A Review on Partial Replacement of Cement by Corn Straw Ash and Partial Replacement of Coarse Aggregate by Construction and Demolition Waste in Concrete

Jency Sara Kurian, Alphonsa Philip

Abstract: The paper reviews the changes of the fresh and harden properties and variation of microstructure in cement by partial replacement of cement by corn straw ash and partial replacement of coarse aggregate by construction and demolition waste in concrete. The production of cement attributed to the emission of green house gases especially carbon dioxide. The paper emphasizes the study of the reduction of cement content and make an eco-friendly concrete. Construction and demolition waste is a main problem in construction industries by land space consumption, pollution etc... The paper attributes the use of CDW in a way that is not harmful to the environment.

Index Terms: CONSTRUCTION AND DEMOLITION WASTE (CDW), CORN STRAW ASH (CSH)

I. INTRODUCTION

Concrete is the most widely used materials in the world.Therefore ,it is essential to minimize the effects of this on the environment.By the production of cement a large volume of CO_2 is emitted. According to C.Chen(2009),cement production causes 5-7% of the total CO_2 emissions,and production process of cement causes,20% of global warming. Wei.Chin et.al explained that cement industry is the main source of emission of hazardous compounds like carbon monoxide and heavy metals. The increased gathering of raw materials for growing cement production results in a decrease in the quantity of non-renewable resources like limestone.. Success in using other alternative materials to act as a binder in concrete that consumes less natural resources, is less expensive, and has less environmental impact would contribute to a more sustainable and healthier environment for future generations. It's feasible that some of these raw elements could be replaced whole or partially by cheaper materials with a comparable composition, lowering the cost of concrete production without sacrificing quality. Cement replacement materials, often known as pozzolans, are the components in question. Meta kaolin (china clay), brick powder, stone dust, industrial wastes (fly ash, silica fume, blast furnace slag, etc.) and agricultural wastes (rice husk ash, wheat straw ash, hazel nutshell and sugarcane bagasse ash, etc.) are all examples of agricultural wastes. Introduce a bio material Cornstraw Ash (CSA),which is a pozzolanic material . This paper investigates the feasibility of using corn stover ash (CSA) as supplementary cementitious material to replace cement in concrete. Currently, a large amount of aggregates are needed to manufacture concrete for infrastructure developments, and these aggregates are mined from natural resources, resulting in enormous depletion. One solution is to use construction and demolition waste as recycled concrete aggregate as an alternative to natural aggregates, while keeping in mind the environmental impact and protection, problems with excess waste materials, and energy and natural resource conservation for long-term development. The use of RCA for structural concrete is growing in popularity, however the material's undesirable and distinct features from natural aggregates are a source of concern, necessitating a methodical approach to standardising the material. Today, a variety of chemicals are used to create unique and innovative concretes. According to N.Singh.et.al construction aggregates have a global demand of more than 26.8 billion tonnes per year. This paper also reviews the partial replacement of coarse aggregate by construction and demolition waste in concrete.

II. CORNSTRAW ASH

Accoring to M.C.G Jueneger et.al The use of biomass ashes as a substitute for typical additional cementitious materials could be a viable option (e.g., blast furnace slag and fly ash). V. Ferreira-Leitão et.al explain Corn wastes are the most frequently used biomass on the world .The high corn production, which reached roughly 1.4 billion metric tonnes in 2018.[K.H. Mo, U.J. Alengaram et.al], is to blame for the significant amount of trash. The main wastes are cob and straw, which when properly burned can provide a large amount of ashes with pozzolanic potential. It is critical to do research on the use of maize straw ash as a supplementary cementitious material in order to prevent waste disposal sites. The possibilities of employing maize cob ash as a pozzolanic additive in the production of cements with up to 25% clinker replacement. A previous study found that replacing cement with cob ash harmed the workability of concrete. Furthermore, concrete made with up to 15% clinker replacement has increased mechanical characteristics and durability. The proportion of amorphous silica in biomass ash is directly related to biomass calcination, which in turn is related to pozzolanic activity. Temperatures above 800 °C and extensive calcination times enhance silica crystallisation, and the material may become inert or have minimal reactivity, according to studies. Carbonaceous chemicals may also linger in the ash after uncontrolled burning, reducing its activity and raising the water requirement of cementitious mixes. Biomass-based pozzolans may include high levels of metallic oxide contamination, such as K_2O and Na_2O, which can create concrete durability issues. These contaminated oxides may operate as fluxes during biomass combustion, speeding up silica crystallisation.

