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2020 ENEA

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Sustainable Economic Development

ISBN: 978-88-8286-394-4

Editorial review: Giuliano Ghisu

Cover design: Cristina Lanari

RECYCLED AGGREGATES: CIRCULAR ECONOMY IN THE CONSTRUCTION SECTOR – THE CASE STUDY OF SARDINIA REGION

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ABSTRACT

The research project funded by Sardegna Ricerche (POR FESR 2014/2020 funds) aimes to define applicable Circular Economy strategies in the construction sector to support the Sardinia Region, in particular recycled aggregates in the structural concrete. The research group of the University of Cagliari, the stakeholders (recycling plants, concrete producers, precast concrete companies) and the Regional Public Administration carry out a synergic work to activate virtuous processes, through case studies, that can be replicated. The analysis regards the recycling of demolished large structure rubble, the use of recycled aggregates in precast concrete companies and the use of aggregates and recycled concrete and their amount in the urban planning of three town of Sardinia.

Keywords: *Construction and Demolition Waste, Recycling, Recycled Aggregates, Mechanical Properties, Circular Economy*

Introduction

The construction sector consumes annually huge amount of aggregates that contribute to environmental losses. Recycling of Construction and Demolition Waste (C&DW) as recycled aggregates in new concrete limits the exploitation of natural resources and the extension of landfills. It is important to highlight and inform that there are no technical or economic obstacle to the use of recycled aggregates obtained by recycling concrete debris [1-5].

A life cycle assessment of a building includes all the stages in the assessment: raw material supply, manufacture of construction products, the construction process stage, use stage, demolition and when the materials are disposed of or recycled and used in new building [6-8]. C&DW are special waste and, therefore, must be disposed in landfills; otherwise, the unlawful practice to litter them causes serious environmental impacts.

The recycled C&DW are usually used as fill materials or in road construction but, in Northern Europe, their use is more noble and profitable: they are also used in reinforced concrete structures.

The European and National Standards impose the recycling of C&DW.

The Minimum Environmental Criteria (CAM), that allow the identification of the design solution, the product or the best service from an environmental point of view throughout the entire life cycle, must be applied according to Italian Legislative Decree No. 50, 2016 and the Law N. 221, 2015. In Italy, at present, there are two important unsolved problems: there isn't an End of Waste criteria for construction waste and selective demolition is not obligatory. The aim of this work is to strengthen the sustainability concept in civil construction and to provide an important contribution to the C&DW management plan of Sardinia.

Methods

The University of Cagliari research group and the stakeholders (recycling plants, concrete producers, precast concrete companies), through case studies, demonstrate the possibility of activating virtuous processes that can be replicated, in order to support and direct to the C&DW management plan of Sardinia.

The case studies examined are the following:

- Recycling of C&DW produced by the demolition of a large building;
- Use of recycled aggregates (RA) in Precast Concrete Companies;
- Use of recycled aggregates and recycled concrete in the urban planning of three town of southern Sardinia.

Recycling of C&DW produced by the demolition of a large building. The football stadium located in Cagliari (Sardinia, Italy, constructed in 1968) will be demolished and a new generation stadium will be built. The large amount of waste consists mainly of reinforced concrete structures. There are two important problem: the landfill disposal and natural aggregates (NA) supply. The Municipality of Cagliari, owner of the Stadium, authorized the research group to start an extensive experimental campaign to characterize the structural concrete element of Sant'Elia Stadium, the RA (according to the CE + marking) and the recycled concrete produced by RA, in order to evaluate their mechanical properties. Figure 1 shows the San'Elia stadium, the demolition operations, the C&DW recycling process and the RA produced.

Figure 1. By demolition to production of RA

The experimental data show that the San'Elia stadium structural concrete has a limited compression strength and the carbonation depth is important (compression strength 21 N/mm^2, carbonatation depth 31 mm). RA produced by demolished concrete, characterized according to the CE + marking, are suitable for structural concrete. Performance of recycled concrete made with coarse RA, even when the replacement percentage of coarse RA reaches 80%, are suitable for structural concrete. In all concrete mixes the same cement dosage was used. The performances of recycled concrete have comparable mechanical performances to the conventional concrete, with the same manufactoring process.

Use of RA in Precast Concrete Companies. Precast concrete companies can have advantages in recycling the scraps of their manufacturing processes or using RA by recycling plants, for the new elements production. This system reduces production costs (the cost of RA is half as much as NA), respects the CAM and therefore respect the Environment.

The concrete blocks are ordinary precast concrete elements, widely used in construction sectors. The experimental campaign to explore the feasibility of using the coarse recycled concrete RA in the concrete blocks production has been carried out. The experimental campaign has shown that it is possible to use the RA to produce precast recycled concrete blocks, without change manufactoring process and additional costs.

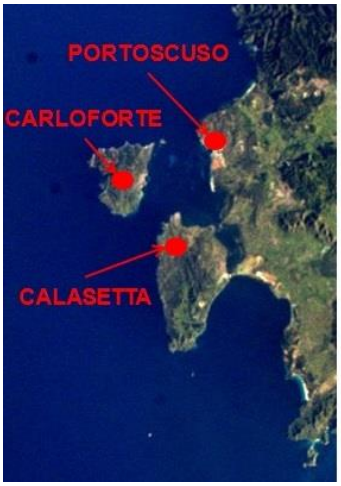
The performance (compressive strength and water absorption) are excellent even when the replacement percentage of RA reaches 100%. Figure 2 shows the production process and the performances obtained.

