IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

EXPERIMENTAL STUDY ON BITUMEN PAVEMENTS IN PARTIAL REPLACEMENT OF CRUMB RUBBER

A dissertation submitted in partial fulfilment of the requirement for

Award of degree of

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2022-23

ABSTRACT

Today disposal of different wastes produced from different Industries is a great problem. These materials pose environmental pollution in the nearby locality because many of them are non-biodegradable, Crumb rubber is one of them. Soil, stone aggregate, sand, bitumen, cement etc. are used for road construction. Natural materials are limited in nature, its quantity is decreasing and cost is increasing. Concerned about this, we are looking for alternative materials for highway construction. Crumb rubber is a material produced by shredding and communicating used tires. This are biotic, disposal product due to which these materials pose to environmental pollution. These presents the laboratory characterization and the evaluation of field performances of gap graded mix of crumb rubber by weight of bitumen, added by a wet process. Acoustical field characterization has been performed by determining, at different speeds, sound levels and noise spectra measured in close proximity. Road profiles along the test sections and sound absorption of compacted sample cores also have been studied to analyze their relationship with the noise emitted. Results show that the use of a binder modified with a high content of crumb rubber reduces the noise emitted by the tire /pavement.

As the first part of this study, we tried to measure the stability of crushed rubber crumb bitumen by performing basic tests such as penetration tests, ductility tests, softening point tests, viscosity tests, flash and flash point tests. bitumen ratio, best percent Marshall value i.e. Marshall stability value, Marshall flow value, voids in air, voids in aggregate and voids in asphalt, evaluation Determined by Marshall stability test as benchmark value for control and good asphalt concrete.

Key words: Bituminous mixtures, Crumb rubber, Surface characteristics, Noise.

CHAPTER-1

INTRODUCTION

1.1 Introduction

Every country's economy mostly depends upon the industries and trades but it is all possible with the transportation. The most common mode of transport in India is road transport including 90% of passenger and 70% freight vehicles moving on roads. Every nation's frugality relies primarily on assiduity and trade, but all of this is made possible by transportation. Road transport is the most common mode of transportation in India, with 90 of buses and 70 of exchanges using it. Maintaining roads in adverse climatic conditions is veritably delicate.

Changing the characteristics of the road face is getting important to reduce the growing conservation problems. Accoutrements similar as rubber can help change the characteristics of roads because they're innately flexible and can be fluently mixed with bitumen to produce a flexible road face.

Rubber isn't a biodegradable material and its disposal causes environmental pollution. thus, the use of waste rubber on the road face improves the characteristics and terrain of the road. The cost of natural structure accoutrements is adding day by day, so there's a need to find druthers to natural coffers that can lead to better roads and lower construction costs. Although rubber tires have proven to be comfortable for humans in numerous ways, they aren't environmentally friendly. Reusing waste rubber in every possible way has come veritably important.

Reusing it as a partial relief of road accoutrements like bitumen can be an environmentally friendly approach. Crumb rubber revision of bitumen has come common practice in the asphalt paving assiduity due to its bettered physical parcels and environmental benefits. For scruple rubber modified bitumen (CRMB), aging is also an ineluctable process and plays a critical part in determining the in- service performance of rubberized pavement. still, compared to neat bitumen, the aging medium for CRMB is much more complex because of the commerce between scruple rubber modifier (CRM) and bitumen and the unique chemical compositions of CRM.

As a first part of this study, an attempt was made to assess the stabilization of the bitumen containing scruple rubber waste in shredded form by performing introductory tests similar as Penetration Test, Ductility Test, Softening Point Test, Viscosity Test and Flash & Fire Point Tests. On the base of the performance of the modified bitumen, the range of optimum probabilities of scruple rubber waste were named for farther examinations related to Bituminous Concrete composites similar as Semi thick Bituminous Concrete (SDBC). Marshall Values, videlicet Marshall Stability Value, Marshall Flow Value, Voids present in air, Voids in summations and Voids in Bitumen, determined from Marshall Stability Test, serve as the standard values to assess the quality of Bituminous Concrete.

SCOPE OF STUDY:

Currently, the disposing of rubber wastes has come a vast problem. roughly 60 percent of waste tires are disposed of via civic and pastoral areas. This causes colourful environmental problems including air pollution (due to burning of tires) and aesthetic pollution which causes severe health related issues. Millions of tonnes of rubber waste are produced annually in India. The use of these accoutrements in trace construction can successfully break pollution and disposal problems. This helps reduce global warming and health problems by reducing pollution from worn tires and minimizing the use of natural summations. This also increases resistance to erosion and cracking.

HAZARDS OF TYRE WASTE

1) Worn tires gain carbon from the combustion process.

2) The quantum of these tire wastes is veritably large, and disposal is dangerous and inconvenient due to land problems in our country.

3) Potentially dangerous substances set up in contact with strong acid results.

4) It has been proven that mosquitoes, in addition to constant vexation, spread colorful dangerous conditions.

5) Tire fires, which pollute the air with large quantities of carbon smothers, hydrocarbons and remainders, are also not veritably dangerous.

6) These tires aren't only prickly to the eyes, but also dangerous to the terrain and health. Small billabongs of undamaged used tires are ideal parentage grounds for mosquitoes.

7) Once started, elaboration is nearly insolvable. ideal the present study envisages the use of waste material. i.e., waste tires mixed with bitumen, which has implicit use in trace and construction assiduity.

OBJECTIVE

- ☞ The largescale use of similar accoutrements won't only help in conserving the ecological balances, but will open up openings for the diligence to produce a low costs material grounded on this waste, for mass scale operations.
- ☞ The study also encourages the use of these potentially dangerous wastes for mass scale without affecting the terrain, civilization, mortal and beast lives.
- ☞ The main ideal of this study is to estimate the performance and parcels of scruple rubber in fresh bitumen.
- ☞ Crumb Rubber Modified Bitumen is designed to maximize resistance to endless distortion and reduce fatigue of asphalt fusions that are used in the most demanding locales

CHAPTER-2

LITERATURE REVIEW

Many civil engineers and experts have conducted various studies to find a way to incorporate rubber powder into existing asphalt to improve the performance of asphalt.

2.1 Parmeet Singh, Akashpatania (May 2018): “Asphalt Modification (with Rubber Powder and Mica): A Case Study on Udhampur and Ram ban Roads” This study investigated the effects of rubber powder and mica on the body and medical equipment. bituminous effect. information. The rubber powder was sieved through a sieve having a mesh size of 700 µm. Both rubber dust and mica affect the hardness, strength and stiffness of raw asphalt. rubber powder in amounts of 3%, 5% and 7% of the sample weight and mica in different amounts of 35%, 45% and 55% of the sample weight. Added sample to asphalt. Because it is a hilly area, there is a high concentration of heavy buildings. Due to the rough terrain, the speed of heavy vehicles cannot exceed 70-80 km/h.

2.2 Nitish Kumar. Dr. HN. Rajakumara (May 2016):

"A Study on the Use of Rubber Tires in Sustainable Road Construction." This study examines changes in asphalt and aggregate to provide and improve sustainability. The purpose of this article is to examine the possibility of using waste rubber as an asphalt mix and mix for construction. This study was carried out in two stages. In the first stage, the properties of the bitumen are changed by adding 1-4% rubber powder. In the second stage, the strength of the asphalt mixture was determined by adding 1-4% rubber powder to the asphalt and replacing 5-15% of the aggregate with waste rubber. The grade of bitumen used in the study is VG30. With the addition of 0.4% rubber to the bitumen, the VG30 bitumen results are within the allowable range, with increased specific gravity, softening point, flash point and combustion values, ductility, needle penetration value reduced, but up to 1% with the addition of rubber powder. The stability and fluidity of bitumen is limited to 1% of rubber powder. By replacing 5% of the aggregate with rubber aggregate, Marshall stability and yield values are at the visible limit.

2.3Patil (December 2016): "Use of rubber in construction" This study investigates the optional mixture of modified bitumen and granular (or) large rubber (or) rubber powder as part of a well-mixed concrete of hot bitumen and rubber. dust extracted from waste products or waste tires. It is a material that can be used to seal cracks and joints, can be used as a jacket, and can be added to hot stones to make special asphalt pavement materials.

2.4 Nabin Rana Magar (2014): Study on the properties of rubber powder modified asphalt by changing the size of the rubber powder. Extensive testing of ordinary asphalt and asphalt modified with rubber powder shows that the penetration rate and softness of normal asphalt can be greatly improved by adding rubber. Rubber is important for modification. The modified rubber granule size is recommended to be the size (0.3-0.15mm) used for commercial use of CRMB.

2.5 Siddharth Roade, (2012): Addition of various proportions of crushed rubber to 60/70 grade bitumen. The mixture is made of 5% asphalt and rubber crumbs in different proportions. Bitumen mixed with rubber crumbs is called crumb modified bitumen (CRMB). It has been found that it is recommended to reduce the amount of Marshal stability from 4% to 12% crumb rubber, followed by a reduction of 15% crumb rubber by weight of bitumen, to obtain a strong suitable mixture.

2.6 ASK Q.Masha an, (2012): In their study, the application of rubber powder modifier in asphalt modification of flexible pavement was demonstrated. From previous work, it was motivated to consider replacing rubber powder in hot mix asphalt to improve rutting resistance and create a better performing pavement by reducing the reduced damage from hot mix asphalt pavement. Thus, the road becomes safer and smoother for road users.

2.7 Masha an et al, (2011a): Penetration is a measure of the hardness or softness of the asphalt binder, indicated by the addition of colloidal particles to the asphalt binder; decreases with the rubber content. Compared to the rubber bituminous binder mixture, penetration yielded lower results with increasing rubber content, indicating that the binder is firmer and heavier. Softening point refers to the temperature at which asphalt reaches a certain softening point. The use of crumb rubber in modified bitumen increases the viscosity and toughness as the crumb rubber increases.

2.8 Becker et al. (2001): Describe that the addition of rubber powder to asphalt can affect the properties of the mixture. Higher amounts indicate significant changes in composition. As the rubber content increases, the viscosity increases at 25°C, the elasticity increases, the softening point increases and the penetration decreases. mixing temperature and mixing time. The optimum mixing temperature and mixing time for CRMB preparation are 175 °C and 45 minutes, respectively. Based on the available tests, the results of the diffusion and solubility coefficients were found in the order given in the literature for water-binding systems.

CHAPTER-3

MATERIALS

3.1 MATERIALS USED

3.1.1 Bitumen:

Bitumen is a black, highly viscous liquid or semi-solid substance found in natural deposits. It is also a by-product of crude oil fractionation. The permeability of bitumen used in road construction in India is 60/70 or 80/100. Bitumen is used as a construction material for paving slabs. Bitumen is obtained from the residue left over from natural bitumen processing plants.

As defined by the American Society for Testing and Materials, bitumen is defined as "a mixture of naturally occurring or pyrolyzed hydrocarbons, or a mixture of both, generally colorless iron, gas, liquid, or antimatter." -Solid or solid, all dissolved in "carbon disulfide". Residual bitumen after distillation Straight bitumen is obtained as a residue. Bitumen used in road construction is called paving grade, and grade used for waterproofing is called industrial grade.

Choose a clear asphalt type based on the climate of the region where the finished pavement will be placed. Bitumen grades 80/100 and 180/200 are used in many parts of India. You can use heavier hides, faster-acting lotions, or thicker resins. The quality of the base bitumen is altered by controlled refining or blending with diesel or other fuels. The consumption of bitumen for VBM as waste is between 17 and 195 kg per 10 m2 of area and for treatment of the black layer between 10 and 12 kg per 10 m2 of area.

Use 10-12 kg of asphalt per 10 square meters for the second layer. Bulk bitumen Bulk bitumen is transported in vehicles equipped with tanks with a capacity of 5,000 to 15,000 liters. According to the PMK, the bitumen content of the mixture should be 4% by weight of the BM mixture.

3.1.2 CRUMB RUBBER:

Shredded rubber is recycled material from tires that have been shredded into small pieces. It is often used as a material in many applications such as grass fill, playgrounds and asphalt pavements. The shredded rubber making process breaks down old tires into small pieces and separates rubber from other materials such as metal and fiber.

The rubber granules are then cleaned and processed to remove impurities before they are packaged and sold. One benefit of the rubber crumb is that it reduces waste by recycling old tires that would otherwise go to landfills. It is also cost-effective and durable for conventional products. However, there are some concerns about the safety of powdered rubber, particularly regarding the health risks from chemical exposure in rubber.

Studies have been done to investigate these issues, and some question the safety of rubber powder, while others find no cause for attention. In general, rubber powder is still widely used and popular in many industries, although research and regular monitoring are required to ensure its safety and stability.

