WP 2.7 Tool no.13

Quality Assessment Tool for the use of CDW as recycled aggregates in water and sewage infrastructures.

WP2 CDW/Soil
CityLoops Seville Cluster

ACKNOWLEDGEMENTS

I would like to express my very great appreciation to Dr Javier Tavira Díaz for his valuable and constructive work during the planning and development of this paper. His willingness to give his time so generously has been very much appreciated.

I also would like to express my deep gratitude to the team, Estrella Ruiz Blancas, Patricia Fernandez Rodriguez, Borja Rocha Martín, and Mónica Fábregas Boja, for their patient guidance, enthusiastic encouragement, advice and assistance in keeping the progress of this work.

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1. INTRODUCTION.

Construction Waste Demolition (CDW) are substances or objects generated from construction and demolition sites that need to be disposal in some other place. Most of these wastes are inert or non-hazardous materials, its main components are concrete, bricks, aggregates, asphalt and in some cases excavation soil. These CDW may have impurities such as gypsum, wood, paper, glass and plastics, organic wastes, packing rests and parts of the existing constructions such as doors and windows are also CDW.

Legislation approved by the public authorities enhance in first place the minimization and reuse of CDW, in second place the production of recycled aggregates through the use of authorized treatment plants, in third place the valorisation of those wastes that are not suitable for recycling, it must be always considered as a last option its elimination in authorized landfill.

According to the Waste Framework Directive (2008/98/EC) of the European Union and the EU Parliament, by 2020 a minimum of 70% of construction and demolition wastes (CDW) should be recovered (European Parliament and Council of the European Union, 2008).

Recycled rate of CDW in Spain is between 30-40%, it is still low and far from the 70% threshold. In Spain CDW are being treated inappropriately. Project designers and construction managers do not consider in most cases the recycled aggregates of CDW as valid materials for new constructions, the main reason for this is besides the lack of legal regulations, it is the scarce knowledge of recycled aggregates and its use as granular layers in pavements and as recycled sand in pipelines.

World aggregate production increased from 21 billion tons in 2007 to 40 billion tons in 2014 (Tam et al., 2018). Natural aggregate extraction harms the environment, and the mineral resource depletion and waste generated per cubic metre of natural aggregate obtained was over 2400 kg (Marinković et al., 2010). Total aggregate production on the European Union (EU) was 2660 million tons, and the total waste generation from construction was 868 million tons in 2014 (European Union, 2017)

Recycled aggregates (RA) production can play an important role in this objective because it can help to reduce the production of natural aggregates (NA) and avoid CDW from filling lands. According to the European National Aggregates Association, Spain produced 96 million tons of NA in 2015, while only one million tons of RA were produced and sold in commercial plants (European Aggregates Association, 2016) from the 20 million tons of CDW. Recycled mixed aggregates (RMA) and recycled concrete aggregates (RCA) production were 80% and 12%, respectively, of the total amount of CDW generated in Spain (CEDEX, 2010). The substitution of NA by RA in water and sewage infrastructures is a plausible solution to meet the 70% recovery rate for CDW (European Parliament and Council of the European Union, 2008).

This guide aims to provide a best practice guide in the use of recycled aggregates in water and sewage infrastructures.

1.1. STUDY OF THE STATE OF THE ART

CDW that are received in treatment plants can be classified into three types depending on their nature and composition:

Concrete blocks: this type of CDW is the most studied and applied to obtain high-quality recycled aggregates (RAs).

Mixed and clean CDW: this waste contains mainly concrete, masonry, asphalts, etc.

Mixed demolition debris: this type is usually associated with a poor selection in origin, due to this a specific pre-treatment for the elimination of some components has to be adopted.

Brito and Agrela (De Brito and Agrela, 2018), presented a proposal for the classification of six types of RA attending to their main constituents.

Type of RA proposed	Composition				Minimum density (SSD)	Water absorption (%)	Los Angeles (%)	Water-soluble sulphate (%)	Proposed applications in road layers
	Rc + Ru (%)	Rb (%)	Ra (%)	Others (%)					
RCA-I	>90	<10	<5	<1	2200	<6	<35	<0.7	Concrete pavement, cement-treated or unbound granular subbases
RCA-II	>85	<15	<10	<3	2100	<8	<37	<0.8	Cement-treated or unbound granular subbases
MRA-I	>70	<30	<10	<5	1900	<8	<40	<0.8	Unbound granular subbases or capping of esplanades
MRA-II	>60	<40	<20	<8	1800	<12	<45	<1.0	Capping of esplanades or subgrades
MRA-III	>40	<60	<30	<15	1650	<15	<50	<1.2	Subgrades and embankments
RAA	<50	<10	>50	<3	2000	<8	<40	<0.8	Unbound granular subbases or capping of esplanades

Figure 1 Classification of RA proposed for international application (De Brito and Agrela, 2018)

RA were used previously in beds and trenches of sewage pipes, Rahman et al. (ref) conducted a study using three different types of fillers; Recycled Concrete Aggregates (RCA), Recycled Mixed Ceramic Aggregates (RMCA) and Recycled Asphalt Aggregates (RAA). The geotechnical properties and leaching results allow the use of RCA and RMCA, the RAA did not meet the Los Angeles wear limit as it was greater than 35.

The fine fraction of Recycled Aggregate is normally used in backfilling and in the bed zone of the pipe, article 510 of the PG-3 (Ministry of Development, 2004) does not allow plasticity in Natural aggregates used in granular bases. In the UK the Manual of Contract Documents for Highway Works (MCHW) (Manual of Contract Documents for Highway Works (MCHW) | Standards for Highways, n.d.) has recommendations for the use of RA in pipe backfilling and bed zones.
Sulphate and Chloride content are the most limiting properties for the use of RA in pipe backfilling and bed zones. Viera et al. carried out two investigations regarding to the use of the fine fraction (maximum size 10mm) of RMA, lab investigations and real scale study results shown that shear resistance and adherence of RA are similar to NA, the leachate study obtained a sulphate content of 3200mg/kg, this value allows the use of this RMA even if there are non-sulphur resistant concretes near the trench.

A catalogue of pavements made with recycled aggregates (CRA) (Public Works Agency of the Regional Government of Andalusia, 2016) was issued on 2016. This catalogue is a pre-normative draft published by the Public Works Agency of the Regional Government of Andalusia (Spain), but its use and implementation are not mandatory right now. This document regulates new uses for RA from CDW, such as cycling pavements, back fill and bedding material in pipes, unpaved rural roads, and structural road layers, establishing the physical-mechanical and chemical properties required for RA for each of these uses of pavement made with recycled aggregates. CRA regulates the physical and chemical properties that RA should comply in order to be used as pipe beds, in case of existence of elements made with cement close to the pipe trench, Chlorides and Sulphate content is limited to 0.1% and 0.5% respectively, in all cases impurities content is limited to 1% and the fine fraction needs to be under 10% (0.063 mm sieve). The fine fraction contains a high proportion of sulphates which comes from cement and mortar making not suitable in this use, however this fine fraction can potentiate puzzolanic reactions (Vegas et al., 2011) moreover with the use of Alkali-activation instead of hydraulic binder higher resistances are obtained according to Bassani et al. (Bassani et al., 2019).

Requirements established for NA as base layers in article 510 of the Spanish specifications PG-3 regulate size distributions, RCA normally meet these requirements but RMA do not, nevertheless this property is not limiting for the use of RMA as it has been proven previously in several experimental sections made by Tavira et al. and Jimenez et al. RA gradation is uniform, this facilitates particle interaction ensuring adherence and higher grade of compaction (Jiménez, 2013). Another factor to be considered in order to achieve a better compaction is to pre-moisten RA. Another limiting property is Los Angeles Test (LAT) for abrasion resistance of RA, RMA have higher values than those prescribed by article 510 of PG3 (LAT<35 for T3 and T4 category of traffic) for its use in granular base layers. Resistance to abrasion in RA is obtained mainly by its NA part while mortar is the less resistant. According to Jimenez (Jiménez, 2013) samples of RA with no more than a 44% of mortar obtains LAA test of under 40%, although some authors such as Barbudo et al. (Barbudo A. et al., 2012) and Vegas et al. (Vegas et al., 2011) consider that the ceramic part deteriorate the abrasion resistance, Jimenez stays that the ceramic fraction is even stronger than the concrete part, this contradiction could be explained because the ceramic part of previous studies had mortar adhered to the bricks.

