



# 3<sup>rd</sup> International Symposium on Asphalt Pavements & Environment

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## ACTIVE FILLER'S EFFECT ON IN-SITU PERFORMANCES OF FOAM BITUMEN RECYCLED MIXTURES

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*University of Parma – University of Florida*

# ACKNOWLEDGMENT



**Giacomo Betti**

**Gordon Airey**

**Kim Jenkins**

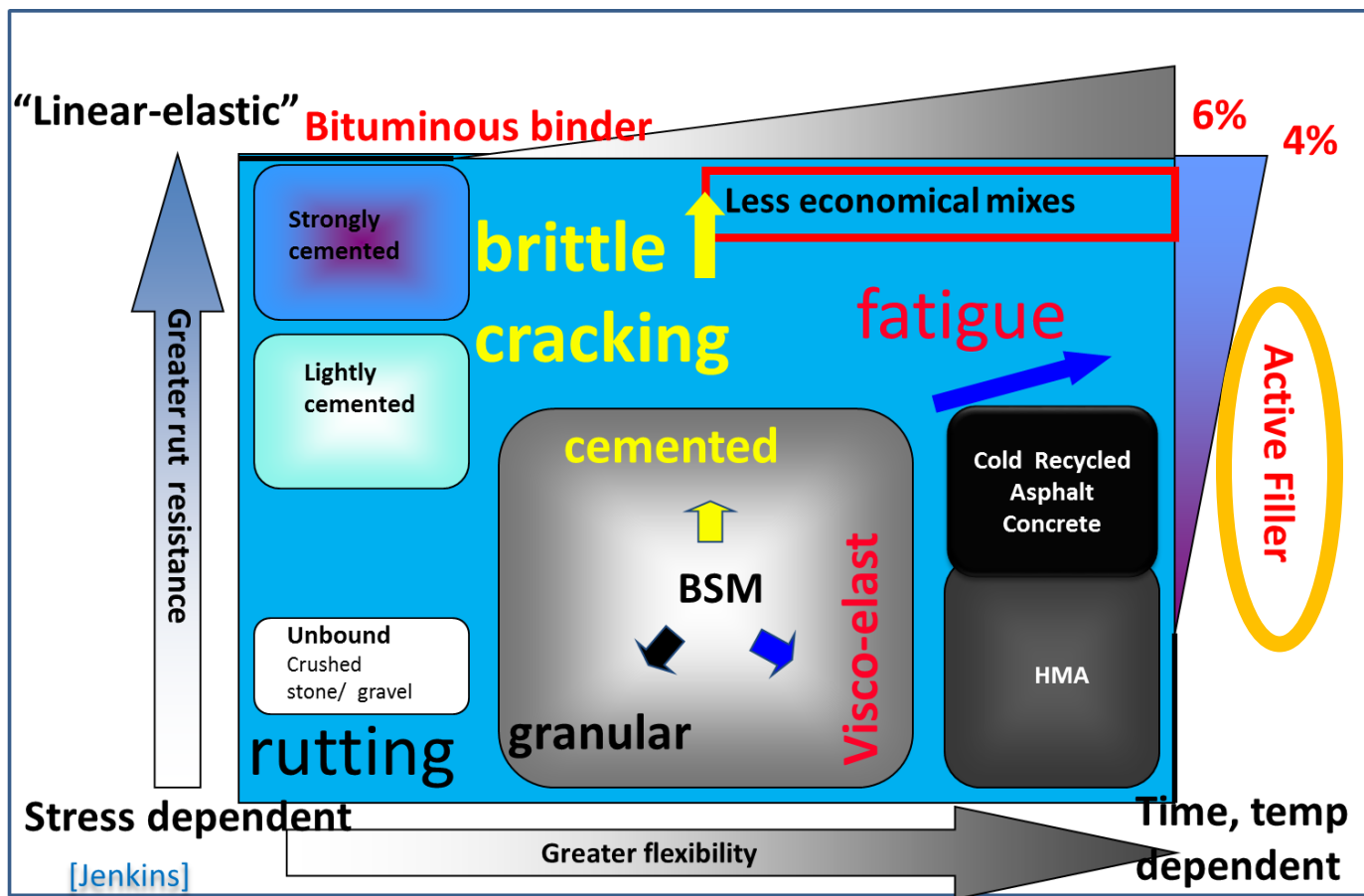
**Alessandro Marradi**

**Wirtgen**

**Unicalce**



# MATERIALS



**Generally cement!**

**Can it be lime?**



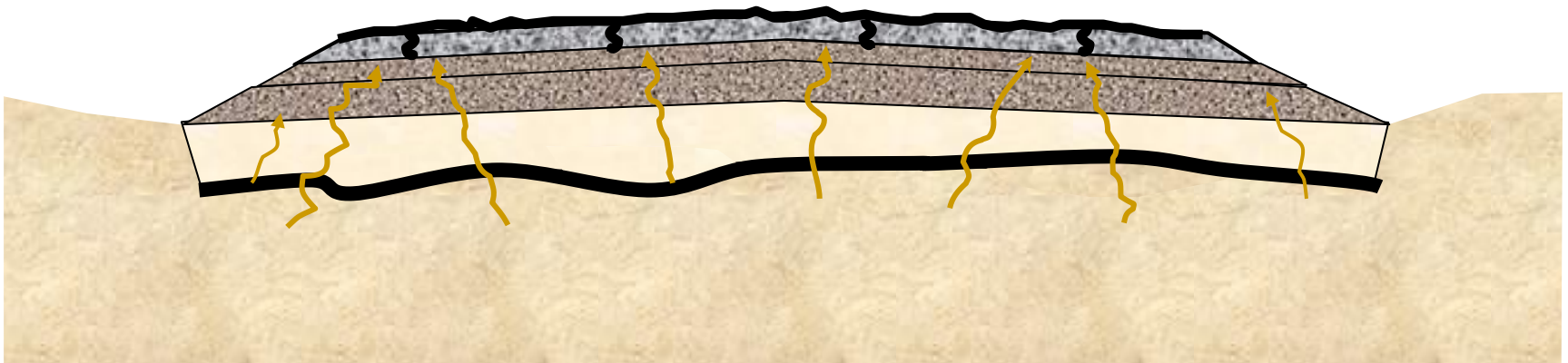
# PROBLEM STATEMENT

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Rising of clay particles:  
it requires to join lime stabilization and cold in place recycling



# PROBLEM STATEMENT



Can we use the lime as active filler to have only one lay down phase?  
Can make sense a «combined lime-bitumen stabilization»?

