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INFLUENCE PROCESS OF MODIFICATION OF BITUMINOUS CONCRETE BY THE NBR ON THE MECHANICAL AND RHEOLOGICAL CHARACTERISTICS

SOUDANI Khedoudja, SAOULA Samia, HADDADI Smail &
AIT MOKHTAR Khedidja
FGC/USTHB. BP 32 El Alia 16111, Bab Ezzouar. Algeria. smail_haddadi@yahoo.f

www.irf2010.com

Outline

1. Introduction and Objectives
2. Presentation materials
3. Results and Discussion
4. Conclusion

Surface of Algeria: 2.381.741 km ².

The population: more than 35.000.000.

It is concentrated primarily in north.

The number of vehicles is higher than 5.000.000.

The Current network is composed of 110.125 km roads ensuring 90% of the volume of the exchanges, of which most important is recorded on the basic economic network.

That reflects the prevalence of the mode of road transport compared to the Other Modes of transportation (train, plane, boat).

Several road programs are launched

- Southern special program
- Development program of the areas of the high plateaus
- Creation of capacity news, is nearly 4.050 km of roads
- Nearly 3.725 km of roads in opening-up.

PROJECT IN PROGRESS

Highway east-west: 1.216 kilometers for Algeria connecting the Moroccan Border to the Tunisian border and cash 2x3 ways. Its delivery is planned for 2012.

The realization of the 2nd Southern By-pass of Algiers between Boudouaou (Boumerdes) and Zéralda (Algiers) on 65 km.

The finishing of the realization of the Trans-Saharan road (Branch Native of Niger) on 175 km and repairing of the RN 1 between North of Tamanrasset and Blida: Under development.

PROJECT TO BE LAUNCHED

- Studies of 17 motorway connections fast on 1396 km.
- Study of highway of the high plateaus on 1300 km.

- Study of the 3rd southern By-pass d' Algiers: Boumerdes - Tipaza southern on 150 km in 2x2 ways.

- Study of the 4th By-pass enters the wilaya of Ain Defla - Bordj Bou Arréridj on 300 km.

- Study of unfolding of the RN 01 out of 320 km.

- In addition to the realization of new airport tracks .

- In recent years, Algeria has a dynamic investment and consumption.

The Algeria product per year :

- 5 million tons of household waste
- More than 300,000 tons of special waste
- 2,000,000 tons of industrial waste

The activities of recycling / recovery are not very well developed although potential for recyclable materials is important (about 760 000 T / year).

Algeria could save over 300 million euros annually by focusing on the development of recycling

One of the potential sectors for recycling and recovery of industrial waste is public works.

The pavement structures are subject in service to very complex solicitations

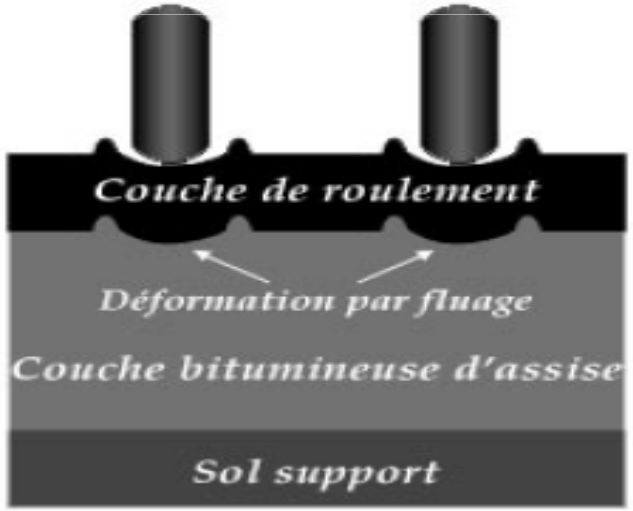
Traffic and weather have an important influence on the behaviour of pavement materials.

In Algeria,

In recent years, the permanent deformations (mainly rutting) have appeared.

The rutting can come from:

- A deformation of the ground support,
- thinning of the bituminous concrete layers by creep

