

NANOTECHNOLOGY FOR SUSTAINABLE PAVEMENTS WITH FLEXURAL STRENGTH

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ABSTRACT

It is customary to consider Marshal Stability or Elastic Modulus of asphalt mixes as measure of strength. However, these strength values don't take into consideration the fatigue load the pavements are expected to undergo. Flexural strength of asphalt mixes is a very important aspect often ignored.

New Organo-Silane nanotechnology, apart from other green benefits, enhances the flexural strength of the asphalt mixes, leading to greater fatigue resistance and increased pavement life.

This paper presents the summary of laboratory studies made at the IMT (Instituto Mexicano del Transporte), Mexico, to assess effect of Organosilanes on asphalt mixes in terms of fatigue-resistance.

KEY WORDS

Nanotechnology, Fatigue Resistance, Flexural Strength, pavement life, Elastic Modulus, Green, Sustainable.

CASE STUDY – INSTITUTO MEXICANO DEL TRANSPORTE (IMT)

Parameters for testing

- Asphalt binder: AC 20 (PEMEX, Mexico) with ZycoTherm: 0.075%; reference OBC 5.5% and with ZycoTherm OBC 5.8%; Aggregates: La Canada Quarry
- Sample size: 50mm H X 63 mm W X 380 mm L
- Air voids: 6%
- Test temperature: 20 °C
- Deformation Frequency: 10 Hz for four levels - 300, 400, 500 & 600 $\mu\epsilon$ (represents pavement deformation under normal transit condition)
- Asphalt mix fatigue life failure criteria: Number of cycles in which the beam stiffness modulus decreases 50% compared to its initial value

