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CHALLENGES IN PRODUCING INNOVATIVE LOW-NOISE ASPHALT MIXTURES WITH RECYCLED MATERIALS AND ADDITIVES: INSIGHTS FROM LIFE SILENTPROJECT

Massimiliano Diamantini[1*] **Patrizia Bellucci**[1] **Giuseppe Chidichimo**[2] **Filippo Praticò**[3]

[1] ANAS S.p.A., Research & Development Department, Via Luigi Pianciani, 16, 00185, Rome, Italy

[2] University of Calabria, TEBAID Consortium, Via P. Bucci, 15D, 87036, Rende (Cs), Italy

[3] Department of Information Engineering, Infrastructure and Sustainable Energy, University Mediterranea di Reggio Calabria, Via dell'Università, 25, 89124, Reggio Calabria, Italy

ABSTRACT

This paper discusses the challenges encountered during the LIFE SILENT project in producing innovative asphalt mixtures designed to develop low-noise, sustainable, and eco-friendly pavements for urban environments. The project's aim to integrate recycled materials and innovative additives into asphalt production revealed several technical and operational issues that required careful consideration and adaptation of traditional processes.

Key challenges included ensuring the proper integration of unconventional materials into the mixture, managing their physical characteristics to prevent compaction issues, and adjusting production parameters, such as the order of ingredient introduction, mixing time, and temperature.

This study provides an overview of the lessons learned during the experimental phase, focusing on the technical adjustments and pre-treatments required to overcome production obstacles. By addressing these challenges, the research offers valuable insights into the potential for scaling up the production of innovative low-noise pavements that combine environmental sustainability with improved performance.

Keywords: *Asphalt Plant, Waste Reuse, Low Noise Pavement.*

1. INTRODUCTION

The LIFE SILENT project represents a significant endeavor to advance the development of sustainable, low-noise pavements for urban environments. This research focuses on the integration of recycled materials and innovative additives into asphalt mixtures, aiming at both addressing environmental concerns and enhancing pavement performance. The experimental project revealed a series of technical and operational challenges in adapting traditional asphalt production processes to accommodate these novel materials. Specifically, the introduction of crumb rubber and other additives needs a thorough re-evaluation of mixture design and production parameters. This paper outlines the key challenges encountered during the production processes of asphalts, including material handling, mixture homogeneity, and environmental compliance, and discusses the innovative solutions developed to overcome these obstacles. Ultimately, the insights gained from this project contribute to the broader goal of fostering sustainable urban infrastructure through the adoption of advanced asphalt technologies. This paper is divided into three sections: the first section (Section 2) provides a literature

*Corresponding author: m.diamantini@stradeanas.it

review related to the plants' structure and the obstacles that emerge during the production phase of the asphalts. The second one (Section 3) provides a critical review of the problems encountered with the use of innovative materials. In the last section (Section 4), some conclusions are drawn.

2. LITERATURE REVIEW

One of the goals of the LIFE SILENT project is to design, manufacture, and test new asphalt mixtures. This new mix formulation includes bitumen, coarse aggregate, filler, and additives, such as crumb rubber and fibers. The production of such a mixture is associated with a few potential risks that can occur at any stage of the production process, including the mixing stage within the production facility, which could significantly compromise the expected performance of the mixture. For this reason, it is essential for designers and producers to be aware of the critical issues that may arise in asphalt plants so that they can address them effectively, not only to prevent performance decline but also to avoid project delays and increases in production costs.
An asphalt plant is a facility designed to produce asphalt mixtures and it typically consists of a dryer drum, conveyor belts, cold feed bins, a hot elevator, storage silos (for filler and powder additives), tanks for storing hot bitumen and liquid additives, pumps, pneumatic and screw conveyors, and control systems. The operational process of each asphalt plant necessitates input materials, such as aggregates (e.g., crushed stones, gravel, sand, and filler), bitumen, and other raw materials that are transformed into asphalt concrete at the end of the production process [1].
The coarse aggregates in various sizes and types are previously stored in the hoppers. Filler, additives and bitumen are stored in tanks and silos.
In any Asphalt Plant, based on the recipe, the control system selects the hoppers, and aggregates are properly dried in the Dryer Drum.
There are two main types of asphalt plants: batch or discontinuous and continuous. A batch plant, whose schematic representation is shown in Figure 1, produces asphalt mixtures in discrete batches, making it suitable for small and medium-sized projects. In contrast, a continuous plant, as shown in Figure 2, produces asphalt mixtures without interruption. The key difference between continuous and batch plants lies in their production method. Batch plants produce asphalt in discrete batches, where materials are loaded, and the binder is injected directly into the mixer. This type of machinery offers high control over the mixture quality and allows for frequent changes in the asphalt recipe.

