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paper Chain

Implementation of Circular Case 1
D5.2 - February (M33)

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WP5, Task 5.1

New Market Niches For the Pulp and Paper Industry Waste based on Circular Economy Approaches

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0. Executive summary

Deliverable D5.2 "Implementation of Circular Case 1" aims to demonstrate the activities and preliminary conclusions of the pilot implementation, obtained for the 2 pilots (asphalt application and the concrete structure). This report belongs to WP5 and this aims to build and validate at industrial scale the replacement of natural fillers and aggregates by fly ash, green liquor dregs, and grits in both asphalt mixtures and precast concrete.

The Portuguese circular case (CC1) covered incorporation of PPI wastes in two types of construction materials. In circular case CC1a the filler in pre-cast concrete is completely replaced by lime ash. In circular case CC1b the fine aggregate in bituminous mixtures is partially replaced by dregs and grits.

Regarding CC1a, two different concrete compositions due to the different concrete strength class for columns and beams (C20/25 and C30/37 class, respectively) were used as reference and were the target for the natural filler replacement by the PPI waste (lime ash). Production time of columns and beams was the same for filler concrete and lime ash concrete formulations. As foreseen, the 3 porticos, plus the reference one, were built and finished in time and now stand for ongoing monitoring processes. Until now the compared characteristics reveal an equal behaviour.

Regarding CC1B, the reference bituminous mixture formulation was a AC14 road surface class type where the natural filler and fine aggregate were partially replaced by dregs and grits PPI wastes. The incorporation went very well according to programming except the bituminous mixture applications that suffered a small delay due to atmospheric conditions (unforeseen rain), but it was solved in the following week (March 6). This did not have any consequence on the related following WPs. The several formulations of bituminous mixtures, the reference plus the ones containing grits and dregs, were applied in a 250 m road surface as planned and now stand for long term monitoring (technical and environmental features control). Production features and time was not changed by the wastes incorporation. Licencing was a long process that delayed the expected program but in the end everything was done as planned.

Keywords

Real Scale	Demonstrator	Implementation	Asphalt	
Precast concrete	Lime ash	Green liquor dregs	Grits	

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Abbreviations and acronyms:

AC: asphalt concrete

PPI: Pulp and Paper Industry

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1. Introduction

The University of Aveiro and Navigator / Raiz have been working together during the last 20 years for the evaluation and conversion of these sub products into new raw materials. Navigator has carried out several R&D and pilot projects with academic and industrial partners, but dregs, grits and lime ash are the most difficult wastes to valorise. Previous research on these PPI wastes conducted by NVG and University of Aveiro (UAVR) has shown that it is possible to incorporate them in several construction materials replacing aggregates or fillers without hindering the final products technical performance.

This could result in relevant environmental and economic benefits due to the reduction of landfill disposal as well as the savings in natural raw materials. Moreover, the centre region of Portugal has a strong manufacturing sector for construction products, creating a good potential for industrial symbiosis. This demo can be a good example to show and replicate for other sectors the added value of valorisation of wastes as alternative raw materials.

The Portuguese circular case cover two types of construction materials. In circular case CC1a the filler in pre-cast concrete is completely replaced by lime ash. In circular case CC1b the fine aggregate in bituminous mixtures is partial replaced by dregs and grits.

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1.1. Objectives

The project aims at demonstrating the technical, environmental and economic feasibility of using some wastes from pulp and paper industries (PPI) in different sectors (construction, mining and chemical). In Portugal, the project will be tested and evaluated using three wastes (green liquor dregs, grits and lime ash) as secondary raw materials for the construction sector. The Portuguese circular case demonstrator involve 2 pilots (CC!a and CC1b) related to the application of wastes in the production of precast concrete and bituminous mixtures for road construction, respectively.

1.2. Pilot´s location

Two pilots have been built in Aveiro. The pilot that incorporates lime ash in precast concrete is located at SPRAL facilities in 119 Lagoa Junco Street, Ilhavo, while the 2nd pilot that incorporates green liquor dregs and grits in an asphalt pavement is located at Navigator company facilities in Celulose Bombeiros road, Cacia Aveiro.

The precast concrete pilot (CC1a) involved the production and assembly of four porticos (columns and beams of an industrial pavilion). The asphalt pavement (CC1b) pilot was made involving the application of a new surface layer at a 250 m road section.

FIGURE 1. GENERAL LOCATION OF THE 2 PILOTS.

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TABLE 1. SUMMARY OF THE PILOTS´ CHARACTERISTICS.

Cicular case	Location	Wastes
1a)	119 Lagoa Junco road, Ilhavo, Portugal	Lime ash
1b)	Celulose Bombeiros road, Cacia, Portugal.	Green liquor dregs and grits

1.3. Portuguese Regulation for precast concrete and asphalt pavements

1.3.1. Circular case 1a): Precast concrete

Precast concrete sector shows a range product for using in different application fields. This sector produces different kind of products, such as linear structural elements (beams, and columns) or foundation elements.

The circular case 1a) pretends to assemble and evaluate four precast concrete porticos. Each portico has a beam and two columns, as can be seen in Figure 2.

FIGURE 2. EXAMPLE OF AN GROUP OF CONCRETE PORTICOS (BEAMS AND COLUMN).

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The elements of Figure 2 are covered by EN 13225 standard, where are indicated the requirements, the basic criteria and evaluation of conformity. Products, that are produced according to this standard, are utilized for construction of the structures of buildings and other civil engineering works, except bridges,

This pilot needs two different concrete compositions due to the different concrete strength class for columns and beams. Columns are reinforced concrete products although the beams are reinforced and prestressed concrete products. These products have a minimum of concrete compressive strength class. Columns concrete class must be equal or higher than C20/25 and beams needs a C30/37 class, respectively.

