EFFECT OF WASTE MATERIALS ON BITUMINOUS MIX PROPERTIES

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Thesis

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Under the supervision

of

Dr. Amardeep

(Assistant Professor)

by

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to

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY

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MAY, 2019

STUDENT'S DECLARATION

I hereby declare that the work presented in the project report entitled **"EFFECT OF WASTE MATERIAL ON BITUMINOUS MIX PROPERTIES"** submitted for partial fulfilment of the requirements for the degree of Master of Technology in Civil Engineering at **Jaypee University of Information Technology, Waknaghat** is an authentic record of my work carried out under the supervision of **Dr. Amardeep** (Asst. Professor). This work has not been submitted elsewhere for the reward of any other degree/diploma. I am fully responsible for the contents of my project report.

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CERTIFICATE

This is to certify that the work which is being presented in the project report titled "**EFFECT OF WASTE MATERIALS ON BITUMINOUS MIX PROPERTIES**" in partial fulfilment of the requirements for the award of the degree of Master of Technology in Civil Engineering submitted to the Department of Civil Engineering, **Jaypee University of Information Technology, Waknaghat** is an authentic record of work carried out by **Unique Vaidya (172603)** during a period from August,2018 to May,2019 under the supervision of **Dr. Amardeep** Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat.

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

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List of Abbreviations

NHAI	National Highway Authority of India
MORT&H	Ministry of Road Transport & Highway
LDPE	Low Density Poly Ethylene
HDPE	High Density Poly Ethylene
PVC	Poly Vinyl Chloride
PP	Polypropylene
PET	Polyethylene Terephthalate
CRMB	Crumb Rubber

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ABSTRACT

In the present scenario road plays an important role by connecting different cities, rural areas to the main national highways or state highways. However, the construction cost of road is quite high. It is the need of the situation to propose an alternative material as the replacement of conventional ones in order to reduce the total cost without compromising with its actual specifications. India has the second largest road network after China while secured the 12^{th} place in producing of the waste also. Therefore, utilisation of the waste materials in the construction of flexible pavement that will prove as a cost-effective method as well as eco-friendly. Various studies were conducted across the world by focusing on the utilisation of different waste materials like plastic waste (i.e. polythene, plastic bottles, plastic bags, wrappers), waste tire rubber, granite sludge etc. Based on the findings of these studies it was concluded that these waste materials could be used in the flexible pavements. According to previous studies, it was examined that the utilisation of waste material up to 30% has been done without compromising its properties and utilisation of waste material in rural areas for development of connectivity of roads is good option and by using waste materials overall construction cost could reduce and areas can develop in better way.

Keywords: Flexible pavement, Waste LDPE, CRMB, Waste engine oil.

CHAPTER 1

INRODUCTION

1.1 General

According to present scenario, Population is increasing day by day and people are using more plastic polymers, automobiles etc. and due to this pollution is also increasing day by day with waste polymers. There are different challenges coming in day to day life for decomposition of waste polymers. There are need of disposal of these waste materials because if these waste materials will not have decomposed then they will remain same on earth for hundreds of years which can increase environmental pollution. There is a solution of decomposing these material is recycling or reusing the waste materials into useful way.

There are new advance researches into new and innovative techniques for utilising waste materials. There are many private companies and highway agencies completed many advance researches and projects for utilising the waste polymers for road construction which are environmentally suitable and by using it performance will also increase. These studies are done for trying to match safe and economical disposal of waste material or for more cost efficiency in road construction. These studies mainly show the waste materials which is having substitute for conventional construction material. In the researches there is main focus on new and innovative invention for utilising waste materials.

1.2 Bitumen

Bitumen is defined by Indian standard institution that it is black or dark brown in colour. It is crystalline and having adhesive properties. It is mainly coming from crude oil by naturally or by refinery processes. Mainly bitumen is adhesive in nature and mixture of hydrocarbons which are generally found in tar, asphalt etc. It is mainly used for

- Road construction
- Construction of platform and runways.
- For water proofing.
- Construction of mastic flooring.
- Lining of canals
- Damp proof course (DPC)

Advantages of bitumen:

- Economical production of bitumen
- Physical and rheological properties are adaptable

- Optimum melting point
- Bitumen is recyclable
- Good binding strength

According to the different reports, it is estimated that around 100 million tonnes of bitumen is used by the world and 80% of bitumen is used for road construction. It is also used for pavements of parking, runways etc.

1.3 Use of waste material

In a road construction, if bitumen is less adhesive in nature then in summers, bleeding from surface may occur or in winters can come which can create serious damage to road due to less load capacity or higher axial load. According to present condition, in the term of high infrastructure development, India has to increase its transportation system. Mainly bituminous mix compromises the crushed and fine aggregates with bitumen which act as a binding agents. If all the polymer waste could have added into it according to the physical and chemical properties of waste materials. On the other side, worldwide authorities of highways is realising that modified bitumen is economical in road construction. In this modified bitumen with waste polymers are best material for flexible pavement. It has ability to reduce maintenance cost but also solve the issues of disposal of waste materials.

CHAPTER 2

LITERATURE REVIEW

2.1 General

Different types of waste materials i.e. waste plastic, CRMB and many more were used in bituminous mix design by researchers across the world. It was observed that the utilization of waste material as the replacement of bitumen can improve the life of the flexible pavement too. Different guidelines were proposed by the researchers across the world regarding the utilization of waste material in the different proportion which is discussed in detail below.

2.2 Literature review

In a recent study, **Ahmadinia et al. (2011)** investigated on waste polymer like plastic bottles for stone mastic asphalt and said asphalt mixture with a polymer is a costly mixture for pavement of roads so it's better to use waste polymers. In this theory plastic bottles were used which is a type of polyethylene terephthalate and it is a polymer which is used for disposable dishes plastic bottles containers and other. In this research material used was waste polymer Portland cement bitumen and crushed aggregates. The waste polymer was used as an additive to the mixture for increased durability and stability.

For testing, the wet and dry process was performed. First was a wet process and in this waste, the polymer was added with the binder or in the second test which was dry process waste polymer blended with crushed aggregates but there were certain steps which were also taken that aggregates were first heated for two hours at 200°C temperature. Bitumen content was 5% to 7%. After selecting appropriate content, it was heated up for 1hour at temperature 150°C. After that bitumen aggregates and filler was mixed. The waste polymer was blended for a few minutes and its % varies b/w 2% to 10%. Marshall compactor was used them for compaction at a temperature of 145°C. After that marshal stability test was performed where polymer stability value increases to a maximum 6% after that it started decreasing. Stability value was higher with all the sample except sample with 10% PET. In marshal flow sample of polyethylene terephthalate (PET) until 4% decreasing after that it starts increasing which means stability of high % PET decreased. In this analysis of variance is used for comparing the different asphalt mixtures and the result of this theory was stability started decreasing after 6% of Polyethylene terephthalate and PET also increases and stiffness and a perfect match was 6% of PET mixture.

Arabani et.al. (2010) examined the effect of the waste tire on asphalt mixture or pavement. According to the author, cracking is the main issue in normal pavement and cracking can occur in after several years in every type of pavement, so for increasing the service life of the pavement, author used a high modulus tire cord mesh, Bitumen of 60/70 grade and different size of aggregate according to the passing % is used as a material in this experiment and different test like marshal test, indirect tensile stiffness modulus test, the dynamic creep test, and indirect test was done on this by taking different tire thread sample of content 0%,1%,3%,5% on the basis of overall wt. of bitumen. These tests are done by using standard marshal apparatus and Nottingham asphalt tester.

In this binder content was taken off 5.3%, 5.5% and 5.7% for all samples and according to marshal test optimum bitumen content for sample 0% or 1% was 5.3% and for the sample, 3% or 5% was 5.7%. In this indirect tensile fatigue test was done for finding out the fatigue characteristics, indirect tensile strength and for examination of material cracking ITFT test was used. According to the resulting sample having 3% of waste, tire thread is having better stiffness than other samples. The conclusion of using waste tire thread material is having desirable properties of pavements. Its stiffness is also high as compare to non-reinforcement samples. On the basis of the results of creep test, rutting depth was found to decrease after 600 MPa. It is due to increase in sample content after 3%. while fatigue life was increasing due to gradually increase in waste tire content. Utilization of waste tire thread was resultant in the improvement in the properties of bitumen.

Akbulut et al. (2012) conducted a research study to utilize granite sludge as a filler material in bituminous hot mixtures. They focused on using a waste material as fillers material in the bituminous mix for increasing the ratio of fine aggregate and stress-bearing capacity, decreasing the void ratio. In the study, granite sludge (sludge is formed during polishing and cutting of granite) was utilised as a filler material. Initially, different tests were conducted to examine the properties of aggregate i.e. abrasion, impact value, presence of voids and many more. It is to note that the weak aggregate should not be included in the mix as these aggregates can warp under the effect of freezing and thawing.

On the basis of the test results, aggregates stripping and adhesion resistance values were found within the limit. In bituminous hot mix test, recycled filler material was added in five different quantitative values for testing. Tests were done for each 0.5% bitumen increment and flow test was conducted. In the test wt. of specimen, wt. in water & surface dry saturated to water were noted. Several curves were made to examine the relationships b/w % of bitumen content and stability, specific gravity, % of void filled with bitumen, and % of void. Resultant optimum bitumen ratios for different design groups i.e. 0%,2%,4%,6% and 8% were found out around 3.83%,4.04%,4.10%,4.76% and 5.11% respectively.

These tests told about the use of waste granite filler materials in bituminous mix design. In this, increase in durability shown by using 6.4 % filler material in bituminous mix. On the basis of result, the maximum stability values came with 0%, 4%, 6% and 8% mix. The Maximum value came with 8% filler Content which was around 1650 kg. The % of voids for different samples containing filler additives in different proportion i.e. 0%,2%,4%,6% and 8% were found out around 3.8%,3.0%,3.2% and 2.5% respectively. Tests samples containing ideal bitumen content were relieved in a water shower at 60°C for 48 hours. Then, the marshall stability test was performed. According to this, the stability loss was lower in 8% filler samples than in others.

After that Indirect filler test was conducted to determine the resistance to plastic deformation of the bituminous hot mixtures at a varying range of temperatures. (5°C, 25°C and 40°C) and the stiffness modulus of bituminous mixes. Indirect tensile strength at 40°C was less than that at 25°C.change in filler level from 6%to 8% at 40°C showed Change in Indirect tensile strength from 264.0kPa to 264. 6kPa. at 5°C. Thus the serving period of 8% filler particles was concluded to be more. Therefore, it was concluded the granite sludge can be reused as a filler material. Optimum bitumen content levels were calibrated i.e. 5.11%, 4.76%, 4.10%, 4.04%, and 3.83% for varying proportion of filler material (i.e. 0%, 2%, 4%, 6%and 8% values respectively). Thus by increasing, recycled granite sludge bitumen level fell under the economical limits. Specimens with 8% filler contents had maximum stability values by filling micro voids in the bituminous hot mixture. Different properties of bituminous hot mixtures with variation in filler type and content indicated that fillers significantly affected the mixture properties. The capacity of bitumen hot mixtures in wearing courses was supposed to be improved if the filler were to be utilised at 7.3%.

Ahmad 2014, utilized low-density polythene was utilised in the bituminous mix design. In this study material taken as waste plastic low-density polyethylene (LDPE), bitumen of VG30 grade and aggregates. Different samples were made with a % of 2%, 4%, 6%, 8%, 10%, 12%, according to the overall wt. of bitumen. There was a various test conducted on the bitumen by following IS code. According to LDPE, in this polythene waste and plastic bottles are cut into small pieces for making different samples of size 2mm- - 3mm. According to MORT&H specification stone aggregates and for filler material stone dust and cement was used in a ratio of 3:2.

In this various test conducted on samples and result was sample having 12% waste having better stability value. Inflow value tests the value was decreased by 34 % as compared to plain bitumen with 12% of LDPE waste which show more stability and in bulk density test value increased by 25% with the same sample. In an air void test, the value decreased by 44% with 12% of the plastic waste sample which shows more stability. So this study concludes that the overall quality improved by 14% by using 12% of LDPE waste sample.

Bhageerathy et al. (2014) examined on the utilisation of plastic waste in construction of road. The materials used in the study were bio-medical syringe plastic waste, bitumen, and aggregates. During the study three normal mix specimens were made and samples containing bitumen content of 4.5 %, 5%, and 5.5% respectively and conducted a marshal test on samples. The optimum bitumen content was 5%. Marshall test was performed on different plastic modified mix samples having plastic values in different proportion like 2%, 3%, 5%, and 7%. In this optimum plastic content (OPC) was recorded as 5 %. On the basis of static creep test, % of permanent strain to plastic and normal modified specimens were found around .33 and .54 respectively. The test results of indirect tensile stiffness modulus tests revealed that the normal mix had less tensile stiffness modulus than the modified mix with plastic. Aggregates with 5% of plastic were tested to examine different properties like aggregate crushing %, aggregate impact value %, los angeles abrasion value %, specific gravity of 13 mm aggregates, specific gravity of 19 mm aggregates, specific gravity of 9.5 mm aggregates, water absorption of 19 mm aggregates %, Water absorption of 13 mm aggregate %, water absorption of 9.5 mm aggregate %. From the test results it was revealed that, aggregate crushing value get decreased by 29% after coating the aggregate with the plastic. While, the aggregate impact value was found to decrease up to 17.7 percent. Los Angeles abrasion value test of coated aggregates were seen to be reduced by 8%, and water absorption for coated aggregates was 0%.

Thus, from this investigation, it was concluded that the optimum value of plastic content will be equal to 5% of wt. of bitumen. The marshal stability value of normal mix was seen to be 53% less than a modified mix with plastic, indicating an increase in load capacity. The reduction in crushing value and impact value of aggregate was found around 27% and 17.7% respectively. Reduction in los angeles abrasion value of coated aggregates with plastic indicated that, these have a superior abrasion resistance as compared to normal mix. In this the permanent strain was decreased by 0.23%, there was an indication towards the increased tensile strength of Plastic modified mix as its average tensile modulus was found to be increased by 47.8% than the normal mix design. Hence, the biomedical waste can be disposed of easily and conveniently by incorporating it in bituminous mixes.

Bansal et al. (2017) worked on waste rubber and plastic material in modified bituminous mix design as the replacement of bitumen. In this study, crushed plastic bottles, plastic bags, waste tire were used as a waste material. In the study, three samples were made by mixing of rubber, plastic with bitumen in individual and combined manner. In this study different type of test like penetration test, ductility test and softening point test was done. For the purpose of testing. In this different samples were made by utilizing the plastic and rubber in varying proportion i.e. 4%, 6%, 8%, 10% and 5%, 10%, 15 % respectively. Maximum stability value was obtained when the mix was prepared in different proportion i.e. 84% of bitumen, 6% plastic, and 10% rubber. In marshal flow value test, the higher value was obtained with the rubber content more than 10%. In case of bulk density, values were found higher for all mixes rather than the conventional method. However, mix having 8% of waste was depicting higher value than other mixes. While the air void found to be increased due to variation in the density of the waste material. This study reveals that the use of waste in road construction will prove more economical than the conventional method and also improves the quality of roads.

Ghalyan and Rana (2017) partial replaced the bitumen by using plastic waste in bituminous concrete. In this study, plastic waste, aggregates, bitumen of 60/70 penetration grade was used as a material. According to study waste was collected from different resources and washed properly for the removal of impurities in the waste. After that waste plastic was cut out in small pieces of size 2.36mm to 4.75mm because small pieces can mix properly and give the better result. After this aggregates were heated at 160°C and waste plastic was added to the heating chamber for giving a coating to aggregates. After that bitumen was also added and heated at the same temperature. Several tests were carried out like an impact value test, ductility test, and marshal stability test according to proper guideline and with different % of plastic samples. So according to the test result, this study concludes that the increase of waste plastic in mix design increase the property of aggregates and enhance the strength. The advantage of using waste plastic is, it's economical and eco-friendly.

Hınıslıoğlu and Agar (2004) investigated a study on the utilization of the waste plastic material in the bituminous mix design. The material used in this study was bitumen AC-20, waste high-density polyethylene (HDPE) and crushed limestone used as an aggregate. Marshal test method was used in this study for finding out the resistance with or without HDPE modified concrete. In this sample made by mixing waste HDPE in 6%,4% and 8% according to the wt. of bitumen content, HDPE, bitumen & aggregates heated up separately at the temperature of 155°C and 165°C and mixed with the help of the mechanical mixer. In this void ratio in samples were around 3.07% to 3.35%. After this process samples were kept in the room for cool down. After samples were kept in water at the temperature of 60°C for 30 minutes and test was done with Marshall test apparatus. All the results were found from each mixed sample.

According to the result, the stability decreases by increasing of waste HDPE content. The maximum stability increases with 4% of HDPE. In this flow increases according to the increase of HDPE content. According to flow result sample having 4%, bitumen content was having the smallest flow value of 3.8 mm. According to Marshall quotient result, the sample with 4% fulfilled all the specification of Marshall quotient. This study concludes that sample with 4% HDPE is having better stability for using in the construction of roads. Marble waste was used as a filler material in the construction of bituminous roads/ flexible pavement by **Karasahin and Terzi (2007).** It is to note that the limestone dust is utilizing across the world in large quantity which works as a filler material. However, there is a number of filler material which exhibits different properties. For the same purpose marble dust was treated first due to the presence of different marble content. Consequently, a marshal sample with 75-100 penetration asphalt cement was prepared. Later on, several samples were cast in order to carry out several tests. After doing several tests and analysis stability of limestone dust was found higher in comparison to marble dust. The void ratio was found higher in case of marble dust comparatively void ratio observed in the case of limestone. In this process, four type of marble dust sample was taken in which two was from the different place and other two was from the different place and used without doing any process on that sample and in the test the optimum bitumen content was 4.7 %. So according to the test result sample having limestone dust the plastic deformation decrease by 8% after that it started increasing which means plastic deformation decrease to a point after that, it starts increasing because the different type of filler material fills the void in the material and increase its stability but after some time. The second sample was which is having marble dust and the result was that it can be used directly without doing any process on it and according to the plastic deformation test marble dust is having higher plastic deformation. By doing all the test the conclusion for limestone dust sample and marble dust was that plastic deformation decreases by 7% after that it starts increasing and both the samples of lime dust and marble dust having the same plastic deformation but marble dust can be used directly in asphalt mix and it is having higher plastic deformation and this type of mix can be used for link roads or local roads.