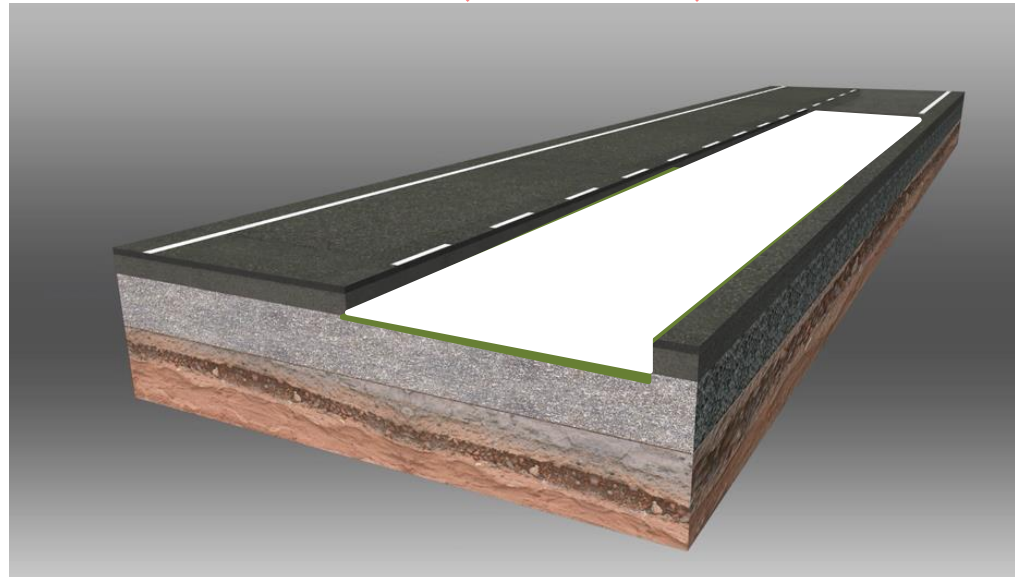
1. Lime to stabilize the clay



2. Cement as active filler



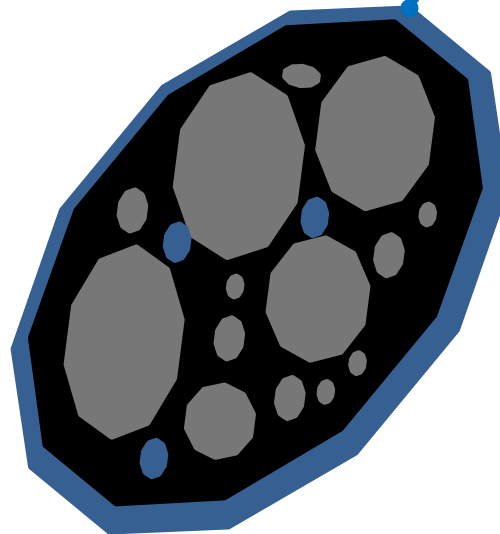
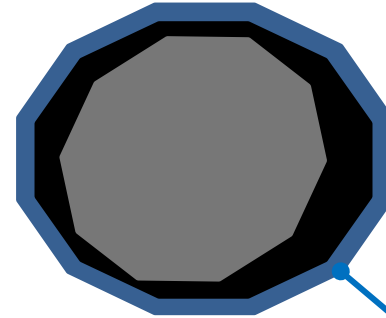
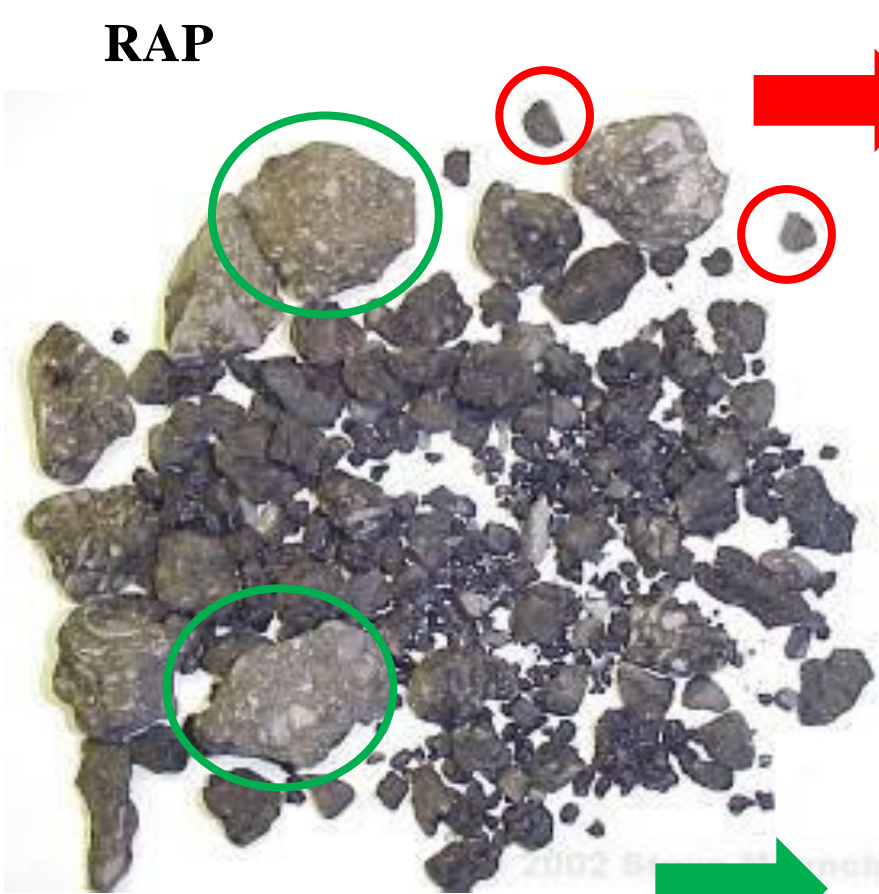
3. mixing, foaming, .....



# PROBLEM STATEMENT



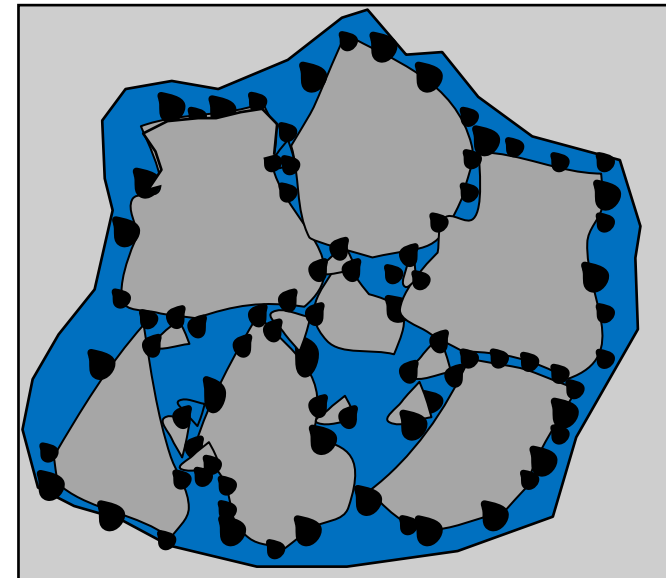
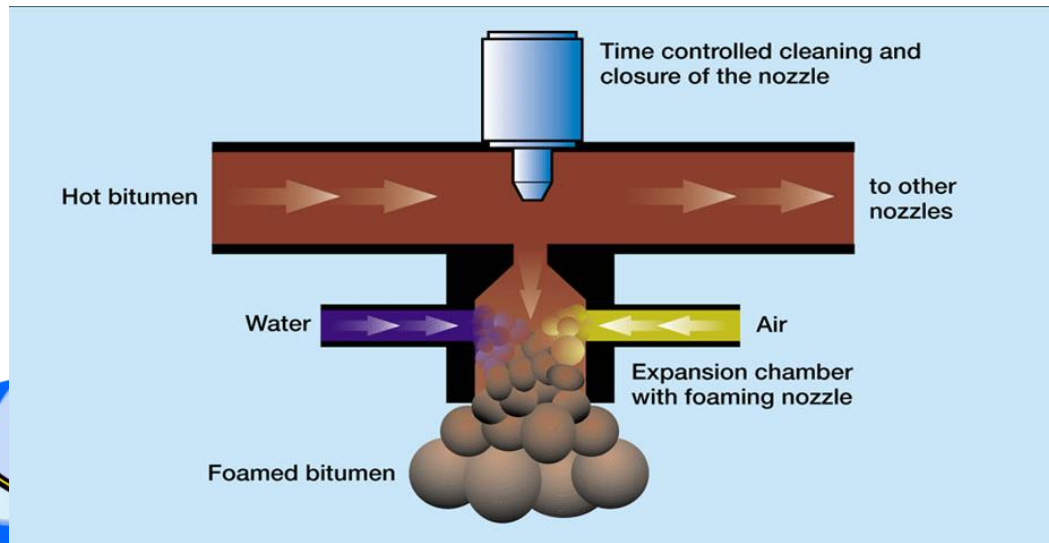
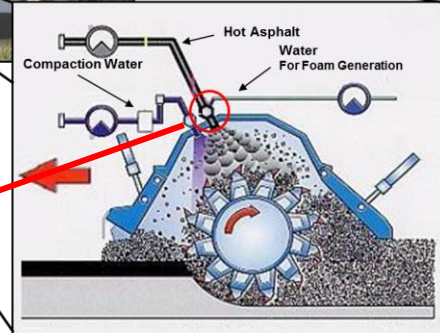
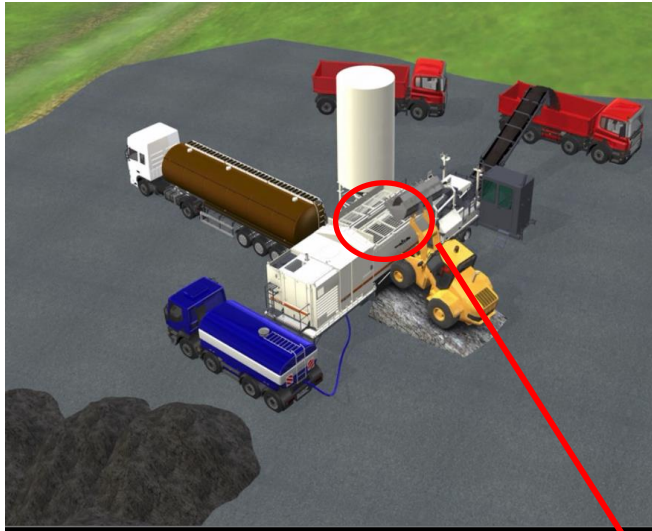
RAP