1.3.2. Circular case 1b) Asphalt pavement

Pavement of a road can be divided into flexible, rigid and semi-rigid pavement. The rigid pavement has hydraulic mixture in surface layer, although the flexible pavement (CC1b) has some bituminous mixture in many layers. These layers can divide into base, binder, regulating and **surface** and are made of bituminous mixtures.

shows the typical structure of a pavement.

TABLE 2. EXAMPLE OF A FLEXIBLE PAVEMENT.

Surface layer(bituminous mixture)
Regulating layer (bituminous mixture)
Base (unbound agreggate)
Sub-base (unbound agreggate)
Subgrade (soil)

In Portugal, there is a public organization (Infrastructures of Portugal) that published different guidebooks for roadworks. There are guidebooks for quality control, earthworks, drainage, pavement, auxiliary works, signalling and safety equipment, integrated artworks and special artworks, tunnels and others. For each type of work, the guidebook defines the material characteristics, constructive methods, categories and measurement criteria

Minimum Requirements of aggregates and bituminous mixtures are specified on pavement guidebook of material characteristics. This guide contains requirements for cold

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and hot bituminous mixture. Table 1 identifies hot bituminous mixture for different layers (base, binder, regulating and surface) of a flexible pavement.

TABLE 3. BITUMINOUS MIXTURE DESIGNATIONS FOR EACH PAVEMENT LAYER

Layer	*Desigantion*	*D (mm)*
Base	AC 32 base (MB)	32
	AC 20 base (Mb)	20
	AC 20 base (MBAM)	20
Binder	AC 20 bin (MB)	20
	AC 20 bin (MBD)	20
	AC 16 bin (MBAM)	16
	AC 14 bin (BB)	14
	AC 4 bin (AB)	4
Regulating	AC 20 reg	20
	AC 20 reg (MBD)	20
	AC 14 reg (BB)	14
	AC 4 reg (AB)	20
Surface	AC14 surf (BB)	14
	AC14 surf (BBr)	14
	AC10 surf (mBBr)	10

Bituminous mixtures (Table 3) of asphalt concrete (AC) are according to EN 13108-1: "Bituminous mixtures – Material specifications – Part 1: Asphalt concrete".

The materials characteristics guidebook defines a particle range size, aggregates and bituminous mixture requirements for each layer. Table 4 presents the particles range size requirements for an AC14.

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The CC1b pilot consists of applying a surface layer on 250 m of road. This layer will have an **AC 14 surface** (BB) and its particle size must be according to defined in Table 4 and Figure 3.

TABLE 4. PARTICLE SIZE RANGE/ SPINDLE REQUIREMENTS FOR AN AC 14 SURFACE.

Sieve Size (mm)	*Accumulated passing (%)*
20	100
14	90-100
10	67-77
4	40-52
2	25-40
0.5	11-19
0.125	6-10
0.063	5-8

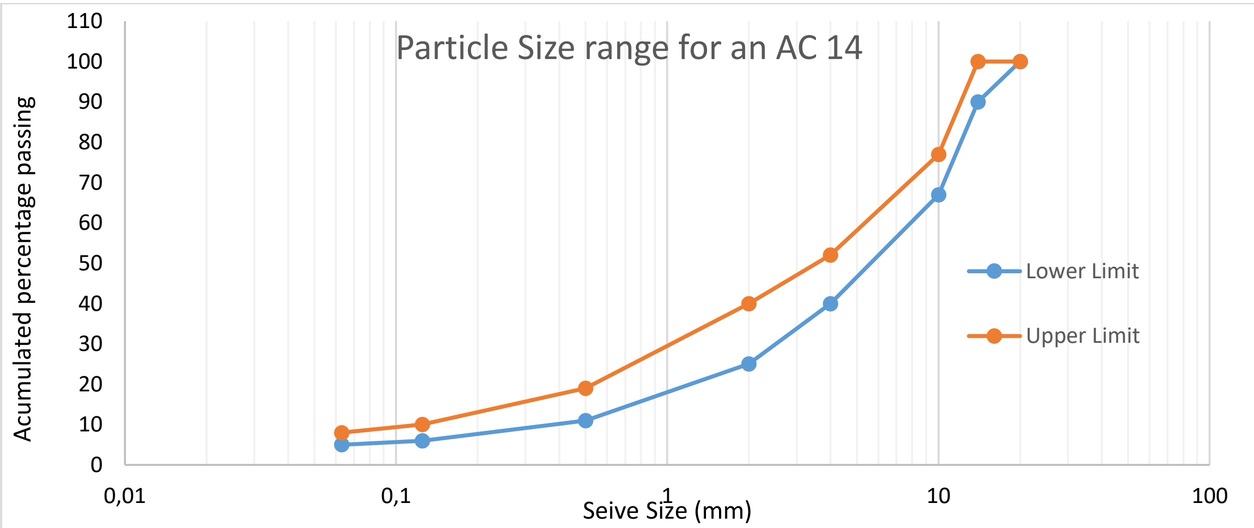

FIGURE 3. PARTICLE SIZE RANGE FOR AN AC 14 SURFACE.

The mixture aggregates (fine and coarse aggregate) have minimum requirements to comply, as can be seen in Table 5. Filler that it is used in bituminous mixture also have minimum requirements to comply, like the particle size range, water content (≤1%), harmful fines (MBF 10) and voids of dry compacted filer (Ridgen) (U28/38). Filler particle range size

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must present 100% of particles passing the 2 mm sieve, 85% to 100% on 0.125 mm sieve and 70% to 100% on 0.063 mm sieve.

TABLE 5. REQUIREMENTS OF AGGREGATES FOR AN AC 14 SURFACE.