Kumar and Vikranth (2017) conducted a study on the utilisation of plastic polypropylene (PP) in flexible pavements. The material utilised in this study was aggregates, bitumen and waste plastic. Various tests were conducted to compare normal aggregate and plastic coated aggregate as well as standard bitumen & bitumen mixed with plastic waste. The value of specific gravity of coated aggregate was more than the normal aggregate and the water absorption test indicated that, coating with plastic reduces the moisture absorption & increases the quality of aggregate. The coating of plastic improved the Aggregate Impact value. The Aggregate crushing value was lower of plastic coated Aggregate thus; it could withstand more load. The Los Angeles abrasion test showed a decreased value of wear and tear for plastic coated Aggregates thus, indicating a longer life. When plastic was added to bitumen the penetration of bitumen decreased. With the increase in plastic waste, the softening value increased. The viscosity value of plastic coated bitumen was Low as compared to conventional bitumen. On addition of polypropylene to bitumen fire point and flash point increased thus preventing hazards. The value of conventional bitumen was less as compared to plastic coated bitumen. From the study, it was concluded that the optimum value of plastic waste added was 9-10% by wt.. On adding plastic waste to bitumen and aggregate, their properties increased by reducing bitumen up to 9-10% cost of construction of Flexible Pavements also decreases and moreover it’s a useful way to preserve our environment.

Kawade et al. (2018) Investigated a study on design and qualitative analysis of flexible pavement containing waste materials. The waste materials utilised in this study as the replacement of natural aggregates were namely crushed stone, steel slag, recycled concrete and CRMB (by cutting waste rubber tires in pieces that could pass through 2.36 mm sieve and were retained on 1.18mm sieve. Marshall Stability test was performed for each type of mixes containing different waste material as the replacement of aggregates and VG-30 bitumen mix. In the case of steel slag, the impact value and crushing value was found to be around 9.33% and 15.42% respectively which is appropriate for highways construction as per to Indian road congress (IRC). While impact value and crushing value of recycled concrete aggregate was 24.69% and 31.47% respectively which are not as per the IRC's specifications. Marshall stability and the flow value of mix containing steel slag was found to be 990.6kg and 2.1mm respectively, which satisfies the IRC's guidelines.

On the other hand, stability and the flow value of the mix containing 100 % of recycled concrete aggregate (RCA) (692.33kg and 1.83mm respectively) was not found as per the IRC specifications. Though, the mix containing 50% RCA as the replacement of natural aggregates was showing the stability value around 1340.3l kg while flow value was found to be 1.96. Therefore, it can be concluded that properties of bitumen mix increase with the addition of rubber crumb up to 50% as the replacement of natural aggregate.

Prasad and Prasad (2009) conducted a study on the performance of waste tire rubber on the model flexible pavement. The materials used in the study were soil, fly ash gravel Road metal and waste tire rubber. Direct shear tests, California bearing ratio test and cyclic load tests were carried out. The results showed that Cohesion and angle of internal friction values for gravel materials were increased from 11. 79 to 27. 48 Kn/m square. And 35°C to 44°C respectively with 6.0 percent of waste tire rubber and after that it decreased. The Cohesion and angle of internal friction values were decreased from 7. 83 to 18. 61 KN/ meter square and 32°C to 38°C respectively for the fly ash with 6.0 percent of tire waste rubber chips and after that, it decreased. From this test, it was concluded that the optimum range of waste tire rubber for gravel and fly ash were 6% and 7% respectively California bearing ratio test results showed that for gravel and fly ash subbase materials, the values increased from 8.1 to 13. 33 and 5. 0 to 8. 71 for 6. 0% and 7. 0 % of waste tire rubber respectively.

Therefore, the optimum % of waste tire rubber for gravel and fly ash were 5% and 6% respectively. The cyclic load test results showed that the load carrying capacity had shown an upward increase in pavement made with waste tire rubber as a component. From the above study, it was concluded that the optimum % of waste tire rubber is 5% and 6 % of dry unit Wt. of soil respectively for gravel and fly ash material reinforced by tire waste rubber. The load carrying volume of the pavement reinforced with waste tire rubber increased and the gravel reinforced waste tire rubber model flexible pavement showed improved performance than fly ash subbase reinforced with waste tire rubber.

Pasandìn and Perez (2017) conducted a study on the performance of bituminous mixt made with recycled concrete aggregates and waste crumb tire rubber. The material used in this study were, bitumen, normal aggregates, and recycled concrete aggregates and waste rubber tire. In this study samples were made with inclusion of 0 %, 35% and 42% RCA. The specimens were made with varying optimum bitumen content (OPC) value i.e. 4% to 6% for different samples. The stiffness of the bituminous mix and fatigue life prediction was calculated. The test results showed that the type of strip loading is responsible for the split pattern. Results of the stiffness test depicted that the primary stiffness of the mix will achieve at hundred cycles against the primary micro-strain at the tenth cycle and the same trend was observed for all the samples. Later, bituminous mix of 35/50 grade containing CRMB was prepared (without addition of recycled concrete aggregates i.e. 0%) which was depicting higher stiffness value in comparison to the mix of same grade having 0% of CRMB and RCA. Consequently, it was concluded that the bitumen mixed having waste CRMB shows the higher stiffness. On addition of recycled concrete aggregates to the mixture in different proportion (35% and 42% recycled concrete aggregates), no difference was noticed in the property of the mix when compared to the normal mix (0% RCA and CRMB) and the bituminous mix of 35/50 grade having CRMB.

However, when recycled aggregates was not added to the mixture the properties of the bitumen were more prominent. From the results, it could be seen that fatigue life of the bituminous mixtures was getting increased due to the inclusion of recycled aggregates. Fatigue life of the bitumen mix of 35/50 grade containing rubber was found lower than the conventional mix of 35/50 grade. For recycled concrete aggregates, initial micro strain was found 303.1µm without addition of recycled concrete aggregates while addition of 35% recycled concrete aggregates was depicting 226.6µm initial micro-strain value. Consequently, increment in the initial macro strain value i.e. 264.7µm was observed with the addition of 42 % recycled concrete aggregates. Therefore, it could be seen that there was no co-relation b/w the initial macro-strain limit and recycled concrete aggregates % (%).

The result also showed that the recycled concrete aggregates % produced more changes in fatigue loss than the type of bitumen used. Consequently, during the ITFT test, fatigue mechanism was found prevalent instead of permanent formation mechanism because of the use of recycled concrete aggregates and the waste tire rubber as a good modifier. Fatigue life of the bitumen in the mixture was found to be increase with the increase in the % of recycled concrete aggregates. When waste rubber tire was used as a modifier, the fatty performance of hot mix asphalt (HMA) made with recycled concrete aggregates was found to be affected. Initially, the mixtures made with bitumen containing rubber of 35/50 grade was showing more fatigue life as comparison to mix made with only bitumen 35/50 grade. However, for initial macro-strain mixtures with bitumen containing rubber of 35/50m grade was depicting higher fatigue life.

Rokade (2012) also utilised the waste plastic and waste rubber tires in Flexible highway pavements. The material used in the study was crumbled rubber, low-density polyethylene (LDPE) and bituminous mix. The semi dense bituminous concrete was made using marshal method of bituminous mix design, using conventional 60/70 grade bitumen to which varying %s of LDPE was added and 60/70 grade bitumen added with different %s of CRMB. The results depicted that with 5% bitumen content, density, and Marshall Stability value were higher. Values for Flow value, Bulk Density, Air Voids, Voids in mineral aggregate (VMA), Voids filled with bitumen were within the parameters of MORT&H.

The test showed that 10% of CRMB of the wt. of bitumen is the best dose for improving the strength of the SDBC mix. The study concluded that Marshall Stability value has shown ascending value and the maximum value has reached by about 25% on addition of low-density polyethylene (LPDE) and (CRMB modified bitumen (CRMB). The density of mix has also increased in case of LDPE and CRMB when compared with 60/70 grade bitumen.

Reddy et al. (2017) performed a study on the properties of pavement using waste plastic in Road Construction. The materials used in the study were bitumen, waste polyethylene terephthalate, crushed granite (coarse aggregate). Marshall test was conducted to obtain a crushing value, impact value, los angeles abrasion value, flakiness index, Elongation index, the specific gravity of coarse aggregates, the specific gravity of fine aggregates, water absorption test values of aggregate. Similarly, physical properties of bitumen like penetration, softening point, ductility, flash point and fire point, specific gravity, and viscosity were also recorded. The optimum binder content was found to be 5.5% for 80/100 grade of bitumen with the stability value of 1190 kg. The flow value along with Maximum stability was 3. 6mm. Gm was found to be maximum of 2.394 gm/cc at 5.5% of bitumen. Percent air void (Vv) varied from 2.5% to 4% by different % from 5% to 6%. Vv was found to be 3.5% with the bitumen content of 5.5%. Plastic was added to the hot aggregate mix with a varying range of 0-12%.

The results showed that with the increase in the % of plastic waste the optimum stability was found to be in the range from 1930 to 1950 kg. The flow values varied from 4.0 to 4.5mm at 8% of plastic waste. The bulk density was found to be maximum b/w 2.29 to 2.35 gm/cc at 8% of waste plastic, and there was a decrease from 2.14 gm/cc at 12% plastic. The study concluded that the Vv was found to be 4.9%to 4.6% at 8% of plastic waste. The properties of bitumen were increased by adding 12%-14% plastic waste as compared to unmodified bitumen. This study also approached towards preserving our environment.

Sultana and Prasad (2012) performed a study on the use of waste plastic as a strength modifier in the surface course rigid and flexible pavement. The materials used in the study were waste polymer low-density polyethylene, High-density polyethylene and polypropylene (PP), bitumen 80/100 penetration grade, cement concrete and water. Plastic coated aggregates, polymer modified bitumen, and concrete cubes were prepared. Aggregate tests, Rheological tests, Performance tests were done on modified mix and unmodified mix.

The results showed, increase in properties of aggregates like impact value, abrasion value, and los-angeles abrasion value. On the basis of result, penetration and ductility value decreases and softening point value increases. Marshall stability test was conducted both on plastic coated aggregates and modified bitumen with waste material and marshall stability value increased by addition of waste material in mix. Loss of stability test resulted that mixes with an index of more than 75% were approved. On the basis of test report, properties of aggregates were improved by using waste material with aggregates. The rheological properties were also improved by adding waste plastic material to unmodified bitumen mix. Penetration and ductility value decreases and softening point value increases. The marshall stability test concluded that low-density polyethylene (LDPE) showed better values as compare to polypropylene (PP). The optimum value for low density poly ethylene was noted 8% for sample made with waste plastic material. On the basis of performance test there was an improvement in flexible pavements than rigid pavements.

Shedame and Pitale (2014) performed a study on bituminous concrete containing plastic waste material. The materials used in the study were aggregates of size (20mm, 10mm), bitumen (60/70grade), stone dust and cement as filler, waste plastic in shredded form. The penetration test, Ductility test, Specific gravity test, and Softening point test were performed on bitumen. On Aggregates Specific gravity, Water Absorption Test, Impact value test, Abrasion test, crushing value test, stripping value Test were conducted. Marshall stability test was carried out to determine the Optimum Binder content for bitumen content (BC) mixes. The properties that were checked in this test included stability, flow value, Bulk specific gravity, Air voids, Voids filled with bitumen and Voids in mineral aggregate. The Plastic Waste was added to 0% to 1% by the increment of 0.25%. Marshall specimen with varying waste plastic content was tested for Bulk density and Stability. The average Optimum Waste Plastic Content value was 0.76%.

The study concluded that when 0.76% plastic by wt. of aggregate and 3% filler was used, it improved the volumetric properties of bituminous mixes which resulted in better performance of BC with plastic waste. Addition of plastic increased the melting point of bitumen. Plastic roads idea was eco-friendly and also increased the road life along with being eco-friendly.

Sutradhar et al. (2015) utilized stone dust, waste concrete, and brick dust as filler material in the bituminous mix design. In this study coarse aggregate of size 2.36 mm, bitumen of grade 85/100, fine aggregates which were kept in 0.075mm sieve and waste filler material like fine sand and stone dust mix, waste concrete dust and brick dust was used as a material. For testing purpose, the marshal test was conducted.

According to the test result, the optimum bitumen content for brick dust and waste concrete dust was found similar to the conventional filler material. It was concluded that the waste concrete dust and brick dust is having the same properties as compared to conventional one and can be used as filler materials.

Somani et al. (2016) conducted a study on strengthening of the flexible pavement by using waste plastic and Rubber. The materials that were used in the study were low-density polyethylene (LDPE), CRMB, aggregate, and bitumen. For aggregate, the tests that were carried out were aggregate impact value test, aggregate crushing value test, flakiness, and elongation index test. For bitumen the tests that were carried out were penetration test, softening point test, ductility test, and viscosity test. Semi-dense bituminous concrete was prepared by adding conventional bitumen with different %s of LDPE and bitumen with the addition of different %s of CRMB.

The results depicted that the Marshall stability and the density will be increased with the addition of vitamin content was up to 6 %. All the other parameters or properties were found as per the specification of MORT&H. It was observed that the mixing of 8% LDPE and 6% bitumen content will result in the higher Marshall stability value (i.e. 945 kg with 3. 26 mm flow value).

Shaikh et al. (2017) conducted a study on the Use of Plastic Waste in Road Construction. The materials used in the study were bitumen 60/70, aggregates, cement, and shredded plastic waste of 2.36mm size. Marshall stability test was performed on both the modified and unmodified bituminous mix. On aggregate the tests performed were aggregate impact value, los angeles abrasion test, water absorption test, specific gravity test, stripping value test. On bitumen the tests performed were penetration value test, ductility test, flashpoint test, fire point test, Softening point test. Marshall stability test was then performed by adding plastic waste. The specific gravity increased from 2.5 to 2.66 and 2.77 on the addition of 10% and 15% plastic content respectively. Aggregate impact value decreased from 10.79% to 8.94% on addition of 15% plastic. Los Angeles abrasion value declined from 12.85% to 10.65% on addition of 15% plastic waste. Water absorption value decreased to 1.1% at the plastic waste of 15% and stripping value was decreased to nil by adding 15% plastic waste. On addition of 15%, plastic waste by wt. of bitumen the marshall stability value increased from 950kg to 1980kg, and the flow value increased from 3.1mm to 5mm at plastic waste of15% by wt. of bitumen.

Thus, the study conducted that modified mix improved the marshall characteristics. With the addition of plastic waste marshall stability value increased, flow value decreased, thus it could withstand heavy loads, hence, increasing the durability of roads and also preserving the environment. Recently,

Sharma et al. (2018) examined the performance of bituminous paving mix containing waste plastic. The material used was crushed basalt type of course aggregate 20 mm, crushed basalt type of fine aggregate 2.36 and down,80/100 penetration grade bitumen, basalt stone dust, and cement as a mineral filler. While the waste plastics namely polyethylene terephthalate (PET), polypropylene (PP), polystyrene (PS), polyvinyl chloride (PVC), low-density polyethylene (LDPE), high-density polyethylene (HDPE) was used in the shredded form. Marshall Stability test was carried out with varying % of plastic waste in order to check the stability of the mix. Later, a comparison b/w the results of BC (Bituminous concrete) mix with waste plastic and plain BC mix was made. Consequently, the stability value of optimum plastic content OPC (optimum plastic content) was found to be 30.1, which was much higher than the optimum bitumen content OBC (optimum bitumen content). The volume of voids in BC mix containing plastic waste was found lower than the plain BC mix. These results were within the parameters of MORT&H-2001 specifications.

The test concluded that the OPC mix showed higher stability as compared to OBC mix and intermolecular binding b/w bitumen and waste plastic enhances the strength, durability, and life of roads.

Sarma and Srikanth (2018) utilised waste polythene in the bituminous paving mix design. The materials used in the study were bitumen, aggregate and waste plastic. Marshall stability test was performed and carried out in two parts to determine optimum bitumen content (OBC) and optimum plastic content (OPC). Different samples were made with different ratio of bitumen, aggregates, and plastic. After that test was conducted at the temperature of 60°c to check the OBC which was found to be 5.8%. Later, disposed milk packets were used to determine OPC. In this. The specific gravity and softening point were taken from the report of milk packets manufacturer and report specified the specific gravity and softening point value around 0.92 and 115°C respectively. So according to the result, the value for plastic content corresponding to maximum stability was equal to 10%. The value of binder content corresponding to maximum bulk specific gravity was found to be equal to 7.5%. Average of the above values came out to be 8.75%.

The results from the test stated that, the OBC was 5.8% and the OPC was concluded to be 8.75%. Thus, it was concluded that addition of plastic waste material content in bitumen increases the stability as comparison to conventional bituminous mix.

Tiwari et al. (2018) conducted a study on modified bituminous binder using plastic waste. The materials utilized in the study were bitumen 60/70 grade, plastic waste (LDPE) shredded into the size of 2.36mm. Bitumen was modified by melting at a temperature of 150°c and adding shredded pieces of low-density polyethylene (LDPE) ranging b/w 2.36mm to 4.75mm. Different tests like penetration test, softening point test, ductility test were performed on modified bitumen. The results showed that penetration value of plastic modified bitumen was reduced by 19.4% for LPDE waste. By adding 2% and 4% plastic the penetration values were 65mm and 62mm, this led to an increase in strength and load-bearing capacity. Ductility value was decreased by about 21.79% for plastic modified bitumen. For 2% to 10% addition of plastic ductility value decreased from 75cm to 61cm. Softening point value increased by 18.6% when plastic was added.

The results showed that on the addition of 2% and 4% plastic the softening point in increased to 49°c and 52°c respectively. The study concluded that use of plastic waste in the proportion of 2% -4% gave penetration values and softening point under the IS code (IS-1203-1978) specifications. Adding 2%-4% plastic higher softening value of 52°c was obtained which helped in withstanding higher temperature susceptibility. In the same way decrease in penetration value gave higher load-bearing capacity. Addition of plastic waste to the bituminous mix also reduced its aging. Thus, it was proved that using plastic waste modified bituminous mix in road construction increased the durability of roads.