Usually RA do not have plasticity because they are not mixed with excavation soils. Percentage of crushed particles, flakiness index and sand equivalent are not limiting properties for its use in granular layers of road pavements. According to Jimenez and Vegas et al. (Jiménez, 2013; Vegas et al., 2011) organic matter content over 1% is an usual value in RA and it does not affect in its performance in granular layers of pavements.

The content of compounds that come from sulphides is usually a limiting property for the use of RA, normally RMA exceed the limit of 1% prescribed by the article 510 of the PG3. Vegas et al. (Vegas et al., 2011) studied samples from three treatment plants of the Basque Country, a 3.74% content of soluble salts did not generate any stability problems in the unbound layers. In article 330 of PG3 there is a limit of 1% applied for

soils used in embankment, this limit goes down to 0.2% in granular subbases, these thresholds are too conservative and unfeasible for RA.
The leaching that happens in RA may be a determining factor for its use in granular layers, in case of the existence of foundations near the RA layer and its concretes contains non-sulphur resistant cement, RA leached could cause damage to these structures, the content of sulphates for a material to be consider inert is 6000mg/kg in a percolation test according to the European Union decision (2003/33/EC). Vegas et al. (Vegas et al., 2011) concluded that sulphates should be limited to 4800 mg/kg. Article 510 of PG3 limits SO3 content to 0.5% for granular layers close to foundations made with concrete with non-sulphur resistant cement. The RA Guide of Central Andalusia studied RA stability of samples made with 4-5% SO3, main conclusion from this study is that Sulphur compounds could raise to 1,3% in the absence of elements vulnerable to sulphate attack.

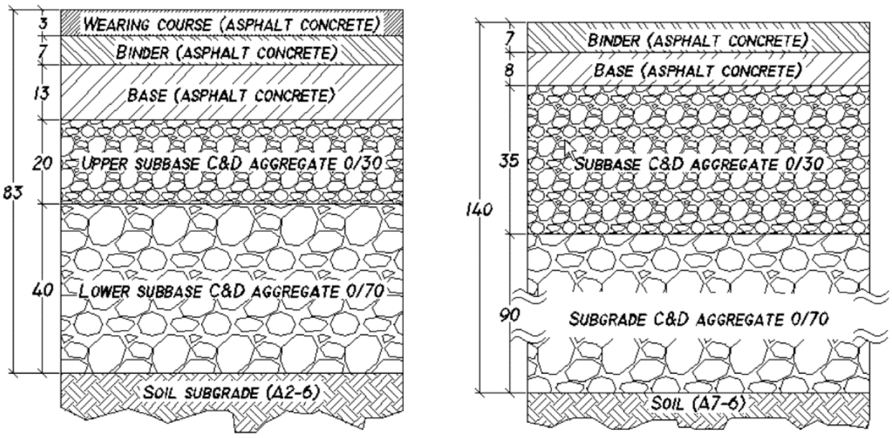
RA have lower densities after compaction than NA, on the other hand optimum moisture is higher. Densities of RMA are more sensible to moisture than RCA. In order to increase the workability of RA is convenient to saturated it with water at least one hour before compaction, this is due to the greater absorption of the RA ((Jiménez, 2013; Tavira et al., 2018b)

Californio Bearing Ratio (CBR) measures the bearing capacity of soils and granular layers, CBR values in aggregates usually meet the following relationship; NA≤RCA≤RMA (Barbudo A. et al., 2012; Jiménez, 2013; Vegas et al., 2011), these slight differences may have their origin in the different mechanical resistance of the ceramic part that compound RMA and RCA. Vegas et al. obtained increases of CBR after 90 days compared to 4 days from 30% to 100% in RA. It can be explained because of the ceramic fine fraction of RA that generates a pozzolanic reaction with the calcium hydroxide present in concrete.

Arm et al. (Arm, 2001) Studied RCA in laboratory three experimental road section a RCA, it was compared with NA obtained from granite crushing. Elastic moduli measured in laboratory of the RCA was over 800 MPa after 25 months. NA moduli did not have increases over time.

Poon et al. (Poon et al., 2006) Determined in laboratory that the fine fraction of RCA, specifically the part bellow 0.15mm and the one between 0.3-0.6mm are the most active, obtaining compressive strengths after seven days of 1.54 and 1.32 MPa respectively. Initially permeability of RCA was higher than NA, however after 7 days, RA permeability decreases and got under NA permeability.

Lancieri et al. (Lancieri et al., 2006) studied two paved experimental road sections built in 1998. RMA composed its granular bases and subbases. On Figure 1 the two paved sections are shown, RMA with a size gradation 0/30mm was used as granular base, MRS with a size gradation 0/70mm was used as granular subbase. Granular base elastic moduli in Road 1 experienced an increase from 235 MPa got to 379 MPa in the 2005 year, meanwhile moduli of granular base of Road 2 kept steady in a mean value of 300 MPa. The increase of RMA of Road 1 can be explained because of the higher mortar content that existed in its constituents, 17% against 13% of Road 2.



Road 1 Road 2

Figure 2 Experimental Road sections (Lancieri et al., 2006)

Jimenez et al. (José Ramón Jiménez et al., 2012) studied a rural unpaved road where RA from selected CDW were used, two RA types were obtained, RCA was made from the foundations wastes of buildings, while a RMA was composed of the aerial structure and partitions of buildings. RCA and RMA exceeded sulphate limits 0.3% - 0.7% respectively. The leaching study obtained a total of 1385mg/l SO4 ions, therefore it would be classified as non-hazardous waste according to Directive 2003/33 / EC. Bearing capacity was similar in both sections, mean deflections obtained with Falling Weight Deflectometer (FWD) gave equivalent moduli of 420 and 489 MPa for section 1 and section 2 respectively. Regarding to International Roughness Index (IRI) performance was worse in the section built with limestone NA.

Jimenez et al. (J. R. Jiménez et al., 2012) built later another experimental section where RA from non-selected CDW were used as granular base, treatment of CDW only consist on a pre-screening and a crushed of the debris with size higher than 40mm, last step consisted on ferro magnetic removal, impurities were removed manually. RMA was used as a granular base with 20 cm of thickness over a NA layer of 25cm. The reference section used a NA layer of 20 cm as granular base. RMA exceeded content limits of article 510 of PG3; gypsum 2.8%, soluble salts 3.0% and soluble sulphates 3.3%. Leaching study obtained a total of 1409 mg/l of SO_4 ions. Therefore, it would be classified as non-hazardous waste according to directive 2003/33/EC. Mean deflections obtained with FWD gave equivalent moduli of 135 MPa and 100 MPa in section 1 and section 2 respectively. Regarding to International Roughness Index (IRI) performance was worse in the section built with NA. A good selection of CDW in origin sharply improves the mechanical performance of RA. IRI of RA layers is better than NA layers, this could be due to the lower resistance of fragmentation of the RA and its capacity to rapidly heal the road surface, which happens to increase its resistance to water exposure. The leachate results showed inert residue values with low SO_4 concentration and even with gypsum concentrations higher than 1.2%.