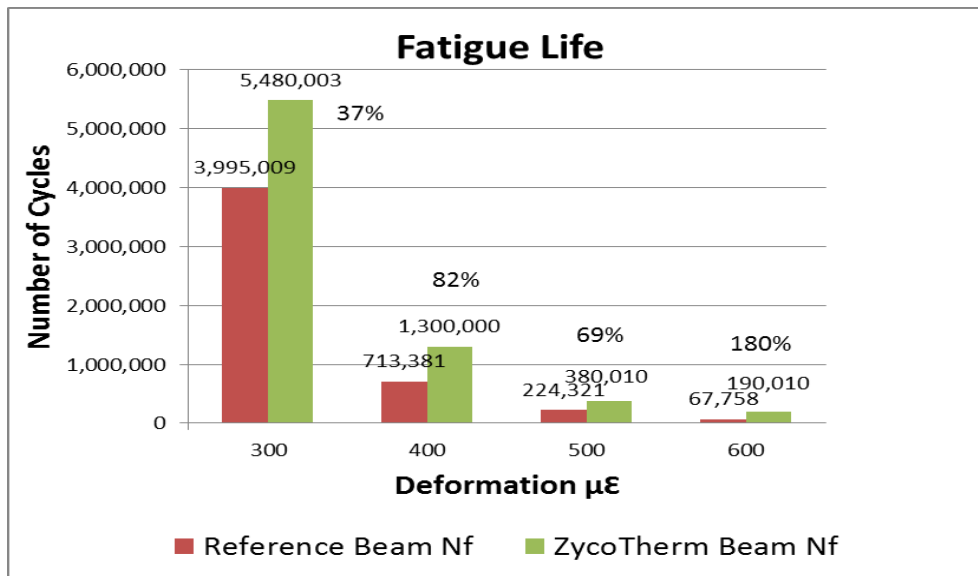


FIGURE 1 Higher Number of Cycles means Higher Fatigue Life

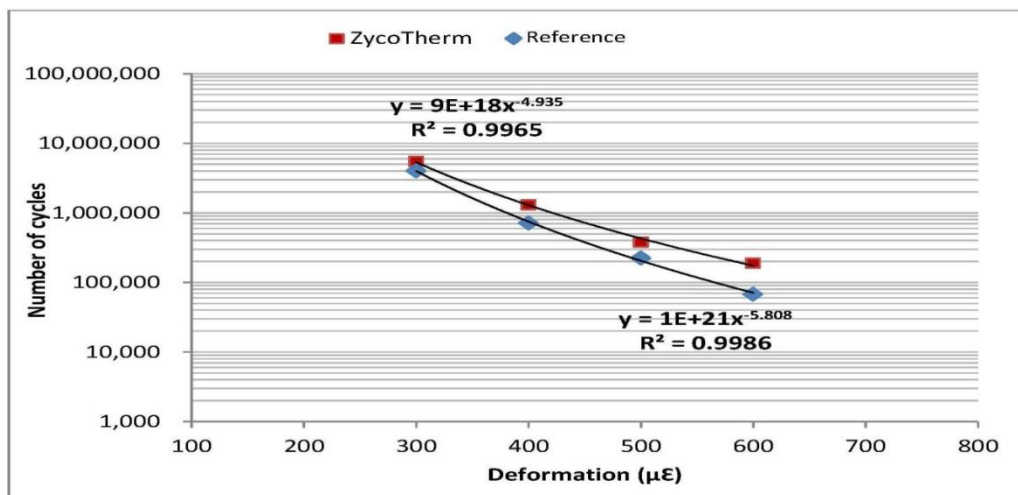


FIGURE 2 Wohler curve (fatigue law)

- For all levels of deformation (300, 400, 500 and 600 μ□.), samples with optimum content of Zycotherm (0.075%) presented extended life for fatigue, so the incorporation of Zycotherm significantly favors the asphalt mix
- The amount of load repetitions recorded for the Zycotherm samples were increased by 37% to 180% depending on the level of deformation (*fig 1*)
- It was also observed that Zycotherm addition to the asphalt mix modifies the slope of the fatigue law, which means that Zycotherm samples are less susceptible to deformation levels, compared with the reference samples(*fig 2*)