Wayal and Wagle (2013) investigated a study on the use of waste plastic rubber in aggregate and bitumen for road materials. The material used in this study was aggregate, bitumen, plastic, and rubber. Different tests were performed to calibrate different properties i.e. crushing values, impact value, abrasion value, the specific gravity of aggregate and bitumen penetration value, ductility, softening point. For checking moisture absorption and void measurement hot stone aggregates (150°c) is mixed with hot bitumen (170°c) and coated with rubber and plastic. This showed a decrease in porosity and improve in quality with respect to soundness, voids and moisture absorption. The soundness test confirmed that the plastic and rubber-coated aggregate didn't show any wt. loss. To study the aggregate impact value, the aggregate was coated with 1%and 2% plastics and rubber by wt. and then subjected to aggregate impact value test. It was seen that the coating of plastic and rubber on aggregate improves the quality. Los Angeles abrasion test found out that there was less wear and tear values of 1% and 2% plastic and rubber-coated aggregate as compared to conventional aggregates. Softening point, ductility and penetration point of bitumen was studied by heating bitumen 10-140 degrees, to this 10% and 20% plastic and crumbled rubber (split in 5%and 10%) was taken in proportion by wt.. Then these values were compared with the conventional values and found better. Hence proving that use of waste rubber and plastic increased the durability and life of roads lastly, Marshall stability test was performed to determine the stability of bituminous mix. For this 1200 GM's of mix was taken with thickness 63.5 mm, approximately 1200 GM's of filler and aggregate was heated at 180-200°C, the values were compared with the conventional mix. This study concludes that on adding 8% polymer and crumbled rubber in the blended mix, the Marshall test, flow(mm), Gmb(gm/cm3), AV (%), VMA (%)VFB (%) increases compared to conventional mix.

Vashisht and Saini (2017) utilized waste plastic and CRMB in the flexible pavement. In this study, the wet and dry process was adopted for preparing the modified bitumen. Samples were prepared according to the ministry of road transport and highway (MORT&H) specification. In the wet process, first bitumen was heated at the temperature of 160°C and temperature was recorded at the time of softening of material. Later, waste material was added in the mix for avoiding agglomeration in the material. In this % of modified agent vary from 1% to 16 %. In the dry process, it was only done with plastic waste by cutting it into small size of around 3mm-6mm and mixed with the aggregate at the temperature of 165°C. On the other hand, bitumen was heated at a temperature of 160°C for having good binding strength. After that sample was made with 8% of plastic waste and 16% of plastic waste. In the present study, CRMB was not utilized in order to make the sample because of the poor bonding quality (i.e. b/w CRMB and aggregates).

As per the result, impact value was found to be increased up to 10% due to the addition of plastic waste (i.e. worked as a coating material for aggregate). The specific gravity of plain and modified aggregates was found to be same while penetration value and ductility value of modified bitumen was lower than the conventional one.

Summary

On the basis of past studies, several methods were identified for utilizing different waste materials i.e. plastic waste, industrial waste, agricultural waste and many more in road construction resultant in a sustainable environment. Use of different waste materials as the replacement of bituminous was found appropriate for the road construction (flexible pavement) as different properties of bitumen were found to be increased or within the limit as specified by Indian standards. Therefore, waste material can be utilized in the construction of low volume roads (i.e. traffic movement will be minimum) which will be beneficial and economical. The main problem which hinders the development of such technologies is the absence of proper guideline of mix design procedures regarding the same. From the present study, it is revealed that the waste materials can be utilized to create a sustainable environment without compromising the actual requirements (i.e. strength). From the future point of view, a study can be extended by proposing an alternative of bitumen (based on waste material) for construction of flexible pavement or maximum utilization of waste material by mixing these wastes in the combined manner (by looking at their chemical properties) in order to replace the bitumen partially or fully.

2.3 Research Objectives

- Minimising the use of bitumen by partially replacing the bitumen with waste material like waste LDPE, HDPE, CRMB, motor oil, steel slag.
- Utilization of waste material in pavement construction to create sustainable environment, cost effectiveness without compromising with the requisite properties.
- Minimising greenhouse emission and landfill scarcity.

CHAPTER 3

METHODOLOGY

3.1 General

The project has been started by deciding the topic. When topic was decided then I started with reading journals related to my topic for literature review and for finding out the gaps and problems. After finding out, what we have to do in our project. I selected some material for project and started collecting material. After collecting all the material, I started testing the material with proper guideline and procedure of testing.

3.2 Methodology flow chart

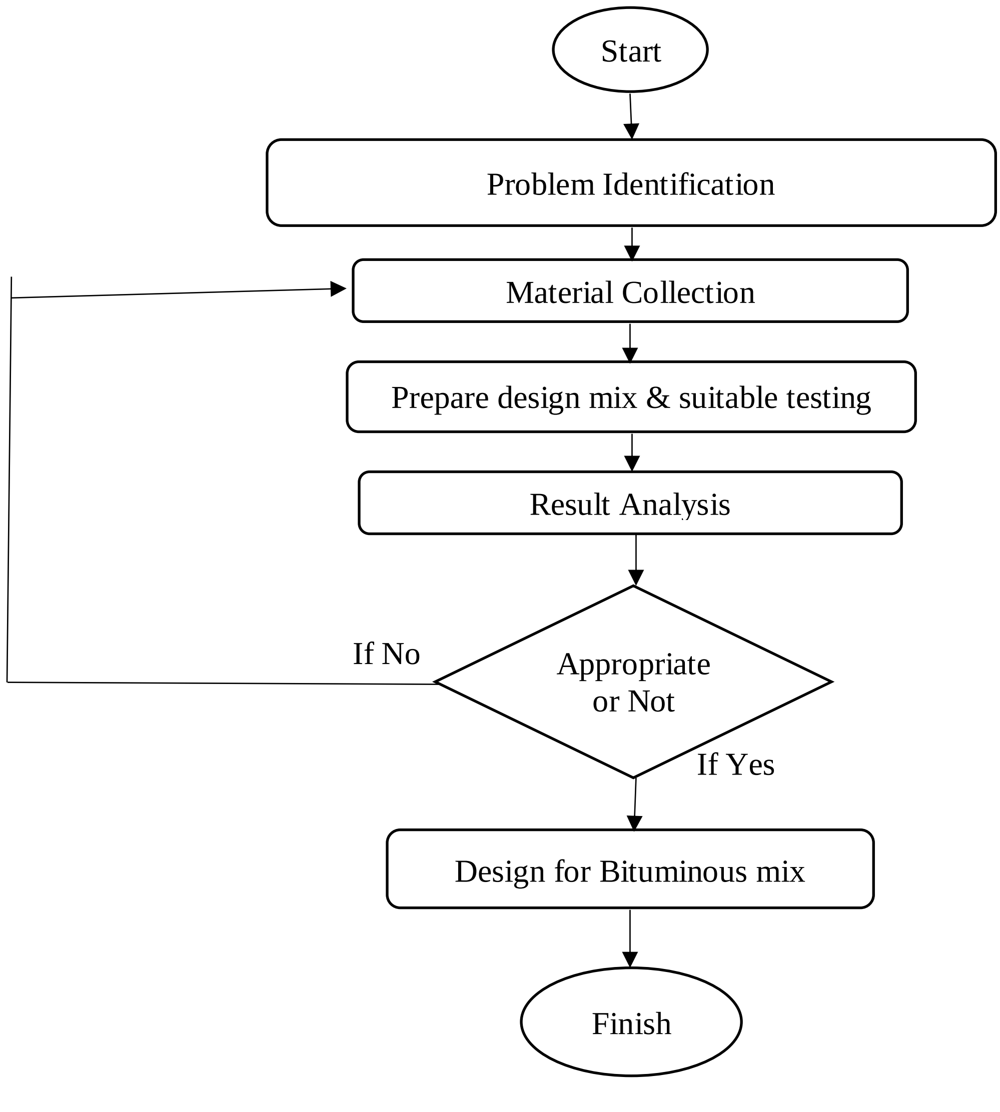

Figure 3.1 Methodology flow chart

3.3 Selection of Material

In the present study, VG10 or 80/100 penetration grade bitumen was selected with different waste material i.e. LDPE, HDPE, CRMB, Engine oil for testing process by making different samples of different compositions. In this study all the waste material selected with respect to their chemical compositions which are discussed in the next sub-section of the present chapter.

3.3.1 Chemical composition of bitumen

Chemical composition of bitumen has been tabulated in Table 3.1 below.

Table 3.1 Chemical Composition of bitumen (Raha Bitumen Co.)

Chemical elements	Element ranges	Unit
Carbon	80.2-84.3	%
Nitrogen	0.2-1.2	%
Hydrogen	9.7-10.7	%
Sulphur	0.8-6.8	%
Oxygen	0.5-1.1	%
Nickel	11-137	ppm
Vanadium	8-1595	ppm
Iron	6-149	ppm
Manganese	0.1-3.8	ppm
Calcium	1-335	ppm
Magnesium	1-134	ppm
Sodium	6-157	ppm

3.3.2 Chemical composition of Polyethylene (LDPE and HDPE)

Chemical composition of Polyethylene has been tabulated in Table 3.2 below.

Table 3.2 Chemical composition of Polyethylene (CHEMIK 2013, 67, 5, 435?445)

Chemical elements	Element %
Carbon	81.90
Nitrogen	0.45
Hydrogen	12.38
Sulphur	1.94
Oxygen	0.0
Calcium	0.98

3.3.3 Chemical composition of waste engine oil

Chemical composition of waste engine oil has been tabulated in Table 3.3 below.

Table 3.3 Chemical composition of waste engine oil (Ikhajiagbe, et.al P.,2014)

Chemical elements	**Weight (mg/kg)**
Iron	3253.65
Manganese	12.36
Zinc	54.13
Copper	33.53
Chromium	23.23
Lead	12.45
Nickel	11.84
Vanadium	8.21
Cadmium	24.85

3.3.4 Physical compositions of CRMB

Physical composition of CRMB has been tabulated in Table 3.4 below.

Table 3.4 Physical composition of CRMB (Behnia, A et.al ., 2017.)

Elements	**Elements %**
Acetone	9.3
Ash content	8.5
Carbon	28.1
Rubber hydro carbon	50.2
Heat loss	0.9
Metal content	0.8
Fibre content	1.5

3.3.5 Chemical composition of CRMB

Chemical composition of CRMB has been tabulated in Table 3.5 below.

Table 3. 5 Chemical composition of CRMB (Donga et.al., 2016.)

Elements	**Elements %**	**Unit**
Carbon	87.53	%
Oxygen	9.25	%
Zinc	1.75	%

Sulphur	1.07	%
Silicon	0.21	%
Magnesium	0.13	%
Aluminium	0.09	%

3.4 Waste production in India

On the basis of different studies and report India is producing different waste materials which can be used for road construction. According to report by FICCI, India generally produce 20 Kg plastic waste in a year. In this maximum waste comes from household items like plastic bags, plastic bottles and packaging material which are mainly of single use and these waste are impossible to decompose without recycling them. These waste are also polluting seas and land. According to the report of National rural road development agency, they constructed a road of 7600 km in 2016, which means construction of road by utilising waste plastic is a good option. According to the report of Lalatendu Mishra, there are around 1 billion of tyres made annually and same replaced in a year. According to the report, only 8% of waste tyres are recycled 10% tyres are burnt for fuel and 6 % tyres are send for other rubber processing and remaining 76% waste tyres are sent for illegally dumping and for landfill. According to this report, India generally produce 12 % of tyres annually. India is also recycling these waste tyres from last 3 decades but still 60% tyres are of no use. Utilization of waste tyre in construction of road can reduce the problem of landfill scarcity & can be dumped in useful manner.

On the basis of different reports, there are gallons of waste oil produced annually by vehicles in India. There are many waste oil recycling plants in India, which can only recycle up to 50% of waste engine oil and other 50% is totally waste. This waste oil can be utilised with bituminous mix for laying in road construct which can reduce the cost of road construction and waste can be utilised in a good manner.

3.5 Methods for testing samples or construction of roads

1. Dry Process
2. Wet process

1. Dry Process:

In dry process aggregates are heated up at particular temperature and shredded pieces or liquid of waste material added in hot aggregates chamber for giving them glossy look when covers the aggregates then bitumen will add to the hot aggregates for making bituminous mix. Generally, this process is use for constructing of roads.

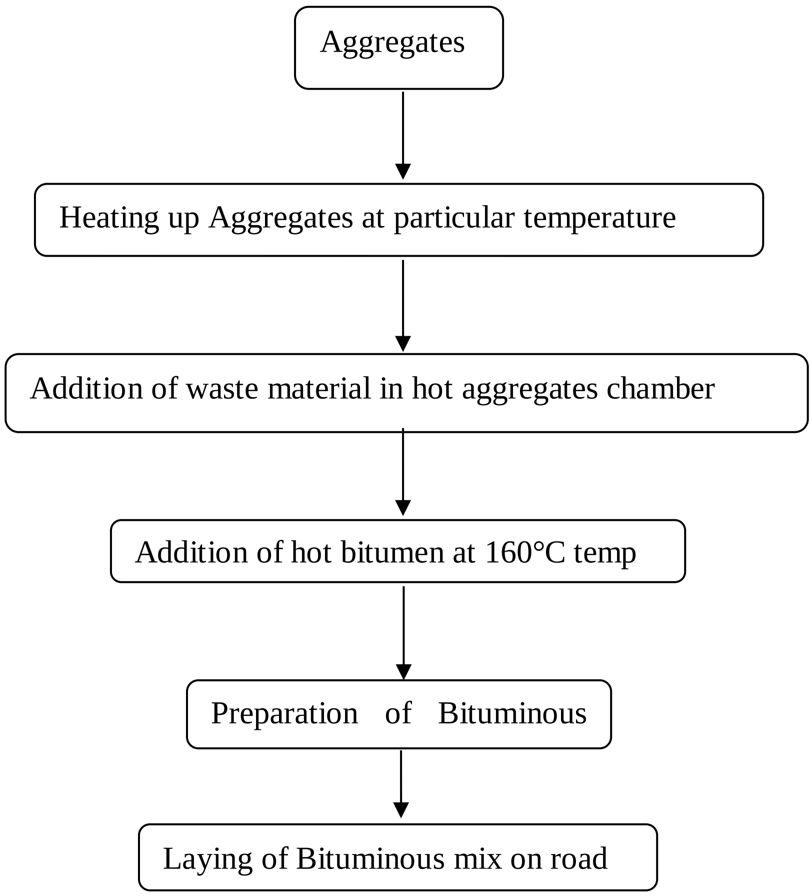

Figure 3.2 Flow chart of dry process

2. Wet Process

In this process bitumen is heat up at around 160°C and shredded pieces of waste material is added in hot bitumen for mixing waste with bitumen after that aggregates added in bitumen mix with aggregates. Generally, this process of construction of road is rarely use.

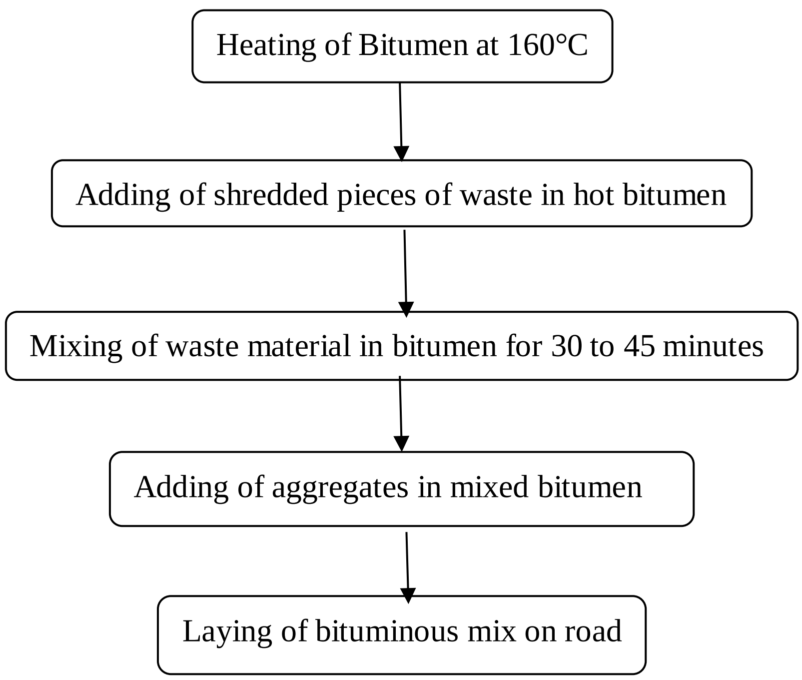

Figure 3.3 Flow chart of wet process

3.6 Test conducted on bitumen with different waste by using wet process

1. **Penetration test (IS 1203,1978)**

   Penetration test of bitumen is done by using apparatus penetrometer. It is done by following proper guideline of IS 1203. Penetration test is done for knowing the hardness or the consistency of bituminous mix. There are different grades of bitumen which are having different penetration value.eg. 80/100 penetration grade means penetration value lies b/w 80 to 100. Penetration test is done in specified load, time, and temp. and reading are comes in millimetre(mm).

2. **Ductility test (IS 1208,1978)**

   The ductility test is done to measure a strength of bitumen. It is done for finding out the ability of stretching of bitumen. Ductility is an important part of construction of road. If ability of stretching of bitumen is less, then cracks can come in road due to less strength in bituminous material. Ductility test result is measured in cm and test of sample is done at specified speed and temperature. For performing ductility test, IS 1208 is followed.

3. **Softening point test (IS 1205,1978)**

   Softening pt. test is done for finding out the softening temperature of bitumen. Its id done by following IS 1205. Softening point test is done by using ring and ball apparatus. Softening point is noted when sample is unable to take the wt. of ball and touches the steel plate.

4. **Specific gravity test (IS 1202,1978)**

   Specific gravity test of bitumen may define as the ratio of mass of specific volume of bituminous material at specific temperature which is equal to volume of water at same temperature. It is done by using density bottle and by following IS 1202.

These test were conducted according to IS standards by making different samples of waste LDPE with bitumen.

3.7 Material used for sample preparation.

In this different samples were made with 0%, 3%, 6%, and 9% LDPE waste, 0% ,2%, 4%, 6%, 8% and 10% engine oil, 0%, 2%, 5%, 8%, 10% CRMB powder, 0%, 2%, 5%, 7% and 9% Of HDPE waste and mixed composition of 2% LDPE + 3% HDPE + 4% Engine oil, 3% HDPE + 4% Engine oil + 5% CRMB powder, 4% Engine oil + 5% CRMB powder + 2% LDPE and 5% CRMB powder + 2% LDPE + 3% HDPE with VG 10 or 80/100 bitumen grade and conducted different test for result and comparison b/w samples.

Fig. 3.4 shredded pieces of waste LDPE

3.8 Sample preparation

In this, wet process was carried out for conducting different tests. So first bitumen was heated up at hot plate for melting after few minutes the bitumen was heated up on induction plate at temperature 160°C. when bitumen started boiling then shredded pieces of waste material was added in it and mixed up for 30 minutes. When mixing was completely done then the bitumen was added in different mould for carrying out different tests. After that I kept the mould for 30 minutes for cooling down then putted into water bath chamber at 25°C temperature for 1 hour and after 1 hour different tests of bitumen penetration test, specific gravity test, softening point test, ductility test was carried out.

CHAPTER 4.