Crumb rubber is a by-product of grinding and modifying tire waste and waste. The color of the granular rubber is dark black, the density of CR is 301.5 kg/m3. CRs are 1-3 mm in size and are used.

In this study, it is aimed to produce CRMB (crushed rubber modified bitumen) binders in the laboratory by mixing CRM (crushed rubber modified bitumen) with base bitumen in a certain ratio. Four percent of the CRM is used in the production process, 5%, 10%, 15% and 22% of the base bitumen mass. These CRMBs are labelled CRMB-5, CRMB-10, CRMB-15, and CRMB-22.

To prepare the CRMB binder, a 5-minute manual mixing process was used to disperse the CRM onto the asphalt base. This is done to ensure that the CRM is balanced in the mix. Then mix the mixture for 30 minutes at 180°C and a shear speed of 6000 rpm using a square mesh boxed Silver-hard shear mixer. This unique combination has been processing optimized to achieve the good properties of CRMB identified in previous studies.

During the mixing test, put the mixing head into the hot bitumen to prevent eddies from forming which can cause oxygen aging. This is done to ensure that the CRM is fully integrated with the asphalt base and to prevent deterioration of the mix due to exposure to weathering.

In summary, the manufacture of CRMB binders in the laboratory involved the use of a high proportion of CRM mixed with a bitumen base. The mixing process is carefully controlled so that the CRM is evenly dispersed in the mix and properly mixed to achieve the desired mechanical properties of the mix. To achieve the desired mixing, use a Silver-heart crusher mixer with a square mesh face at a given temperature and shear rate with the mixing head at heat.

The basic properties, composition and particle gradation of CRM are shown in Table 1.

Table 1: Basic properties and particle size distribution of CRM

Properties	**Description or value**
Source	Scrap truck tires
Color	Black
Morphology	Porous
Specific gravity (g/cm3)	1.15
Decomposition temperature ©	200
Chemical composition	
Total rubber (natural and synthetic)	55
Carbon black (%)	25
Processing agents (%)	20
Gradation	
Sieves (mm)	**Passing (%)**
0.710	100
0.500	93
0.355	63
0.180	21
0.125	9
0.063	2

3.2 ADVANTAGES OF CRUMB

Crushed rubber, a recycled material from shredded tires, is increasingly used as an asphalt additive to produce crushed rubber modified bitumen (CRMB). The use of CRMB in road construction has many advantages over conventional asphalt, which has become popular in recent years. This article discusses some of the benefits of using CRMB on asphalt.

1. **Increased strength**: One of the key benefits of CRMB is its ability to improve the strength and durability of asphalt pavements. Adding rubber granules to asphalt improves its resistance to cracking, rust and warping. This provides more comfortable roads that can withstand traffic jams and bad weather.

2. **Reduced maintenance:** Another important aspect of using CRMB in bitumen is its reduced maintenance. CRMB pavement requires less maintenance than asphalt pavement due to its durability. This lowers overall network maintenance costs and minimizes traffic impact. three. Enhanced security:

3. Using the CRMB overlay is more secure with enhanced security. Adding rubber pellets to asphalt improves traction, reducing the risk of accidents and crashes, especially in wet weather.

4**.Environmentally friendly:** The use of CRMB in bitumen is an environmentally friendly alternative to traditional bitumen. Zero waste by recycling old tires to help reduce the amount of waste sent to landfills. Not only does this help reduce its carbon footprint, it also saves energy and resources normally used to create new products.

5. **Affordability:** CRMB is an economical alternative to traditional asphalt paving. Although the initial cost of CRMB is slightly higher, it is very beneficial in the long run due to its durability and reduced maintenance costs over the lifetime of the coating. Reducing the need for maintenance and repairs can also reduce traffic congestion and further reduce overall costs.

6**. Flexibility**: CRMB is more flexible than conventional bitumen. Adding rubber powder to the asphalt will make the road easier, making it better against thermal expansion and contraction. This will help reduce the risk of cracks and potholes as well as making the pavement last longer.

7.Enhanced noise reduction: The use of CRMB on asphalt also helps reduce traffic noise. Adding rubber granules to asphalt helps improve the sound absorption properties of the pavement, reducing overall ambient noise.

In summary, the use of CRMB in asphalt has many advantages over asphalt pavement. It increases durability, reduces maintenance, improves safety, is environmentally friendly, cost-effective, flexible and reduces noise, making it a popular choice for road construction. Therefore, demand for CRMB will increase as governments and private enterprises seek to improve the reliability and efficiency of their networks.

3.3 SOURCES OF GENERATION OF CRUMB RUBBER:

Another source of rubber dust is waste from tire production. The manufacturing process generates a lot of waste, including scrap or defective tires, that can be used to produce rubber powder.

Also, rethreaded tires are another source of rubber dust. Re-threading is a process that replaces the tread of a tire with new rubber, thereby prolonging the life of the tire. During this process, excess rubber is removed and can be reused for rubber powder.

It can also be made from other rubber products such as rubber powder, rubber hoses, conveyor belts, and rubber gaskets. These products are generally discarded at the end of their life, but can be recycled into rubber pellets for a variety of uses.

The rubber powder production process requires grinding the tire into small pieces using special equipment. With larger crumbs used in parks and playgrounds and smaller parts used in construction, the size of rubber pellets can vary according to the needs of the application.

The removed tires are then treated to remove contaminants such as metal, fibres and other materials found in the tires. The benefits of clean rubber pellets can be used for many applications

Overall, a typical scrap tire contains (by weight):

- 70 percent recoverable rubber
- 15 percent steel
- percent fiber

CHAPTER-4

METHODOLOGY

4.1 Crumb Rubber Manufacturing Technologies

Generally, tire crumbs are produced by reducing tires to a particle size of 3/8" to 40 mesh and removing 99% or more of the metal and fabric from the remaining tire.

- Ambient process
- Cryogenic process

4.1.1Ambient grinding Process

Environmental grinding can be done in two ways: granulation or crushers. In ambient systems, rubber, rubber or other raw materials are kept at room temperature when they enter the pyrolysis mill or granulator. The media grind is great for parts of any size, including full tires. It can be done in two ways: granulation or crushing.

In ambient systems, rubber, rubber or other raw materials are kept at room temperature when they enter the pyrolysis mill or granulator. Media grinding is a multi-step process that uses several machines (usually three) to separate the rubber, metal, and fabric from the rubber.

Whether you are using pelletizing equipment or blast mills, the first step is usually to cut the raw material into small pieces. The second machine in the series will grind flakes, separating rubber from metal and fabric. The finished mill then grinds the product according to product specifications.

After each processing step, the particles are sorted by passing them through sieves that return large particles to the granulator or grinder for further processing. Magnets are used throughout the process to remove wires and other metal impurities.

In the final stage, the fabric is removed with a separate air machine. Rubber products produced in the granulation process often have rough cut shapes, rough textures, and similar cutting-edge sizes.

The usage areas of the rubber crumbs or granules produced in this process include safety and cushioning surfaces for playgrounds, race tracks and walking/running tracks. pyrolysis mills - primary, secondary or clarifier - are all similar and work on the same principle: they use two large circles, one or both of which are serrated. The roll configuration is what sets them apart. These rollers move with different tolerances on the forehead. The product size is controlled by the difference between the rolls.

Crushing mills are low speed machines that operate at around 30-50 RPM. Rubber is usually passed through two to three mills for further size reduction and greater release of metals and fiber.

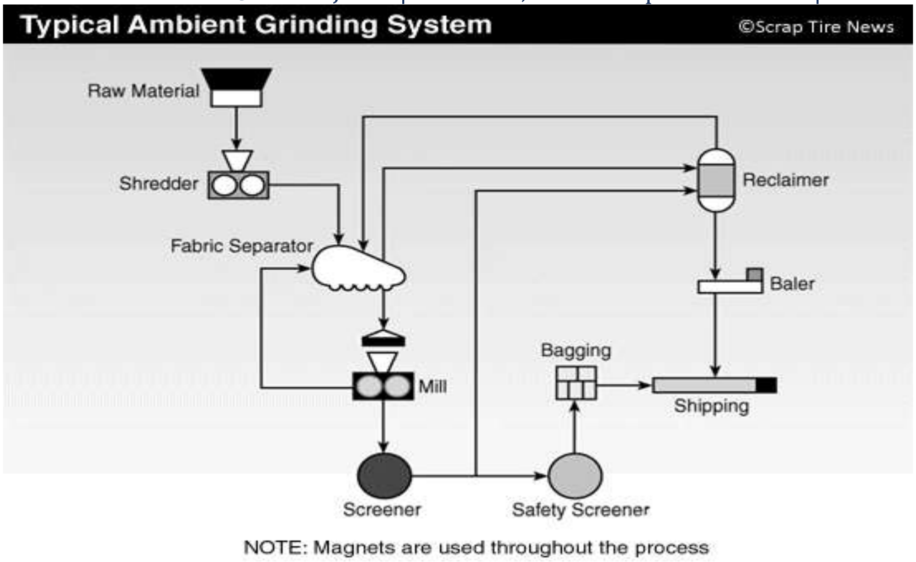


Fig: 4.1 Typical Ambient Grinding Process Diagram

4.2 CRYOGENIC GRINDING PROCESS

Cryogenic grinding is the process of reducing the size of materials at extremely low temperatures using liquid nitrogen. The special process is designed for processing materials that are difficult to grind or grind using the process. One material that is often processed using cryogenic compression is rubber pellets.

Shredded Rubber is a product made from recycled tires. Tires are shredded and then ground into small pieces called crumb rubber. These materials are often used to create many products such as parks, playgrounds and roads.

However, grinding rubber powder with conventional methods can be difficult and ineffective. Cryogenic Milling is a process designed to overcome these issues. The process involves cooling the rubber to -196°C using liquid nitrogen. The cooled rubber is then used in a grinder or grinder designed for cryogenic grinding.

Another benefit of cryogenic grinding is that it reduces the heat generated during grinding. Heat generation can cause problems such as melting, clogging and product deterioration. Cryogenic grinding can increase the efficiency and effectiveness of the grinding process by reducing energy production.

The cryogenic collision on also has environmental benefits. The process reduces emissions of volatile organic compounds (VOCs) produced in conventional grinding methods using liquid nitrogen. This is important because VOCs cause air pollution and affect human health.

The cryogenic grinding process for crumb rubber typically involves the following steps:

1. Rubber pre-cooling - First, use liquid nitrogen to cool the rubber powder to -80°C

2. Grinding the rubber - then grind the rubber with a grinder or grinder designed for cryogenic grinding before cooling it. The grinding process usually takes a few minutes.

3. Sieve the rubber - After grinding, the rubber powder is sieved to remove any larger particles that may have formed during grinding.

4. Packaging - The final product is then packaged and shipped to the customer.

There are many factors that affect the effectiveness of cryogenic grinding of rubber powder. These include:

- Temperature - The temperature of the liquid nitrogen used in the process can affect the performance of the grinding process. Lower temperatures generally produce better grinding.
- Milling Time – The milling time of the rubber affects the size of the granular rubber. Longer grinding times often result in smaller pieces.
- Grinder Type – The type of grinder or grinder used for cryogenic grinding can affect the efficiency and effectiveness of the process. It is important to choose a grinder designed for cryogenic grinding.

In summary, cryogenic grinding is a process frequently used in the production of rubber powder. The process has many advantages, including the production of small particles, different particle size distributions, reduced electricity and environmental benefits. It is generally considered a good and effective way of grinding rubber powder, although there are several important factors that affect the effectiveness of the process.