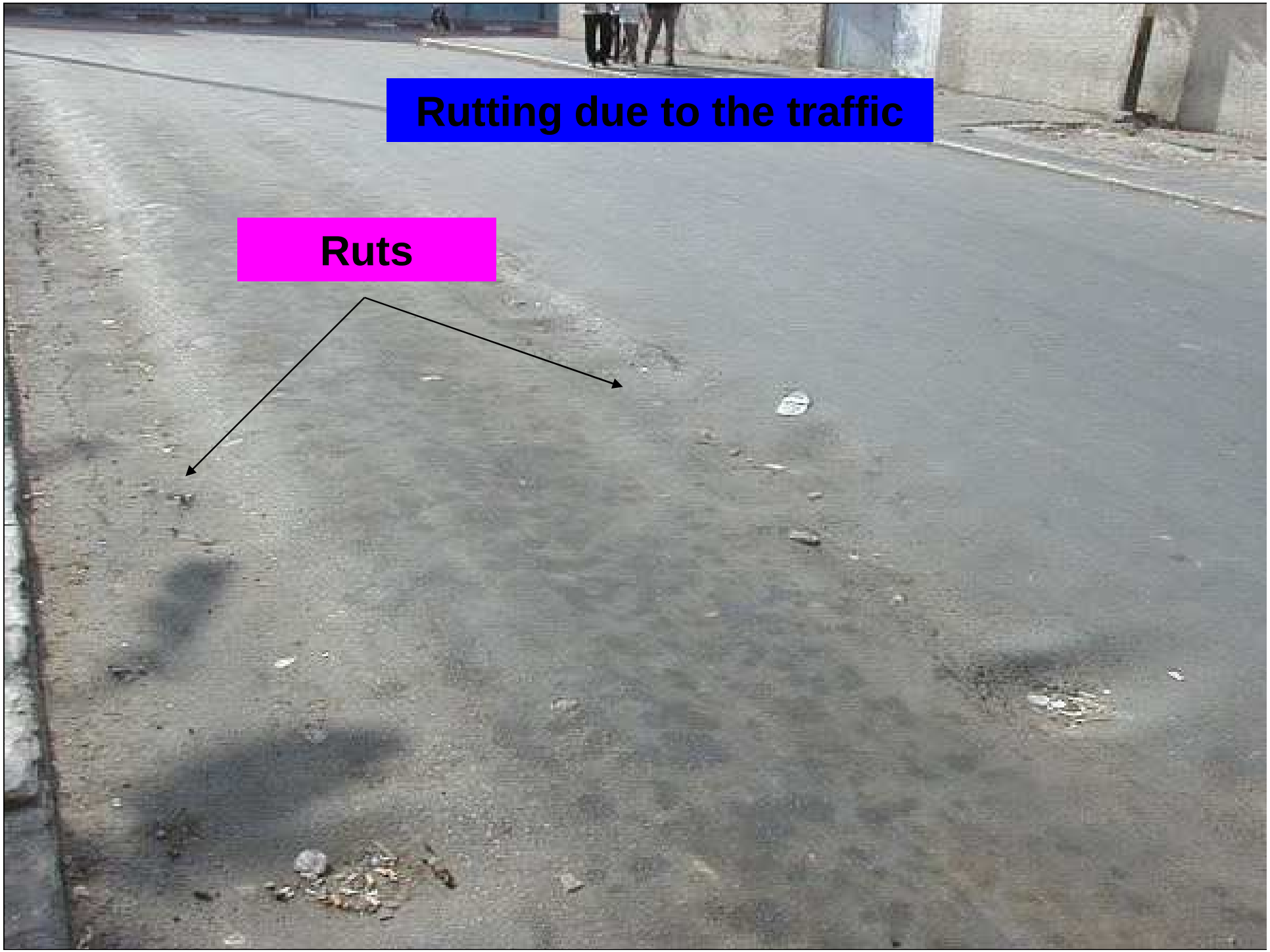


High temperatures in summer favours this phenomenon.

The addition of polymers in the asphalt concrete is a promising technique.

This operation allows to :

- Improve the performance of the bituminous concrete
- Reduce the frequency of the pavement repairing


Rutting due to the traffic
Ruts

The objective of this study is the recycling of industrial waste in road pavements to:

- Improve the mechanical properties of asphalt concrete (economy of aggregates and asphalt)

- Increasing the lifespan of the layer of pavement (sustainability)

- Preserve the environment.

Characterisation methods applied to the bitumen concrete

In this study, **Marshall test** and **static creep test** were performed.

Marshall test was performed in accordance with **ASTM D 1559**.

The specimens were compacted by applying 50 blows on each side of the specimen at 150 ℃.

