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Effect of Nano Clay and LDPE in Bitumen

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Abstract— *This project is done for identifying the use of various modifiers in bitumen, based on different requirements. Many researchers tried with all types of plastic waste as a partial replacement in bitumen. Recently, very few researchers are using nanoclay for modifying the bitumen. This project is an attempt to try both modifiers individually and as a composite, and the possible changes in the property of base bitumen are found and hence based on temperature and other factors suitable modifiers are suggested.*

Keywords — *Nano Clay, Montmorillonite, Low Density Poly Ethylene, VG 40 grade Bitumen, Nano montmorillonite clay, Nanocomposites*

I. INTRODUCTION

For country like India wherein the temperature, rainfall and the climatic conditions are highly varying from one place to other, we can't use same type of bitumen everywhere. So, enhancing the base bitumen based on the field requirement is the need of the hour. Thus modifiers are planned to be used in bitumen which changes the bitumen's property based on our requirement.

A. Need for the study

The nonrenewable source like oil is not sufficiently available and hence the extraction of its by-product bitumen is also challengeable. When certain modifiers are used, the quantity of bitumen may be reduced since it exhibits similar properties like bitumen. Modifiers are used in bitumen to enhance its properties like strength and durability.

B. Objectives

- To use modifiers like Nano clay and LDPE in bitumen
- To analyse the effect of Nanoclay and LDPE individually and as composite in bitumen

II. REVIEW OF LITERATURE

Van de Ven et. al in their work tried nano clay in bituminous mixture. They found that when nano clay is added the viscosity of the binder increases and thus ageing resistance is high since only less contact with air and in particular oxygen. So, viscosity is one among the main factor related to ageing of bitumen.

Jeroen Besamusca et. al found that increase in viscosity increases the stiffness. Also it was analysed like viscosity does not depend on temperature only but also on the shear rate. If temperature is low to medium modifiers increase the fatigue temperature. This is still more prominent when there is increase in percentage of modifiers.

Saeed Ghaffarpour Jahromi et. al from their experimental work suggested that, for the polymer and clay to be a successful nano composite, only mechanical forces won't be sufficient. Thermal force is also required.

Saad Issa Sarsam used modifiers nano fly ash (3%, 6%, 9%, and 12%) and nano silica fumes (2%, 3%, 4%). Nano silica increased the viscosity. Also it was stated that modifiers of nano size have a positive effect on asphalt.

Saeed Ghaffarpour Jahromi et. al used two nano elements Cloisite and Nano fill. In cloisite the penetration was less and softening point was more. Nano fill has more ductile nature. They suggested like based on field conditions respective modifiers must be used.

Lamya et. al studied the effect of different percentages of Nano clay in bitumen and hence concluded from their experiments that the penetration was less for 9% nano clay concentration. Also for same percentage of nano clay softening point and viscosity increased when compared to its counter parts the conventional bitumen, 3% and 5%.

S Ghaffarpour suggested from their work that addition of nano clay in the form of Cloisite and nano fill increased the final deformation resistance and fatigue resistance. Also there is a dependence on temperature factor, though modified with nano clay.

S Rajasekaran et. al, used 4.5% of bitumen and modified with 5% LDPE and 10% LDPE. It was found that the softening point was in the range of 100 -120˚C. Though plastics are used there was no gas emission in this temperature range, which will be environment friendly.
Jun Yang stated that addition of Nano clay increased the viscosity, rutting and fatigue resistance. It improved the asphalt mixture property mostly at temperature. .

III. MATERIALS

A. Bitumen
B. LDPE (Low Density Poly Ethylene covers)
C. Montmorillonite Nano Clay (NC)
D. Composites

A. VG 40 grade Bitumen

VG – 40 grade bitumen is used in heavy loaded area such as toll booths, industrial area and truck parking lots. Due to its higher viscosity it has higher resistance to the stress.

B. Low Density Poly Ethylene (LDPE)

The Low density polyethylene is got from radical polymerization. The density of LDPE lies in the range of 0.91 to 0.93.

