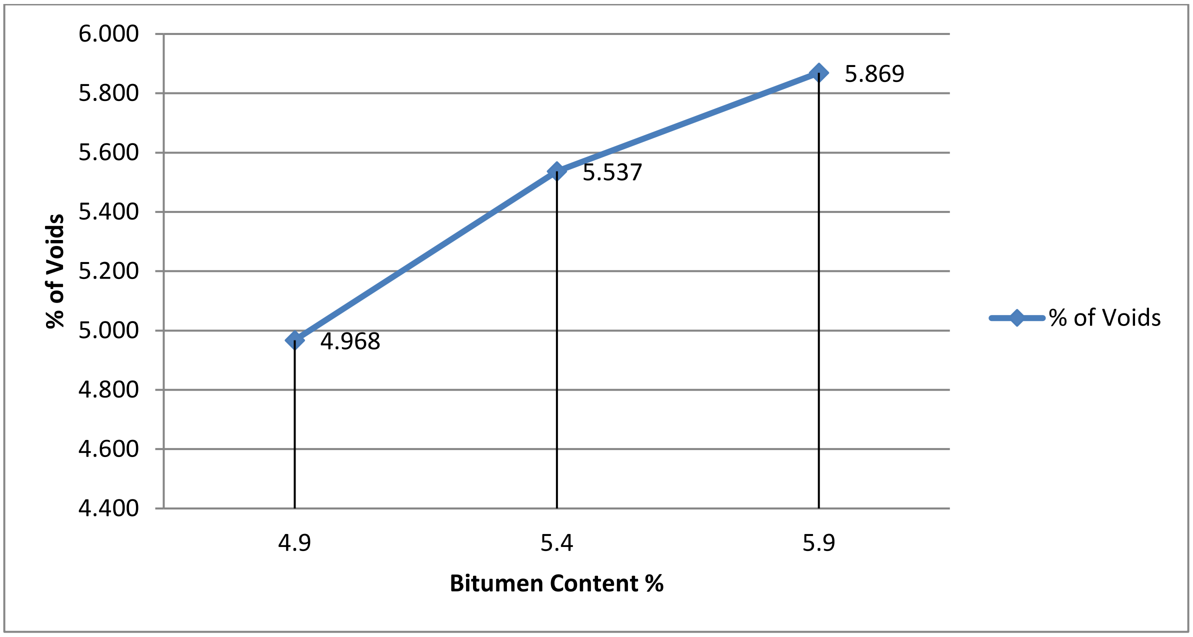


FIGURE 4.4 BITUMEN CONTENT v/s % OF VOIDS

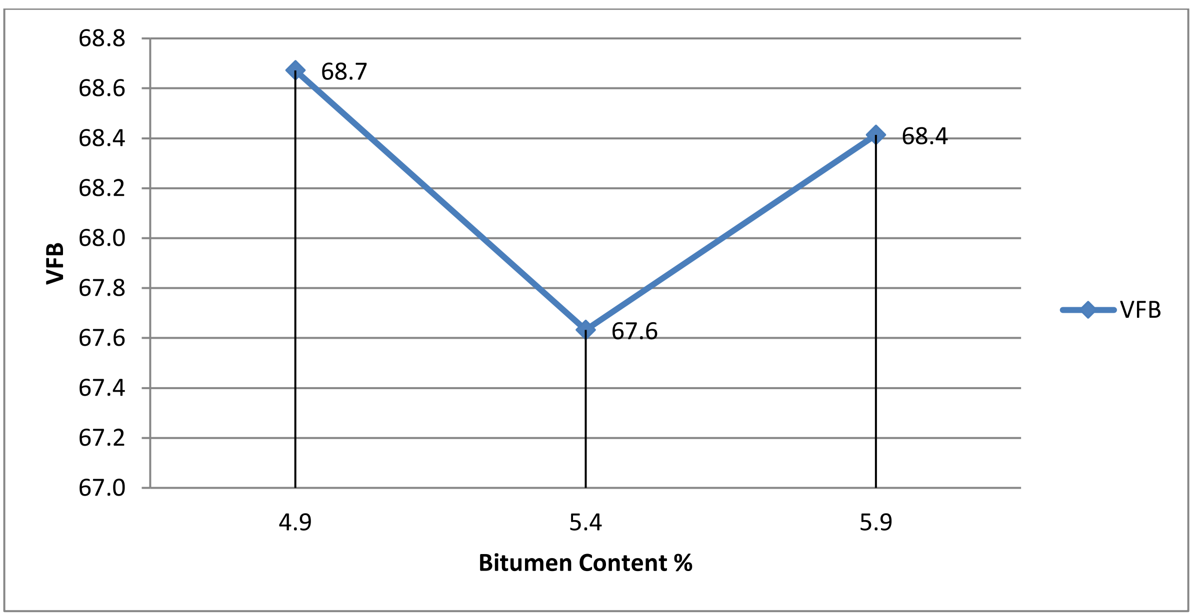


FIGURE 4.5 BITUMEN CONTENT v/s VFB

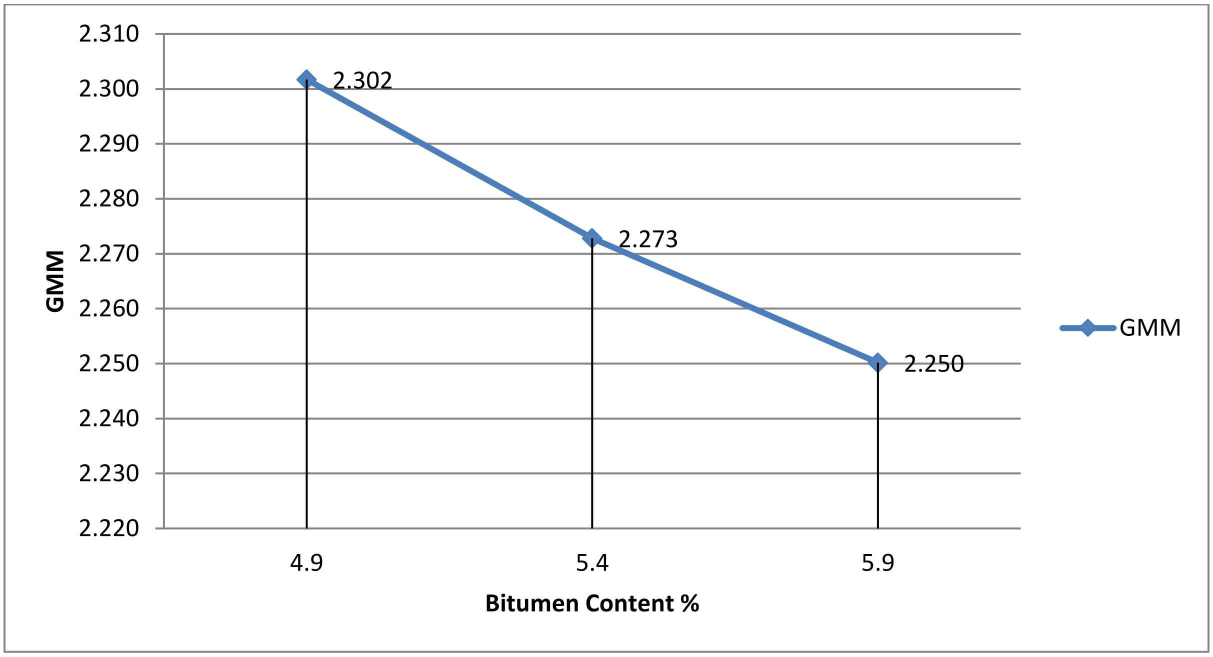


FIGURE 4.6 BITUMEN CONTENT v/s GMM

4.7 MARSHALL MIX DESIGN RESULTS OF BC GRADE-II WITH GLASS FIBER (0.1%, 0.2%, 0.3%, 0.4%)

TABLE 4.7 MARSHALL STABILITY AND FLOW RESULT FOR GLASS FIBER WITH BITUMEN CONTENT 4.9%

Bitumen Content (%)	Glass Fiber Content (%)	Height of Specimen (mm)	Corrected Stability (Kg)	Flow (mm)
4.9	0.1	71	1203	3.5
	0.2	70.7	1010	3.4
	0.3	69.7	1413.4	3.5
	0.4	68	1379.9	3.7

TABLE 4.8 MARSHALL VAROIUS PARAMETERS RESULTS FOR GLASS FIBER WITH BITUMEN CONTENT 4.9%

Weight in air (Wa) Gm	Weight in Water (Ww) gm	Theoretical specific gravity Gt	Bulk specific gravity Gm	Air voids %Vv	% Volume of bitumen (Vb)	Voids in mineral agg. (VMA)	Voids field with Bitumen (VFB)
1247.7	695.3	2.422	2.261	6.666	10.455	17.121	61.749
1253.7	710.3	2.422	2.307	4.735	10.671	15.407	69.282
1246	701.7	2.422	2.289	5.489	10.587	16.076	65.937
1266	714.3	2.422	2.295	5.245	10.641	15.859	67.343

TABLE 4.9 MARSHALL STABILITY AND FLOW RESULT FOR GLASS FIBER WITH BITUMEN CONTENT 5.4%

Bitumen Content (%)	Glass Fiber Content (%)	Height of Specimen (mm)	Corrected Stability (Kg)	Flow (mm)
5.4	0.1	66.7	1100.1	3.5
	0.2	69	945.7	3.6
	0.3	68.3	1377.5	3.4
	0.4	70	1097.2	3.6

TABLE 4.10 MARSHALL VAROIUS PARAMETERS RESULTS FOR GLASS FIBER WITH BITUMEN CONTENT 5.4%

Weight in air (Wa) Gm	Weight in Water (Ww) gm	Theoretical specific gravity Gt	Bulk specific gravity Gm	Air voids %Vv	% Volume of bitumen (Vb)	Voids in mineral agg. (VMA)	Voids field with Bitumen (VFB)
1257.3	700	2.406	2.260	6.087	11.462	17.550	66.847
1259.7	708	2.406	2.284	5.084	11.585	16.669	69.714
1280.7	726.7	2.406	2.312	3.914	11.727	15.641	75.304
1266.7	722	2.403	2.326	3.320	11.800	15.120	78.711

TABLE 4.11 MARSHALL STABILITY AND FLOW RESULT FOR GLASS FIBER WITH BITUMEN CONTENT 5.9%

Bitumen Content (%)	Glass Fiber Content (%)	Height of Specimen (mm)	Corrected Stability (Kg)	Flow (mm)
5.9	0.1	66.7	1100.1	3.5
	0.2	67.7	1080.8	3.8
	0.3	68.7	1317.6	3.8
	0.4	67.3	1020.6	3.7

TABLE 4.12 MARSHALL VAROIUS PARAMETERS RESULTS FOR GLASS FIBER WITH BITUMEN CONTENT 5.9%

Weight in air (Wa) Gm	Weight in Water (Ww) gm	Theoretical specific gravity Gt	Bulk specific gravity Gm	Air voids %Vv	% Volume of bitumen (Vb)	Voids in mineral agg. (VMA)	Voids field with Bitumen (VFB)
1272.3	707	2.390	2.252	5.787	12.423	18.210	68.982
1235.3	696.7	2.390	2.297	3.926	12.668	16.594	78.040
1253.7	705.3	2.390	2.287	4.331	12.615	16.946	74.933
1260.3	713.3	2.390	2.304	3.613	12.710	16.323	77.899