Requeriments	*Unit*	*Standard*	*AC 14 surface (BB)*
Fines Quality	g/kg	NP EN 933-9	MB_{10}, if acumated passing for 0.063 mm is betewen 3 and 10%
			MB_{10} for filer
Particle shape of coarse agreggates - Flakiness index	-	NP EN 933-5	FL_{20}
Percentage of crushed and broken surfaces in coarse aggregates particles	%	NP EN 933-5	$C_{100/0}$
Resistance to fragmentation of coarse gareggates, Los Angels coefficient	%	NP EN 1097-2, section 5	LA_{20} or LA_{30} for granitoid rock
Resitance to wear of coarse agreggate, micro-Deval coefficeint	%	NP EN 1097-1	$M_{DE}15$
Particle density	Mg/m^3	NP EN 1097-6	To declare
Water absorption	%	NP EN 1097-6	≤ 1
Bulk density	Mg/m^3	NP EN 1097-3	To declare
Polish stone value of coarse aggreggate for surface layer	%	NP EN 1097-8	$P_{SV}50$
Durability against freeze-thaw (Water absorption value as a screening test for freeze-thaw resistance)	%	NP EN 1097-6 and NP EN 1367-2	If WA >2%, the value of the magnesium suçphate must be framed in MS_{35}
Resistance to thermal shock	%	NP EN 1367-5 and NP EN 1097-5, section 5	To delcare
Affinity between aggregate and bitumen	-	EN 12697-11	To declare
Sonnenbrand of basalt	%	NPEN 1367-3 and NP EN 1097-2, section 5	Loss of mass after boiling ≤ 1 and SB_{LA} ≤ 8

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Table 6 shows the properties of an AC 14 surface.

Table 6. Bituminous mixture requirements for an AC14 surface.

Properties	Limits	Units
Number of blows to each side	75	-
Stability	7.5 to 15	kN
Flow	2 to 4	mm
Marslhall quotient	≥ 2	mm
Conserved strenght	≥ 80	%
Air voids content (VM)	3 to 5	%
Voids content in the mineral aggregate	≥ 14	%
Minimium Binder Content	≥ 2	%

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2. Circular case 1a: Precast concrete

This pilot has four porticos (columns and beams) for an extension of an industrial pavilion. One portico was produced with two Spral reference concrete formulations, one composition for columns and other composition for beams. Three porticos were also produced with same formulations, but the natural filler was full replaced by lime ash.

2.1. Location

The portico elements were built in December and January and it took place in 119 Lagoa Junco road, Ilhavo (Figure 4) and consisted on production of eight columns and four beams for four porticos of a pavilion. The porticos will be assembled at Spral plant.

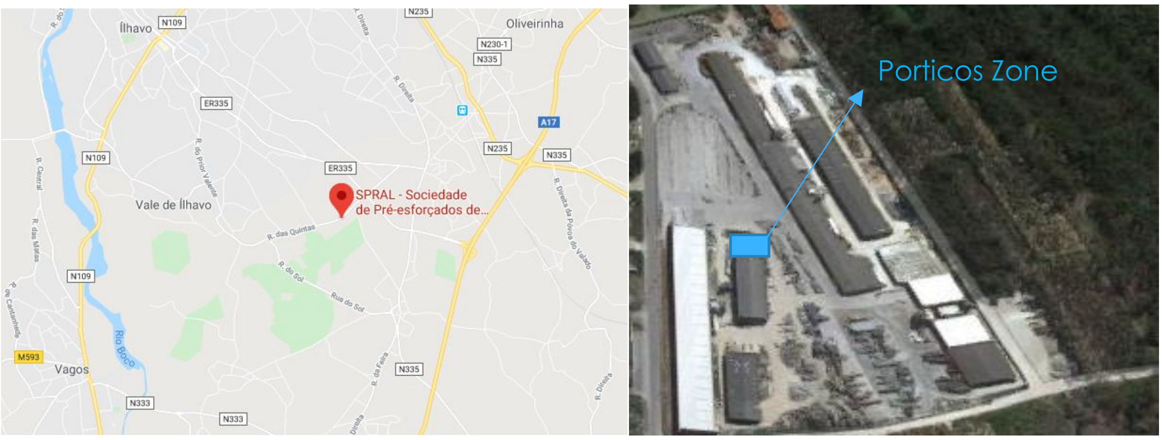

FIGURE 4. INSTALLATION LOCAL OF PORTICOS.

2.2. Pilot design

Lime ash sent from Navigator has needed no pre-treatment. Lime ash composition and particle size distribution are very similar to the filler used in SPRAL concrete production. The only restriction was the transportation from the Navigator plant to SPRAL. Lime ash particle size are very fine and due to that the transportation need to be in a tanker truck that then sends the material to a silo through which the material enters directly in concrete production. Transport must be carried out by a waste manager.

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Figure 5 shows the operations diagram of circular case 1A). In the CC1a pilot as the lime ash quantity was lower, transportation was made in a closed container and manually introduced into concrete production.

FIGURE 5. OPERATIONS DIAGRAM OF CIRCULAR CASE 1A).

Circular case 1a) needed an environmental licence to implement the demonstrator. This case was inserted in the simplified regime (article 32 of decree law nº 178/2006). After, the process was submitted **online** in a specific platform (SILIAMB) according to Ordinance nº. 399/2015, Nov 5 which defines the instruction elements for licensing process, such as location and wastes amounts.

The licensing process had a schedule to get the Single Environmental Title (TUA), as can be seen in Table 7.