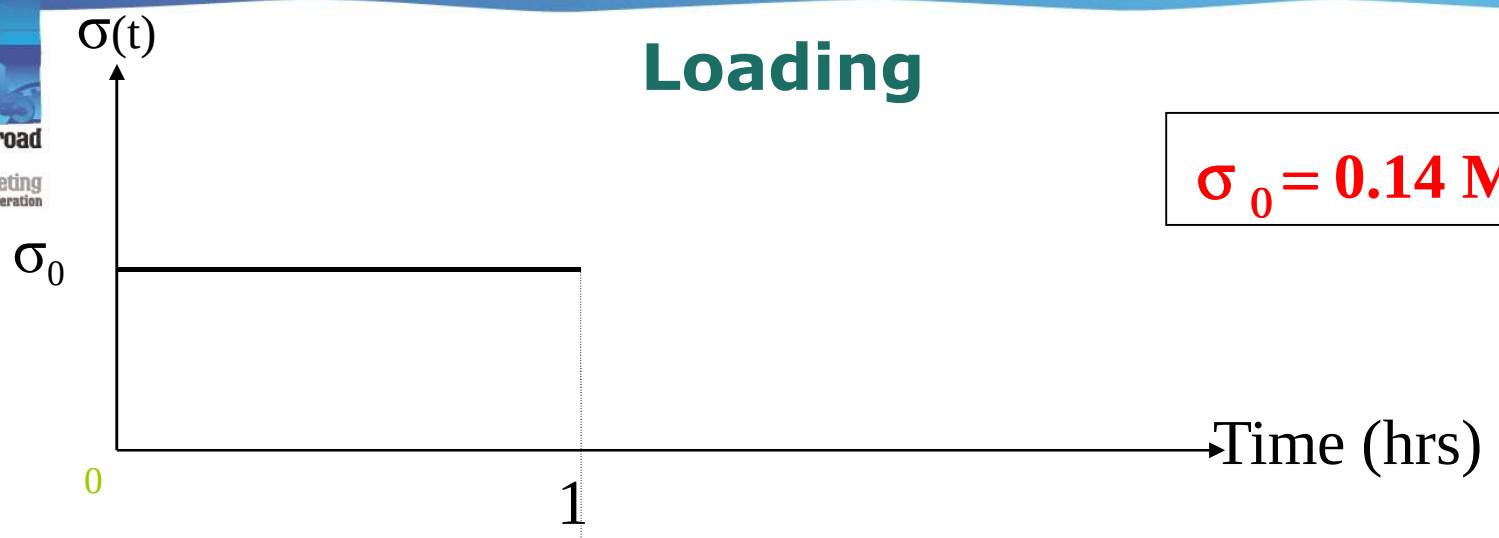
Static creep test

Device based on the oedometric apparatus

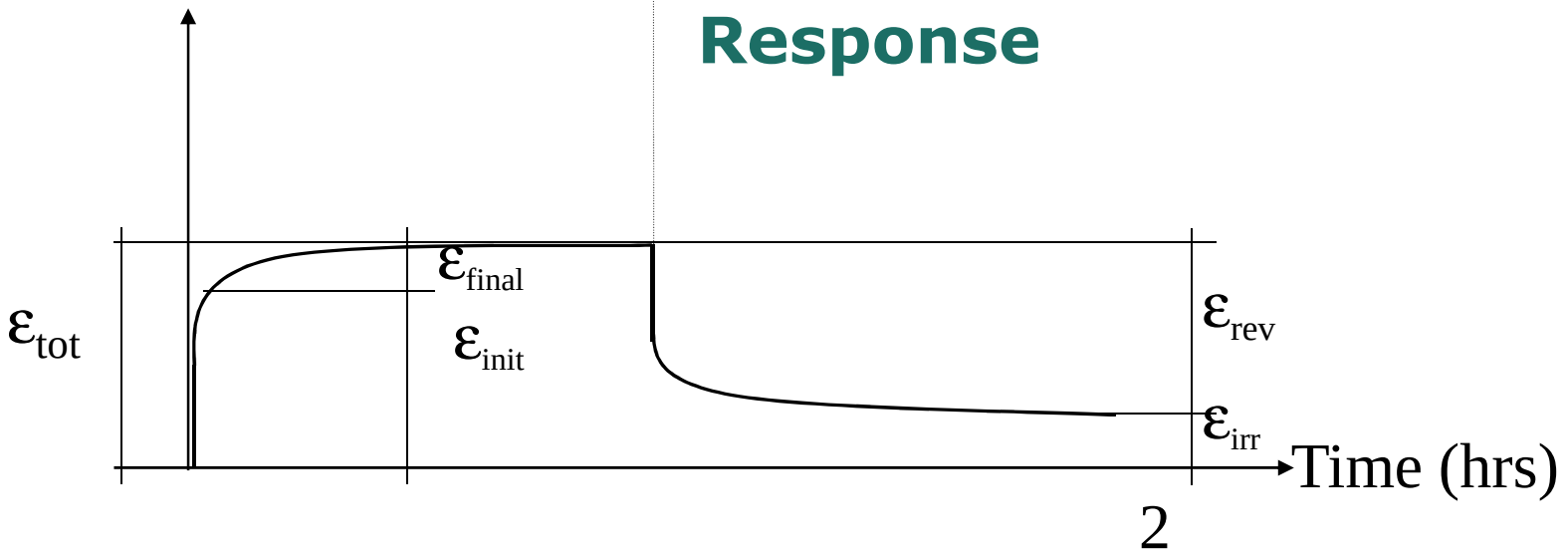
The test consists of applying a constant axial load to the cylindrical asphalt concrete during one hour then to discharge during 1 hour.

Loading

$\sigma_0 = 0.14$ MPa



Response



The applied stress and the components of the deformation measured during the test are represented by figure before, where:

ε_{Tot} : Total deformation recorded after 1h loading.

ε_{init} : Initial deformation recorded after 15s loading.

ε_{final} : Complementary final deformation recorded after 1h loading.

ε_{irr} : Irreversible or permanent deformation

ε_{rev} : Recoverable deformation.

σ_0 : Compression stress applied on the specimen.

The deformations during the test are calculated by the relation

$$\varepsilon\ (t, T) = \frac{\Delta h}{h_0} * 1000 \quad [‰]$$

MATERIALS CHARACTERISATION AND PREPARATION OF THE SAMPLES

Aggregates

- Crushed aggregates are used.

- The chemical analysis shows that :

  * the sand (0/3) is calcareous

  * the gravel (3/8 and 8/15) contains an important proportion of silica and oxides (basalt).