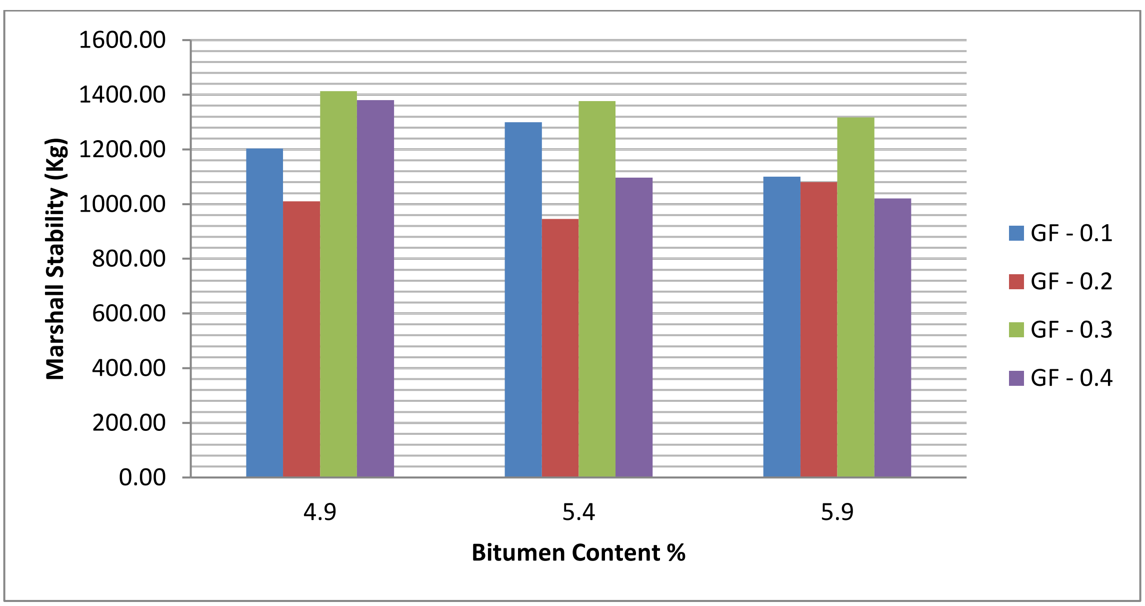


FIGURE 4.7 BITUMEN CONTENT v/s MARSHALL STABILITY

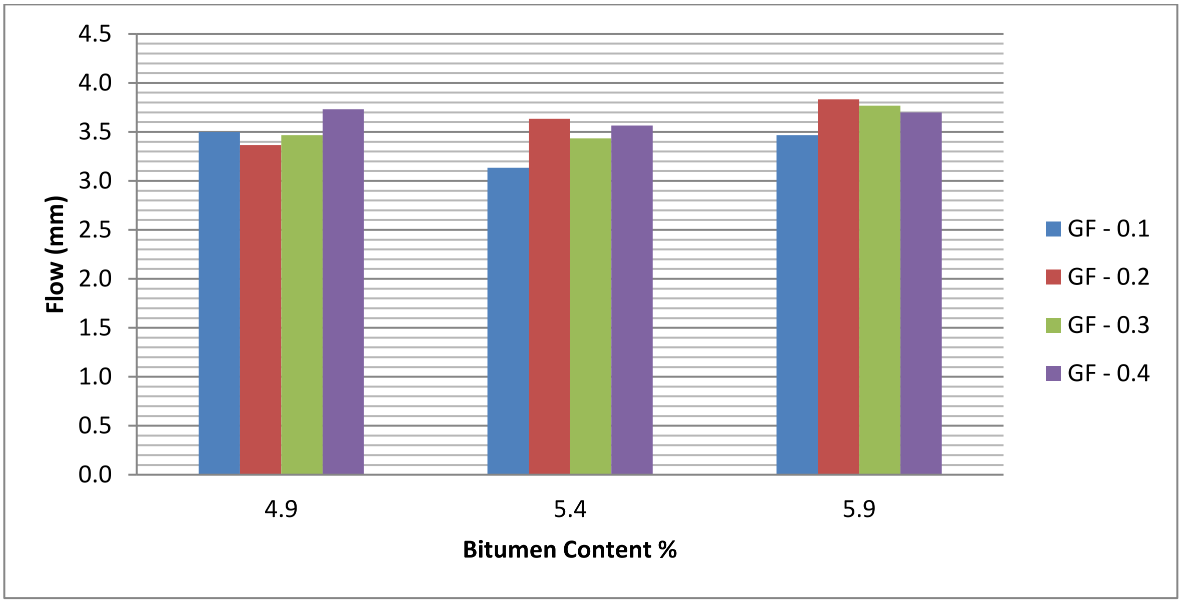


FIGURE 4.8 BITUMEN CONTENT v/s MARSHALL FLOW

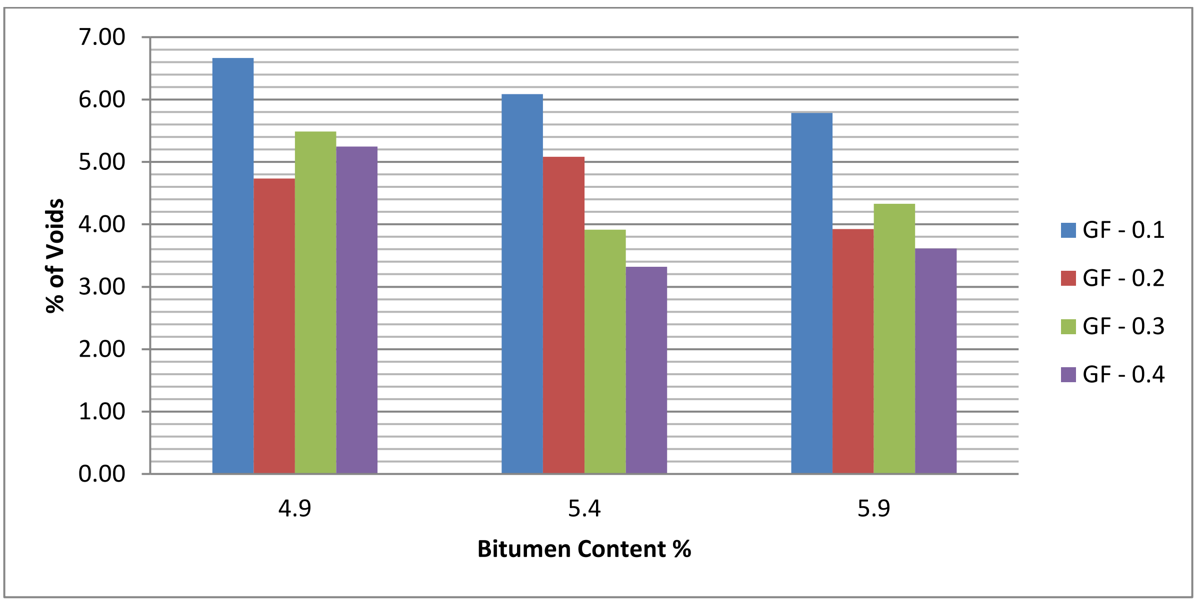


FIGURE 4.9 BITUMEN CONTENT v/s % OF VOIDS

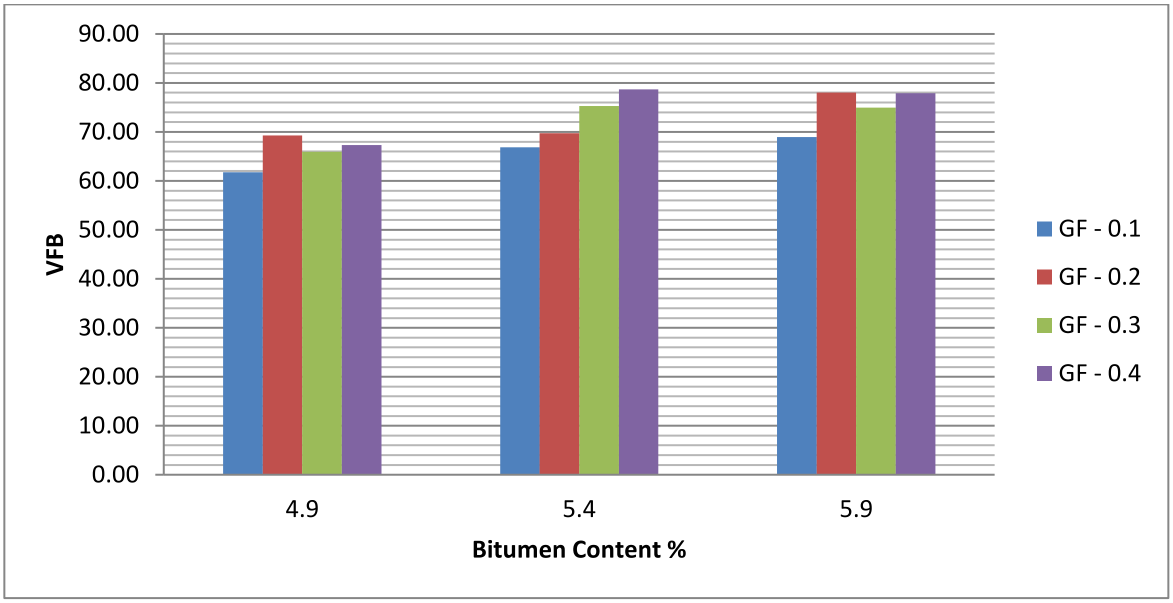


FIGURE 4.10 BITUMEN CONTENT v/s VFB

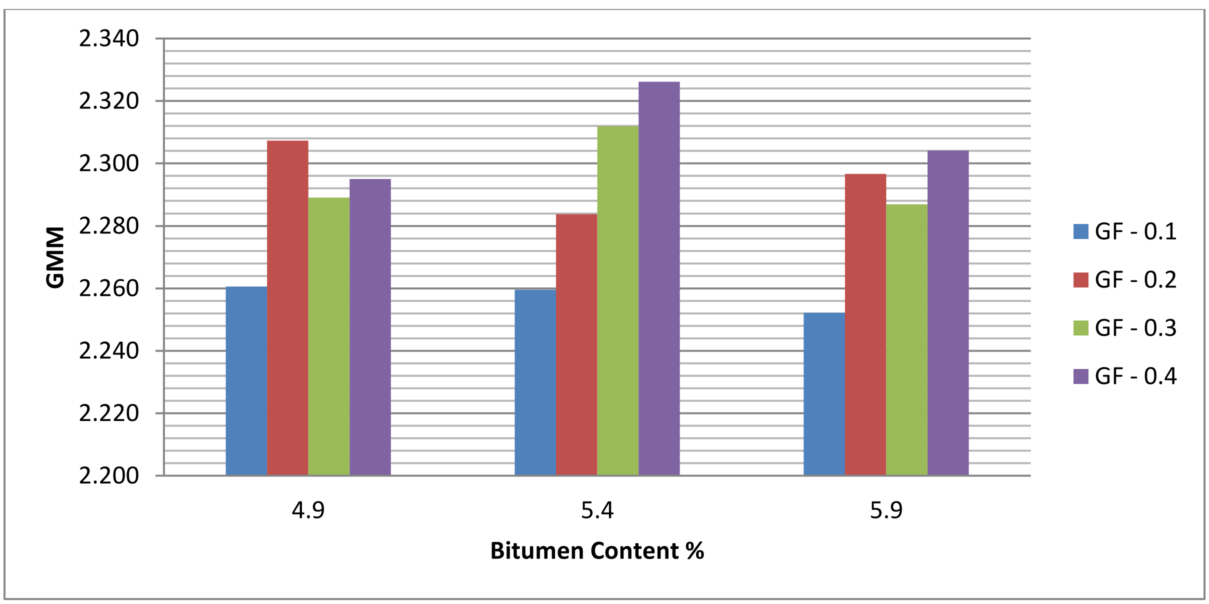


FIGURE 4.11 BITUMEN CONTENT v/s GMM

4.8 MARSHALL MIX DESIGN RESULTS OF BC GRADE-II WITH POLYPROPYLENE FIBER (0.1%, 0.2%, 0.3%, 0.4%)

TABLE 4.13 MARSHALL STABILITY AND FLOW RESULT FOR POLYPROPYLENE FIBER WITH BITUMEN CONTENT 4.9%

Bitumen Content (%)	Glass Fiber Content (%)	Height of Specimen (mm)	Corrected Stability (Kg)	Flow (mm)
4.9	0.1	69.3	1080.4	3.3
	0.2	68.3	1176.3	3.6
	0.3	69.7	1401.5	3.8
	0.4	69	1221.8	3.6

