Street furniture with high resistance to marine environment and aesthetic finish

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1 Introduction

The Spanish coastline, with an extensión of some 8 000 km [1], with approximately 5 000 km on the mainland and the rest on islands, is home to 36.5% urbanization, characterized by the presence of promenades that facilitate access to the beach [1]. However, urban furniture, such as benches, face challenges in this aggressive environment: those made of wood swell due to humidity, requiring frequent treatments that eliminate anti-vandalism protection; while those made of concrete suffer cryptoefflorescence and cracks due to the porosity and corrosion of steel.

Faced with these limitations, a new urban furniture proposal arises that uses self-compacting concrete with recycled tire fibers, offering mechanical strength without reinforcement, resistance to chloride attack, and crack-free aesthetic finish thanks to additive manufacturing techniques, at a lower economic and environmental cost than traditional fiber-reinforced ultra-high-strength concretes.

2 Methods

The development of this work can be divided into 5 different activities:

The first 4 Activities that make up this work will be developed successively, given their dependence. Activity 5 considers the management of this work, both economic and technical.

ACTIVITY 1 will start with the design and development of the new working concrete, concrete based on UHPFRCs with better environmental value and aesthetic characteristics than the same. After its achievement, the mold manufacturing process necessary to obtain the expected aesthetic characteristics of the furniture pieces will be defined, establishing the

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manufacturing methodology, the material to be used and the thickness of the walls as a result of ACTIVITY 2.

ACTIVITY 3 contemplates the development of 3 molds to elaborate the prototypes and the execution of 12 pieces of furniture, 4 of each type, evaluating the result obtained in the same.

ACTIVITY 4 consists of the design of a new accelerated chloride affection test, which would allow to know the long-term behavior of different elements exposed to marine environments in a shorter time, thus verifying the correct condition of the work pieces after their exposure to different environments and their suitability for their location on the waterfront.

Finally, ACTIVITY 5 will be focused on technical and administrative management, as well as quality control and risk assessment during the work.

