LIFE CDW CIRCLE: Value added Recycled Materials from Construction and Demolition Waste

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Introduction

In Italy, the most recent data on construction and demolition waste (CDW), dated 2022, show a production of about 62 million tonnes. This type of waste is mostly originated from renovation operations (micro-demolition), new construction projects and large-scale demolition. Given the high quantities produced not only at the national level, but also at the European level, the European Union invites member states to improve the management of these materials, e.g. through a wider adoption of selective demolition practices or through a more intensive sorting of CDW in facilities (ISPRA, 2024).

The great heterogeneity of CDW entering the recovery plants, combined with the treatment operations consisting almost exclusively of crushing, deferrization, sorting and screening, contributes to the production of recycled aggregates (RAs) with reduced mechanical properties and poor market appeal. In fact, according to ANPAR Italy, more than 90% of the RAs produced is reused for "*low grade*" operations (road construction or environmental recovery), while only about 7% is reused for "*high-grade*" operations, such as for new concrete production, thus fully exploiting their real potential.

At the regulatory level, Italy has recently published Decree 28 June 2024, No. 127 (Ministry of Environment and Energy Security, 2024), which aims to clarify the management, responsibilities, and documentation required to ensure that CDW meet the criteria for the End of Waste status.

Despite the significant progress made on CDW recovery in recent years, the operators are still facing several difficulties in promoting the use of the RAs. Although the percentage of CDW recovery in Italy is around 80%, large quantities of RAs are in fact still destined for on-site storage, mainly due to their reduced quality, the lack of a competitive market with virgin raw materials, reduced knowledge of their real potential, and gaps or misunderstandings in terms of bureaucracy and regulations (Damgaard *et al*, 2022).

The aim of the present work is to provide a brief overview of the characteristics of RAs and the challenges of their reuse for concrete production. Subsequently, the European Life CDW Circle project will be presented, which aims to achieve the total recycling of CDW entering the plant, thanks to the implementation of a new treatment plant equipped with an optical sorting technology able to separate inert materials (aggregates) from lightweight materials (bricks, ceramics and tiles), in order to produce RAs with high added value for the construction industry.

Recycled Aggregates (RAs): main properties and critical aspects of their reuse

As mentioned before, the factors that most influence the properties and composition of RAs are demolition techniques, composition of CDW waste entering the plant and treatment technologies. In general, outgoing RAs have lower mechanical properties than the quarry aggregates commonly used in the construction sector; therefore, a correct and complete evaluation of their characteristics is a key factor, especially when they are used for concrete production.

In particular, the treatment technologies still adopted in Italy are mainly based on mechanical operations such as crushing, deferrization, simple separation and screening, which do not allow obtaining RAs of a quality suitable for concrete production. In fact, RAs are made up of the original old aggregate to which, however, the old cement paste remains "*adhered*"; the latter, due to its reduced mechanical properties, turns out to be the main responsible for the low quality of RAs (Rémond *et al*, 2019). In addition, if the separation step is not very thorough, the outgoing RAs could be composed not only of inert material, but also of undesired fractions such as bricks and ceramics; the presence of these fractions also contributes to the low quality of RAs.

The separation technologies currently on the market or already operative in treatment plants can be divided into three main categories: "*dry*", "*wet*" and "*innovative*" (Schnellert & Mueller, 2010). Their operating methods depend mainly on the organisation and capacity of the considered plant, the composition and characteristics of the processed waste and the required quality of the final RAs.

The most widespread separation technology in Italy is the "*dry*" separation technology, which in turn is divided into separation by density (using air separators) and separation by magnetic or electronic properties (using magnets or electrical conductors). On the other hand, "*wet*" separation is still not widespread in Italian treatment plants, despite its

better performance in terms of removing undesired fractions; in fact, this technology requires the presence of a recirculation and treatment circuit for process water, so as to limit water consumption.

However, quite often, dry and wet separation processes are not sufficient to ensure the production of RAs with characteristics suitable for final reuse. Only in recent years research has focused on the possibility of using "*innovative*" separation technologies for the treatment of CDW waste, already widely used with other types of waste (plastic, glass, etc.) and based on artificial intelligence (Cirelli Angulo *et al*, 2013, Dodampegama *et al*, 2023). The latter offer several benefits such as improving the quality of RAs and reducing water and energy consumption. On the other hand, these are not without disadvantages, such as higher initial investment and maintenance costs (in terms of trained personnel, sensors, upgrades, etc.). However, the higher quality of the final RAs and their greater market attractiveness may, in the long run, repay the high initial investment.

Life CDW Circle project

Given the above, it is crucial to adopt solutions capable of improving the quality of the RAs produced by treatment plants. A better and more accurate separation of inert fractions from light and undesired fractions in the separation phase would lead to more homogeneous and certainly higher-performing RAs. The Life CDW Circle project, November 2023 – April 2027, co-funded by the European Union and consisting of 8 partners, aims to install an advanced CDW treatment plant capable of performing a more thorough sorting of mineral materials according to texture and colour (optical sorting technology). Once produced, the RAs will be subjected to technical and environmental characterisation and used for the production of C25/30 and C30/37 concretes, which will also be characterised and tested during the project. Full-scale elements (e.g. beams) will also be produced and tested with these concretes. From an environmental point of view, leaching and ecotoxicity tests will be carried out on both the granular RAs and the monolithic concretes.

Thus, the Life CDW Circle project represents a national and European innovation in the treatment and recovery of CDW, bringing several benefits to the sector: reduced consumption of raw materials, improved waste management, reduced CO_2 emissions and more efficient use of resources.

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