# Performance Of Bitumen Mixes with Partial Replacement of Aggregates With Construction And Demolition Waste And Bitumen With Molasses

**Dr. D. Koteswara Rao[1], Sajida Sulthana Mohammed[2], Uriti Tarun[3], J. Jayaprakash[4], K.Alekhya Sahithi[5], V.Kathyayani[6]**

[1]*Professor, Head Of The Civil Engineering Department, OSD To Hon'ble Vice Chancellor, University College Of Engineering Kakinada(A), Kakinada, Andhra Pradesh, India*
[2]*Assistant Professor(C), Department Of Civil Engineering, University College Of Engineering Kakinada(A) , Kakinada, Andhra Pradesh , India*
[3,4,5,6]*U.G Students, Dept. Of Civil Engineering, University College of Engineering Kakinada(A), Kakinada, AP, India*

---------------------------------------------------------------------***---------------------------------------------------------------------

**Abstract -** The management of the enormous quantities of construction and demolition (C&D) materials produced in urban areas is becoming an increasingly difficult problem. In keeping with these ideas, this study recommends a suitable proportion of C&D waste to be used in bituminous mixes and focuses on using RCA (recycled concrete aggregate) to improve bituminous mix effectiveness in terms of mechanical, volumetric, and moisture sensitivity. The results of this experiment show that at the optimum bitumen and construction and demolition waste levels, respectively, the marshal stability values increased from the conventional mix to the improved mix. From a conventional mix to a modified mix, flow values are decreased *(4.4mm -3.4mm shown in 6.2 and 7 sections). From the results, it is observed that 6% bitumen and 20% C&D waste are suitable to prepare bituminous mix surface layers for medium and light traffic conditions, whereas for heavy and very heavy traffic conditions strength is not sufficient and another material must be used as a partial replacement, so molasses was chosen as the partial replacement of bitumen sugar molasses, the addition material investigated in this study, it obtained by boiling sugarcane juice and removing sugarcane crystals so that a thick brown syrup is obtained. Molasses is a relatively cheap material and has not been used as a bitumen modifier before. A material was synthesized using sugar cane juice. The base bitumen was modified with molasses and construction and demolition waste separately to investigate the effects of those modifications on bitumen and bituminous mixture properties by laboratory tests, including viscosity, penetration, softening point, ductility, and Marshall Stability.*

***Key Words: Bituminous Mix*, Molasses, Construction and Demolition Waste, Marshall Stability, Softening Point**

## 1.INTRODUCTION

As traffic demand increases rapidly along with increasing axle loads, there is a requirement for a huge quantity of highway construction materials. Aggregates obtained by processing natural stone form the major portion of these materials. Because natural stone resources are depleting very quickly, highway engineers are concerned about meeting the high demand for natural aggregates for pavement construction. They are exploring waste and locally available materials to replace natural aggregates to the extent possible in view of cost and preservation for better and essential uses. Also, when such materials are used, sustainability needs to be ensured. With the use of these materials, the environment is highly benefited in terms of natural resource conservation, optimization of landfill use, savings in waste-dumping charges, possible emission reductions, and savings in energy use. Concrete is a very common material for buildings and other structures. Demolition of concrete structures because they have attained their expected life or for other reasons is a common feature in urban areas and on large project sites. This creates quantities of construction and demolition (C&D) waste. C&D wastes, when recycled and reused as aggregates in new construction, are collectively known as recycled concrete aggregate (RCA). A number of studies have sought potential uses for these materials in construction. To date, only limited literature is available on the use of RCA in bituminous mixes for road construction. Because the physical, chemical, and mechanical properties of RCA are different from those of conventional aggregates, extensive research is needed to substantiate RCA's suitability for this purpose. In general, RCA is rough, porous, flat, and irregular in frontage shape. It also has low specific gravity along with high porosity and water absorption compared with natural coarse stone aggregate (Lee et al. 2012; Perez et al. 2012). Bitumen, a viscoelastic material, is the lone deformable element in a bituminous paving structure and plays a very important role in pavement behavior. The most important properties of a bituminous mixture are its stability and flow. Optimum stability can handle traffic requirements sufficiently and prevent excess rutting (Kalantar et al. 2012). As for the general performance of bituminous pavement, distress occurs in hot climates as rutting and in cold climates as cracking due to the sensitivity of bitumen and bituminous mixes to lower temperatures and traffic. To overcome these problems in a flexible pavement, the performance of either the bitumen or the mix must be improved. A significant amount of research has been carried out to enhance the properties of these two components in different ways for conventional bituminous paving mixes. Modification of bitumen using molasses to improve binder properties over a range of varying temperatures has a long history. The use of molasses directly in a mix is permitted. The additive material in examination in this study, sugar beet molasses, is produced from raw sugar juice in sugar refineries after the juice is heated and sugar crystals are removed. Due to cost and planning issues, this thick, dark brown syrup with a sugar concentration of between 40 and 50 percent cannot be utilized to crystallize additional the sugar saccharose. It is utilized in various industries, including the manufacture of ethanol, animal feed, yeast factories, and fertilizers. On average, 20–25% of it is made up of water. Although its low price, sugar beet molasses has never been utilized as a bitumen modifier. Molasses was made from sugar cane juice. The base bitumen was modified with sugar beet molasses to investigate the effects of those modifications on bitumen and bituminous mixture properties by laboratory tests such as penetration, ductility, softening point, and Marshall Stability.