RESULTS ANALYSIS

4.1 General

In the present chapter, result analysis of different test which were conducted for bitumen by using different composition of waste i.e. LDPE, CRMB and waste engine oil gas has been done in order to find out the optimum usage value as the replacement of bitumen.

4.2 Testing of bitumen with waste LDPE

4.2.1 Penetration test result of bituminous mix with waste LDPE

Penetration test carried out by following proper guideline of IS code IS 1203 with different sample of bitumen with 0%, 3%, 6%, and 9% LDPE.

Table 4.1 Penetration test result of bitumen with waste LDPE

Samples with different compositions	Test result
0%	80
3%	45
6%	60
9%	85
12%	70

Fig. 4.1 Penetrometer

Fig. 4.2 Sample for penetration test

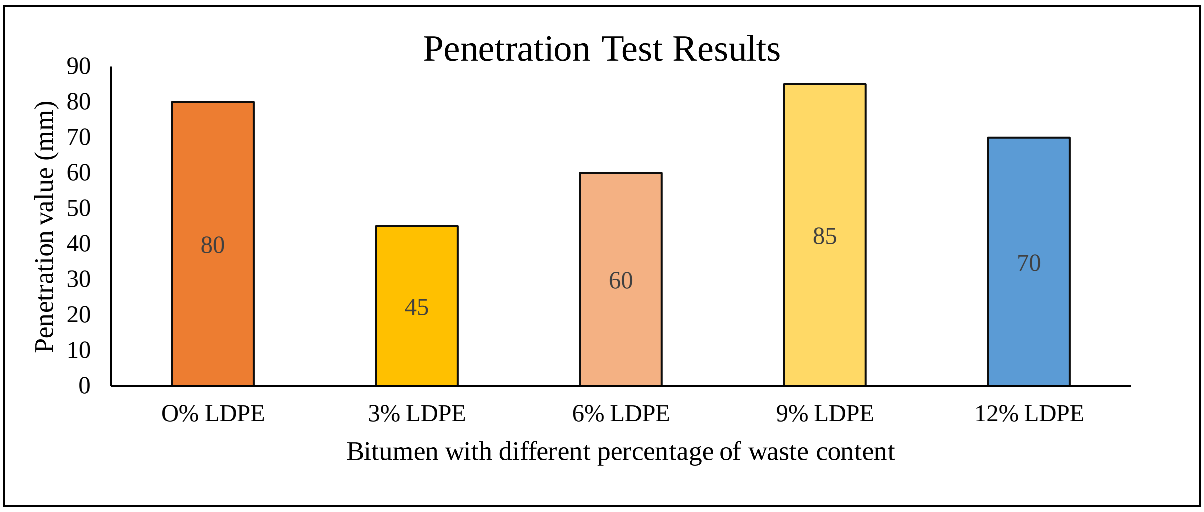

Fig. 4.3 Penetration test result graph

The Penetration test which was conducted by using penetrometer shows that, samples having 0% LDPE is having maximum penetration value. According to the results the LDP is lowering the penetration value of VG 10 grade bitumen but penetration value is increasing by increasing the LDPE content in bitumen sample.

4.2.2 Ductility test result of bitumen with waste LDPE

Ductility test was done with proper guideline of IS 1208 with different samples of bitumen with 0%, 3%, 6%, 9% samples.

Table 4.2 Ductility test result of bitumen with waste LDPE

Samples with different compositions	Test result
0%	75 cm
3%	77 cm
6%	78 cm
9%	80 cm
12%	75 cm

Fig. 4.4 Ductility test sample

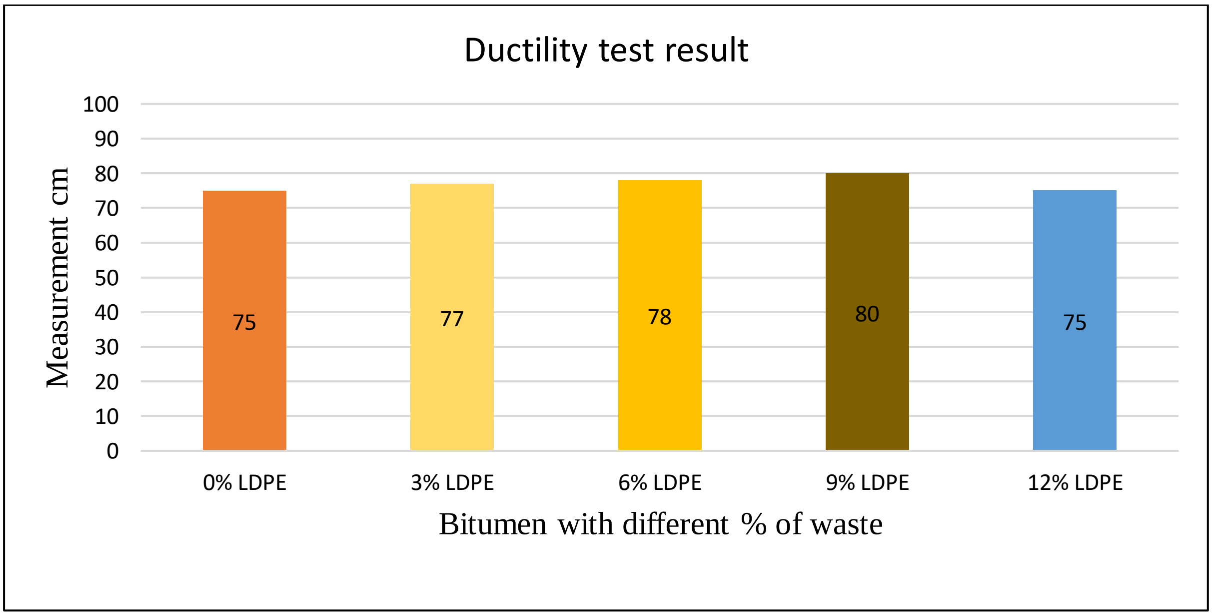

Fig. 4.5 Ductility test result graph

The ductility test which was done by following IS 1208 and done by using ductility testing machine shows that the increase of waste LDPE content in bituminous mix is increasing the ductility value of modified bitumen which is showing more strength in bitumen with more waste LDPE content.

4.2.3 Softening point test result of bitumen with waste LDPE

Softening point test was conducted with different samples 0%, 3%, 6%, and 9% of LDPE mixed with bitumen and there are different results of samples which are

Table 4.3 Softening point test result of bitumen with waste LDPE

Sample with different compositions	Test result
0%	46°C
3%	59°C
6%	55°C
9%	49°C
12%	52°C

Fig. 4.6 Softening point test apparatus

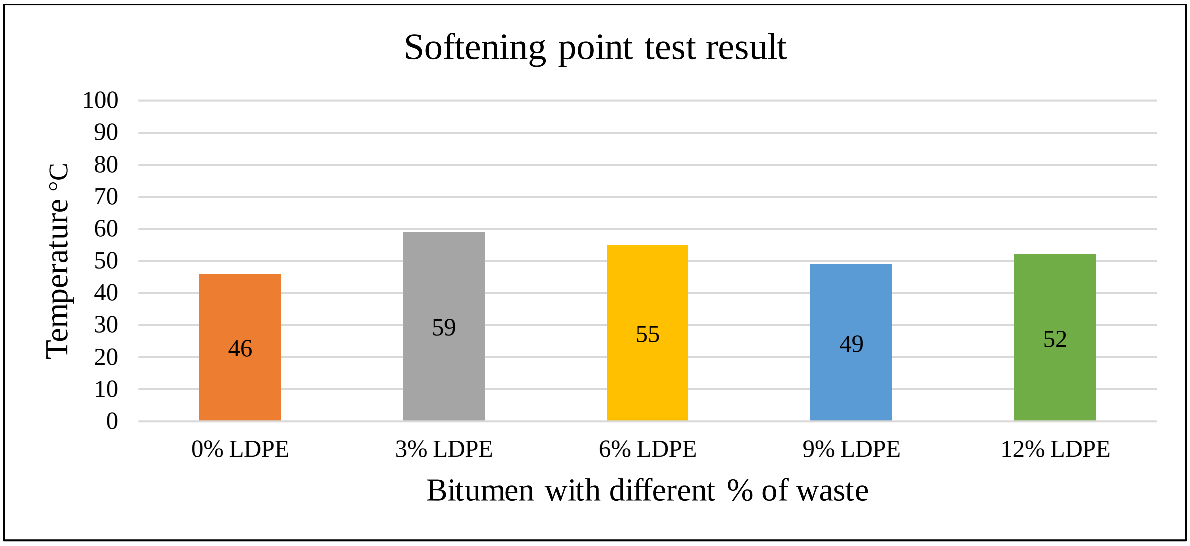

Fig. 4.7 Softening point test result graph

The softening point test done was by following IS code IS-1205. The test was conducted by using ring and ball apparatus with different samples 0%, 3%, 6%, 9% LDPE waste with bitumen. According to the test result, increasing content of waste LDPE in bitumen increasing the softening temperature of bitumen.

4.2.4 Specific gravity test result of bitumen with waste LDPE

Specific gravity test result was conducted by two different specific gravity bottles of different size for different samples 0%, 3%, 6%,9% of LDPE waste mixed with bitumen and result is as follow.

Table 4.4 specific gravity test result of bitumen with waste LDPE

Sample with LDPE waste	Wt. of empty bottle	Wt. of bottle with distilled water	Wt. of bottle with half-filled bitumen	Wt. of bottle with bitumen and distilled water	Specific gravity calculation
0%	55gm	114gm	80gm	115gm	1.04
3%	55gm	114gm	80gm	115gm	1.04
6%	30gm	84gm	64gm	85gm	1.03
9%	30gm	84gm	64gm	85gm	1.03

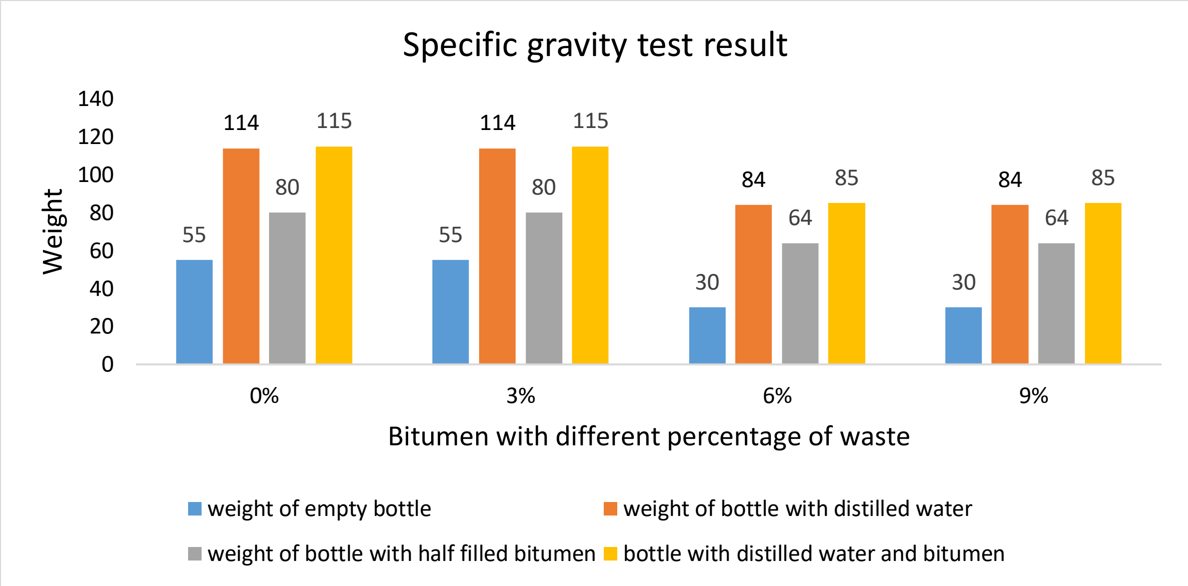

Fig. 4.8 specific gravity test result graph

In specific gravity test, test was conducted with two different bottles and different samples of modifies bitumen and result of all four samples were almost same.

4.2.5 Marshall stability test result of bitumen with waste LDPE

Marshall stability test result was conducted by making sample of bitumen with different compositions of waste material which was 0%, 3%, 6%,9% of LDPE waste, which was mixed with bitumen. In this different size of aggregates were taken by following proper guideline and result is as follow.

Table 4.5 Marshall stability test result with waste LDPE

Bitumen Content in %	Stability of conventional mix 0% (KN)	Stability of mix having 3% LDPE waste	Stability of mix having 6% LDPE waste	Stability of mix having 9% LDPE waste	Stability of mix having 12 % LDPE Waste
3	5.4	5.1	5.6	6.1	5.9
4	7.1	5.8	6.2	6.8	6.9
5	6.2	6.5	6.7	6.8	6.4

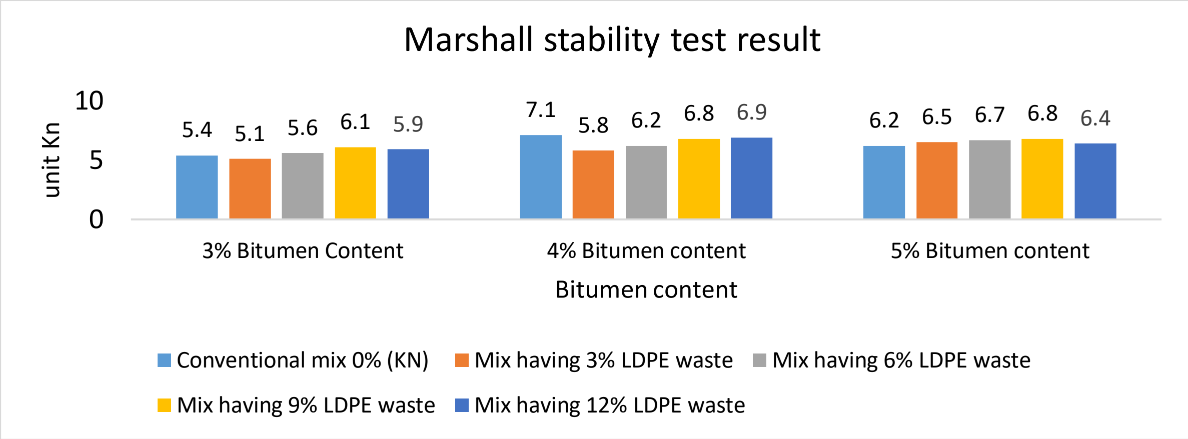

Fig. 4.9 Marshall stability test result graph with waste LDPE

Marshall stability test was conducted with four different samples and according to the result, sample having 9% of LDPE waste is showing maximum stability value.

4.3. Testing of bitumen with waste engine oil

4.3.1 Penetration test result of bitumen with waste engine oil

Penetration test carried out by following proper guideline of IS code IS 1203 by making different sample of bitumen with 0%, 2%, 4%, 6%, 8% and 10 % waste engine oil.

Table 4.6 Penetration test result of bitumen with waste engine oil

Samples with different compositions	Test result
0%	80
2%	55
4%	65
6%	80
8%	90
10%	85

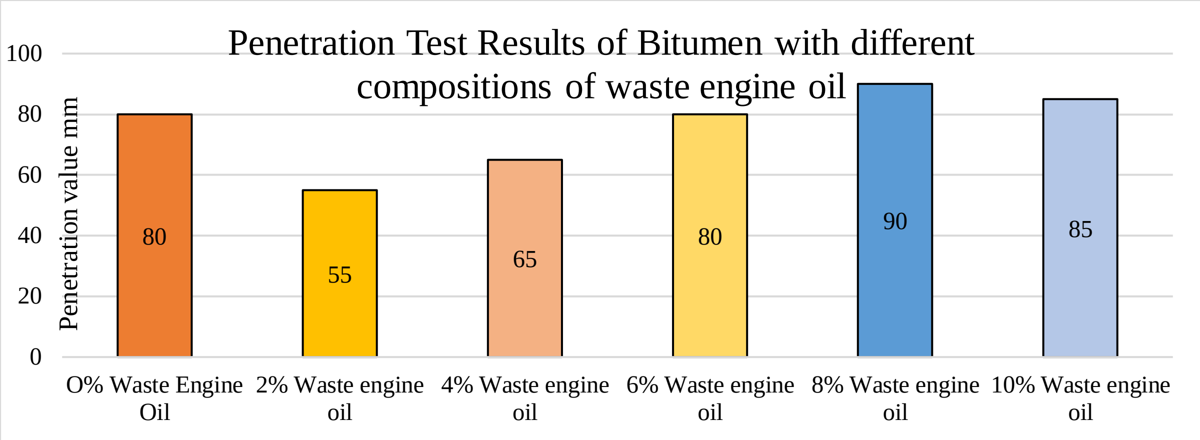

Fig. 4.10 Penetration test result graph of bitumen with waste engine oil

The Penetration test which was conducted by using penetrometer shows that, samples having 8% waste engine oil is having maximum penetration value. According to the results the waste engine oil is lowering the penetration value of VG 10 grade bitumen but penetration value is increasing by increasing the waste engine oil content in bitumen sample till 8% of waste engine oil content.

4.3.2 Ductility test result of bitumen with waste Engine oil

Ductility test was done with proper guideline of IS 1208 by making different samples of bitumen with 0%, 2%, 4%, 6%, 8% and 10% of waste engine oil.

Table 4.7 Ductility test result of bitumen with waste engine oil

Samples with different compositions	Test result
0%	75 cm
2%	60 cm
4%	63 cm
6%	70 cm
8%	76 cm
10%	72 cm

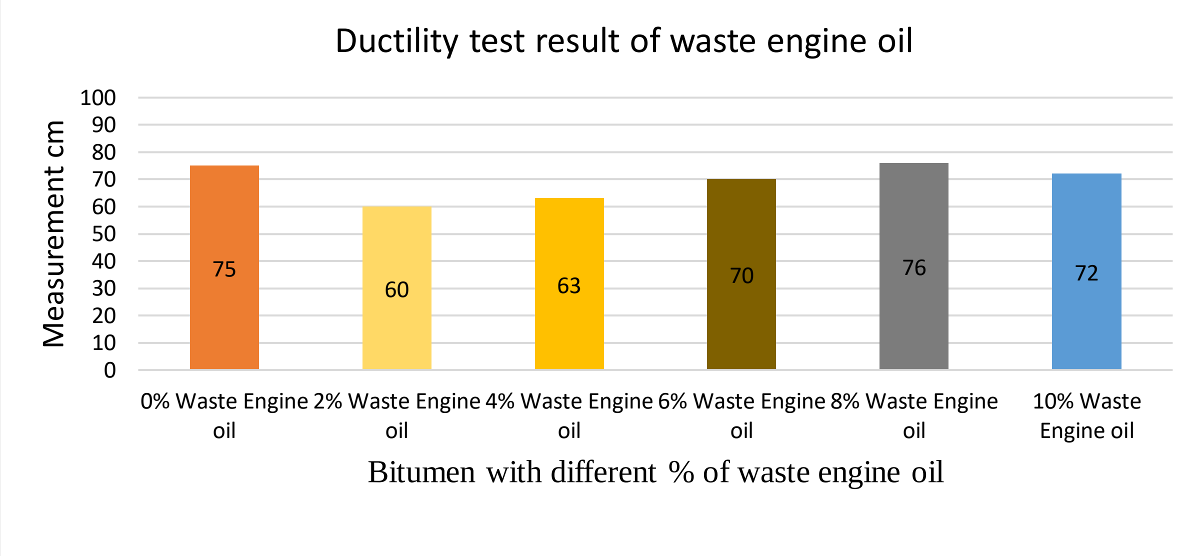

Fig. 4.11 Ductility test result graph

The ductility test which was done by following IS 1208 and done by using ductility testing machine shows that the increase of waste engine oil content in bitumen is increasing the ductility value of modified bitumen till 6% of waste engine oil content and it is showing more strength in bitumen with 6% of waste engine oil content.