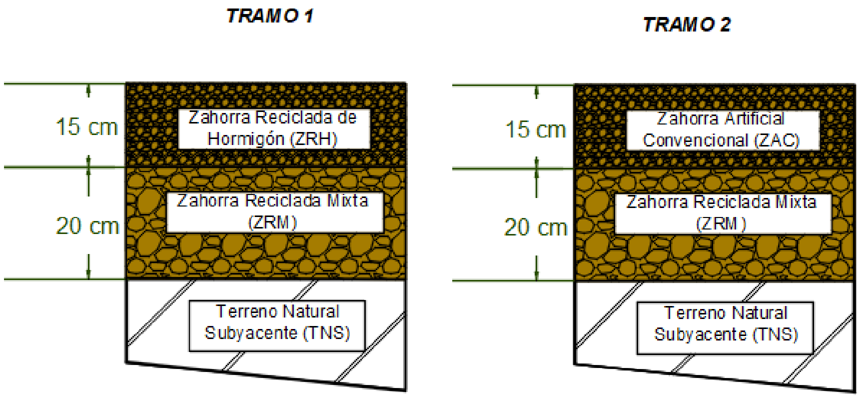


Figure 3 Sections of experimental Unpaved Road built with selected CDW (José Ramón Jiménez et al., 2012)

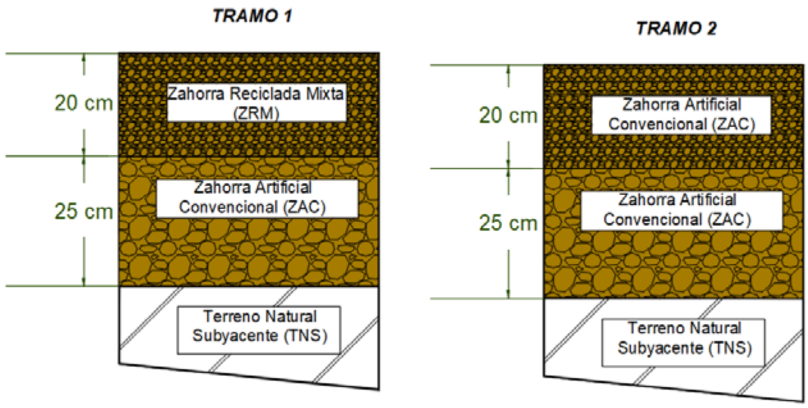


Figure 4 Sections of experimental Unpaved Road built with non-selected CDW (J. R. Jiménez et al., 2012)

Tavira et al. (Tavira et al., 2018b) studied two recycled materials that were produced in a recycling plant located 5 km North of the Experimental Section (ES), Mixed Recycle Soil (MRS-1) used in granular subbases and Recycled Mixed Aggregates (RMA-1) used in both granular bases and subbases. There were laboratory studies to characterize the properties of recycling aggregates. The ES test these materials under real traffic and weather conditions. During its construction, several density, plate load, and falling weight deflectometer tests were performed to determine the bearing capacity of all layers. A laser profiler determined the IRI. After the road was opened to traffic, a follow up of deflections and IRI measurement was performed during the following seven years of the study. Elastic moduli of each layer studied was calculated using Two different methods: back calculation and forward calculation. Low quality recycled mixed aggregates can be used as substitutes for natural aggregates as unbound layers. The mechanical performance and surface roughness values obtained from the experimental road shown an acceptable behaviour. Backcalculation and Forward calculation of moduli shown acceptable values for recycled granular layers. Moduli value for RMAS-1 averaged 349 MPa and MRS-1 averaged 158 MPa, these recycled materials can be used as unbound layers in low volume traffic roads. International Roughness Index (IRI) was similar in the three sections obtaining values under 3 m/km which according to World Bank it corresponds with a new pavement.

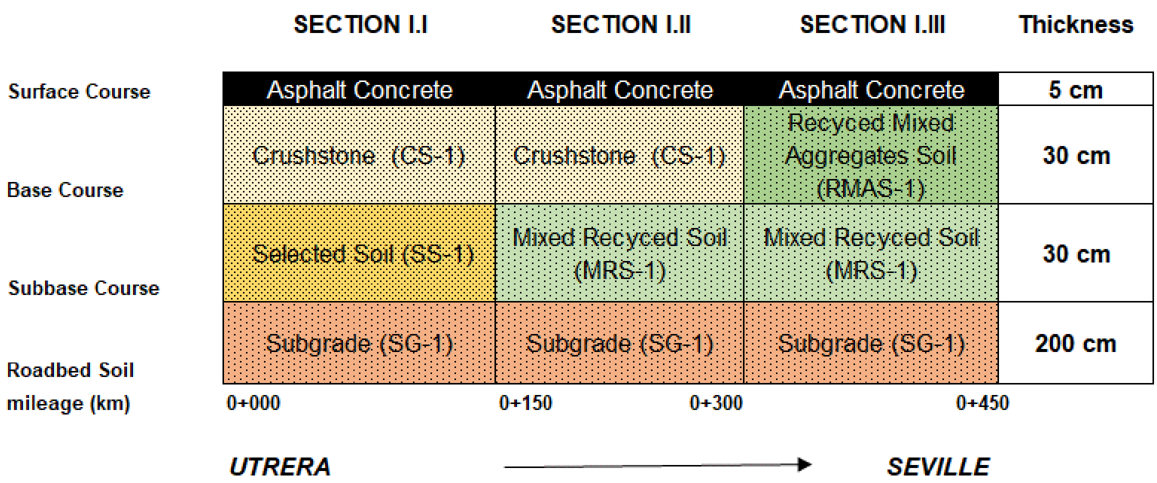


Figure 5 Experimental Road cross sections (Tavira et al., 2018b)

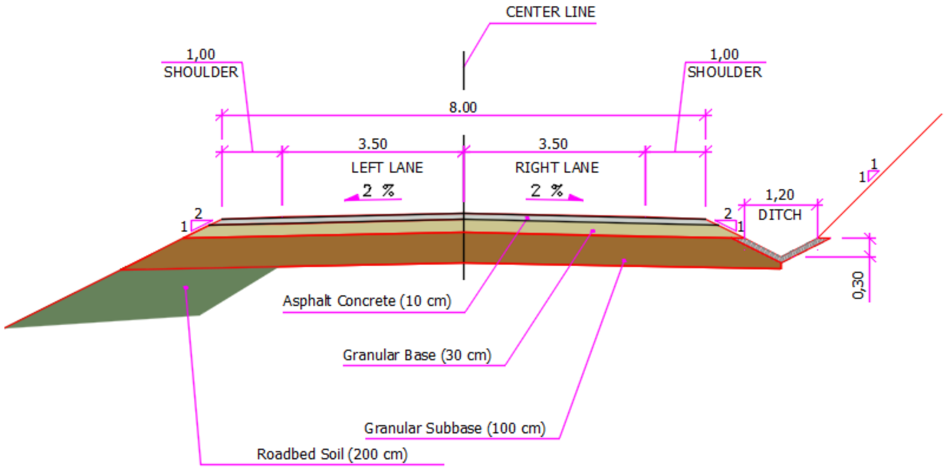
Tavira et al. (Tavira et al., 2018a) studied an experimental bike lane (EBL) that was built using two recycled materials from CDW: a recycled mixed aggregate (RMA-1) and a recycled mixed material from screening waste (RMSW-1). Deflections were measured with a FWD to evaluate the mechanical behaviour of the structural layers and to determine the Young's modulus of the natural and recycled materials. Bearing capacity and its evolution during a period of two years was more than acceptable. It exceeded the limits established by regulations for the construction of bike lanes. Moreover, its bearing capacity increased after two years to ensure the use of these two recycled materials as granular layers in bike lanes. Over the two years subbase layers made with screenings wastes obtained a mean modulus of 200 MPa, granular bases made with recycled aggregates obtained a mean modulus of 420 MPa, these moduli value increase for the mixed recycled materials can be explained by certain latent hydraulicity of the cement particles or by various pozzolanic activities of the ceramic particles.