TABLE 4.14 MARSHALL VAROIUS PARAMETERS RESULTS FOR POLYPROPYLENE FIBER WITH BITUMEN CONTENT 4.9%

Weight in air (Wa) Gm	Weight in Water (Ww) gm	Theoretical specific gravity Gt	Bulk specific gravity Gm	Air voids %Vv	% Volume of bitumen (Vb)	Voids in mineral agg. (VMA)	Voids field with Bitumen (VFB)
1252.7	706.7	2.422	2.294	5.269	10.611	15.880	66.997
1244	704.3	2.422	2.307	4.735	10.671	15.406	70.776
1241.7	707.3	2.422	2.324	4.049	10.748	14.797	72.956
1246	704	2.422	2.299	5.064	10.634	15.698	68.274

TABLE 4.15 MARSHALL STABILITY AND FLOW RESULT FOR POLYPROPYLENE FIBER WITH BITUMEN CONTENT 5.4%

Bitumen Content (%)	Glass Fiber Content (%)	Height of Specimen (mm)	Corrected Stability (Kg)	Flow (mm)
5.4	0.1	69	1092.4	3.7
	0.2	68.3	1140.3	3.7
	0.3	69	1281.7	3.8
	0.4	69.3	1102	3.5

TABLE 4.16 MARSHALL VAROIUS PARAMETERS RESULTS FOR POLYPROPYLENE FIBER WITH BITUMEN CONTENT 5.4%

Weight in air (Wa) Gm	Weight in Water (Ww) gm	Theoretical specific gravity Gt	Bulk specific gravity Gm	Air voids %Vv	% Volume of bitumen (Vb)	Voids in mineral agg. (VMA)	Voids field with Bitumen (VFB)
1249	701	2.406	2.200	5.256	11.564	16.820	69.030
1250.7	704.3	2.406	2.290	4.831	11.616	16.446	70.934
1239	699	2.406	2.295	4.614	11.642	16.256	72.029
1225.3	687.3	2.406	2.278	5.337	11.554	16.890	68.596

TABLE 4.17 MARSHALL STABILITY AND FLOW RESULT FOR POLYPROPYLENE FIBER WITH BITUMEN CONTENT 5.9%

Bitumen Content (%)	Glass Fiber Content (%)	Height of Specimen (mm)	Corrected Stability (Kg)	Flow (mm)
5.9	0.1	67.7	972.6	3.7
	0.2	69.3	1140.3	3.8
	0.3	70	1161.9	3.7
	0.4	68	1078.1	3.3

TABLE 4.18 MARSHALL VAROIUS PARAMETERS RESULTS FOR POLYPROPYLENE FIBER WITH BITUMEN CONTENT 5.9%

Weight in air (Wa) Gm	Weight in Water (Ww) gm	Theoretical specific gravity Gt	Bulk specific gravity Gm	Air voids %Vv	% Volume of bitumen (Vb)	Voids in mineral agg. (VMA)	Voids field with Bitumen (VFB)
1255.7	703.3	2.390	2.277	4.746	12.560	17.306	74.636
1254.3	700	2.390	2.264	5.296	12.488	17.784	71.210
1249.3	700.3	2.390	2.276	4.802	12.553	17.355	72.333
1284.3	713.7	2.390	2.253	5.769	12.425	18.195	69.23

