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1.3.4. REPORT ON THE POSSIBILITIES TO REUSE OR RECYCLABILITY OF BUILDINGS MATERIALS IN ITALY

OERCO2
ONLINE EDUCATIONAL RESOURCE FOR INNOVATIVE STUDY OF CONSTRUCTION MATERIALS LIFE CYCLE

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1. Introduction

Construction industry is one of the main consumers of raw materials and responsible of a great waste streams production, due to the huge amounts of non-renewable resources used in construction processes. In particular, construction and demolition wastes (C&DW) represent one of the most voluminous streams of waste generated worldwide, since building materials account for almost half of all products generally used in construction. Moreover, construction and demolition wastes accounts for about 25-30% in mass of the whole wastes produced in Europe, which means about 180 million tons per year.

Unfortunately, in Italy materials resulting from construction and demolition wastes are often still considered as waste for disposal, rather than resources for processing and reuse. Indeed, only the 28% in mass of construction and demolition waste is recycled, while the remaining 72% is still disposed. The reason why of these percentages is basically caused by a no-selective demolition process. On the other hand, large quantities of natural primary aggregates and building materials are extracted each year. At global level, 60% of the raw materials extracted from the lithosphere are used for civil works and buildings construction. Moreover, a great amount of land is currently dedicated to the disposal of those materials, leading to the increase the ecological footprint of construction industry.

Construction and demolition wastes include several categories of materials, which can be recovered depending on the source and the separation technique used. Indeed, most of the materials obtained during dismantling can be recycled by means of an appropriate selective demolition process and treatment and then transformed in recycled raw materials which represent a resource for new construction.

In particular, the use of C&DW may bring economic and environmental benefits, related to:

- lesser need for their transportation into landfill,
- reduced spaces designed for dumps,
- considerable saving in usage of traditional quarry materials.

The life cycle approach makes possible a specific assessment of construction waste streams in terms of environmental sustainability, taking into account impacts related both to their recycling process and to their usage as new materials [1].

With reference to these issues, many Italian literature and experimental studies have been conducted with the aims to analyse processes and materials involved in the Italian C&DW management. In particular, this paper will show some Italian studies that have dealt with C&DW, with a specific reference to the evaluation of their environmental impact in terms of CO_2 emissions related to the recycling process.

More in detail, in this paper are reported those mainly focused on:

- an overall assessment of the end-of-life phase of buildings and C&DW management;
- recycled materials (environmental impact evaluation related to the recycling process and/or their utilization in comparison with traditional materials).

In order to increase the recycling amounts of C&DW, it's necessary to know the specific composition and characteristics of the waste. Indeed, the typical components of C&DW include concrete, mortar, bricks, wood, metal, drywall, asphalt and smaller amounts of packaging materials, such as paper and plastic. For what concerns recycled materials, the major researches in Italy are referred to the most commonly used construction materials, which represent also the main components of C&DW.

2. Construction and demolition waste management

The growth of waste generation rates is an important issue worldwide. According to Waste Framework Directive[1], one of the pivotal issue of a continuous progress related to eco-efficient waste management consists in ensuring the prevention, control and remediation process relative to the environmental components, associated in particular to waste minimization and valorisation.

With reference to the environmental impact generated by construction and demolition waste, several studies in Italy have been considered. Specially, a high number of these deal with the environmental sustainability related to construction and demolition waste management.

For instance, Sara Zanni et al. [2] carries out a study, in partnership with University of Romania. The study is focused on the analysis and the evaluation of environmental impacts related to construction and demolition waste management system in two selected locations, one for each

[1] *Directive 2008/98/EC on waste (Waste Framework Directive)*

country. The assessment, based on LCA methodology, indicates that the environmental impact indicator with more incidence is the Global Warming and the related CO_2 emissions. Finally, the study aims to propose the sustainability of some C&DW management scenarios as potential alternatives to the current system.

Alessandra Bonoli et al. [3] carries out another similar study in partnership with University of Romania. The study proposes the evaluation of the Ecological Footprint as a new indicator and methodology for the environmental sustainability assessment related to waste production, in particular concerning the generation of construction and demolition waste. The evaluation is based on LCA methodology, using indicators like CO_2, land use and nuclear footprints. Results of the research show that the highest impact on the environment is induced by CO_2 emissions, due to incineration process, although it contributes to the reduction of waste destined to landfills. The evaluation demonstrates that Ecological Footprint can represent a good indicator to assess the sustainability of C&DW integrated management systems in different countries and locations. In order to achieve a good level in construction and demolition waste management it's necessary take into account the environmental impacts of each stage of the end-of-life phase of buildings. Several studies have been considered in Italy according to this issue. Pierluca Vitale et al. [4] investigates the environmental performance of the overall end-of-life phase of a specific residential building in South of Italy, with a particular focus on the management of the generated demolition waste. Through the LCA approach, the evaluation takes into account the selective demolition, preliminary sorting and collection of main components of the building, together with the processes of sorting, recycling and/or disposal of main fractions of the demolition wastes. The estimated contributions of the environmental impact of each stage of the investigated C&DW management indicate a pivotal role of the recycling of the different waste streams. In particular, the recycling of reinforcing steel plays a paramount role, accounting for the 89% of the total impacts related to global warming.

3. Environmental impact of recycled materials for construction industry

Concrete is the most consumed material in the Italian and European construction sector, and the second most consumed substance on Earth after water. Consequently, the consumption of

aggregates, which represent the major component in concrete mixes, is constantly increasing. For this reason, the depletion of natural resources and the availability of aggregates represent currently the most important environmental issue in construction sector. In last decades, waste reuse/recycling has been considered as a valuable option to substitute the conventional aggregates in concrete production as well as to reduce waste generation.