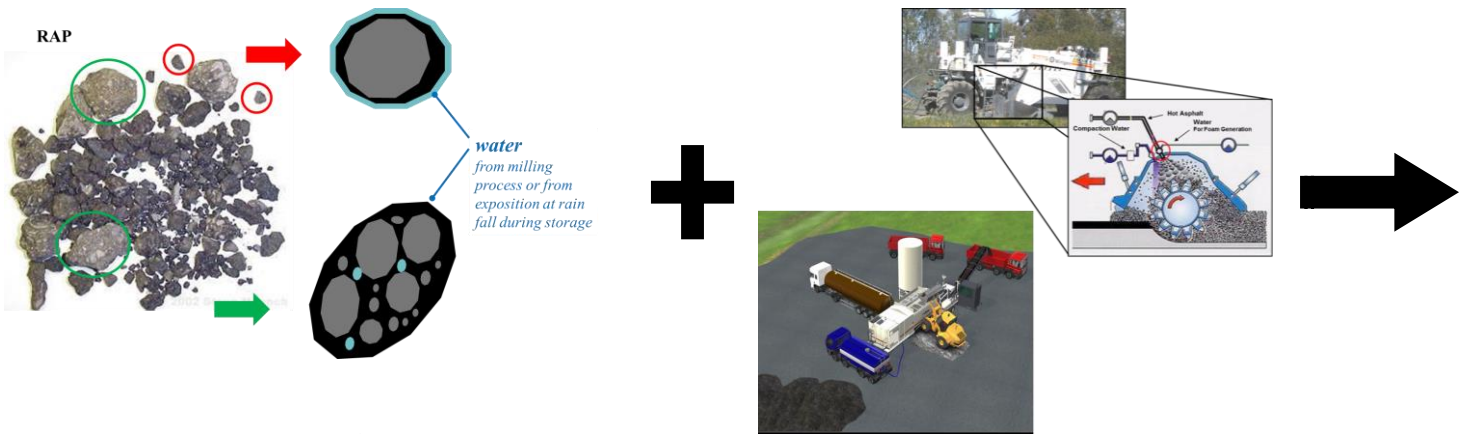
*water*  
from milling  
process or from  
exposition at rain  
fall during storage



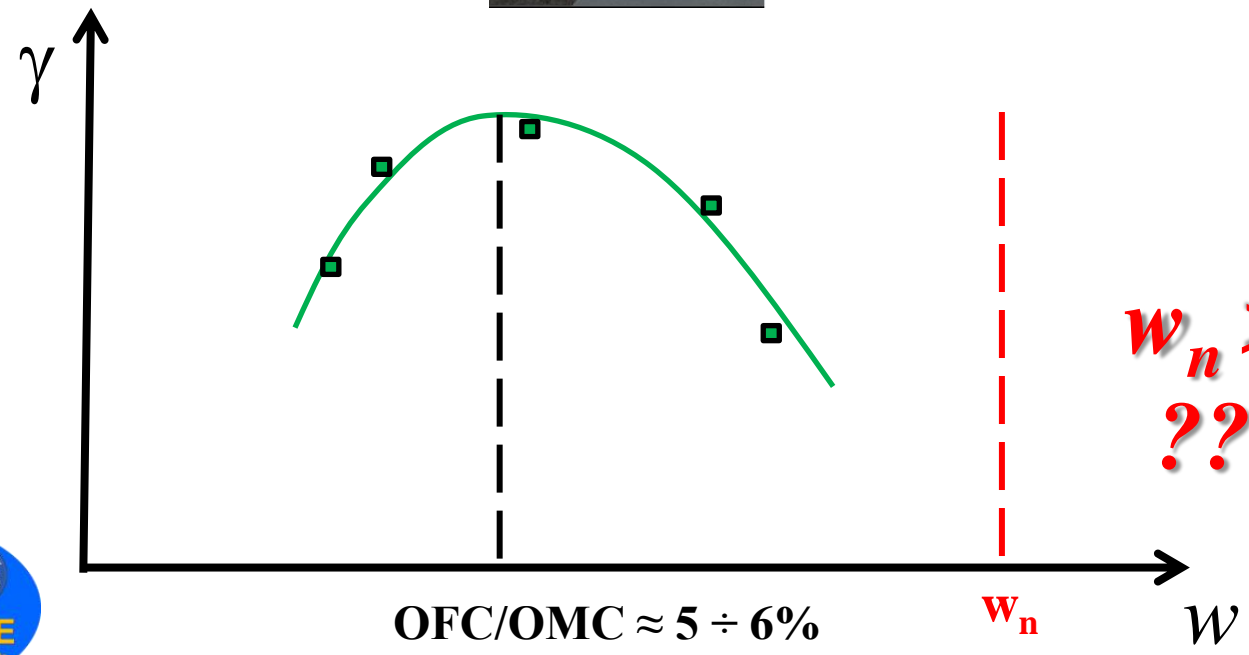
# PROBLEM STATEMENT



# PROBLEM STATEMENT



Water



$w_n \gg OFC$   
 ??????????

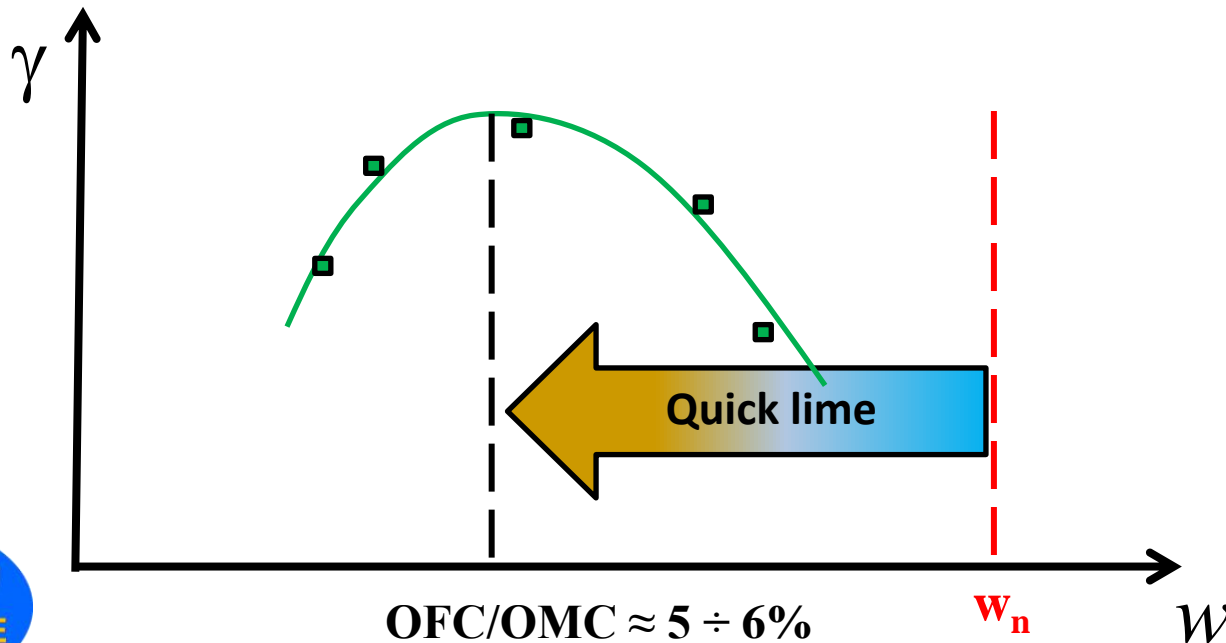




# PROBLEM STATEMENT



*Can we use this hydrated lime as active filler?*



# PROBLEM STATEMENT



- **Can the lime be used instead of cement?**
- **Can the lime partially replace the cement in the total amount of active fillers?**