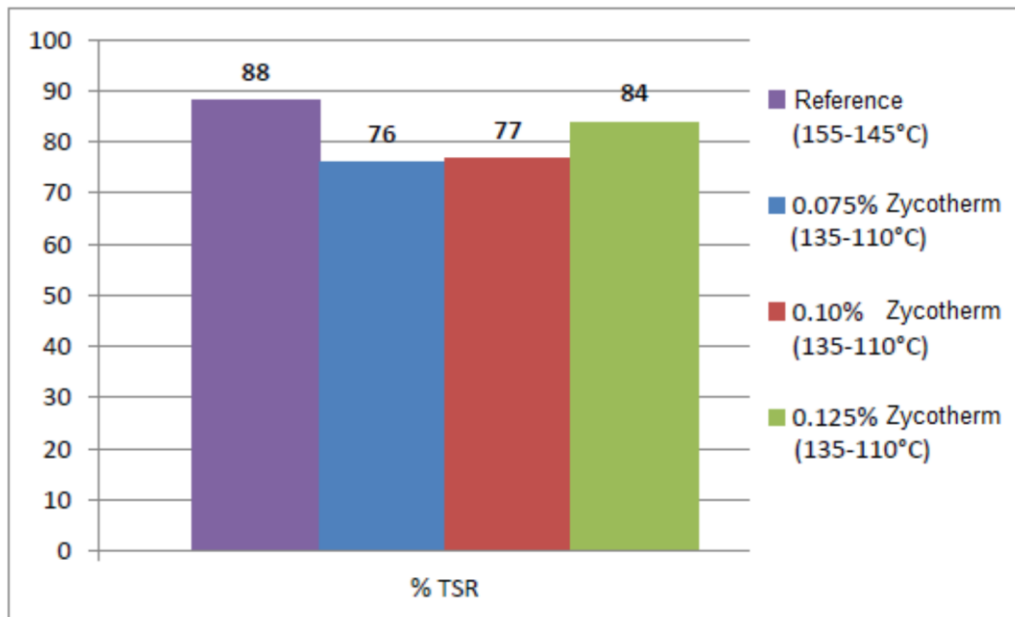


FIGURE 3 Effect of Zycotherm on TSR

- It was observed that with the addition of Zycotherm in the highest dosage (0.125%) the TSR specification was achieved ($\geq 80\%$), even when mixing and compaction temperatures were reduced to 135° and 110° (*fig. 3*)
- Asphalt mixes with 0.075% and 0.1% presented slightly inferior to 80% TSR values. The conditioned specimens with additive presented 2 to 3 saturation cycles to achieve saturation levels between (70-80%)
- For all missing dosages, it can be estimated that TSR results will be acceptable for temperature reduction
- It was observed that for mixing 135°C and compaction 110°C temperatures, TSR increased when the Zycotherm dosage was increased as well (*fig 3*)