Viscosity for bituminous mixes, whose use in conjunction with RCA has up until now been scanty. Because of its common available size fractions, RCA was used as the replacement filler in a dense bituminous mix with query dust as filler. For comparison, similar bituminous mixes were prepared using filler only, with partial replacement of filler and partial replacement of bitumen with molasses and finding optimum values and finally found the strength of mix.

## 2.LITERATURE REVIEW

### 2.1 Mustafa Musleh Razahi1, Avani C. (2020)

This article examines the use of Sisal and Coir fibers as stone matrix asphalt additives. The SMA is strengthened by fibers and polymers, which are additions with a high asphalt percentage and coarse particle content. Coarse aggregates serve the important purpose of providing stone to stone network and intermixing in the mixture, which gives strength and a long-lasting, rich mortar. Stone matrix asphalt added fibers and polymers to prevent the SMA mix from leaking. The transportation industry uses a variety of natural fibers, including hemp, banana, coir, and sisal. Stability in SMA mixes decreases as the number of fibers increases. The mix's strength and durability are boosted, and it doesn't drain thanks to the addition of sisal and coir fibers. All of the research showed that the mix's stability, flow value, and volumetric characteristics were evaluated using the Marshall Stability test, and that the mix's stability, flow value, and volumetric characteristics were ascertained using the Marshall Mix Design. A different test called Drain Down was employed in several studies to calculate the quantity of Drain Down from uncompacted Stone Matrix Asphalt (SMA).

### 2.2 K. Karunakar (2018)

In this article include study of glass fiber and carbon fiber in SMA. Carbon fibers will be added to the SMA mixes in addition to the glass, and the characteristics of the mixtures will be found. It was selected to use carbon fibers in the current research since they are readily available in India. Preparing asphalt concrete mixes with two types of fibers (carbon and glass) at dosages of 0.3%, 0.4%, and 0.5% by weight of the total mix will be used to conduct detailed laboratory experiments. The mixture volumetric characteristics will be found as well as marshal stability.

### 2.3 Siva Gowri Prasad S. (2018)

In this study, coconut fiber, banana fiber are used to determine the Marshall property of mix, All these fibers play an important role in providing stability to bitumen binder in the mix and preventing drainage during manufacturing, transit, and development. Based on laboratory experiments that looked at flow and stability, the goal of this study is to investigate if coconut and banana fiber may be utilized as a stabilizing element in a combination. Cement is utilized as a mineral filler, and VG30 grade bitumen is used as a binder. A stone matrix asphalt mix with a nominal maximum aggregate size of 20mm,10mm is used with fiber as an additive to improve stability and bulk specific gravity while lowering flow value. At 0% drain down, coconut and banana fibers exhibited optimum fiber levels of 0.3 and 0.4%, respectively.

From the literature, it was found that researchers have used different materials like coconut fibers, waste plastics, asbuton, natural rocks, etc., to prepare SMA mixes, and the results were within the permissible limits. In this regard, C&D waste is used to prepare the SMA Mix in the present investigation.

### 2.4 Sina Aminbakhsh(2016)

Bitumen-aggregate combinations have been used to pave roadways for ages because they are relatively cheap and easy-to-supply construction materials. Although the primary part of this combination consists of aggregates, bitumen plays a major role in pavement performance because it binds aggregate particles, provides water proofing properties, and contributes to the stability and durability of mixtures. Rutting, fatigue, low-temperature cracking, and stripping are known as the major distresses of roadway pavements. Their formation on roadway pavement is related to the bitumen properties used in the structure. At high temperatures, bitumen loses its cohesion, and one of the prominent pavement distresses, rutting, is formed under heavy loadings. Fatigue cracking occurs when the repetition of traffic loadings exceeds the threshold value, which depends on the material and mixture properties. Low-temperature cracking appears because of bitumen shrinkage at low temperatures. Stripping arises as a result of aquatic effects and poor adhesive bonds at the bitumen-aggregate interface. Increases in traffic volumes and axle loads, together with extreme weather conditions, made researchers investigate feasible ways of improving bituminous mixture performance, one of which may be the modification of bitumen with additives. Several additive materials have been used in this regard, such as block copolymers, rubbers, thermoplastic polymers, thermosetting plastics, and others.

Literature studies show that additives that are used either in bitumen or in bituminous mixtures provide additional resistance against the formation of distresses

**2.5Rose Mary X. (2018)**

A significant amount of coarse aggregate content makes up SMA. They are held together by a thick covering of asphalt, stabilized by fibers and mineral filler. Better bonding and superior stone contact are present. There is a severe draining issue with SMA Mix. Stabilizing agents such as polymers, mineral fibers, and cellulose fibers are used to keep the mixture from draining. SMA's structural features enable it to provide pavement resilience and longevity while optimizing resistance to rutting and deformation. The Marshall characteristic and volumetric parameters are used to calculate the optimum bitumen and fiber contents for the SMA Mix. Several studies have been conducted to assess the performance characteristics of SMA mixes that use different types of fibers as stabilizers. The fibers help improve bonding and promote aggregate-aggregate contact. The amount of binder that flows down decreases considerably when fibers are added. It may be possible to extend the SMA research to a larger geographic region by utilizing a range of accessible local fibers. Pineapple fiber, which has a high cellulose content, may be used as a stabilizing agent in SMA future studies.