TABLE 7. SCHEDULE TO GET THE SINGLE ENVIRONMENTAL TITLE (TUA) FOR PRECAST CONCRETE

Data	Action
April 11th	Submission of licensing on SILIAMB (Online platform for requiring the license)
April 16th	Payment of single collection document (SCD)
May 3rd	Request of additional elements by licensing body
May 15th	Reply and submission of additional elements
May 15th	Return on analysis of the proces
July 19th	Issuing of the licenses, named as Unique Environmental Title (TUA)
December 6th	Communication of beginning of the intial activity.
January 3rd	Application for extension of the licence.
February 5th	Payment of extension of the licence.

The licensing process code of circular case 1a) is PL20190405000538, and it generated a Single Environmental Title with code TUA20190719000282. This TUA identifies the general conditions and rules that the the demosntrator must comply.

During the license period, CCDR and APA were the bodies we have to report (communications, emails, inspection, title request and wastes register (MIRR). They will

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receive an audit application to verify the wastes management operations implementation.

Fillers to be used in the construction sector, namely for the PCC production, must have a moisture content close to zero and at least 70 and 85 % of particles below 63 and 125 µm, respectively. This information must be according to EN 12620:2002 (aggregates for concrete). Thus, filler is transported in tanker truck from the producer to a user silo.

Lime ash moisture content is less 1% and its particle size is similar to filler. It is also stored in a silo at the Navigator plant. Thus, lime ash doesn´t need any treatment and it can transport directly between Navigator and SPRAL.

The pilot includes construction of the structure of an industrial pavilion, and it has four assembled porticos (columns and beams of variable section). One is the reference concrete portico containing natural filler, although other porticos contain the waste (lime ash) replacing the natural filler on its composition. Lime ash replaced 100% of natural filler.

The characteristics of each column are:

- Section: 0.5*0.4 m
- Height: 10.25m
- Concrete: C30/37

The characteristics of each variable section beam are:

- Section at the support: 0.4*0.56 m
- Section at ½ span half: 0.4*1.4 m
- Length: 19.80 m
- Length of ½ span half: 9.90m
- Concrete: C40/45

The 4 concrete porticos are distanced five meters a part. Figure 6 and Figure 7 show the construction localization of the industrial pavilion at SPRAL's installation and disposition of the porticos, respectively.

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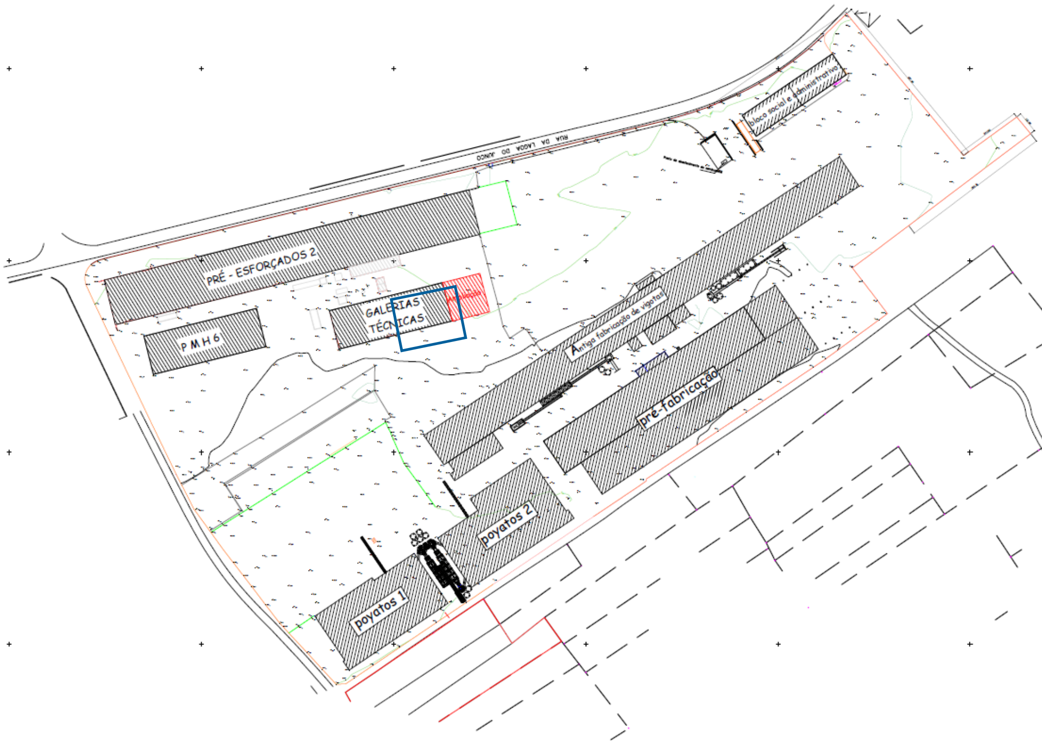

FIGURE 6. LOCATION OF INDUSTRIAL PAVILION (BLUE SQUARE).

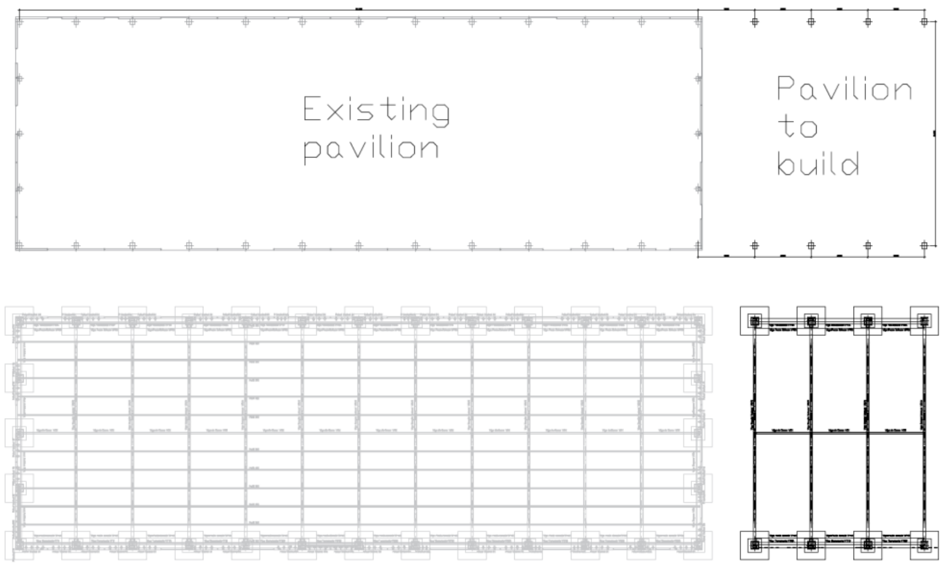

FIGURE 7. DISPOSITION OF THE 4 PORTICOS AT SPRAL FACTORY.