Mix	Average Density (Kg/m^3)	Average Absorption ($g/(m^2 \cdot s^{0.5})$)	Average Compressive Strength (N/mm^2)
NA	2069	108.9	3.77
20% RA	2009	103.9	3.58
50% RA	2087	93.3	3.58
70% RA	2039	126.3	2.85
100% RA	1954	111.1	3.40

Figure 2. Concrete blocks manufacturing process with recycled aggregates and their performances

Use of RA and recycled concrete in the urban planning. Three case studies have been carried out in the South of Sardinia (towns: Carloforte, Calasetta and Portoscuso) to explore the feasibility of RA using in compliance with urban and coastal areas planning, that include construction of cycle and pedestrian path, new buildings and existing buildings maintenance.

The estimated amount of aggregate required for the new constructions is approximately 2 t/m^2, 0.1 t/m^2 for the maintenance of existing constructions and 0.5 t/m^2 for cycle and pedestrian paths. The evaluation shows that up to 800,000 tons of C&DW by concrete can be recycled. Figure 3 shows the towns geographical location and assessments.



Town	Calasetta		Carloforte		Portoscuso	
% RA	30%	80%	30%	80%	30%	80%
RA in new constructions (t)	8673	23127	15336	40897	18753	50008
RA in maintenance of constructions (t)	152	404	342	911	486	1296
Town	Calasetta		Carloforte		Portoscuso	
% RA	100%		100%		100%	
RA in subbase layers (t)	34198		167872		66989	
Town	Calasetta		Carloforte		Portoscuso	
Total RA (t)	43022	57729	183550	209675	86228	118794
Recycled concrete C&DW (t)	86044	115458	367100	419359	172456	236587

Figure 3. Towns geographical location and assessments

Conclusions

1. The concrete with coarse recycled aggregates has comparable mechanical performances to the conventional concrete, even when the natural aggregates replacement percentage reaches 80%.
2. The performance of recycled concrete is not related to the parent concrete mechanical properties, but it is essential to define carefully the mix design.
3. Concrete blocks, ordinary precast concrete elements, can be produced using RA, without changes in the manufactoring process. The recycled concrete blocks properties are not significantly affected by RA also when replacement percentage reaches 100%.
4. Waste mapping and selective demolition processes should be promoted and enforced to facilitate recycling.
5. Trade association, University of Cagliari Research Group and Regional Public Administration carry out pilot projects to demonstrate the feasibility of using recycled aggregates in structural concrete, in precast concrete elements and not only as fill materials or in road construction.

The Authors would like to acknowledge SardegnaRicerche for the financial support (POR FESR 2014/2020 - Asse Prioritario I "Ricerca Scientifica, Sviluppo Tecnologico e Innovazione").

References

1. L. Pani, L. Francesconi, G. Concu (2011). Influence of replacement percentage of recycled aggregates on recycled aggregate concrete properties. Fib Symposium Prague, 8-10 June, ISBN 978-80-87158-29-6.
2. L. Pani, L. Francesconi, G. Concu (2013). Relation between Static and Dynamic Modulus of Elasticity for Recycled Aggregate Concrete. First International Conference on Concrete Sustainability 27-29 May, Tokyo, ISBN 978-4-86384-041-6 (-C3050), 676-681.
3. L. Pani, G. Balletto, S. Naitza, L. Francesconi, N. Trulli, G. Mei, C. Furcas (2013). Evaluation of mechanical, physical and chemical properties of recycled aggregates for structural concrete. Proceedings Sardinia Symposium, XIV Intern. Waste Management and Landfill. S. Margherita di Pula, Italy; 30 September – 4 October, Publisher by CISA, ISBN 9788862650281.
4. L. Francesconi, L. Pani, F. Stochino (2016).Punching shear strength of reinforced recycled concrete slabs. Construction and Building Materials 127 (2016) 248–263.
   doi: https://doi.org/10.1016/j.conbuildmat.2016.09.094
5. F. Stochino,L. Pani, L. Francesconi, F. Mistretta (2017).Cracking of Reinforced Recycled Concrete Slabs. International Journal of Structural Glass and Advanced Materials Research, Volume 1, Issue 1, Pages 3-9.doi: https://doi.org/10.3844/sgamrsp.2017.3.9
6. A. Rao, K.N. Jha, S. Misra (2007). Use of aggregates from recycled construction and demolition waste in concrete. Resources, Conservation and Recycling, 50(1), 71–81. doi: https://doi.org/10.1016/j.resconrec.2006.05.010
7. C. Meyer (2009). The greening of the concrete industry. Cement and Concrete Composites, 31(8), 601–605. doi: http://dx.doi.org/10.1016/j.cemconcomp.2008.12.010
8. K. Kovler, N. Roussel (2011). Properties of fresh and hardened concrete. Cement and Concrete Research, 41(7), 775–792. doi: http://dx.doi.org/10.1016/j.cemconres.2011.03.009