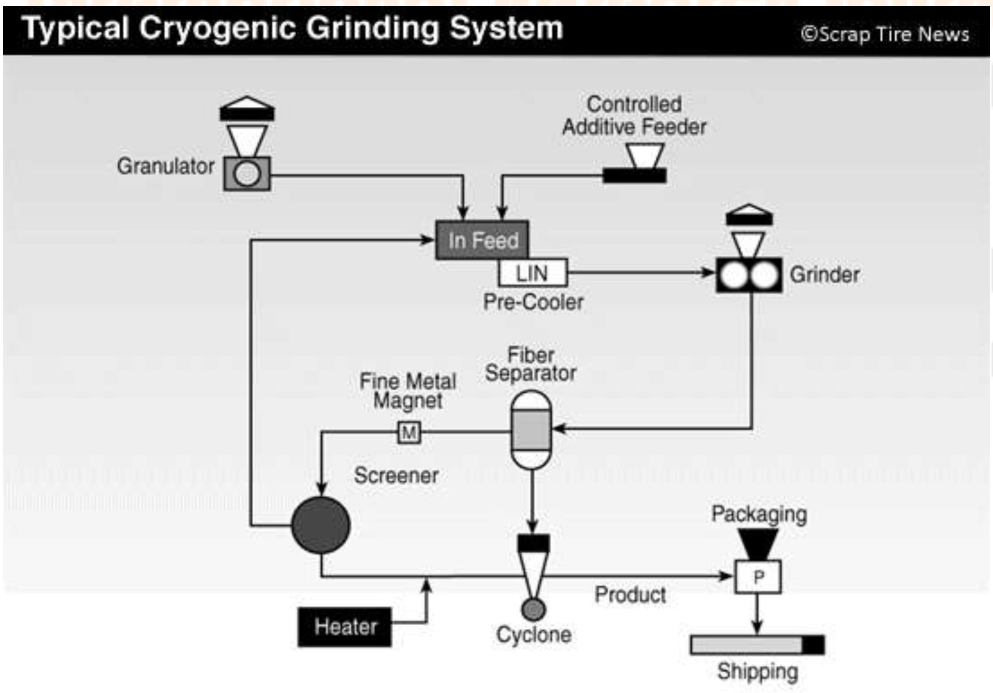


Fig: 4.2 Typical Cryogenic Grinding Process Diagram

4.3 METHODS OF MIXING:

1. Wet process
2. Dry process

4.3.1 WET PROCESS:

Definition:

The wet process was first developed by Charles H. McDonald (McDonald, 1981) and refers to the modification of bitumen with 5-25% by mass of fine tire crumb at an elevated temperature. The wet process includes the blending of crumb rubber with bitumen at high temperatures and produces a viscous fluid through rubber-bitumen interaction (Takallou, 1988). The interaction process depends on a number of variables, such as blending temperature, blending time, type and amount of mechanical mixing, crumb rubber type, size and specific surface area of the crumb rubber and the type of bitumen. During the interaction process, the aromatic fraction of the bitumen is absorbed into the polymer network of the natural and synthetic rubber.

The method of blending rubber and bitumen can be divided into three categories: batch blending, continuous blending and terminal blending. In batch blending the batches of fine rubber crumb are mixed with bitumen during production. Continuous blending describes those wet process technologies that have a continuous production system. Terminal blending is associated with wet process technologies that have products with extended storage (shelf life) characteristics and are produced at bitumen supply terminals. Special care must be taken during mixing to ensure accurate proportioning of crumb rubber, right temperature and a uniform blend to enable an even reaction within the blend. Special pumps are required to ensure a uniform accurate binder discharge for mixture production.

Mixture Design Considerations:

Construction of modified hot bituminous mixtures is typically the same as conventional paving procedures. The wet process is compatible with the Marshall and Heems methods of mixture design although the stability is lower compared to conventional mixtures because of the 1-2% higher binder content (Hertzman, 1992). Typically, 15-22% by mass of binder, ground crumb rubber is used with a typical range of 1.2 mm to 0.075 mm (Hertzman, 1992). Grading requirements are finer for dense graded mixtures. An increased volume of mineral aggregate is required to maintain adequate air voids. Another requirement is to open the gradation of the mixture to allow room for the swelled rubber particles.

The mixing and laying temperatures are slightly higher due to increased bitumen viscosity. It should be noted that the blend of bitumen-rubber must be kept stirred or agitated to prevent stratification or separation of the crumb rubber modifier (Epps, 1994). The mixing temperatures ranges from 175-205o C and the modified binder are then transferred to a heated reaction tank for 30-60 minutes at a temperature of 165-190o C. In terms of compaction, pneumatic tire roller compaction is not suitable for wet processed mixtures, as bitumen-rubber tends to stick to rubber materials. Steel-wheel drum rollers have been successfully used, with some liquid detergent added to the drum water to help lubricate the drum

Recently mixture design using rubber-modified bitumen has come under scrutiny because of the discovery that the acid content in the bitumen (carboxylic acid) has a dramatic effect on the bitumen-rubber blend (OSU, 1997). Although, this may not be significant, it is difficult to overlook when developing a mixture design, as compatibility of the bitumen/polymer system is essential to produce durable mixtures. The compatibility of binder/polymer systems is determined by the structural arrangement of the polymer particles, chains or groups within the bitumen matrix

Studies conducted by Takallou and Sainton demonstrated that rubberized binder has to be used within 1 hour of its production as the interaction process continues after mixing while the mixture is at storage temperatures. The viscosity reaches its maximum after approximately 45 minutes, remaining high for 1 to 2 hours and then decreases. The assumed reason is that due to the thermal ageing, the cross-linked networks of the rubber are broken reducing the polymer to its original structure that causes degradation of the binder. They also found that storage time significantly increased if extender oil and catalysts (ethylene unsaturated polymer or copolymer) are used in the blend.

STEP INVOVED IN WET PROCESS:

This process involves the use of water to facilitate the mixing of bitumen with other materials. Here is a brief overview of the steps involved in the wet process of mixing bitumen:

Step 1: Aggregate Preparation The first step in the wet process of mixing bitumen is preparing the aggregate. This involves cleaning the aggregate to remove any dirt, dust, or other contaminants. The aggregate is then dried to remove any moisture that may interfere with the mixing process.

Step 2: Mixing Water Once the aggregate is prepared, water is added to the mixer. The amount of water added will depend on the type of aggregate being used and the desired consistency of the mix.

Step 3: Bitumen Addition After the water has been added, the bitumen is added to the mixer. The bitumen is heated to a temperature that is high enough to allow it to flow freely but not so high that it is burnt or degraded. The bitumen is then slowly poured into the mixer and mixed thoroughly with the water.

Step 4: Aggregate Addition Once the bitumen has been mixed with the water, the aggregate is added to the mixer. The aggregate is added in small batches to ensure that it is evenly distributed throughout the mix.

Step 5: Mixing Process The mixer is then turned on and the mixing process begins. The mixer rotates at a slow speed to ensure that the aggregate is evenly distributed throughout the mix. The mixing process continues until the desired consistency is achieved.

Step 6: Storage Once the mixing process is complete, the mix is transferred to a storage tank where it is allowed to cool and settle. The settling process allows any air bubbles to rise to the surface and escape, ensuring that the mix is compact and free of voids.

Step 7: Quality Control Before the mix can be used in road construction, it must undergo quality control tests. These tests ensure that the mix meets the required specifications for density, durability, and other factors. If the mix passes the quality control tests, it can be used in road construction.

In conclusion, the wet process of mixing bitumen involves the use of water to facilitate the mixing of bitumen with other materials. This process ensures that the mix is evenly distributed and free of voids, resulting in a strong and durable road surface.

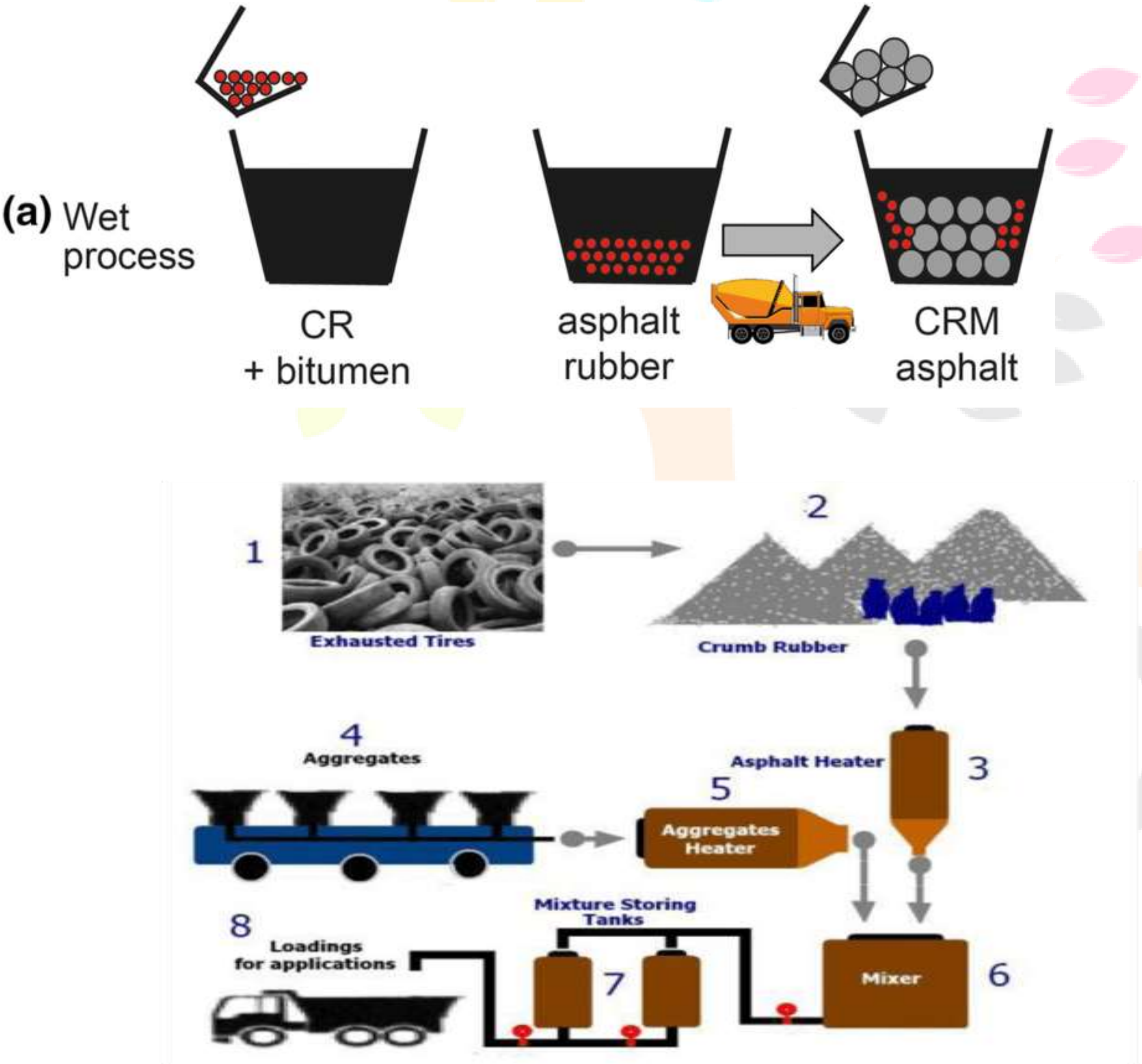


Fig ;4.3 Wet process

DRY PROCESS:

The dry process of mixing bitumen, also known as the "cold mix" process, is a method of preparing bituminous materials for use in construction without the need for heating. It involves the use of a special emulsifying agent that allows the bitumen to be mixed with water at ambient temperatures.

The history of the dry process dates back to the early 1900s, when asphalt emulsions were first introduced as a means of coating aggregates for road construction. In the early days, the emulsions were prepared by mixing bitumen with soap solutions, but this process was not very efficient and often resulted in poor-quality materials.

In the 1920s, a new type of emulsifying agent was developed that was much more effective at producing stable emulsions. This agent was based on the use of specialized surfactants that helped to disperse the bitumen particles in the water more effectively. This led to the development of the modern cold mix process, which has become a popular alternative to traditional hot mix methods in certain applications.

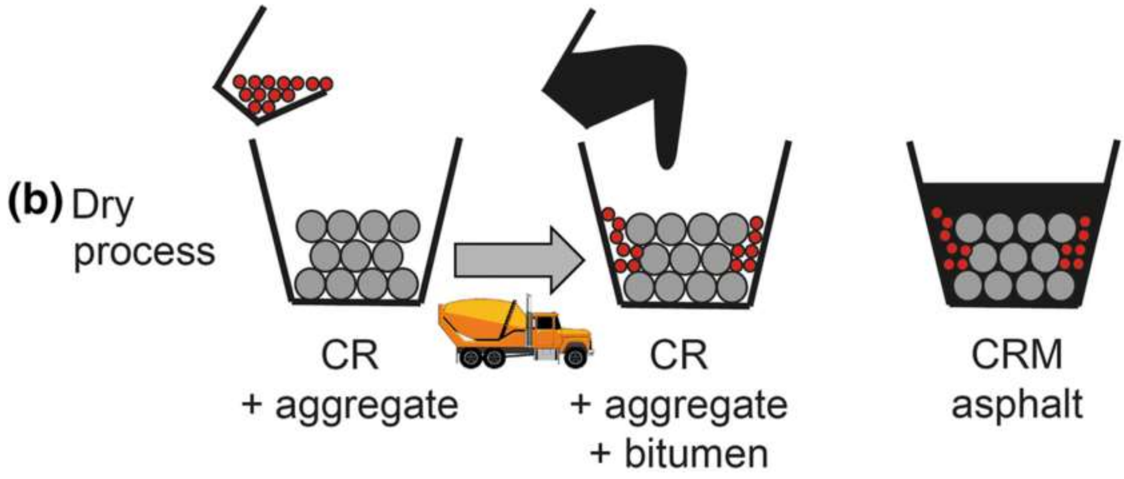
Today, the dry process is widely used for road construction, pavement repairs, and other applications where the use of heated bitumen is not practical or cost-effective. The process involves mixing the bitumen emulsion with aggregates and other additives to produce a durable and stable material that can be applied at ambient temperatures.