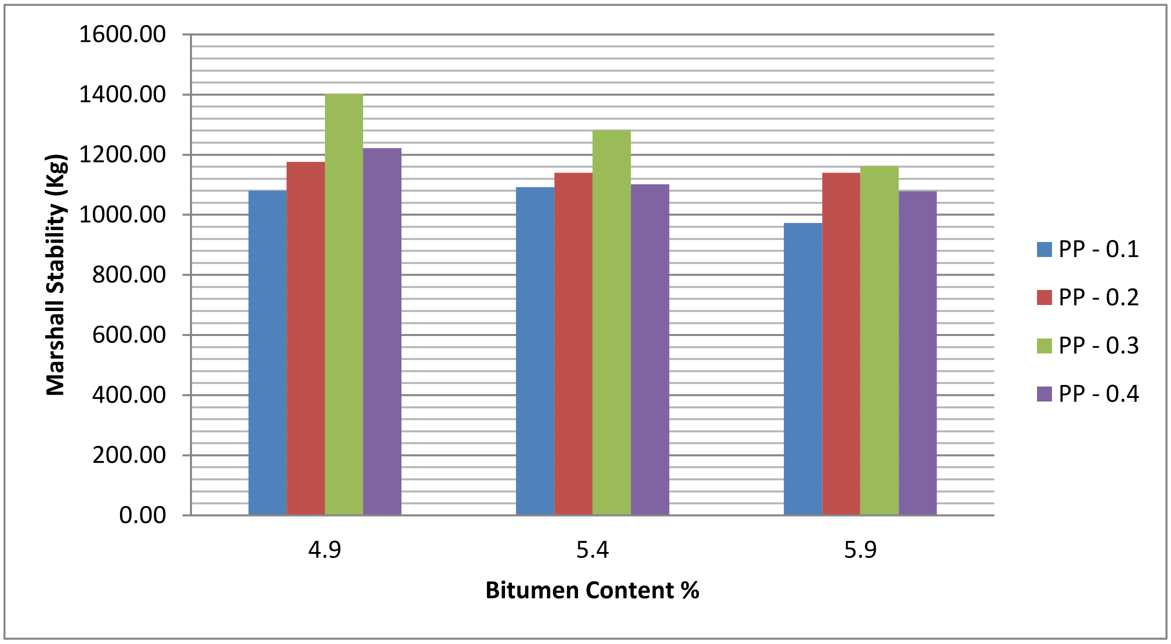


FIGURE 4.12 BITUMEN CONTENT v/s MARSHALL STABILITY

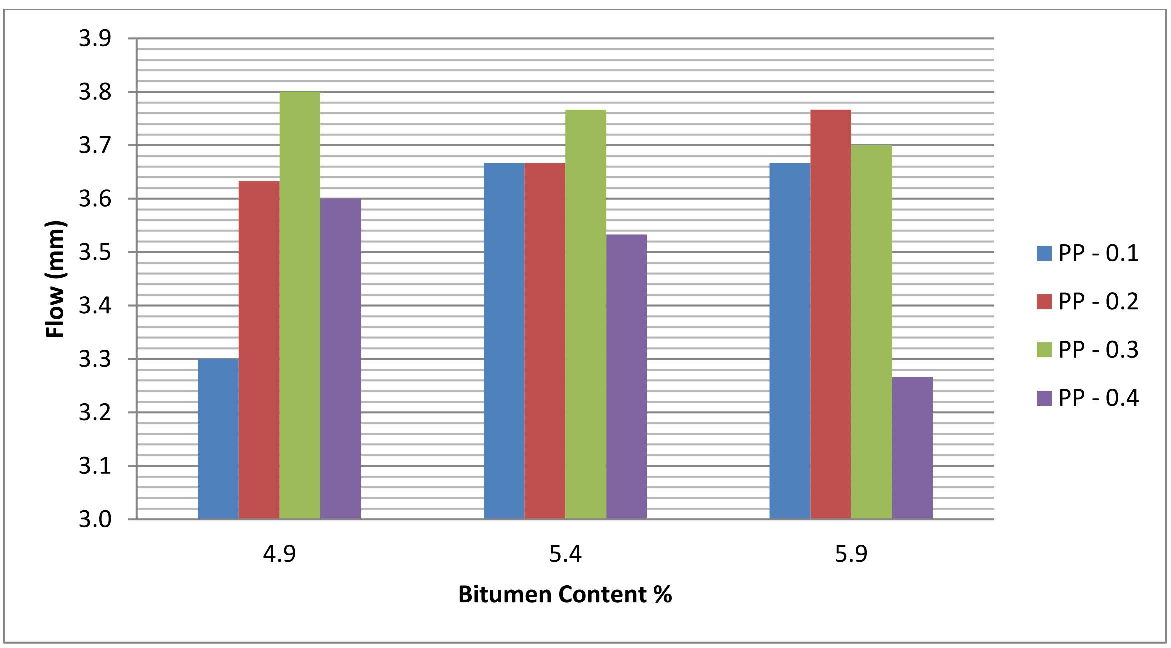


FIGURE 4.13 BITUMEN CONTENT v/s MARSHALL FLOW

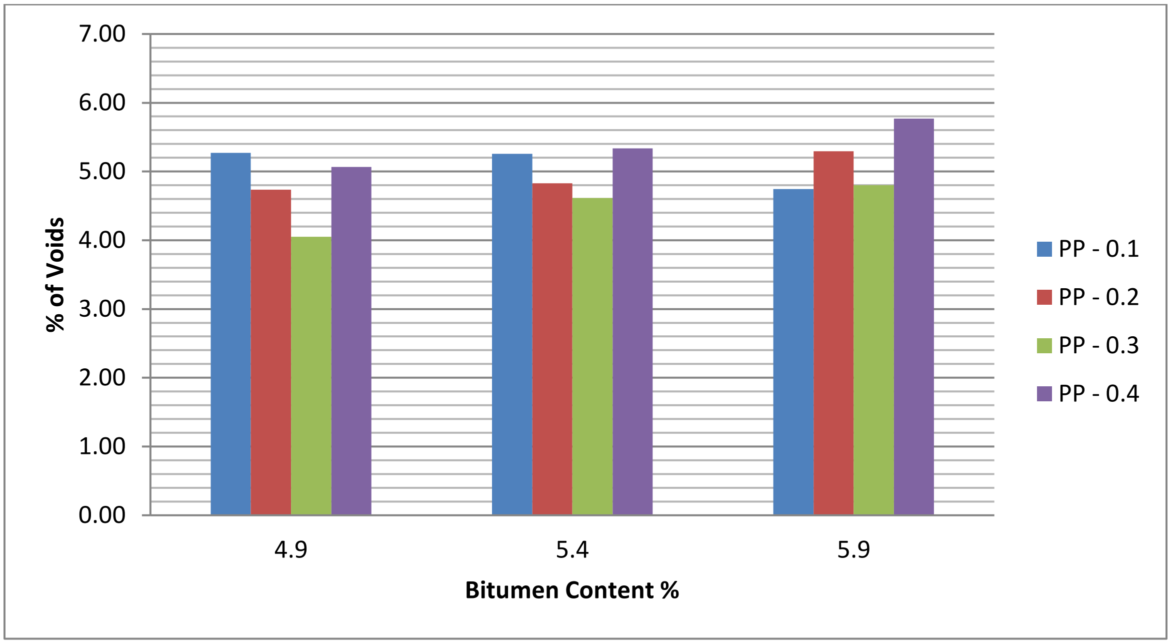


FIGURE 4.14 BITUMEN CONTENT v/s % OF VOIDS

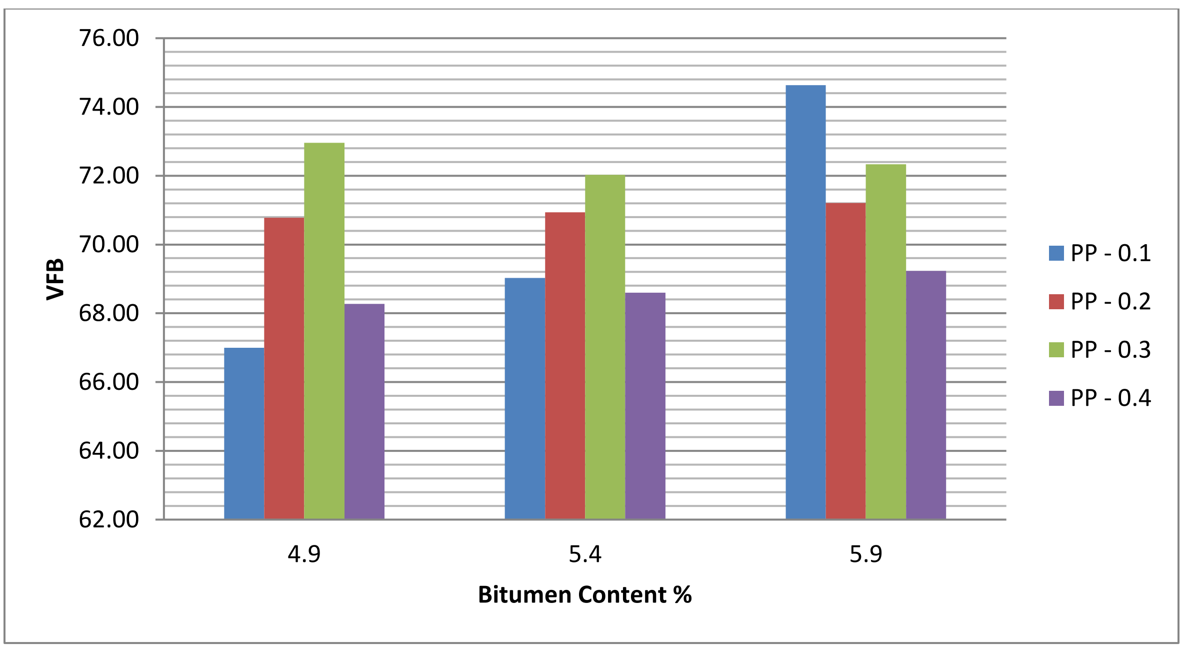


FIGURE 4.15 BITUMEN CONTENT v/s VFB

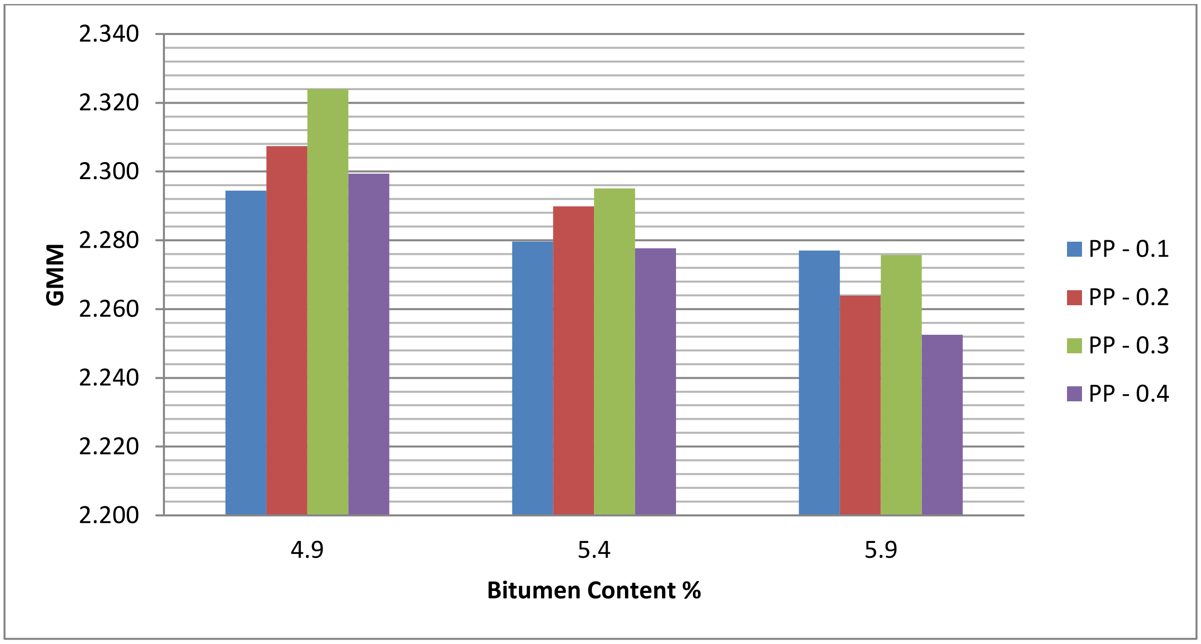


FIGURE 4.16 BITUMEN CONTENT v/s GMM

4.9 SUMMARY OF MARSHALL TEST RESULTS

TABLE 4.19 SUMMARY OF MARSHALL TEST RESULTS

Bitumen Content (%)	Corrected Stability (Kg)	Flow (mm)	Bulk specific gravity (Gm)	Air Voids % (Vv)	Voids field With Bitumen (VFB)
4.9	1048.6	3.8	2.302	4.968	68.7
5.4	1106.5	3.5	2.273	5.537	67.6
5.9	1344.6	3.6	2.250	5.869	68.4

TABLE 4.20 SUMMARY OF RESULT WITH ADDITIVE GLASS FIBER

Bitumen Content %	Glass Fiber Content %	Corrected Stability (Kg)	Flow (mm)	Bulk specific gravity (Gm)	Air Voids % (Vv)	Voids field With Bitumen (VFB)
4.9	0.1	1203.03	3.5	2.261	6.666	61.749
	0.2	1010.0	3.4	2.307	4.735	69.282
	0.3	1413.44	3.5	2.289	5.489	65.937
	0.4	1379.9	3.7	2.295	5.245	67.343
5.4	0.1	1299.53	3.1	2.260	2.260	66.847
	0.2	945.7	3.6	2.284	5.084	69.714
	0.3	1377.51	3.4	2.312	3.914	75.304
	0.4	1097.2	3.6	2.326	3.320	78.711
5.9	0.1	1100.10	3.5	2.252	5.787	68.982
	0.2	1080.80	3.8	2.297	3.926	78.040
	0.3	1317.62	3.8	2.287	2.287	74.933
	0.4	1020.5	3.7	2.304	3.613	77.899

TABLE 4.21 SUMMARY OF RESULT WITH ADDITIVE POLYPROPYLENE FIBER

Bitumen Content %	Polypropylene Fiber Content %	Corrected Stability (Kg)	Flow (mm)	Bulk specific gravity (Gm)	Air Voids % (Vv)	Voids field With Bitumen (VFB)
4.9	0.1	1080.45	3.3	2.294	5.269	66.997
	0.2	1176.27	3.6	2.307	4.375	70.776
	0.3	1401.47	3.8	2.324	4.049	72.956
	0.4	1221.79	3.6	2.299	5.064	68.274
5.4	0.1	1092.42	3.7	2.280	5.256	69.030
	0.2	1140.34	3.7	2.290	4.831	70.934
	0.3	1281.68	3.8	2.295	4.614	72.029
	0.4	1102.01	3.5	2.278	5.337	68.596
5.9	0.1	972.64	3.7	2.277	4.746	74.636
	0.2	1140.34	3.8	2.264	5.296	71.210
	0.3	1161.90	3.7	2.276	4.802	72.333
	0.4	1078.05	3.3	2.253	5.769	69.232

4.10 STRIPPING TEST RESULTS

TABLE 4.22 STRIPPING TEST RESULTS

Bitumen Content %	**Without additives %**	**Glass Fiber Content %**	**GF Result %**	**Polypropylene Fiber Content %**	**PP Result %**
4.9	96	0.1	97	0.1	99
		0.2	96	0.2	97
		0.3	97	0.3	96
		0.4	97	0.4	96
5.4	96	0.1	98	0.1	97
		0.2	97	0.2	96
		0.3	97	0.3	96
		0.4	96	0.4	95
5.9	98	0.1	98	0.1	98
		0.2	97	0.2	97
		0.3	97	0.3	96
		0.4	96	0.4	96

4.11 INDIRECT TENSILE TEST RESULTS

TABLE 4.23 INDIRECT TENSILE STRENGTH RESULT WITHOUT ADDITIVES

Bitumen Content (%)	ITS Unconditional (kPa)	ITS Conditional (kPa)	% ITR
4.9	517.64	444.46	85.86
5.4	536.97	471.29	87.77
5.9	503.89	424.84	84.21

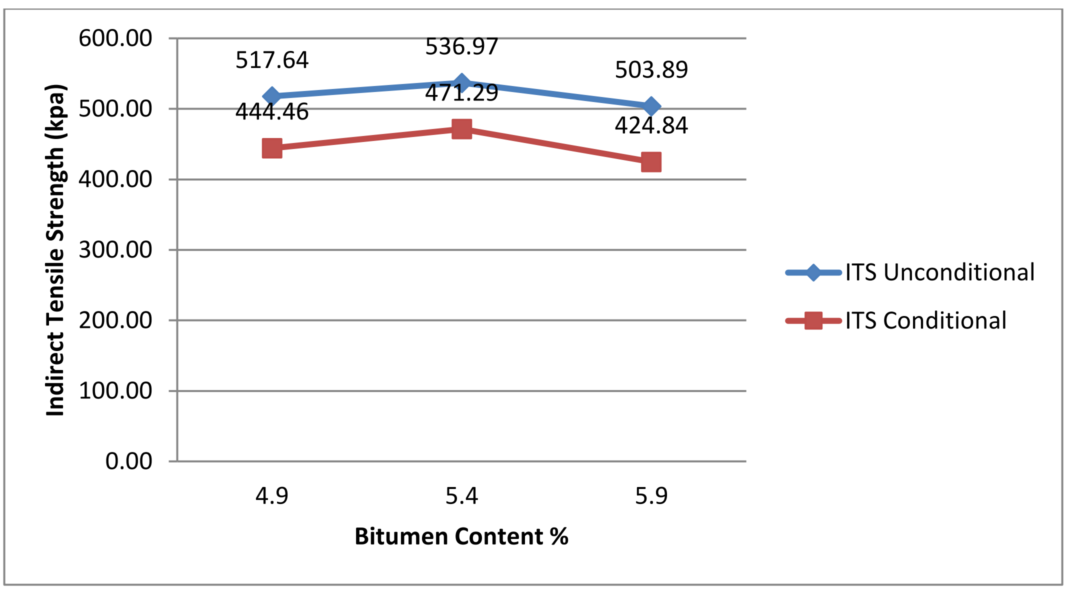


FIGURE 4.18 ITS v/s BITUMEN CONTENT

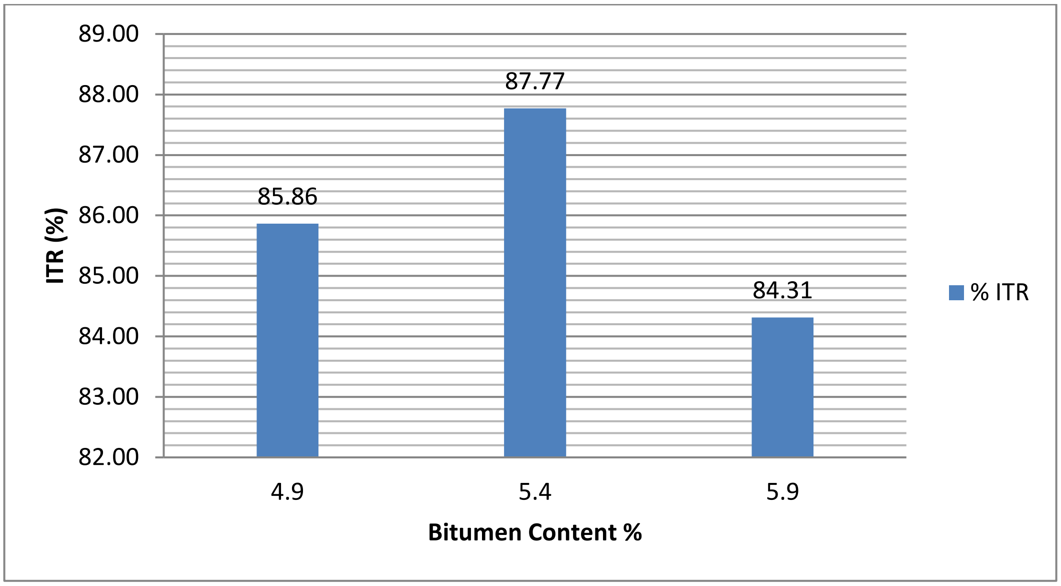


FIGURE 4.19 ITR v/s BITUMEN CONTENT

TABLE 4.24 INDIRECT TENSILE STRENGTH RESULT WITH ADDITIVES GLASS FIBER FOR BITUMEN CONTENT 4.9%

Bitumen Content (%)	Glass Fiber (%)	ITS Unconditional (kPa)	ITS Conditional (kPa)	% ITR
4.9	0.1	510.91	444.46	86.99
	0.2	497.25	431.00	86.68
	0.3	517.44	470.91	91.01
	0.4	504.27	451.19	89.47