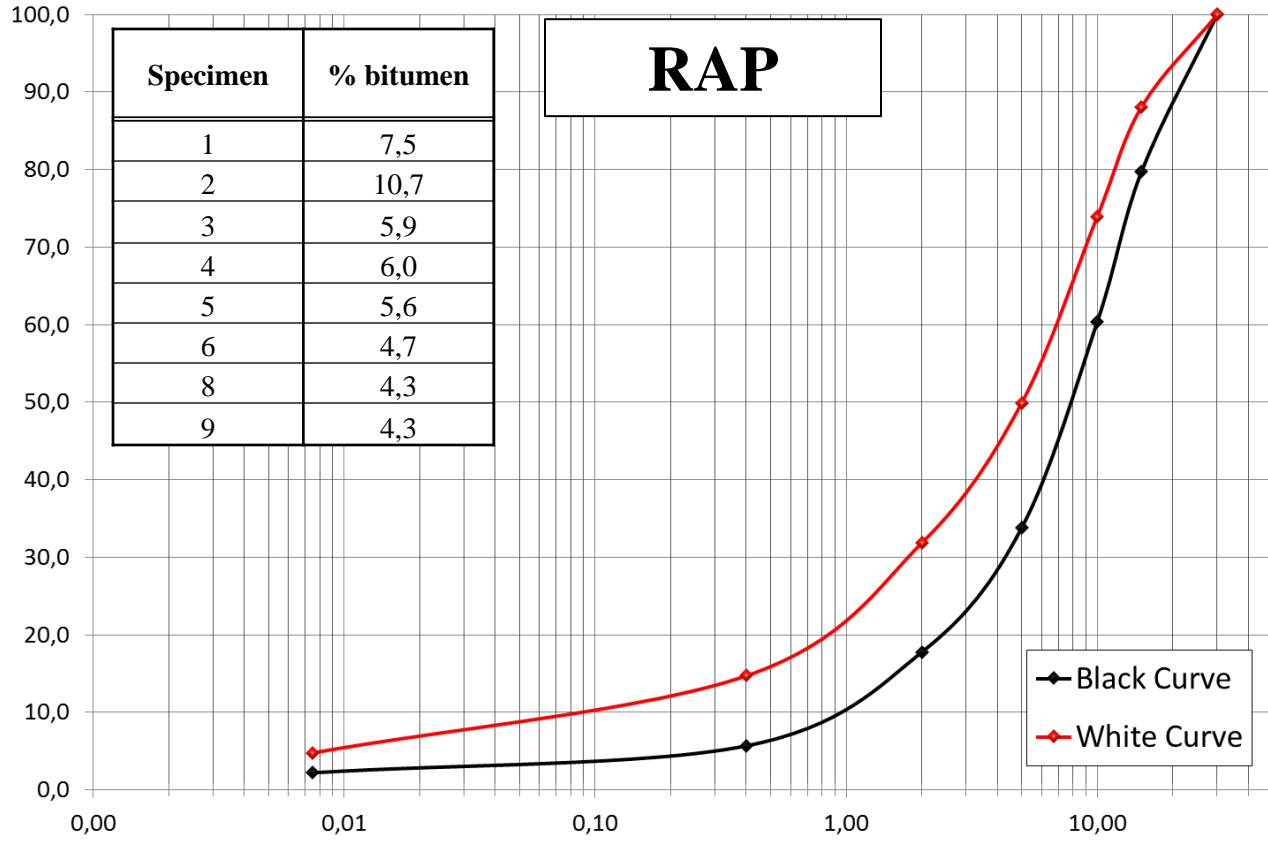
# OBJECTIVE AND SCOPE



- Evaluate the influence on bearing capacity of introducing lime in foam bitumen recycled mixtures
- Evaluate the influence on bearing capacity of use of lime instead of cement in foam bitumen recycled mixtures



# MATERIALS



## Bitumen for foaming

Pure bitumen  
 Pen@25°C: 70 -100  
 $T_{R\&B}$ : 51°C

## Active fillers

Portland cement  
 Hydrated lime

## Mineral filler

Limestone



# MIXTURES



Total amount of filler: 4.5%

| Mix | %binder | %cement | %lime | %mineral filler |
|-----|---------|---------|-------|-----------------|
| 3A  | 2       | 1.0     | 2.0   | 1.5             |
| 3B  | 2       | 1.0     | 0     | 3.5             |
| 5C  | 3       | 2.5     | 2.0   | 0               |
| 5D  | 3       | 2.5     | 0     | 2.0             |
| 5E  | 3       | 0       | 2.0   | 2.5             |
| 5F  | 3       | 0       | 3.0   | 1.5             |

**"Only RAP" mixtures  
designed following «Italian market»'s standards**

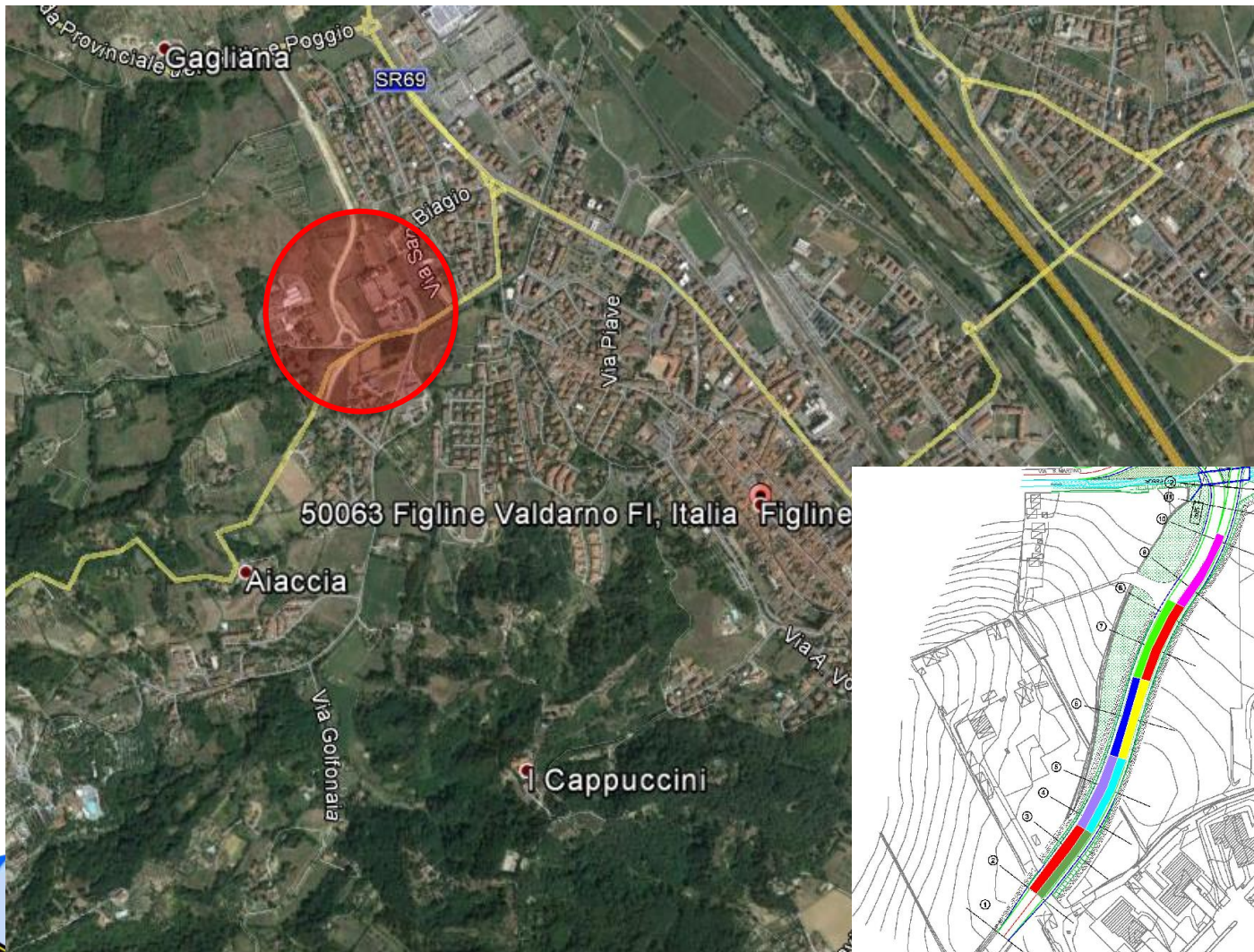


# TRIAL SECTION - FLORENCE (ITALY)

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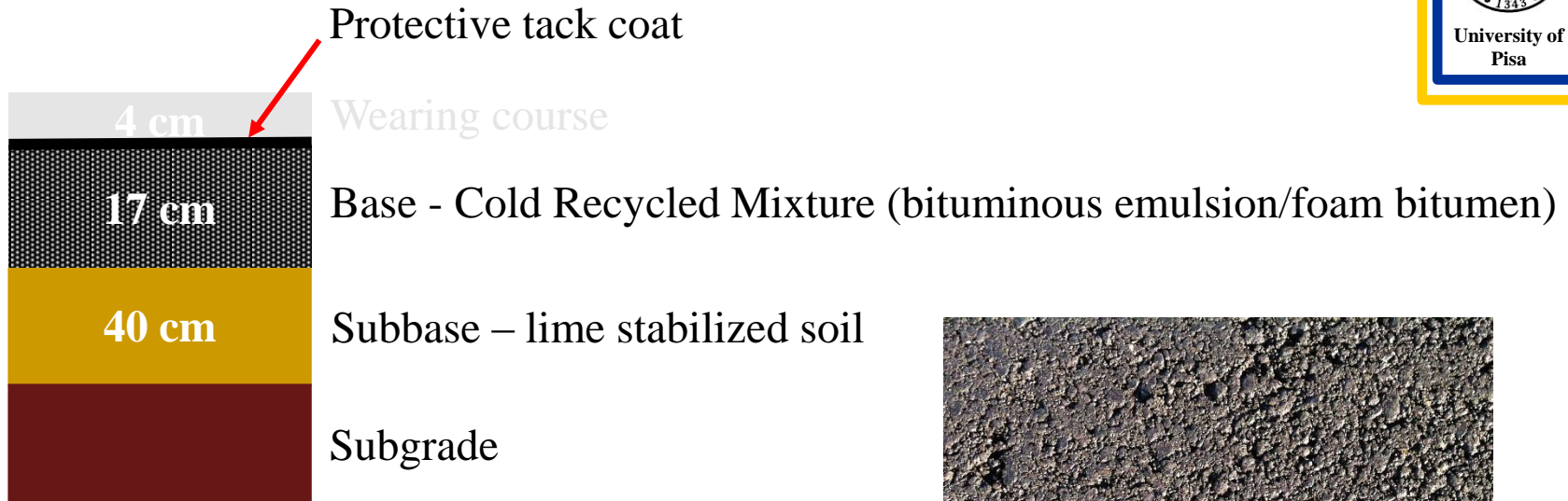
University of Stellenbosch University of Nottingham