	SECTION I	SECTION II	SECTION III	Thickness
Surface Course	Asphalt Concrete	Asphalt Concrete	Asphalt Concrete	4 cm
Base Course	Recycled Mixed Aggregates (RMA-1)	Crushstone (CS-1)	Recycled Mixed Aggregates (RMA-1)	15 cm
Subbase Course	Selected Soil (SS-1)	Recyced Mixed Aggregates Screening Wastes (RMSW-1)	Recyced Mixed Aggregates Screening Wastes (RMSW-1)	25 cm
Roadbed Soil	Subgrade (SG-1)	Subgrade (SG-1)	Subgrade (SG-1)	200 cm
mileage (km)	0+300	0+400	0+500	0+700

Figure 6 Cross sections of the Experimental Bike Lane (Tavira et al., 2018a)

Figure 7 Images of the Experimental Bike Lane (Tavira et al., 2018a)

Tavira et al. (Tavira et al., 2019) studied two RA that were obtained from the demolition of 105 dwellings near to the Cordoba Airport, these RA formed the granular layers of an Experimental section in the road CH-2, RMA composed the granular subbase and RCA constituted the granular base layer. A mobile jaw crusher made from the foundations and concrete of the existing rigid pavements the RCA, while structural parts of the houses, walls and roofs constituted the RMA. A comparison section was built with NA in the base layer. Chemical and physical properties were studied in laboratory, densities and moisture content were controlled during the construction of the road, deflections and Surface regularity was measured for a period of ten years. The number of daily vehicles was above 9000, this road would be classified as a T2 (200-799 heavy traffic vehicles per day and lane). RA obtained a higher bearing capacity than NA.



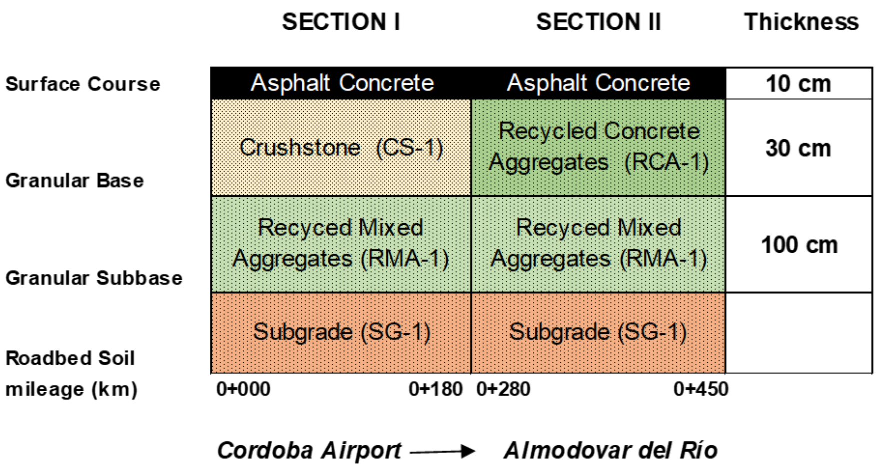


Figure 8 Cross Sections of The Experimental Section CH-2 (Tavira et al., 2019)

1.2. RESULTS OBTAINED FROM THE ARCO PROJECT

The Arco Project (Emasesa, Vorsevi, Contrat, Ariterra, Grupo Investigación TEP-107, 2014) was developed from 2012 until 2014, the following companies participated: EMASESA (water company of Seville Area), Contrat (Construction company), Vorsevi (Laboratory of quality control), Aristerra (recycling company of CDW) and the University of Seville (Research groups TEP-107 “Structures and Geotechnics” and TEP-172 “Architecture: Design and Technique”). Five experimental sections of running water and sewage pipes trenches were conducted in this study, a recycled concrete sand (Ru+Rc>90%) was used in pipe backfilling and beds zone, RMA (Rc>50%, Rb<15% y Ra<5%) was used to cover the rest of the trench. NA, sand, and selected soil were used in comparison sections. Static load and dynamic plate tests were measured, RMA obtained values higher to 100 MPa in the Ev2 which were higher to those obtained by the selected soil layer. On the other hand, a 4800 mg/kg value of sulphate content obtained in RA indicated that leachate could damage nearby concretes of foundations or pipes.

2. CDW VOLUME ESTIMATION TOOL IN WATER AND SEWAGE WORKS

For the proper management and control of the CDW generated in building works, it is necessary to have data applicable to construction, depending on its characteristics. In this way it could be known the volumes of the different types of waste produced, the cost and the destination.

In this way, it has to be identified the different types of waste that will be generated. In order to classify the generated residues, it has to be chosen from the EUROPEAN WASTE CATALOGUE AND HAZARDOUS WASTE LIST.
In the case of EMASESA the most common waste could be classify in:

- Non-contaminated materials, coming from excavation.
- Waste from the construction activity.
- Hazardous waste.

The most common waste that it can be produced from building works could be seen below.

CDW: Hazarous		
Potentially dangerous and other.		
Waste paint and varnish containing organic solvents or other dangerous substances	08 01 11*	
Mineral-based non-chlorinated engine, gear and lubricating oils	13 02 05*	x
Other fuels (including mixtures)	13 07 03*	
Packaging containing residues of or contaminated by dangerous substances	15 01 10*	x
Metallic packaging containing a dangerous solid porous matrix (for example asbestos), including empty pressure containers	15 01 11*	
Absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances	15 02 02*	x
Oil flters	16 01 07*	x
Lead batteries	16 06 01*	
Mercury-containing batteries	16 06 03*	
Alkaline batteries (except 16 06 03)	16 06 04*	
Mixtures of, or separate fractions of concrete, bricks, tiles and ceramics containing dangerous substances	17 01 06*	
Glass, plastic and wood containing or contaminated with dangerous substances	17 02 04*	
Bituminous mixtures containing coal tar	17 03 01*	
Coal tar and tarred products	17 03 03*	
Metal waste contaminated with dangerous substances	17 04 09*	
Cables containing oil, coal tar and other dangerous substances	17 04 10*	
Soil and stones containing dangerous substances	17 05 03*	
Soil and stones other than those mentioned in 17 05 03	17 05 04*	
Insulation materials containing asbestos	17 06 01*	
Other insulation materials consisting of or containing dangerous substances	17 06 03*	
Mixed construction and demolition wastes other than those mentioned in 17 09 01, 17 09 02 and 17 09 03	17 06 04*	
Construction materials containing asbestos	17 06 05*	
Gypsum-based construction materials contaminated with dangerous substances	17 08 01*	
Construction and demolition wastes containing pcb (for example pcb-containing sealants, pcb-containing resin-based floorings, pcb-containing sealed glazing units, pcb-containing capacitors)	17 09 02*	
Other construction and demolition wastes (including mixed wastes) containing dangerous substances	17 09 03*	
Fluorescent tubes and other mercury-containing waste	20 01 21*	

Excavation and stone materials.		
17 01 Concrete, bricks, tiles and ceramics.		
Concrete	17 01 01	X
Bricks	17 01 02	X
Tiles and ceramics	17 01 03	
Mixture of concrete, bricks, tiles and ceramics other than those mentioned in 17 01 06	17 01 07	X
17 05 Soil (including excavated soil from contaminated sites), stones and dredging spoil		
Soil and stones other than those mentioned in 17 05 03	17 05 04	X
dredging spoil other than those mentioned 17 05 05	17 05 06	
17 09 Other construction and demolition waste		
Mixed construction and demolition waste other than those mentioned in 17 09 01, 17 09 02 and 17 09 03	17 09 04	

Non-stony materials		
17 02 Wood, glass and plastic		
Wood	17 02 01	X
Glass	17 02 02	
Plastic	17 02 03	X
17 03 Bituminous mixtures, coal tar and tarred products		
Bituminous mixtures containing other than those mentioned in 17 03 01	17 03 02	
17 04 Metals (including their alloys)		
Copper, bronze, brass	17 04 01	
Aluminium	17 04 02	
Lead	17 04 03	
Zinc	17 04 04	
Iron and steel	17 04 05	
Tin	17 04 06	
Mixed metals	17 04 07	X
Cables other than those mentioned in 17 04 10	17 04 11	
17 08 Gypsum-based construction material		
Gypsum-based construction materials other than those mentioned in 17 08 01	17 08 02	
20 MUNICIPAL WASTES (HOUSEHOLD WASTE AND SIMILAR COMMERCIAL, INDUSTRIAL AND INSTITUTIONAL WASTES) INCLUDING SEPARATELY COLLECTED FRACTIONS		
Biodegradable waste	20 02 01	X
Mixed municipal waste	20 03 01	X
Paper and cardboard	20 01 01	X
Discarded electrical and electronic equipment other than those mentioned in 20 01 21, 20 01 23 and 20 01 35	20 01 36	
Waste from sewage cleaning	20 03 06	

In order to estimate the production of waste, during this work is has been developed a spreadsheet. Depending on the materials used in the infrastructures this tentative table has to be set.