C. Montmorillonite Nano Clay (NC)

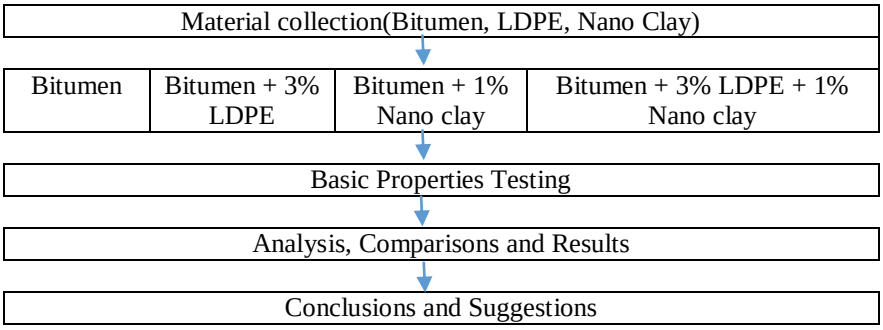
Montmorillonite is one type of clay which has an alumina sheet sandwiched inside the two silica sheet, it also has highest surface area compared to other clay minerals such as kaolinite, illite.

D. Composites

Sample-1 Bitumen + 3% Low Density Poly Ethylene.
Sample-2 Bitumen + 1% Nano clay
Sample-3 Bitumen + 1% Nano clay and 3% Low Density Poly Ethylene, making a composite.

All samples are checked for its properties before and after addition of their respective modifiers.

IV. Methodology



V. EXPERIMENTAL ANALYSIS, COMPARISONS AND RESULTS

A. Penetration test

Table 1. Penetration of modified bitumen and unmodified bitumen

Type	Conventional	3 % LDPE	1% NC	3% LDPE + 1% NC
Penetration @ 25˚C	40.3	34.7	35.5	34.6

By modifying with LDPE modifiers, the penetration attained is very less which specifies it can be used in high temperature wherein heavy stress is encountered. Nano clay modified bitumen has less penetration compared with conventional bitumen. In composites, the value is near to the LDPE penetration.

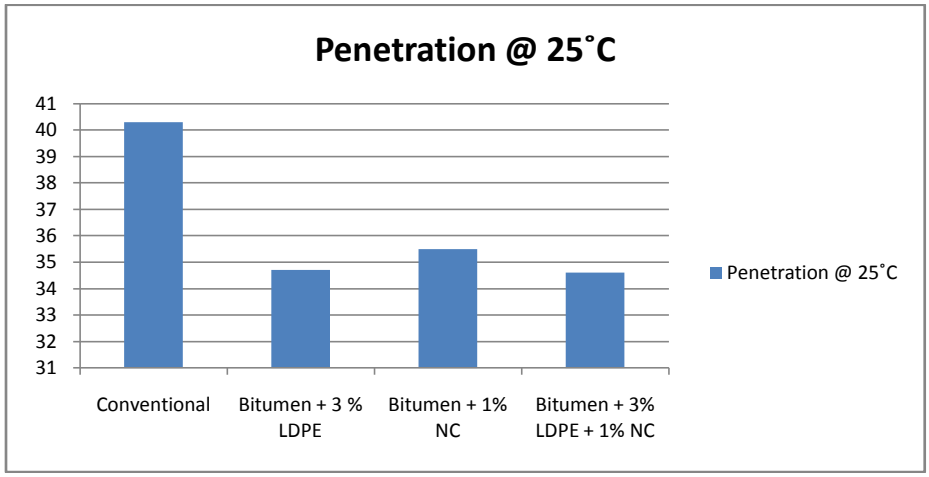


Figure 1. Shows the Penetration of modified bitumen and unmodified bitumen

B. Ductility test

Table 2. Ductility of modified bitumen and unmodified bitumen

Type	Conventional	Bitumen + 3 % LDPE	Bitumen + 1% NC	Bitumen + 3% LDPE + 1% NC
Ductility(cm)	76	25	78	24.3

Due to the modification with LDPE bitumen, the ductility value has been reduced adversely. But the Nano clay modifier has given good ductility results compared to conventional bitumen. In the composites the LDPE dominates over the Nano clay and thus got very less ductility values.