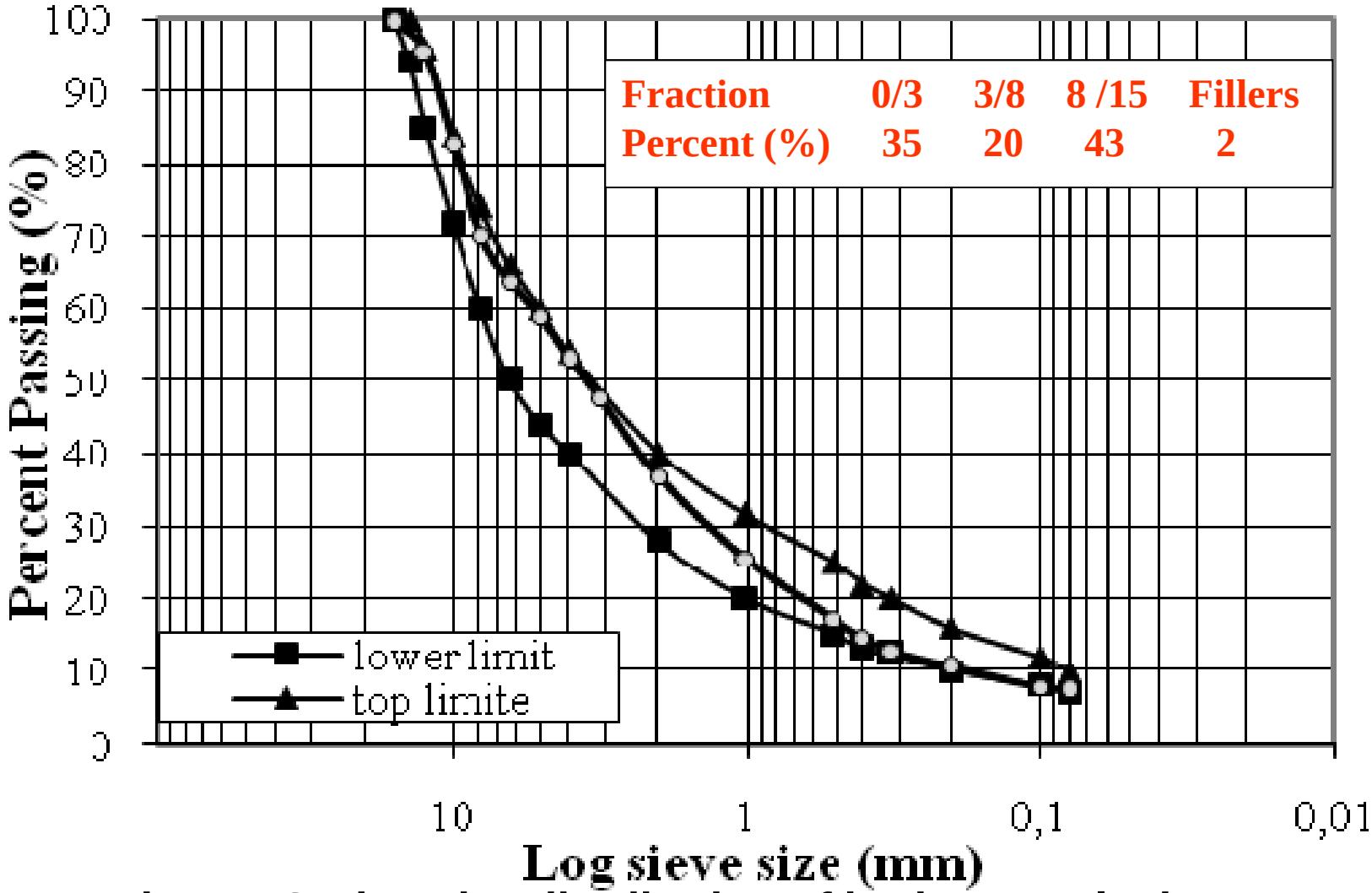


Figure: Grain seize distribution of both control mixtures.

- **Bitumen** NAFTEC Company produces the asphalt cement.

Table : Characteristics of the bitumen used in this investigation

Tests	Standard	AC 35-50	Specifications
Penetration (25°C, (1/10 mm), $Pen_{25°C}$	ASTM D5-73	43	35-50
Softening Point (°C), SP	ASTM D36-76	50.60	50/58
Specific gravity (g/cm3)	ASTM D70-76	1.02	1,0–1,1
Flash point (°C)	ASTM D92-78	270	≥ 250
Fire point (°C)	ASTM D92-78	304	
Ductility à 25°C (50 mm/min) (mm)	ASTM D113-79	>1000	≥ 600

Polymer (dark industrial waste)

SAEL Company (Elastomers Application Society) provides it

The specific gravity = 1.25.

Figure : Grain seize distribution of NBR

Preparation of the bitumen concrete

Marshall specimens are used for the Marshall test and creep test

The optimum bitumen content (o.b.c.) of each mix is about 5,8 %

The aggregates are heated at 165 ℃.

Mixing is generally performed at about 155-160 degrees Celsius,

Paving and compaction are performed at about 150 degrees Celsius.

Three types of bituminous concrete have been considered

The first is obtained by mixing the unmodified bitumen with aggregates

It is the reference mix

The second is obtained by mixing the polymer modified bitumen with aggregates(wet process) .

The NBR contents used to prepare the binders are 2%, 3% and 4% by weight of o.b.c.

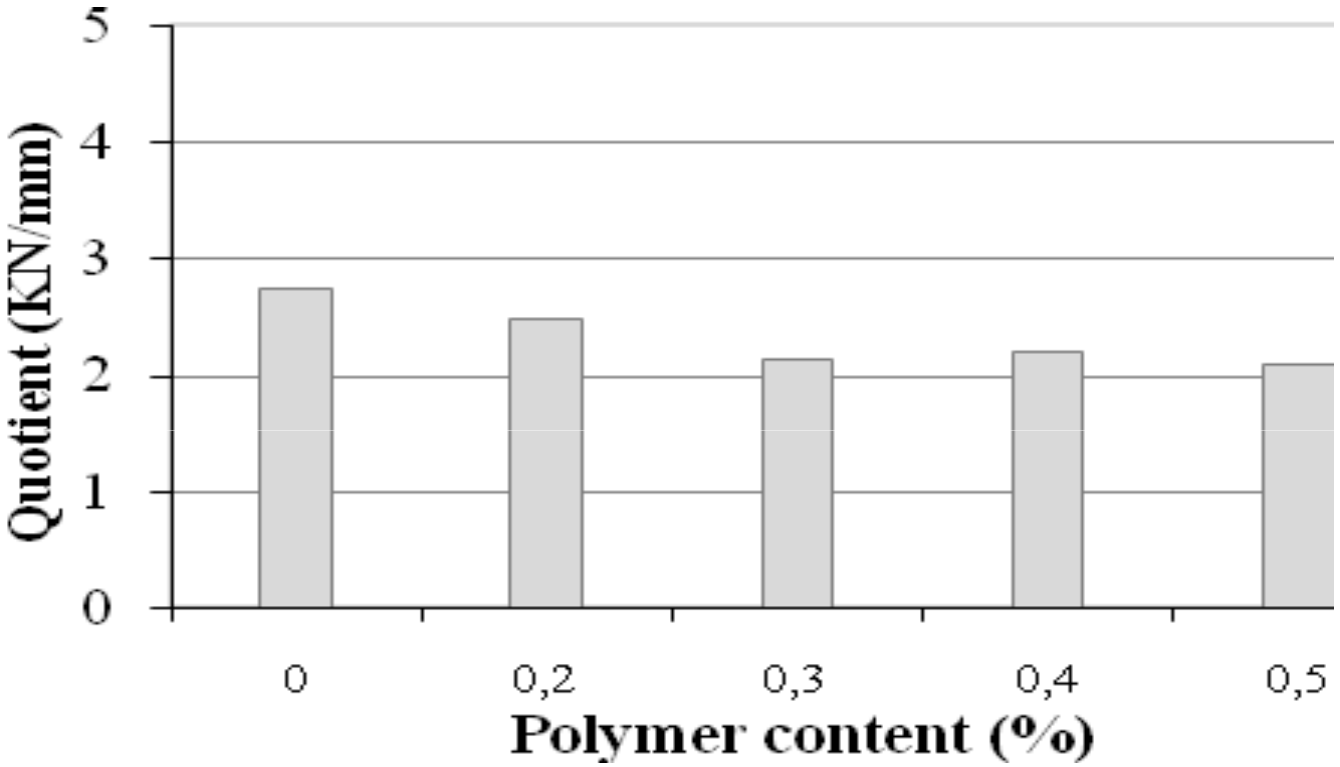
The third is obtained by mixing the unmodified bitumen, the NBR and the aggregates at the same time (dry process).