4.3.3 Softening point test result of bitumen with waste Engine Oil

Softening point test was conducted with different samples 0%, 2%, 4%, 6%, 8% and 10% of waste engine oil mixed with bitumen and there are different results of samples which are

Table 4.8 Softening point test result of bitumen with waste engine oil

Sample with different compositions	Test result
0%	46°C
2%	55°C
4%	53°C
6%	52°C
8%	48°C
10%	51°C

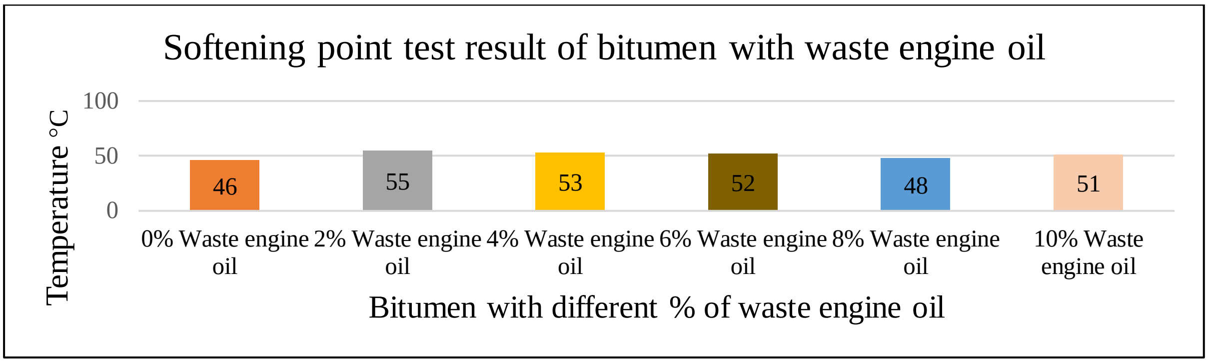

Fig. 4.12 Softening point test result graph

The softening point test done was by following IS code IS-1205. The test was conducted by using ring and ball apparatus with different samples 0%, 2%, 4%, 6%, 8%, and 10% waste engine oil with bitumen. According to the test result, increasing content of waste in bitumen increasing the softening temperature of bitumen till 6% of waste engine oil content.

4.3.4 Specific gravity test result of bitumen with waste engine oil

Specific gravity test result was conducted by two different specific gravity bottles of different size for different samples 0%, 2%, 4%, 6%, 8%, and 10% of waste Engine oil mixed with bitumen and result are as follow.

Table 4.9 Specific gravity test result of bitumen with waste engine oil

Sample with Engine oil waste	Wt. of empty bottle	Wt. of bottle with distilled water	Wt. of bottle with half-filled bitumen	Wt. of bottle with bitumen and distilled water	Specific gravity calculation
0%	55gm	114gm	80gm	115gm	1.03
2%	43gm	95gm	78gm	95gm	0.97
4%	30gm	84gm	64gm	85gm	1.03
6%	30gm	84gm	64gm	85gm	1.03
8%	35gm	88gm	72gm	93gm	1.04
10%	55gm	114gm	80gm	115gm	1.03

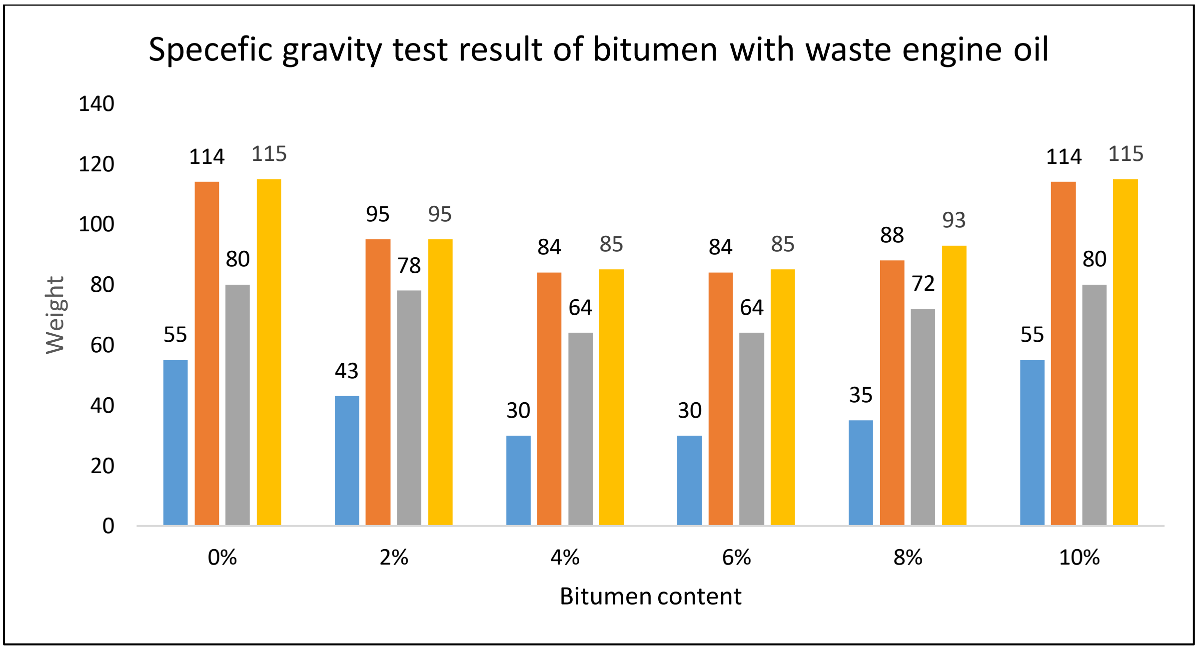

Fig. 4.13 Specific gravity test result graph

In specific gravity test, test was conducted with different size of bottles and different samples of modified bitumen and result of all samples were almost same.

4.3.5 Marshall stability test result of bitumen with waste Engine oil

Marshall stability test result was conducted by making sample of bitumen with different compositions of waste material which was 0%, 2%, 4%,6%,8% and 10% of Engine oil waste, which was mixed with bitumen. In this different size of aggregates were taken by following proper guideline and result is as follow.

Table 4.10 Marshall Stability test result of bitumen with waste engine oil

Bitumen Content in %	Stability of conventional mix 0% (KN)	Stability of mix having 2% Engine oil waste	Stability of mix having 6% Engine oil waste	Stability of mix having 8% Engine oil waste	Stability of mix having 10 % Engine oil waste
3	5.4	Sample failed	5.7	5.9	5.4
4	7.1	Sample failed	6.3	7.3	6.1
5	6.2	Sample failed	6.5	6.7	6.4

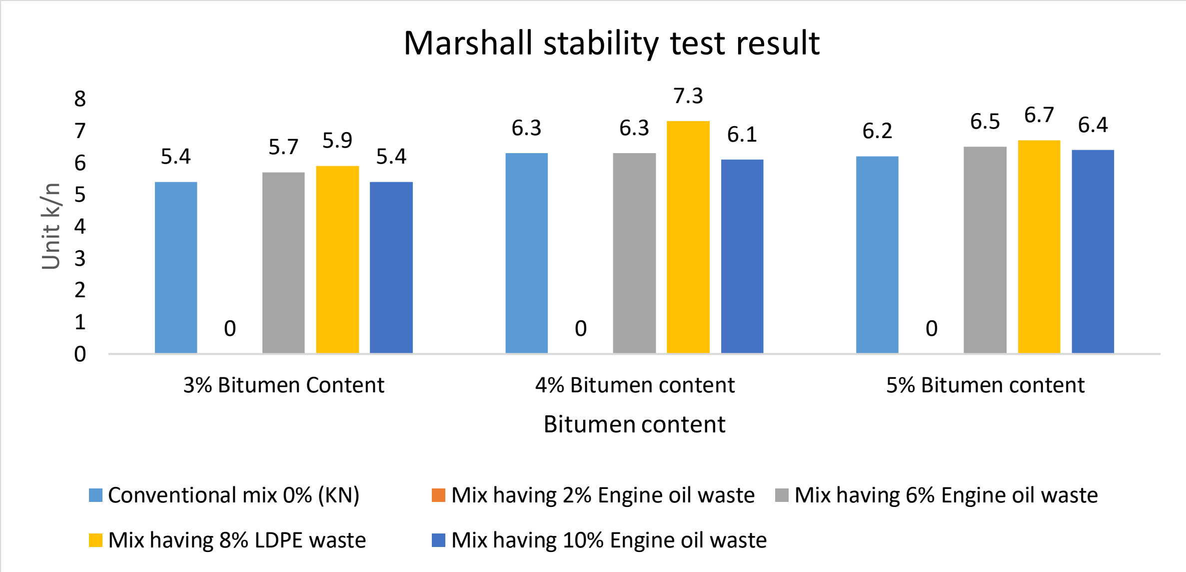

Fig. 4.14 Marshall stability test result graph

Marshall stability test was conducted with three different samples and according to the result, sample having 8% of Engine oil waste is showing maximum stability value.

4.4 Testing of bitumen with waste CRMB powder

4.4.1 Penetration test result of bitumen with waste CRMB

Penetration test carried out by following proper guideline of IS code IS 1203 by making different sample of bitumen with 0%, 2%, 5%, 8 % and 10% of waste CRMB.

Table 4.11 Penetration test result of bitumen with waste CRMB

Samples with different compositions	Test result
0%	80
2%	35
5%	65
8%	85
10%	80

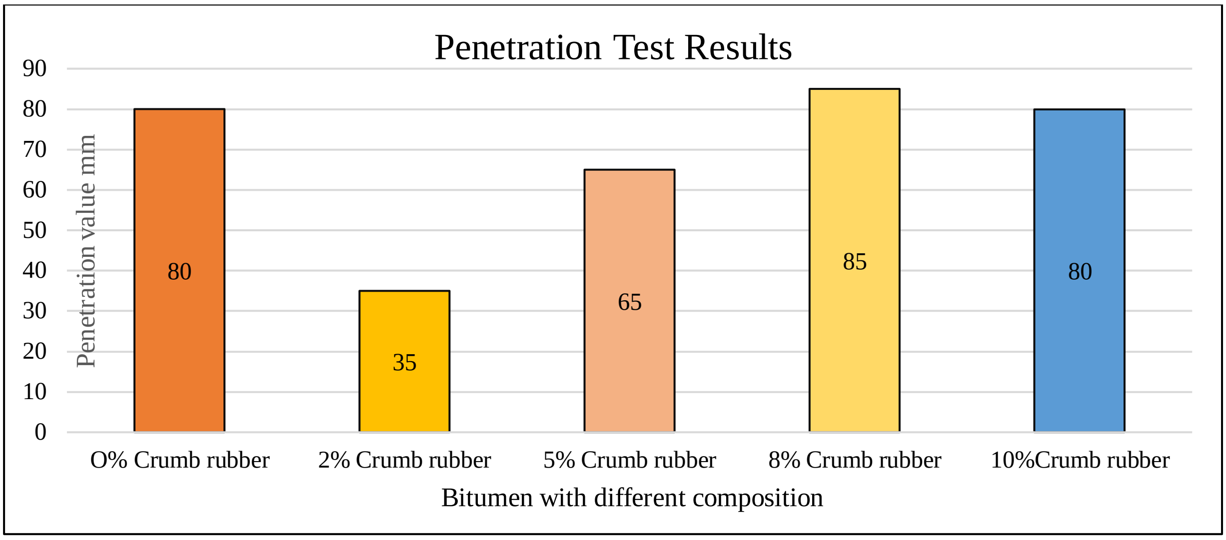

Fig. 4.15 Penetration test result graph of bitumen with waste CRMB

The Penetration test which was conducted by using penetrometer shows that, samples having 8% waste CRMB is having maximum penetration value. According to the results the waste CRMB is lowering the penetration value of VG 10 grade bitumen but penetration value is increasing by increasing the waste content in bitumen sample till 8% of content.

4.4.2 Ductility test result of bitumen with waste CRMB.

Ductility test was done with proper guideline of IS 1208, by making different samples of bitumen with 0%, 2%, 5%, 8% and 10% of waste CRMB powder.

Table 4.12 Penetration test result of bitumen with waste CRMB

Samples with different compositions	Test result
0%	75 cm
2%	30 cm
5%	52 cm
8%	77 cm
10%	59 cm

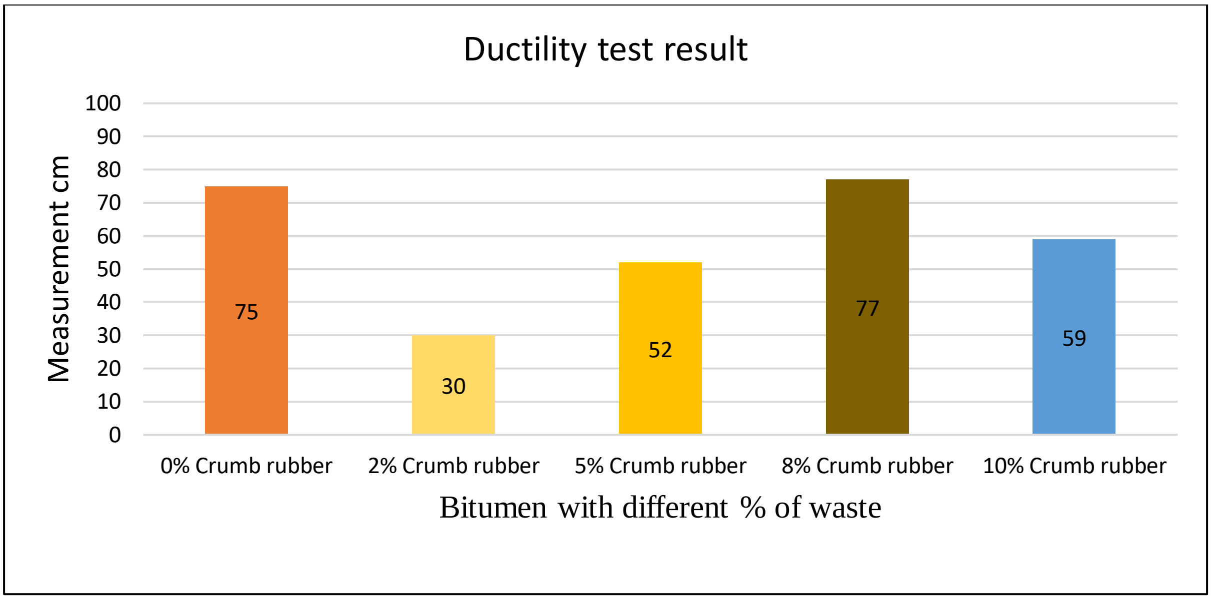

Fig. 4.16 Ductility test result graph of bitumen with waste CRMB

The ductility test which was done by following IS 1208 and done by using ductility testing machine shows that the increase of waste CRMB content in bitumen is increasing the ductility value of modified bitumen till 8% of waste CRMB content and it is showing more strength in bitumen with 8% of waste CRMB content.

4.4.3 Softening point test result of bitumen with waste CRMB powder

Softening point test was conducted with different samples 0%, 2%, 5%, 8% and 10% of waste CRMB mixed with bitumen and there are different results of samples which are

Table 4.13 Softening point test result of bitumen with waste CRMB powder

Sample with different compositions	Test result
0%	46°C
2%	58°C
5%	53°C
8%	47°C
10%	52°C

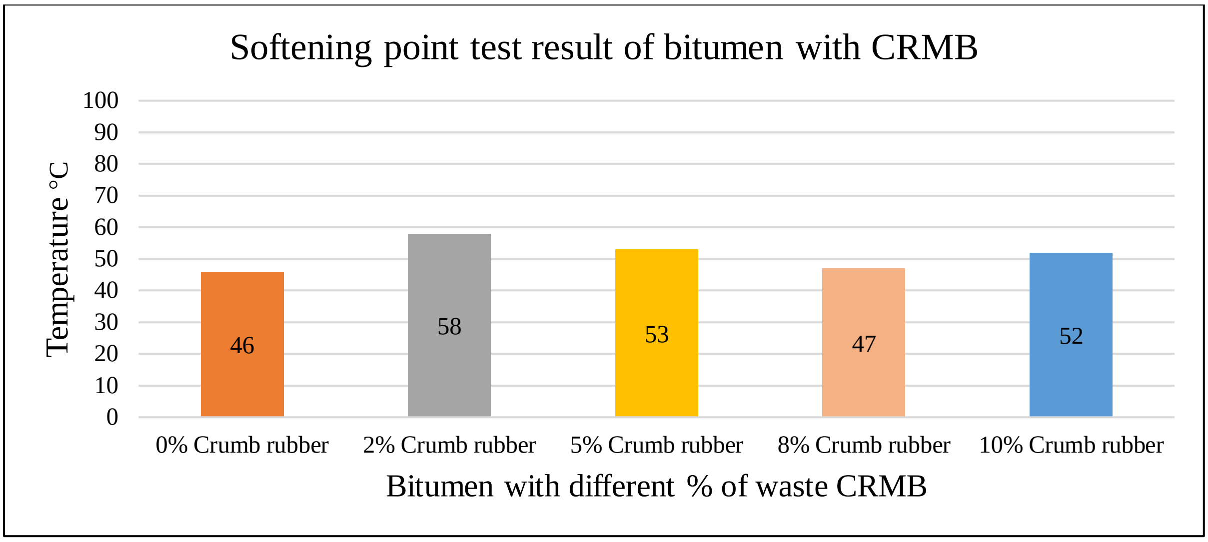

Fig. 4.17 Softening point test result graph of bitumen with waste CRMB powder

The softening point test done was by following IS code IS-1205. The test was conducted by using ring and ball apparatus with different samples 0%, 2%, 5%, 8%, and 10% waste CRMB with bitumen. According to the test result, increasing content of waste in bitumen, increasing the softening temperature of bitumen till 8% of waste CRMB content.