**2.6Sambhav Jain, Harpreet S., Tanuj C. Et Al. (2017)**

This article examines the results of an investigation involving a stone matrix asphalt mix made with VG 30 bitumen and various fibers as additions, including coconut fiber, glass fiber, and jute fiber. SMA mixes that include different kinds of fibers. The study procedure includes drain down testing and SMA mix design. Compared to all other fibers used in stone matrix asphalt, cellulose fiber has a smaller drain down value and greater Marshall Stability. Whereas other types of additions drain within the given limits, cellulose fiber drains the least. The findings show that there is very little drain down of a mix based on cellulose fiber during field production.

## 3.OBJECTIVE AND SCOPE

- To compare the various properties of the bituminous road and the modified bituminous road with molasses and construction and demolition waste.
- To identify the optimum proportion of molasses and construction and demolition waste to be added in the bitumen mix for getting the required strength for the pavement from medium traffic to heavy traffic and very heavy traffic conditions.
- To study the properties of natural aggregate and construction and demolition aggregate.
- To convert molasses into binder and decrease environment pollution due to bitumen.
- To decrease the bitumen content.
- To increase the life of pavement

## 4. METHADOLOGY AND MATERIALS

Mixes were prepared using conventional VG 30–grade bitumen and molasses with a coarse aggregate fraction comprising recycled concrete aggregate (RCA) and natural aggregate (NA), along with stone dust as the filler. Each mix type was evaluated in terms of Marshall characteristics, flow number. A flowchart of the experimental methodology is shown in Fig. 1

### 4.1 MATERIALS USED FOR BITUMINOUS MIX DESIGN

### 4.1.1 Aggregates

The demolition concrete used in the mix designs, collected from the University College of Engineering Kakinada campus, Kakinada, India, comprised reinforced cement concrete (RCC) slabs, beams, columns, basements and the like, from old buildings and from concrete specimens cast for laboratory testing and research (Fig3). It was first processed and then crushed to obtain RC aggregate fractions of the required sizes, as shown in Fig. 2. The NA used was collected from a local stone quarry in the sizes required for the production of conventional bituminous mix. As determined in the laboratory, the physical properties of the RCA and the NA are provided in Table 1. It is observed that the RCA has a higher impact and los angels' abrasion compared with the natural aggregate (NA). The other physical properties—specific gravity, aggregate crushing value, and water absorption, flakiness, and elongation —were found to be satisfactory for RCA, according to the Ministry of Road Transport and Highways.

(MoRTH 2013) specifications.