- The contents of NBR used were 0,2- 0,3 – 0,4 and 0,5%.
- Incorporation of the polymer was gradually made in order to ensure the homogeneity of the mixture.

RESULTS AND DISCUSSION

Marshall Test

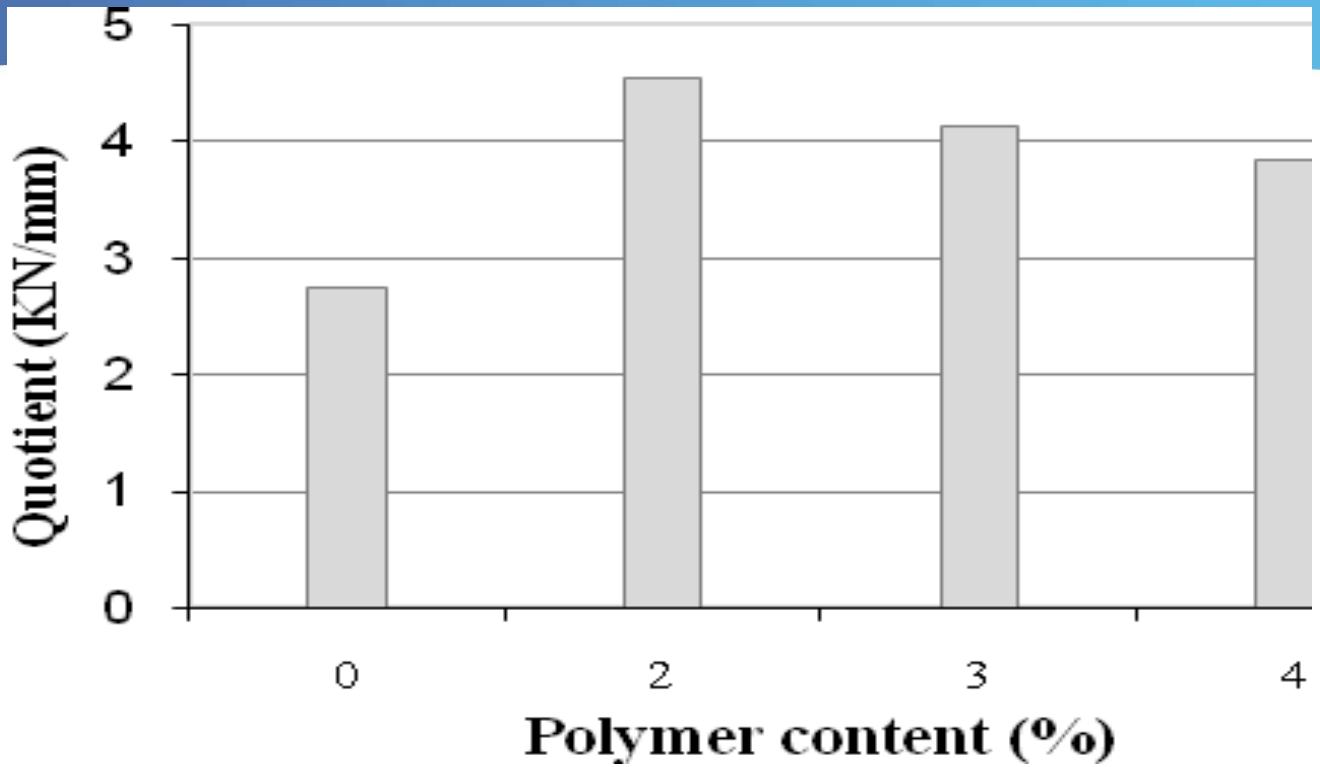
Dry process



Marshall Quotient of the different bituminous concrete mixtures with dry process versus the NBR content

The quotient falls with NBR content compared to the mixture of reference (0% NBR).