Overall, the dry process of mixing bitumen represents a significant advance in the field of road construction, and has helped to make the process more efficient, cost-effective, and environmentally friendly.

The method of mixing bitumen with dry process involves the following steps:

1. Aggregate Preparation: The aggregates are prepared by screening, washing, and drying to remove any impurities and moisture.
2. Heating Bitumen: Bitumen is heated in a separate container to a temperature of 150-160°C to make it more fluid.
3. Mixing Aggregates: The heated bitumen is poured over the aggregates and mixed thoroughly using a mechanical mixer until all the aggregates are coated with bitumen.
4. Moisture Content Check: The mixture is checked for moisture content using a hydrometer. If the moisture content is high, the mixture is dried further by adding more aggregates.
5. Cooling: The mixture is then allowed to cool to a temperature of about 120°C.
6. Storage: The mixture is stored in a suitable container until it is ready for use.
7. Laying: The mixture is laid using a paver at a suitable temperature and compacted using a roller.

The dry process of mixing bitumen is commonly used in road construction projects because it is faster and more economical compared to the wet process. However, care must be taken to ensure that the correct proportion of bitumen and aggregates is used to achieve the desired properties of the final mixture.



DRY PROCESS

CHAPTER-5

EXPERIMENT TEST

5.1 EXPERIMENTS

Tests to be conducted on the Crumb rubber modified bituminous to examine the properties of the CRMB.

- Ductility test
- Softening point test
- Penetration test
- Flow viscosity test
- Flash & Fire point test
- Marshal stability test

5.2 DUCTILITY TEST:

The ductility is a distinct strength of bitumen, allowing it to undergo notable deformation or elongation. The ductility is defined as the distance in centimeter, to which a standard sample or briquette of the material will be elongated without breaking. The finer rubber particles resulted in higher ductility elongation and also, that toughness would increase as rubber content increases.

A concerted effect of both time and temperature was noted with minimal elastic recovery value bettered at maximum time and maximum temperature of two hours and 240 °C, independently. The bitumen- rubber revision redounded in a better rutting resistance and advanced rigidity. still, the modified binder was susceptible to corruption and oxygen immersion. There were problems of low comity, because of the high molecular weight.

Furthermore, the recycled tire rubber decreases reflective cracking, which in turn increases durability. In using waste tire rubber, there are however, several practical and experimental issues, such as it requires an elevated composite of temperatures and extended digestion time during the mixing process for it to be diffused in the bitumen. The flexibility worth gets affected by variables, for instance, pouring temperature, test temperature, rate of pulling.

The ductility test is a common test performed on bituminous materials to measure their tensile properties. This test is used to determine the elongation and deformation characteristics of the material. In this article, we will discuss the complete process and procedure for performing the ductility test on bitumen with grade VG30 and partial replacement of crumb rubber with 5%, 10%, 15%, and 20%.

Materials Required:

- Bitumen with grade VG30
- Crumb rubber with various percentages of partial replacement (5%, 10%, 15%, and 20%)
- Ductility machine
- Ductility briquette mould
- Ductility testing machine with gauge and loading device
- Water bath
- Thermometer
- Stop watch

Process:

1. Preparation of Bitumen-Crumb Rubber blend: Firstly, the bitumen with grade VG30 is heated to a temperature of 160-170°C. Then, the crumb rubber with various percentages of partial replacement (5%, 10%, 15%, and 20%) is added to the bitumen and stirred continuously until the crumb rubber is completely dissolved in the bitumen. The blended bitumen-crumb rubber mixture is then allowed to cool to room temperature.
2. Preparation of Ductility Briquettes: The ductility briquette mould is cleaned and dried. The mould is then filled with the blended bitumen-crumb rubber mixture, taking care not to introduce any air bubbles. The filled mould is placed in a water bath at a temperature of 27±0.5°C for 30 minutes to ensure that the bitumen-crumb rubber blend has completely set. After 30 minutes, the mould is removed from the water bath, and the excess bitumen on the top of the mould is removed using a straight edge.
3. Mounting of Briquettes: The briquettes are mounted in the jaws of the ductility testing machine in such a way that the longitudinal axis of the briquette coincides with the axis of the testing machine. The distance between the grips is adjusted to 100mm. The machine is switched on and allowed to run for a few minutes to ensure that it is properly calibrated.

4. Test Procedure: The load is applied to the briquette at a constant rate of 50mm per minute until the briquette breaks. The load at which the briquette breaks is noted and recorded. The test is repeated with three samples for each percentage of crumb rubber partial replacement. The average value of the three tests is taken as the final value.
5. Calculation of Ductility: The ductility of the briquette is calculated as the distance in millimeters that the briquette stretches before it breaks. The ductility is calculated using the following formula:

Ductility = (Length of stretch/Original length) x 100

Results and Discussion: The ductility of bitumen with grade VG30 and partial replacement of crumb rubber with 5%, 10%, 15%, and 20% was tested using the above procedure. The results are tabulated below:

Note: If the bitumen sample reaches the water bath bottom or the water surface, the test is not normal. The density of water must be risen with additives to have a normal test. If the normal test does not achieve, the ductility is not obtainable.

5.2.2 Equipment required:

Figure 5.1: The Briquette

Figure 5.2: The pulling device

5.2.3 Significance of severity test severity is the property which does not permit Bitumen to suffer large deformation without breaking. Bitumen with high severity is generally tenacious but do not have good cling parcels Rigidity must be caught on at two different temperatures in order to pronouns on the on the felicity of the material.

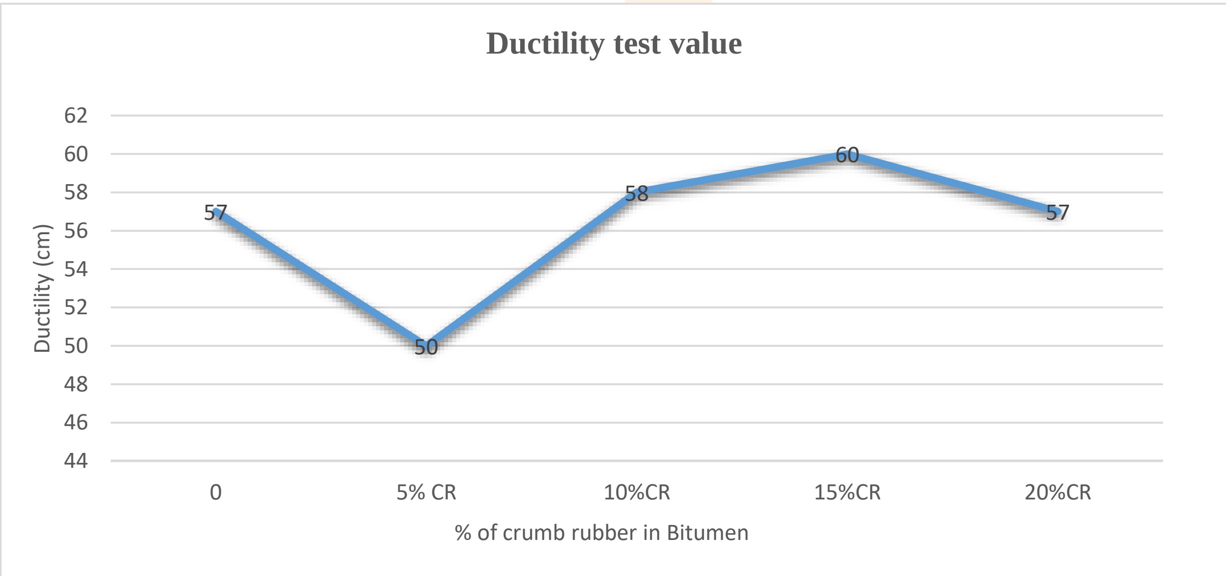
RESULTS

Severity is the property of bitumen that permits it to suffer great deformation or extension. severity is defined as the distance in cm, to which a standard sample or briquette of the material will be stretched without breaking.

Standard Value As per IS1205- 1978, the standard value ranges from not lower than 50. severity test values of various proportions of scruple rubber in bitumen was shown in Table and graphically represented.

Test table:

Test samples	Value
0	57
5% CR	50
10%CR	58
15%CR	60
20%CR	57



5.3 SOFTENING POINT TEST:

Bitumen is a complex material that does not have a distinct melting point. As the temperature rises, the bitumen gradually softens and its viscosity decreases therefore the softening point is defined. "The softening point is the temperature at which a material softens beyond some arbitrary softness". It can be determined by the softening point test.

5.3.1 Softening point test of bitumen by ASTM D36:

The softening point test is a commonly used test to determine the softening point temperature of bitumen. The test is used to determine the temperature at which bitumen becomes soft and starts to flow under the effect of heat. The softening point is an important parameter that determines the suitability of bitumen for use in various applications, including road construction.

In this article, we will discuss the complete process and procedure of the softening point test on bitumen with grade VG30 and partial replacement of crumb rubber with 5%, 10%, 15%, and 20%.

Materials Required:

- Bitumen VG30
- Crumb rubber (5%, 10%, 15%, and 20%)
- Softening point apparatus
- Thermometer
- Stopwatch
- Heat source
- Filter paper

Procedure:

1. Take a clean and dry softening point apparatus and place a filter paper at the bottom of the ring.
2. Weigh 3-4 grams of bitumen VG30 and pour it into the apparatus. Repeat this process for all the crumb rubber-modified bitumen samples (5%, 10%, 15%, and 20%).
3. Add the crumb rubber to the bitumen VG30 in the following ratios: 5%, 10%, 15%, and 20%. Mix the crumb rubber and bitumen thoroughly using a mechanical mixer or a magnetic stirrer.
4. Heat the apparatus using a heat source until the temperature reaches 5°C above the expected softening point. The expected softening point for bitumen VG30 is around 55-60°C.
5. Once the temperature is reached, stop heating the apparatus and allow it to cool for 30 seconds.
6. Insert the thermometer into the bitumen and lower it gently until it touches the bottom.
7. Start the stopwatch and note down the temperature when the bitumen touches the bottom of the thermometer.
8. Repeat steps 4-7 for all the crumb rubber-modified bitumen samples.
9. Clean the apparatus thoroughly after each test to avoid any contamination.

Figure 5.3.1: The component of the ring and ball test apparatus

Calculations:

- Calculate the softening point temperature of each sample using the following formula:
- Softening Point Temperature = Temperature reading - 5°C
- Where, Temperature reading is the temperature at which the bitumen touches the bottom of the thermometer.

Fig 5.3.2

Results:

Plot a graph with the softening point temperature on the y-axis and the percentage of crumb rubber on the x-axis. The graph will show the effect of partial replacement of crumb rubber on the softening point temperature of bitumen VG30.

Discussion: The results of the softening point test on bitumen with grade VG30 and partial replacement of crumb rubber with 5%, 10%, 15%, and 20% can be analyzed to determine the effect of crumb rubber on the softening point temperature of bitumen. The softening point temperature is an important parameter that determines the suitability of bitumen for use in road construction.

The results may show that the addition of crumb rubber has a slight effect on the softening point temperature of bitumen VG30. The softening point temperature may decrease slightly with an increase in the percentage of crumb rubber. This is due to the fact that crumb rubber is a rubber-like material and is more flexible than bitumen. The addition of crumb rubber reduces the rigidity of the bitumen, resulting in a slight decrease in the softening point temperature.

However, the decrease in the softening point temperature may not be significant and may not affect the performance of bitumen in road construction. The addition of crumb rubber to bitumen has several other benefits, including improved durability, increased elasticity, and reduced environmental impact.

Figure 5.3a: The rings which contain bitumen, on a surface coated with a mixer of glycerin and dextrin.