Figure 8 and Figure 9 show the portico cross section of industrial pavilion and variable beam section, respectively.

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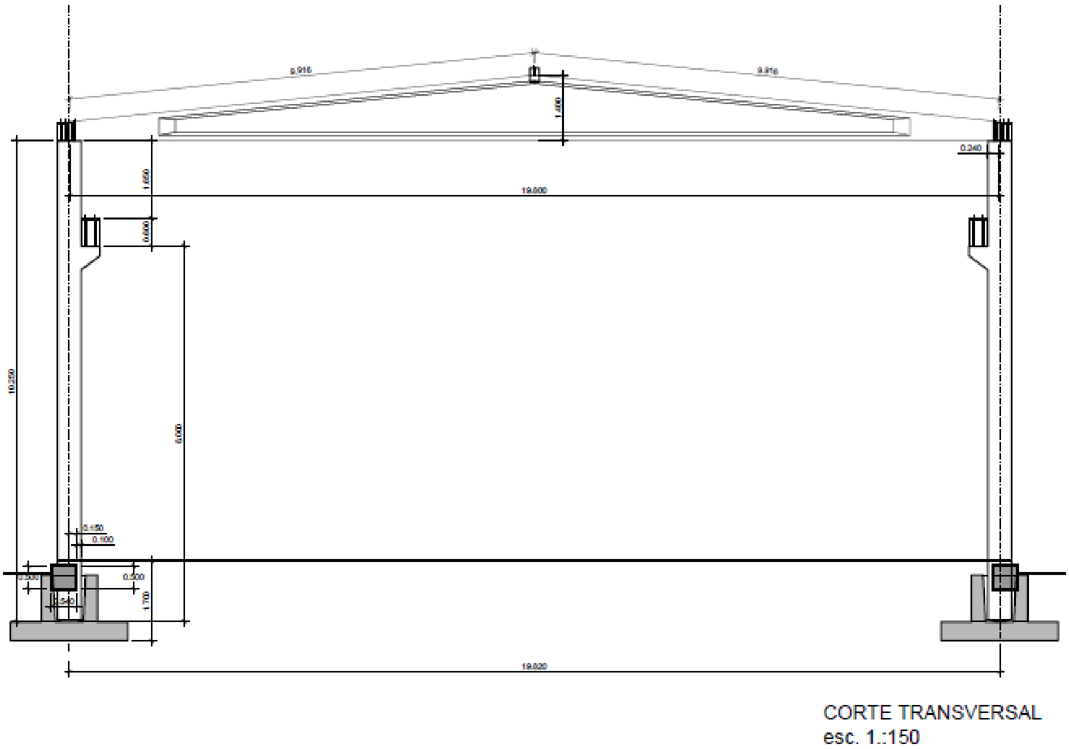
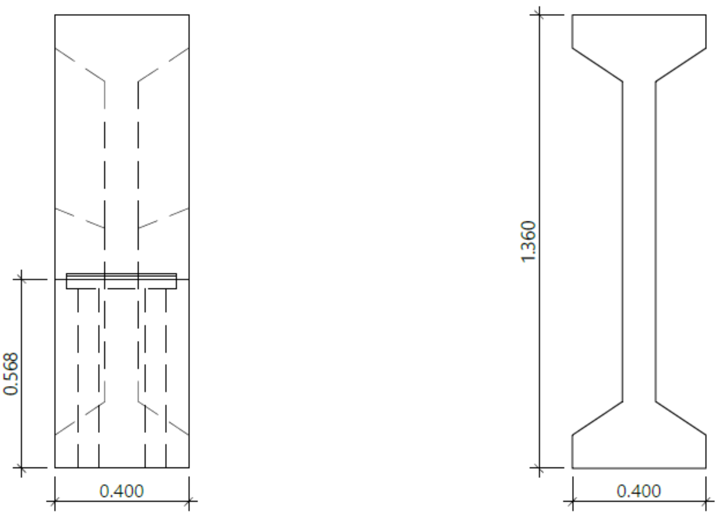


FIGURE 8. PORTICO CROSS SECTION OF INDUSTRIAL PAVILION.



A) B)

FIGURE 9. VARIABLE SECTION BEAM: A) SECTION AT THE SUPPORT; B) SECTION AT ½ SPAN HALF

Porticos have slight different compositions for columns and beams as it is possible to see in Table 8.

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TABLE 8. FORMULATION OF THE COLUMN AND BEAM.

Raw material	Column	Beam
Coarse aggregate (12/25mm)	28.9 (%)	28.9 (%)
Coarse aggregate (8/12mm)	16.6 (%)	16.6 (%)
Coarse sand	24.7 (%)	24.6 (%)
Fine sand	14.5 (%)	14.4 (%)
Cement	10.81(%)	13.1(%)
Filler	4.6 (%)	2.4(%)
Superplasticizer	1.34 % of cement	1.38% of cement
water/ cement ratio W/C	0.43	0.43

Each column and beam will consume 2.1m^3 and 5.0m^3 of precast concrete, respectively.

