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# Material Modification for Flexible Pavement Using Acrylic Resin

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**Abstract**: Acrylic resins are a group, related to thermoplastic or thermosetting plastic substances derived from acrylic acid, meth acrylic acid or other related compounds.Increasing traffic loading and volumes on roads have led to the use of polymer modified binders to improve the performance of bitumen in terms of strength, durability, and resistance to rutting. The effect of adding Acrylic resin with different molecular weights can change the asphalt properties. The achieved improvement was found to be dependent on polymer molecular weight. Moreover, the results explained that the compatibility between Acrylic resin and asphalt binder is improved upon further aging especially with low molecular weight polymer. The experimentation at several institutes indicated that acrylic resin can be utilized as binding material for various activities. The use of acrylic resin in road construction is based on Economic, Technical and Ecological criteria. If these acrylic resins can be suitably utilized in road construction, the flexible pavement problems like stripping of bitumen from aggregate, melting of bitumen at high temperature, rutting, fatigue, cracks can be minimized to a large extent.

**Keywords:** Acrylic resin, Air voids, Flow, Marshal Density, Marshal Stability.

## 1 INTRODUCTION

In recent scenario, a world without roads, cars, motorcycles and bicycles is almost unimaginable. India is having second largest road network of over 5.4 lakh KM in the world. Due to extreme climatic conditions, growth of traffic and increasing maintenance expenditure on roads in India there is a necessity to develop sustainable technologies and economical road construction. The entire road infrastructure with its diversity of transport concepts now has a prominent − almost dominant – position in our society. The question is therefore not so much whether there will still be a road infrastructure in the future, but rather how will society view these mobility facilities in, say, thirty or forty years' time. Comparing the road infrastructure and means of transport of today with those of forty years ago, it becomes clear that in the next forty years' time everything will again look a lot different to how it looks today. Societies are constantly developing and, consequently so are people's requirements regarding the use, structure and design of the road infrastructure − not just roads in urban areas (urban roads), but also the motorways (interurban roads) between the major European cities. It is also quite conceivable that the future construction and design of infrastructure constructions such as bridges and tunnels will be subject to different requirements. In view of the lengthy time span of 10 to 15 years between planning infrastructure facilities and its actual completion, followed by an operational period of at least 25 years, more clarity of these future needs, demands and requirements becomes essential in order to make the right choices for today. Making the future more identifiable and tangible reveals the gaps of knowledge and indicates which new technologies will have to be developed to meet the future demands and requirements. Besides generic developments like shortage of clean environment, space and energy, spotting and extrapolating the social and economic trends and technical advances offer starting-points for forming a more realistic image of the future and the associated needs and demands related to road transport.

## 2 LITREATURE REVIEW

### 2.1 Review: 1

**Improvement of Asphalt Properties Using Polymethyl Methacrylate**

Reda A Haggam,Ismail M. Ibrahim, Mohamed El-Shafie Abdelatif,etc. Egyptian Petroleum Research Institute

Increasing traffic loading and volumes on roads have led to the use of polymer modified binders to improve the performance of bitumen in terms of strength, durability, and resistance to rutting. This research studies the effect of adding poly methyl methacrylate (PMMA) with different molecular weights on asphalt properties.

The achieved improvement was found to be dependent on polymer molecular weight. Moreover, the results explained that the compatibility between PMMA and asphalt binder is improved upon further aging especially with low molecular weight polymer (PMMA).

### 2.2 Review: 2

**Modified bitumen and its use for preparing asphalt mixtures and bituminous products**

Marjan TUSAR, Marjana NOVIC, Ema SUSTERSIC,etc.

The present invention relates to modified bitumen, comprising 50 to 99.9 parts by weight of bitumen and 0.1 to 50 parts by weight of poly methyl methacrylate/aluminium hydroxide (PMMA/ATH) composite dust and its use for preparing asphalt mixtures and bituminous products.