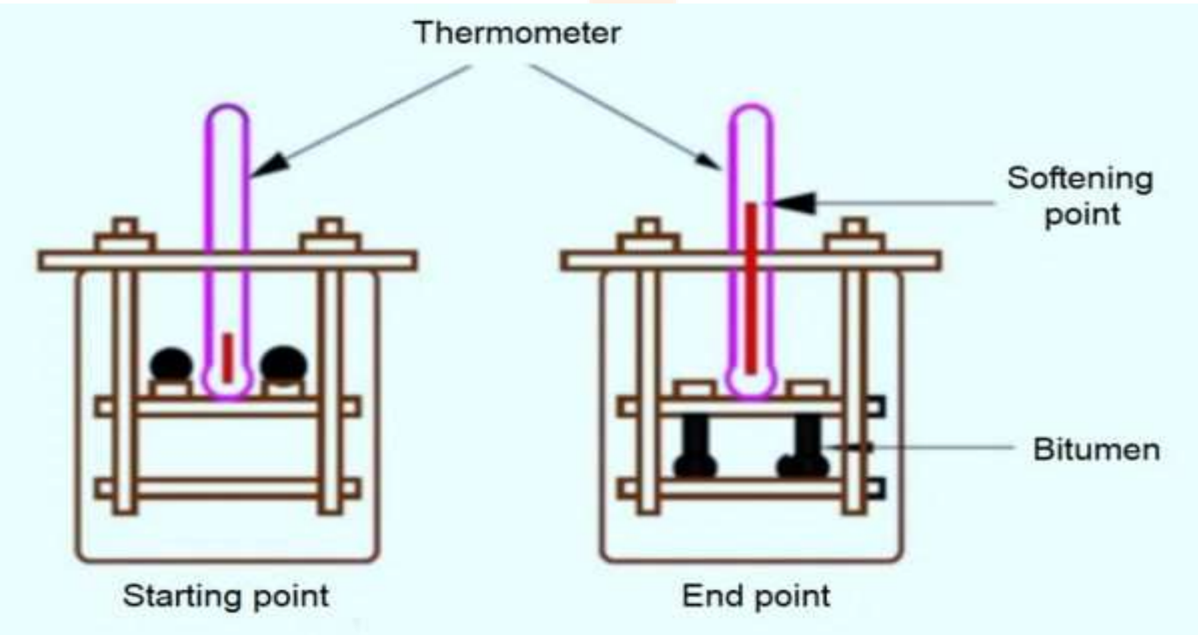


Figure 5.4b: Schematic of ring and ball test for measuring softening point

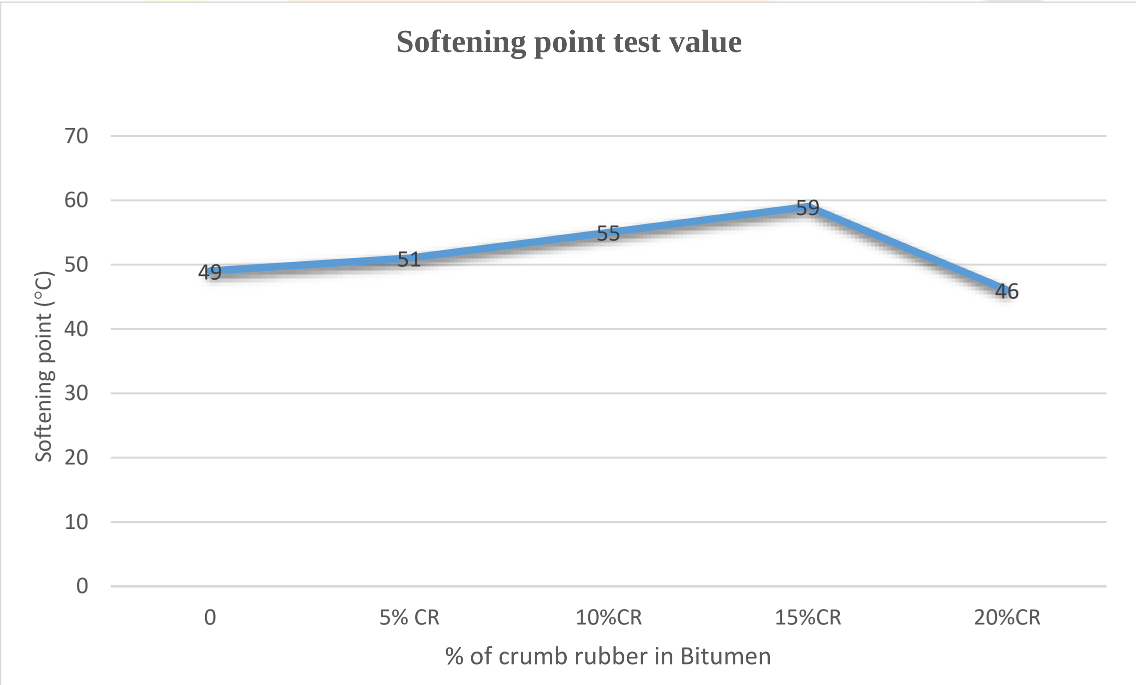
NOTE:

For bitumen with a softening point of 40- 60 °C, the maximum difference between the two readings shouldn't exceed 1 °C. For 61- 80 °C soft spots, the difference should be lower than1.5 °C. The test is invalid and is repeated.

RESULTS

As per IS1205- 1978. The softening point of a bituminous material is the temperature at which the material attains a certain degree of wispiness under specified conditions of test. Bitumen Softening test values of various proportions of rubber tire in bitumen was shown in Table and graphically represented Test table.

Test samples	Value
Normal sample	49°C
5% CR	51°C
10%CR	55°C
15%CR	59°C
20%CR	46°C



5.3.2 Significance of Softening point:

The softening point is a crucial property of bitumen that is determined through testing. It refers to the temperature at which bitumen starts to soften and deform under the effect of heat. The softening point is an important parameter that is used to determine the suitability of bitumen for various applications, especially in the construction of roads and pavements.

The significance of the softening point lies in its ability to provide a measure of the temperature at which bitumen becomes soft and begins to flow under the effect of heat. This temperature is significant for several reasons:

1. Suitability for Road Construction: The softening point is an essential parameter that determines the suitability of bitumen for use in road construction. It helps to determine the temperature at which bitumen can be effectively used in road pavement applications.
2. Durability: The softening point is a crucial factor that affects the durability of bitumen. If the softening point is too low, the bitumen will become too soft and deform under the weight of traffic. This deformation can lead to cracks and potholes, reducing the durability and lifespan of the pavement.
3. Temperature Sensitivity: The softening point is also an indicator of the temperature sensitivity of bitumen. Bitumen with a low softening point tends to soften and deform more readily under high temperatures, making it unsuitable for use in regions with high temperatures.
4. Elasticity: The softening point is closely related to the elasticity of bitumen. Bitumen with a higher softening point tends to be more rigid and less flexible than bitumen with a lower softening point. This property affects the ability of bitumen to withstand stress and deformation under traffic loads.
5. Consistency: The softening point is an important factor that determines the consistency of bitumen. Bitumen with a higher softening point tends to be more viscous and less flowable than bitumen with a lower softening point. This property affects the workability and ease of application of bitumen.

5.4 Penetration test of Bitumen:

To determines the hardness or softness of bitumen by measuring the depth in millimeter to which a standard loaded needle will penetrate vertically in five seconds while the temperature of the bitumen sample is maintained at 25 0C.Also, the Penetration test of bitumen is used to measure the consistency of bitumen. This test is applied almost exclusively to bitumen. For seamen, cutbacks, and mixes other thickness tests are used. We use this test to classify bitumen grounded on penetration value. This helps to choose the proper bitumen in the asked rainfall conditions for safe road construction. The soft bitumen (advanced penetration) is used in cold rainfall to avoid cracking. In hot rainfall, the hard bitumen (lower penetration) is used since it does not get soft due to the heat.5.4.1 Equipment for Penetration test:

A penetrometer consisting of a needle assembly with a total weight of 100 grams and a device for releasing and locking needle in any position.

To read the penetration value, a graduated dial is attached as shown Penetration value can be read with this dial up to 0.1 mm.

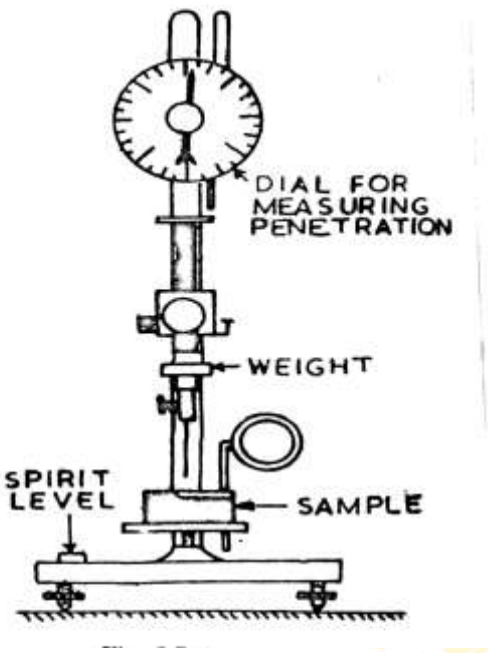


Fig 5.4: Penetrometer

Procedure for Penetration Test of Bitumen:

Penetration testing is a commonly used method to measure the consistency of bitumen, particularly in road construction. The test involves measuring the depth (in tenths of a millimeter) to which a standard needle or cone penetrates the surface of a bitumen sample under specified conditions of temperature, load, and time. In this article, we will outline the complete process and procedure of penetration testing on bitumen with grade VG30 and partial replacement of crumb rubber with 5%, 10%, 15%, and 20%.

Materials Required:

- Bitumen Sample (Grade VG30)
- Crumb Rubber
- Penetration Testing Apparatus
- Thermometer
- Bath or Heating Plate
- Stopwatch
- Filter Paper

Procedure:

1.Preparation of Bitumen Sample: Firstly, prepare the bitumen sample by heating it to a temperature of 60°C to 70°C in a heating bath or on a heating plate. Stir the sample to ensure that the temperature is uniform throughout the sample. The sample should be completely fluid and free from air bubbles before testing.

2.Preparation of Penetration Testing Apparatus: The penetration testing apparatus consists of a needle or cone with a specified weight that is allowed to penetrate the bitumen sample under specific conditions. Ensure that the apparatus is clean and free from any dirt or debris. Place the needle or cone in the apparatus and ensure that it is cantered over the sample.

3.Partial Replacement of Crumb Rubber: To prepare bitumen with partial replacement of crumb rubber, add the desired amount of crumb rubber (5%, 10%, 15%, or 20%) to the bitumen sample. Heat the mixture to a temperature of 160°C to 170°C and stir the mixture until the crumb rubber is completely dispersed in the bitumen.

4.Temperature Calibration: Before starting the test, it is essential to calibrate the temperature of the sample. Insert a thermometer into the sample and record the temperature. Ensure that the temperature of the bitumen sample is within the specified range of 25°C to 30°C for testing.

5.Conducting the Test: Place the sample on a stable surface and lower the needle or cone onto the surface of the sample. Apply a load of 100 grams for 5 seconds to allow the needle or cone to penetrate the sample. The penetration depth is measured in tenths of a millimeter using a micrometer screw gauge.

6.Repeat the Test: Repeat the test at least three times on different parts of the sample and take the average value of the penetration depth. Ensure that the sample is heated to the specified temperature and that the needle or cone is clean and free from any dirt or debris before each test.

7.Clean-up: Clean the penetration testing apparatus with a filter paper and remove any residue or dirt from the needle or cone.

8.Record the Results: Record the average penetration depth for each sample in tenths of a millimeter.

Calculation:

Calculate the penetration value by averaging the penetration depths obtained from the three tests conducted on each sample. The penetration value is expressed in tenths of a millimeter.

Penetration value = (average of three tests)/10

Interpretation of Results: The penetration value obtained from the test indicates the consistency of the bitumen. A higher penetration value indicates a softer bitumen, while a lower penetration value indicates a harder bitumen. The ideal penetration value for bitumen with grade VG30 is between 60 and 70 tenths of a millimeter.

Partial replacement of crumb rubber in bitumen affects the penetration value. With an increase in the percentage of crumb rubber, the penetration value decreases, indicating a harder bitumen. The decrease in penetration value is due to the reinforcement provided

Precautions:

- The sample should be stirred thoroughly to ensure homogeneity.
- The standard needle should be cleaned and checked for accuracy before each test.

- The test should be conducted at the specified temperature and time.
- The apparatus should be kept clean to avoid contamination.
- The penetration value should be reported accurately.

