

# STUDY OF THE DIFFUSION BETWEEN AGED BITUMEN AND BIO-/BITUMINOUS BINDERS THROUGH RHEOLOGICAL MEASUREMENTS

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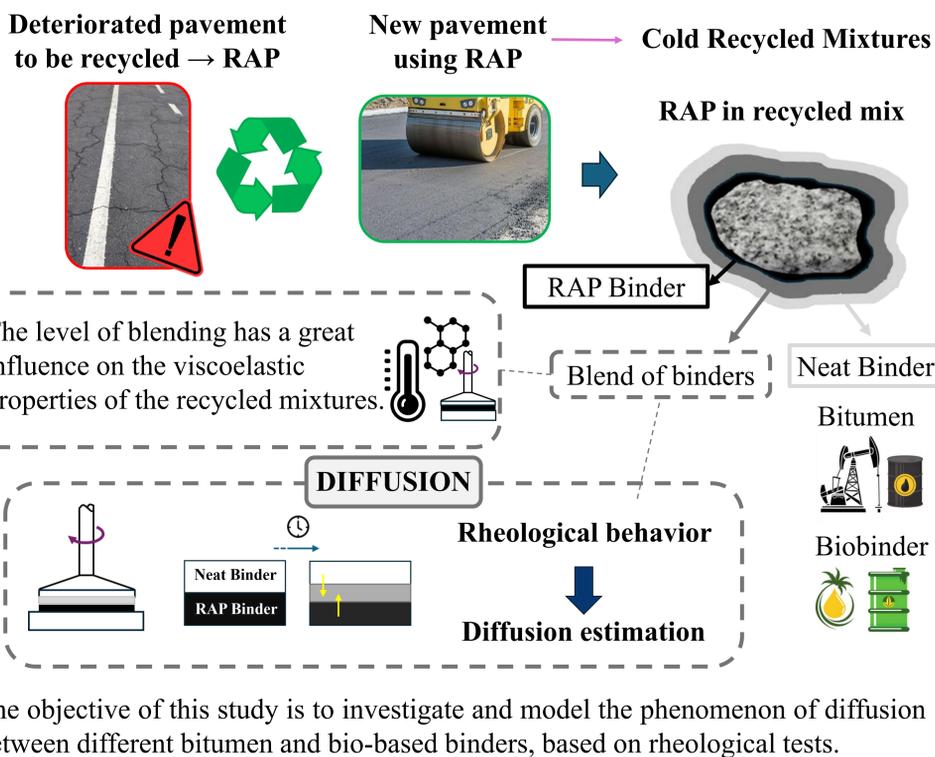
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## Context and objective



## Materials and Methods

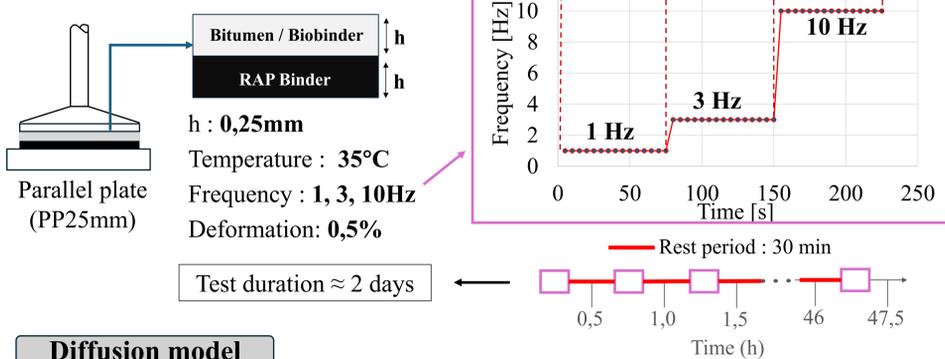
### Materials physical characteristics

Physical characteristics	Materials		
	RAP Binder	160/220 Bitumen	Biobinder
Penetration (0,1 mm) – NF EN 1426	16	185	> 300
Softening point (°C) – NF EN 12697-3	66,2	40,4	33,1

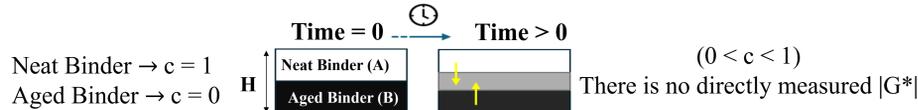
### Methods

#### Rheological tests

- Double-Layer (DL) structure in DSR



#### Diffusion model



#### Diffusion model

#### Mixing law

#### Second Fick's law

$$\frac{\partial c(x,t)}{\partial t} = D \frac{\partial^2 c(x,t)}{\partial x^2}$$

Finite Element Model solve the equation and obtain  $c(x,t)$

$c(x,t)$ : local concentration

$D$ : Diffusion coefficient

$t$ : time

$x$ : thickness coordinate (diffuse layer)

#### Mixing law (from rheological properties)

- Local modulus ( $G_{blend}^*$ )

$$\ln G_{blend}^* = c \ln G_A^* + (1 - c) \ln G_B^*$$

- Global modulus ( $G_{total}^*$ )

$$G_{total}^* = \frac{H}{\int_0^H \frac{dx}{G_{blend}^*(x)}}$$

Estimation of diffusion coefficient  $D$  by fitting the numerical model to experimental rheological data

