COMPATIBILITY BETWEEN FIBERS AND MODIFIED BITUMEN

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Abstract
This paper shall discuss the problems created by the use of PP and PES fibers or geotextiles in road construction.
Following aspects are considered : the temperature ageing on synthetic materials, the difference of behavior when used with or without bitumen, the description of the testing methods used in laboratory pointing out the phenomenon. This research is actually conducted at the State University of Liege.
Key words : geotextiles, synthetic fibers, bitumen, asphaltic material, temperature, interlayer.

1. Introduction

The association of fibers and bitumen in roads applications (including Reflective Cracking problems) is stressed by the temperature at which these two components are mixed. This temperature is depending from the site conditions and namely :

- the bitume temperature (emulsion or hot bitume);
- the ways fibers and bitume are mixed (fabric saturated on site or premix in a mixer of free fibers and bitume);
- the underlayer temperature;
- the thickness of the layer;
- the temperature and the thickness of an overlay

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Polyester and polypropylene fibers have different degradation temperatures :
150 to 160°C for the polypropylene;
250 to 260°C for the polyester.
If for the second one the adequation for a use in association with bitume (emulsion or hot) is evident, the rejection of the first one is not automatic for the association with hot bitume taking into account the real on site conditions.

In this paper, we give indications on that matter and we stress the researchers and contractors to do more investigations for a better knowledge of the real on site conditions.

2. Thermodegradation of the fibers

2.2. The fibers

A set of 8 different fibers has been selected : 5 polypropylene and 3 polyester.
The Table 1 gives indications about these.

Table 1. Fibres characteristics

Raw material	Fiber length (mm)	Presentation
PP	6	FF
PP	12	FF
PP + PE	20	FF
PP	∞	NW - TB
PP	∞	NW - NP
PES	10	FF
PES	∞	NW - NP
PES	∞	W

where :
PP = polypropylene
PE = polyethylene
PES = polyester
FF = free fibers
NW = non woven
W = woven
NP = needpunched
TB = thermobonded
∞ = infinite

2.2. The bitumen

For this research a 50/60 bitumen has been used. This is a rather common product used in road construction.

2.3. Thermodegradation procedure

The selected fibers are placed on glass plates. Fibers are exposed to two ageing conditions (1 set of fibers per ageing) :

Ageing 1 : 30 minutes at a given temperature (200, 160, 120, 100, 80) for the fibers alone.
Ageing 2 : 30 minutes at a given temperature (idem) saturated with the bitumen.

2.4. Analysis

The fibers are analysed before and after these ageing conditions. After ageing 2, the bitumen is eliminated by solvant prior to the analysis.

The next observations are made :

- microscope analysis;
- infra-red (I.R.);
- differential scanning calorimetry (D.S.C.).

For the infra-red (I.R.) analysis, a ray is directed to the tested sample. Parts of this incident ray are absorbed.
The study of the corresponding wave length and intensity of the absorbed rays helps to identify the chemical composition of the product.

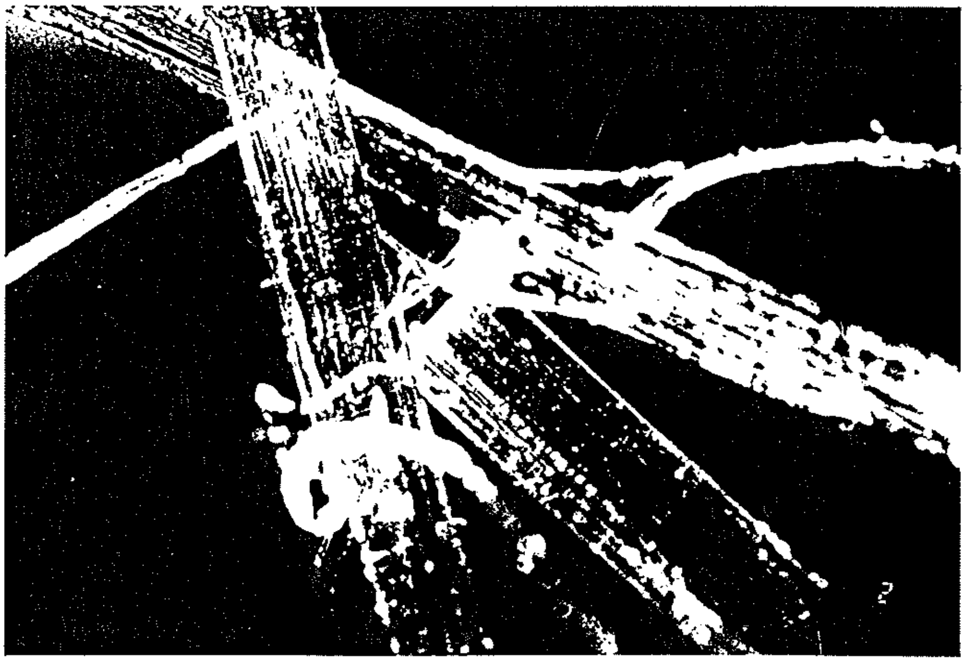
The D.S.C. analysis consists in studying the difference in energy flow between a reference and the studied material in function of the temperature. It permits to point out any structural changes in the product in function of the temperature.

3. Test results

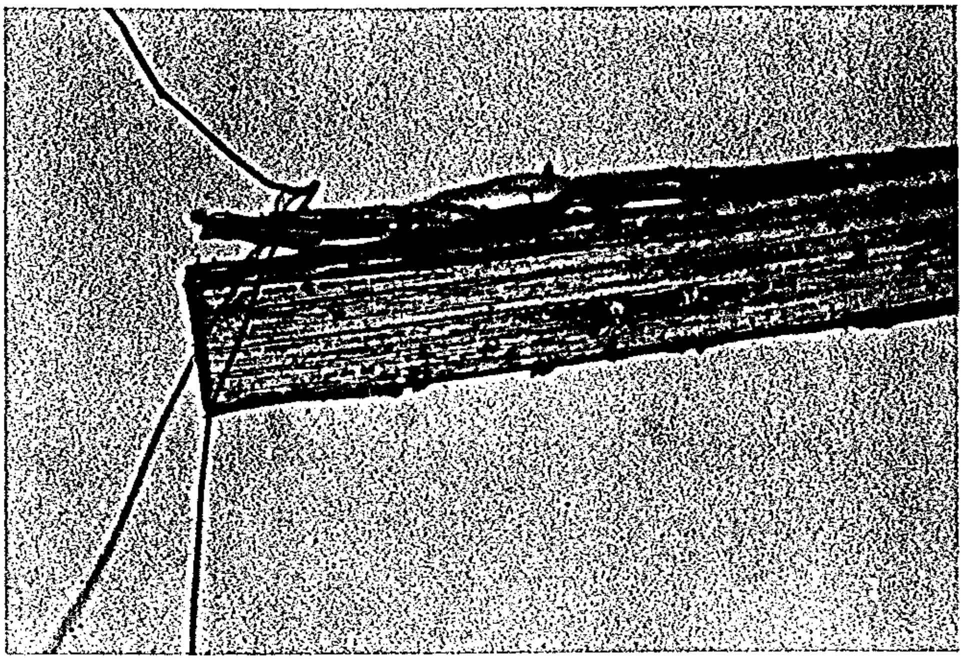
3.1. Typical observations

The typical types of observations are tested hereafter :