3. HANDLING RECOMENDATIONS

3.1. SELECTIVE DEMOLITION

To minimize the amount of CDW that is send for disposal at landfill, selective demolition should be considered during deconstruction or demolition, hazardous wastes such as asbestos, plumbing, etc.. must be dismantle carefully not letting them mixed with other elements. Curbs, paving stones, and any other parts of street furniture such as benches, bollards, litter bins should be removed and store adequately in order to be used in the future in some other part of the city. The asphalt layer will be milled not mixing it with other granular layer or waste materials. In case of demolition of footings or concrete slabs products obtained should be keep apart from excavation soil or bricks that could be found while removing the concrete.

3.2. CLASSIFICATION OF CDW

CDW should be weighed at the entrance of the treatment plant, a classification of the CDW is highly recommended, there are two factors to be considered the first one is the predominant content of CDW, attending to its main constituent, CDW would be classified as concrete, mixed or asphalt. The second factor would be the grade of impurities contained on each group of CDW, depending on the degree of cleanliness of the CDW the treatment would require less or higher costs, in the following table these two concepts are related:

Table 1 Classification of the CDW at arrival to treatment plant (Barbudo et al., 2019)

	Clean	**Dirty**	**Very Dirty**
Concrete	Storage	Manual Cleaning	Disposal at landfill
Mixed			
Asphaltic			

3.3. USE OF CDW ACCORDING TO ITS CLASSIFICATION

Three storage areas will be displaced, stockpiles on each area will contain clean material of concrete, mixed or asphaltic. In case that the CDW is dirty because of impurities, manual cleaning of hazardous elements will be done. When the CDW is very dirty the only option is to send it for disposal at landfill, this is because the high costs needed for its treatment make it unfeasible.

3.4. CDW TREATMENT LINE

The following CDW treatment line with three stages is proposed:

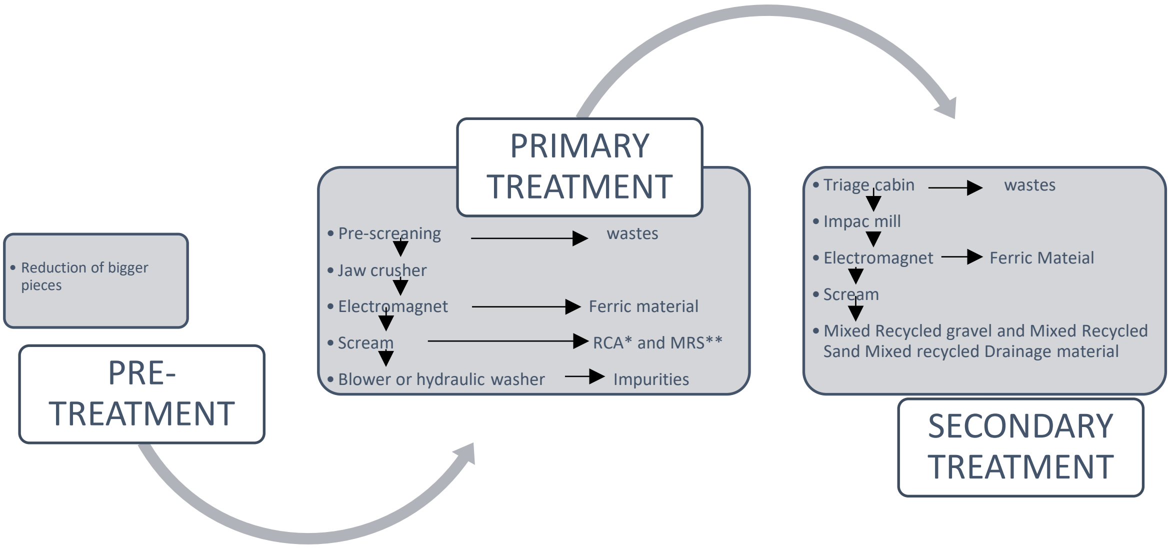


Figure 9 Treatment process of CDW

*RCA Recycled Concrete Aggregates

** MRS Mixed Recycled Soil

3.4.1. PRE-TREATMENT

On this stage with the use of a demolishing or vibrating hammer, larger elements are reduced into smaller and more manoeuvrable size materials. This treatment is not always necessary, and its object is to improve manoeuvrability by reducing the volume of larger particles before entering the recycling process.

3.4.2. PRIMARY TREATMENT

After completion of this phase and a granular subbase soil is obtained, depending on the nature of the CDW, it can be a Recycled concrete aggregates (RCA) or Mixed recycled soil (MRS). A pre-screening is set at the start of the process obtaining wastes that are remove, the rest of the material is introduce in a jaw crusher, then an electromagnet removes all ferric material, after that a second scream the fine part obtained is RCA or MRS, the coarse part is blowed and washed.

3.4.3. SECONDARY TREATMENT

That coarse part obtained in the primary treatment is introduced in a Triage Cabin where impurities are removed, after it is crushed in an impact mill, then electromagnet removes the ferric material that could appear, at this stage a scream is done and the finer material obtained would be mixed recycled drainage material while the coarse would be mixed recycled gravel and mixed recycled sand.

3.5. QUALITY CONTROL SYSTEM

During the develop of ARCO Project, a pilot trench was designed as a test of the real behaviour of the CDW material in order to calibrate the resistance and deformation parameters obtained in the laboratory. On the one hand, a model was carried out in the application of finite elements selected as adequate, a trench of CDW material with the mechanical parameters tested and its behaviour in a real trench was predicted. The execution of said trench, as well as its control and subsequent testing, provided the data that, compared with the analytical results, allowed us to define the real behaviour of the material. Known and calibrated this behaviour, we proceeded to the design of real trenches, already with pipe included, and several tests on urban roads help to make a behaviour analysis of these trenches. The underneath procedure was followed:

- Pre-modelling of the pilot trench. A series of type trenches composed of CDW-type materials was modelled in a still unknown natural terrain, in order to assess, in principle, the influence that the characteristics of the natural material of walls and bottom have on the fill. The modelling of the material outside the trench has been carried out considering the following guiding parameters.
    - E= 10 Mpa
    - c'=10 kPa
    - Φ'=30º

  The direct conclusion obtained from this verification is that for a trench of dimensions 1.5x1.5 meters, the terrain surrounding the trench would have practically no influence in its Ø30 cm load plate test. It therefore seems that this should be the section to build in the pilot test in order to evaluate the material with the least possible interference.

In this way, a pilot trench was done with the following characteristics:

- Two trenches would be built on similar land, with firm land in which the influence of the environment in the trenches is minimized and without affecting the water table. Dimensions of the trenches.
    - Width: 1,5 m
    - Height: 1,5 m
    - Slope of the walls: Vertical
    - Length: min 30m
- Refill:
    - One of them will be executed with selected soil and another with recycled CDW gravel.
    - The selection of recycled material would be carried out in such a way as to avoid the typical segregations of the stockpiles and to guarantee the homogeneity of the products.
    - It would also be verified that the material is wet.
    - It will be made by layers with a thickness not exceeding 20cm.

    - Any higher thickness must be justified in order to comply with the proposed compaction.
    - Before filling, the bottom of the excavation will be compacted to a density equal to 95% of the modified proctor test.
    - The fillings will also be compacted to 95% of the modified proctor test.
    - In all compaction processes, care would be taken to achieve the optimum humidity percentage established.
- The trenches would be kept free of surface loads (without traffic) during the entire period of their control.

And real control tests were carried out, in order to regulate the execution processes and obtain the desired performance parameters, both in absolute terms, and in relation to the selected conventional reference material, a series of control tests were carried out. Additionally, a series of prescriptions for plate load tests were established, given the importance of these tests.