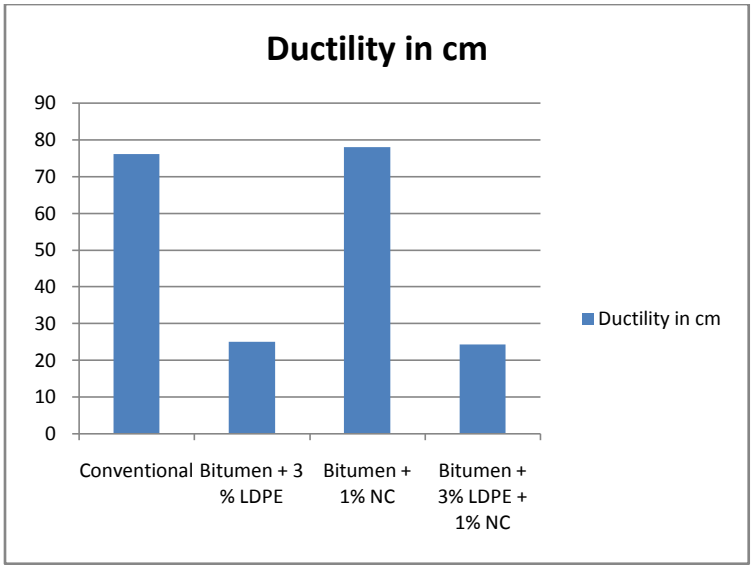


Figure. 2 Shows the ductility of modified bitumen and unmodified bitumen

C. Flash point and Fire point

Table 3. Flash point and Fire point of modified bitumen and unmodified bitumen

Type	Conventional	Bitumen + 3 % LDPE	Bitumen + 1% NC	Bitumen + 3% LDPE + 1% NC
Flash point(˚C)	200	210	188	194
Fire point(˚C)	230	240	220	238

When LDPE is added, the bitumen takes more time and temperature to reach the Flash and fire point when compared to the conventional bitumen. This is good and is suggested for high temperature regions. When Nano clay is added, it reaches the flash and fire point very soon, hence can be used in low temperature regions. Considering the composites, both the LDPE and NC, together they gave a moderate effect on bitumen combining both the properties of LDPE and NC.