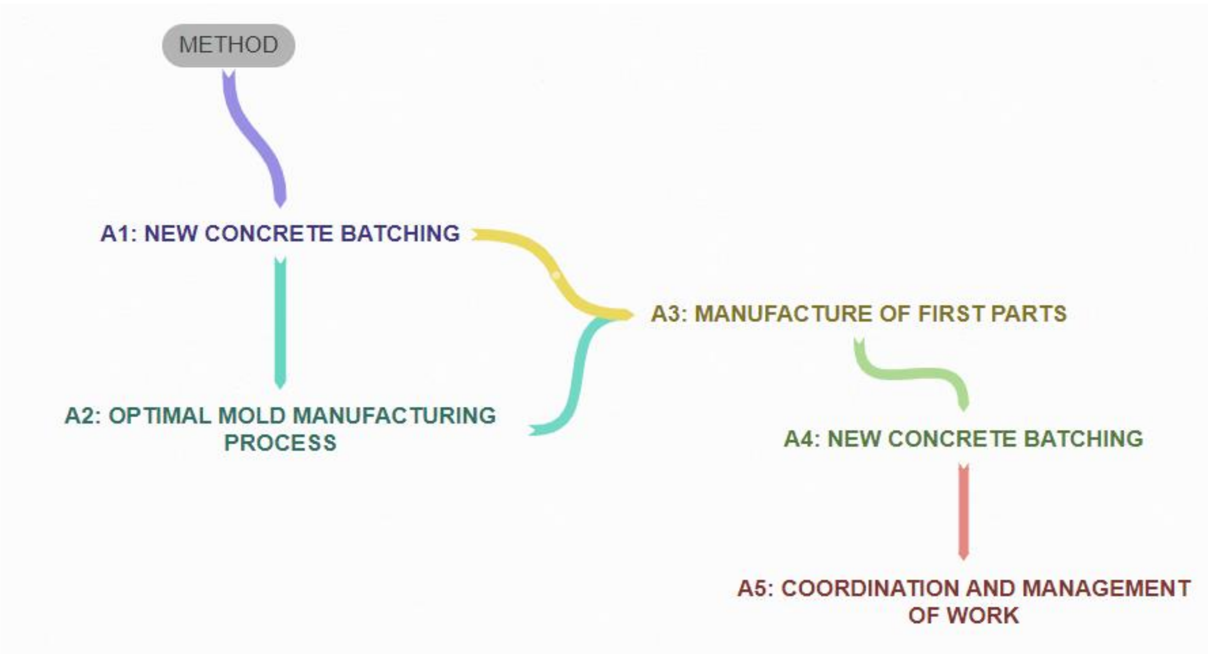

Figure 1: Scheme of Activities. Source: Own elaboration

3 Results

Concrete, composed of cement, water, aggregates and chemical admixtures, is widely used in construction because of its strength and versatility. Cement acts as a binder, water allows setting, aggregates provide volume and strength, and admixtures improve specific properties. Concrete manufacturing involves mixing these components, pouring the mixture into molds and allowing it to set.

Concrete structures must comply with the *Código Estructural [2]*, which establishes safety and durability requirementss based on exposure to aggressive agents such as moisture, corrosion and chemicals. Exposure levels vary from dry environments to highly corrosive coastal areas.

To improve durability, proper dosing of concrete is essential, selecting the precise proportions of components to ensure strength and compactness. The correct batching and selection of materials will guarantee the longevity and resistance of the concrete structures.

The water/cement ratio (W/C) in concrete is very important because it influences the hydration reaction of the cement, which allows the mix to harden and become strong. A high W/C ratio makes concrete easier to work with, but can decrease its strength and increase the possibility of cracking. A low W/C ratio produces a stronger, more durable concrete, but can make it more difficult to handle. Controlling the W/C according to design specifications and environmental conditions is essential for concrete quality and durability.

The strength of concrete depends on the level of saturation : too much water weakens the concrete, while not enough water hinders proper setting. The correct dosage of the components, including the amount of water, cement, aggregates and admixtures, is vital to obtain high quality concrete. Superplasticizing admixtures reduce the amount of water required, improving the workability and strength of concrete.

Tests of mixures with different W/C ratios, quantities of admixtures and fine aggregates (limestone filler) show that these factors influence the density, setting time and strength of concrete. Adding filler improves the workability, cohesion, and strength of concrete, and controlling the proportions is decisive to avoid negative effects.

The Taguchi table method helps to optimize concrete batching through a design of experiments that identifies the optimal combination of variables. In laboratories, standard specimens allow reliable testing to evaluate the mechanical properties of concrete, adequately representing the conditions of a real structure.

The following table shows the Taguchi L8 design (2^7) (orthogonal array). L8 means 8 runs. 2^7 means 7 factors with 2 levels each. If the full factorial design were used, it would have $2^7 = 128$ runs. The L8 arrangement (2^7) requires only 8 runs, a fraction of the full factorial design. This arrangement is orthogonal ; the factor levels are weighted equally throughout the design. The columns of the table represent the control factors, the row of the table represent the runs (combination of factor levels), and each cell of the table represents the factor level for that run [3].

Tabla 1: Example of a Taguchi table. Source: [3]

	A	B	C	D	E	F	G
1	1	1	1	1	1	1	1
2	1	1	1	2	2	2	2
3	1	2	2	1	1	2	2
4	1	2	2	2	2	1	1
5	2	1	2	1	2	1	2
6	2	1	2	2	1	2	1
7	2	2	1	1	2	2	1
8	2	2	1	2	1	1	2

4 Conclusions

In conclusion, the Spanish coast presents a high percentage of urbanization, with urban furniture such as benches facing challenges due to the aggressive environment. In view of this, a proposal for urban furniture using self-compacting concrete with recycled tire fibers arises, offering mechanical strength without reinforcement, corrosion resistance and aesthetic finish without cracks.

This work is divided into five activities, from the design of the new concrete to the management of the work. To improve the durability of the concrete, precise component dosages must be selected, such as the water/cement ratio and the use of superplastic admixtures and fine aggregates. Optimizing these variables through methods such as the Taguchi table and laboratory testing can ensure the quality and strength of concrete in harsh coastal environments.

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