2.3. Pilot execution

Lime ash transport from Navigator to SPRAL industrial site was made in a CDW type container (Fig. 10)

FIGURE 10. LIME CONTAINER IN SPRAL.

The lime ash was manually placed on a conveyor belt that transports it directly to the concrete mixture (Fig 11).

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FIGURE 11. LIME ASH TRANSPORTATION TO CONCRETE MIXTURE.

Figure 11 shows the reinforcement for precast concrete column inside the mould.

FIGURE 12. PRECAST CONCRETE COLUMN FORM AND REINFORCEMENT

.

Concrete discharge into column form is presented in Figure 13.

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FIGURE 13. CONCRETE DISCHARGE.

During the discharge process, concrete samples were prepared. This samples will be used in monitorization process (Fig. 14)

FIGURE 14. COLLECTED SAMPLES FOR MONITORING.

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FIGURE 15. FRESH CONCRETE COLUMN DRYING AND HARDENING IN FORM.

After placing the concrete in the mould, it is necessary to wait for it dry and harden sufficiently (consequent shrinkage) to remove the column from the mould without causing damage (Fig. 15).

FIGURE 16. COLUMNS AS FINAL PRODUCT.

Figure 16 shows the columns after removed from form.

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FIGURE 17. BEAM IRON REINFORCED.

Figure 17 presents iron reinforcement for a beam.

Internal strain and thermal sensors were installed for future monitoring in the concrete beam upper part (filler beam and lime ash beam concrete). The sensors are installed at 5 m and 9.70m of the support section. Figure 18 shows the installed internal thermal sensor.

FIGURE 18. BEAM INTERNAL THERMAL SENSOR.

Three days after removal of the beam from the mould it was prestressed. Figure 19 show some of Paperchain partners verification visit near a final beam.

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FIGURE 19. FINAL BEAM.

Land preparation for the four-portico installation. Heavy machinery is required due to the dimensions of the elements (Fig.20).

FIGURE 20. LAND PREPARATION.

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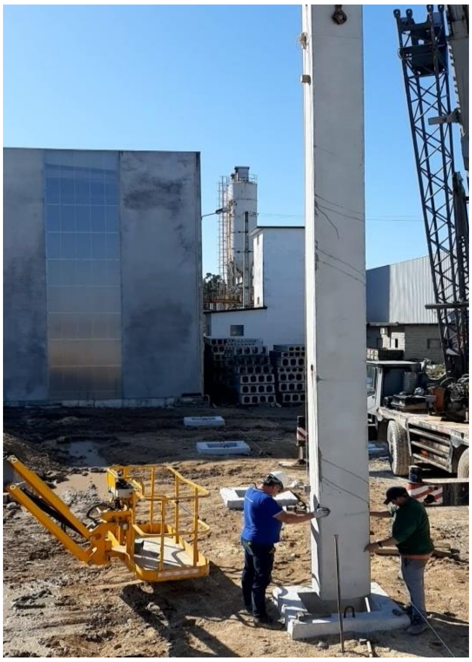
In next figure it is possible to see the concrete bases for the columns. In Figure 21, on right side, the columns bases are 5 m apart.

FIGURE 21. BASE FOR COLUMN.

When columns were inside base, concrete is added to ensure adhesion and immobility (Fig. 22)



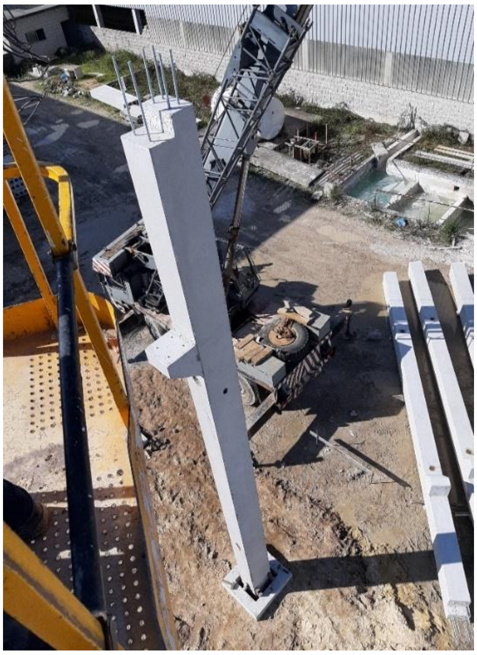


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Figure 22. columns placement.

Eight columns are placed it´s time to start the beams placement (Fig. 23)

Figure 23. Beams placement.

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FIGURE 24. FINAL PORTICOS.

Figure 24 right side shows the final four porticos.

Figure 25 shows the external sensors in beams. These sensors measure the air temperature and the strain of concrete.

Other type of external sensors will the relative humidity (RH) and temperature in the air.

FIGURE 25. BEAM EXTERNAL THERMAL, SHRINKAGE AND FLOW SENSORS.

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2.4. Efficiency parameters

Production time was set as the efficiency parameter and, although the lime ash was manually introduced in concrete mixture, the production time of columns and beams was the same for filler concrete and lime ash concrete.

2.5. Monitoring

2.5.1. Environmental monitoring.

. pH will be measured in columns for filler concrete and lime ash concrete.
. Control of leachate results for all compositions.
. Control of soluble salts for all compositions.

2.5.2. Technical monitoring.

In situ

. Beams internal thermal sensors will measure the strain and temperature inside concrete.
. Beams sensors to measure relative humidity (RH) and temperature in the air.
. Beams sensors to measure the strain of concrete.
. Elasticity modulus (PUNDIT) will be measure on columns for both compositions (filler and lime ash formulations).
. Schmidt Hammer will be used to measure the superficial strength of columns for both compositions.