- On the existing soil:
    - Modified proctor test (UNE 103501)
    - 30 cm surface loading plate (NLT 357)
- Over the filling layers:
    - Composition (UNE-EN 993-11)
    - Granulometry (UNE-EN 933-1+A1)
    - Plasticity (UNE 103103 – UNE 103104)
    - Free swelling (UNE 103601)
    - Collapse (NLT 254)
    - Organic matter (UNE 103204+Err)
    - Soluble salts (NLT 114)
    - Modified proctor test (UNE 103501)
    - California Bearing Ratio (CBR) 95% PM (UNE 103502)
- The organic matter content determinations in the CDW will be repeated on a sample by manually segregating the particles of bituminous origin
    - In the CDW, the granulometry will be repeated after the modified proctor test.
- The following tests will also be carried out on the CDW:

- Electric conductivity (UNE 77308)
- Sulphates content (EHE-08 – UNE 83963)
- Acidity Baumann-Gully test (EHE-08 – UNE 83962)
- Apparent density of the particles (UNE-EN 1097-6+A1)
- Water absorption (UNE-EN 1097-6+A1)
- Gypsum content (NLT 115)
- Flakiness index. (UNE-EN 933-3+A1), before and after compaction for proctor test.
- Consolidation test on selected soil (UNE 103405)

- Over the execution of the fillings, in each trench:
    - Checking density and moisture in each layer (ASTM D-3017-05 ASTM D-2922-05)
    - 3 load plate tests (UNE 103808:2006) over the last layer
    - 3 dynamic load plate tests (UNE 103807-2)
    - On-site resistivity testing in recycled material trench (four electrode method).
- On the trenches, after completion:
    - The 3 load plates tests will be repeated in the trench executed with the CDW according to the following conditions:
        - 15 days after completion of the execution.
        - After a month, having kept the trenches suitably saturated by irrigation and daily flooding in this last 15-day period.

As result of these tests, the following quality assessment program has been developed. In the case of this guide, it is recommended that the quality control system in production process must be based on Annex C of the UNE EN 13242: 2003 + A1 2008 standard. Aggregates for granular layers and layers treated with hydraulic binders for use in structural layers of pavements. The CDW processor must have established a Production Control Manual that contains at least the following aspects:

- Record of each entry of material that must include: the nature and classification of the CDW, place of origin, supplier, carrier, weight and destination of the same.
- Criteria for the acceptance of CDW. The types of CDW that are accepted and the maximum percentages of any contaminant carried by the CDW must be specified. The

acceptance or not of a material at the entrance will be done visually by specialized personnel.

- Method of production. It must include a flow diagram of the processes to be followed by the CDW from when it enters the plant until it is transformed into recycled material. In this diagram, the differences should be included if they exist in the CDW processing depending on their nature. In the same way, it will include the destination and storage area of each material produced (sale, landfill, authorized manager, internal works, etc.).
- Description of the finished product. It must include the specifications of each type of material guaranteed by the producer.
- Inspection and sampling process of the finished product. For granular materials and materials treated with hydraulic binders for use in structural layers of pavements, it will be necessary that they have the CE marking according to the UNE EN 13242 standard. The frequency and sampling are those indicated in the aforementioned standard shown in the table below. For other types of recycled materials, such as soil for embankments, drainage material and sand for pipe beds, the Association of Construction and Demolition Waste Management Companies of Andalusia (AGRECA) has drawn up a regulation for the certification of recycled products in which it proposes the test frequencies and requirements shown in the second table.
- Record book. In addition to all the data included in first bullet, the quantities of recycled aggregates produced classified by type, the results of the tests carried out on each material must be recorded, comparing them with the specifications of each one of them. Documentation to be delivered to the buyer. It will include, in addition to the specifications guaranteed by the producer, in which the product has been produced under a quality control system in accordance with the Production Control Manual, including general details thereof.

PROPERTIES	TEST METHOD	MINIMUM TEST FREQUENCY (1)
Granulometry.	EN 933-1	1 each week.
Flakiness index.	EN 933-3	1 each month.
Percentage of Crushed Particles.	EN 933-5	1 each month.
Sand equivalent.	EN 933-8	1 each week.
Methylene blue test.	EN 933-9	1 each week.
Resistance to fragmentation.	EN 1097-2	2 each year.
Particle density.	EN 1097-6:2000, cap 7, 8 ó 9	1 each year.
Water absorption.	EN 1097-6:2000, cap 7, 8 ó 9	1 each year.
Components that modify the setting and hardening speed of mixtures treated with hydraulic binders: Sodium hydroxide. Fulvic acid (if it does not pass the sodium hydroxide test). Comparative resistance test. Setting time.	EN 1744-1:2010+A1	1 each year.
Resistance to freezing and thawing.	EN 1367-1 o EN 1367-2	1 each 2 years.
Total sulphur content.	EN 1744-1	1 each year.
Acid soluble sulphates.	EN 1744-1	1 each year.
Hazardous substances (2), in particular: release of heavy metals	EN 12457-4	Before using new CDW

(1) The frequency of the tests refers to production periods.

(2) Unless otherwise specified, only if required for CE marking purposes.

TEST	Regulatory standard of the test	MINIMUM REQUIREMENTS			FREQUENCY	
					>5000 t/month	< 5000 t/month
RECYCLED SOILS						
Granulometry	UNE 103101	Selected	#20 > 70% ó #0,080>35%		Biweekly.	Biannual.
			Max Size<100mm	#0,40 <15% ó		
				#2<80%#0/40<75%#0/080<25%		
		Tolerable	#20 > 70% ó #0,080>35%			
Plasticity	UNE 103103/ UNE 103104	Selected soil: LL <30 e IP<10. · Tolerable soil tolerable: LL<65 e IP>0,73* (LL-20) if LL>40 where LL= Liquid limit e IP= Plasticity index			Biweekly.	Biannual.
Soluble salt content	NLT 114	< 2% for selected soil			Monthly.	Biannual.
		< 4% for tolerable soil				
Gypsum content	NLT 115	< 2% for selected soil				
		< 5% for tolerable soil				
Organic matter content	UNE 103204	<0,2% if it comes from excavation soil				
		<1% if it comes from CDW				
		<2% if it comes from bituminous material				
California Bearing Ratio (CBR)	UNE 103502	CBR >5 for selected soil			Biannual.	
		CBR >3 for tolerable soil				
RECYCLED SANDS FOR PIPE BEDS						
Granulometry	UNE-EN 933-1	Fines content (<0.063mm) <4%			Monthly.	Biannual.
Plasticity	UNE 103103/ UNE103104	LL< 30 e IP <10				

Total sulphur	UNE-EN 1744-1	<1,5% SO_3		
Acid soluble sulphates.	UNE-EN 1744-1	<1% SO_3		
Chloride content	UNE-EN 1744-5	< 0,1% for materials in contact with reinforced concrete or iron pipes.		
RECYCLED DRAINING MATERIALS				
Granulometry	UNE-EN 933-1	Max size <80 mm	Monthly.	Biannual.
		Fine fraction under 0,063 mm <5%		
Total sulphur.	UNE-EN 1744-1	<0,5% SO_3 for materials in contact with concrete	Quarterly	
		< 1,3% SO_3 in other cases		
Flakiness index.	UNE-EN 933-3	<35		
Los Angeles wear test.	UNE-EN 1097-2	LA<45(1)		

(1) When the traffic load is equal to or less than T4 this value can be increased to 50.

3.5.1.MATERIAL QUALITY CONTROL TESTS

The purpose of this point is to verify that the material used in each unit complies with the technical specifications of the project or in the applicable regulations. Representative samples of the material collected or dumped on site will be taken to perform the following tests depending on the unit in question.

Granular material beds. In general, the granular material to be used in the support bed and the kidney-shaped pipes will be non-plastic, will be free of organic matter and will have a maximum size of 25 mm, being able to use coarse sand or preferably grave.

Every 1000 m of trench, the tests indicated below will be carried out, expressing the acceptance criteria in italics:

- One granulometric analysis by sieving, S / UNE 103-101 / 95
    - Maximum size of 25 mm.
- One determination of Atterberg limits, S / UNE 103-103 y 103104
    - Non-plastic material.