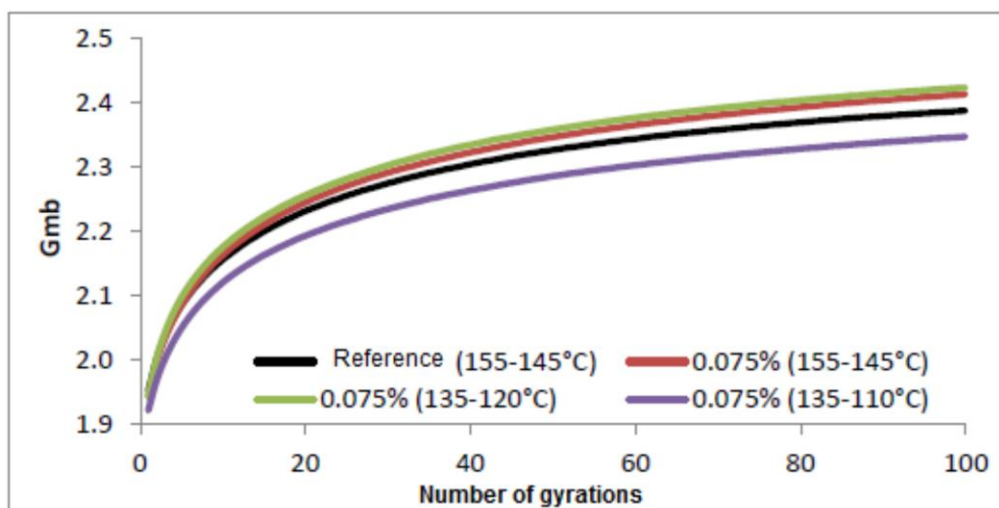


FIGURE 4 Effect of Zycotherm (@0.075%) on compaction density

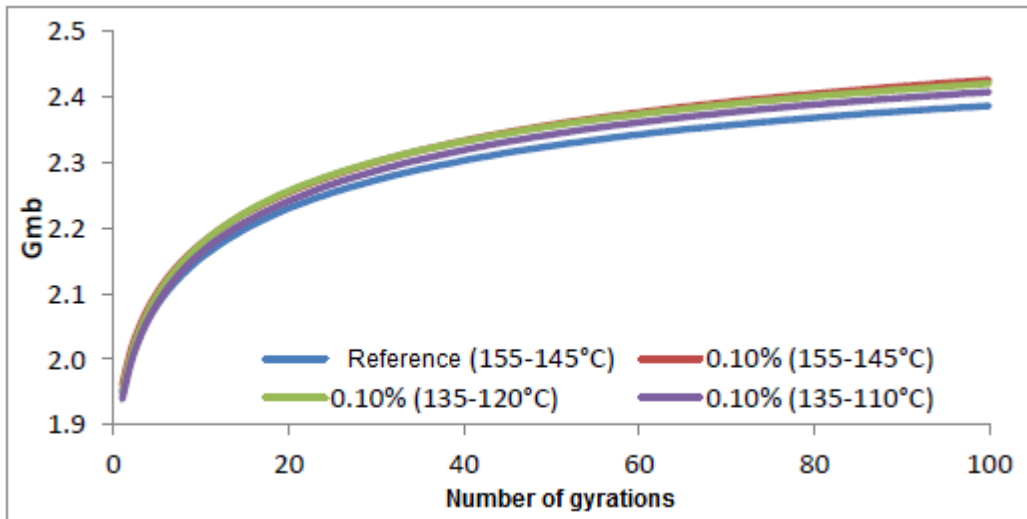


FIGURE 5 Effect of Zycotherm (@0.1%) on compaction density

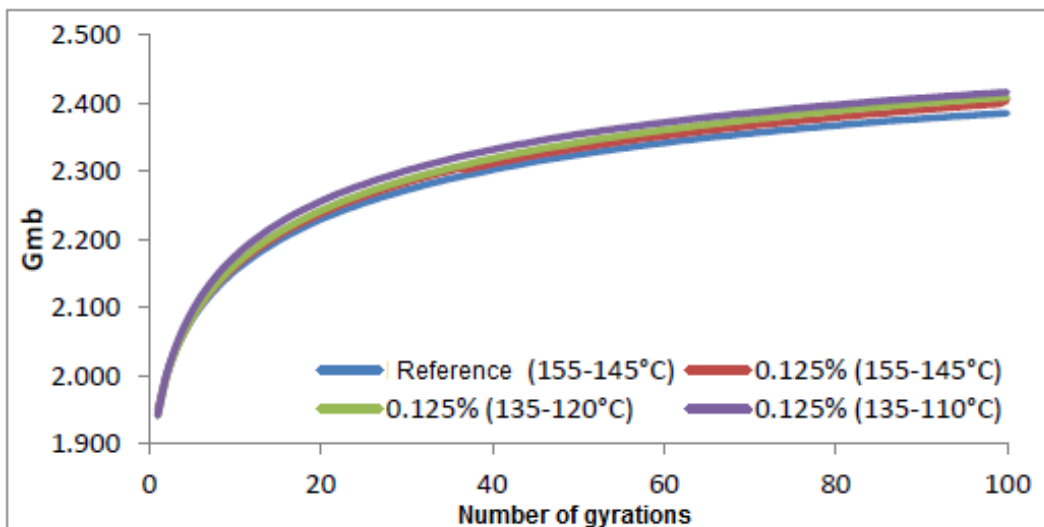


FIGURE 6 Effect of Zycotherm (@0.125%) on compaction density

- When Zycotherm is used a greater compaction can be achieved for the same and lower temperatures than the reference mix(*fig 5, 6*)
- If mixing and compaction temperatures are reduced benefits in time can be obtained; more time for hauling and waiting before compaction is possible with the Zycotherm addition.
- Fuel savings during the mixing process and less carbon footprint benefits can be obtained as well