The environmental comparison between traditional and recycled concrete (produced using waste as raw materials) has been performed in several Italian studies and results show generally clear environmental benefits for all recycled concrete options, mainly due to the avoided impacts associated with the avoided disposal of waste.

For instance, Alessandra Bonoli et al. [5] investigates the amount of environmental impact of C&DW recycling/reuse, specifically related to the production of aggregates. For the purpose of the study, the author performs a comparison with the environmental performance of natural inert processing, in terms of global impact addressing the whole process and for each technological phase. The analysis is carried out according to LCA methodology and based on primary data collected directly from the Italian Emilia–Romagna Region. Results show that the environmental impacts generated by C&DW recycling accounting for about 40% of the impacts induced by natural inert processing. In particular, a great difference appears in terms of global warming potential, since the production of 1 tonne of aggregate from crushed inert generates 103.000 g of CO_2 equivalent, compared with 15.000 g of CO_2 generated from recycling of C&DW (almost 7 times lower).

Loredana Napolano et al. [6] carries out a similar study, with reference to the evaluation of lightweight aggregates (LWAs) manufactured with raw materials supplied by nature or waste. Aim of this study is to investigate the environmental footprint of different lightweight concretes made of different LWAs by means of a life cycle assessment methodology. Results highlight that the production of lightweight aggregates made with the use of industrial waste as secondary raw materials presents lower environmental impact with respect to the production of those made with natural ones. Indeed, clay extraction, its transportation and production contribute to high environmental impacts of the natural aggregates. Furthermore, taking into account the production of concretes, in those made with natural lightweight aggregates the environmental

impact accounts for about 55% of the total environmental burden, while in those made with recycled aggregates the environmental impact accounts only for 15% of the total environmental burden.

Moreover, Silvia Bamonti et al. [7] investigates on the recycling performance of construction and demolition waste, both by technical and environmental point of view. A comparative LCA study of concrete with aggregates and cement replacement (C&DW or ceramic scraps and fly ashes) is performed by the author, in order to identify the most suitable concrete recipe toward sustainability. The comparison among several recipes proposed in the study shows that the replacement of cement represent a crucial factor for climate change damage reduction. Indeed, the 13% of damage reduction is obtained by a 10% of additional replacement of natural aggregates with C&DW.

According to Valeria Corinaldesi et al. [8], in order to promote the reuse of C&DW in concrete it is necessary to achieve three concepts: assurance of safety and quality, decrease of environmental impact and increase of cost-effectiveness of construction. Results of the study show that recycled aggregate concrete can acquire satisfying quality as structural concrete and obtain improvement for what concerns both environmental impact and costs.

However, as affirmed by Flora Faleschini et al. [9], in some case recycled aggregates supply chain may not be as sustainable as expected, principally due to the high environmental loads of transportation. The study aims to compare the environmental impact due to quarrying, transportation, recycling and landfilling of C&DW. Recycled aggregates plant is responsible for higher direct emissions than natural aggregates one (related, for instance, to dust emissions or leaching into water bodies). However, natural aggregates facility is globally responsible for higher emissions than the recycled aggregates plant, according to the greater number of pre-processing involved in the natural aggregates productive chain. For this reason, the author highlights the importance of the interactions between the two productive chains, in order to allow the reduction of the environmental loads associated to facilities starting up.

For what concerns the production of coarse recycled aggregates, the fine fraction, also called recycled sand, is involuntary produced and it represents a large amount of the crushed construction and demolition wastes. Therefore, in order to solve the problem of fine fraction,

several authors investigated the properties of concrete containing fine recycled concrete aggregates. Moreover, mortars manufactured with recycled sand are studied in recent years, such as Luciana Restuccia et al. [10] and Giacomo Moriconi et al. [11]. Both the authors investigate an innovative mortar mix design for using recycled sand from C&DW, by partial replacement of standardized sand with recycled sand. The main aim of these researches is to analyse how improving the quality of the recycled aggregates, in order to foster a sustainable and more efficient use of construction and demolition waste and to reduce the environmental impact related to their generation.

With reference to the production of bricks, many researchers have studied the utilization of waste materials to produce bricks, aims to the environmental protection and a sustainable development. For instance, Antonella Petrillo et al. [12] carries out a study regarding the possibility of utilizing C&DW as secondary raw materials in the industrial production of geopolymer paving blocks, in order to reduce the demand of natural materials that would need quarrying. Moreover, a comparative evaluation of carbon footprint of both geopolymer and traditional concrete paving blocks is provided. Indeed, geopolymer bricks represent the result of one of the way to produce bricks from waste materials and in Italy are considered as a new family of eco-sustainable masonry unit.

Although the utilization of construction and demolition waste for the production of recycled materials for building application, crushed C&DW are usually utilised in Italy also as unbound aggregates in road construction applications. Considering the strong impact of road infrastructures on both the surrounding environment as well as on the consumption of locally available natural resources, several Italian studies have been conducted. For instance, Marco Guerrieri e al. [13] investigates on different road construction techniques with the aims to quantify the potential environmental impacts associated with C&DW utilization in road construction. The environmental effects due to the use of recycled materials, such as the Reclaimed Asphalt Pavement from dismissing of damaged pavements layers and the reuse of fine soil from excavation, traditionally sent to landfill, is taken into account by the author. The comparison between different scenarios shows interesting results in terms of related emissions. Indeed, the utilization of recycled materials allows to achieve a remarkable reduction in energy

consumption (up to 34%) and pollutant emissions (up to 30% of CO_2 emissions) compared to the scenario where only virgin materials are used.

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