1.Readings are taken as units of penetration

2.Where, 1 unit = (1/10) mm

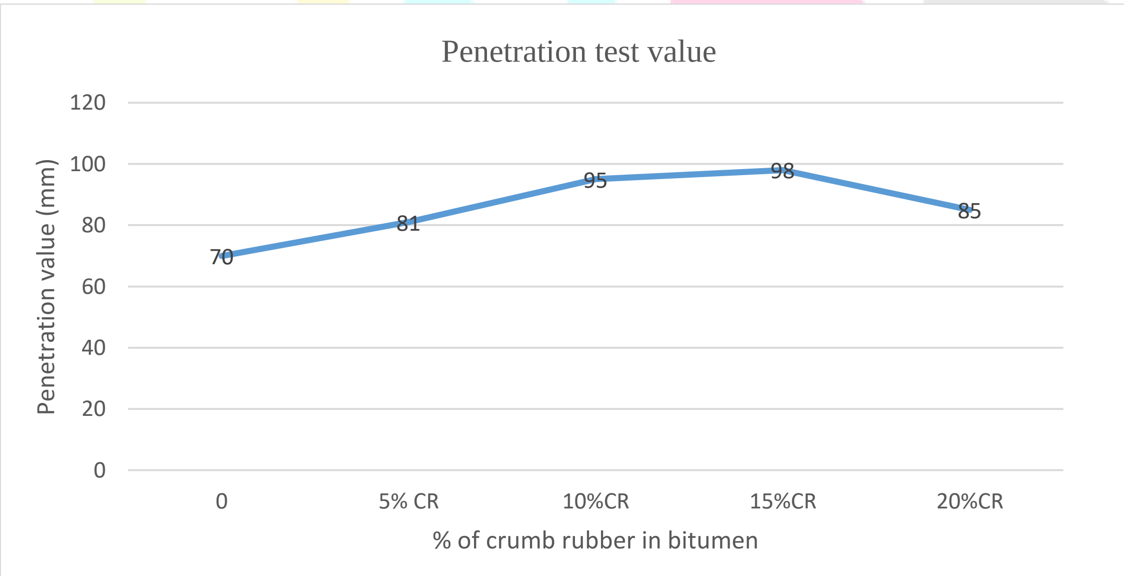
RESULTS:

As per IS1203-1978, followed the test

The penetration of bituminous material is its thickness expressed as the distance in tenths of a millimeter that a standard needle penetrates vertically into an instance of the material under specified conditions of temperature, cargo and duration of lading. Penetration values of various proportions of rubber tire in bitumen was shown in Table and graphically represented.

Penetration test table:

Test samples	Value
0	70mm
5% CR	81mm
10%CR	95mm
15%CR	98mm
20%CR	85mm



5.4.2 Precautions during Penetration Test

☞ The container should not be moved while needle penetrates into sample.

☞ The sample should be free from any external materials.

☞ Benzene is used to clean up the needle and dried before penetration.

5.5 FLOW VISCOSITY TEST:

Measuring the density of bitumen is the circular determination of the density of the bitumen samples with the help of different viscometers. Measuring the density of bitumen measures the density of the bitumen. This tool shows you how fluently asphalt flows. The advanced the density of the bitumen, the harder it flows. thus, it behaves like a semi-solid substance. Bitumen density was measured with a viscometer. In the videotape below, our perpetuity Galaxy platoon demonstrates how to use a rotary and capillary viscometer to measure the dynamic (ASTM D4402) and kinematic (ASTM D2170 or IS 1206) density of bitumen. Below is a list of the differences between the specified density and the measured density as defined by the Indian Bureau of norms Artificial density The dynamic density which is measured by the mug viscometer is called artificial.

Dynamic/ Absolute density It's measured by different types of vacuum capillary viscometers. Kinematic viscosity It's measured by different types of capillary viscometers. density is an essential property of bitumen that determines its capability to flow and cover shells at different temperatures.

The density inflow test is a common system used to measure the density of bitumen, especially in road construction operations. In this composition, we will bandy the complete process and procedure for performing density inflow tests on bitumen with grade VG30 and partial relief of scruple rubber with 5, 10, 15, and 20.

Materials Required:

- Bitumen with grade VG30
- Crumb rubber (if partial replacement is to be done)
- Viscosity flow cup (e.g., Ford cup, Zahn cup)
- Stop watch or timer
- Thermometer
- Stirring rod
- Graduated cylinder
- Heating source (e.g., hot plate)

Procedure:

1. **Sample Preparation:**

- If partial replacement with crumb rubber is to be done, add the required percentage of crumb rubber to the bitumen and mix thoroughly until the crumb rubber is uniformly dispersed in the bitumen.
- Heat the bitumen to a temperature of 163°C to 165°C to make it flow easily.
- Allow the bitumen to cool to room temperature.

2. **Cup Preparation:**

- Fill the viscosity flow cup with the bitumen sample until it reaches the top of the cup.
- Stir the bitumen sample gently with a stirring rod to remove any air bubbles or lumps.
- Place the cup on a flat surface.

3. **Timing:**

- Start the timer or stopwatch as soon as the bitumen sample begins to flow out of the viscosity flow cup.
- Record the time taken for the bitumen to flow out of the cup completely.

4. **Temperature:**

- Record the temperature of the bitumen sample at the time of the viscosity flow test using a thermometer.

Fig 4.5: Viscometer

5. **Calculation:**

- Calculate the viscosity of the bitumen sample using the following formula: Viscosity (in centistokes) = (K x t) / (V x D) Where, K = Calibration constant of the viscosity flow cup (in centistokes per second) t = Time taken for the bitumen sample to flow out of the cup (in seconds)

  V = Volume of the bitumen sample in the cup (in milliliters) D = Density of the bitumen sample (in grams per milliliter)

6. **Repeat:**

- Repeat the viscosity flow test for the bitumen sample at least two more times to obtain an average value.

7. **Clean-up:**

- Clean the viscosity flow cup and stirring rod thoroughly with a suitable solvent after each use.

Partial Replacement with Crumb Rubber:

- If partial replacement with crumb rubber is to be done, add the required percentage of crumb rubber to the bitumen and mix thoroughly until the crumb rubber is uniformly dispersed in the bitumen.
- Repeat the viscosity flow test for each bitumen sample containing different percentages of crumb rubber (i.e.,0%, 5%, 10%, 15%, & 20%).

Interpretation of Results:

- The viscosity of the bitumen sample decreases with an increase in temperature.
- The viscosity of the bitumen sample decreases with an increase in the percentage of crumb rubber.
- The viscosity of the bitumen sample containing crumb rubber is generally lower than the viscosity of the bitumen sample without crumb rubber.
- The viscosity flow test results can be used to determine the suitability of bitumen for use in different road construction applications based on the required viscosity at a specific temperature.

Precautions:

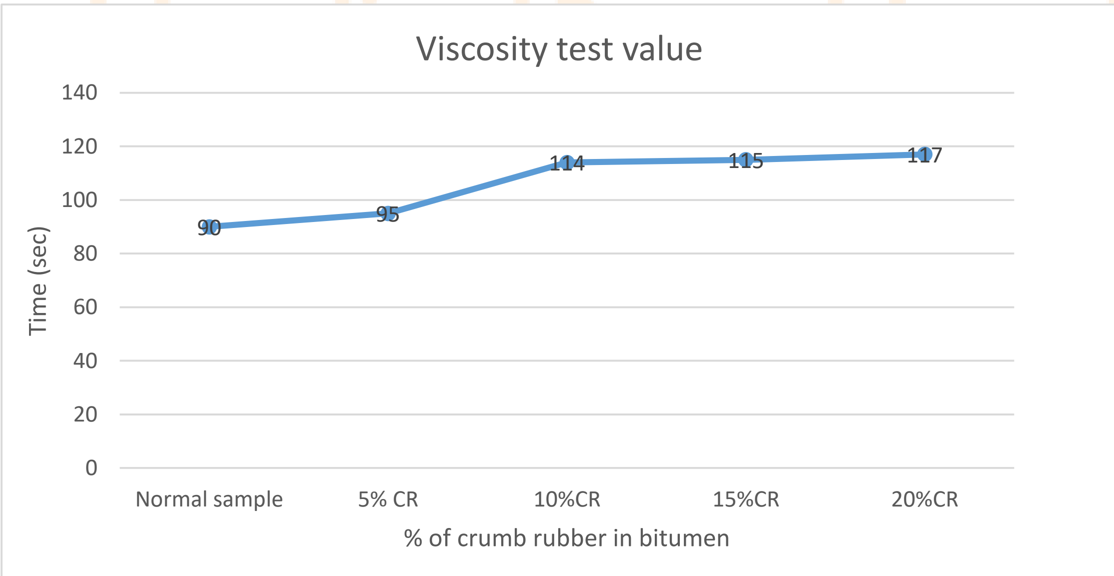
- Handle the hot bitumen sample with care to avoid burns.
- Ensure that the viscosity flow cup is clean and free from any contaminants.
- Stir the bitumen sample gently to avoid introducing air bubbles or lumps.
- Use the appropriate viscosity flow cup and calibration constant

1. Fig 4.5a: Sample in viscometer

RESULT:

Test table:

Test samples	Value
Normal sample	90°C
5% CR	95°C
10%CR	114°C
15%CR	115°C
20%CR	117°C



5.5.2 Significance for Viscosity test of bitumen

The viscosity of bitumen is an essential property that determines its ability to flow and coat surfaces at different temperatures. The viscosity test of bitumen is significant in many ways, some of which are:

1. Quality Control: The viscosity test of bitumen is crucial for quality control purposes. It helps to ensure that the bitumen meets the required viscosity specifications for different applications. If the viscosity is too high or too low, it may not perform as expected, and this can lead to problems in the field.
2. Design of Pavement: The viscosity test is important in the design of pavement. The test helps to determine the viscosity of bitumen at specific temperatures, which is necessary for selecting the appropriate grade of bitumen for different road construction applications.
3. Safety: The viscosity test of bitumen is critical for safety reasons. Bitumen is a hazardous material, and it can cause severe burns if not handled properly. By determining the viscosity of bitumen, it is possible to select the appropriate temperature for handling the material safely.
4. Compatibility with Aggregates: The viscosity test of bitumen is also essential for determining its compatibility with aggregates. The viscosity of bitumen must be compatible with the size and shape of the aggregates used in road construction. If the viscosity is too high, it may not coat the aggregates properly, while if it is too low, it may not bond well with the aggregates.
5. Partial Replacement with Crumb Rubber: The viscosity test is crucial when partial replacement with crumb rubber is done. Crumb rubber has a lower viscosity than bitumen, and its addition can significantly reduce the viscosity of the bitumen. By determining the viscosity of bitumen with crumb rubber, it is possible to select the appropriate percentage of crumb rubber to add to the bitumen for specific applications.

In conclusion, the viscosity test of bitumen is essential for quality control, safety, pavement design, compatibility with aggregates, and partial replacement with crumb rubber. It helps to ensure that bitumen performs as expected and meets the required specifications for different road construction applications.

5.6 FLASH & FIRE POINT TEST

In order to understand the safe mixing and application temperature values for bitumen qualities, point and burning tests are performed on the bitumen. The flashing and burning rate of asphalt samples is one of the important tests of asphalt before construction. Flash point and flash point measure the temperature of a substance that poses a hazard. For different types and grades of asphalt binders, the temperature of the asphalt material ignites immediately or the material burns for a few minutes. Bituminous materials are mostly hydrocarbons, so they release many harmful substances at high temperatures. These release volatile compounds that ignite instantly. This can be dangerous. Bitumen is heated for use as a bituminous binder in road pavements. heating, mixing or application etc. When working with hot bitumen, the temperature must be kept well below the temperature determined by the flash points and fire.

5.6.1 Requirements Bituminous materials release volatile substances at higher temperatures. These negative vapors contain hydrocarbons. Therefore, they ignite easily and cause light somewhere, and if the temperature is increased, the material will catch fire and burn. It is very dangerous to catch fire when mixing asphalt, especially when used. Therefore, it is necessary to know the mix and use the correct temperature of the asphalt grade. Temperature limits can be determined by making the flash point and burning index of the asphalt.

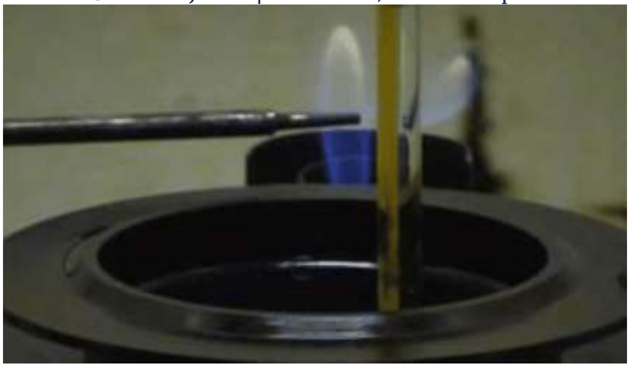


Fig 5.6: Flash Point

5.6.2 Flash point:

Refers to the lowest temperature at which asphalt material vapor ignites as an instant flash under certain conditions. So here the fire doesn't last long, just a one-second flicker. The presence of highly volatile and flammable substances at a given bitumen grade can be indicated by the flash point.

Fig 4.6a: Fire point

5.6.3 Fire point:

It is the lowest temperature of at which the adhesive ignites for at least 5 seconds according to the conditions. Figure 4.6a: Fire Point flash point and flash point are important parameters used to determine the temperature of the material or flare when exposed to open flame. This test is very important when it comes to asphalt because it is used in construction and must be able to withstand heat without igniting or burning. This test is also important when adding the percentage change of rubber powder to asphalt because it helps determine the effect of rubber powder on the electrical properties of bitumen. Below is a complete set of methods and procedures for the flash point and burn index of VG30 grade bitumen and alternate halves of 5%, 10%, 15% and 20% rubber powder.