In Laboratory

Using the samples from SPRAL production:
. Compressive strength at different cure times will be measured for all compositions.
. Density, capillarity and water absorption will be measured to all compositions.
. Elasticity modulus (PUNDIT) will be measured to all compositions.

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3. Circular case 1b: Road pavement

This pilot concerns the use of a bituminous mixture of type AC 14 on a road surface layer.

This surface layer road was divided into four sections; a standard bituminous mixture section, a section where the fine aggregates were partial replaced by grits, a section where the fine aggregates were partial replaced by dregs and a section where the fine aggregates were partial replaced by grits and dregs.

3.1. Location

The road surface layer was prepared to be built in February but unexpected rains have delayed the process at Navigator plant (Figure 26).

Figure 26. Local to apply the bituminous mixture.

3.2. Pilot design

Navigator wastes for bituminous mixture (dregs and grits) need a pre-treatment. These wastes needs a licenced waste manager (Dilumex) to transport and make the pre-treatment. Dilumex makes wastes pre-treatment which consists of drying and sieving (particles smaller than ten millimetres). After pre-treatment, waste manager transports the treated wastes to a bituminous central.

The bituminous mixture central produces the standard bituminous mixture and waste-based bituminous mixture (dregs, grits). The different bituminous mixtures are transported to the Navigator where the different bituminous mixture are applied in different sections.

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Figure 27 shows the operations diagram of circular case 1b).

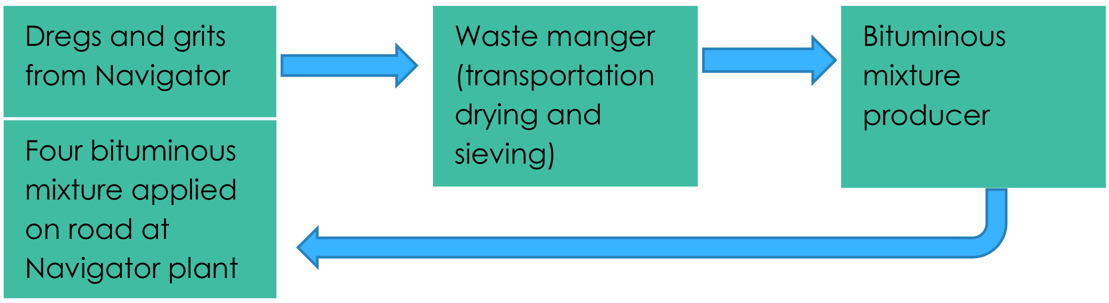

FIGURE 27. OPERATIONS DIAGRAM OF CIRCULAR CASE 1B).

Circular case 1b needed an environmental licence to implement the demonstrator. This case was inserted in the simplified regime (article 32 of decree law n° 178/2006). After, the process was submitted **online** in a specific platform (SILIAMB) according to Ordinance nº. 399/2015, Nov 5 which defines the instruction elements for licensing process, such as location and wastes amounts.

The licensing process had a schedule to get the Single Environmental Title (TUA), as can be seen in Table 9.

TABLE 9. SCHEDULE TO GET THE SINGLE ENVIRONMENTAL TITLE (TUA) FOR PRECAST CONCRETE

Data	Action
April 11th	Submission of licensing on SILIAMB (Online platform for requiring the license)
April 16th	Payment of single collection document (SCD)
May 3rd	Request of additional elements by licensing body
May 15th	Reply and submission of additional elements
May 15th	Return on analysis of the proces
July 19th	Issuing of the licenses, named as Unique Environmental Title (TUA)
December 6th	Communication of beginning of the intial activity.
January 3rd	Application for extension of the licence.
February 5th	Payment of extension of the licence.

The licensing process code of circular case 1a) is PL20190405000563, and it generated a Single Environmental Title with code TUA20190719000281. This TUA identifies the general conditions and rules that the the demosntrator must comply.

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During the license period, CCDR and APA are the bodies we have to report (communications, emails, inspection, title request and wastes register (MIRR). They will receive an audit application to verify the wastes management operations implementation.

Navigator tissue factory already has the road base layers. The different bituminous mixtures are applied as surface layer. The section to be paved has a total area of 2800 m^2. The new layer will be divided into four sections (standard, dregs, grits and dregs plus grits), as can be seen in Figure 28. Different colours identify the type of bituminous mixture:

- green is reference bituminous mixture (bm)
- rose is bm with grits
- light blue is bm with dregs
- dark blue is bm with grits and dregs.

The last section with dregs and grits mixed together will not be produced since the central had no conditions to prepare this combination of wastes together. This is feasible and the impact of both wastes is going to be monitored anyway.