University of Parma



# TRIAL SECTION - FLORENCE (ITALY)



Thanks to a particular work plan the wearing coarse was layed down 10 months after wearing course

➔ **All mixtures had the curing process without traffic load**

➔ **First LWD/FWD test campaign directly on CRM layer**





# LWD & FWD

## 1<sup>ST</sup> TEST CAMPAIGN



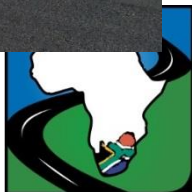
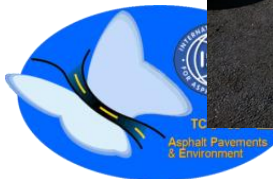
Protective tack coat



Base - Cold Recycled Mixture (bituminous emulsion/foam bitumen)

Subbase – lime stabilized soil

Subgrade



# LWD & FWD TESTS RESULTS

## TEMPERATURE SENSITIVITY



Generalized version of Asphalt Institute's equation for temperature correction calibrated with results from test section

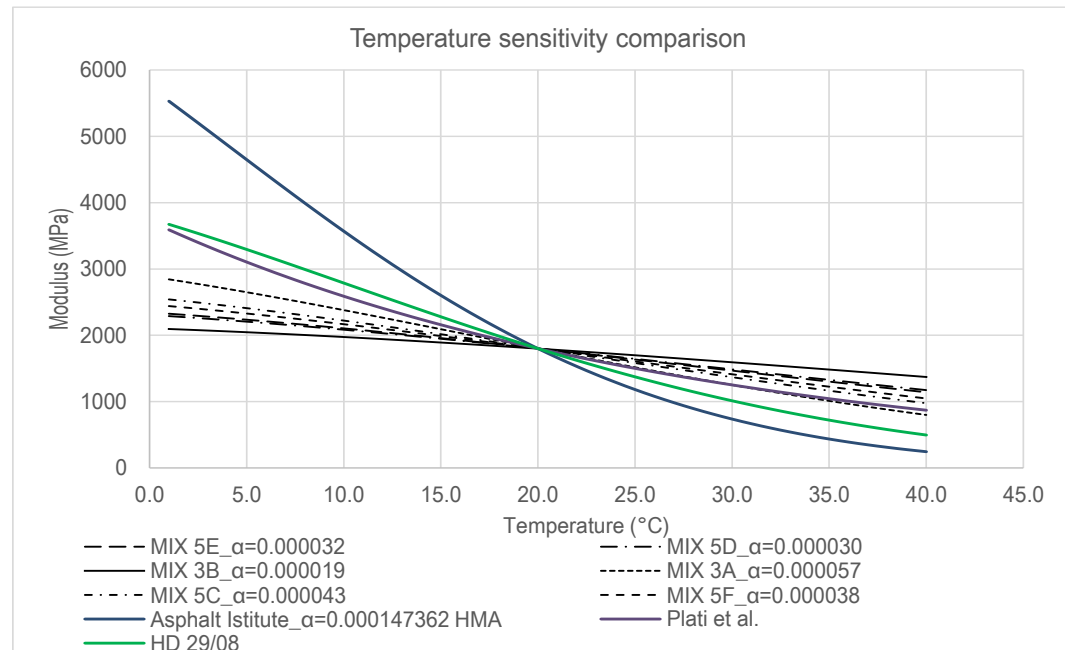
$$E_{T_s} = 10^{\alpha \cdot (T^2 - T_s^2)} \times E$$

$E_{T_s}$  modulus at the reference temperature

$E$  modulus at test temperature

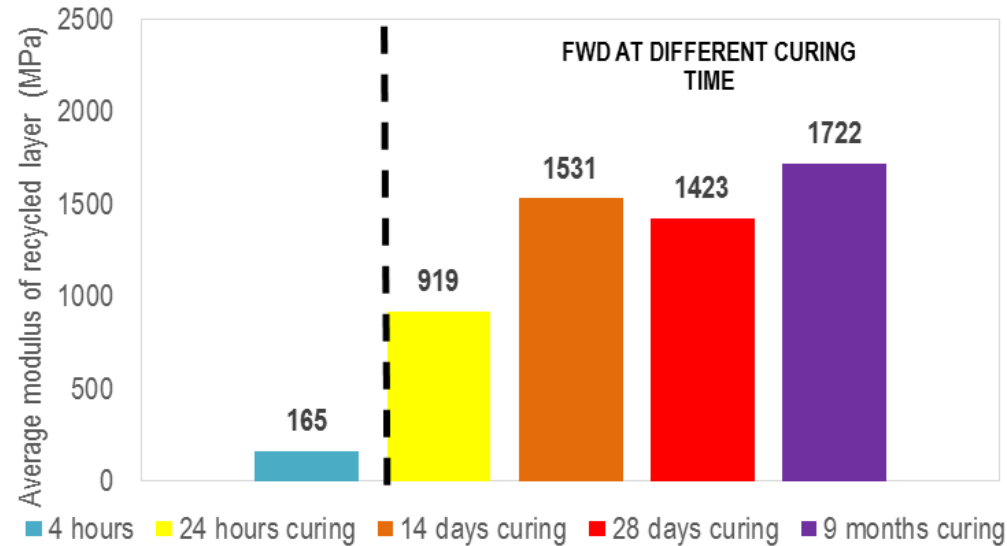
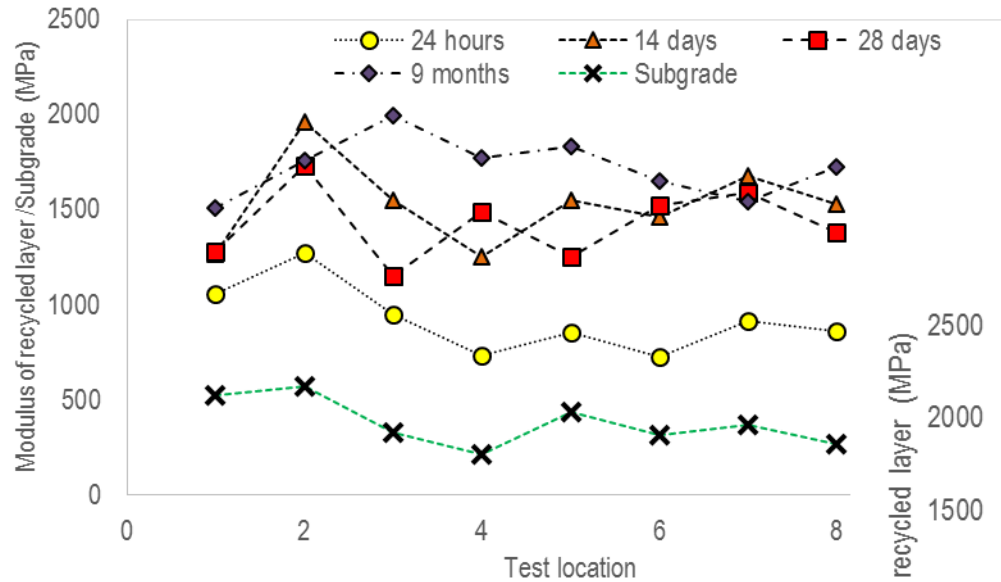
$T$  (°F) test temperature,  $T_s$  (°F) reference temperature

$\alpha$  temperature sensitivity parameter.



