ACTION 6 – UPSCALING PROCESS AND LIFE CYCLED ANALYSIS

ACTION 6.1. Industrialization and feasibility report

1. INTRODUCTION

This document contains a description of the industrialization process for the manufacture of new barriers prototype nº 2, as well as the legal requirements needed for its placing on the market due to its condition of safety item, subject to compliance of the assigned CE Marking for construction products (Directive 89/106/CE). In addition, an economic study of these barriers is also included.

2. OBJECTIVE

This action aims to study de industrialization process to manufacture the New Jersey barriers prototype nº 2, in addition to the economic analysis and the needed requirements setting for the placing on the market of the new barriers.

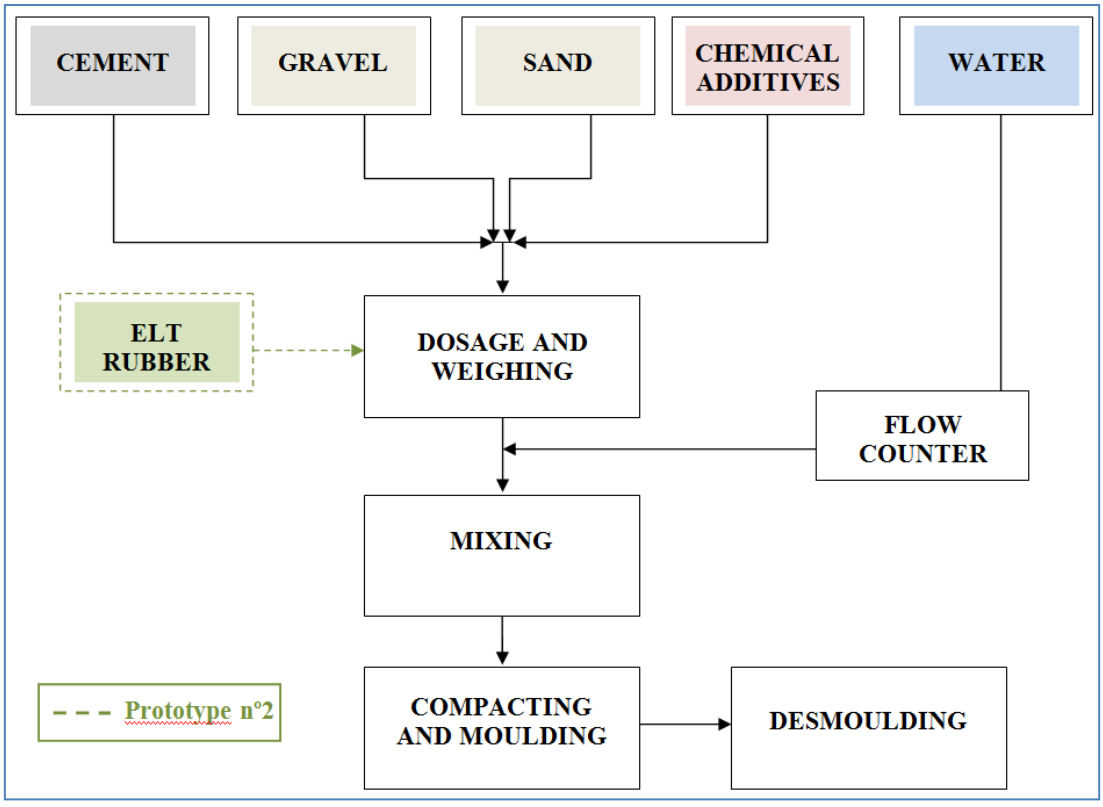
3. INDUSTRIALIZATION OF THE MANUFACTURING PROCESS (PROTOTYPE Nº 2)

As above mentioned, SIGNUS has selected a company that currently manufactures conventional New Jersey barriers to outsource the services of manufacturing the test samples for the early trials, as well as the manufacturing of the barriers modules for the validation test (crash test) and the implementation in a real highway. The fact of working with a company that counts with a barrier manufacturing industrial process has allowed the industrial implementation of the manufacturing process of rubber-concrete barriers to be a much easier task.

The conventional industrial process was considered as the reference and the differences when manufacturing rubber-concrete barriers have been identified.

The manufacturing process at an industrial level of the prototype nº 2 is equivalent to the one used to manufacture conventional concrete barriers with slight differences resulting from the formulation settings. The main difference between prototype nº 2 and conventional New Jersey barrier is the concrete formulation, since the ELT rubber is added to replace a percentage of the aggregates.