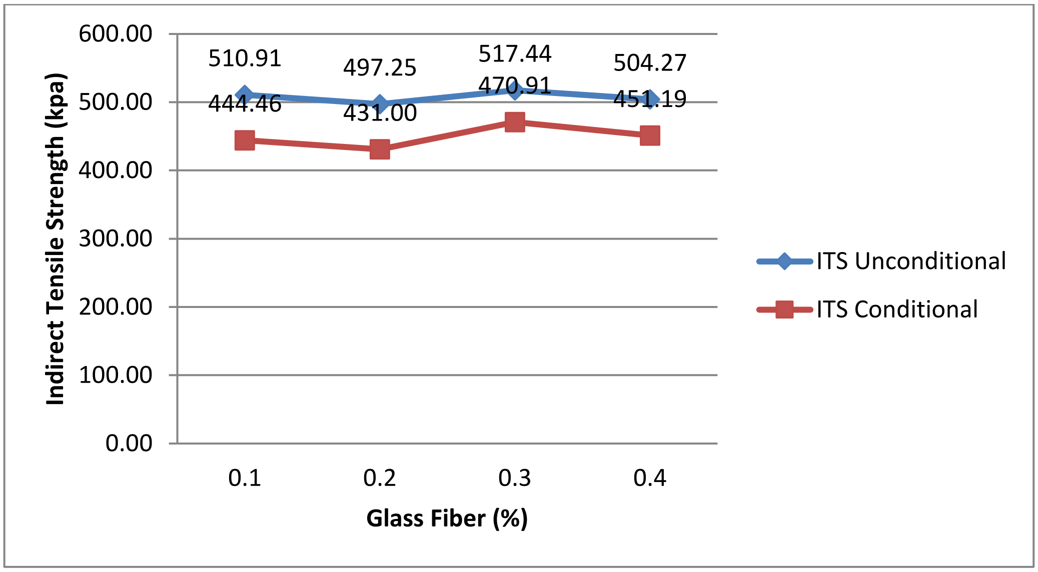


FIGURE 4.20 ITS v/s BITUMEN CONTENT

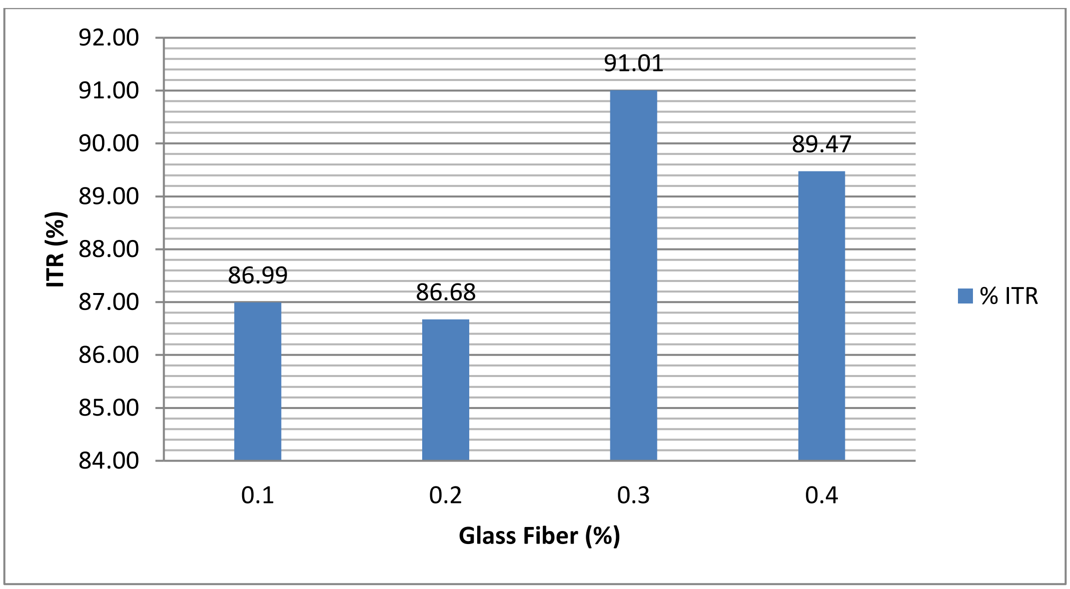


FIGURE 4.21 ITR v/s BITUMEN CONTENT

TABLE 4.25 INDIRECT TENSILE STRENGTH RESULT WITH ADDITIVES GLASS FIBER FOR BITUMEN CONTENT 5.4%

Bitumen Content (%)	Glass Fiber (%)	ITS Unconditional (kPa)	ITS Conditional (kPa)	% ITR
5.4	0.1	510.43	431.10	84.46
	0.2	543.89	464.18	85.34
	0.3	477.25	424.36	88.92
	0.4	537.26	457.83	85.22

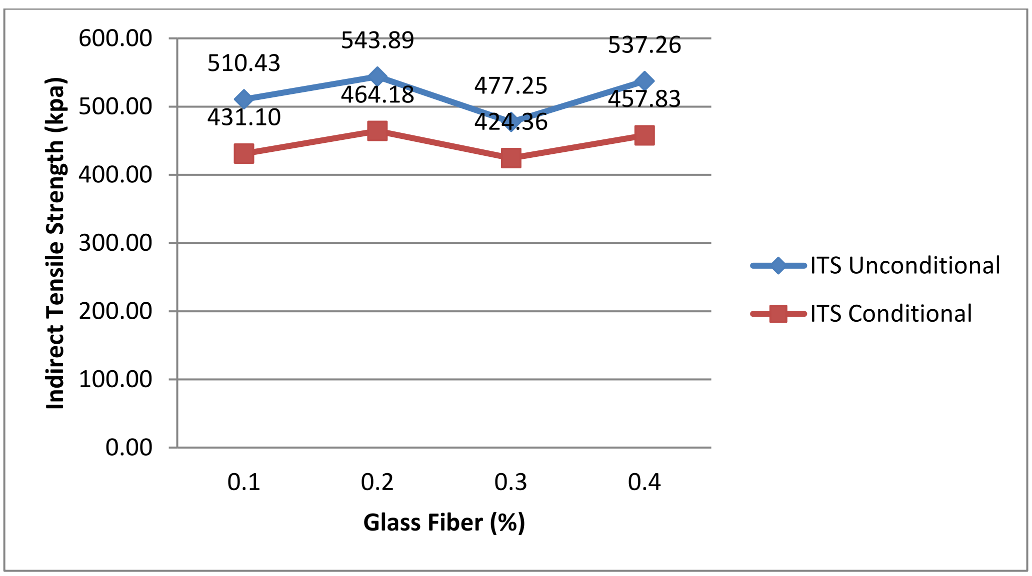


FIGURE 4.22 ITS v/s BITUMEN CONTENT

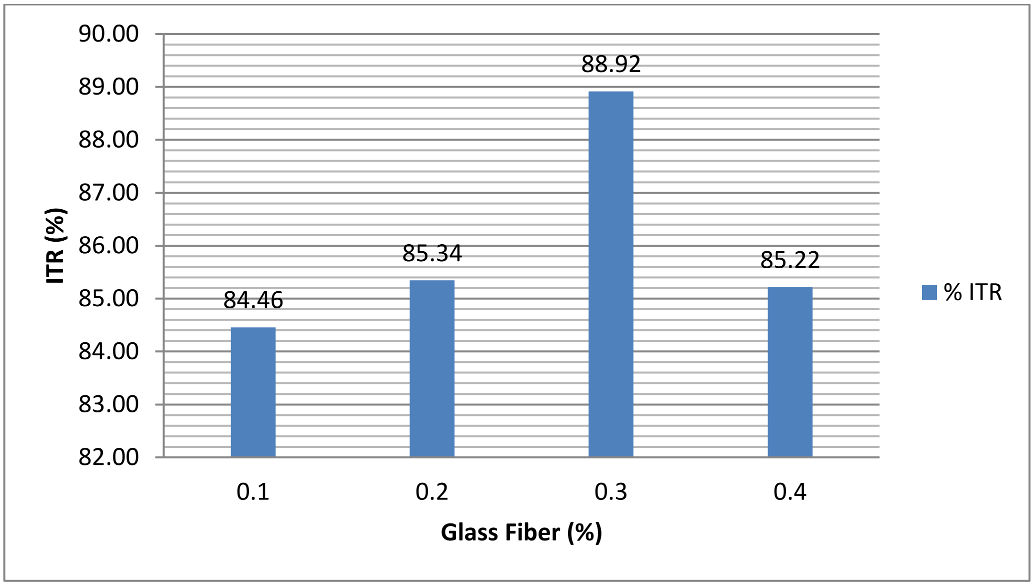


FIGURE 4.23 ITR v/s BITUMEN CONTENT

TABLE 4.26 INDIRECT TENSILE STRENGTH RESULT WITH ADDITIVES GLASS FIBER FOR BITUMEN CONTENT 5.9%

Bitumen Content (%)	Glass Fiber (%)	ITS Unconditional (kPa)	ITS Conditional (kPa)	% ITR
5.9	0.1	503.79	418.11	82.99
	0.2	503.98	431.77	81.67
	0.3	471.10	425.04	90.22
	0.4	490.52	418.11	85.24