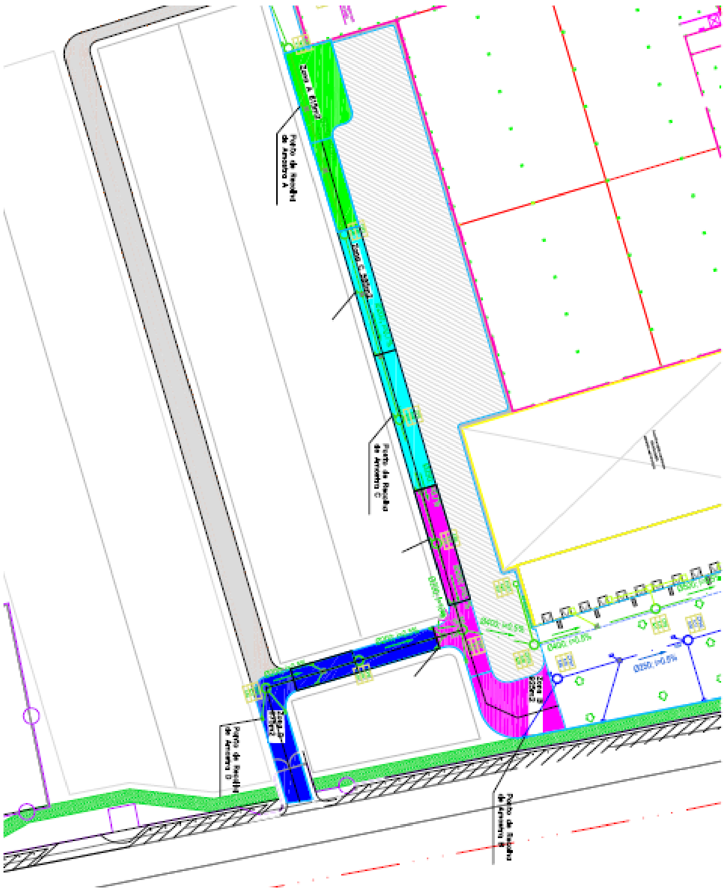

FIGURE 28. WORK PLANT.

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Reference bituminous mixture of type AC 14 surface has granite coarse aggregate (6/14mm), calcareous and granite crushed aggregate (0/5mm), recuperated filler and bitumen 50/70.

3.3. Pilot execution

Dregs and grits needed a pre-treatment (drying and sieving). This process was made by waste manager (Dilumex) in its installation with a solar oven to dry wastes. Figure 29 shows grits and dregs at the drying process.

FIGURE 29. GRITS AND DREGS DURING DRYING PROCESS.

Figure 30 shows the equipment to make dregs sieving and sieve size upper limit was 10mm.

FIGURE 30. SIEVING EQUIPMENT.

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Both wastes were cradled in big bags and transported on a semi-trailer, as can be seen in figure 31.

FIGURE 31. DREGS AND GRITS FREIGHT.

Bituminous central has a line to incorporate recycled aggregates. These aggregates don´t pass through the drying drum and they go directly to mixer. In addition, the central have only a recycling feeder which limits the fact of making a 2-component mixture introduction (dregs plus grits). Figure 32 shows a part of asphalt mixing plant.

a) b)

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c)

D)

FIGURE 32. ASPHALT MIXING PLANT: A) RECYCLING FEEDER; B) RECYCLING LINE; C) AFTER DRYING DRUM; D) MIXER

Both wastes (dregs and grits) are discharged in a recycling feeder, but the central produced only three bituminous mixture of the pilot design (reference, dregs and grits containing mixtures). Thus, the central doesn´t have conditions to produce the bituminous mixture with dregs and grits. All bituminous mixtures were transported in a tipper truck from central to Navigator plant, as shown in Figure 33.

FIGURE 33. DISCHARGED BITUMINOUS MIXTURE TO A TIPPER TRUCK.

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Figure 34 shows the road base where applied bituminous mixtures were planned.

FIGURE 34. ROAD TO APPLY BITUMINOUS MIXTURES.

Surface layer will be applied in the beginning of March once rain stops after the underlying layer has suffered cold planning to create adhesion (skid) between layers.

MEGAVIA used a road paver and a roller to apply the different bituminous mixtures. Each bituminous mixture (reference, dregs and grits) were applied in the first week of March as soon as rain stopped. First section to apply was the reference mixture, then second section to apply was mixture with dregs. Last section to apply was mixture with grits.

3.4. Efficiency parameters

Production time was also set here as the efficiency parameter, considering the process starting at the bituminous mixture central plant and then the deposition of the different asphalt layers containing the dregs and grits compared to the reference (no-wastes) bituminous mixture, the production time of bituminous mixture was the same with or without wastes.

3.5. Monitoring

3.5.1. Environmental monitoring.

The drainage system has gullies that are connected to the residual rainwater system that is connected to the Salgueiral ditch. The rainwater is going to be drained of the surface layer and then proceeds to the gullies to be collected. The main water source is rainwater and the samples will be collected on rainy days or the road will be sprinkled by a truck and then water is collected.

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For each stretch there is at least one gully to collect a water sample. The samples will be analysed in a laboratory according to decree law 183/2009. The Law decree 183/2009 defines the limit values for establishing the type waste (inert, non-dangerous or dangerous), Table 12.
A rain water sample that is not in contact with pavement will be collected. This sample will evaluate water composition and it applies as a reference sample.

3.5.2. Technical monitoring.

The monitoring will be developed in situ and in the laboratory. In situ, there will be collected cores to evaluate different properties, such as thickness, voids, adhesion, bulk density, binder content and Marshal test (stability and flow). The collected cores are after tested in the laboratory. Lab samples of the different bituminous mixture to be applied will be made with the mixtures during application. Enough samples will be collected and made to perform all the indicated tests during 1 year (0, 3, 6 9- and 12-months testing).

4. Conclusions

The main conclusion of the Circular cases demonstration ocurring in Portugal is that they will be ready for the monitoring during WP5 final stage. The pilots went very well according to expectations and programming except the bituminous mixture applications that suffered a small delay due to atmospheric conditions (unforeseen rain) that will be solved in a week. This will not have anty consequence on the nesxt WPs of the project since results have already been collected and given and others will come from the monitoring satge until the end of 2020.

All samples for monitoring were collected and some more will be collected during the monitoring period in-situ.

All data needed for WP6, WP7 and WP8 will be given to these WPs leaders concerning the results and operation of this WP5 work.

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5. References

Internal sources

Paperchain Deliverables:
1. Deliverable 2.1: Baseline Reporte – PPI waste streams valorisation potential.
2. Deliverable 8.1: Report on transition assessment for circular economy processes.
3. Deliverable 4.1: Report on solutions feasibility and constraints.
4. Deliverable 2.2: Quality assurance procedures for the circular model demos.

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