Corn straw

2.1 properties of corn straw ash

2.1.1 Particle size distribution

Mahmoud Shakouri et.al explainsThe particle size distribution of three different types of milled CSA is shown IN FIG .2. The median particle size (d50) of Acid washed -CSA, Water washed-CSA, and Untreated-CSA is 18.8 m, 17.2 m, and 54.8 m, respectively, according to the results of this test. The slagging effect during the combustion process, which can be caused by the high potassium content of the ash, can be blamed for the higher particle size of U-CSA [29]. For A-CSA, W-CSA, and U-CSA, the specific surface area is 1493 m2 /kg, 1740 m2 /kg, and 804.4 m2 /kg, respectively. These findings indicate that milling time and energy would be required for U-CSA to achieve fineness levels comparable to A-CSA and W-CSA.

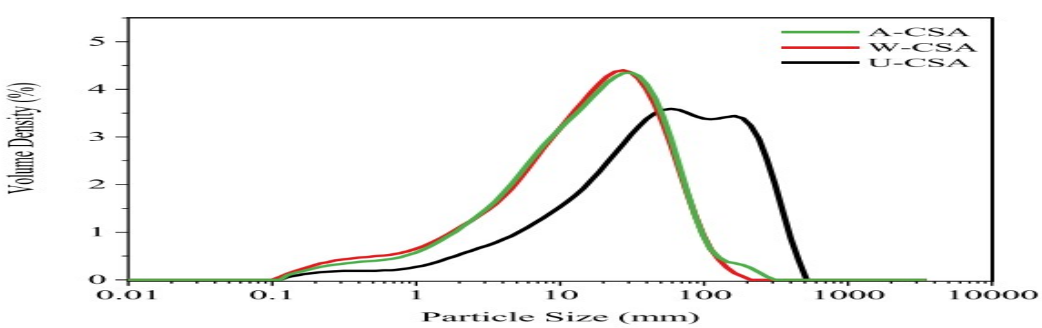


Fig .2 Particle size distribution

2.1.1 Microscopic observation by SEM

According to Chunyu Songet.al Figure 3 depicts the morphology of maize stalks at the microscopic level, from low to high multiples. Corn stalk has a honeycomb-shaped high porosity structure, which contains two forms of porosity: intraparticle porosity and interparticle porosity. Corn stalks with a high porosity structure have a high water absorption and retention capacity. Water has a significant impact on many physical properties of plant concrete, including thermal and acoustic properties.

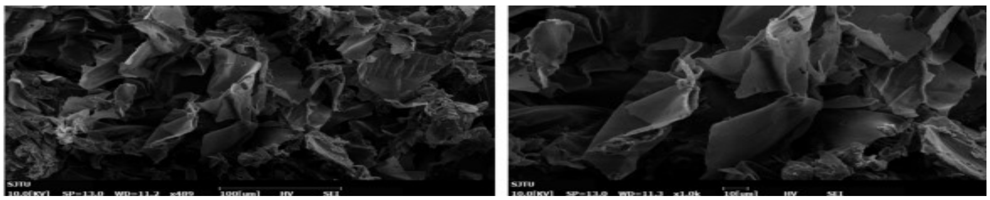


Fig.3 Morphology of corn straw ash

2.1.3 Chemical Composition[ASH(Mahmoud Shakouri.et.al(2020)]

Constituent	Percentage
SiO_2	47.78
Al_2O_3	9.40
Fe_2O_3	8.31
CaO	16.70
MgO	7.80
Mn_2O_3	2.70
K_2O	5.42
Na_2O	1.89