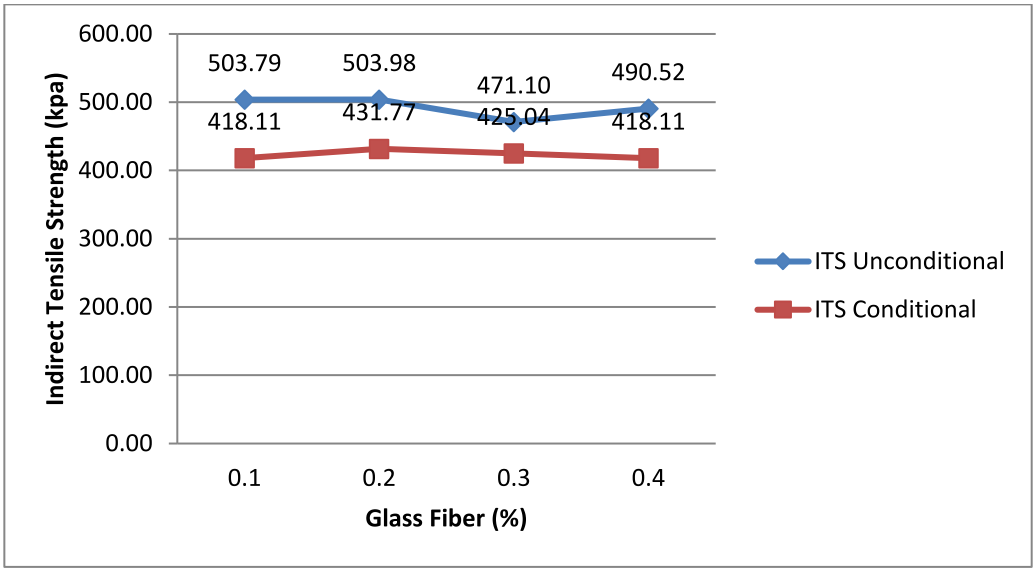


FIGURE 4.24 ITS v/s BITUMEN CONTENT

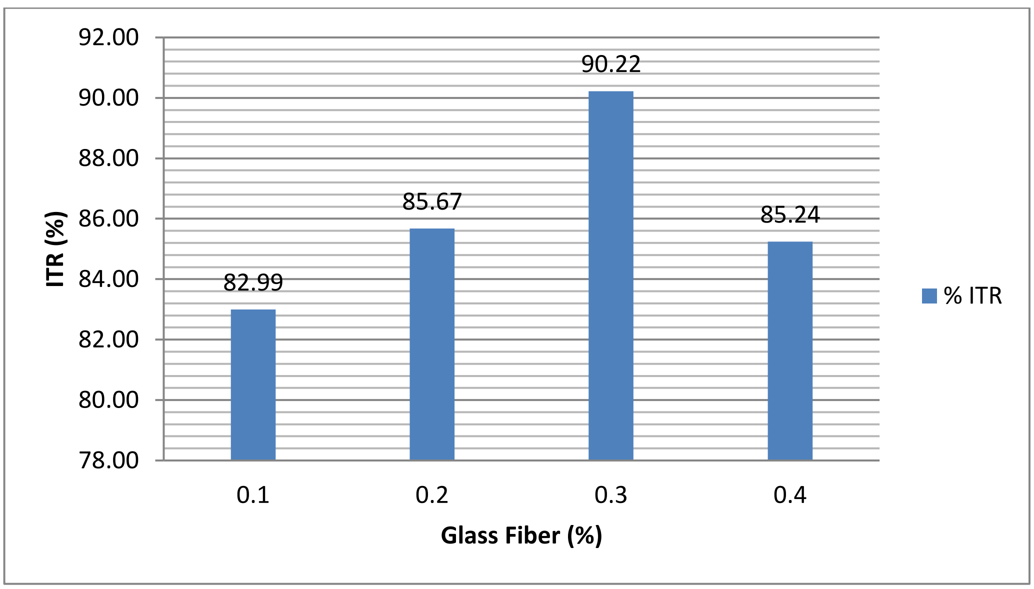


FIGURE 4.25 ITR v/s BITUMEN CONTENT

TABLE 4.27 INDIRECT TENSILE STRENGTH RESULT WITH ADDITIVES POLYPROPYLENE FIBER FOR BITUMEN CONTENT 4.9%

Bitumen Content (%)	Polypropylene Fiber (%)	ITS Unconditional (kPa)	ITS Conditional (kPa)	% ITR
4.9	0.1	510.52	417.82	81.84
	0.2	490.90	404.75	82.45
	0.3	490.62	417.54	85.10
	0.4	484.27	411.48	84.97

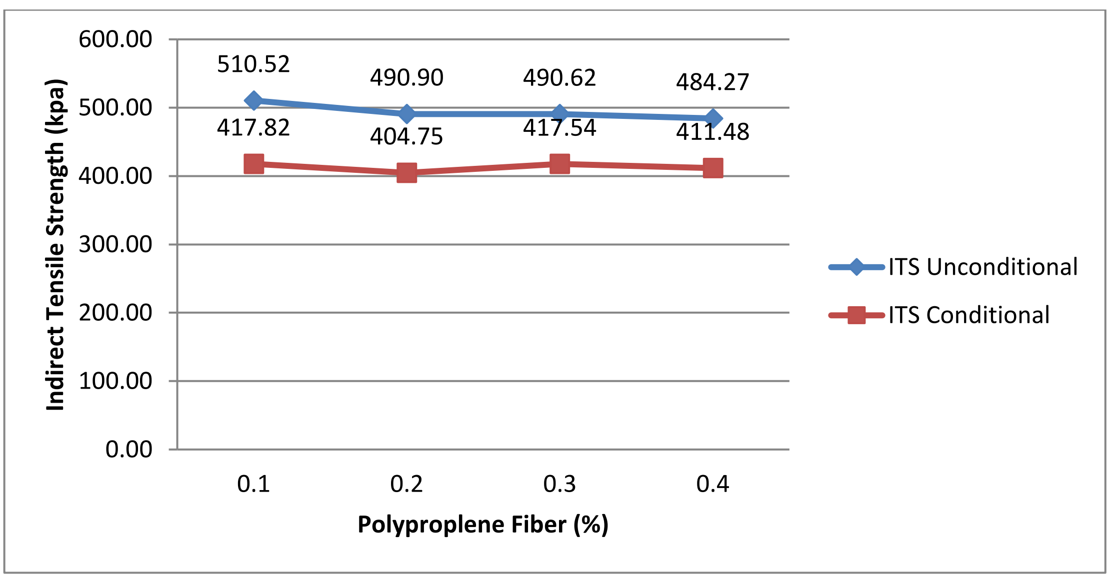


FIGURE 4.26 ITS v/s BITUMEN CONTENT

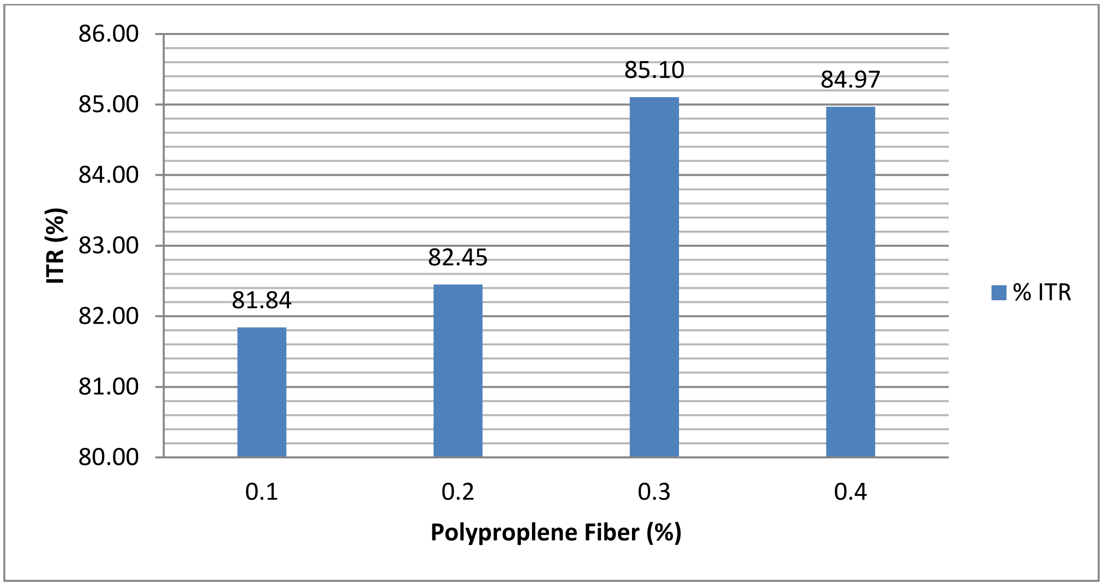


FIGURE 4.27 ITR v/s BITUMEN CONTENT

TABLE 4.28 INDIRECT TENSILE STRENGTH RESULT WITH ADDITIVES POLYPROPYLENE FIBER FOR BITUMEN CONTENT 5.4%

Bitumen Content (%)	Polypropylene Fiber (%)	ITS Unconditional (kPa)	ITS Conditional (kPa)	% ITR
5.4	0.1	523.89	437.73	83.55
	0.2	530.52	451.10	85.03
	0.3	523.89	464.46	88.66
	0.4	463.79	398.01	85.82

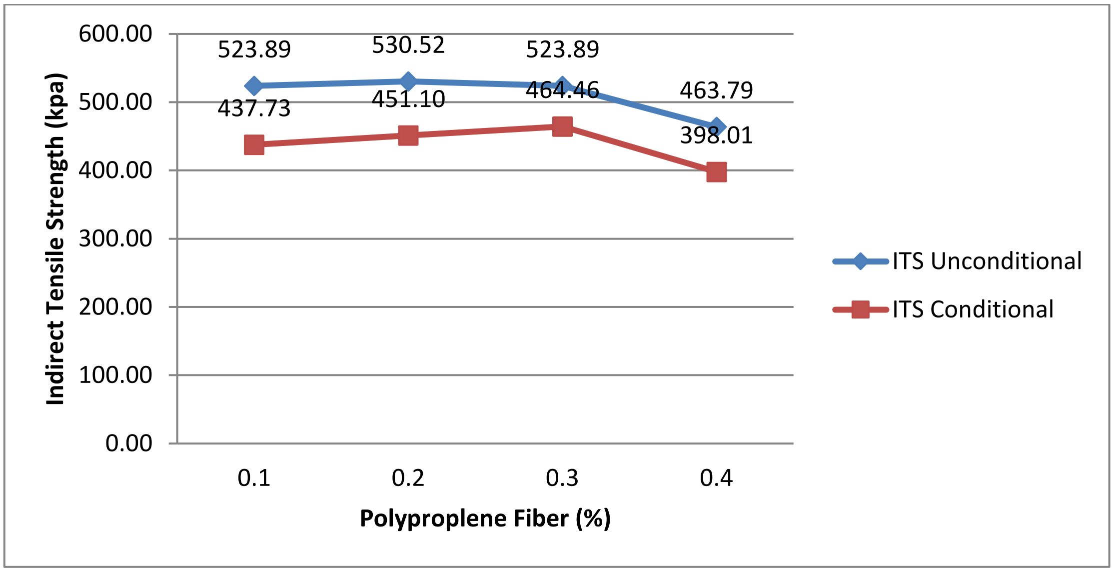


FIGURE 4.28 ITS v/s BITUMEN CONTENT

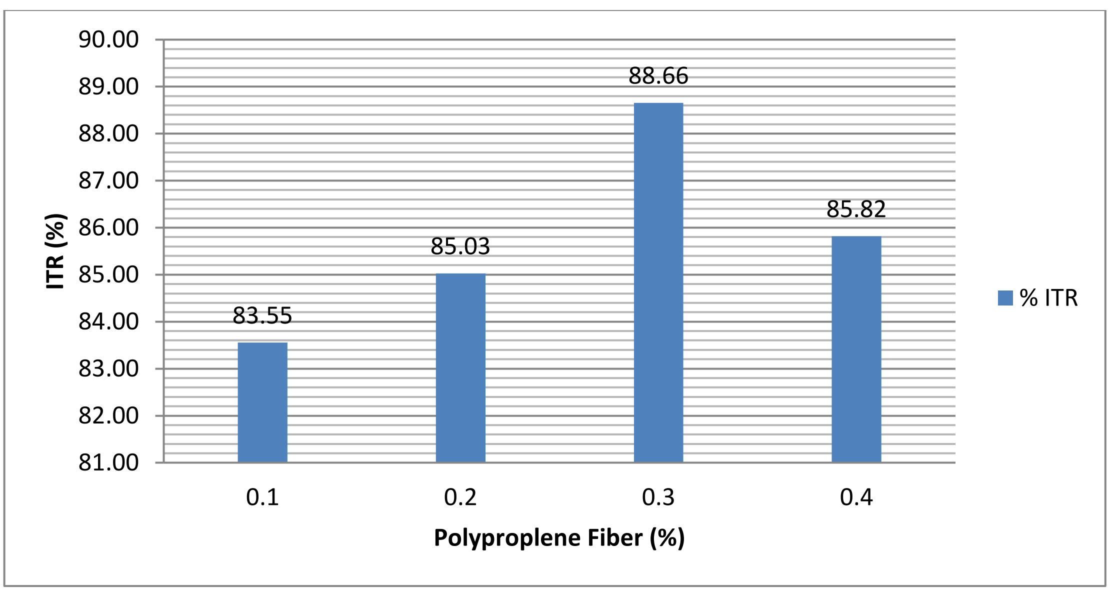


FIGURE 4.29 ITR v/s BITUMEN CONTENT

TABLE 4.29 INDIRECT TENSILE STRENGTH RESULT WITH ADDITIVES POLYPROPYLENE FIBER FOR BITUMEN CONTENT 5.9%

Bitumen Content (%)	Polypropylene Fiber (%)	ITS Unconditional (kPa)	ITS Conditional (kPa)	% ITR
5.9	0.1	523.98	424.75	81.06
	0.2	543.89	444.94	81.81
	0.3	537.74	444.75	82.71
	0.4	523.98	424.36	80.99