### 2.3 Review: 3

**Asphalt concrete modi□cation with waste PMMA/ATH**

**E. Sustersic • M. Tusar • A. Zupancic Valant**

According to this review the recycling of waste PMMA/ATH powder can be used in asphalt concrete mixture. Waste PMMA/ATH is generated in large amounts during shaping process of acrylic sheets. Recycling waste polymers rationally and efficiently has become one of the priorities of road pavement industry in recent years. Therefore, in this study waste PMMA/ATH powder was incorporated in an asphalt mixture. In one case waste PMMA/ATH was used as an asphalt binder modifier and in other case as a partial replacement for fine aggregate fraction.

By considering above reviews…

Since all reviews shows the binding capacity of PMMA in changing bitumen properties, and it is a type of acrylic resin. Hence it is mixed with bitumen to check its binding capacity. Acrylic resin is also having the property of UV Radiation absorption hence the melting of bitumen due to high temperature can be prevented.

## 3 MATERIALS USED

### 3.1 BITUMEN

Ordinary Bitumen of 60/70 grade is used for BC course.

### 3.2 COARSE AGGREGATES

Aggregates which possess sufficient strength, hardness, toughness and soundness are chosen, keeping in view the availability and economic consideration.

Two sets of aggregates were chosen,

One set for trial and error testing's which may have passing 12.5mm and retaining 10mm.

Another set may have actual gradation of aggregates specified by IRC for BC course.

### 3.3 ACRYLIC RESIN

Acrylic also known as Poly methyl methacrylate (PMMA) which is a transparent thermoplastic often used in sheet form as a lightweight or shatter-resistant alternative to glass. The same material can be utilized as a casting resin, in inks and coatings, and has many other uses. Although not a type of familiar silica-based glass, the substance, like many thermoplastics, is often technically classified as a type of glass (in that it is a non-crystalline vitreous substance) hence its occasional historic designation as acrylic glass. Chemically, it is the synthetic polymer of methyl methacrylate. The material was developed in 1928 in several different laboratories by many chemists, such as William Chalmers, Otto Röhm and Walter Bauer, and was first brought to market in 1933 by the Rohm and Haas Company under the trademark Plexiglas.

## 4 METHODOLOGY AND TESTING

A set one of aggregates passing 12.5mm and retaining 10mm are weighed which can approximately fill an mould of 7.5cm*7.5cm*7.5cm, it may be around 700gms. Bitumen of 11% of weight of aggregates are taken approximately. To this a varying percentages of acrylic resin is added in the range of 0%,3%,5%,7%,10%,15%,20%,25% i.e. each specimen may have single percentage of acrylic resin and correspondingly bitumen content is reduced.

Specimens are tested under UTM to know load v/s displacement values, best results are taken carried out to actual method of testing which is MARSHAL STABILITY TEST.

### 4.1 SPECIMEN COBINATIONS

**Specimen 1:** Bitumen + Aggregates+3% Acrylic resin
**Specimen 2:** Bitumen + Aggregates+5% Acrylic resin
**Specimen 3:** Bitumen + Aggregates+7% Acrylic resin
**Specimen 4:** Bitumen + Aggregates+10% Acrylic resin
**Specimen 5:** Bitumen + Aggregates+15% Acrylic resin
**Specimen 6:** Bitumen + Aggregates+20% Acrylic resin
**Specimen 7:** Bitumen + Aggregates+25% Acrylic resin

## 5 EXPERIMENTAL OBSERVATIONS

The specimens are tested under UTM and the results are tabulated. Then a graph showing Load vs Displacement is plotted. Load is in KN & Displacement is in mm.