4.4.4 Specific gravity test result of bitumen with waste CRMB powder

Specific gravity test result was conducted by two different specific gravity bottles of different size for different samples 0%, 2%, 5%, 8% and 10% of waste CRMB powder mixed with bitumen and result are as follow.

Table 4.14 Specific gravity test result of bitumen with CRMB powder

Sample with Engine oil waste	Wt. of empty bottle	Wt. of bottle with distilled water	Wt. of bottle with half-filled bitumen	Wt. of bottle with bitumen and distilled water	Specific gravity calculation
0%	55gm	114gm	80gm	115gm	1.03
2%	39gm	98gm	64gm	99gm	0.97
5%	32gm	85gm	67gm	87gm	1.06
8%	35gm	94gm	60gm	95gm	0.99
10%	55gm	114gm	80gm	115gm	1.03

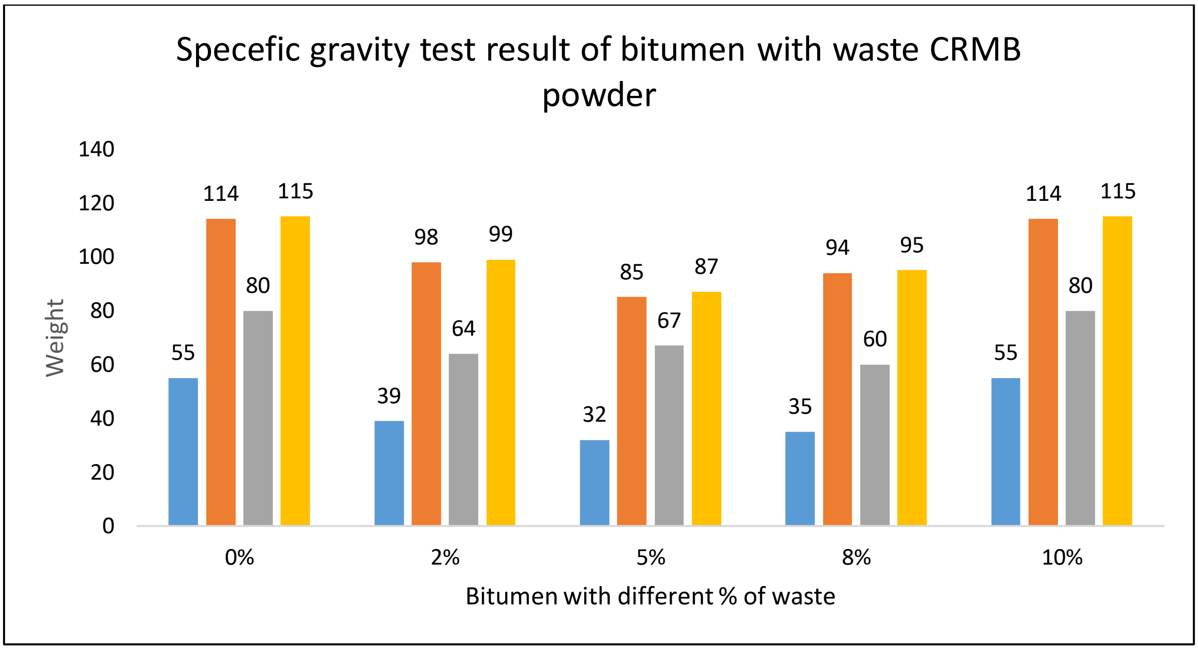

Fig. 4.18 Specific gravity test result of bitumen with CRMB powder

In specific gravity test, test was conducted with different size of bottles and different samples of modified bitumen and result of all samples were almost same.

4.4.5 Marshall stability test result of bitumen with waste CRMB powder

Marshall stability test result was conducted by making sample of bitumen with different compositions of waste material which was 0%, 2%, 5%,8% and 10% of CRMB waste, which was mixed with bitumen. In this different size of aggregates were taken by following proper guideline and result is as follow.

Table 4.15 Marshall Stability test result of bitumen with CRMB

Bitumen Content in %	Stability of conventional mix 0% (KN)	Stability of mix having 2% CRMB waste	Stability of mix having 5% CRMB waste	Stability of mix having 8% CRMB waste	Stability of mix having 10 % CRMB Waste
3	5.4	5.5	5.9	6.3	6.5
4	7.1	6.8	7.3	7.4	7.2
5	6.2	6.4	6.5	6.7	6.9

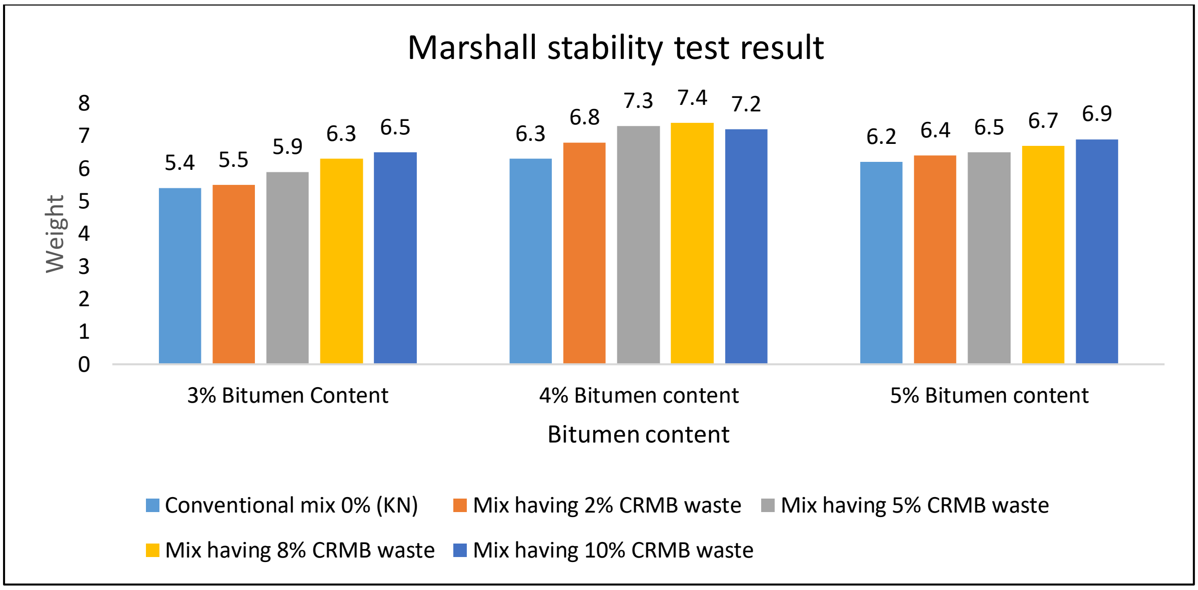

Fig. 4.19 Marshall stability test result graph

Marshall stability test was conducted with four different samples and according to the result, sample having 8% of CRMB is showing maximum stability value.

4.5 Testing of bitumen with High Density Poly ethylene (HDPE)

4.5.1 Penetration test result of bitumen with waste HDPE

Penetration test carried out by following proper guideline of IS code IS 1203 by making different sample of bitumen with 0%, 2%, 5%, 7 % and 9% of waste HDPE.

Table 4.16 Penetration test result of bitumen with waste HDPE

Samples with different compositions	Test result
0%	80
2%	45
5%	70
7%	80
9%	65

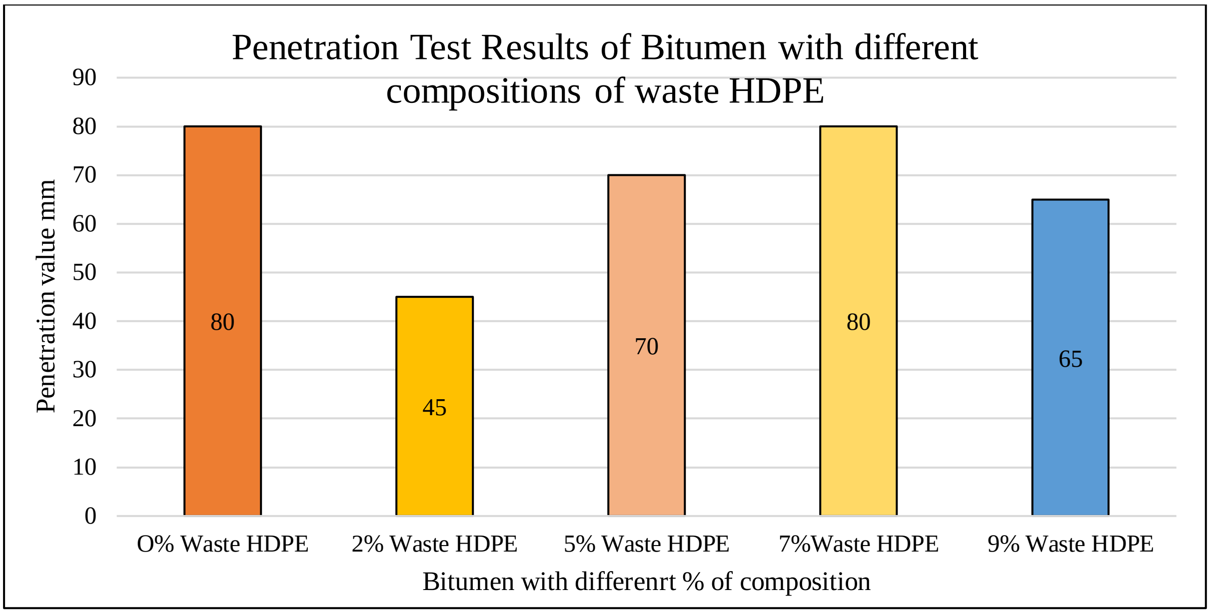

Fig. 4.20 Penetration Test Results graph of Bitumen with different compositions of waste HDPE

The Penetration test which was conducted by using penetrometer shows that, samples having 7% waste HDPE is having maximum penetration value. According to the results the waste HDPE is lowering the penetration value of VG 10 grade bitumen but penetration value is increasing by increasing the waste content in bitumen sample till 7% of content.

4.5.2 Softening point test result of bitumen with waste CRMB powder

Softening point test was conducted with different samples 0%, 2%, 5%, 7% and 9% of waste HDPE mixed with bitumen and there are different results of samples which are

Table 4.17 Softening point test result of bitumen with waste HDPE

Sample with different compositions	Test result
0%	46°C
2%	57°C
5%	51°C
7%	48°C
9%	50°C

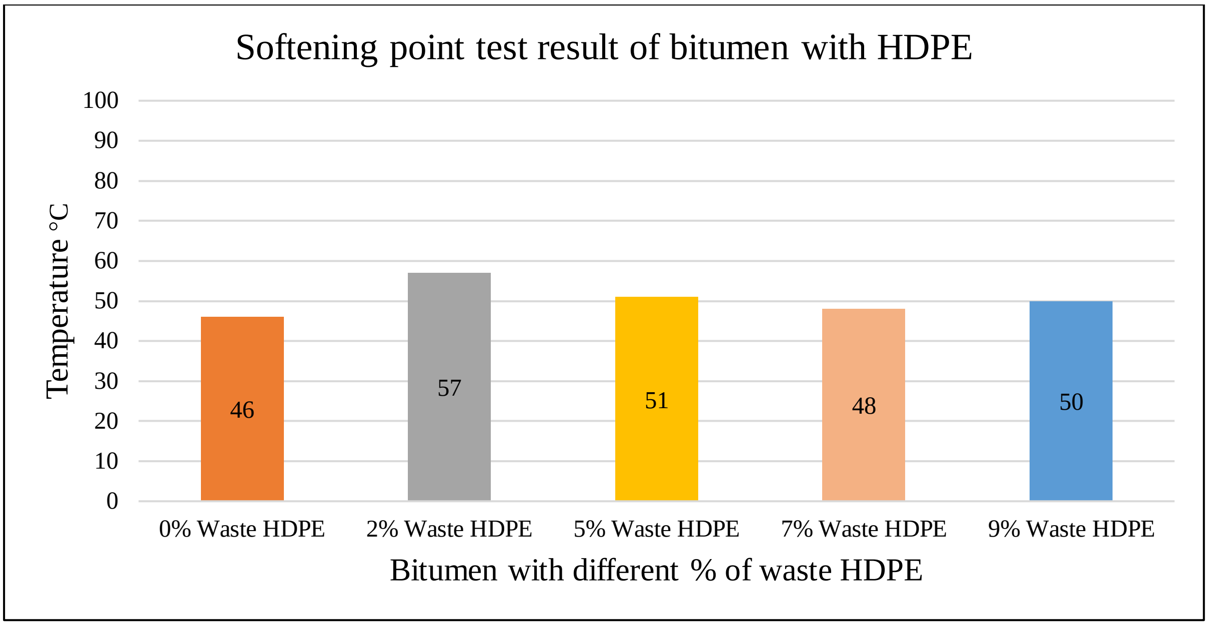

Fig. 4.21 Softening point test result of bitumen with HDPE

The softening point test done was by following IS code IS-1205. The test was conducted by using ring and ball apparatus with different samples 0%, 2%, 5%, 7%, and 9% waste HDPE with VG10 bitumen. According to the test result, increasing content of waste in bitumen, increasing the softening temperature of bitumen till 7% of waste HDPE content.

4.5.3 Ductility test result of bitumen with waste HDPE.

Ductility test was done with proper guideline of IS 1208, by making different samples of bitumen with 0%, 2%, 5%, 7% and 9% of waste HDPE.

Table 4.18 Ductility test result of bitumen with waste HDPE.

Samples with different compositions	Test result
0%	75 cm
2%	37 cm
5%	57 cm
7%	78 cm
9%	73 cm

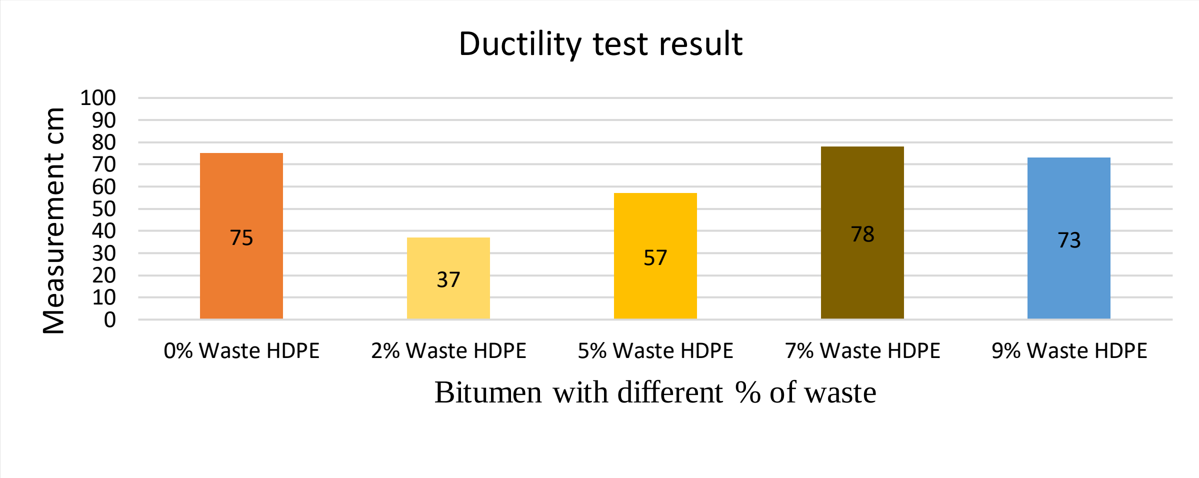

Fig. 4.22 Ductility test result graph of bituminous mix with waste HDPE

The ductility test which was done by following IS 1208 and done by using ductility testing machine shows that the increase of waste HDPE content in bitumen is increasing the ductility value of modified bitumen till 7% of waste HDPE content and it is showing more strength in bitumen with 7% of waste HDPE content.

4.5.4 Specific gravity test result of bitumen with waste HDPE

Specific gravity test result was conducted by different specific gravity bottles of different size for different samples 0%, 2%, 5%, 7% and 9% of waste HDPE mixed with bitumen and result are as follow.

Table 6.19 Specific gravity test result of bitumen with waste CRMB powder

Sample with Engine oil waste	Wt. of empty bottle	Wt. of bottle with distilled water	Wt. of bottle with half-filled bitumen	Wt. of bottle with bitumen and distilled water	Specific gravity calculation
0%	55gm	114gm	80gm	115gm	0.96
2%	47m	106gm	65gm	108gm	1.04
5%	31gm	90gm	56gm	89gm	0.96
7%	45gm	105gm	71gm	107gm	1.04
9%	51gm	110gm	76gm	111gm	1.03

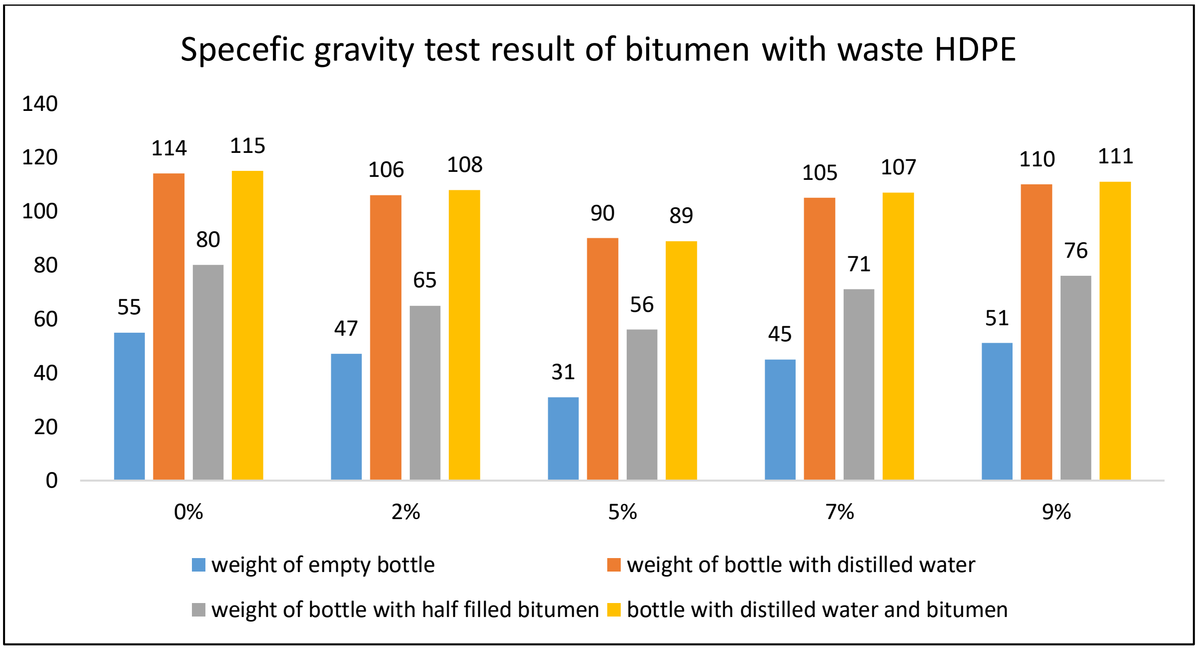

Fig. 4.23 Specific gravity test result graph of bitumen with waste HDPE

In specific gravity test, test was conducted with different size of bottles and different samples of modified bitumen and result of all samples were almost same.