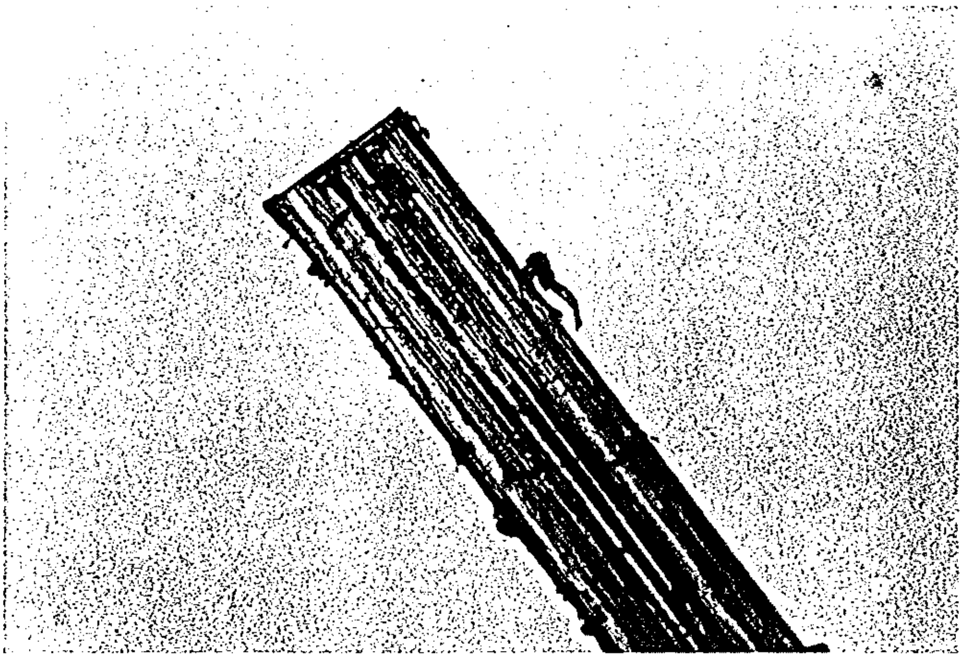
A. Microscopy



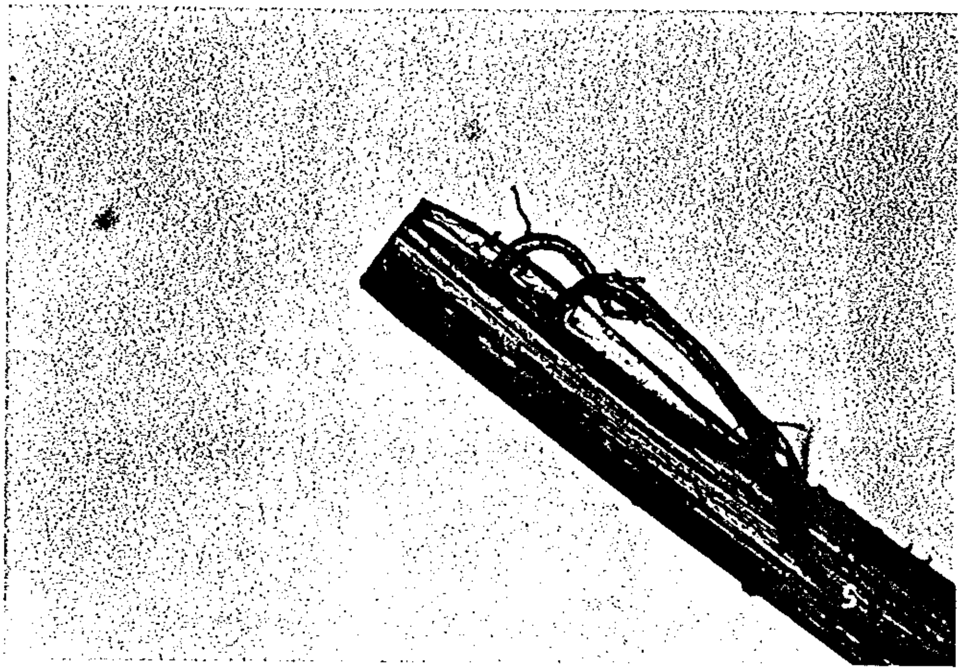
PP - before ageing



PP - ageing 1
80°C

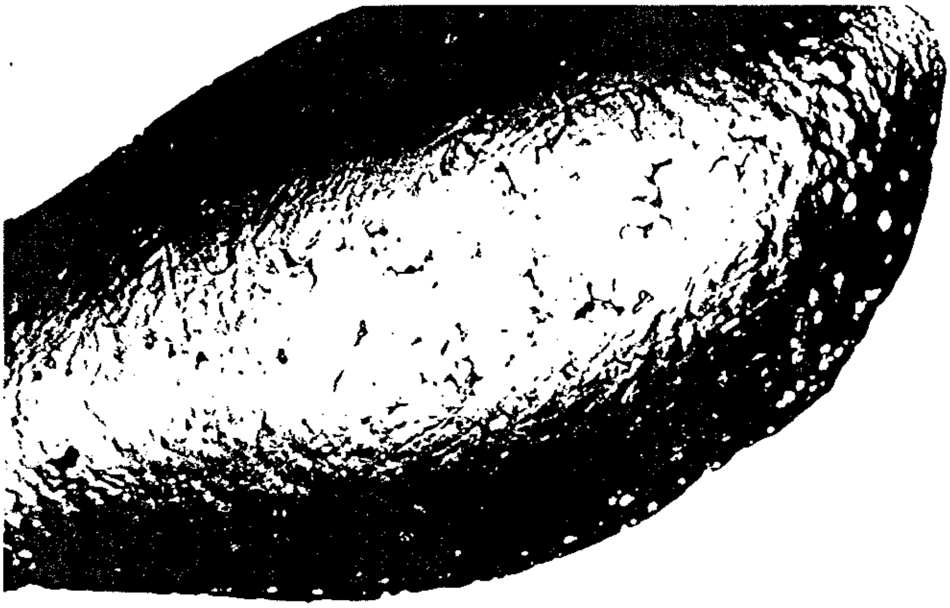


PP - ageing 2
80 °C

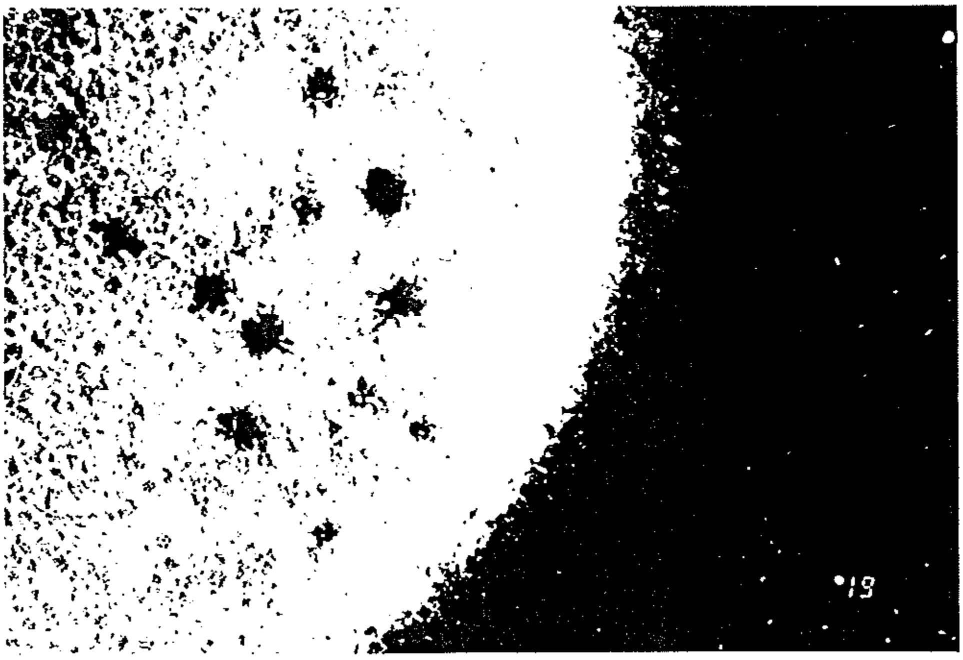


PP ageing 1
160°C

PP ageing 2
160°C

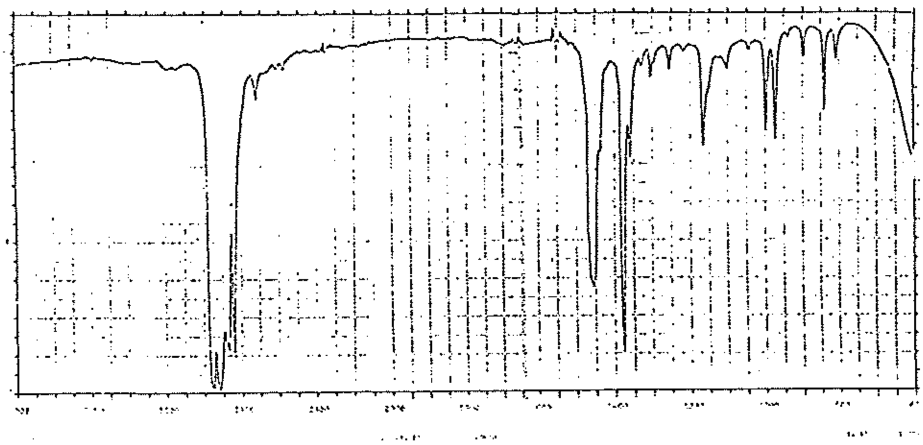


PP - ageing 1
200°C