Wet process



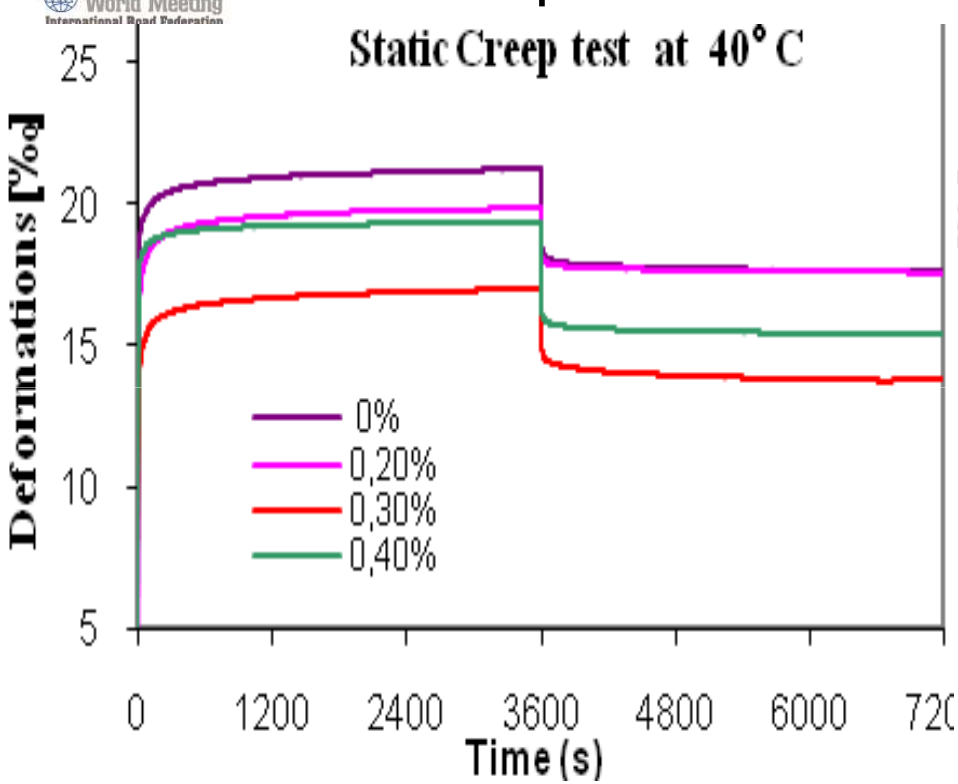
Marshall Quotient of the different bituminous concrete mixtures with wet process versus the NBR content

According to the Marshall results, a considerable improvement of the mechanical characteristics of the modified bituminous concrete is observed (figure 4).

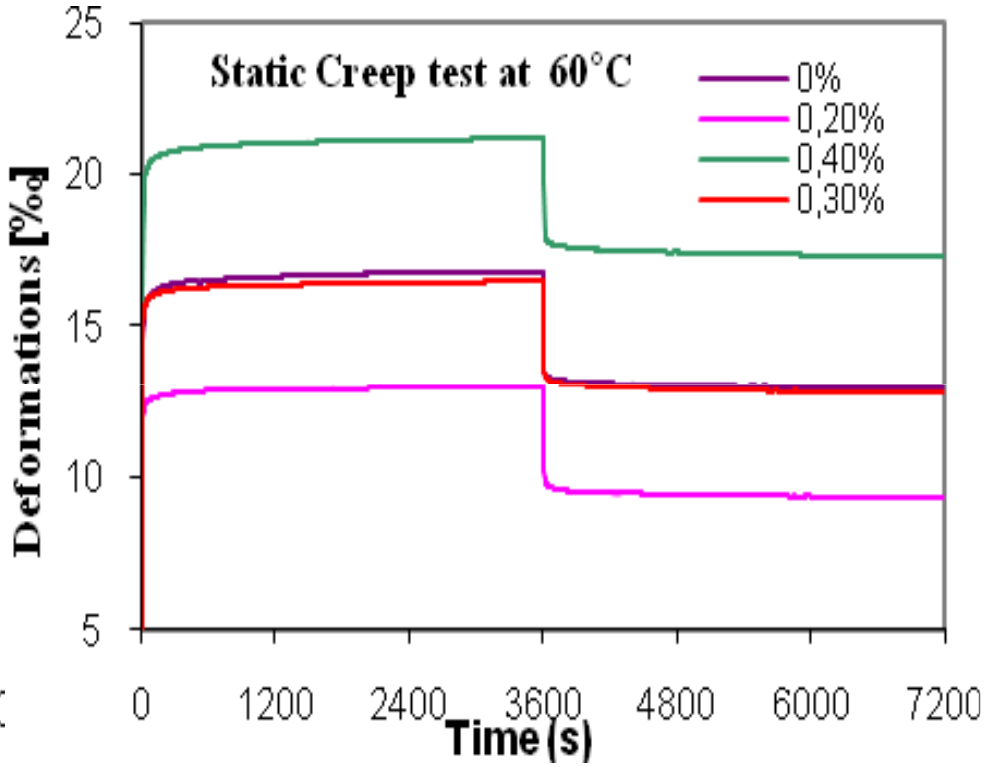
The optimum is obtained for 2% of NBR

Static creep test

The creep tests were carried out on bituminous mix containing bitumen AC 35/50. The tests are carried out at various temperatures: 40 and 60 ℃.