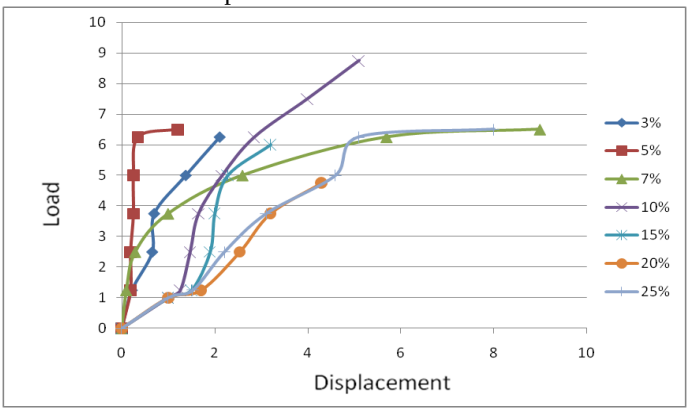


Figure 1: Load vs Displacement for acrylic granules

## 6 CALCULATIONS FOR STRESS AND STRAIN

Deflection is calculated by formulae:

Def = $( M + \frac{D}{100})$

Where M = main scale reading

D = Vernier scale reading or divisions

Stress is calculated by formulae:

Stress = $\frac{P}{A}$

Where P = load

A = area

Strain is calculated by formulae:

Strain = $\frac{\Delta L}{L}$

Where $\Delta L$ = deflection

L = Length

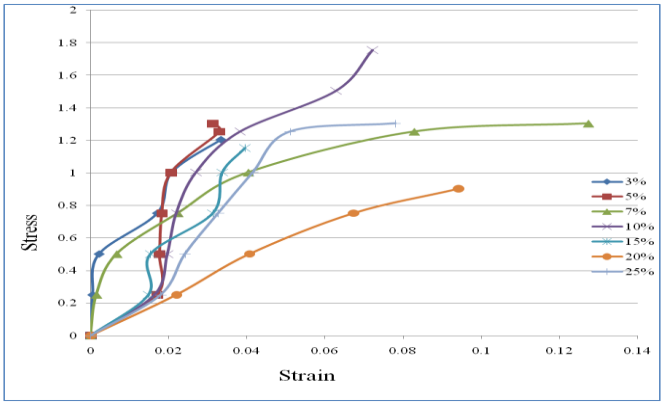


Figure 2: Stress vs Strain

## 7 RESULTS AND DISCUSSIONS

The elastic modulus of each component is obtained from the stress strain curve. The behavior of specimen is as like the traditional stress strain behavior of flexible pavement. Based on the composition the maximum load carrying capacity is increased and elastic modulus is also increased. It is evidenced that in the graph, the acrylic resin composition of 7%, 10% and 15% are showing better values of stress-strain among all. Hence the Marshal Stability test is conducted for the selected percentage of acrylic resin added to the bituminous mix and the Stability, Density, Flow value and Air void ratios are obtained for the better analysis.

## 8 MARSHAL STABILITY TEST

### 8.1 Mix Design

- Desired grading of mix is selected from the recommended gradation for the particular type of pavement layer by IRC.
- Sieve analysis is carried out on the samples of aggregate collected and the proportion in which they should be mixed to obtained desire gradation(by any one of method such as graphical method or trail method).
- The maximum permissible size of coarse aggregates for the preparation of Marshall Stability test specimen is 25 mm.
- The present project is carried for the top most layer of BC course.

### 8.2 Methodology of specimen

The graded aggregates of 1200g i.e., set two aggregates are mixed up with bitumen and acrylic resin. For every percent of addition of acrylic resin the same amount of bitumen will be reduced. The specimen combinations are as follows,

**Specimen 1:** Agg. +0% of acrylic resin +7% of bitumen
**Specimen 2:** Agg. +7% of acrylic resin +6.98% of bitumen
**Specimen 3:** Agg. +10% of acrylic resin+6.75% of bitumen
**Specimen 4:** Agg. +15% of acrylic resin+6.38% of bitumen

### 8.3 EXPERIMENTAL OBSERVATIONS

The Marshal Stability Test is conducted and the readings were tabulated. For the readings obtained the following graphs are plotted against Bitumen and various parameters for the analysis.