# LWD & FWD TESTS RESULTS

*Mix 5D\_3%FB\_2,5%C\_0%L\_2%MF*



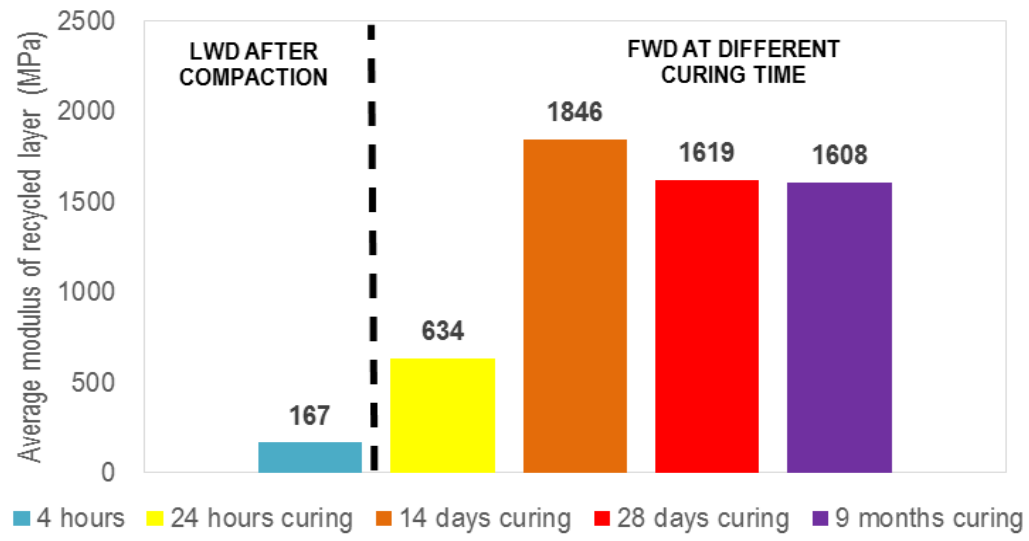
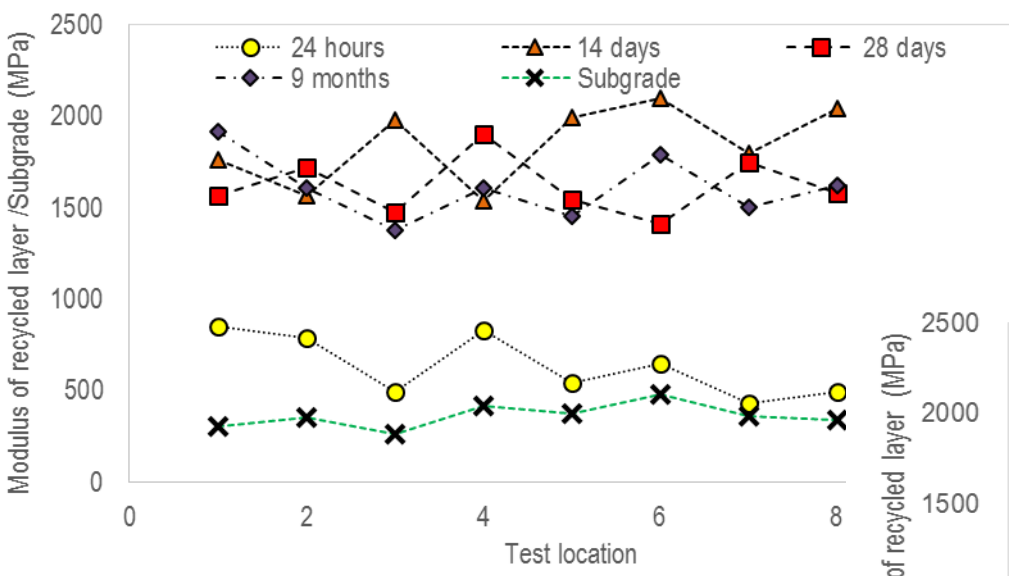
*Minimum requirement of Italian Road Authority (ANAS)*

- 45 MPa 4 hours after compaction
- 170 MPa 24 hours after compaction



# LWD & FWD TESTS RESULTS

MIX\_5E\_3%FB\_0%C\_2%L\_2,5%MF

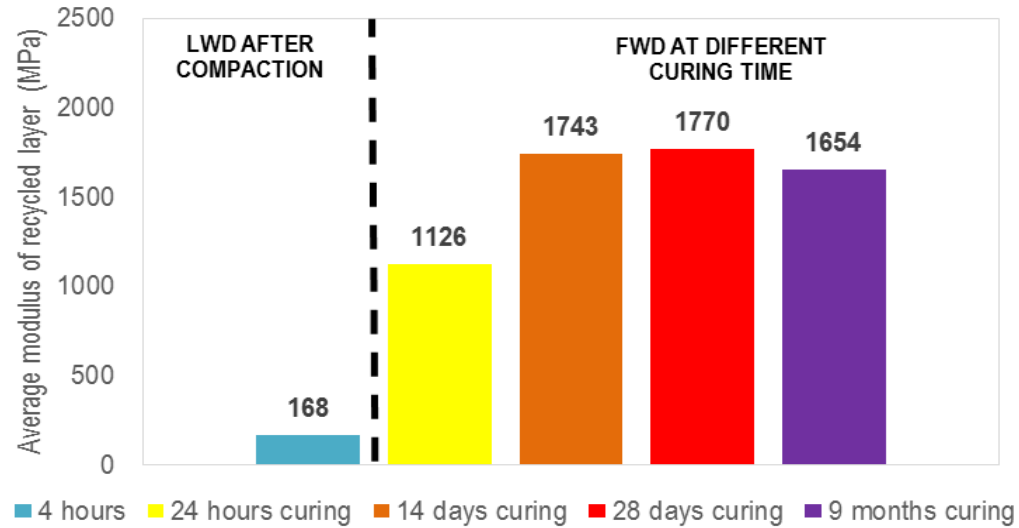
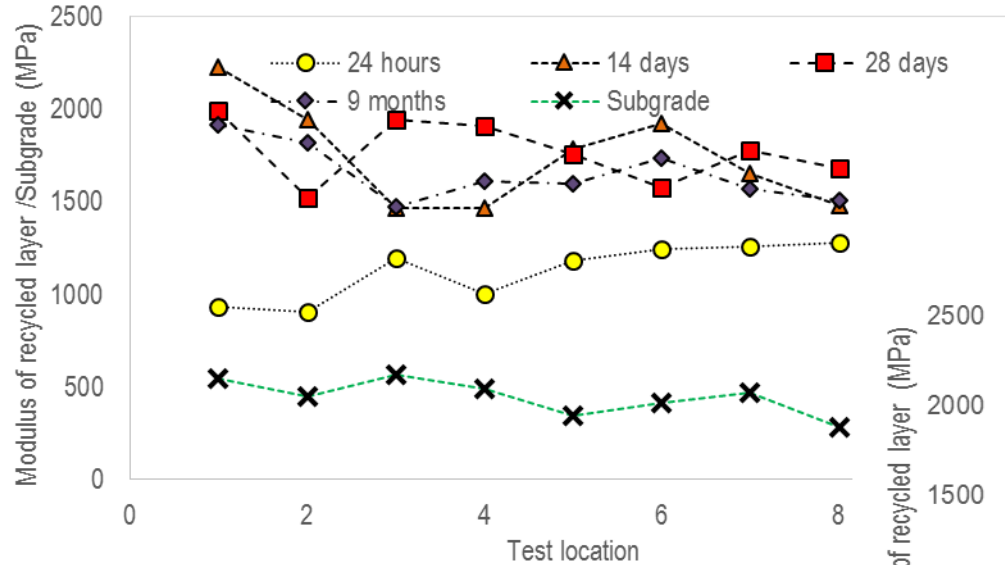


- Minimum requirement of Italian Road Authority (ANAS)**
- 45 MPa 4 hours after compaction
  - 170 MPa 24 hours after compaction



# LWD & FWD TESTS RESULTS

MIX\_3B\_2%FB\_1%C\_0%L\_3.5%MF



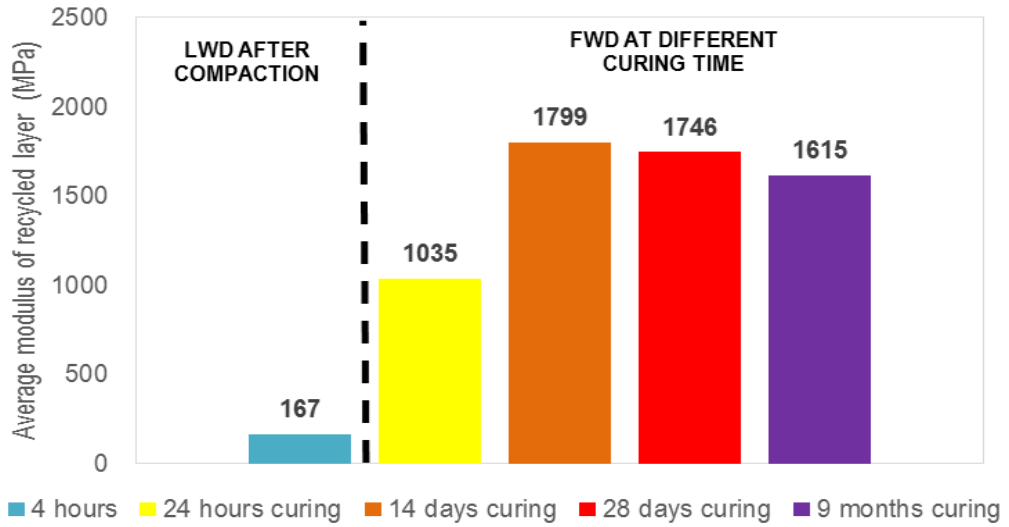
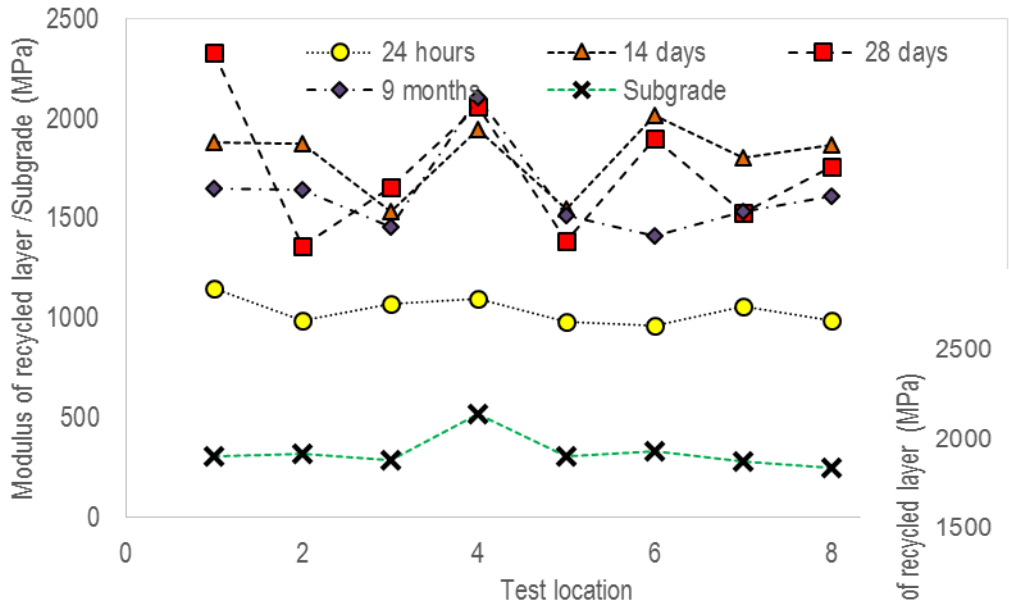
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# LWD & FWD TESTS RESULTS