4.5.5 Marshall stability test result of bitumen with waste HDPE

Marshall stability test result was conducted by making sample of bitumen with different compositions of waste material which was 0%, 2%, 5%,7% and 9% of HDPE waste, which was mixed with bitumen. In this different size of aggregates were taken by following proper guideline and result is as follow.

Table 4.20 Marshall stability test of bitumen with waste HDPE

Bitumen Content in %	Stability of conventional mix 0% (KN)	Stability of mix having 2% HDPE waste	Stability of mix having 5% HDPE waste	Stability of mix having 7% HDPE waste	Stability of mix having 9 % HDPE Waste
3	5.4	5.1	5.5	5.7	5.4
4	7.1	5.8	6.2	7.1	6.7
5	6.2	5.4	6.4	6.6	6.8

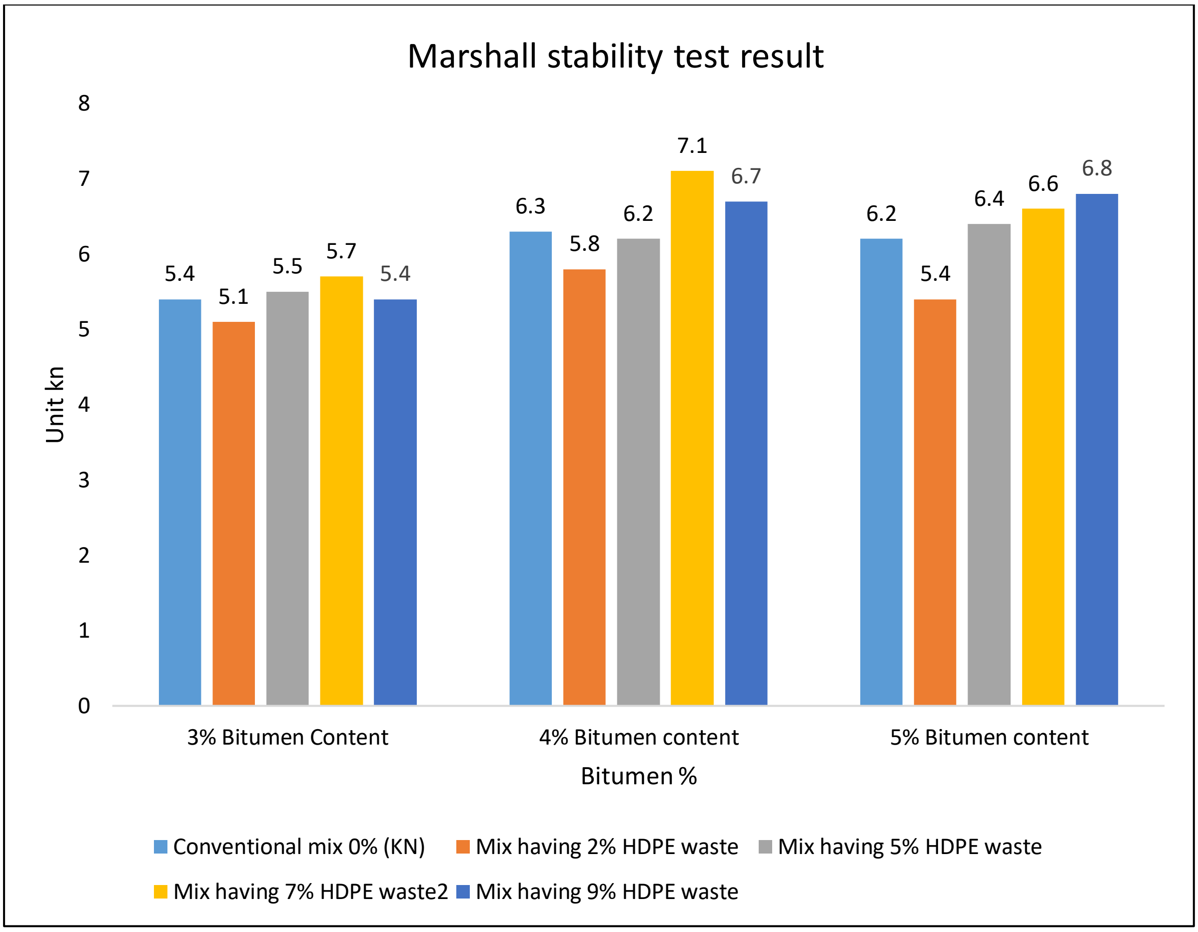

Fig. 4.24 Marshall stability test result graph of bitumen with waste HDPE

Marshall stability test was conducted with three different samples and according to the result, sample having 7% of HDPE waste is showing maximum stability value.

4.6 Testing of bitumen with mixed composition of waste HDPE, LDPE, Engine oil and CRMB powder.

4.6.1 Penetration test result of bitumen with waste HDPE, LDPE, Engine oil and CRMB powder.

Penetration test carried out by following proper guideline of IS code IS 1203 by making different sample of bitumen by making four samples mixed composition of different waste content with VG10 bitumen. Samples were made with 2% LDPE + 3% HDPE + 4% Engine oil, 3% HDPE + 4% Engine oil + 5% CRMB powder, 4% Engine oil + 5% CRMB powder + 2% LDPE and 5% CRMB powder + 2% LDPE + 3% HDPE.

Table 4.21 Penetration test result of bitumen with waste HDPE, LDPE, Engine oil and CRMB powder.

Samples with different compositions	**Test result**
0%	80
2% LDPE + 3% HDPE + 4% Engine oil	80
3% HDPE + 4% Engine oil + 5% CRMB powder	89
4% Engine oil + 5% CRMB powder + 2% LDPE	85
5% CRMB powder + 2% LDPE + 3% HDPE.	82

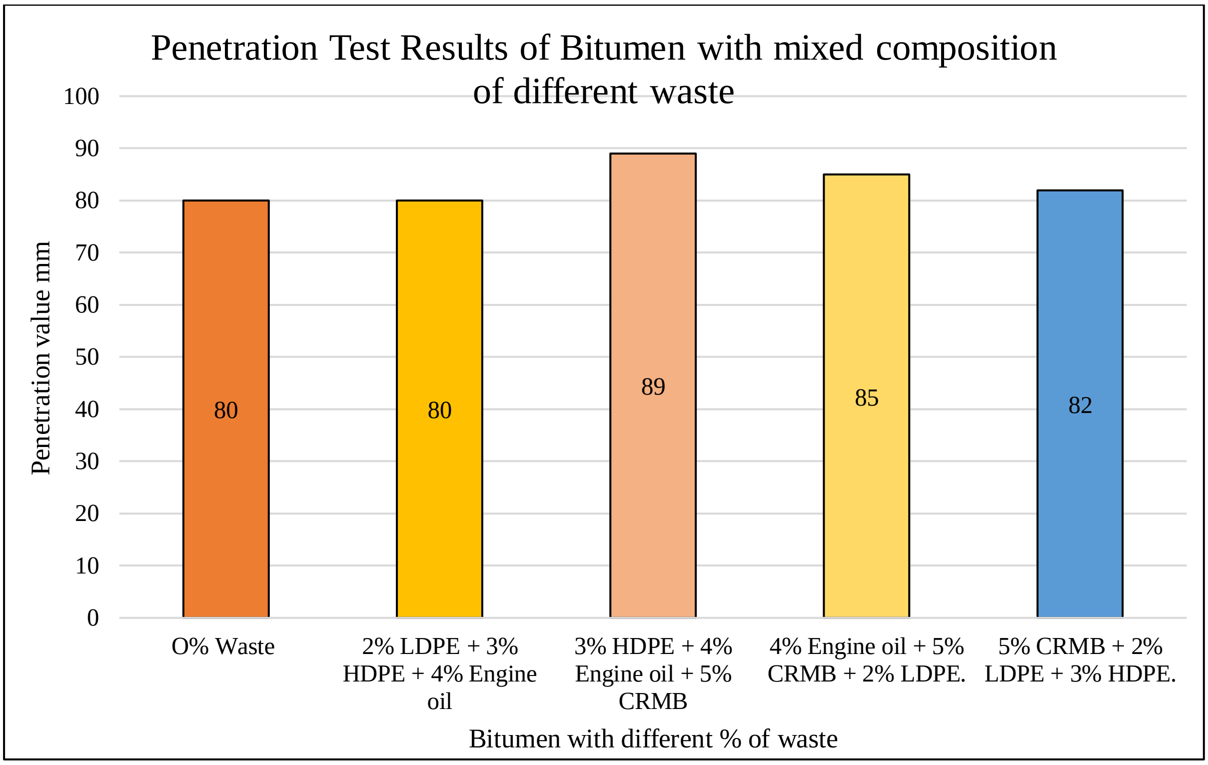

Fig. 4.25 Penetration Test Results graph of Bitumen with mixed composition of different waste

The Penetration test which was conducted by using penetrometer shows that, samples having 3% HDPE + 4% Engine oil + 5% CRMB powder is having maximum penetration value.

4.6.2 Softening point test result of bitumen with waste HDPE, LDPE, Engine oil and CRMB powder.

Softening point test was conducted with different samples with mixed composition of different waste content with VG10 bitumen. Samples were made with 2% LDPE + 3% HDPE + 4% Engine oil, 3% HDPE + 4% Engine oil + 5% CRMB powder, 4% Engine oil + 5% CRMB powder + 2% LDPE and 5% CRMB powder + 2% LDPE + 3% HDPE.

Table 4.23 Softening point test result of bitumen with waste HDPE, LDPE, Engine oil and CRMB powder.

Sample with different compositions	Test result
0%	46°C
2% LDPE + 3% HDPE + 4% Engine oil	47°C
3% HDPE + 4% Engine oil + 5% CRMB powder	42°C
4% Engine oil + 5% CRMB powder + 2% LDPE	45°C
5% CRMB powder + 2% LDPE + 3% HDPE.	48°C

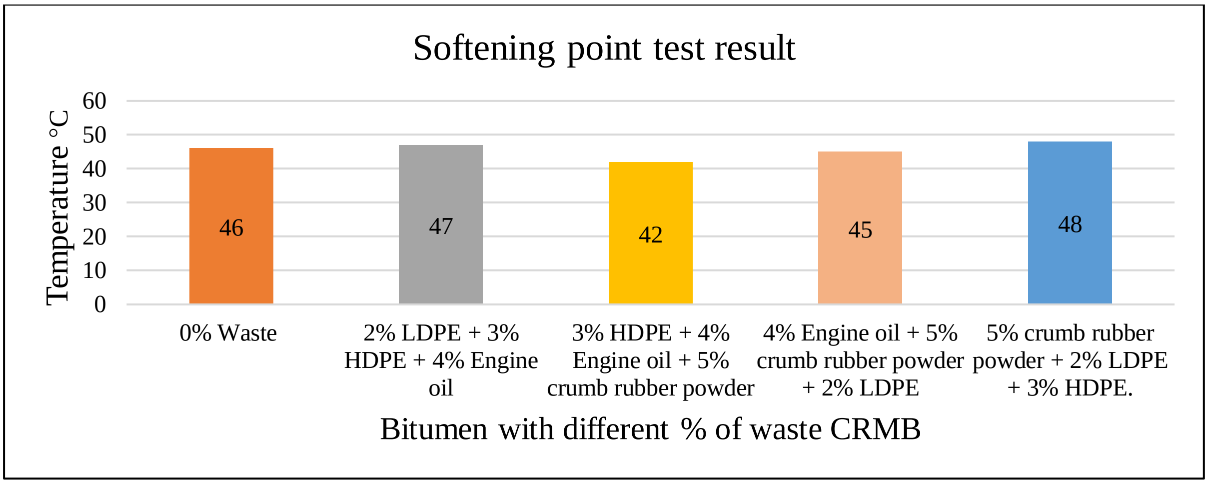

Fig. 4.26 Softening point test result graph

In softening point test result, the test was conducted with four different sample made with different composition and On the basis of result, sample having 5% CRMB powder + 2% LDPE + 3% HDPE shoes maximum softening point value.

4.6.3 Ductility test result of bitumen with waste HDPE, LDPE, Engine oil and CRMB powder.

Ductility test was done with proper guideline of IS 1208, by making different samples with mixed composition of different waste content with VG10 bitumen. Samples were made with 2% LDPE + 3% HDPE + 4% Engine oil, 3% HDPE + 4% Engine oil + 5% CRMB powder, 4% Engine oil + 5% CRMB powder + 2% LDPE and 5% CRMB powder + 2% LDPE + 3% HDPE.

Table 4.24 Ductility test result of bitumen with waste HDPE, LDPE, Engine oil and CRMB powder.

Samples with different compositions	Test result
0%	75 cm
2% LDPE + 3% HDPE + 4% Engine oil	72 cm
3% HDPE + 4% Engine oil + 5% CRMB powder	87 cm
4% Engine oil + 5% CRMB powder + 2% LDPE	82 cm
5% CRMB powder + 2% LDPE + 3% HDPE.	79 cm

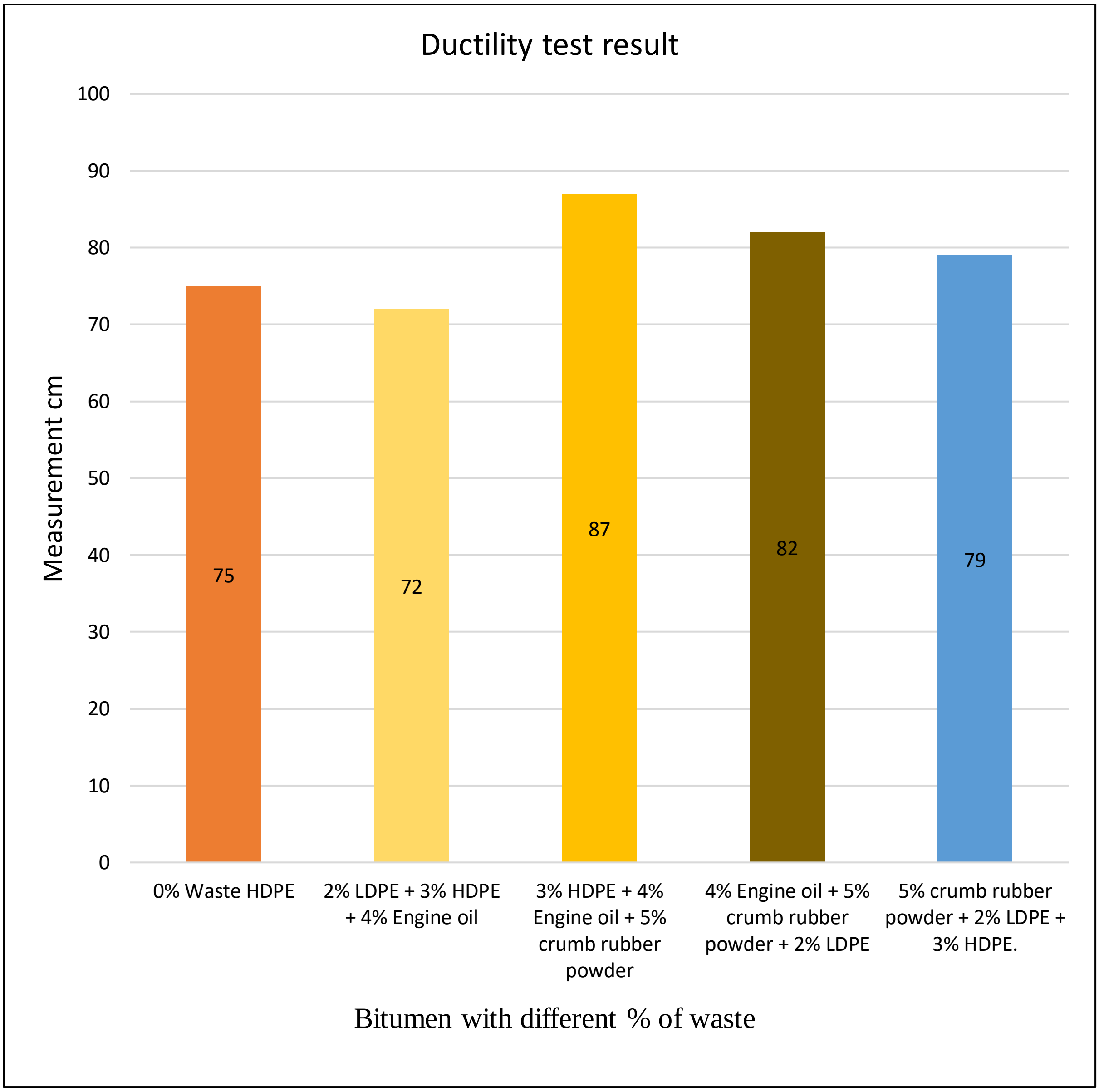

Fig. 4.27 Ductility test graph of bitumen with mixed composition

In ductility test result, the test was conducted with four different sample made with different composition and On the basis of result, sample having 3% HDPE + 4% Engine oil + 5% CRMB powder shoes maximum ductility value.

4.6.4 Specific gravity test result of bitumen with waste HDPE, LDPE, Engine oil and CRMB powder.

Specific gravity test result was conducted by two different specific gravity bottles of different size for different samples with mixed composition of different waste content with VG10 bitumen. Samples were made with 2% LDPE + 3% HDPE + 4% Engine oil, 3% HDPE + 4% Engine oil + 5% CRMB powder, 4% Engine oil + 5% CRMB powder + 2% LDPE and 5% CRMB powder + 2% LDPE + 3% HDPE.

Table 4.25 Specific gravity test result of bitumen with waste HDPE, LDPE, Engine oil and CRMB powder.