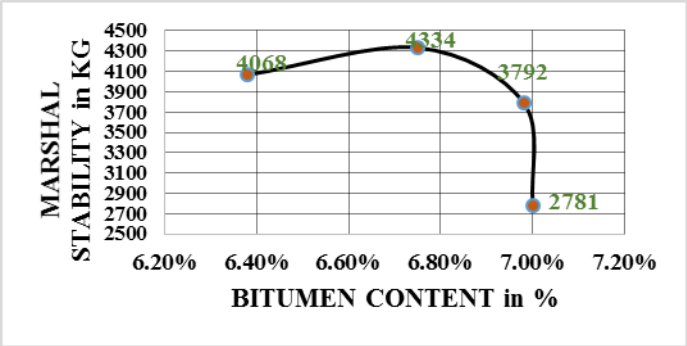


Figure 3: Bitumen vs Stability

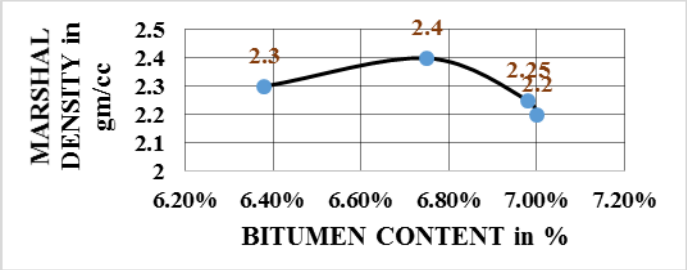


Figure 4: Bitumen vs Density

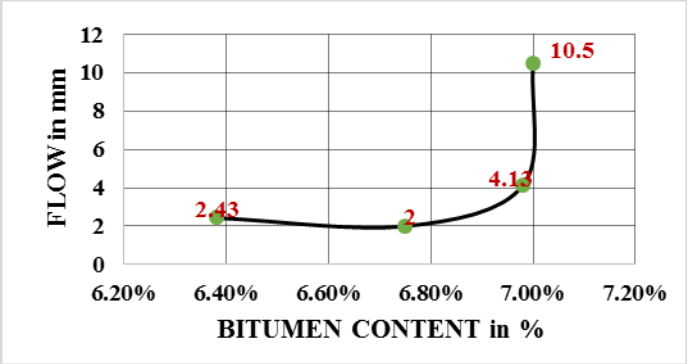


Figure 5: Bitumen vs Flow

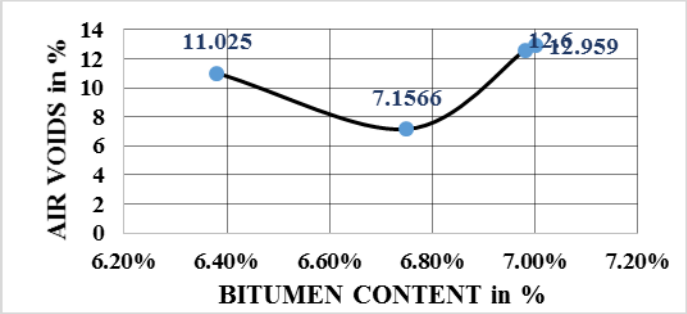


Figure 5: Bitumen vs Flow

## 9 CONCLUSION

1. The graphs plotted against various content of bitumen and properties of behavior of marshal stability molds, shows the good results at 10% of acrylic content which as high marshal stability, high marshal density, less flow value and less air void content. Hence we can conclude that among 7%, 10% and 15%, 10% is the optimum content of acrylic resin.
2. The acrylic resin added in the bituminous mixes can increase the stability and density of the mix which is designed for the BC course. It is found that at 10% of acrylic resin replaced with the bitumen content will yield more strength, stability, and density with low air voids and less flow value.
3. It is found that, the Stability is increased twice, when compared to the normal bituminous mix i.e. without adding acrylic resin. Hence the thickness of the pavement layer may be reduced to half of normal thickness which results in economy of cost by reducing quantity of aggregate, bitumen and their by achieving the work in less duration of time with better quality.
4. The material ACRYLIC RESIN has a property of UV Radiation absorption which may prevent melting of bitumen in high temperature. So that the bond between bitumen and the aggregate is attained.

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