MIX\_3A\_2%FB\_1%C\_2%L\_1.5%MF

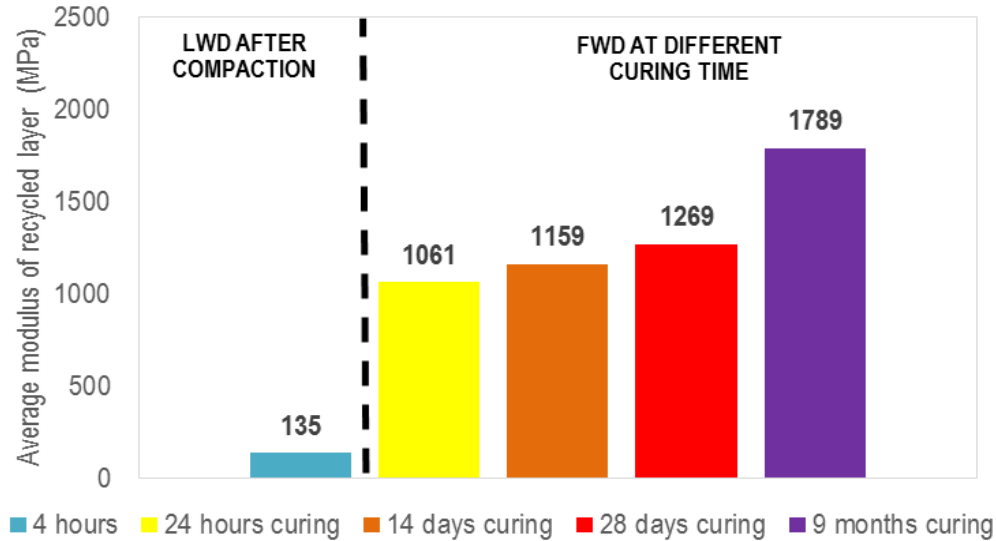
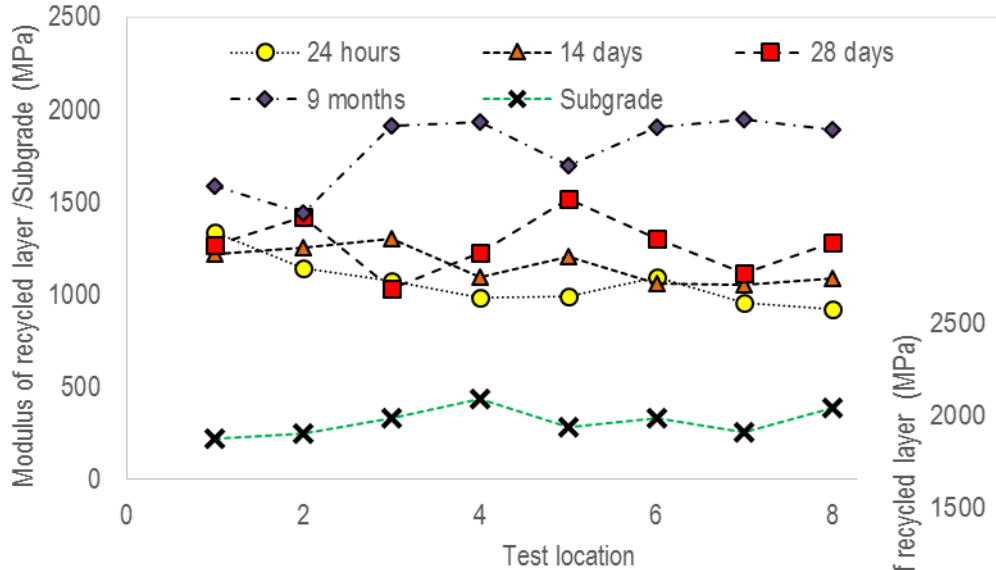


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# LWD & FWD TESTS RESULTS

MIX\_5C\_3%FB\_2.5%C\_2%L\_0%MF



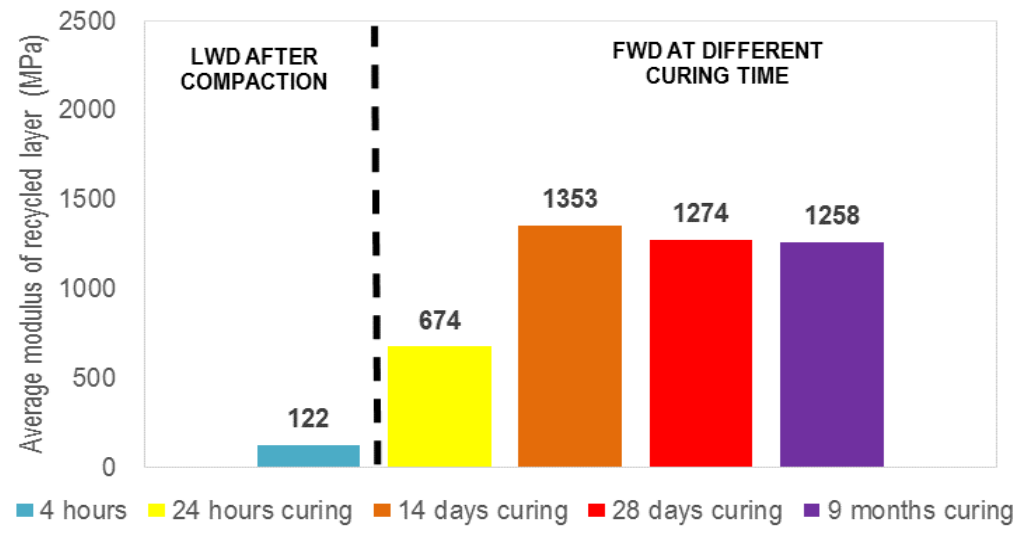
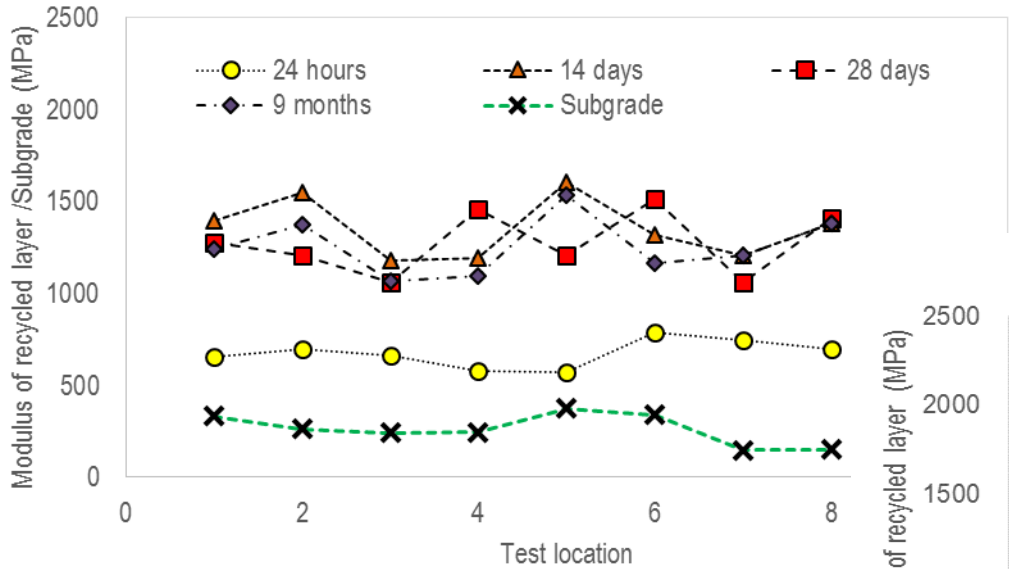
*Minimum requirement of Italian Road Authority (ANAS)*