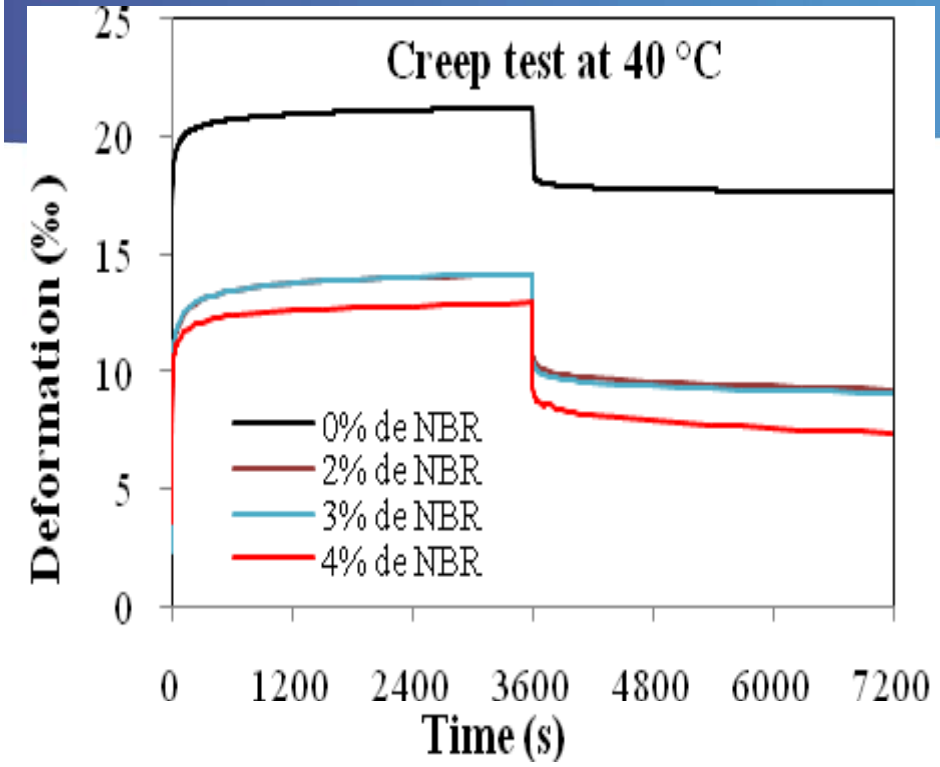


Curves of creep-recovery for the different Contents of NBR at 40℃ by dry process

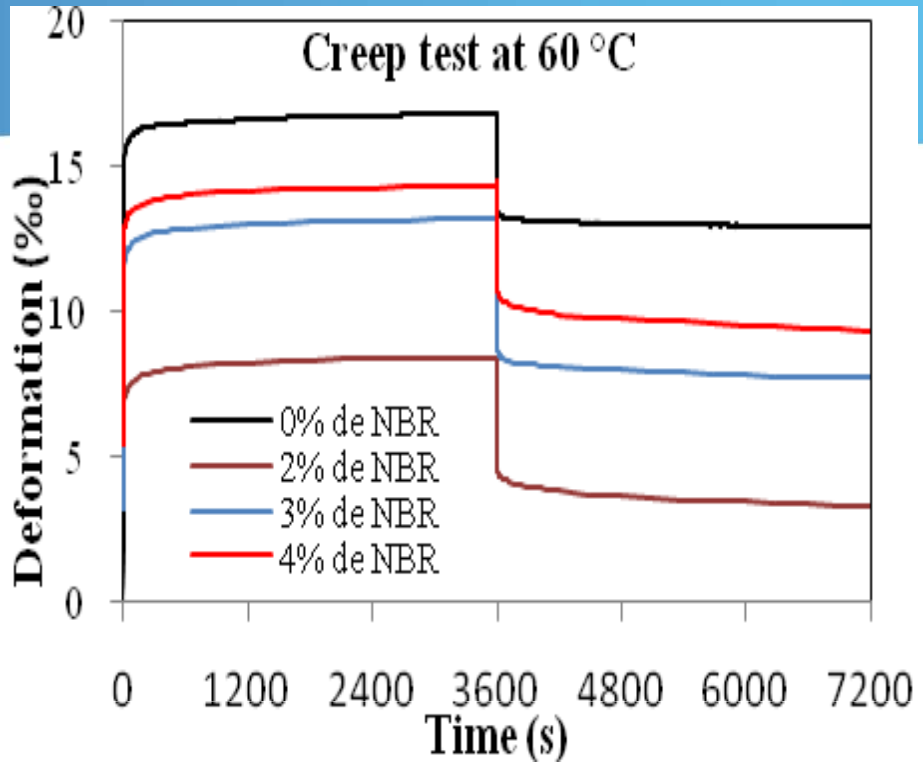


Curves of creep-recovery for the different Contents of NBR at 60℃ by dry process

we observe that the recovery is not complete because of the existence of permanent deformation (irreversible).



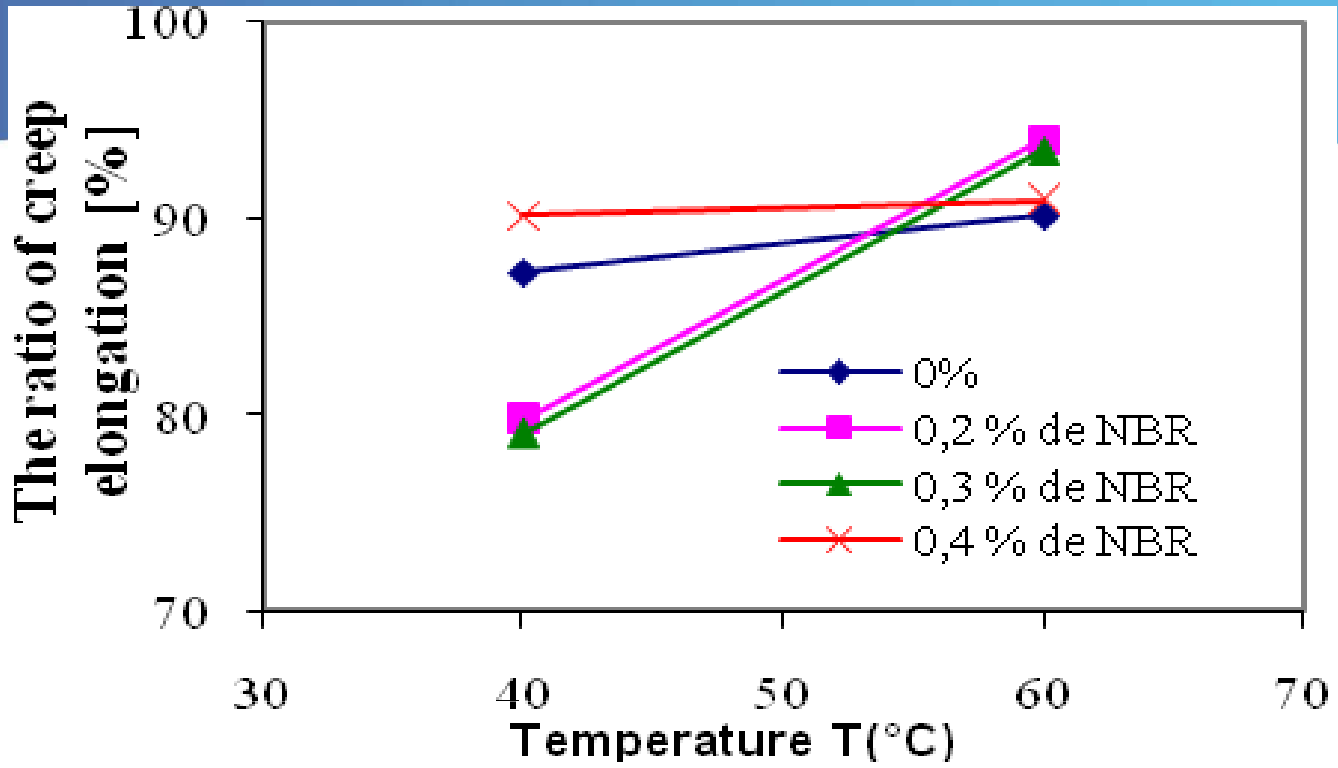
Curves of creep-recovery for the different contents of NBR at 40℃ by wet process