- One organic matter content, S / UNE 103-204/93 Y UNE 103-204/93 Err
    - Percentage < 1 % unless reclaimed bituminous asphalt it could be raise to 2%

Trench filling. The materials to be used must have at least the characteristics of the selected soils, as defined in PG-3. For every 5,000 m^3 of material from the same source, the following analyses will be carried out, which will serve as a reference to take densities in each trench, and in the sub-bases of the compacted unit:

- One granulometric analysis by sieving, S/ UNE 103-101/95
    - Maximum size of 100 mm.
    - Fine fraction under 25% passing in the 0.080 mm sieve.
- One modified Proctor test, S/UNE 103 501/94, including maximum density measurement and optimum moisture.
- One determination of Atterberg limits, S / UNE 103-103 y 103104
    - Liquid limit < 30
    - Plasticity index <10

3.5.2. EXECUTION QUALITY CONTROL TESTS

Trench filling. To check the adequate compaction of the trench fill, for every 45 m, or fraction, of trench and alternate layer, the following tests will be carried out.
list, expressing in italics the acceptance or rejection criteria.

- Three density and moisture “in situ” tests by radioactive isotopes, ASTM-D 2922 y ASTM-D 3017
    - o Density "in situ" > 95 %, max density modified Proctor test.
    - o Moisture, optimum moisture - 2% ≤ moisture ”in situ” ≤ optimum moisture + 1%

3.5.3. TESTS FOR LEACHING OF RECYCLED AGGREGATES

Leaching tests are used to determine the contaminant level of elements that RA may unleashed due to the long-term effect of ground water. RA should be tested according to UNE-EN 12457-3:2004 to be classified according to the European Landfill Directive (2008/56/EC) as; Inert, Non-Hazardous or Hazardous. This test consists of a two-step batch leaching test that that uses a solution of 175 g of dry sample of the material, two liquid/solid ratios (an L/S of 2 and L/S of 10) and deionised water as leaching fluid. According to the European directive these are the limit values for waste:

	Compliance test UNE EN 12457-3					
	I≤	NH	H	I≤	NH	H
	L/S = 2 (mg/kg)			L/S = 10 (mg/kg)		
As	≤0.1	0.1-0.4	0.4-6	0.5≤	0.5-2	2-25
Ba	≤7	7-30	30-100	≤20	20-100	100-300
Cd	≤0.03	0.03-0.6	0.6-3	≤0.04	0.04-1	1-5
Cr	≤0.2	0.2-4	4-25	≤0.5	0.5-10	10-70
Cu	≤0.9	0.9-25	25-50	≤2	2-50	50-100
Hg	≤0.003	0.003-0.05	0.05-0.5	≤0.01	0.01-0.2	0.2-2
Mo	≤0.3	0.3-5	5-20	≤0.5	0.5-10	10-30
Ni	≤0.2	0.2-5	5-20	≤0.4	0.4-10	10-70
Pb	≤0.2	0.2-5	5-25	≤0.5	0.5-10	10-50
Sb	≤0.02	0.02-0.2	0.2-2	≤0.06	0.06-0.7	0.7-5
Se	≤0.06	0.06-0.3	0.3-4	≤0.1	0.1-0.5	0.5-7
Zn	≤2	2-25	25-90	≤4	4-50	50-200
Sulphate	≤56	56-1000	1000-2500	≤100	100-2000	2000-5000

Inert (I); Non-Hazardous (NH); Hazardous (H)

It would be advisable to at least perform this test before starting to use new types of CDW which could have hazardous contaminants.

4. CIRCULAR PROCUREMENT, CIRCULAR CLAUSES IN PUBLIC PROCUREMENT IN EMASESA.

EMASESA has a strong commitment to preserving, reusing and recycling the materials generated during water and sanitations works, as a part of its program of good practices in environmental sustainability and corporate responsibility performance.

In 2009 EMASESA approved as a very starting point related to circular economy- a guide addressed to works managers wherein develops a strategy to reduce the environmental impact of its typical works, including some obligations related to waste generation. In this document, the company shows great concerns about recycling, re-using and re-manufacturing the largest possible percentage of materials. The guide is incorporated to the processes of the company, and becomes a duty for waterworks contractors, with clauses of this kind:

- Perform demolitions according to deconstruction criteria.
- Make the most of used materials.
- Reuse work cuts whenever possible.
- Recycling stone materials and reusing them as subbases in urbanization works, such as draining material, etc.
- Effective improvements in waste management require a need to define a hierarchy of priorities. In order of importance, these are:
    - Minimize the use of necessary subjects and resources. In other words, reducing the consumption of raw materials as well as the use of materials that may make it difficult or impossible to recyclability or subsequent reuse.
    - Reuse materials. Take advantage of the materials disassembled during the tasks of down that can be used later.
    - reuse ceramics, tiles, etc.
- 3R strategy: reduce + reuse + recycle.

As a result, EMASESA demands to all its works contractors the implementation of a waste management plan.

Since 2017 the company is also focused on recycling construction and demolition waste (RCD in Spanish), by rewarding in every contract those tenderers who commit

themselves to use recycled aggregates in base units and subbases of projected pavements (as well as the obligation of reusing of the pavement itself):
The use of recycled aggregates in the base units and/or subbases of the projected pavements shall be rewarded with three points. The new units shall in no case entail a budgetary change to the work.
These aggregates shall comply with the "Guide to Recycled Arids of Central Andalusia of the Agencia de Obra Pública", which includes technical specifications and recommendations for the following uses: recycled soils, recycled “zahorras”, recycled gravels, recycled sands, draining material and cement flooring.
If the use of RCDs is offered in under an award criteria, for the accreditation of the use of recycled materials in granular layers, a letter of commitment from the company or entity supplying recycled aggregates must be shown, indicating: the technical specifications of the recycled material to be supplied, its conformity with the provisions of the "Guide of Recycled Aggregates of Central Andalusia of the Agencia de Obra Pública" , and the availability for supply in the quantities demanded by the bidder.
EMASESA is currently considering new actions in the course of Cityloops project, such as defining within the tender documents the exact measures of recycled and reused work units, or the insertion of award criteria related to the implementation of circular economy plans suggested by tenderers, as well as reaching to agreements with waste plants in order to ensure the reutilization of work materials.

In other way, further efforts has to be made, in order to improve public procurement related to circular economy. Examples of those aspects are:

- Extend the use of good practices in the public companies, in order to train the people of the organization to improve the management of waste generated in production systems, about circularity oportunities.
- Specify aspects related to circular economy in bidding for infrastructure works projects, and also supply contracts.
  Bidding for infrastructure works projects.

Establish the obligation in the specifications to improve good circular practices, rewarding the technical criteria for the best memory and the greatest commitment to this separation and delivery to plants.

Reward during the tender, as an award criterion, the highest volume of material delivered to the CDW recycling plants. It would be possible to measure the volume of demolition waste delivered separately for future reuse.

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WP 2.7 Tool no.13

Quality Assessment Tool for the use of CDW as recycled aggregates in water and sewage infrastructures.

WP2 CDW/Soil
CityLoops Seville Cluster

5. APENDIX I

5.1. INTRODUCTION.

This guide is intended to be a small manual on the methodology for calculating the amounts of Construction and Demolition Waste (CDW).

During the making of the guide it has been determined that the procedure should tend towards a standardization of the parameters and calculations carried out.

Therefore, below is a brief summary of the measures adopted, the concepts and lines that are standardized for the calculation and some explanatory comments on how to carry out an CDW Study using this methodology in a simple way.

5.2. SPREADSHEET LINES.

In the spreadsheet it can be found several lines in which data of the construction has to be included. It has to be taken in to account that the user has to know the different aspects that has to be included to calculate the production of CDW in the construction.

The data included, shows different activities developed in water infrastructure's building works, so it can be used in the framework of the project CityLoops.

In the case of it could be needed a new line, it is recommended to copy the data from another line and complete the information, and not changing cells with functions.