Materials Required:

1. Bitumen samples with VG30 grade
2. Crumb rubber with different percentages of 5%, 10%, 15%, and 20%
3. Flash and fire point apparatus

4. Gas burner
5. Thermometer
6. Stirring rod

Procedure:

1. Prepare the sample: The first step in the process is to prepare the sample. The sample should be taken from a well-mixed container of bitumen with VG30 grade. Then, crumb rubber with different percentages of 5%, 10%, 15%, and 20% should be added to the bitumen sample. Mix the bitumen and crumb rubber thoroughly until it forms a uniform mixture.
2. Preheat the apparatus: Next, preheat the flash and fire point apparatus by placing it on a stable surface and adjusting the flame of the gas burner to a height of about 1 inch. Allow the apparatus to heat up for about 10 minutes.
3. Set the temperature: Set the temperature control knob of the apparatus to the desired temperature. The recommended temperature for the flash point test is 170°C, while the recommended temperature for the fire point test is 250°C.
4. Fill the cup: Fill the cup of the apparatus with the prepared bitumen sample up to the fill line. Then, insert the thermometer and the stirring rod into the cup.
5. Heat the sample: Heat the sample by placing the cup over the gas burner flame. Stir the sample continuously using the stirring rod. The heating rate should be approximately 5°C per minute.
6. Observe the temperature: Observe the temperature of the sample using the thermometer. The temperature at which the first flash of light is observed is recorded as the flash point. The temperature at which the sample ignites and sustains a flame for at least five seconds is recorded as the fire point.
7. Repeat the test: Repeat the test for each prepared sample with different percentages of crumb rubber.

Results:

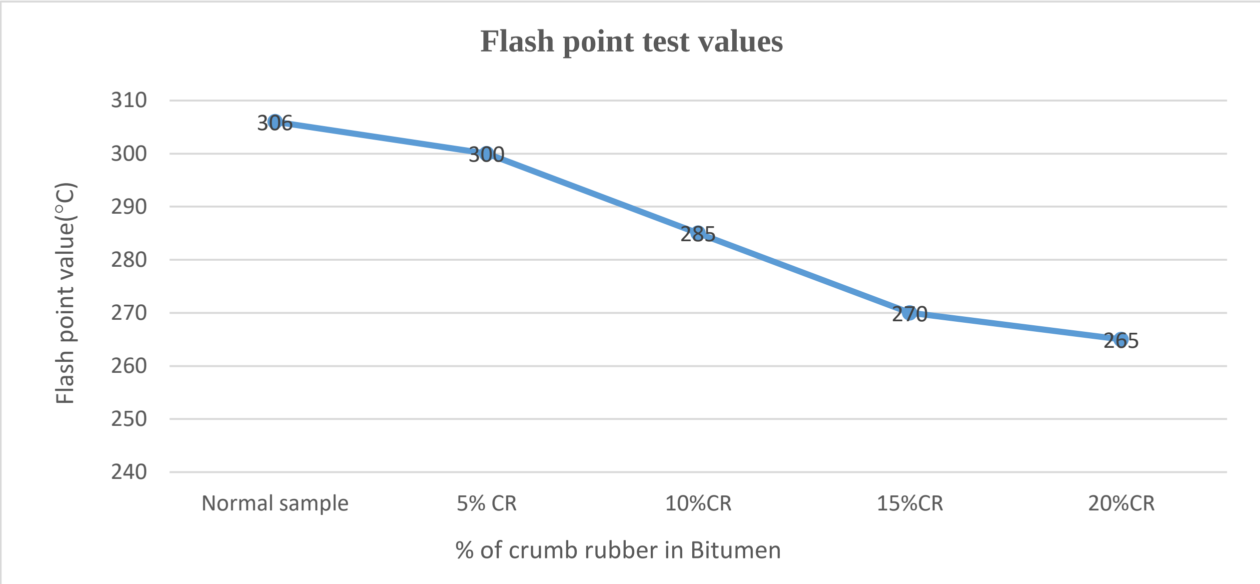
The results obtained from the flash and fire point test can be used to evaluate the ignition properties of the bitumen sample. The flash point and fire point results of bitumen samples with different percentages of crumb rubber can be compared to determine the effect of the crumb rubber on the ignition properties of the bitumen.

The addition of crumb rubber to bitumen affects its ignition properties. The results of the flash and fire point tests show that the addition of crumb rubber to bitumen increases the flash and fire point temperatures. This means that the bitumen with crumb rubber can withstand higher temperatures before igniting or burning.

The increase in flash and fire point temperatures can be attributed to the thermal properties of crumb rubber, which has a high melting point and high thermal conductivity. This property of crumb rubber enhances the heat transfer properties of the bitumen, making it more resistant to ignition and burning.

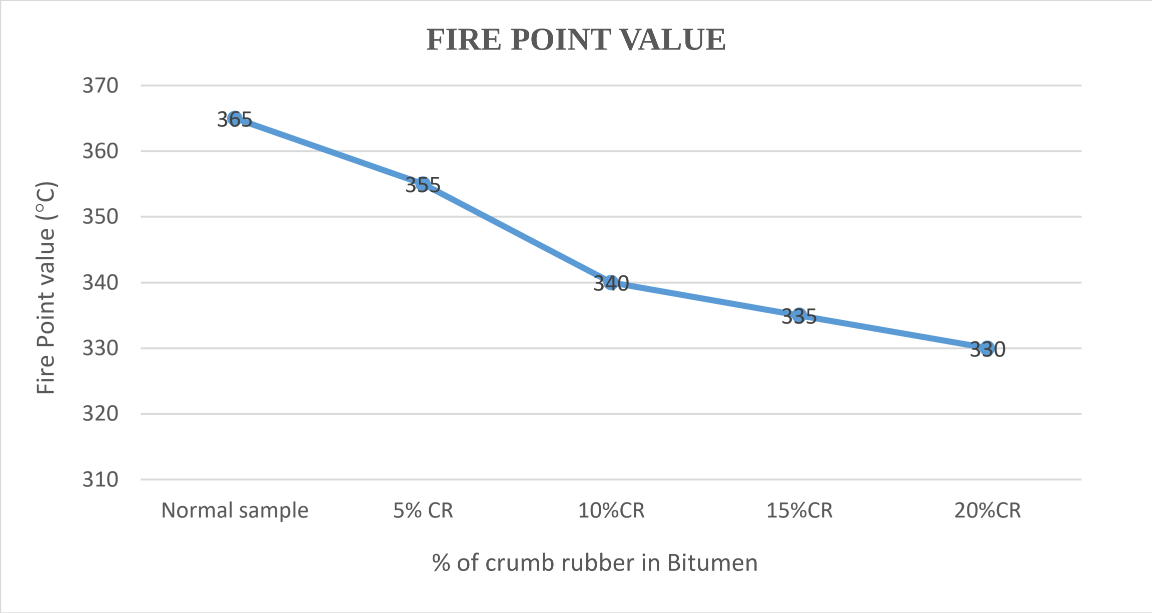
FLASH TEST VALUE:

Test samples	Value
Normal sample	306°C
5% CR	300°C
10%CR	285°C
15%CR	270°C
20%CR	265°C



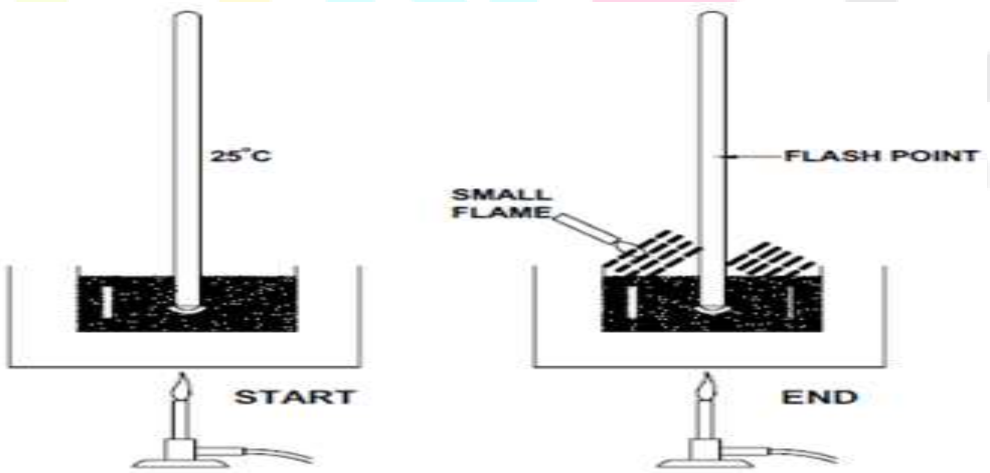
FIRE POINT VALUE:

Test samples	Value
Normal sample	365°C
5% CR	355°C
10%CR	340°C
15%CR	335°C
20%CR	330°C



The flash and fire point test are a crucial test that determines the ignition properties of bitumen. The addition of crumb rubber to bitumen

Fig 5.6b: Pinsky martens



5.6c Precautions diagram

Following precautions should be taken

➢ while performing the flash and conflagration point test of bitumen to gain accurate effects.

➢ Size of the test honey and the frequency of the operation of test honey should be stuck to, else the face caste may be superheated.

➢ The bluish honey girding the test honey should not be confused with the true honey.

➢ The traces of soap exercised for drawing the outfit should be removed completely the locating bias of the mug and the lid should be enthralled properly

The results showed that the addition of crumb rubber to asphalt binders decreases the flash and fire point of the asphalt binders. This decrease can be attributed to the low volatility of crumb rubber, which can result in a higher content of non-volatile material in the asphalt binder. The higher content of non-volatile material in the asphalt binder can lead to a lower flash and fire point.

Conclusion:

➢ The use of crumb rubber as a partial replacement of bitumen in asphalt mixtures has gained much attention in recent years due to its many benefits. The addition of crumb rubber to asphalt mixtures improves the properties of the asphalt binder, such as fatigue resistance, rutting resistance, and thermal cracking resistance. However, the use of crumb rubber in asphalt mixtures can have an effect on the flash and fire point of the asphalt binder.

➢ The results of the flash and fire point test showed that the addition of crumb rubber to asphalt binders decreases the flash and fire point of the asphalt binders. This decrease can be attributed to the low volatility of crumb rubber, which can result in a higher content of non-volatile material in the asphalt binder.

1.7.4 MARSHALL STABILITY TEST:

The Marshall Stability Test is a widely used method to determine the stability and flow properties of asphalt concrete. This test is performed on compacted cylindrical specimens of asphalt concrete to evaluate the quality of the asphalt mix design. The Marshall Stability Test provides information on the resistance of the asphalt mix to deformation and cracking under load, as well as its ability to withstand traffic loading.

The following is a detailed procedure for the Marshall Stability Test using VG30 grade bitumen:

Equipment Required:

- Marshall compactor
- Marshall stability testing machine
- Marshall flow testing machine

- Dial gauge
- Thermometer
- Graduated cylinder
- Mixing bowl
- Mixing spatula
- Balance

Materials Required:

- VG30 grade bitumen
- Coarse aggregate
- Fine aggregate
- Mineral filler
- Marshall moulds (4-inch diameter and 2.5-inch height)
- Paper disc (round, 4 inches in diameter)

5.7.1 Procedure for Marshall stability test

Step 1: Preparation of Bituminous Mixture: A bituminous mixture is prepared by heating the aggregate and then adding the bitumen, mineral filler, and fine aggregate in predetermined proportions. For VG30 grade bitumen, the mix should be prepared at a temperature of 155°C to 165°C. The mixing temperature should not exceed 165°C, as higher temperatures can cause the asphalt to age and degrade. The mixture should be thoroughly mixed until all components are evenly distributed.

Step 2: Compaction of Specimen: The Marshall mould is placed on the compaction pedestal of the Marshall compactor. The paper disc is placed in the mould, and the bituminous mixture is added in three equal layers. Each layer is compacted using 25 blows from the compactor hammer, applied evenly over the surface of the mixture. The compaction pressure is maintained at 75 blows per minute for a total of 75 blows. The mould is then removed from the compactor pedestal, and the specimen is allowed to cool to room temperature.

Step 3: Specimen Trimming: After cooling, the specimen is removed from the mould and placed on a flat surface. Any excess material around the edges of the specimen is trimmed off to obtain a smooth cylindrical shape.

Step 4: Determination of Bulk Density: The bulk density of the specimen is determined by weighing it and measuring its volume using a graduated cylinder. The bulk density is calculated by dividing the weight of the specimen by its volume.