III. CONSTRUCTION AND DEMOLITION WASTE

Due to a shortage of acceptable disposal locations for construction and demolition waste (CDW) and incorrect disposal procedures, the huge amounts of trash created by the construction industry harm the environment. These issues, on the other hand, create an impetus to develop recycling alternatives. V. Corinaldesi, et.al focus that there is currently no standard definition of CDW that is applicable all across the world. On the definition of CDW, researchers and academics in industrialised countries have differing viewpoints.Building wastes created during construction and decoration are classed as urban solid waste, according to the MOHURD's "Classification of Urban Solid Waste and Emissions" (CJ/ton3030-1996).

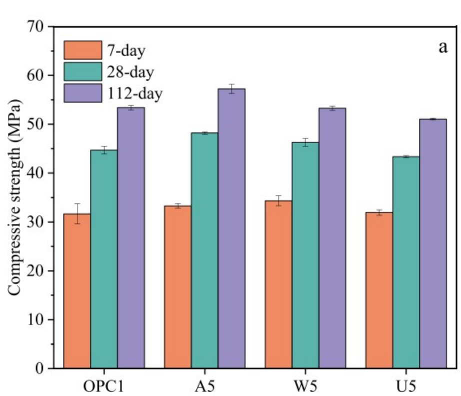
3.1.1 Properties of CDW

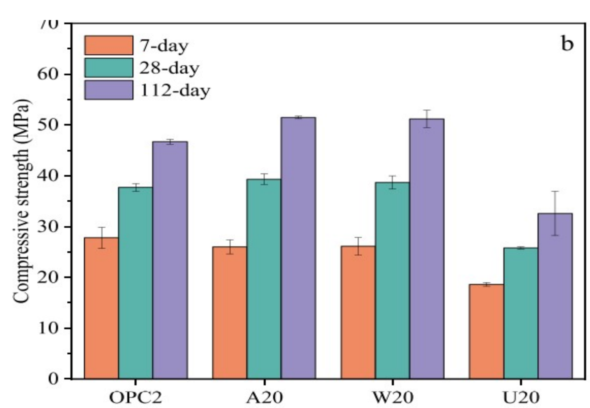
PROPERTY	NATURAL AGGREGATE	RECYCLED AGGREGATE
FINENESS	6.25	5.45
SPECIFIC GRAVITY	2.657	2.469
BULK DENSITY	Compact state=1.55kg/L Loose state=1.404kg/L	Compact state1.44kg/L Loose state1.31kg/L
CRUSHING VALUE	27.56%	28.1%
IMPACT VALUE	21.176%	29.66%
WATER ABSORPTION	0.311	2.24

IV. PROPERTIES OF CORN STRAW ASH ON CONCRETE

4.1 Compressive Strength

According to Christopher .L.Exstrom et.al ,the general trend in reveals that adding CSA to concrete at a 5 percent replacement level improves its compressive strength marginally. W5 has a score of 34.4.The highest 7-day compressive strength is MPa, which is 8.4% greater.3.0 percent higher than A5 concrete, 7.5 percent higher than OPC1, and 7.5 percent higher than U5.specimens. However, at 112 days, A5 had the highest pressure (54.2 MPa).Fig .4 explains the Compressive strength is 7.1 percent higher than OPC1 and 12.1% higher than OPC2.W5 specimens scored 7.4 percent higher than U5 specimens. When working with small groups,SCM reaction or chemical consequences are unlikely to occur in large volumes of SCMs.compressive strength, and a minor increase in tensile strength. The filler effect accounts for a significant portion of the compressive strength.The extent of cement hydration is increased .According A.Rheem et.al to With the exception of 5% CSA substitution, which was greater than the control after 3 days of curing, the CSA interlocking paving stones had lower compressive strengths than the control. The strength declined as the amount of corn stalk ash in the mixture increased, from 5.08 N/mm2 for a 5% CSA replacement to 2.47 N/mm2 for a 25% replacement. The highest compressive strength was found when OPC was replaced with CSA by 5%.