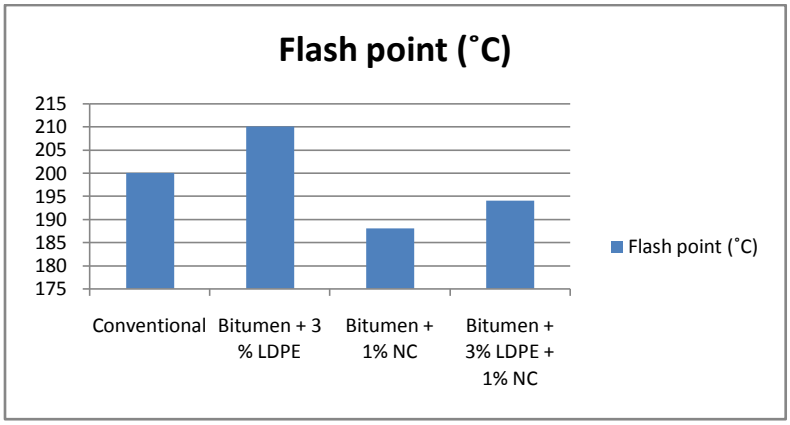


Figure 1. Shows the Flash point of modified bitumen and unmodified bitumen

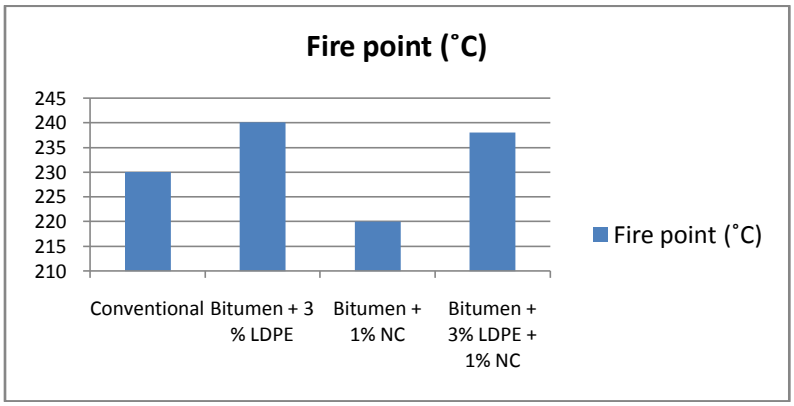


Figure 4. Shows the Fire point of modified bitumen and unmodified bitumen

D. Specific gravity of bitumen

Table 4. Specific gravity of modified bitumen and unmodified bitumen

Type	Conventional	Bitumen + 3 % LDPE	Bitumen + 1% NC	Bitumen + 3% LDPE + 1% NC
Specific gravity	0.99	1.02	1	1.01

In specific gravity not much variation is observed among the different combination of samples since all are having similar specific gravity value.

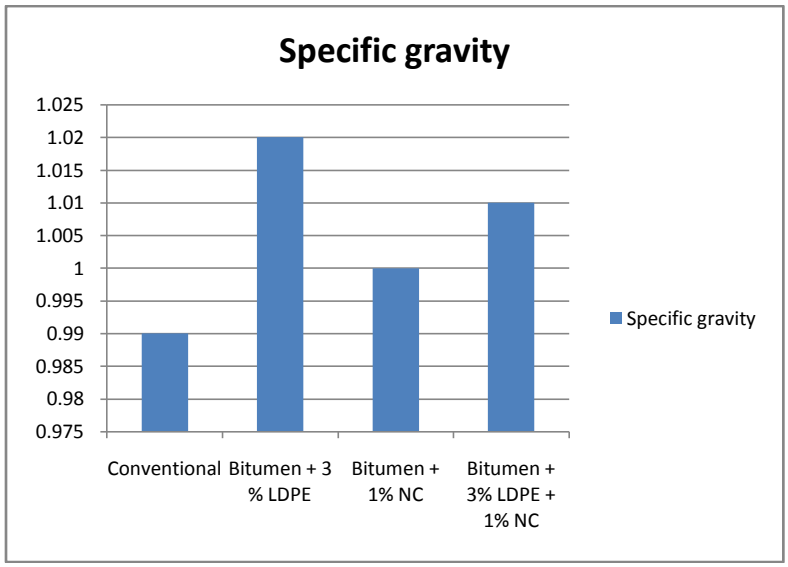


Figure. 5 shows the specific gravity of modified bitumen and unmodified bitumen

E. Softening Point

Table 5. Softening point of modified bitumen and unmodified bitumen

Type	Conventional	Bitumen + 3 % LDPE	Bitumen + 1% NC	Bitumen + 3% LDPE + 1% NC
Softening point(˚C)	62	67	57	60

The softening point of LDPE modified bitumen is high compared to conventional bitumen and NC modified bitumen. In composites, NC dominates the LDPE since the softening point values are near the NC values.