Curves of creep-recovery for the different contents of NBR at 60℃ by wet process

For the various contents of NBR, the deformations remain definitely lower than that of the bituminous concrete reference.

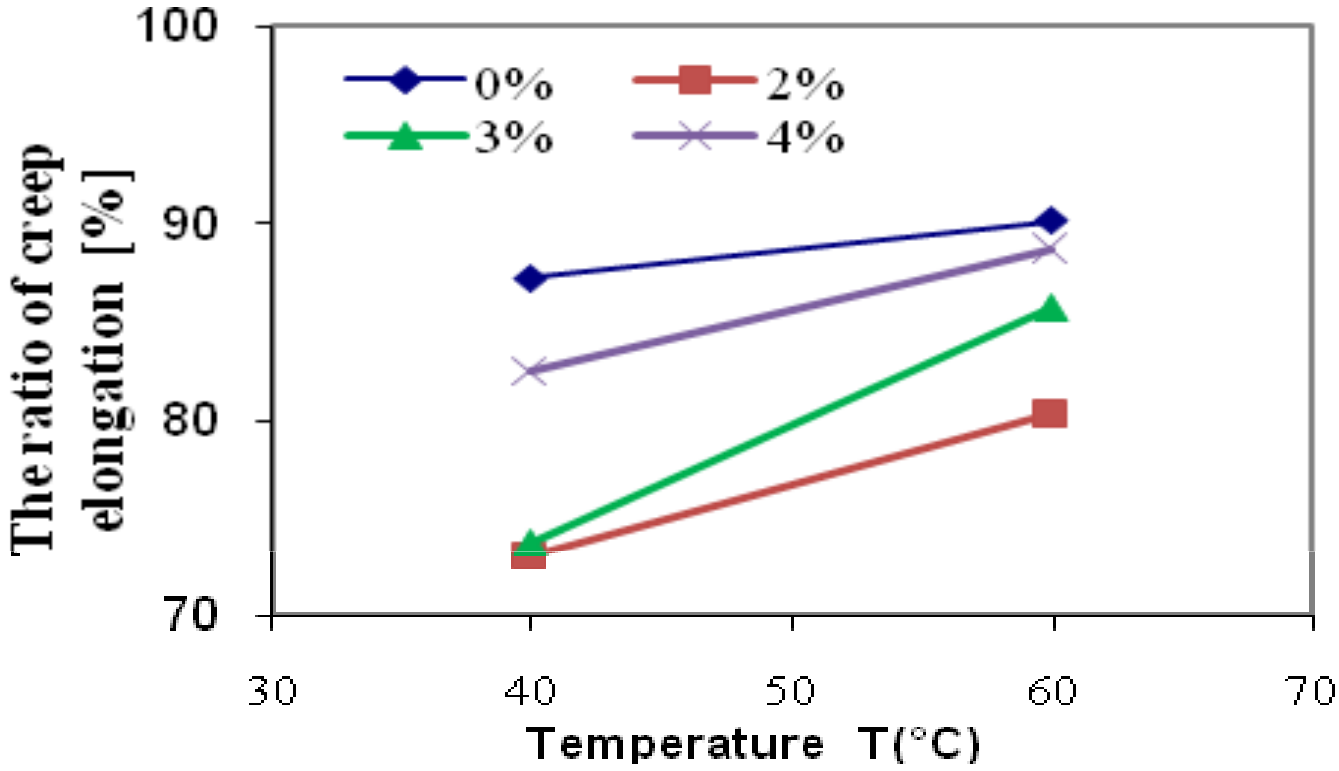
These results confirm those obtained by Marshall test for the lowest deformations which are recorded for 0.2 and 0.3% of NBR at extreme temperatures (40 ℃ and 60 ℃).



The ratio of elongation by dry process

This Figure shows the evolution of this rate allows us to assess the ability of a bituminous concrete to retard the creep deformation.

So the rate of creep deformation indicates that at 40℃ the contents of NBR at 2 and 3% exhibit good creep resistance opposed to 60℃ where the control bituminous concrete has a better behavior than the modified bituminous concrete.



Elongation ratio (wet process)

Figure shows a considerable reduction of the rate of deformation, which translates a better resistance to the permanent deformations for the extreme temperatures (40℃ and 60℃) a nd particularly for the content of 2% of NBR.

CONCLUSION

According to the results obtained, we are being able to conclude that the method of modification by wet process gives a better behaviour of the bituminous concrete resulting in a better permanent resistance to the deformations such as rutting under extreme conditions.

- A stability increase indicates that the modified bituminous concretes are much stronger than the reference bituminous concrete
- The modified bituminous concrete is highly resistant to permanent deformation (rutting) in bituminous concrete
- By combining the test results Marshall with those of static creep, the mixture of 2 % of NBR content seems to be better in improving performance of the pavement.

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Thank you