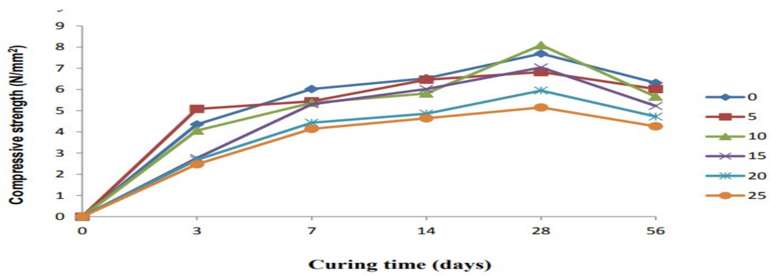


Fig.4 compressive strength

4.2 Water absorption

The impacts of CSA % substitution on the interlocking paving stone's water absorption rate are presented. The rate of water absorption rose with increasing amounts of corn stalk ash, with values ranging from 3.56 percent for the control trial to 11.8 percent for a 25 percent CSA substitution, as shown in the graph. This suggests that the interlocking stone's water affinity rose as the CSA content grew, which is consistent with previous findings showing a higher CSA content in concrete enhanced its water affinity (Udoeyo et al., 2006; Sashidhar and Rao, 2010; Chowdhury et al., 2015).

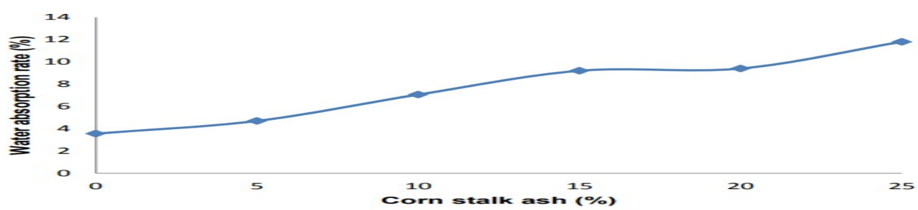


Fig .5 Water Absorption

4.3 Density

The impact of replacing corn stalk ash with other materials on the density of interlocking paving stones at various levels. The curing durations. The density of the CSA interlocking was found to be high.Stones decreased as corn stalk ash content grew, but increased as curing progressed.time. With CSA substitution, density dropped from 1940 kg/m3 to 1900 kg/m^3 after 3 days of curing.1760 kg/m3 for the control for the CSA substitution at a rate of 25% A drop in density was also seen after 7 days.CSA replacement ranges from 0% to 25%, but with a higher density than 3 day replacements. At the 14-day and 28-day mark. The density of the CSA replacements decreased after 56 days of curing, but it was still higher than the 28-day results.

V. PROPERTIES OF CDW ON CONCRETE

5.1. Absorption by immersion, porosity, and bulk density.

Literatures show that the samples containing CDW materials possess higher values for porosity than the reference mortars, as has been discussed in literature . It exhibited higher porosity and water absorption values than the CRA mortars, largely because of the MRA material’s elevated absorption capacity and the high w/c ratio used in the manufacturing process. Similar results werefound by Martínez et al. , in which mortars made from ceramic aggregates exhibited absorption and porosity values from 20.7% to 23.3% at 28 days, compared to values from 32.3% to 33.9%, for MRA mortars, both with w/c ratios ranging from 1.6 to 1.78. Although the porosity of the MRA is demonstrably higher, consideration must also be given to the pore size distribution in the material. Corinaldesi states that mortars with CDW exhibit a greater open porosity because of the inherent porosity of the aggregate, but they may also possess slightly fewer small pores (with diameter > 1 lm). The bulk density of the hardened mortar was observed to decrease with an increase in the replacement level for both the recycled aggregate types, as previously observed in other studies. This is largely because the bulk density of CDW is lower than that of the reference aggregate, and these results are consistent with previous investigations. The densities of the mortars made with the CRA material were lower than those made with the MRA material for all the replacement levels because the bulk density of the CRA itself is lower.