Fig3: Collection of RCA From Jntuk Dismantled Building

Fig2: Preparation of RCA in The Laboratory

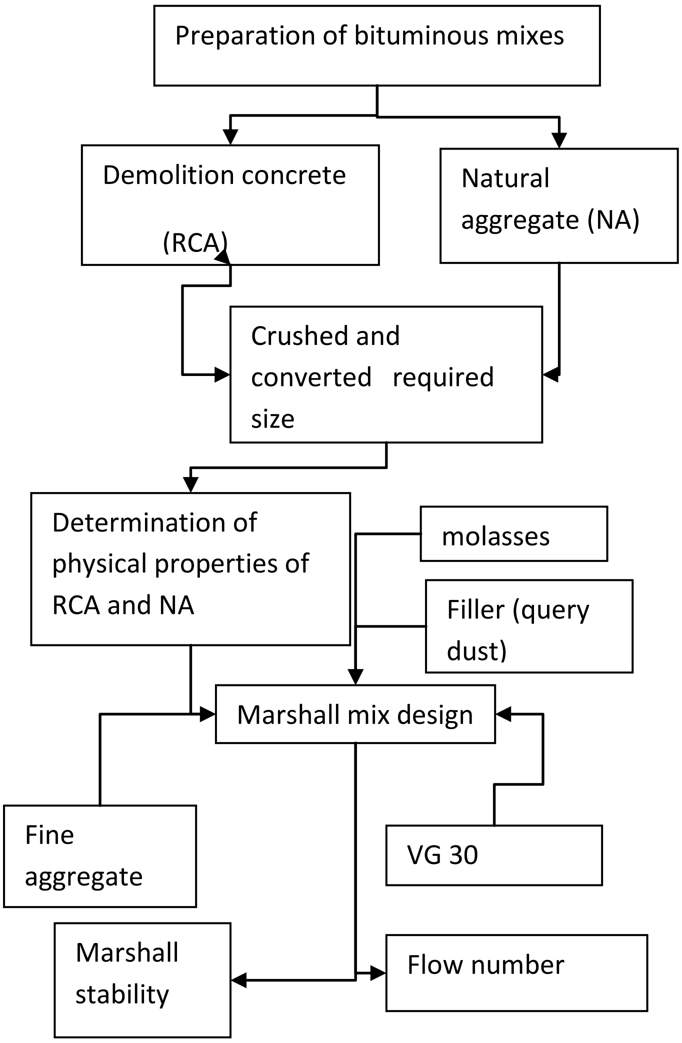



FIG1: Flow Chart Of Experimental Methodology

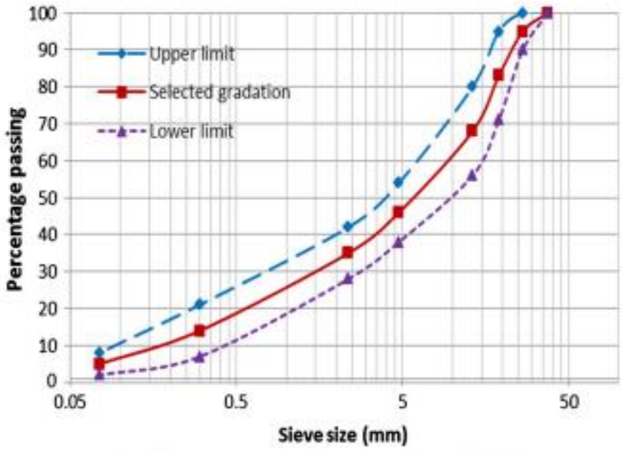



Fig. 7. DBM gradation. (Data from MoRTH 2013.)

| TESTS | RESULTS NA | RESULTS C&D | I S STANDARDS | REFERRED CODE |
|---|---|---|---|---|
| IMPACT | 11.41% | 24.43% | MAX 18% | IS:2386(IV) |
| CRUSHING | 21.30% | 16.51% | MAX 30% | IS:2386(IV) |
| ABRASION | 8.20% | 38.20% | MAX 30% | IS:2386(IV) |
| SPECIFIC GRAVITY | 2.73 | 1.32 | 2.5 - 3 | IS:2386(III) |
| WATER ABRASION | 0.59% | 1.97% | MAX 2% | IS:2386(III) |
| FINE AGGREGATE | | | | |
| specific gravity | 2.73 | - | 2.5-3 | IS:2386(III) |
| water absorption | 0.59 | - | MAX 2% | IS:2386(III) |
| FILLER | | | | |
| SPECIFIC GRAVITY | 3.14 | - | 3.15 | IS:269-1989 |

Table1 physical properties of RCA and NA

### 4.1.2 BITUMEN AND FILLER

In India, VG 30–grade bitumen is commonly used in lower bituminous layers [IRC 37 (IRC 2012)]. Bitumen acts as a binding agent for aggregates in bituminous mixes. Collected from a government organization, it was used for the preparation of the bituminous mixes in this experimental work; its physical properties when partially replaced with molasses is shown in 6.1.2. Query dust (QD), used as the filler, was collected from local sources. Its specific gravity was found to be 3.14 in the laboratory, shown in Table1

### 4.1.3 MOLASSES (modification of base bitumen)

Sugar beet molasses, which in this paper will simply be called molasses, were sourced from a sugar factory near Kakinada and used directly within the base bitumen in certain amounts. The specifications of the molasses used in the modification process of the base bitumen are given in Table 3.

| property | Value |
|---|---|
| Density | 1.3g/cc |
| Physical state | Semi liquid |
| Saccharose | 51% |
| Invert sugar | 2% |
| Inorganic oxides | 24% |
| water | 22% |

Table3: Specification for Molasses

## 5. MIX DESIGN

As per the Ministry of Road Transport and Highways (MORTH 2013), the aggregate gradation recommended for a 20-mm nominal maximum aggregate size (NMAS) bituminous mix was considered. Individual mixes were prepared as per the conventional Marshall procedure specified in ASTM D1559 (ASTM 1989). The gradations are shown in Fig. 7, and the corresponding midpoint gradation was selected for the preparation of Marshall specimens of different mixes having different coarse aggregate fractions. Before the hot bitumen was added to the preheated aggregates and filler, the required amount of molasses (as a partial replacement for optimum bitumen) was added to the heated bitumen. The mix was then manually mixed until a uniform mix was obtained. Optimum bitumen content was obtained with varying bitumen content as a percentage of the aggregate weight (i.e., 4%,5%,6%,7%). combinations of bituminous mix were prepared with varying RCA (powdered form), NA optimum value was found and used in the mix; query dust was used as the filler fraction in all of them. five additional combinations modified by molasses (by replacement with bitumen) and with query dust as the filler fraction were also prepared with optimum values of bitumen and RCA (recycled concrete aggregate). Specimens of all combinations were tested for Marshall and other engineering characteristics. The optimum bitumen content (OBC) was determined on the basis of average bitumen content corresponding to maximum stability, maximum unit weight, at a bitumen content of 6% at 3.81% air voids. The molasses content varied by 4-8% of the optimum bitumen content with optimum RCA. The optimum bitumen and optimum molasses were decided based on the maximum stability value, satisfying other Marshall characteristics.