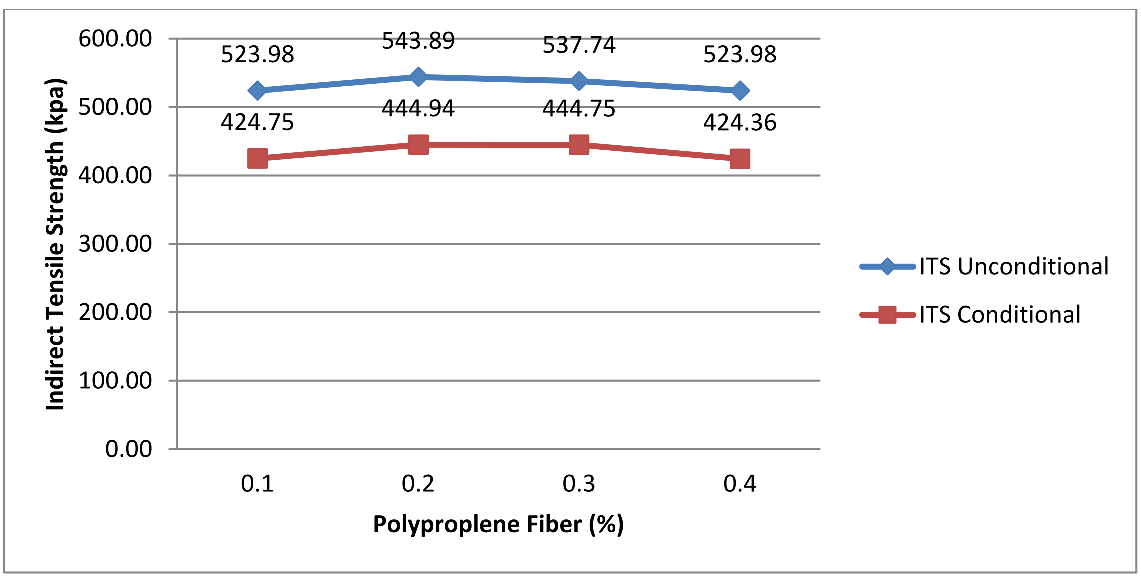


FIGURE 4.30 ITS v/s BITUMEN CONTENT

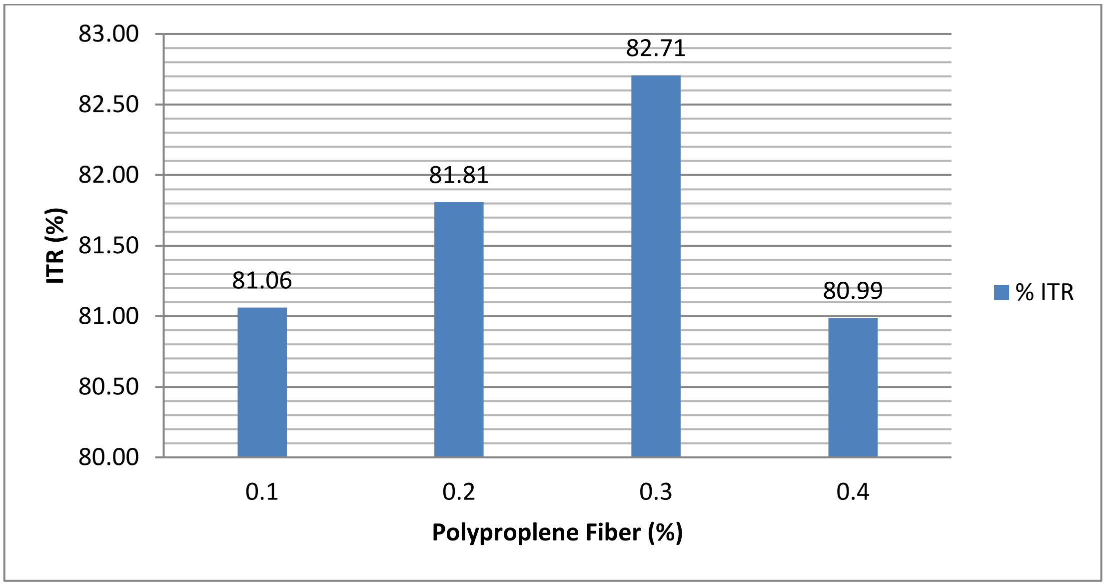


FIGURE 4.31 ITR v/s BITUMEN CONTENT

TABLE 4.30 SUMMARY TABLE FOR GLASS FIBER RESULT OF ITS & ITR

Bitumen Content %	Glass Fiber Content %	ITS Unconditional (kPa)	ITS Conditional (kPa)	% ITR
4.9	0.1	510.91	444.46	86.99
	0.2	497.25	431.00	86.68
	0.3	517.44	470.91	91.01
	0.4	504.27	451.19	89.47
5.4	0.1	510.43	431.10	84.46
	0.2	543.89	464.18	85.34
	0.3	477.25	424.36	88.92
	0.4	537.26	457.83	85.22
5.9	0.1	503.79	418.11	82.99
	0.2	503.98	431.77	81.67
	0.3	471.10	425.04	90.22
	0.4	490.52	418.11	85.24

TABLE 4.31 SUMMARY TABLE FOR POLYPROPYLENE FIBER RESULT OF ITS & ITR

Bitumen Content %	Polypropylene Fiber Content %	ITS Unconditional (kPa)	ITS Conditional (kPa)	% ITR
4.9	0.1	510.52	417.82	81.84
	0.2	490.90	404.75	82.45
	0.3	490.62	417.54	85.10
	0.4	484.27	411.48	84.97
5.4	0.1	523.89	437.73	83.55
	0.2	530.52	451.10	85.03
	0.3	523.89	464.46	88.66
	0.4	463.79	398.01	85.82
5.9	0.1	523.98	424.75	81.06
	0.2	543.89	444.94	81.81
	0.3	537.74	444.75	82.71
	0.4	523.98	424.36	80.99

TABLE 4.32 COMBINED SUMMARY TABLE FOR ALL TESTS RESULTS

Bitumen Content (%)	**Fiber Content (%)**	**Marshall Stability Test**		**Stripping Value Test**		**Indirect Tensile Strength Test**	
		Stability Value (Kg)		**Stripping Value (%)**		**ITR (%)**	
	Glass and Polypropylene Fiber	GF	PP	GF	PP	GF	PP
4.9	0	1048.6	1048.6	96	96	85.86	85.86
	0.1	1203	1080.4	97	99	86.99	81.84
	0.2	1010	1176.3	96	97	86.68	82.45
	0.3	1413.4	1401.5	97	96	91.01	85.10
	0.4	1379.9	1221.8	97	96	89.47	84.97
5.4	0	1106.5	1106.5	96	96	87.77	87.77
	0.1	1100.1	1092.42	98	97	84.46	83.55
	0.2	945.7	1140.34	97	96	85.34	85.03
	0.3	1377.5	1281.68	97	96	88.92	88.66
	0.4	1097.2	1102.01	96	95	85.22	85.82
5.9	0	1344.6	1344.6	98	98	84.21	84.21
	0.1	1100.1	972.64	98	98	82.99	81.06
	0.2	1080.8	1140.34	97	97	81.67	81.81
	0.3	1317.6	1161.90	97	96	90.22	82.71
	0.4	1020.6	1078.05	96	96	85.24	80.99

CHAPTER – 5 CONCLUSION

CONCLUSIONS

- It is observed from the performing physical properties of aggregates results are fulfilled as per requirement of IS 2386 (Part iii & iv) – 1963.
- It is observed from the performing physical properties of Bitumen results are fulfilled as per requirement of IS 73:2013.
- It is observed from the experiment result the Marshall stability of bitumen mix has improved by adding 0.3% of Glass fiber for binder content 4.9%.
- By adding 0.3% Glass fiber give the highest value of the Marshall Stability test for binder content 5.4%.
- It is observed from the experiment result the Marshall stability of bitumen mix has improved by adding 0.3% of Glass fiber for binder content 5.9%.
- By adding 0.3% Polypropylene fiber give the highest value of the Marshall Stability test for binder content 4.9%.
- It is observed from the experiment result the Marshall Stability of bitumen mix has improved by adding 0.3% of Polypropylene fiber for binder content 5.4%.
- It is observed from the experiment result the Marshall stability of bitumen mix has improved by adding 0.3% of Polypropylene for binder content 5.9%.
- From the stripping test, aggregate coating value is fulfilled as per requirement minimum 95%.
- By adding 0.3% Glass fiber give the highest value of the indirect tensile test for binder content 4.9%, 5.4%, and 5.9%.
- By adding 0.3% Polypropylene fiber give the highest value of the indirect tensile test for binder content 4.9%, 5.4%, and 5.9%.
- The Bitumen mix for BC grade – ii, Stability value improved with adding Glass fiber and Polypropylene fiber as additives materials.

- It is observed from the test results when 0.3% fiber added in the mix then both Marshall Stability Value and Indirect tensile ratio increased.

REFERENCES

[1] Polagani sateesh, Pallati aviansh, "A Study on the Performance of Glass fibre modified Bitumen in Dense Bitumen Macadam" International Journal of Advanced in Management, Technology and Engineering Sciences, Volume 7, Issue 12, 2017

[2] M.S.Eisa et.al. "Effect of adding glass fiber on the properties of asphalt mix", International Journal of Pavement Research and Technology, 2020

[3] Mahmoud Ameri et. Al. "Experimental and numerical investigation of the properties of the Hot Mix Asphalt Concrete with basalt and glass fiber", M. Ameri et alii, Frattura ed Integrità Strutturale, 50 (2019) 149-162 Published: 01.10.2019

[4] SHREYAS.R.S, Ms. Nandini.K, "Use of Glass fiber in Recycled Asphalt Pavement", International Journal of Scientific Research and Review, Volume 8, Issue 6, 2019

[5] Er.Mohammed Ayoub Mirza et al, "Use of Glass fibre in Bituminous Mixes", International Journal for Technological Research in Engineering, Volume 6, Issue 9, May-2019

[6] Serkan Tapkın, "The Effect of Polypropylene fibers on Asphalt Performance", www.elsevier.com/locate/buildenv, accepted 2 February 2007

[7] Disha Rajyaguru, "Contribution of Polypropylene fibers in Modification of VG 30 Bituminous Mix", International Journal of Engineering Sciences & Research Technology, Rajyaguru*, 5(4): April, 2016

[8] Niyazi Ugur Koçkal, Sevil Köfteci, "Aggressive Environmental Effect on Polypropylene Fibre Reinforced Hot Mix Asphalt", Published by Elsevier Ltd.

[9] Abdullah Ahmad, "Fatigue Behavior of Polypropylene Fiber Reinforced Bituminous Concrete Mix", International Journal of Engineering Research & Technology (IJERT), Vol. 4 Issue 02, February-2015

[10] K. Sri Harsha, "Partial Replacement of Bitumen with Glass fiber in Flexible Pavement", International Journal of Civil Engineering and Technology (IJCIET), Volume 8, Issue 4, April 2017

[11] D6927 – 15 "Standard Test Method for Marshall Stability and Flow of Asphalt Mixtures".