5.2 Compressive strength

Concrete's compressive strength is widely regarded as its most useful mechanical attribute since it usually gives a general idea of the concrete's quality and It is inextricably linked to other qualities. Researchers in the past have reported a loss in RAC compressive strength as low as 10%.The measured compressive strength of the concrete containing the RA material is analogous to previous findings by Neno et al. , Samiei et al. , and Zhao et al. , who found that this property decreased as the percentage of NAs replaced by residue increased . The concrete made with the CRA aggregate had higher compressive strength values than the concrete made with the MRA aggregate, especially at replacement levels greater than 50%, which is consistent with earlier research . Furthermore, sample age was shown to have a statistically significant effect on compressive strength, and values higher than 8 MPa at 91 days. When compared to mortars built with natural sand, recycled concrete was shown to have worse qualities such as compressive strength. This was expected since the performance of the aggregates, rather than the strength of the cement matrix, becomes increasingly important . Despite the relevance of compressive strength in classifying mortar materials, Silva believes that the selection criteria for concrete should be primarily based on workability and bond strength.

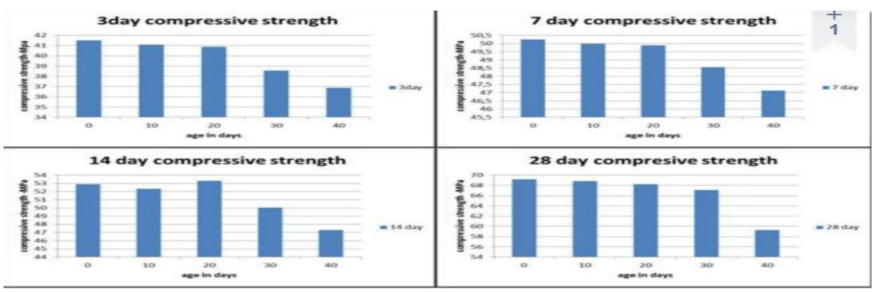


Fig.6 compressive Strength(Jairo José de Oliveira Anndrade et.al 2018)

5.3 Flexural strength

The flexural strength behaves differently from the compressive strength, increasing slightly as the percentage of RA material utilised increases. However, this rise is not without its drawbacks.As seen in the ANOVA, was not considered statistically significant.Demonstrated to be important elements in flexural strength determination Martnez et al. found no significant changes in flexural strength between the replacement and the original in a similar research. percentages ranging from 75% to 100% Furthermore, the flexural strength has been improved. In all cases, the replacement % is found to have a bigger influence than the aggregate type, as demonstrated by Jiménez et al, Furthermore, the kind of RA had a statistically significant impact on all mechanical properties, whereas the amount of residue had a statistically significant impact on just the compressive strength. The age of the samples at the time of testing had the greatest impact on mechanical qualities, while only the aggregate type had a significant impact on bond strength, while the % of RA content had no effect. Similar results were achieved by Jiménez et al. , who found that CRA mortars combined with a 10% replacement ratio had the highest bond values. Despite the fact that there was no statistically significant difference between the mean values for all investigated replacement levels, there was no statistically significant difference between the mean values for all investigated replacement levels.