Preparation Of Bituminous Mix

Preparation Of Bituminous Mix Mould

Testing Of Marshall Stability

## 6.RESULTS AND CONCLUSIONS:

### 6.1 Bitumen Test Results:

### 6.1.1 Bitumen with Out Molasses

WITHOUT MOLASSES

| Sno | test | result | IS standard | IS code |
|---|---|---|---|---|
| 1 | penetration | 52.66 | 50-70mm | IS: 1203-1978 |
| 2 | ductility | 108.7cm | min 75cm | IS:1208-1978 |
| 3 | specific gravity | 0.98 | 0.97-1.02 | IS:1202-1978 |
| 4 | softening point | $53.35^0$c | min $47^0$c | IS:1205-1978 |
| 5 | viscocity | 300pa-s | 240-360pa-s | IS 1206-PART-2 |

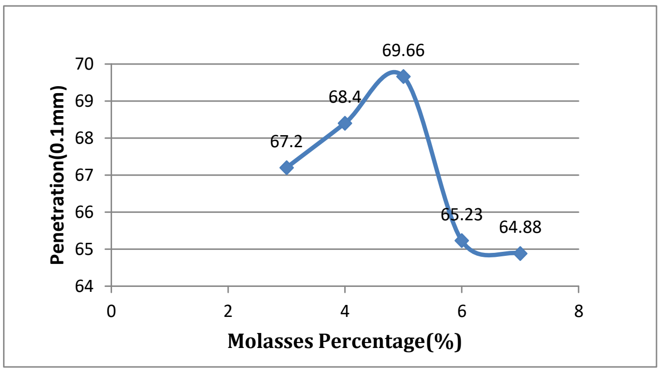
### 6.1.2 With Molasses

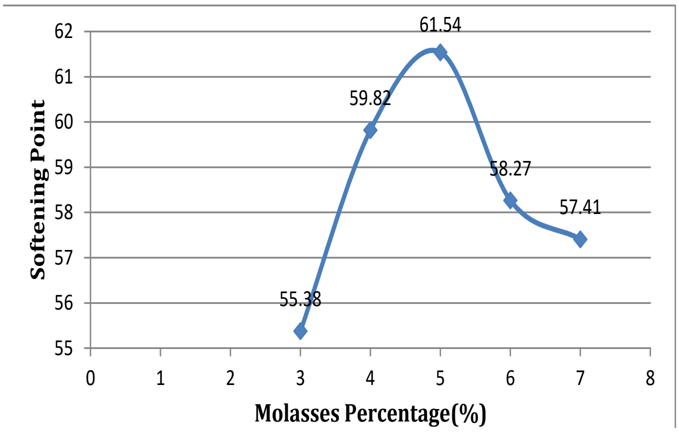
The optimum percentage obtained is 5%, obtained from below table and graphs.

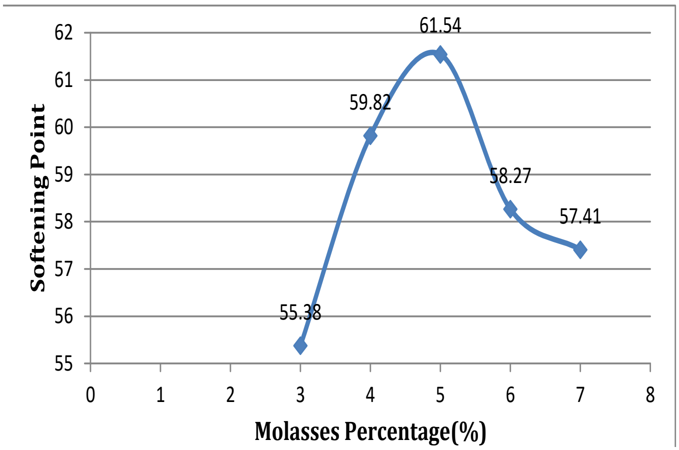
| Sno | molasses percentage | penetration (mm) | softening($^0$c) |
|---|---|---|---|
| 1 | 3 | 67.2 | 55.38 |
| 2 | 4 | 68.4 | 59.82 |
| 3 | 5 | 69.66 | 61.54 |
| 4 | 6 | 65.23 | 58.27 |
| 5 | 7 | 64.88 | 57.41 |

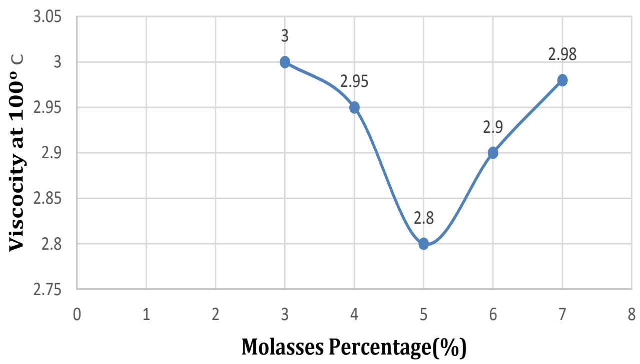
| molasses percentage | viscocity at $100^0$ C | Ductility at $25^o$ C(cm) | Ductility at $15^o$ C(cm) |
|---|---|---|---|
| 3 | 3 | 100 | 100 |
| 4 | 2.95 | 100 | 100 |
| 5 | 2.8 | 100 | 100 |
| 6 | 2.9 | 100 | 100 |
| 7 | 2.98 | 100 | 100 |

Graphs for the above results are shown below:




### 6.2 Optimum Bitumen Content Values Given Below:

The Optimum value of bitumen content is 6%,which was obtained from the below table and graphs.