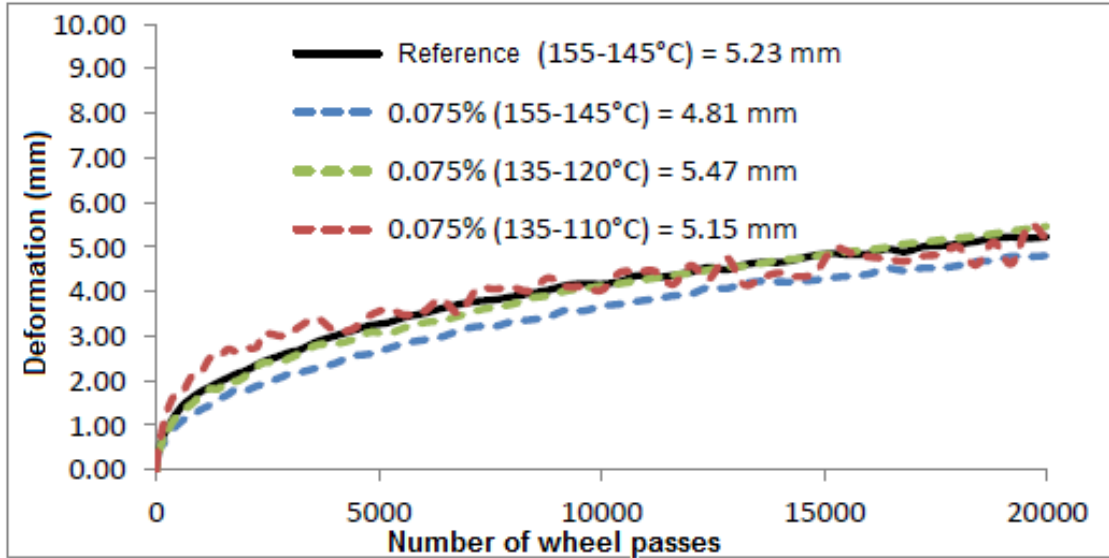


FIGURE 7 Wheel Tracking performance for ZT @ 0.075%

- When the 0.075% additive dosage is incorporated into the asphalt mix, it is observed that deformation is maintained with acceptable tolerance, for similar temperatures as the reference mix
- When mixing and compaction temperatures are reduced, deformation is still within high transit levels, according to AMAAC specifications
- There is no affectation in rutting behavior when lowering mixing and compaction temperatures. (fig 7)

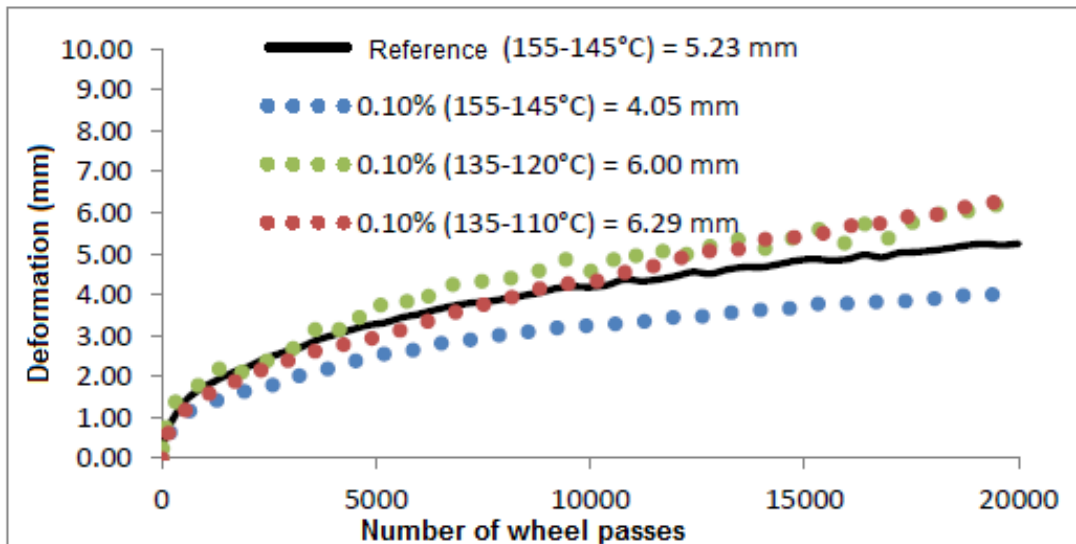


FIGURE 8 Wheel Tracking performance at ZT @ 0.1 %

- The asphalt mix with Zycotherm present a superior behavior when produced and compacted at the same temperatures as the reference mix
- When adding 0.1% of Zycotherm to the mix the mixing temperature can be lowered in 20°C and compaction temperature to 35°C, deformation is slightly affected, but it is still within the high transit levels and this results may be between the test dispersion (*fig 8*)
- If mixing and compaction temperatures are reduced benefits in time can be obtained; more time for hauling and waiting before compaction is possible with the Zycotherm addition

CONCLUSION

In summary, addition of ZycoTherm, the Organosilane additive to bitumen

1. Allows the mixing temperature to be lower
2. Gives equivalent or better compaction at lower compaction temperatures.
3. Results in acceptable levels of TSR at lower mixing temperatures.
4. Gives excellent rut resistance at lower mixing and compaction temperatures.

Overall, the Organosilane technology, in addition to lower mixing temperatures, allows lower compaction temperature and gives all the benefits stated above.