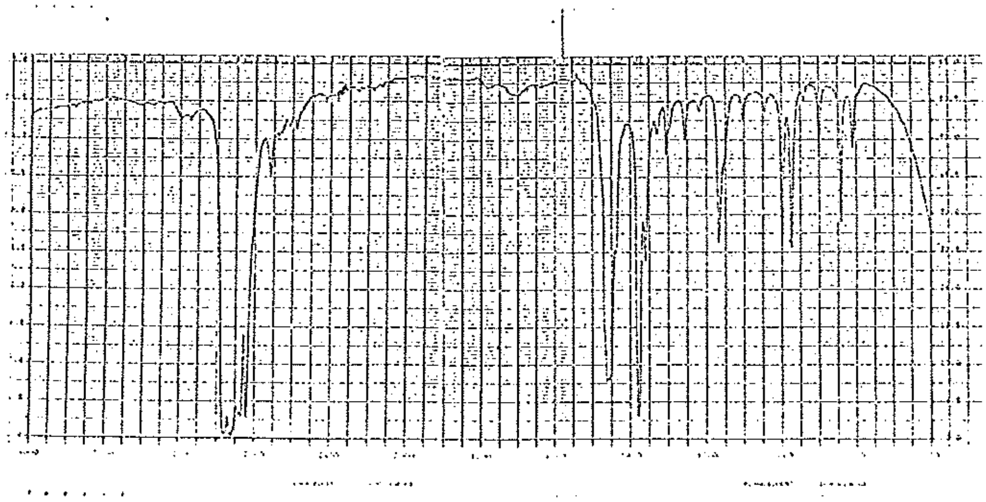


PP - ageing 2
200°C

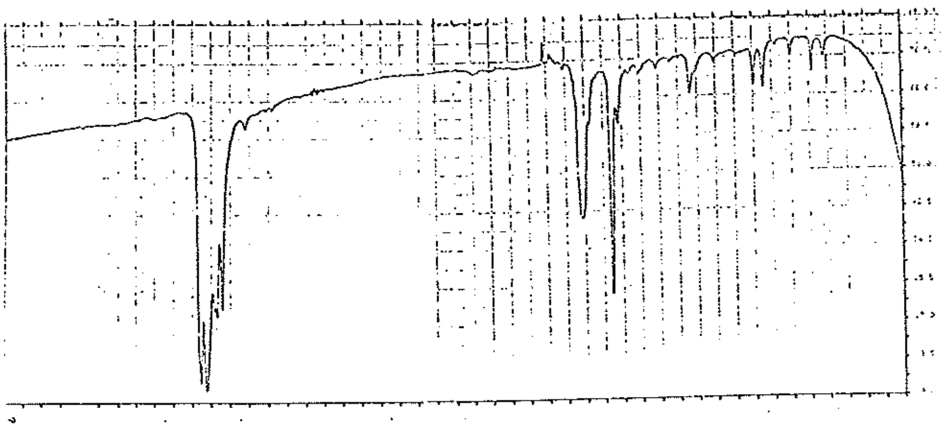
B. Infra-red



PP before ageing



PP ageing 1
200°C



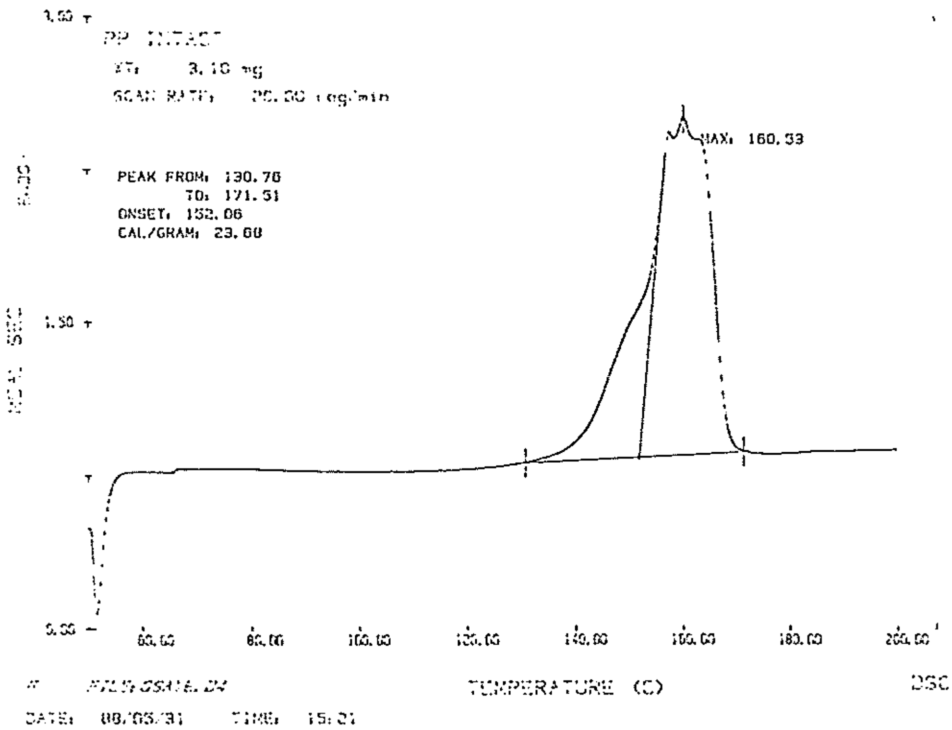
PP ageing 2
200°C

Remarks :
we note, for PP, a modification of I.R. absorption. I.R. spectrum for $1/\lambda$ = 1700 cm^{-1}, corresponding to the presence of bonding C = O.