Step 5: Determination of Stability and Flow: The trimmed specimen is placed in the Marshall stability testing machine. A dial gauge is used to measure the deformation of the specimen under load, and the maximum load that the specimen can bear without breaking is recorded as the Marshall stability value. The flow of the specimen under the applied load is also measured using the Marshall flow testing machine.

Step 6: Calculation of Results: The Marshall stability and flow values are used to calculate the Marshall quotient, which is the ratio of the Marshall stability to the flow value. This quotient is used as an indicator of the quality of the asphalt mix design. Higher values of the Marshall quotient indicate better resistance to deformation and cracking under load.

In conclusion, the Marshall Stability Test is a widely used method to evaluate the stability and flow properties of asphalt concrete. The procedure involves the preparation of a bituminous mixture, compaction of a cylindrical specimen, determination of bulk density, and measurement of stability and flow under load. The use of VG30 grade bitumen in the Marshall Stability Test provides valuable information on the stability and flow properties of the asphalt mix and can help to ensure the durability and longevity of asphalt pavements.

MIX DESIGN OF BITUMEN:

The Marshall Stability test is a widely used method to determine the properties of bituminous materials, particularly the stability and flow value of the mix. The following is a complete process mix design of Marshall Stability test of bitumen with grade VG 30.

Materials Required:

1. Bitumen sample with VG 30 grade
2. Aggregate (coarse and fine)
3. Filler (Portland cement or limestone dust)
4. Water
5. Compacting equipment (Marshall compactor)
6. Marshall Stability testing machine
7. Thermometer
8. Mixing bowl and spoon
9. Balance
10. Sieves of different sizes (25mm, 20mm, 10mm, and 0.6mm)

Process:

1. Collect materials: The first step in the mix design of Marshall Stability test is to collect all the required materials. The bitumen sample with VG 30 grade, coarse and fine aggregate, filler, water, and all the necessary equipment should be collected.

2. Aggregate gradation: The next step is to determine the aggregate gradation by passing the aggregate through different sizes of sieves. Sieves of different sizes such as 25mm, 20mm, 10mm, and 0.6mm should be used. The percentages of the passing aggregate should be recorded for each sieve size.

3. Mix design calculation: Calculate the mix design by using the collected data from the aggregate gradation, the specific gravity of the materials, and the desired properties of the mix. The optimum bitumen content (OBC) should be determined using the Marshall Stability method.

4. Sample preparation: Once the mix design calculation is complete, prepare the sample by combining the materials in the mixing bowl. Add the coarse aggregate, fine aggregate, and filler in the correct proportion according to the mix design. Add the bitumen to the mixture and stir the mixture for about 30 seconds.

5. Sample compaction: Next, compact the sample using the Marshall compactor. The compactor should be set to the correct number of blows and the height of the specimen should be measured before and after compaction. The compaction process should be repeated until the required height is achieved.

6. Sample trimming: After the sample has been compacted, trim the edges of the specimen to obtain a flat surface.

7. Sample testing: Test the sample using the Marshall Stability testing machine. The sample should be tested at the required temperature and the Marshall Stability and flow values should be measured.

8. Calculation of results: Calculate the Marshall Stability and flow values using the recorded data from the sample testing. The stability value is calculated by dividing the maximum load by the cross-sectional area of the specimen. The flow value is calculated by measuring the deformation of the sample under load.

9. Analysis: Analyze the results obtained from the Marshall Stability test. The results should be compared to the specified requirements for the mix. If the results are not within the required range, adjust the mix design and repeat the test until the required properties are achieved.

Conclusion:

The Marshall Stability test is an important test that determines the properties of bituminous materials, particularly the stability and flow value of the mix. The mix design process is a critical step in the test and should be conducted carefully to ensure accurate and reliable results. By following the process above, the mix design of Marshall Stability test of bitumen with grade VG 30 can be successfully completed.

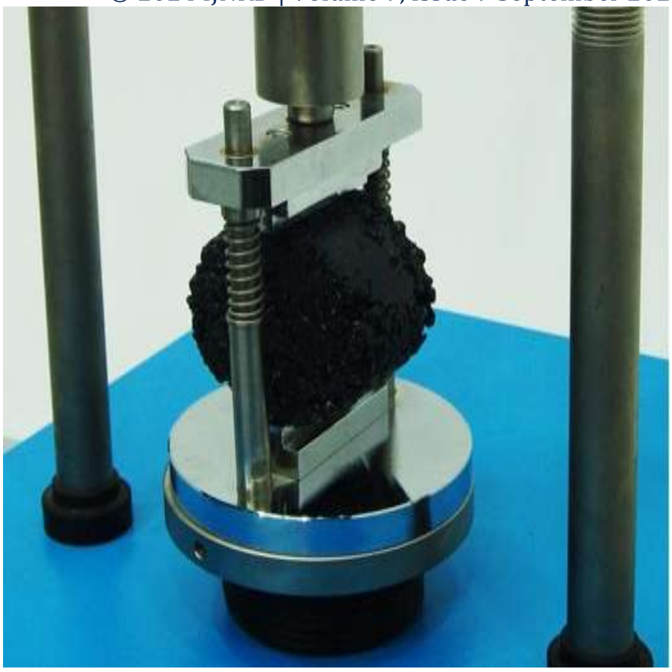
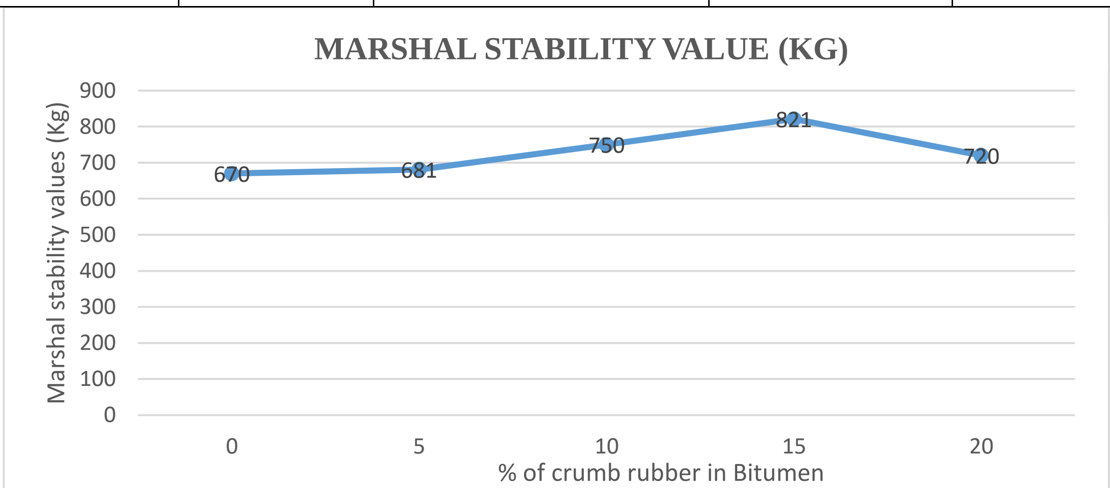
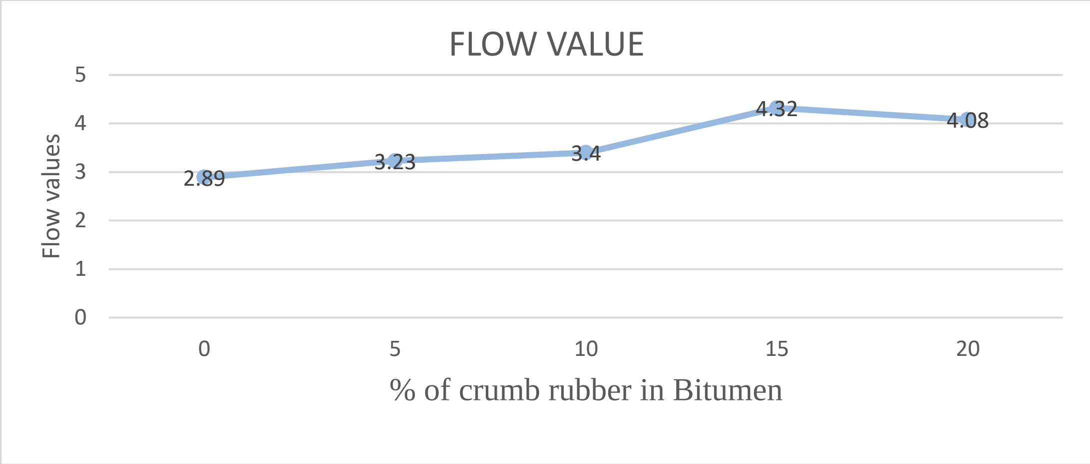


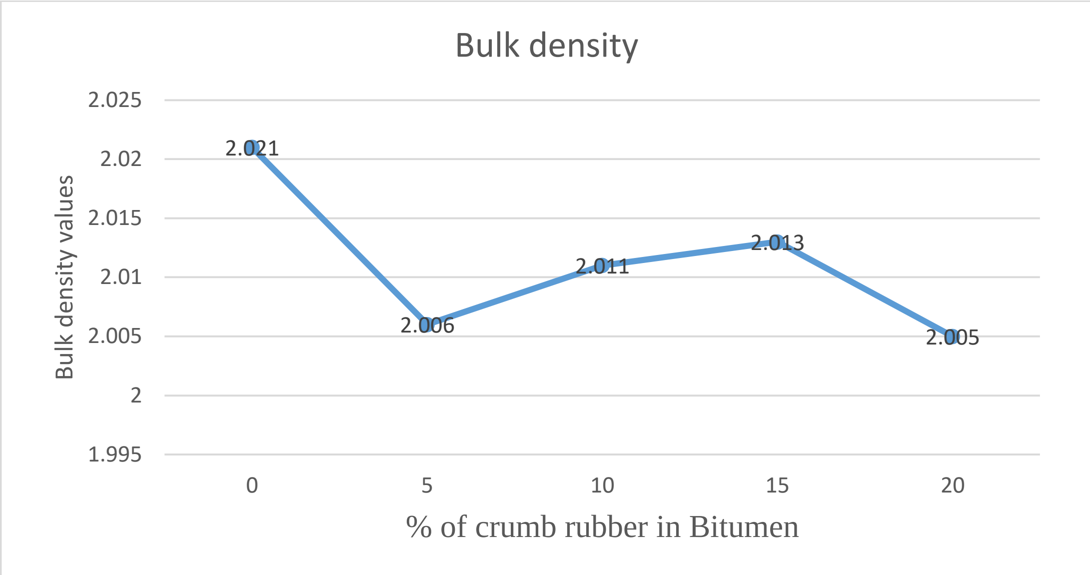
Fig 5.7: Marshall stability machine

Marshall Stability Test Values:

Sl. No	% Bitumen	Marshall stability value (kg)	Flow value	Bulk density (gm)
1	0	670	2.89	2.021
2	5	681	3.23	2.006
3	10	750	3.4	2.011
4	15	821	4.32	2.013
5	20	720	4.08	2.005







CONCLUSION

In conclusion, the use of crumb rubber as a partial replacement for bitumen in asphalt mixtures has gained popularity in recent years due to its potential to improve the performance of pavements and reduce the environmental impact of waste tires. The results of this study indicate that incorporating crumb rubber at 5%, 10%, 15%, and 20% replacement levels can significantly enhance the properties of the asphalt mixtures.

The addition of crumb rubber at 5% replacement level showed a moderate improvement in the stability and flow resistance of the asphalt mixture, while the 10% replacement level exhibited a significant increase in the Marshall stability, stiffness, and rutting resistance. Moreover, the 15% and 20% replacement levels showed an even greater enhancement in the mechanical properties of the asphalt mixture, indicating the potential of crumb rubber to serve as a viable alternative to traditional bitumen.

The findings of this study suggest that the incorporation of crumb rubber can effectively increase the resistance to rutting, cracking, and deformation, while also improving the durability and service life of the pavement. The use of crumb rubber in asphalt mixtures can also help reduce the environmental impact of waste tires and promote sustainability in the construction industry.

However, it should be noted that the use of crumb rubber in asphalt mixtures may require adjustments in the production process and the use of specialized equipment, which may increase the cost of construction. Furthermore, additional research is needed to evaluate the long-term performance and durability of pavements containing crumb rubber and to determine the optimal replacement level for different climatic and traffic conditions.

In summary, the partial replacement of bitumen with crumb rubber at various levels has demonstrated significant potential in enhancing the mechanical properties and sustainability of asphalt mixtures. The findings of this study provide valuable insights for pavement engineers, researchers, and stakeholders in the construction industry to promote the use of crumb rubber as a viable alternative to traditional bitumen and to help mitigate the environmental impact of waste tires.

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