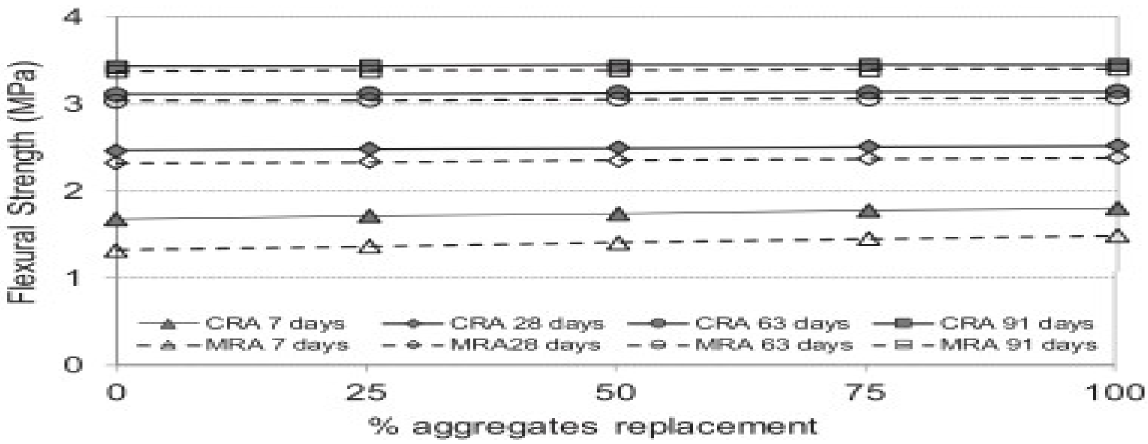


Fig 7 Flexural Strength (Jairo José de Oliveira Andrade et.al 2018)

5.5 Split Tensile strength

Although the recycled aggregate content has been increased, the split tensile strength results at 28 days reveal a negative trend in strength. The tensile strength of 100% RCA was the lowest, at only 3.41 MPa, with tensile strength losses ranging from. The difference between a synthetic aggregate specimen and a natural aggregate specimen ranges from 9% to 24%. The use of a plasticizer boosted the reduction in splitting tensile force by a factor of two, and the percentage rose by 4% when both silica fume and a superplasticizer were applied.

VI. CONCLUSION

The research examines how partial replacement of cement with maize straw ash and partial replacement of coarse aggregate with construction and demolition debris in concrete affects the fresh and harden characteristics as well as the microstructure. Cement manufacture is linked to the release of greenhouse gases, particularly carbon dioxide. The focus of the paper is on researching ways to reduce cement content and create environmentally friendly concrete. Construction and demolition waste is a major issue in the construction industry due to land consumption, pollution, and other factors. The use of CDW in an environmentally friendly manner is credited in the study.

REFERENCES

[1] Dr. Ghassan K. Al-Chaar* and Dr. Mouin Alkadi(2013) "Natural Pozzolan as a Partial Substitute for Cement in Concrete" The Open Construction and Building Technology Journal DOI: 10.2174/187483680130701003.

[2] Jieru Zhang, Gengyuan Liu, Bin Chen et.al (2014) "Analysis of CO2 Emission for the cement

[3] manufacturing with alternative raw materials: A LCA-based framework". Energy Procedia 61 (2014) 2541 – 2545.

[4] Yongquan Wei , Chunyu Song et.al (2019) "Experimental investigation on two new corn stalk biocomposites based on magnesium phosphate cement and ordinary Portland cement".Construction and building materials 224(2019)700-710.

[5] Karen L. Scrivener et.al (2018) "Eco-efficient cements: Potential economically viable solutions for a low-CO2 cement-based materials industry" Cement and Concrete Research.

[6] M. F. M. Zain (2015) "A knowledge-based system for mix design of concrete containing pozzolanic materials". AEI 2008: Building Integration Solutions.

[7] Lei Lang et.al (2020) "Experimental Investigation on Concrete Using Corn Stalk and Magnesium Phosphate Cement under Compaction Forming Technology".ASCE

[8] Mahmoud Shakouri et.al (2020) "Pretreatment of corn stover ash to improve its effectiveness as a supplementary cementitious material in concrete" Cement and Concrete Composites112(2020)103658.