| S.NO | w1(g) | w2(g) | w3(g) | Bitumen Content(%) | Bulk Density | th sp gra | $V_a$(%) |
|---|---|---|---|---|---|---|---|
| 1 | 1246 | 1250 | 640 | 4 | 2.04 | 2.42 | 15.7 |
| 2 | 1210 | 1220 | 684 | 5 | 2.26 | 2.39 | 5.44 |
| 3 | 1254 | 1260 | 708 | 6 | 2.27 | 2.36 | 3.81 |
| 4 | 1210 | 1214 | 672 | 7 | 2.23 | 2.32 | 3.88 |

continuation of the table...

| | | | | Height | stability(kg) | | |
|---|---|---|---|---|---|---|---|
| | $V_B$(%) | VMA(%) | VFB(%) | (mm) | measured | corrected | Flow(mm) |
| 15.7 | 3.45 | 19.15 | 18.02 | 65 | 590 | 566.4 | 5.1 |
| 5.44 | 4.86 | 10.3 | 47.18 | 63.5 | 667 | 667 | 4.5 |
| 3.81 | 13.2 | 17.01 | 77.6 | 63.5 | 724 | 724 | 4.4 |
| 3.88 | 6.67 | 10.55 | 63.22 | 63.5 | 623 | 623 | 4.6 |

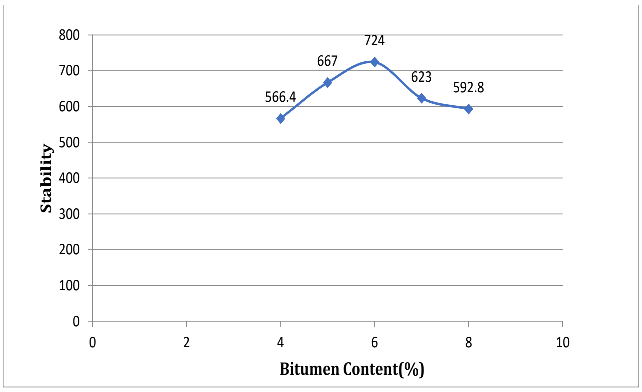
Where,

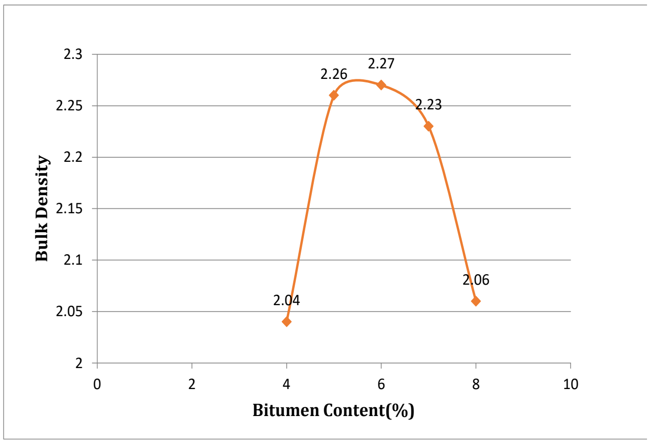
W1: weight of specimen in air

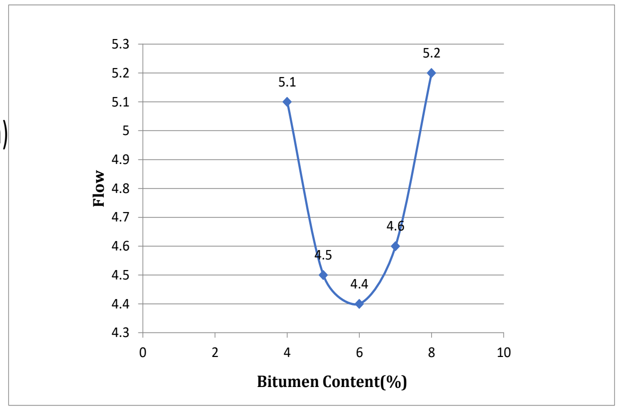
W2: weight of specimen after water bath

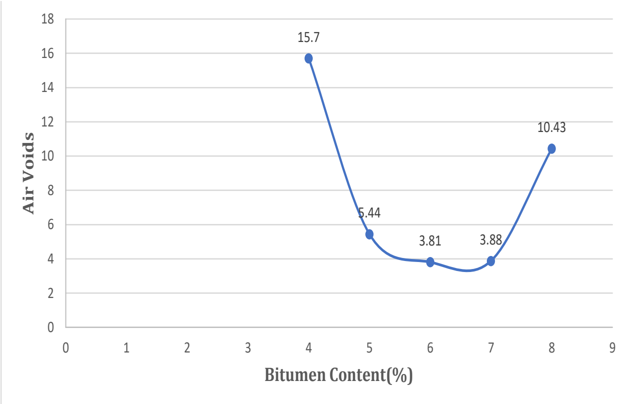
W3: suspended weight of specimen in water bath

Graphs for the above table shown below:



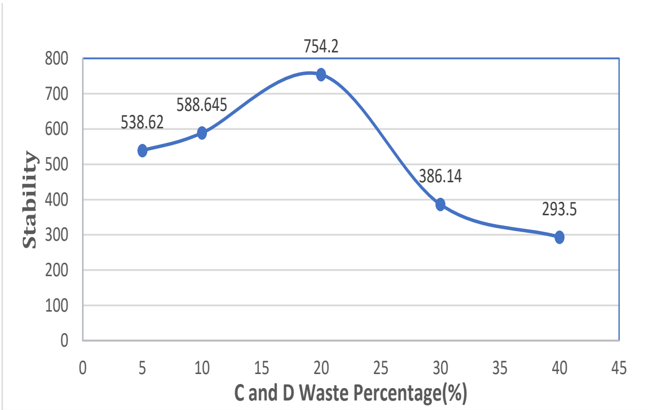




## 7.OPTIMUM RCA VALUES:

The Optimum value of RCA obtained is 20%, obtained from the below graphs and tables where maximum stability seen.

| | | | ht of specimen | stability | | |
|---|---|---|---|---|---|---|
| Sno | c and d(%) | bitumen(%) | (cm) | measured(kg) | corrected(kg) | flow(mm) |
| 1 | 5 | 6 | 6.63 | 573 | 538.62 | 3.5 |
| 2 | 10 | 6 | 6.76 | 618 | 588.645 | 3.6 |
| 3 | 20 | 6 | 6.8 | 838 | 754.2 | 3.4 |
| 4 | 30 | 6 | 6.9 | 449 | 386.14 | 3.8 |

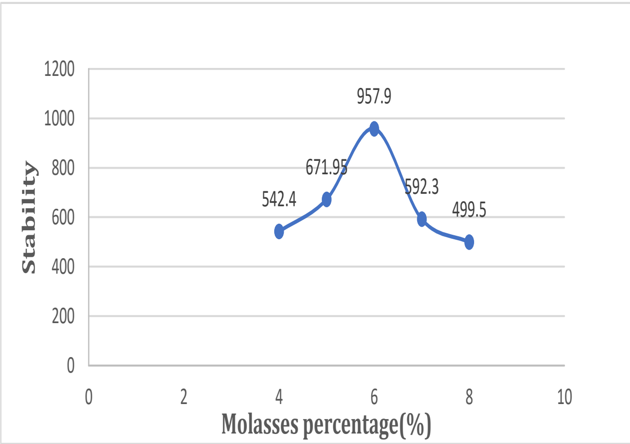


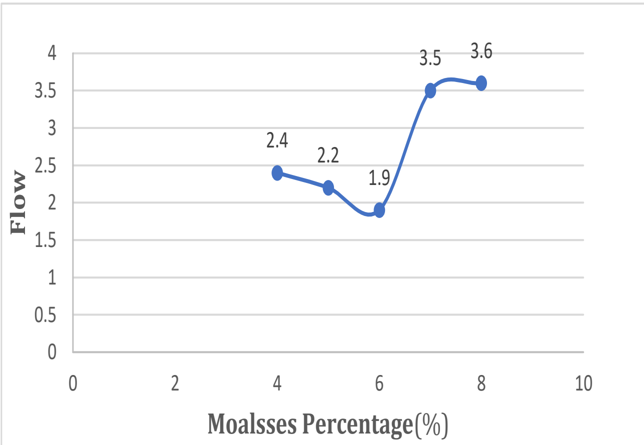
## 8.Optimum Molasses Values:

The Optimum value of molasses obtained is 6%, where maximum stability and minimum flow is seen.

| sno | molasses (%) | bitumen(%) | c and d(%) | ht of specimen (mm) | stability(kg) measured | stability(kg) corrected | flow(mm) |
|---|---|---|---|---|---|---|---|
| 1 | 4 | 6 | 20 | 65.1 | 565 | 542.4 | 2.4 |
| 2 | 5 | 6 | 20 | 69.9 | 755 | 671.95 | 2.2 |
| 3 | 6 | 6 | 20 | 66.7 | 1030 | 957.9 | 1.9 |
| 4 | 7 | 6 | 20 | 65.1 | 617 | 592.3 | 3.5 |
| 5 | 8 | 6 | 20 | 63.5 | 550.15 | 499.5 | 3.6 |

Graphs for the above table is shown below




## 9.CONCLUSION

Based on the experimental investigations carried out on DBM mixes prepared with coarse aggregates (NA, RCA) with stone dust as filler, and on modifications of the same mixes with molasses, the following conclusions are drawn:

- At optimum values maximum stability seen.
- The Optimum bitumen content is 6%.
- The Optimum RCA content is 20%.
- The Optimum molasses is 6% of optimum bitumen.
- 6% (by total weight of aggregates) +20%RCA (by total weight of aggregates) +6% molasses (by optimum bitumen content) gives the required stability of pavements for heavy and very heavy traffic roads because Marshall stability value required is more than 910kg (obtained is 958kg).
- Whereas 6%bitumen (by total weight of aggregates) +20%RCA (by total weight of aggregates) is sufficient for roads with low to medium traffic conditions because Marshall stability required is 545kg to 910 kg (obtained is 754kg). Then no need for partial replacement of bitumen with molasses.
- A decrease in bitumen utilization in pavements directly correlates with a reduction in the cost of laying pavement (using 6% as partial replacement of bitumen) so economically good.
- The use of the creative technology not only strengthened the road construction but also increased the road life span as well as will help to improve the environment and also creating a source of income (as cost decreases).
- From graphs maximum load carried is found.