Sample with Engine oil waste	Wt. of empty bottle	Wt. of bottle with distilled water	Wt. of bottle with half-filled bitumen	Wt. of bottle with bitumen and distilled water	Specific gravity calculation
0%	55gm	114gm	80gm	115gm	1.03
2% LDPE + 3% HDPE + 4% Engine oil	48gm	98gm	59gm	99gm	1.1
3% HDPE + 4% Engine oil + 5% CRMB powder	31gm	85gm	64gm	89gm	1.06
4% Engine oil + 5% CRMB powder + 2% LDPE	43gm	94gm	77gm	95gm	1.03
5% CRMB powder + 2% LDPE + 3% HDPE.	57gm	112gm	83gm	111gm	0.96

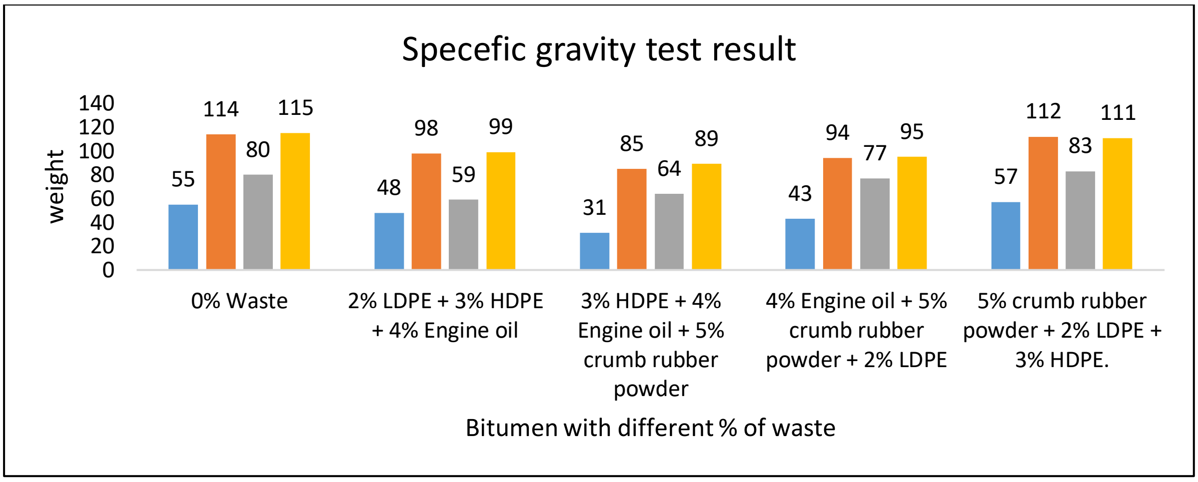

Fig. 4.28 Specific gravity test graph of bitumen with mixed composition

In specific gravity test, test was conducted with different size of bottles and different samples of modified bitumen and result of all samples were almost same.

4.6.5 Marshall stability test result of bitumen with waste HDPE, LDPE, Engine oil and CRMB powder.

Marshall stability test result was conducted by making sample of bitumen with different samples with mixed composition of different waste content with VG10 bitumen. Samples were made with 2% LDPE + 3% HDPE + 4% Engine oil, 3% HDPE + 4% Engine oil + 5% CRMB powder, 4% Engine oil + 5% CRMB powder + 2% LDPE and 5% CRMB powder + 2% LDPE + 3% HDPE.

Table 4.26 Marshall stability test result of bitumen with waste HDPE, LDPE, Engine oil and CRMB powder.

Bitumen Content in %	Stability of conventional mix 0% (KN)	Stability of mix having 2% LDPE + 3% HDPE + 4% Engine oil	Stability of mix having 3% HDPE + 4% Engine oil + 5% CRMB powder	Stability of mix having 4% Engine oil + 5% CRMB powder + 2% LDPE	Stability of mix having 5% CRMB powder + 2% LDPE + 3% HDPE.
3	5.4	5.9	6.3	6.7	6.5
4	7.1	7.3	7.1	7.5	6.9
5	6.2	6.4	6.7	6.5	7.1

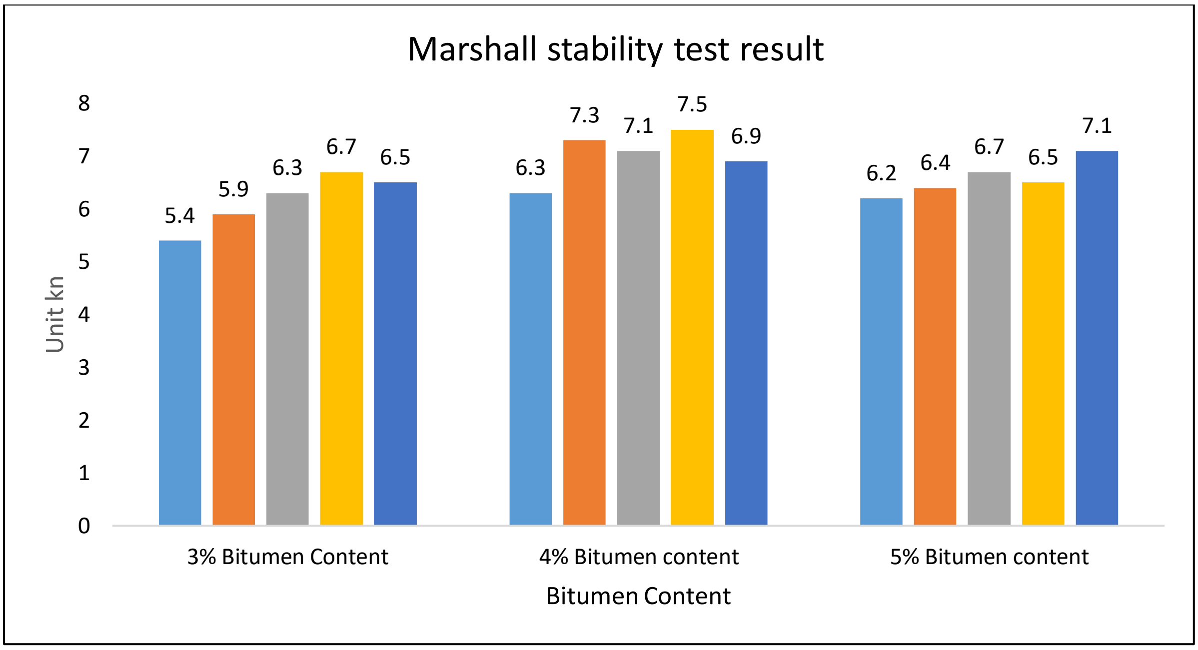

Fig. 4.29 Marshall stability test result graph of mixed composition with bitumen

Marshall stability test was conducted with four different sample of mixed composition and according to the result, sample having Stability of mix having 4% Engine oil + 5% CRMB powder + 2% LDPE waste is showing maximum stability value.

CHAPTER 5

DISCUSSION AND CONCLUSION

5.1 General

In the present study different waste material were taken i.e. waste LDPE, HDPE, CRMB and Engine oil and replaced the bitumen partially in several ranges which are already discussed in Chapter 3. In this study different samples were made with different composition of waste with VG10 bitumen. Waste material are taken according to their chemical composition which is required on the basis of Indian standard. In this sample are made with 0%, 3%, 6%, and 9% LDPE waste, 0% ,2%, 4%, 6%, 8% and 10% Waste engine oil, 0%, 2%, 5%, 8%, 10% CRMB powder, 0%, 2%, 5%, 7% and 9% Of HDPE waste and mixed composition of 2% LDPE + 3% HDPE + 4% Engine oil, 3% HDPE + 4% Engine oil + 5% CRMB powder, 4% Engine oil + 5% CRMB powder + 2% LDPE and 5% CRMB powder + 2% LDPE + 3% HDPE with VG 10 or 80/100 bitumen grade.

5.2 Discussion and conclusion

In this study, testing of bitumen with waste LDPE, HDPE, waste CRMB and waste engine oil has been used and the result shows that, utilizing of waste LDPE is lowering the penetration value but when we are increasing the waste content in bitumen then penetration value is also increasing. In softening point test result, the result shows that the increasing of LDPE in bitumen is decreasing the softening point of modified bitumen, same like this the ductility value is first decreased then started increasing by increasing the waste content as compare to conventional method and specific gravity of all the samples are almost same. In the case of waste engine oil, first penetration value is decreased but by increasing waste content, the value also increased but only till 8% of waste engine oil content in bitumen. According to ductility test and softening point test result, the value increased till 6% of waste engine oil content which means 6% of waste engine oil can be used with bitumen. According to test result of bitumen with CRMB powder, the penetration value, ductility value and softening point test result value increased till 8% of waste CRMB content, which means 8% content can be used with VG 10 grade Bitumen. In the case of waste HDPE sample with VG10 bitumen, the penetration test result shows the decreasing in resulting while utilising 2% of waste HDPE with bitumen but after increasing the waste content, the penetration value also increased till 7% of waste HDPE content. In ductility test result the result shows, decrease in value of ductility while utilising 2% of waste content but value started increasing by increasing the waste content. In softening point test result, the value first increased with 2% waste content but started decreasing by increasing the waste content. According to the mixed composition of all the sampled made with four different waste, the sample with 3% HDPE + 4% Engine oil + 5% CRMB powder is having maximum penetration value. In softening point test result the result shows that sample is having 5% CRMB powder + 2% LDPE + 3% HDPE is having maximum value of softening point. According to the result of ductility test, the result shows that the sample having 3% HDPE + 4% Engine oil + 5% CRMB powder is more ductile then other samples and in specific gravity test result, the values of all samples are almost same.

5.3 Future scope

From the future perspective, present study can be extended by increasing the percent utilisation of waste material as the replacement of bitumen (i.e. individually or in combine manner). Beside this, other suitable waste materials can be introduced based on their chemical and physical analysis. Different loading effect due to the movement of traffic and the temperature stresses (i.e. responsible for the pavement failure) can be examined in the future.

References

1. Ahmadinia, E., Zargar, M., Karim, M.R., Abdelaziz, M. and Shafigh, P. (2011). Using waste plastic bottles as an additive for stone mastic asphalt. *Materials & Design*, 32(10), pp.4844-4849.
2. Arabani, M., Mirabdolazimi, S.M. and Sasani, A.R. (2010). The effect of waste tire thread mesh on the dynamic behavior of asphalt mixtures. *Construction and Building Materials*, 24(6), pp.1060-1068.
3. Akbulut, H., Gürer, C., Çetin, S. and Elmacı, A. (2012). Investigation of using granite sludge as filler in bituminous hot mixtures. *Construction and Building Materials*, 36, pp.430-436.
4. Annual Report of ministry of road transport and highway (MORT&H). 2015-2016. Government of India
5. Ahmad, M.S. (2014). Low-density polyethylene modified dense graded bituminous macadam. *International Journal of Engineering Trends and Technology*, 16, pp.366-372.
6. Bhageerathy, K.P., Alex, A.P., Manju, V.S. and Raji, A.K. (2014). Use of biomedical plastic waste in bituminous road construction. *(IJEAT)*, pp.2249-8958.
7. Bansal, S., Misra, A.K. and Bajpai, P. (2017). Evaluation of modified bituminous concrete mix developed using rubber and plastic waste materials. *International Journal of Sustainable Built Environment*, 6(2), pp.442-448
8. Ghalayan, P. and Rana, E.S. (2017). Partial replacement of bitumen by using plastic waste in bitumen concrete. *International Journal of Latest Research in Engineering and Computing*, 5(2), pp.7-12.
9. Hınıslıoğlu, S. and Ağar, E. (2004). Use of waste high density polyethylene as bitumen modifier in asphalt concrete mix. 58(3-4), pp.267-271.
10. Jambeck, J.R., Geyer, R., Wilcox, C., Siegler, T.R., Perryman, M., Andrady, A., Narayan, R. and Law, K.L. (2015). Plastic waste inputs from land into the ocean. *Science*, 347(6223), pp.768-771.
11. Karaşahin, M. and Terzi, S. 2007. Evaluation of marble waste dust in the mixture of asphaltic concrete. *Construction and Building Materials*, 21(3), pp.616-620
12. Kawade, N, Chalke, S, Dawale, N., Jangam, U., and Parulekar. (2018). Design and Qualitative Analysis of Flexible Pavement by Using Waste Material. International engineering, science& Technology research journal.

13. Kumar, T.K. and Vikranth, J. (2017). A Study on the use of plastic waste (Polypropylene) in flexible pavements. *International Journal of Engineering and Management Research*, Volume-7, Issue-3.
14. Pasandín, A.R. and Pérez, I. (2017). Fatigue performance of bituminous mixtures made with recycled concrete aggregates and waste tire rubber. *Construction and Building Materials*, 157, pp.26-33.
15. Prasad, D.S.V. and Prasada Raju, G.V.R. 2009. Performance of waste tire rubber on the model flexible pavement. ARPN *Journal of Engineering and Applied Sciences*, 4(6), pp.89-92.
16. Rajmane, P.B., Gupta, A.K. and Desai, D.B. (2009). Effective utilization of waste plastic in the construction of flexible pavement for improving their performance. *Journal of Mechanical and Civil Engineering*, pp.27-30.
17. Rokade, S. (2012). Use of waste plastic and waste rubber tires in flexible highway pavements. *In International conference on future environment and energy, IPCBEE* (Vol. 28).
18. Reddy, M.S. Reddy, Y.R. and Takhelmayum, G. (2017). Experimental Investigation on the Properties of Pavement using Waste Plastic in Road Construction. International Journal of Advances in Scientific Research and Engineering (IJASRE*)*, 3.
19. Rajput, P.S., and Yadav, R.K. (2016). Use of Plastic waste in bituminous road construction. *International Journal of Science Technology & Engineering*, 2(10), pp.509-513.
20. Shedame, P.P. and Pitale, N.H. (2014). *Experimental study of bituminous concrete Containing plastic waste material*. International Organization of Science and Research- Journal of mechanical and civil engineering (IOSR-JMCE). ISSN: 2320-334X, Volume 11, Issue 3 Ver. II (May- Jun. 2014), PP 37-45
21. Sk, A.S. and Prasad, K.S.B. (2012). Utilization of waste plastic as a strength modifier in the surface course of flexible and rigid pavements. *International Journal of Engineering Research Application*, 2(4), pp.185-91.
22. Sharma, A. and Goud, M.M. (2018). International Journal of Technical Innovation in Modern Engineering & Science International Journal of Technical Innovation in Modern Engineering & Science, 4(5).
23. Sarma, M.S., and Srikanth, B. (2018). *Study on the use of waste polythene in bituminous paving mix design*. International Journal for Modern Trends in Science and Technology ISSN: 2455-3778 :: Volume: 04, Issue No: 06, June 2018

24. Shaikh, A., Khan, N., Shah, F., Shukla, D. and Kale, G. (2017). Use of plastic waste in road construction. International Journal of Advance Research and Development. Volume2, Issue5.
25. Sutradhar, D., Miah, M., Chowdhury, G.J. and Sobhan, M.A. (2015). Effect of using the waste material as a filler in the bituminous mix design. *American Journal of Civil Engineering*, 3(3), pp.88-94.
26. Somani, maharaniya, Kumawat, Rangera. (2016). Strengthen of the flexible pavement by using waste plastic and rubber. scholarly peer reviewed research publishing Journal- International Journal of Civil Engineering *(SSRG-IJCE)*, Volume 3, Issue 5 – May-2016
27. Tiwari, M.M., Singh, U.P., Gupta, P., Kumar, R. and Bharti, S. (2018). Modify bituminous blinder using plastic waste. *Journal of transportation systems*, 3(1).
28. Trimbakwala. (2017). Plastic Roads - Use of waste plastic in road construction; Int J Sci Res Publ 4) (ISSN: 2250-3153),
29. International Journal of Scientific and Research Publications (IJSRP), Volume 7, Issue 4, April 2017 Edition [ISSN 2250-3153].
30. Vashisht, R. and Saini, M. (2017). Experimental Study of Materials Used in Flexible Pavement Using Waste Plastic and CRMB. Journal of Civil Engineering and Environmental Technology. Volume 4, Issue 2; April-June, 2017, pp. 121-123.
31. Wayal, A.S., and Wagle, M.D. (2013). Use of Waste Plastic and Waste Rubber in Aggregate and Bitumen for Road Materials. Polymer, 40(88), p.36, International Journal of Emerging Technology and Advanced Engineering
32. (IJETE), ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 3, Issue 7, July 2013.
33. Ikhajiagbe, B., Anoliefo, G.O., Omoregbee, O. and Osigbemhe, P., 2014. Changes in the intrinsic qualities of a naturally attenuated waste engine oil polluted soil after exposure to different periods of heat shock. Resources and Environment, 4(1), pp.45-53.
34. Donga, P.D., Shah, D. and Bhavsar, J.K., 2016. Impact resistance of waste rubber fiber silica fume concrete. Journal of Civil Engineering and Environmental Technology, 3(4), pp.274-279.
35. Lalatendu, M., 2016. Turning waste tyre into ‘green steel,’. The Hindu.
36. CHEMIK 2013, 67, 5, 435?445
37. Ikhajiagbe, B., Anoliefo, G.O., Omoregbee, O. and Osigbemhe, P., 2014. Changes in the intrinsic qualities of a naturally attenuated waste engine oil polluted soil after

exposure to different periods of heat shock. *Resources and Environment*, *4*(1), pp.45-53.

38. Behnia, A., Ranjbar, N., Chai, H.K., Abdullah, A.I. and Masaeli, M., 2017. Fracture characterization of multi-layer wire mesh rubberized ferrocement composite slabs by means of acoustic emission. *Journal of cleaner production*, *157*, pp.134-147.
39. Donga, P.D., Shah, D. and Bhavsar, J.K., 2016. Impact resistance of waste rubber fiber silica fume concrete. *Journal of Civil Engineering and Environmental Technology*, *3*(4), pp.274-279.
40. IS 1203, 1978. “Methods for Testing Tar and Bituminous Materials: Determination of Penetration”. Bureau of Indian Standards. New Delhi, India.
41. IS 1202, 1978. “Methods for Testing Tar and Bituminous Materials: Determination of Specific gravity”. Bureau of Indian Standards. New Delhi, India.
42. IS 1205, 1978. “Methods for Testing Tar and Bituminous Materials: Determination of Softening point”. Bureau of Indian Standards. New Delhi, India.
43. IS 1208, 1978. “Methods for Testing Tar and Bituminous Materials: Determination of Ductility”. Bureau of Indian Standards. New Delhi, India.
44. Is: 2386 Part (3), 1963. “Methods of test for aggregates for concrete”. Bureau of Indian Standards. New Delhi, India.