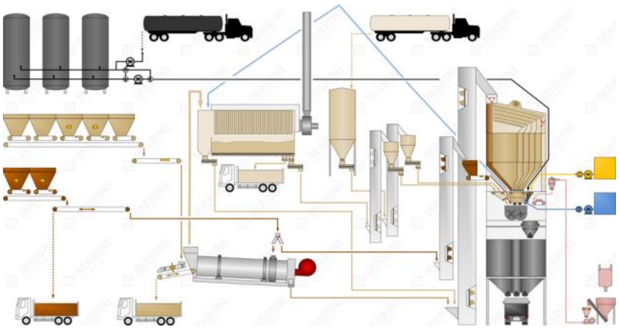

Figure 1. Schematic representation of a Discontinuous Plant (source: Schema di un impianto discontinuo per asfalto - Marini Makina A.Ş.).

In contrast, continuous plants produce asphalt continuously at high rates, without interruption, as the materials are processed within the dryer drum.
The coarse aggregates, bitumen, filler and other aggregates are mixed in the last part of the Dryer Drum.

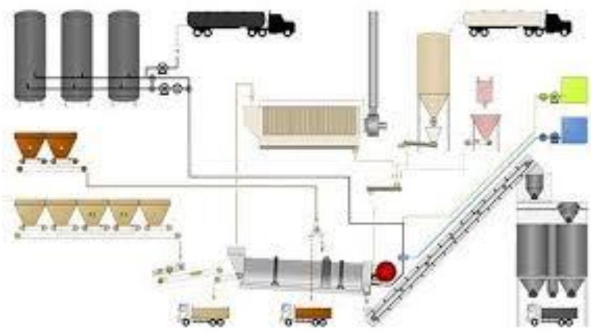

Figure 2. Schematic representation of a Continuous Plant (source: Schema di un impianto discontinuo per asfalto - Marini Makina A.Ş.).

The control systems used in modern facilities are very important because they play an important role in the efficiency of the entire production process: controlling and monitoring the final temperature of the coarse aggregates and asphalt, ensuring the accurate proportioning of materials, controlling the production

rate, and ensuring the safety of the process. The Emission Control Systems (filters, scrubbers, dust collectors) collect and capture dust and any type of emission.
In recent years, to improve the performance of asphalt mixtures, crumb rubber has been added to hot mix asphalt [2]. Crumb rubber, recycled from end-of-life tires (ELTs), has a powder-like consistency and can be incorporated into the mixture using different technologies, including the wet and dry methods. In the wet method, the rubber is added directly to the bitumen, modifying the base binder and resulting in a more resistant and durable asphalt mixture [3].
On the other hand, with the dry method, crumb rubber is added directly to the asphalt mixture during production at the asphalt plant.
One of the main goals of the LIFE SILENT project is to develop a new sustainable, eco-friendly bituminous conglomerate and to improve its durability by preventing fractures and increasing load distribution, mechanical properties and shear resistance. A key part of this project is the design and testing of a new asphalt formulation incorporating fibers derived from waste materials, such as recycled cardboard. These materials are properly treated. The chemical treatment of the fibers makes them suitable for mixing with bitumen to produce the bituminous conglomerate and enables the formation of strong bonds between the fibers [4]. Furthermore, to reduce energy consumption and improve environmental performance, special chemical additives will be used to help maintain the fluidity of bitumen at lower temperatures [5][6][7][8][9].