[9] Charles Prado Ferreira de Lima et.al(2021) "Evaluation of corn straw ash as supplementary cementitious material: Effect of acid leaching on its pozzolanic activity"Cement 4(2021)1000007.

[10] Orhan Aksog et.al (2016) "Durability of concrete made by partial replacement of fine aggregate by colemanite and barite and cement by ashes of corn stalk, wheat straw and sunflower stalk ashes." Construction and Building Materials106(2016)253-263

[11] S.Sakthivel et.al (2019) "Experimental investigation on concrete with banana fiber and partial replacement of cement by banana leaf ash." International Research Journal of Engineering and Technology. Volume: 06.

[12] Jugal R et.al (2018) "Experimental Investigation on Properties of Concrete by Partial Replacement of Cement with Banana Leaves Ash." 6th International Conference on Recent Trends in Engineering & Technology (ICRTET - 2018).
[13] Rodrigo C. Kanning et.al (2014)."Banana leaves ashes as pozzolan for concrete and mortar of Portland cement". Construction and Building Materials.54(2014)460-465.
[14] Shaojun Xiong et.al (2010) "Corn Stalk Ash Composition and Its Melting (Slagging) Behavior during Combustion". Energy Fuels 2010, 24, 4866–4871 : DOI:10.1021/ef10059.
[15] Mahmoud Shakouri et.al(2020) "Pretreatment of corn stover ash to improve its effectiveness as a supplementary cementitious material in concrete". Cement and Concrete Composites112(2020)103658.
[16] Evi Aprianti et.al (2015)Supplementary cementitious materials origin from agricultural wastes – A review.74(2015)176-187.
[17] M.C.G. Juenger, R. Snelling, S.A. Bernal, Supplementary cementitious materials: new sources, characterization, and performance insights, Cem. Concr. Res. 122 (2019) 257–273, doi:10.1016/j.cemconres.2019.05.008.
[18] V. Ferreira-Leitão, L.M.F. Gottschalk, M.A. Ferrara, A.L. Nepomuceno, H.B.C. Molinari, E.P. Bon, Biomass residues in Brazil: availability and potential uses, Waste Biomass Valori. 1 (2010) 65–76, doi:10.1007/s12649-010-9008-8.
[19] K.H. Mo, U.J. Alengaram, M.Z. Jumaat, S.P. Yap, S.C. Lee, Green concrete partially comprised of farming waste residues: a review, J. Clean. Prod. 117 (2016) 122–138, doi:10.1016/j.jclepro.2016.01.022. [19] N. Singh, S. Singh, Carbonation resistance and microstructural analysis of low and high volume fly ash self compacting concrete containing recycled concrete aggregates, Constr. Build. Mater. 127 (2016) 828–842, https://doi.org/10.1016/ j.conbuildmat.2016.10.06
[20] P.S. Lovato, E. Possan, A.B. Masuero, D.C.C. Dal Molin, J.D. Ribeiro, Modeling of mechanical properties and durability of recycled aggregate concretes, Constr. Build. Mater. 26 (2012) 437–447, https://doi.org/10.1016/ j.conbuildmat.2011.06.043.
[21] C. Thomas, J. Setién, J. Polanco, P. Alaejos, M. Sánchez de Juan, Durability of recycled aggregate concrete, Constr. Build. Mater. 40 (2014) 1054–1065, https://doi.org/10.1016/j.conbuildmat.2012.11.106.
[22] S. Laserna, J. Montero, Influence of natural aggregates typology on recycled concrete strength properties, Constr. Build. Mater. 115 (2016) 78–86, https:// doi.org/10.1016/j.conbuildmat.2016.04.037.
