MOISTURE DAMAGE RESISTANCE OF BITUMINOUS MIXTURES MANUFACTURED WITH WASTE BIOMASS FLY ASHES FROM THE PAPER INDUSTRY AS FILLER

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INTRODUCTION

Biomass fly ashes (bioashes) are solid byproducts generated during the combustion of biomass. One of the main drawbacks of using biomass combustion as an energy source is the environmental management of the resulting bioashes. In this regard, some researchers have analysed the feasibility of using **bioashes as filler** for bituminous mixtures with encouraging results. Nevertheless, previous investigations concluded that the use of biomass waste fly ashes from the paper industry (**BioFAPI**) lead to bituminous mixtures with **inadequate water resistance**.

OBJECTIVES

In this research two main objectives exist:

1) Find ways to improve the **water resistance** of hot-mix asphalt (HMA) made with BioFAPI as filler.
2) Deep in the **knowledge** of HMA and cold asphaLt mixtures (CAM) made with BioFAPI as filler.

METHODOLOGY

In this research, **BioFAPI** (figure 1) were used as **filler**.

Two types of mixtures were tested:

- HMA type **AC 22 base B50/70 G** (figure 2). In this mixture a quarry siliceous aggregate was used in the coarse fraction, whereas a quarry limestone aggregate was used in the fine fraction. A penetration-grade bitumen **B50/70** was chosen for the manufacture of HMA. According to the Marshall method, the resulting optimum bitumen content was **4.25%** with an **air void content (Va) of 6.25%.**
- CMA type **GE1** (figure 3). A hornfels (siliceous aggregate) was used to manufacture this mixture. A slow-setting cationic bitumen emulsion, **C60B5 GE**, with 60% bitumen content was selected to manufacture the grave emulsion. The optimal contents were **3% bitumen and 6% water**, giving a **Va of 11.3%**.

In order to **improve the water resistance of the HMA** made with BioFAPI, the following solutions were tested:

- Curing the HMA for 2 h in an oven before compaction at 160ºC to simulate the transport and spread time of the HMA and let the bitumen absorption occurs.
- Using 1% of hydrated lime $Ca(OH)_2$ type CL90S as filler.
- Increasing the bitumen content from 4.25% to 4.55%.

The **moisture damage resistance of HMA and CAM** was studied:

- Following the UNE-EN 12697-12 for the HMA
- Following the immersion–compression test, according to the Spanish NLT-162 standard for the CAM

RESULTS AND DISCUSSION

The control HMA mixture comply with the Spanish specifications in terms of water resistance (TSR=80.4%≥80%). On the contrary, the HMA made with BioFAPI displays inadequate water resistance (table 1). Curing the HMA manufactured with BioFAPI as filler 2 h in the oven, leads to mixtures with similar water resistance (table 1). Using 1% of hydrated lime as filler slightly improves the water resistance of the HMA made with BioFAPI as filler. Nevertheless, this increase in TSR was clearly insufficient (table 1).

An increase in the bitumen content from 4.25% to 4.4% leads to a notably increase in the TSR (table 2). In contrast, when the bitumen is increased from 4.4% to 4.55%, the TSR decreases by 0.7% (table 2).

In the case of **CAM mixtures** (table 3) the control mixture and the mixture made with BioFAPI, present similar RSR. Both results **exceed the 75%** specified by ATEB for roadways with heavy-traffic category **T2 or higher** (annual average daily heavy traffic higher than 200).

Thus, it can be concluded that **BioFAPI may be used as alternative eco-friendly filler for the manufacture of CAM.** Nevertheless, further investigation is needed.

IMAGES AND CHARTS

FIGURE 1. BioFAPI

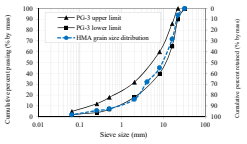

FIGURE 2. Grain size distribution of AC 22 base B50/70 G

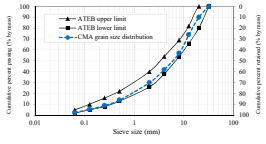

FIGURE 3. Grain size distribution of GE1

Solution used to improve the water resistance of the mixture	Bitumen content (%)	ITSd (Mpa)	ITSw (Mpa)	TSR (%)
No	4.25%	1.44	0.83	57.9
2 hours of curing time in the oven		1.94	1.10	56.5
1% of hydrated lime		1.535	0.944	61.5

TABLE 1. EFFECT OF CURING TIME AND HYDRATED LIME

Bitumen content (%)	ITSd (Mpa)	ITSw (Mpa)	TSR (%)
4.25	1.44	0.83	57.9
4.40	1.39	0.93	67.1
4.55	1.52	1.01	66.6

TABLE 2. EFFECT OF BITUMEN CONTENT

GE1	Residual binder content (%)	Water content (%)	USC_{DRY} (Kpa)	USC_{WET} (Kpa)	RSR (%)
Control	3.0%	6.0%	2.914	2,379	81.6
Biomass fly ashes as filler			3,434	2,810.1	81.8

TABLE 3. GRAVE EMULSION RESULTS

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