Innovative products and technologies for sustainable road pavements: asphalt mixtures with high percentages of RAP and recycled plastics

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Introduction

This Ph.D. research is related to an agreement between MUR (Ministero dell'Università e della Ricerca) and Iterchimica S.p.A. Recently, Iterchimica developed **SUPERPLAST ECO**, a **polymeric compound** originated from plastic waste typically not reclaimed or recyclable through traditional plastic recycling processes. In such a way, plastic wastes destined previously for landfills or incineration will be utilized with an eco-friendly approach incorporating them in road asphalt pavement.

Many studies have consistently shown that asphalt mixtures modified with plastics are characterized by an improvement in rutting performance regardless of either the dry or wet method. Regarding **fatigue resistance**, the literature is divided: several studies reported that there is an improvement in such performance when recycled plastics are incorporated; others have shown neither improvements nor deteriorations. Therefore, the added plastic-type appears to be a critical factor in determining these properties.

PH.D. research objectives

This Ph.D. research aims to experimentally investigate **innovative products** and sustainable solutions for asphalt road pavement construction. Specifically, the goal is to design AC16 mixtures for binder courses with a high percentage of Reclaimed Asphalt Pavement (RAP) and different contents of SUPERPLAST ECO. The performances of different asphalt mixtures will be compared, in particular regarding fatigue behavior. Furthermore, the doctoral research program aims to characterize SUPERPLAST ECO, assess the dispersion of the polymeric compound inside the mixture, and evaluate the damage due to UV radiations to the wearing course layers with plastics.

Materials

RAP

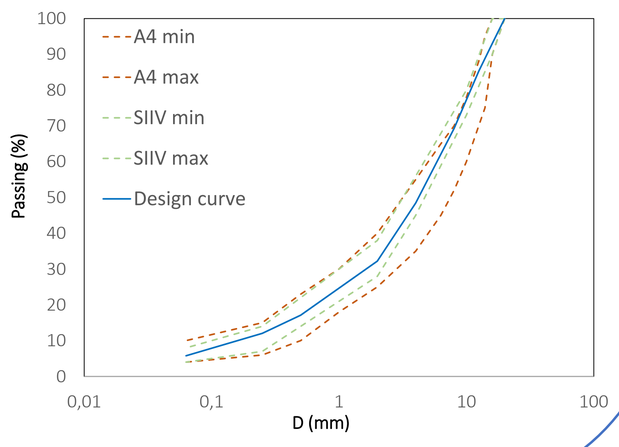
- Recycled asphalt material recovered from existing pavements

SUPERPLAST ECO

- A patented polymeric compound manufactured by Iterchimica
- It consists of 100% recycled plastics in a 4-6 mm granule shape
- It is specifically formulated to be added within asphalt mixtures using the dry method.

Virgin aggregates	RAP (50%)	Rejuvenator	Polymeric compound	Virgin bitumen
				
• Sand 0/5 • Gravel 8/16 • Gravel 16/22	• RAP 0/12 (30%) • RAP 0/20 (20%)	• ITERLENE ACF2000 GREEN (0.3% by the wt. of RAP)	• SUPERPLAST ECO (0.3%, 0.4%, and 0% by the wt. of mix)	• Neat bitumen • Polymer-modified bitumen (PMB)

- Preliminary tests: particle size distribution analysis, apparent specific gravity, and bitumen content within the RAP.
- The chosen particle size distribution (PSD) curve complies with two Italian specifications, namely the A4 motorway and the SIIV specifications.
- The design curve is determined considering a “white” RAP content of 50%. This choice optimizes the virgin aggregates and the added virgin bitumen used.



Adding RAP methodologies inside in-plant-produced asphalt mixtures

During the first year of doctoral research, several plants were visited to gain insights into the various technologies and methodologies used for incorporating RAP into asphalt mixtures.

Several processes are recognized:

- cold RAP addition (batch plants)
- preheating RAP in a second drum (batch plants)
- using a drum that can simultaneously heat RAP and virgin aggregates (batch and continuous asphalt plants).


Methodology

Three AC16 mixtures will be designed to compare their performances, with a particular emphasis on fatigue behavior:

- AC16 - SP1, characterized by a polymeric compound content of 0.3% by weight of the mix and a neat virgin binder.
- AC16 - SP2, characterized by a polymeric compound content of 0.4% by weight of the mix and a neat virgin binder.
- AC16 - PMB, without polymeric compound content and with a virgin polymer-modified binder.