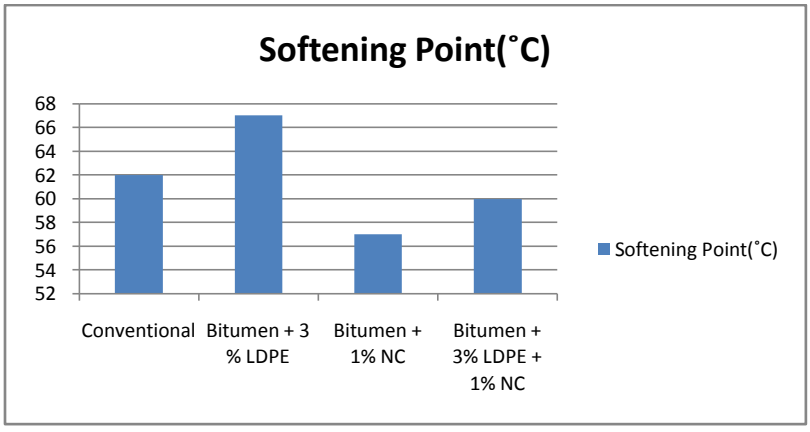


Figure. 6 Shows the softening point of modified bitumen and unmodified bitumen

F. Viscosity Test

Viscosity having inverse nature of fluidity has a main role during application of bitumen on the aggregates.

Table 6. Viscosity of modified bitumen and unmodified bitumen

Type	Conventional	Bitumen + 3 % LDPE	Bitumen + 1% NC	Bitumen + 3% LDPE + 1% NC
Viscosity(seconds)	17	40	38	25

When there is high viscosity there is more stiffness. All the samples exhibited more viscous nature then the conventional bitumen. Nano clay is having more viscous nature than the composites in all the trials. This is the rare behavior encountered which has to be studied in depth with varying percentages of LDPE and NC. Since, so far the composites exhibited a value on an average of both the individual samples or taking up the property of any one sample as it dominates. But in this case, it is neither reaches any of the LDPE and NC values but gives a very less value compared to both.

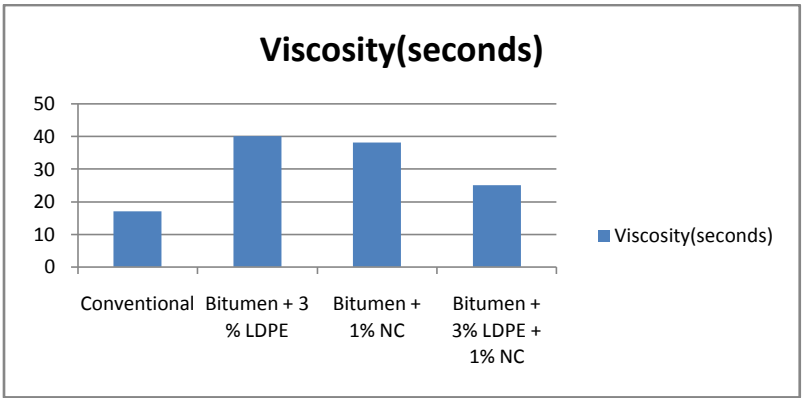


Figure. 7 Shows the viscosity of modified bitumen and unmodified bitumen

Table 7. Basic Properties of modified bitumen and unmodified bitumen

Type	Conventional	Bitumen + 3 % LDPE	Bitumen + 1% NC	Bitumen + 3% LDPE + 1% NC
Penetration @ 25˚C	40.3	34.7	35.5	34.6
Ductility in cm	76	25	78	24.3
Flash point (˚C)	200	210	188	194
Fire point (˚C)	230	240	220	238
Specific gravity	0.99	1.02	1	1.01
Softening Point(˚C)	62	67	57	60
Viscosity(seconds)	17	40	38	25

VI. Conclusions and Discussions

For areas of hot climate, LDPE modified bitumen is preferred since it will not soften soon even if the high temperature is reached on roads.
For humid climate regions, laying the road itself is a big challenge since the weather takes up the heat while laying the road from the materials used. But Nanoclay having siliceous ingredients has much resistance for temperature susceptibility and hence Nano clay is preferred in cold climatic regions.
For mixed climatic regions we can go for composites of LDPE and Nano clay, which takes up the positivity in each modifier and thus enhancing the properties of mix like strength and durability.

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