3. PROBLEMS ENCOUNTERED

Any commercial asphalt plant utilizing innovative materials such as crumb rubber and fibers is facing adjustment challenges. Some of the difficulties related to the use of ELTs, fibers, and additives were addressed within the LIFE SILENT project. This project developed a mixture containing these elements, in addition to the standard asphalt constituents, to be produced using the dry method at a traditional discontinuous asphalt plant.
The introduction of rubber powder and other innovative components into the mixer represents a significant challenge, as traditional plants were not specifically designed for these materials. This is due to the following characteristics of these materials:

- Crumb rubber and fibers are low-density (<<1g/cm^3), are made of low-cost waste materials, and have a powder-like consistency.
- There is a number of liquid additives that were used.

During the production of asphalt, additives and fibers must be inserted into the mixer at different times to prevent them from reacting exclusively with each other. Different methods were investigated for liquid additives, including 1) the use of a dedicated line composed of tank, pipeline, and pump. 2) the use of the existing bitumen line, combining additives and bitumen.
As mentioned above, ELTs and treated fibers, characterized by a powdery consistency, could create problems in the asphalt plant.
The problems that could arise include the following:

- The materials could compact inside their respective feed pipes and create blockages that would reduce or block their regular flow.
- Given their consistency, they might not flow when discharged from the special weighing device into the mixer.

One solution that could be applied for addressing these issues is to form the powder materials into pellets. The palletization process, although offering advantages in terms of handling and dosing powdery materials such as ELTs and fibers, can present several disadvantages from the economic and chemical points of view, implying a new experimental campaign in the laboratory. The traditional palletization process often involves moistening the material to facilitate pellet formation; however, this process could be incompatible with the characteristics of fibers. Consequently, a palletization method for fibers that does not require the addition of moisture could be investigated. Collaboration with the plant owner is crucial to ensure that the developed solutions are practical and applicable to the real-world context, with the aim of overcoming the limitations of palletization methods, which can involve additional costs and operational complexities. The introduction of powder-like materials, using manual or automated feeding systems without compressed air, represents a potential solution, for example, using biodegradable bags.
Another important, eco-friendly and cost-effective advantage of the LIFE SILENT mixture could be linked to lower mixing temperatures (WMA). Lowering the

mixture temperature involves lowering the heating temperature of coarse aggregates, one of the most energy-intensive steps in asphalt production (cf. ANAS RUFAS project) and results in a reduction of emissions from the asphalt plant's chimney and a decrease in perceived bad odors.
The last parameter that requires control is the mixing time, owing to the quantity of components in the bitumen conglomerate mixture, to achieve homogeneous asphalt. Mixing time is defined as the duration needed to thoroughly blend the heated aggregates, bitumen, and any added additives within the asphalt plant's mixer.
The mixing time must be appropriate for the specific asphalt mix being prepared. An insufficient mixing time will result in a non-homogeneous final product, while excessive mixing can lead to asphalt overheating and significantly reduced product quality.
The WMA developed in the LIFE SILENT project, as previously detailed, incorporates rubber powder and fibers in addition to hot aggregates, filler, and modified bitumen. Achieving a uniform distribution of these various elements within the mixture has fundamental importance. The rubber powder must not clump or concentrate in localized areas, and the fibers must be distributed homogeneously, as they are essential for enhancing the mechanical properties of the asphalt.

4. CONCLUSION AND OUTLOOKS

The LIFE SILENT project has the aim of demonstrating the feasibility and potential of producing innovative, low-noise asphalt mixtures utilizing recycled materials and advanced additives. However, the experimental phase highlighted several critical challenges that must be addressed for successful large-scale implementation. The need for precise material handling, particularly with powder-like substances and reactive chemicals necessitates the development of tailored production methodologies. Furthermore, optimizing mixing parameters, such as temperature and time, is essential to ensure mixture homogeneity and environmental compliance.
The exploration of alternative palletization techniques and manual feeding systems, as well as the adoption of warm mix asphalt (WMA) technologies, has shown promise in mitigating these challenges. By documenting these findings and the solutions developed, this research provides valuable guidance for future projects aiming to integrate sustainable practices into asphalt production. The successful application of these technologies holds the potential to significantly reduce the environmental impact of urban pavements while enhancing their performance and longevity.

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