The following diagram describes the industrial process of manufacturing a conventional concrete barrier and the differences against the manufacturing of prototype nº 2 by adding the ELT rubber through dosage and weighing equipment equal to the ones used for the cement, aggregates and other chemical additives. The rest of the formula just requires dosage adjustments for the mix to behave properly:



Hereafter it is described the manufacturing process of conventional concrete New Jersey barrier, and also are identified the modifications to perform in the industrial processes of the manufacturing plant at the present time, with the aim to adapt them to the manufacturing of prototype nº 2 developed by SIGNUS with the addition of the ELT rubber.

The following stages in the manufacturing process are mainly differentiated:

- Dosage and weighing
- Mixing
- Compacting and moulding
- Demoulding

Phase 1. Dosage and weighing

In the previous laboratory test it was obtained the formulation of the rubber-concrete in addition to the quantities in the mass of each one of the components by volume unit (m^3), the type of cement, the type and maximum size of aggregates as well as their particle size distribution, the maximum size of the ELT rubber, the water/cement ratio, and if the addition of chemical additives is necessary or not.

To guarantee the reproduction of the exact formulation defined in the laboratory, but at an industrial level, the barrier manufacturing plants count with dosage and weighing equipment to mix each one of the components in the specified ratio. All these processes are fully automated.

In the event that the addition of any aggregate to the concrete is needed, the plant counts on supplementary storage silos with their corresponding weighing systems. In this regard, this equipment may be used to the addition of the ELT rubber in the concrete without additional cost. The ELT rubber, being a granular material, adapts to a certain kind of silo since the particles do not stick to the silo´s walls or among each other.

On the other hand, when the silo needs to be cleaned to store other type of material, the cleaning process simply involves the application of pressurized air or water.

Therefore, the dosage and weighing of the ELT rubber in a concrete-barrier manufacturing industrial plant can be achieved without problems through the conventional systems used for the rest of materials, being technically feasible.

Depending on the amount of material aggregated in each mixing, the weighing and addition of materials may be performed manually. The industrial manufacturing times allow that an addition of this kind does not involve any delay regarding the conventional process.

Phase 2. Mixing

The mixing consists in combining the different materials that constitute the concrete to obtain a mix of uniform property. The mixing makes possible for the mix composed by the cement and water to completely encircle the aggregates, and to fulfill its conglomerate function. Just the same as the dosage and weighing stage, the mixing stage is automated, and the control of both stages can be carried out by a single qualified person, independently of the rubber use or not.

In the rubber-concrete industrial manufacturing tests, no differences were noted when adding the rubber into the mixer together with the rest of concrete components. The fresh concrete obtained looked good and its workability is the proper one. Therefore, this stage of the process is neither affected when producing rubber-concrete prototype nº 2 industrially.

Phase 3. Compacting and moulding

Once concluded the mixing process, the rubber-concrete is transferred into the mould until it is fully filled.

Figure 1. Dumping of the concrete in the mould

Similarly to the previous stages, the compacting and moulding of the rubber-concrete did not register any further complications thanks to the correct formulation, with the addition of superplasticisers. Therefore, the acquisition or modification of the equipment used is not required.

Phase 4. Demoulding

The compression strength resistance of a precast concrete barrier must be at least of 35 MPa. According to the Regulation UNE EN 13369:2004 “Common rules for precast concrete products”, the barrier may be demoulded when its compression resistance reaches at least a 60% of the final value (35 MPa), that is, when it reaches at least 21 MPa.

One of the most important manufacturing parameters is the time of the demoulding process, since it affects the production and therefore the costs.

The addition of rubber to the concrete barriers does not have a significant influence in the manufacturing times, and therefore its production capacity is not decreased. This influences the financial feasibility positively, as it will be further explained on the subsection 5 of the present document.

New Jersey barrier (prototype nº 2)

4. REQUIREMENTS TO PLACE ON THE MARKET THE NEW JERSEY BARRIERS: CE MARKING

The precast concrete safety barriers used as vehicle restraint system on roads must comply with the ZA annex of the standard UNE-EN 1317-5:2008+A1, regarding the conformity assessment and CE Marking, with the aim to satisfy the legal and regulatory requirements applicable, besides exposing other general aspects the manufacturer needs to know.

The CE Marking is a symbol indicating that the product complies with the essential requirements of the Directives applicable, and that guarantee that the manufacturer fulfilled all the appropriate actions to guarantee its compliance.

As the CE Marking in the safety barriers is mandatory in order to place the product on the market, in the process of searching the barrier manufacturing companies at the beginning of the project, one of the selection criteria was that the company that would produce the prototype nº 2, was already selling barriers with CE Marking, so it would count with the experience and the internal manufacturing control this kind of certificate requires.