It's an oxydation phenomenon.
The structure of polypropylene being

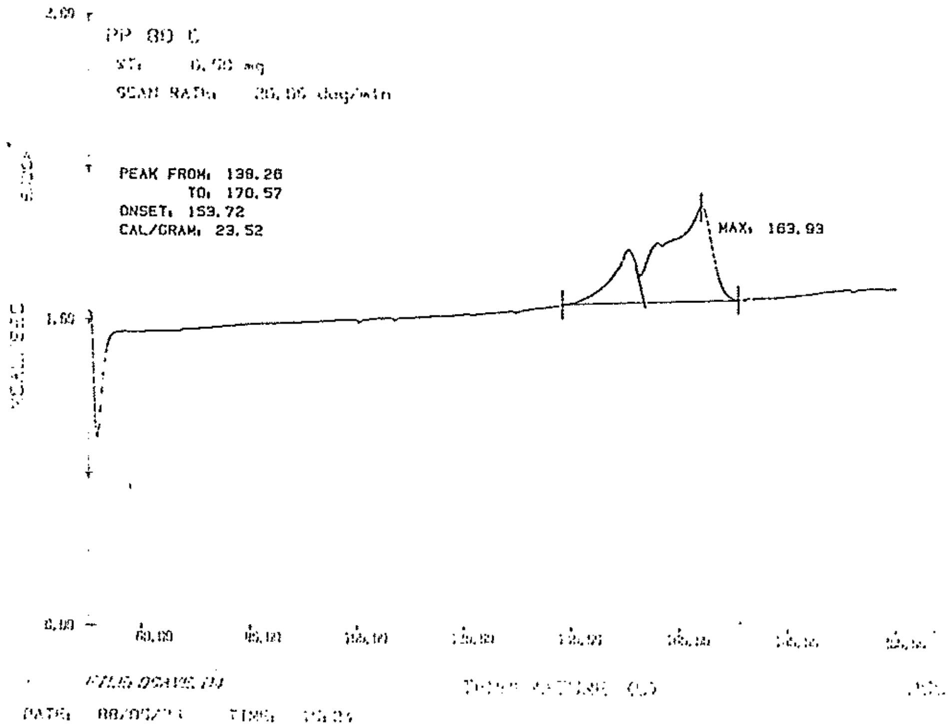
$$\left(CH_2 - \underset{\displaystyle CH_3}{\underset{|}{CH}} \right)$$

When the temperature increases, it produces oxydation and rupture of the bonding with formation of C = O groups. We don't notice any other degradation.