CONSTRUCTION AND DEMOLITION WASTE EVALUATION TOOL

PROJECT NAME

CODE	**CONCEPT**	**Ud**	**AMOUNT**	**Swell factor (%)**	**DENSITY (t/m^3)**	*INCLUDED SWELL FACTOR* **TOTAL (m^3)**	*INCLUDED DENSITY* **TOTAL (t)**	**CDW TAX (€/ m^3)**	**MANAGING COSTS (€)**
	WATER NETWORK BUILDING WORKS								
	PREVIOUS WORKS								
XX.XX.XXX.XX	Clearing and mechanical cleaning of the land, including removal of materials to landfill	m2	0,00	24%	1,40	0,00	0,00	1,52	0,00
	EXCAVATIONS								
XX.XX.XXX.XX	Open pit excavation, with manual means, in castings, including the protection and felling of existing services, the necessary shoring and depletion, as well as the leveling, compaction and cleaning of the surface of the excavation bottom	m3	0,00	24%	1,40	0,00	0,00	1,52	0,00
XX.XX.XXX.XX	Open pit excavation, with mechanical means, in castings, including the protection and felling of existing services, the necessary shoring and depletion, as well as the leveling, compaction and cleaning of the surface of the excavation bottom	m3	0,00	24%	1,40	0,00	0,00	1,52	0,00
XX.XX.XXX.XX	Trench excavation in an undeveloped area and in rocky terrain, at any depth, including the extraction of products to the edges as well as the depletion and refining of the bottom and slopes of the trench.	m3	0,00	24%	1,40	0,00	0,00	1,52	0,00
XX.XX.XXX.XX	Manual trench excavation in an urbanized area and in any kind of terrain except rock, for depths not exceeding 2.50 m, including the extraction of land at the edges, the protection and shoring of existing services and simple shoring by means of vertical planks, straps and wooden struts, as well as the depletion and refinement of the bottom and slopes of the trench.	m3	0,00	24%	1,40	0,00	0,00	1,52	0,00
XX.XX.XXX.XX	Mechanical trench excavation in an urbanized area and in any kind of terrain except rock, for depths not exceeding 2.50 m, including the extraction of land at the edges, the protection and shoring of existing services and simple shoring by means of vertical planks, straps and wooden struts, as well as the depletion and refinement of the bottom and slopes of the trench.	m3	0,00	24%	1,40	0,00	0,00	1,52	0,00

After filling the name of the project, the rest of the spreadsheet could be filled. The spreadsheet is divided in different parts as PREVIOUS WORKS, EXCAVATIONS, etc. For the building works proposed, the Swell factor and the density data has been calculated

The code of each line could be changed according the user needs. Usually, that codes could be chosen from construction databases. It has been done a selection of similar concepts, in order to group aspects that produces the same o very similar amount of waste.

CODE	**CONCEPT**	**Ud**	**AMOUNT**	**Swell factor (%)**	**DENSITY (t/m^3)**	*INCLUDED SWELL FACTOR* **TOTAL (m^3)**	*INCLUDED DENSITY* **TOTAL (t)**	**CDW TAX (€/ m^3)**	**MANAGING COSTS (€)**
	WATER NETWORK BUILDING WORKS								
	PREVIOUS WORKS								
XX.XX.XXX.XX	Clearing and mechanical cleaning of the land, including removal of materials to landfill	m2	0,00	24%	1,40	0,00	0,00	1,52	0,00
	EXCAVATIONS								
XX.XX.XXX.XX	Open pit excavation, with manual means, in castings, including the protection and felling of existing services, the necessary shoring and depletion, as well as the leveling, compaction and cleaning of the surface of the excavation bottom	m3	0,00	24%	1,40	0,00	0,00	1,52	0,00
XX.XX.XXX.XX	Open pit excavation, with mechanical means, in castings, including the protection and felling of existing services, the necessary shoring and depletion, as well as the leveling, compaction and cleaning of the surface of the excavation bottom	m3	0,00	24%	1,40	0,00	0,00	1,52	0,00
XX.XX.XXX.XX	Trench excavation in an undeveloped area and in rocky terrain, at any depth, including the extraction of products to the edges as well as the depletion and refining of the bottom and slopes of the trench.	m3	0,00	24%	1,40	0,00	0,00	1,52	0,00
XX.XX.XXX.XX	Manual trench excavation in an urbanized area and in any kind of terrain except rock, for depths not exceeding 2.50 m, including the extraction of land at the edges, the protection and shoring of existing services and simple shoring by means of vertical planks, straps and wooden struts, as well as the depletion and refinement of the bottom and slopes of the trench.	m3	0,00	24%	1,40	0,00	0,00	1,52	0,00
XX.XX.XXX.XX	Mechanical trench excavation in an urbanized area and in any kind of terrain except rock, for depths not exceeding 2.50 m, including the extraction of land at the edges, the protection and shoring of existing services and simple shoring by means of vertical planks, straps and wooden struts, as well as the depletion and refinement of the bottom and slopes of the trench.	m3	0,00	24%	1,40	0,00	0,00	1,52	0,00

5.3. FORMULAS IN THE SPREADSHEET.

In the spreadsheet. Is has been taken on to account that no formula has to be used, as all formula needed are included in I column, and so, only the column F has to be filled. The concepts included in formula could be seen below.

Concept		Column I.
Connections	Up to ND 300 ND 300 to 500 *(Bigger diameters have to be*	3 m^3 6 m^3
Drinking water connections	Up to 6 meters from 6 meters	2,4 m^3 (1x6x0,4) 3,4 m^3 (1x9x0,4)
Sewerage connections	Up to 6 meters from 6 meters	8,64 m^3 (1,8x6x0,8) 14,4 m^3 (2x9x0,8)
Drinking water connections with mix CDW	Cylinder ND 250 mm 34 mm wall and length from 6 to 9 meters	The calculus done is about the difference between external and internal
Scupper unit	Both in soil excavations and demolition of mixtures	2,88 m^3 (1,2x3x0,8)
Demolition and pipes disassembly.	Up to ND 300 From ND 300 to 1000 Concrete up to ND 500 Concrete up to ND 1000	Wall 27,5 mm Wall 102 mm Wall 75 mm Wall 110 mm The calculus done is about
Curb lifting and demolition	Curb Foundation die	0,75 m3 (1x0,25x0,3) 0,04 m3 (0,2x0,2)
Demolition and pavement building	Tiles Curb Asphalt Concrete Asphalt on land Asphalt on curb	Material thickness 50 mm Material thickness 120 mm Material thickness 100 mm Material thickness 200 mm Material thickness 210 mm Material thickness 70 mm

5.4. RESULTS

When filling the different data in to the spreadsheet, it will be obtained the results in each row. In this way it will be obtained the amount of CDW generates in each category, as volume, weight and management costs.

		VOLUME (m^3)	WEIGHT (t)	CDW TAX (€/ m^3)	MANAGEMENT COSTS (€)
SOIL TAX		0,00	0,00	1,52	**0,00**
		VOLUME (m^3)	WEIGHT (t)	CDW TAX (€/ m^3)	MANAGEMENT COSTS (€)
CDW TAX		0,00	0,00	12,59	**0,00**
		VOLUME (m^3)	WEIGHT (t)	CDW TAX (€/ m^3)	MANAGEMENT COSTS (€)
CONCRETE		0,00	0,00	**6,02**	**0,00**
		VOLUME (m^3)	WEIGHT (t)	CDW TAX (€/ m^3)	MANAGEMENT COSTS (€)
ASBESTOS		0,00	0,00	**0,94**	**0,00**

CityLoops is an EU-funded project focusing on construction and demolition waste (CDW), including soil, and organic waste (OW), where seven European cities are piloting solutions to be more circular.

Høje-Taastrup and Roskilde (Denmark), Mikkeli (Finland), Apeldoorn (the Netherlands), Bodø (Norway), Porto (Portugal) and Seville (Spain) are the seven cities implementing a series of demonstration actions on CDW and OW, and developing and testing over 30 new tools and processes.

Alongside these, a sector-wide circularity assessment and an urban circularity assessment are to be carried out in each of the cities. The former, to optimise the demonstration activities, whereas the latter to enable cities to effectively integrate circularity into planning and decision making. Another two key aspect of CityLoops are stakeholder engagement and circular procurement.

CityLoops runs from October 2019 until September 2023.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 821033.