[12] D6931 – 17 "Standard Test Method for Indirect Tensile (IDT) Strength of Asphalt Mixtures".

[13] IS: 1201 – 1220, 1978 "Method for testing tar & bitumen material (first Revision)" Indian Standard, New Delhi, 1978

[14] MORTH "Specification for road & Bridge work" (Fifth Revision)

[15] IRC 37 – 2001 "Guideline for The Design of Flexible Pavement" The Indian Roads Congress, New Delhi, 2001

[16] IRC 111 – 2009 "Specification for Dense Graded Bituminous Mixes" The Indian Roads Congress, New Delhi, 2001

[17] IS 2386 (Part III) – 1963 "Methods of Test for Aggregates for Concrete" Specific gravity, Density, Voids, Absorption and Buckling – Bureau of Indian Standards

[18] IS 2386 (Part IV) – 1963 "Methods of Test for Aggregates for Concrete" Mechanical Properties - Bureau of Indian Standards

[19] IS 6241 – 1971 "Method of Test for Determination of Stripping Value of Road Aggregates - Bureau of Indian Standards

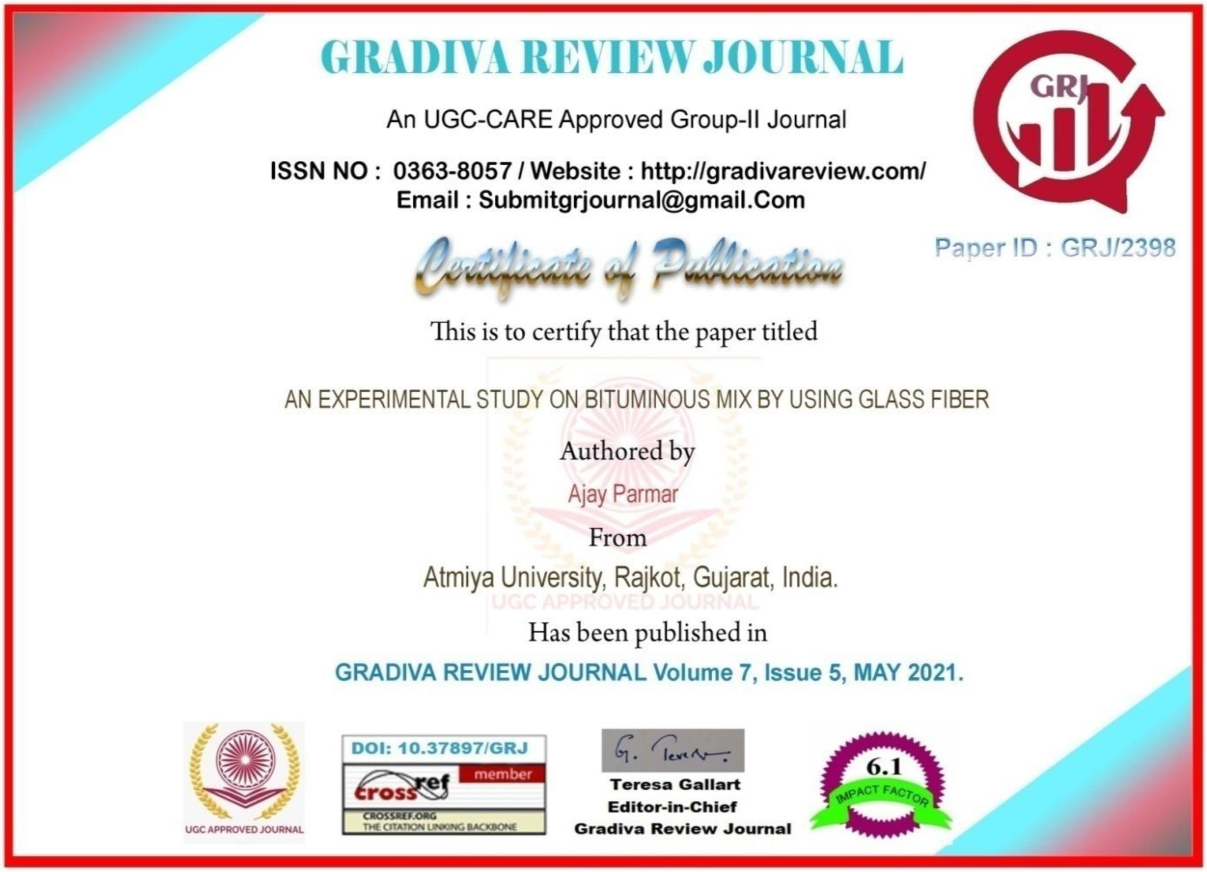
[20] IS 73 – 2013 "Paving Bitumen – Specification"

[21] MS – 2 "Asphalt Mix Design Methods" 7th Edition, Asphalt Institute

[22] S.K.khanna and C.E.G Justo, Highway Engineering", Nem chand & bros, Roorkee.

ANNEXURE – A

RESEARCH PAPER CERTIFICATE


GRADIVA REVIEW JOURNAL

An UGC-CARE Approved Group-II Journal

ISSN NO : 0363-8057 / Website : http://gradivareview.com/

Email : Submitgrjournal@gmail.Com

Paper ID : GRJ/2398

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This is to certify that the paper titled

AN EXPERIMENTAL STUDY ON BITUMINOUS MIX BY USING GLASS FIBER

Authored by

Ajay Parmar

From

Atmiya University, Rajkot, Gujarat, India.

Has been published in

GRADIVA REVIEW JOURNAL Volume 7, Issue 5, MAY 2021.

UGC APPROVED JOURNAL

DOI: 10.37897/GRJ

crossref member

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6.1 IMPACT FACTOR

ANNEXURE – B

REVIEW CARD

ATMIYA UNIVERSITY
सुहृदं सर्वभूतानाम्

ATMIYA UNIVERSITY
FACULTY OF ENGINEERING & TECHNOLOGY

Master of Technology

(Dissertation Review Card)

Name of Student : Ajay Bhupendrabhai parmar

Enrollment No. : | 1 | 9 | 0 | 0 | 4 | 1 | 0 | 1 | 2 |

Student's Mail ID:- ajayparmar1398@gmail.com

Student's Contact No. : 9725687445

College Name : ATMIYA University

College Code : | 0 | 5 | 1 |

Branch Name : civil (Transportation)

Theme of Title : Pavement Material

Title of Thesis : Experimental study on the Effect of Glass Fiber and polyproplene Fiber on Bitumen mix.

Supervisor's Detail	***Co-supervisor's Detail***
Name : Mr. Ashraf Mathakiya	**Name :**
Institute : Atmiya University	**Institute :**
Institute Code : 051	**Institute Code :**
Mail Id : ammathakiya@aits.edu.in	**Mail Id :**
Mobile No. : 9974078377	**Mobile No. :**

~ 1 ~

❖ **Comments For Internal Review (   ) (Semester 3)**

Exam Date : 09/02/2021

Sr. No.	Comments given by Internal review panel (Please write specific comments)	Modification done based on Comments
1	Change Methodology chart	done
2	Give slide change number	
3	Change objective and scope	
		(Guide Sign.)

Particulars	*Internal Review Panel*	
	Expert 1	Expert 2
Name :	Mr. Mayurvsinh Jadeja	Mr. Ashraf Mathakiya
Institute :	Atmiya University	Atmiya University
Institute Code :	051	051
Mobile No. :	7874800084	9974078377
Sign :		

Particulars	*Internal Guide Details*	
	Expert 1	Expert 2
Name :	Mr. Ashraf Mathakiya	
Institute :	Atmiya University	
Institute Code :	051	
Mobile No. :	9974078377	
Sign :		

~ 2 ~

Enrollment No. of Student : | 1 | 9 | 0 | 0 | 4 | 1 | 0 | 1 | 2 |

❖ **Comments of Dissertation Phase-1 (   )** **(Semester 3)**

Exam Date : 09 /02 / 2021

Title : Experimental study on the Effect of Glass Fiber and polypropolene fiber on Bitumen mix.

....

1. Appropriateness of title with proposal. (Yes/ No) ____________
2. Whether the selected theme is appropriate according to the title ? (Yes / No) ____________
3. Justify rational of proposed research. (Yes/ No) ____________
4. Clarity of objectives. (Yes/ No) ____________

~ 3 ~

Enrollment No. of Student : | 1 | 9 | 0 | 0 | 4 | 1 | 0 | 1 | 2 |

Exam Date : 09 / 02 / 2021

Sr. No.	Comments given by External Examiners (DP-I) : (Please write specific comments)	Modification done based on Comments
1.)	Need to study the concept of theoritical max. specific gravity.	done
2.)	Give a chart of no. of moulds (details of mould casting).	
		(Internal Guide Sign.)

- *Approved* ✓
- *Approved with suggested recommended changes* ☐
- *Not Approved* ☐

Please tick on any on.
If approved/approved with suggession then put marks ≥ 50 %.

➢ ***Details of External Examiners :***

Particulars	*Full Name*	*University / College Name & Code*	*Mobile No.*	*Sign.*
Expert 1				
Expert 2				

~ 4 ~

Enrollment No. of Student : 1 9 0 0 4 1 0 1 2

❖ **Comments of Mid Sem Review (   )   (Semester 4)**

Exam Date : 18/ 4 / 2021

Sr. No.	**Comments given by External Examiners :** i) The appropriateness of the major highlights of work done; State here itself if work can be approved with some additional changes. ii) Main reasons for approving the work. iii) Main reasons if work is not approved.	**Modification done based on Comments**
1	Change graphical Representation of result	done
2.	Complete pending work	
3.	formatting as per university guidel.	
		Internal Guide Sign.

- *Approved* ✓
- *Approved with suggested recommended changes*
- *Not Approved*

Please tick on any on. If approved/approved with suggession then put marks ≥ 50 %.

➢ ***Details of External Examiners :***

Particulars	*Full Name*	*University / College Name & Code*	*Mobile No.*	*Sign.*
Expert 1				
Expert 2				

~ 5 ~

Enrollment No. of Student : | 1 | 9 | 0 | 0 | 4 | 1 | 0 | 1 | 2 |

❖ **Comments of DP-II Review (   )**   **(Semester 4)**

Exam Date : ____/____/________

Sr. No.	**Comments given by External Examiners :** i) Main reasons for approving the work. ii) Main reasons if work is not approved.	**Modification done based on Comments**

- *Approved* ☐
- *Not Approved* ☐

Please tick on any one.

If approved then put marks ≥ 50 %.

➢ ***Details of External Examiners :***

Particulars	***Full Name***	***University / College Name & Code***	***Mobile No.***	***Sign.***
Expert 1				
Expert 2				

~ 6 ~

ANNEXURE – C

PLAGIARISM REPORT

Curiginal

Document Information

Analyzed document	PLAGIARISM - DP 2 EXPERIMENTAL STUDY ON THE EFFECT OF GLASS AND POLYPROPLENE FIBER-converted.pdf (D110230846)
Submitted	7/7/2021 11:28:00 AM
Submitted by	Dr. Sheetal Tank
Submitter email	librarian@atmiyauni.ac.in
Similarity	19%
Analysis address	librarian.atmiya@analysis.urkund.com

Sources included in the report

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W	URL: https://jespublication.com/upload/2020-110301.pdf Fetched: 7/28/2020 8:52:35 AM	1
W	URL: https://businessdocbox.com/Construction/65754745-Effect-of-using-waste-material-as-filler-in-bituminous-mix-design.html Fetched: 7/29/2020 4:01:56 PM	3
W	URL: https://www.researchgate.net/publication/330184833_CARBON_FIBER_MODIFIED_BITUMEN_IN_BITUMINIOUS_MACADAM Fetched: 12/20/2019 5:39:50 PM	7
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