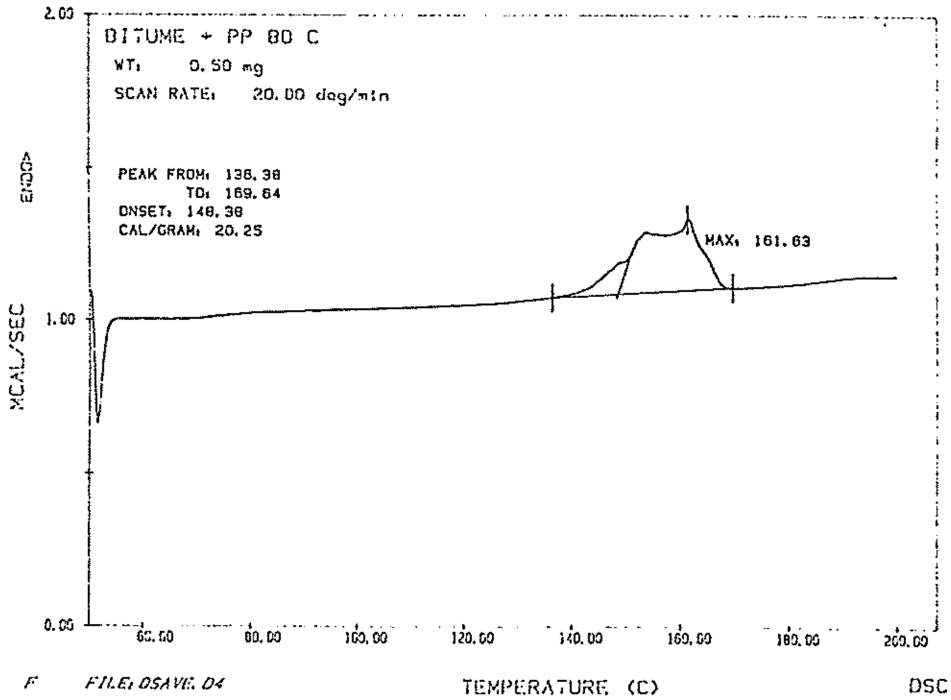
C. Differential Scanning Calorimetry



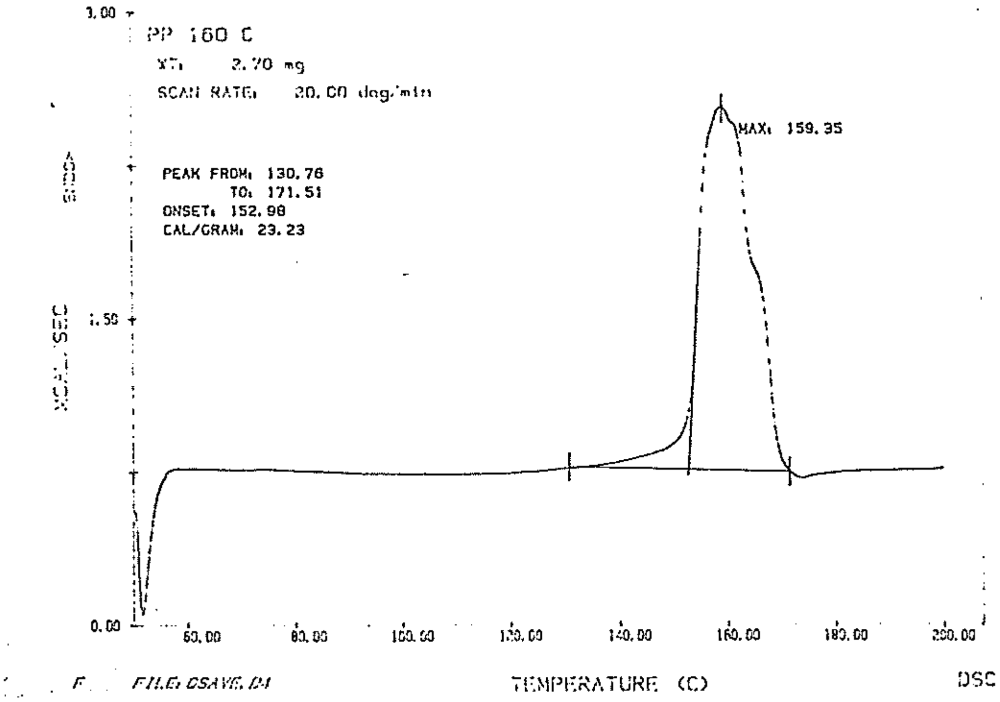
PP before ageing



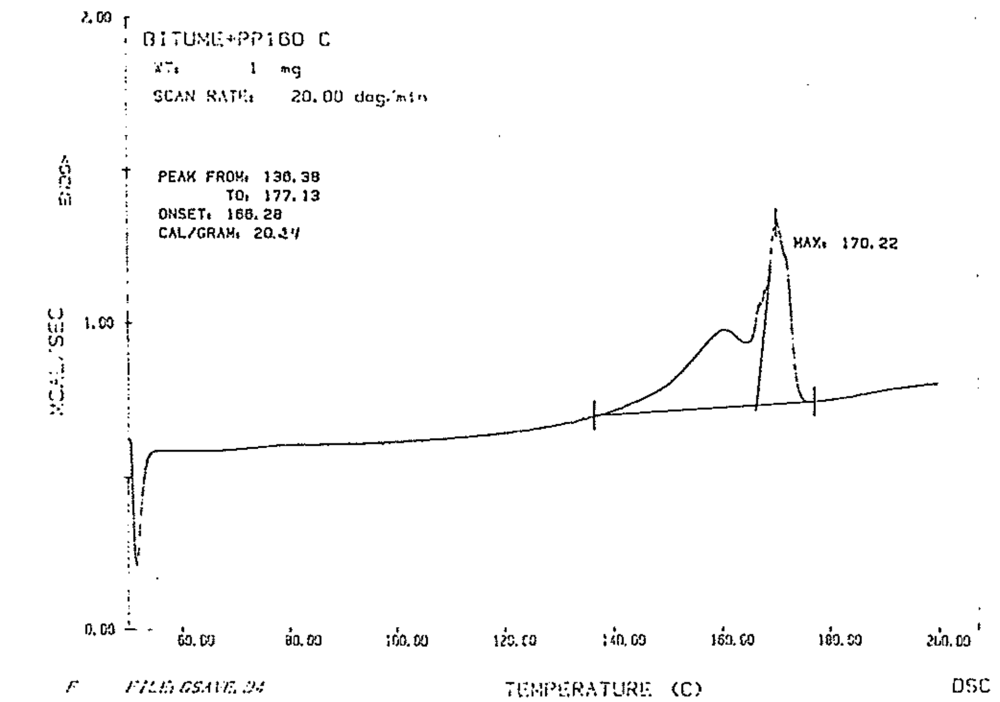
PP ageing 1
80°C



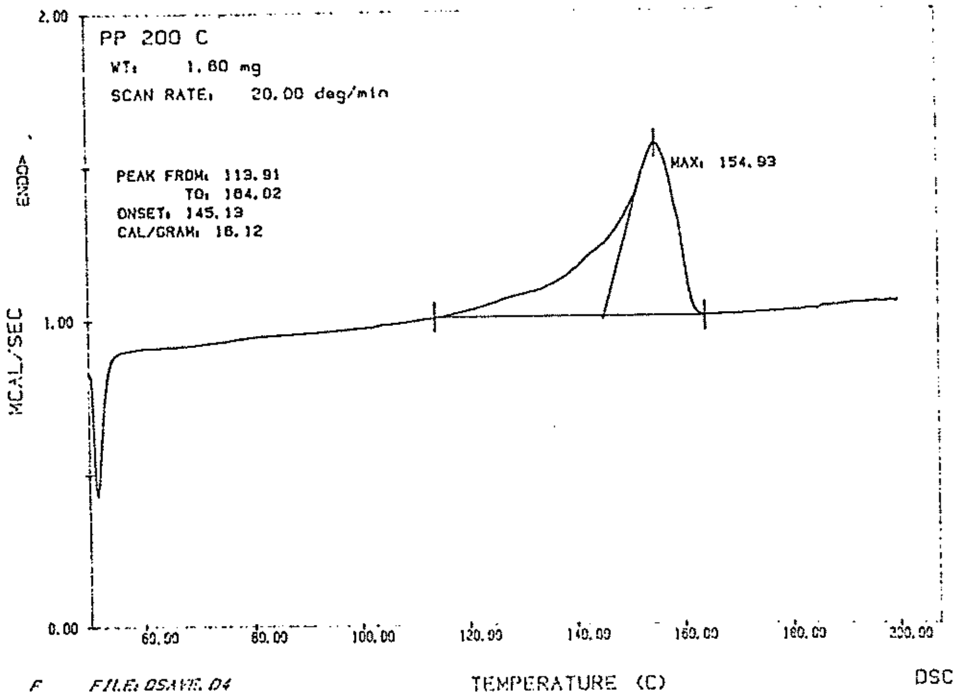
PP ageing 2
80°C



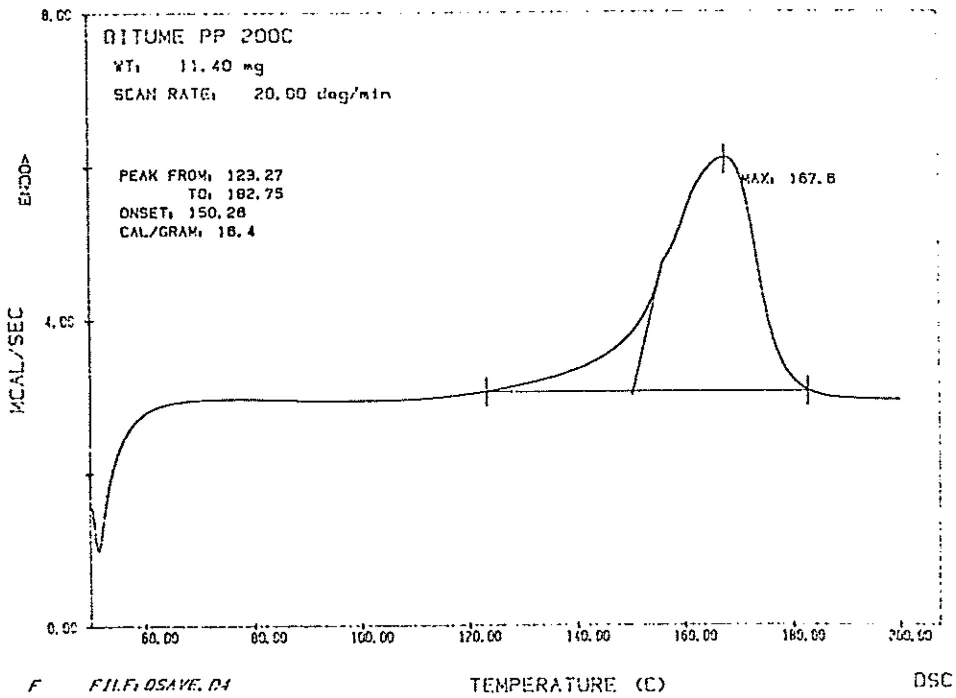
PP ageing 1
160°C



PP ageing 2
160°C

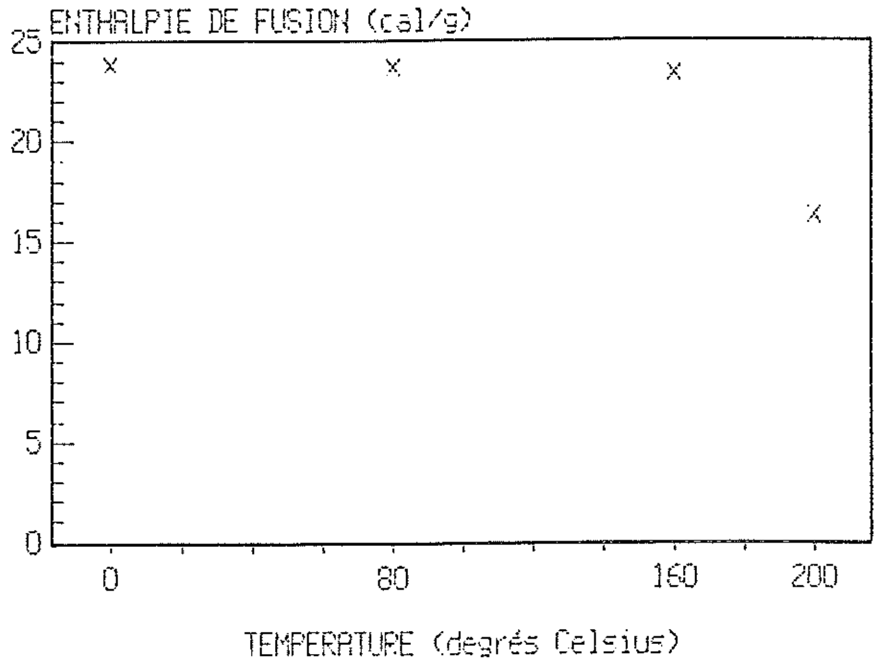


PP ageing 1
200°C

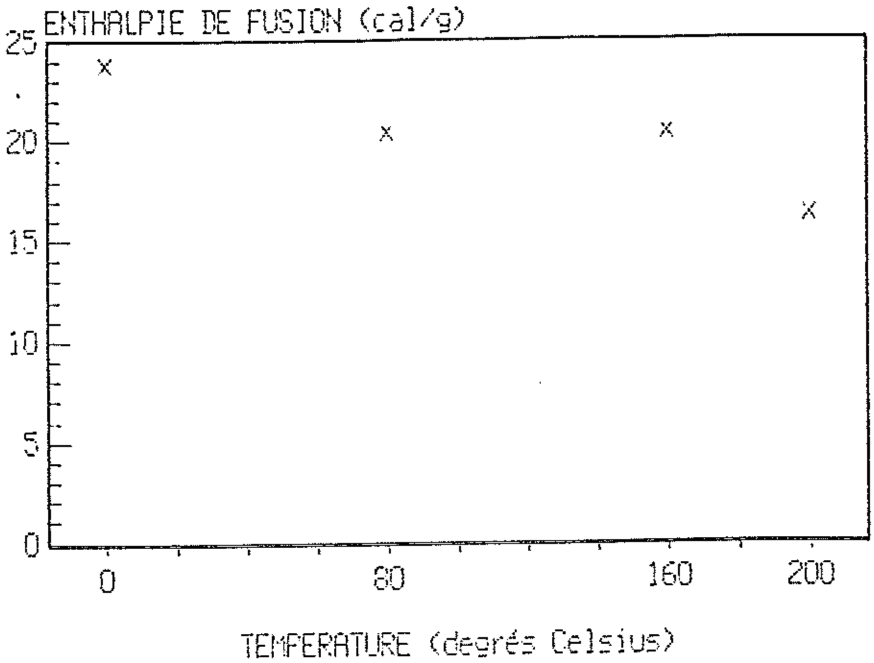


PP ageing 2
200°C

Remarks :
the PP-fibers being melted after their placement in the drying stove, we notice differences between the curves coming from D.S.C. Indeed, there is in the fibers a preferential orientation of the cristallites so that the energy necessary to obtain their fusion (or enthalpy of fusion) is more important; it is confirmed by the number of calories/gr.
Moreover, the different peaks we notice on the diagram, for the fibers which haven't been treated, correspond to the suppression of these interactions : indeed, because of the fibers stretching during their fabrication, a preferential orientation happens in the molecular organization of the product.
The energy necessary to destroy this organized structure is so more important than the required one when the fibers are melted.
In the case of an ageing in bitumen, the fibers are also melted. We separated the polymer from the bitumen by dilution in methyl-dichloride.
We don't observe fundamental difference between the graphs obtained for the fibers ageed or not in bitumen; the behavior of these seems to be the same, if we except the remarks done with I.R. analysis. The same programs were made for the 8 types of fibers, for the 2 types of ageing and for 4 various temperatures. However, we have to notice a little difference for the value of enthalpy of fusion, for fibers ageing with or without bitumen.



PP ageing 1



PP ageing 2

3.2. Results analysis

The D.S.C. diagrams show us that in fact the fusion of the polyester is starting around 230°C and is achieved around 270°C with a maximum at 250-260°C.
Thus for all normal site conditions, no fusion process can be expected.

For polypropylene, the fusion starts around 110 to 130°C (depending from the origin), it is achieved at 180°C with a maximum around 160°C.
Usually, in Belgium, an asphaltic material is laid down at temperatures about 160°C, following the instructions of the C.R.R. (Centre de Recherches Routières).
This temperature corresponds to a critical temperature for polypropylene; we carried out experiments in order to find out the real temperatures in polypropylene when it's laid down.
So we layed down a geotextile on a concrete support, at a temperature of 25°C; as first step, we impregnated it with bitumen at 150°C; after cooling - it is the second step - we spread an asphaltic material at 160°C, as shown figure 1.

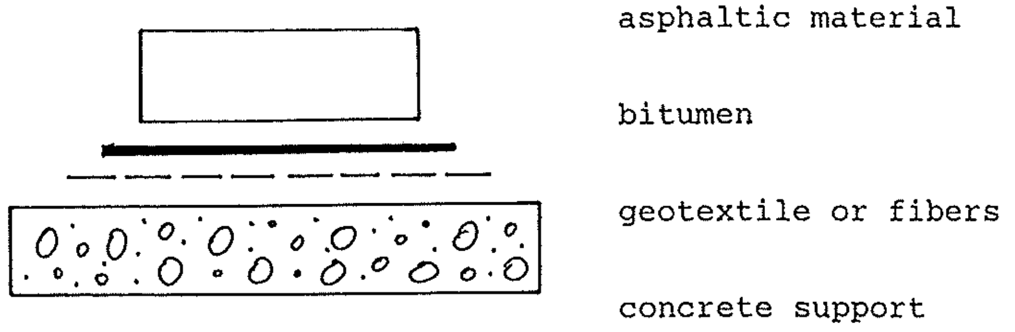
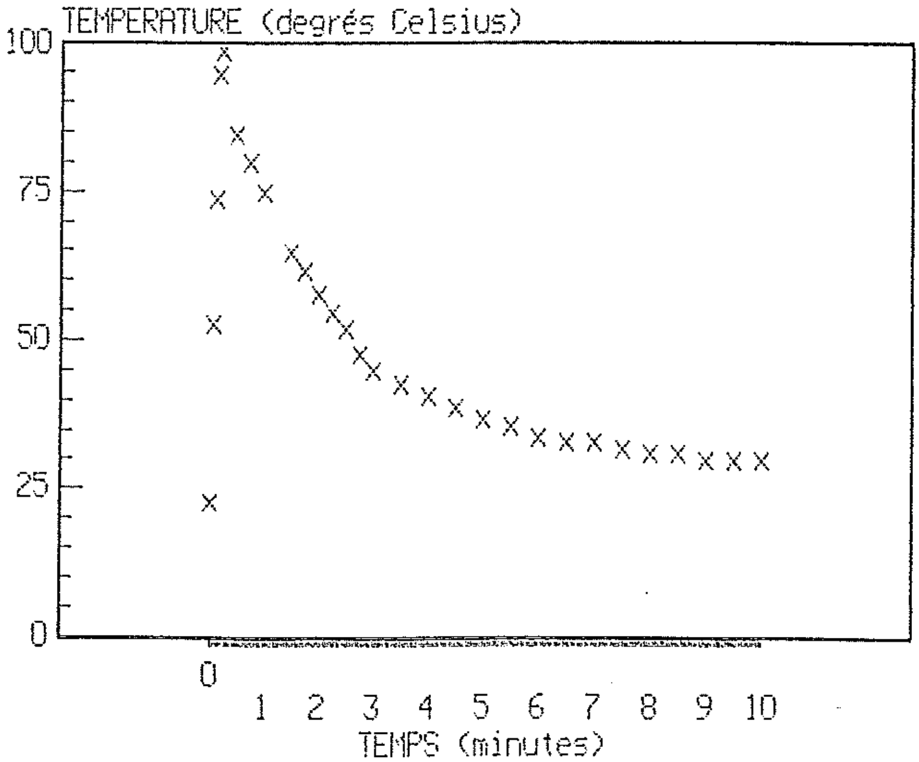


Fig. 1.