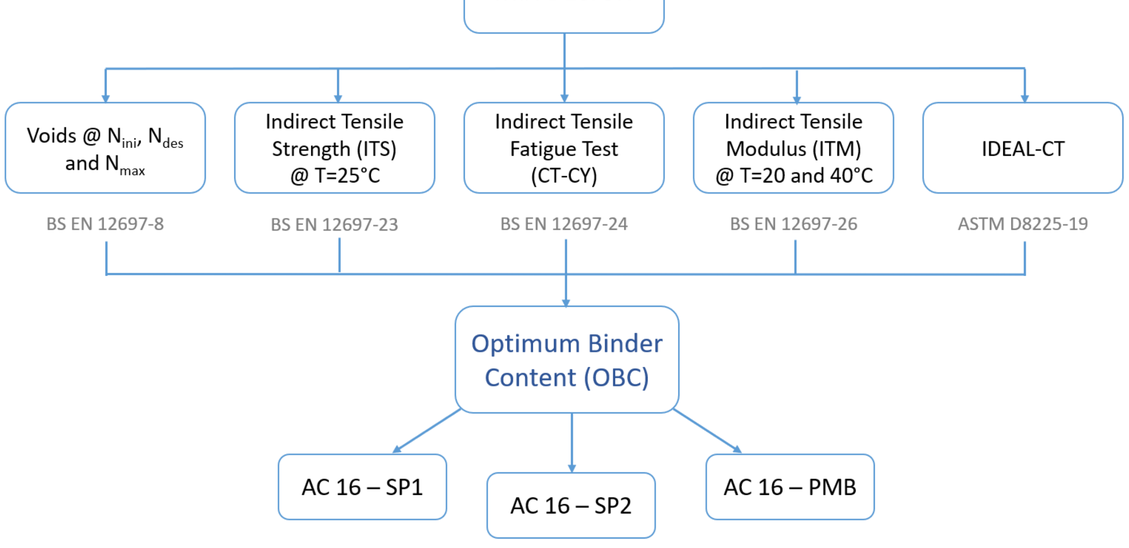
Mixing procedure

The laboratory mixing procedure consists of sequential steps, with two primary objectives:

- achieving homogeneity in the mixture
- replicating the processes occurring in asphalt plants, while considering the limitations imposed by laboratory equipment.


Mix design

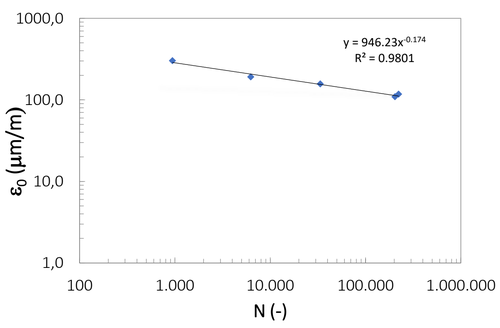
- Mix design aims at determining the optimal composition of a mixture.
- The approach used in this study considers both volumetric and performance-related parameters.



First laboratory results

- An asphalt mixture characterized by an initial binder content of 5.45% by weight of the mixture and a SUPERPLAST ECO content of 0.3% was prepared.
- It is important to highlight that the term "binder" contains all components that "bind" the aggregate structure: bitumens (virgin and from RAPs), polymeric compound, and rejuvenator.

Tests		Temperature	Average values	Limits
Voids at	$N_{initial}$	-	9.4 %	11-14 %
	N_{design}	-	1.2 %	3-6 %
	N_{max}	-	0.4 %	>2 %
Indirect Tensile Strength		25 °C	2.16 MPa	1.20 – 2.20
Stiffness Modulus		20 °C	9849 MPa	8 000 – 15 000 MPa
		40 °C	2364 MPa	900 - 6 000 MPa
CTI_{index} (Ideal CT)		25 °C	18	-



- The mechanical parameters meet the requirements, but the volumetric parameters are not achieved.
- Asphalt mixtures with lower binder content will be produced to determine the OBC.

Ongoing and future activities

- Mix design study for the definition of the three final mixtures.
- Fatigue analysis (with 4-Point Bending Test) and comparison between laboratory-produced and plant-produced mixtures.
- SUPERPLAST ECO characterization and dispersion inside asphalt mixtures.
- Damage by UV radiation in wearing course added with plastics.

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