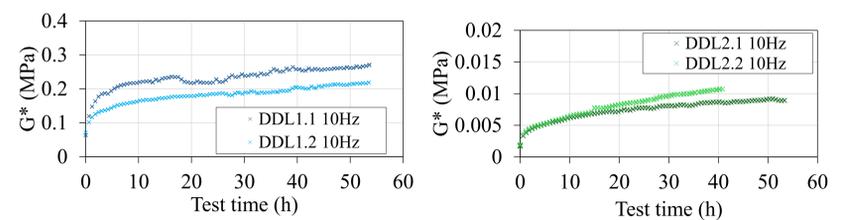
## Results

### Experimental results : Diffusion test

- Double Layer (Neat Binder // Aged Binder)

- DDL1 : 160/220 Bitumen // RAP Binder
- DDL2 : Biobinder // RAP Binder

\*DDL : Diffusion Double Layer (duplicate to see repeatability)

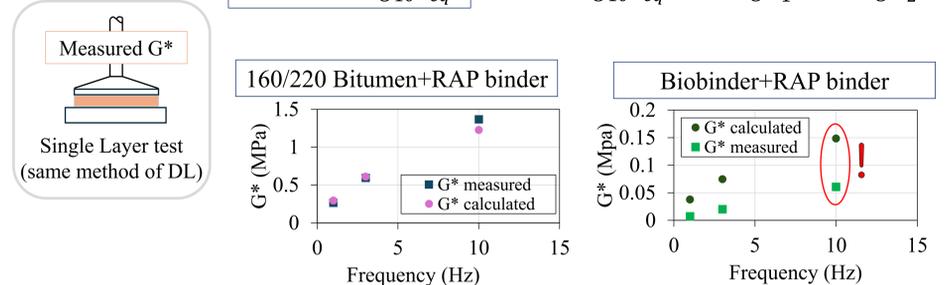


\*Same behavioral trend for 1 and 3Hz

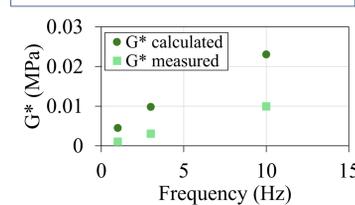
- Mixing law : log-linear

Perfect blend of 50% Aged Binder and 50% Neat Binder on a Single Layer test

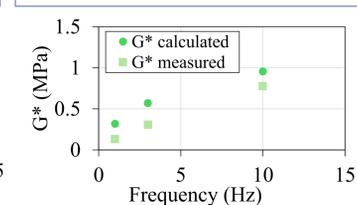
$$\text{Calculated } \log_{10} G_{eq}^* \rightarrow \log_{10} G_{eq}^* = 0,5 \log G_1^* + 0,5 \log G_2^*$$



### 75%BioBinder+25%RAP Binder

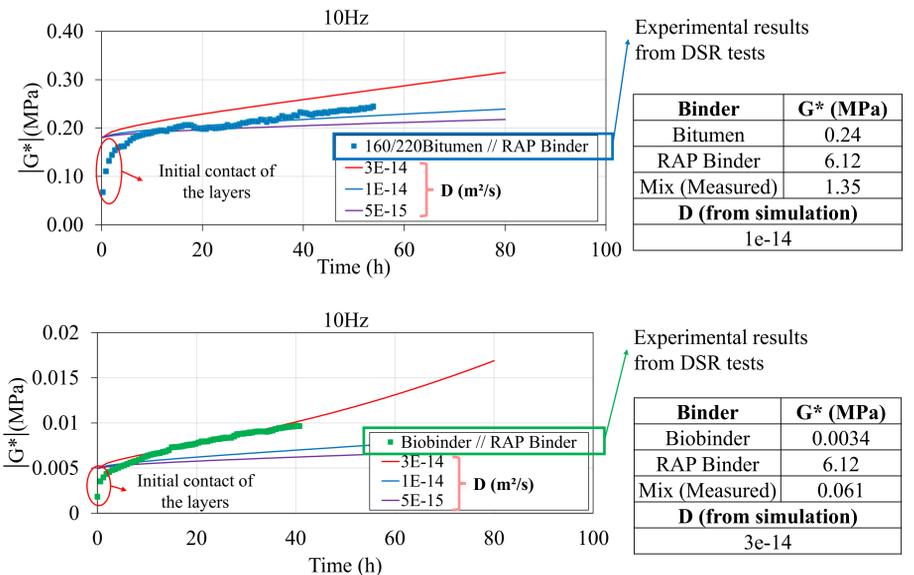


### 25%Biobinder+75%RAP Binder



For Biobinder evaluations : don't follow log-log law, in the concentrations studied.

### Modeling of Diffusion : Estimation of coefficient D



## Conclusions

- The results showed faster diffusion when the biobinder was used compared to a bituminous binder.
- The mixture between the biobinder and the aged binder does not follow the log-log mixing law.
- The behavior suggests that mass transfer between the layers occurs slowly. Nevertheless, the method proved to be sensitive in detecting variations in the rheological behavior of the system