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Recycling 2019- Mechanical and decontaminating behaviour of recycled mortars with TiO_2 - A. Barbudo- University of Cordoba

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Circular economy is an economic model of production and consumption, which involves sharing, leasing, reusing, repairing, refurbishing, and recycling existing materials and products. When it comes to implementing a circular economy, it pretends for the current model to close the life cycle of resources, strengthening sustainability and caring for the environment. The use of waste as secondary raw materials is one of the actions to establish the circular economy model.

The construction and demolition wastes (CDW) constitute one of the most important waste streams in Europe, due to its high production rate per capita and the technical and economic feasibility of recycling it. CDW arises from activities such as the construction of buildings and civil infrastructure, total or partial demolition of buildings and civil infrastructure, road planning and maintenance. There is a high potential for recycling and re-use of CDW, since some of its components have a high resource value. Usually, technology for the separation and recovery of CDWis well established, readily accessible and inexpensive.

Use of aggregates from recycling in products with low mechanical requirements is a common practise in construction sector. There is research experience that demonstrates the mechanical capacity of recycled mortars produced from recycled aggregates from CDW. However, there are few studies on the use of mixed recycled sand with a high percentage of ceramic particles.

In addition, the incorporation of photocatalysts in construction materials has emerged as a promising technology to develop products with special properties as air decontamination, self-cleaning and self-sterilizing ability under UV-Vis light irradiation. This compound allows the oxidation and subsequent elimination of NOx present in the atmosphere, one of the most relevant for air pollution, that contribute to the formation of smog and acid rain, as well as affecting tropospheric ozone. In areas of high motor vehicle traffic, such as in large cities, the nitrogen oxides emitted can be a significant source of air pollution.

Photocatalysis is the activity occurring when a light source interacts with the surface of semiconductor materials, the so called photocatalysts. The greater porosity of ceramics particles characteristic of mixed recycled sand from CDW respect to natural sand, could suggest a higher penetration of the sun's UV rays and, for this reason, it was intended to obtain a mortar with a greater decontaminating capacity through their evaluation of photocatalytic power. One of the most widely used decontaminating construction materials is photocatalytic cements which include nano- TiO2 in its composition.

In this research two different series of mortars were produced. One of them contained traditional Portland cement (CEM I 52’5 N) and the other one photocatalytic cement, (CEM I 52’5 with nano-TiO2). Both cement were supplied from the same company. Further, a natural sand (NS) and a mixed recycled sand (RS) from CDW were used for it. Each of these series was composed of 4 mixtures with 4 replacement rates by volume of NS by RS (0%, 20%, 40% and 100%). The dosage of mortars has been calculated based on the data indicated in the standard “EN 196-1. Methods of testing cement. Determination of strength” in consideration of final water amount, absorption at 15 min of sands and their humidity. The kneading was carrying out in accordance with cited standard.

Subsequently, prismatic specimens were manufactured with measurements of 40x40x160 mm with the mortar obtained in each case. These prismatic specimens were stored in a climatic chamber under controlled conditions of 20 ± 2° C of temperature and 65% of relative humidity until the test age. These were evaluated through mechanical properties, specifically, compressive, and flexural strength, after 28 days of curing time. Likewise, a sample was extracted from the centre to each prismatic specimen mortar to analyse its photocatalytic power according to a standardised methodology, through NOx reduction capacity.

Mechanical strengths, compressive and flexural were very similar as the percentage of RS increases, up to 40% replacement of NS by RS, with an average strength of 48 MPa and 15 MPa, respectively. When the replacement rate was 100% a slight decrease (decrease of 21% and 19%, respectively) was observed in the mechanical strength values. The values registered in flexural strength test show a very good performance of these mortars for their possible use in pavements (values greater than 12 MPa in all mortars).

A small increase (16%) in compressive strength was also observed in the series produced with photocatalytic cement, while the flexural strengths were not affected by this aspect. This fact could be explained by the different natural resources which both cements have been manufactured, and despite having been manufactured by the same company (although in different factories).

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Regarding the mortar decontaminating capacity, the incorporation of RS instead of NS, slightly improved decontaminating capacity although this fact did not produce a significant increase in the decontaminating capacity of the mortar. All the mixtures were classified as "category 1" that is, with a decontaminating power, measured as the reduction of NOx, comprised between 4% and 6%. However, the mix with 100% RS and made with photocatalytic cement showed a porous appearance and a greater decontaminating capacity.
This research produced mortars with decontaminating capacity reintroducing a waste into the productive cycle and contributing to the implementation of the circular economy model.

Keywords: Circular Economy, Construction and Demolition Waste, Recycled Aggregates, Recycled Mortar, Photocatalytic Mortar, Decontaminating Capacity