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# LWD & FWD TESTS RESULTS

*Mix\_5F\_3%FB\_0%C\_3%L\_1,5%MF*



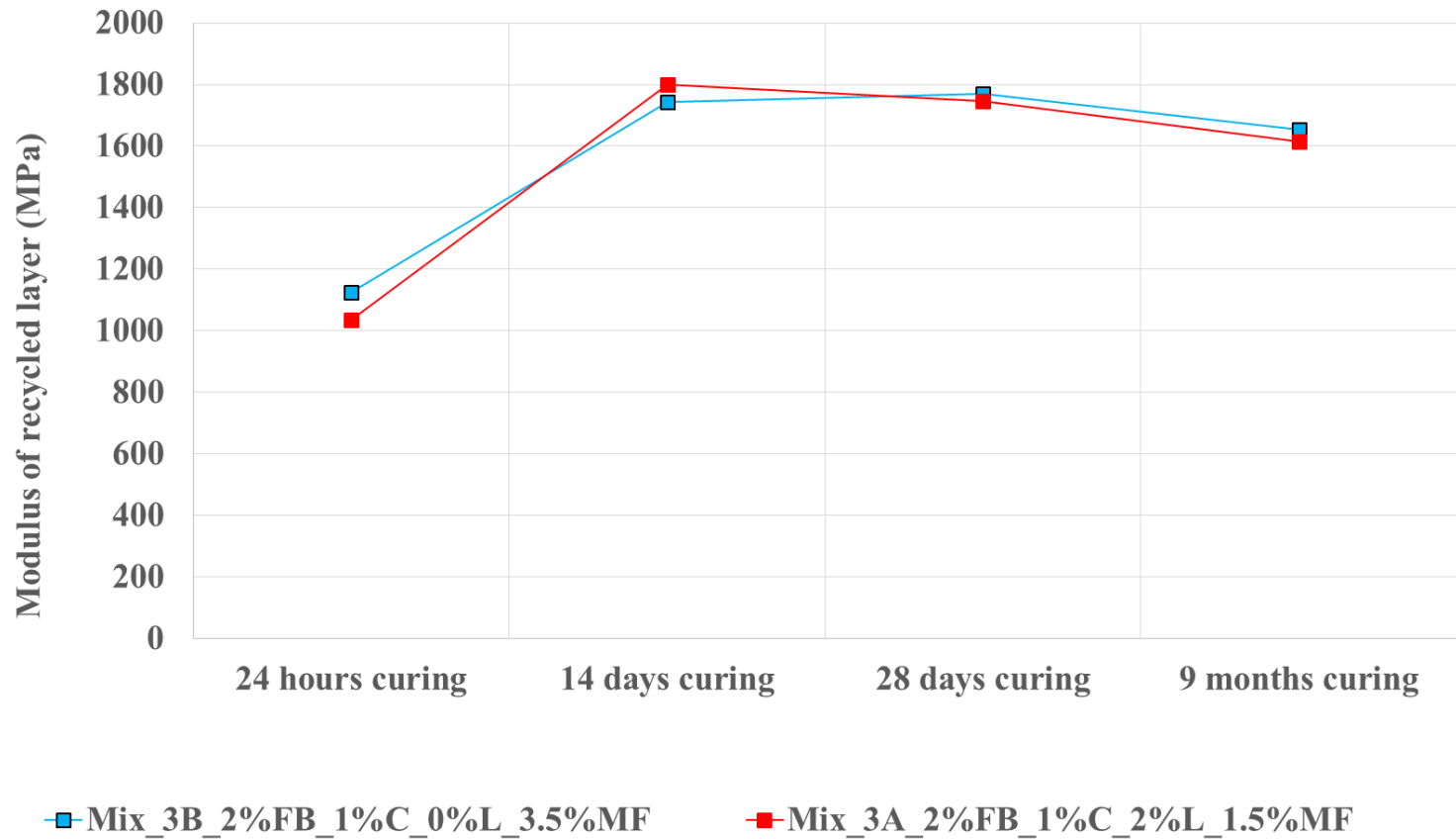
- Minimum requirement of Italian Road Authority (ANAS)**
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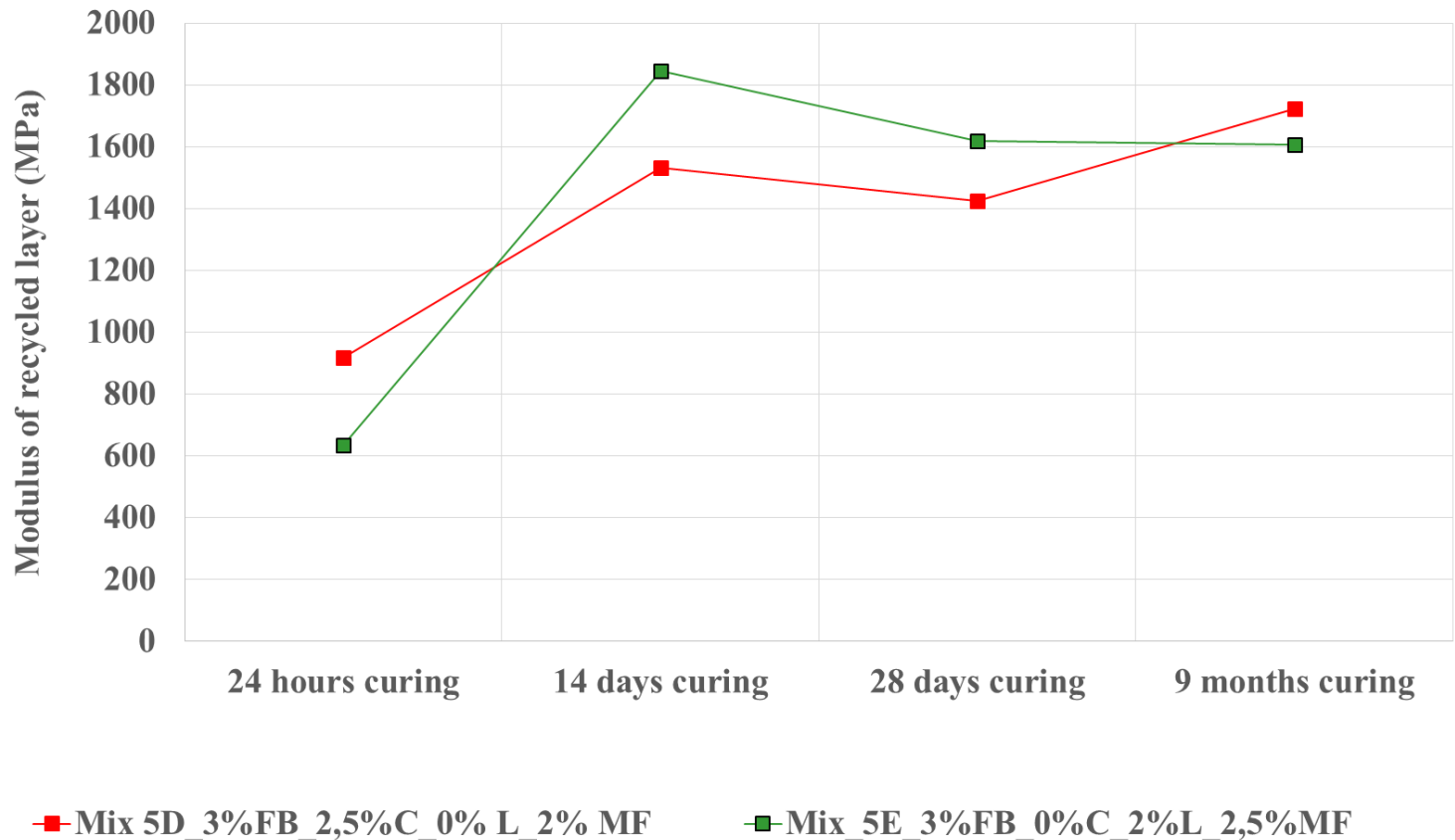
# LWD & FWD TESTS RESULTS

## LIME & CEMENT



# LWD & FWD TESTS RESULTS

## LIME VS CEMENT



# CONCLUSIONS



- **The lime can be used instead of cement!**
- **The lime Can partially replace the cement in the total amount of active fillers!**



# COLD RECYCLING & LIME

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## THANKS !!



## QUESTIONS??