We noticed, with thermocouples, the evolution of the temperatures, first at the level of the geotextile (T_1) and secondly, inside the asphaltic material (T_2).

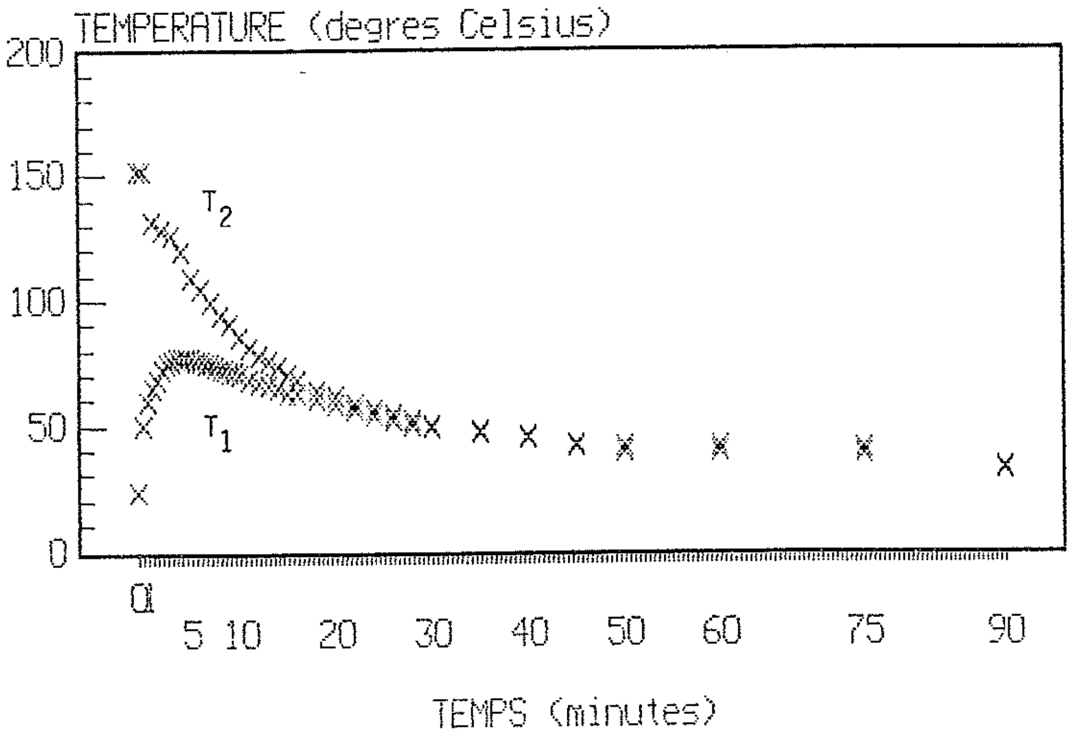
First step



Variation of the temperature at the level of the geotextile (T_1)

We note that, for bitumen laid at 150°C, the maximum temperature we obtain at the level of the geotextile is 98°C.

Second step



Variation of the temperature at the level of the geotextile (T_1) and in the asphaltic material (T_2)

In this case, we compared the evolution of the temperature at the level of the geotextile and in the mass of the asphaltic material. We see that, after about only 30 minutes, we obtain under laboratory conditions (T° = 25°C) and for thickness of 3 cm, similar temperatures.
We notice that the temperature maximum isn't, in the conditions described herebefore, over 80°C.
So we can say that, at the interface fundation

- the PP fiber temperature won't be higher than 100°C for an overlay laid down at 150°C. That would not be the case if the fibers were mixed with the asphaltic material;

- the PP oxydation, detected by the I.R. analysis, causes a decrease of the fiber mechanical properties.

The general conclusion of this study is that we must be careful when we use PP for asphaltic material. A systematic study of the temperatures at the interface fundation-overlay, at the level of the geotextile, compared with the study of the mass-temperature inside the asphaltic material, would prevent any problem of that type.

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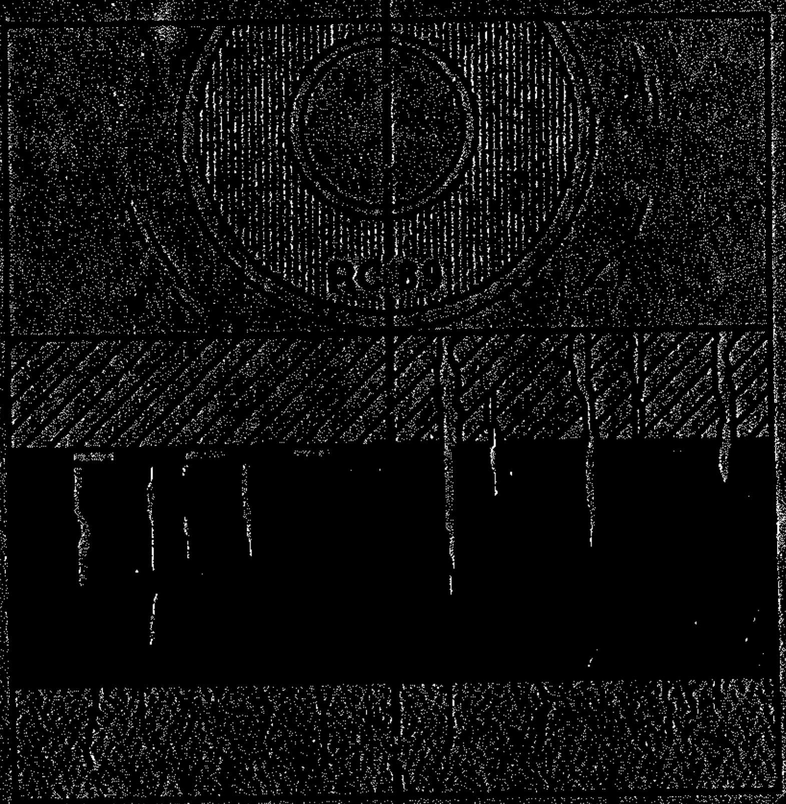
REFLECTIVE CRACKING IN PAVEMENTS

Assessment and Control



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