The CE Marking is performed by the manufacturer or the person responsible for the product placement on the market, based in the certification system indicated in the regulations or in the document corresponding to its product. These systems are enforced according to the product characteristics, being the system 4 the least demanding, (self-certification) and 1+ the most demanding one.

With respect to precast concrete products with structural character, the usual system that affects them is 2+. However with barriers, due to the additional safety character requested from them regarding other structural precast, the system to follow might be a more demanding one, that is number 1.

In this certification system, the manufacturer must dispose of an internal production control system, and to carry out additional trials of samples during the manufacturing of the barriers.

Likewise, the manufacturer is compelled to file his internal production control system in the factory to a third party (Notified Body), to be certified based in some initial trial, an initial inspection of the factory and even the internal production control in factory and surveillance, evaluation, continual approval of the production control in the factory via periodic yearly inspections. In the special case of restraint systems, it must also verify the validity of the thickness of concrete cover and the assessment of the crash test reports carried out.

Certification System 1	Tasks
MANUFACTURER	- Initial type-test of the product (crash test) - Factory production control (FPC) - Additional trials of samples taken during the manufacturing of the barriers
NOTIFIED BODY	- Initial inspection of the factory and the FPC - Surveillance, evaluation, continual approval of the FPC - Durability (verification of the thickness of concrete cover) - Evaluation of existing crash test reports

Completing all these tasks, finally the manufacturer fulfill the "Declaration of Conformity" for the product and later the Notified Body issues a "Conformity certification of the factory production control".

- **Regulation UNE-EN 1317-5:2008 +A1**

The European Standard UNE-EN 1317-5 defines the requirements for the evaluation of conformity of the following vehicle restraint systems: safety barriers, crash cushions, end terminals, transitions and mix vehicle and pedestrian systems. That is, the Standard settles the CE Marking conditions.

The ZA Annex defines the behavior requirements for safety barriers.

Characteristics		Chapters of requirements of the standard that applies	Observations
Behavior facing impact	Containment Level	3.2. de la EN 1317-2	Class N1…H4
	Impact Severity	3.3 de la EN 1317-2	Class A, B
	Working width	3.4 de la EN 1317-2	Meters (class)
	Dynamic Deflection	3.4. de la EN 1317-2	Meters
Durability		4.3. de la EN 1317-5	

5. ECONOMIC STUDY

In this subsection it is financially examined the cost of the new barrier (prototype nº 2). On this purpose, is taken as reference the real setting of a conventional safety barriers manufacturing company, whose financial cost is contrasted and consistent with the market in Spain. The differences to consider when manufacturing the prototype nº 2 barriers have also been identified.

Costs summary

In the table below it is summarized how the diverse costs may influence the economic feasibility of prototype nº 2.

Type of cost	Costs	Manufacturing and Transport of prototype nº 2
Fixed Costs	Staff	⟷
	General	⟷
Variable Costs	Materials	↑
	Energy consumption	⟷
	Transport	↓↓↓↓↓

Legend				
↑ < 5%	↑↑ <10%	↑↑↑ <15%	↑↑↑↑ <20%	↑↑↑↑↑ <25%

If solely the materials and transport costs are taken into account, given that these are the ones that differ, the result is that prototype nº 2 proves to be more cost-effective than the conventional New Jersey barrier.

6. CONCLUSIONS.

- The rubber-concrete barrier manufacturing process has been carried out successfully in an industrial plant. The differences in the production process are irrelevant regarding a conventional barrier, and they do not involve any change or modification in the conventional industrial equipment.

- The rubber-concrete formulation defined in the laboratory has behaved industrially exactly the same way as in the laboratory, without problems arising with the concrete´s workability.

- To avoid difficulties in the industrialization process and the placing on the market of the products, SIGNUS has worked with a barrier manufacturer at industrial level.

- After economically studying the manufacturing of prototype nº 2 and having contrasted it with a conventional safety barrier manufacturing real settling; it has been determined that there are no considerable differences in the main concepts that may influence their price.

- The weight of the barrier of prototype nº2 has been verified to have decreased regarding a conventional barrier. The weight, geometry and dimensions of the new barrier involve a saving in the transport costs.

- The economic analysis denotes that the costs corresponding to prototype nº 2 may reach a lower level to the one of a conventional barrier, given that the transport cost are significantly lower and return the possible increase in materials when introducing the ELT rubber.

7. BIBLIOGRAPHY

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