## 10.ACKNOWLEDGEMENT

The authors would like to thanks our Institute (JNTUK KAKINADA) All Faculty members of Civil Engineering Department for giving all encouragement needed for completion of Project successfully.

## 11.REFERENCES

[1]Metin Guru ; M. Kürşat Çubuk; Deniz Arslan; and Sina Aminbakhsh(2016)" Effects of Sugar Beet Molasses and Molasses-Based Boron Oxide Compound on Bitumen Properties" Journal of Materials in Civil Engineering 29(4):04016252

DOI:10.1061/(ASCE)MT.1943-5533.0001790

[2]Shivkumar1 ; Narayana Harish, Ph.D.2 ; Sukomal Mandal, Ph.D.3 ; and Ramappa Prabhakara, Ph.D.4(2018)" Investigations on Stone Matrix Asphalt Using Construction Demolition Waste as Partial Replacement to Coarse Aggregates for Sustainable Roads" DOI:10.1061/9780784482032.036

[3]Mr. Rishi Dubey1, Mr. Tarun Kumar Narnaure2(2021) "A Review of Studies on Stone Matrix Asphalt by using various

Additive" International Research Journal of Engineering and Technology (IRJET) Volume: 08 Issue: 10IRJET- A Review of Studies on Stone Matrix Asphalt by using Various Additives by IRJET Journal - Issuu

[4] Jyoti Prakash Giri1 ; Mahabir Panda2 ; and Umesh Chandra Sahoo3" Performance of Bituminous Mixes Containing Treated Recycled Concrete Aggregates and Modified by Waste Polyethylene" Journal of Materials in Civil Engineering ,Volume 30, Issue 8

https://doi.org/10.1061/(ASCE)MT.1943-5533.0002384

[5](Prof. Vasudevan.) "A technique to dispose waste plastics in an ecofriendly way – Application in Construction of flexible pavements" Construction and Building Materials Vol. 8 Department of Chemistry, Thiagarajar College of Engineering, Madurai, Tamil Nadu, India, pp 311–320.

[6] Textbook of Highway Engineering by V. K. Kumawat

[7]Reference book Highway Material Testing & Quality Control by G. Venkatappa Rao & K Ramachandra Rao.

[8] Textbook of Highway & Traffic Engineering by Subhash C Saxena Guidelines of NHAI for Construction of Flexible Pavement (http://nhai.gov.in).

[9] Guidelines of PWD Maharashtra for Construction of Flexible Pavement (www.mahapwd.com).

[10]IRC (Indian Roads Congress). 2012. Guidelines for the design of flexible pavements, third revision. IRC 37. New Delhi: IRC.

[11]Lastra-Gonzalez, P., M. A. Calzada-Pérez, D. Castro-Fresno, Á. VegaZamanillo, and I. Indacoechea-Vega. 2016. "Comparative analysis of the performance of asphalt concretes modified by dry way with polymeric waste." Constr. Build. Mater. 112: 1133–1140.

https://doi.org/10 .1016/j.conbuildmat.2016.02.156

[12]Mills-Beale, J., and Z. You. 2010. "The mechanical properties of asphalt mixtures with recycled concrete aggregates." Constr. Build. Mater. 24 (3): 230–235. https://doi.org/10.1016/j.conbuildmat.2009.08.046.

[13]MoRTH (Ministry of Road Transport and Highways). 2013. "Specifications for road and bridge works. fifth revision." In Indian Roads Congress. New Delhi, India: MoRTH.

[14]Paranavithana, S., and A. Mohajerani. 2006. "Effects of recycled concrete aggregates on properties of asphalt concrete." Resour. Conserv. Recycl. 48 (1): 1–12. https://doi.org/10.1016/j.resconrec.2005.12.009.

[15] Perez, I., A. R. Pasandín, and L. Medina. 2012. "Hot mix asphalt using C&D waste as coarse aggregates." Mater. Des. 36: 840–846.

https://doi .org/10.1016/j.matdes.2010.12.058.

[16]Airey, G. D. (2003). "Rheological properties of styrene butadiene styrene polymer modified road bitumens.

" Fuel, 82(14), 1709–1719.

**BIOGRAPHIES:**

NAME: DR. D KOTESWARA RAO
Qualification: B.Tech, M.Tech (G.T.E), C.C.A & D.T.W, Ph.D, Professor at JNTUK,KAKINADA

NAME:Smt.Md.Sajida Sulthana
Qualification: M.Tech. (Jntuk) Assistant professor(C) at JNTUK, KAKINADA

Name : Mr. Tarun
Qualification : B.E. (Civil) U.G. Student at JNTUK,KAKINADA

Name : Miss.Alekhya Sahithi
Qualification : B.E. (Civil) U.G. Student at JNTUK,KAKINADA

Name : Mr. Jaya Prakash
Qualification : B.E. (Civil) U.G. Student at JNTUK,KAKINADA

Name : Miss.kathyayani
Qualification : B.E. (Civil) U.G. Student at JNTUK,KAKINADA