[23] A. Cabral, V. Schalch, D. Dal Molin, J. Ribeiro, Mechanical properties modeling of recycled aggregate concrete, Constr. Build. Mater. 24 (2010) 421–430, https://doi.org/10.1016/j.conbuildmat.2009.10.011.
[24] S. Silva, J. Andrade, Investigation of mechanical properties and carbonation of concretes with construction and demolition waste and fly ash, Constr. Build. Mater. 153 (2017) 704–715, https://doi.org/10.1016/ j.conbuildmat.2017.07.143.
[25] V. Corinaldesi, G. Moriconi, Behaviour of cementitious mortars containing different kinds of recycled aggregate, Constr. Build. Mater. 23 (2009) 289–294, https://doi.org/10.1016/j.conbuildmat.2007.12.006.
[26] H. Higashiyama, F. Yagishita, M. Sano, O. Takahashi, Compressive strength and resistance to chloride penetration of mortars using ceramic waste as fine aggregate, Constr. Build. Mater. 26 (2012) 96–101, https://doi.org/10.1016/ j.conbuildmat.2011.05.008.
[27] V. Tam, C. Tam, A review on the viable technology for construction waste recycling, Resour. Conserv. Recycl. 47 (2006) 209–221, https://doi.org/ 10.1016/j.resconrec.2005.12.002
[28] C. Neno, J. de Brito, R. Veiga, Using fine recycled concrete aggregate for mortar production, Mater. Res. 17 (2014) 168–177, https://doi.org/10.1590/S1516- 1439201300500016
[29] P. Martínez, M. Cortina, F. Martínez, A. Sánchez, Comparative study of three types of fine recycled aggregates from construction and demolition waste (CDW), and their use in masonry mortar fabrication, J. Cleaner Prod. 118 (2016) 162–169, https://doi.org/10.1016/j.jclepro.2016.01.05
[30] V. Corinaldesi, Mechanical behavior of masonry assemblages manufactured with recycledaggregate mortars, Cem. Concr. Compos. 31 (2009) 505–510, https://doi.org/10.1016/j.cemconcomp.2009.05.00
[31] Martínez, M. Etxeberria, E. Pavón, N. Díaz, A comparative analysis of the properties of recycled and natural aggregate in masonry mortars, Constr. Build. Mater. 49 (2013) 384–392, https://doi.org/10.1016/ j.conbuildmat.2013.08.049.
[32] J. Silva, J. de Brito, R. Veiga, Recycled red-clay ceramic construction and demolition waste for mortars production, J. Mater. Civ. Eng. 22 (3) (2010) 236– 244, https://doi.org/10.1061/(ASCE)0899-1561(2010) 22:3(236).
[33] C. Neno, J. de Brito, R. Veiga, Using fine recycled concrete aggregate for mortar production, Mater. Res. 17 (2014) 168–177, https://doi.org/10.1590/S1516- 1439201300500016
[34] R. Samiei, B. Daniotti, R. Pelosato, G. Dotelli, Properties of cement-lime mortars vs. cement mortars containing recycled concrete aggregates, Constr. Build. Mater. 84 (2015) 84–94, https://doi.org/10.1016/j.conbuildmat.2015.03.04
[35] Z. Zhao, S. Remond, D. Damidot, W. Xu, Influence of fine recycled concrete aggregates on the properties of mortars, Constr. Build. Mater. 81 (2015) 179– 186, https://doi.org/10.1016/j.conbuildmat.2015.02.03
[36] R.B.J.D.R. Silva, Performance of cementitious renderings and masonry mortars containing recycled aggregates from construction and demolition wastes, Constr. Build. Mater. 105 (2016) 400–415, https://doi.org/10.1016/ j.conbuildmat.2015.12.17
[37] Marios N. Soutsos et.al "Concrete building blocks made with recycled demolition aggregate" Construction and Building Material 25(2011)726-735
[38] Jairo José de Oliveira Andrade et.al "Evaluation of mechanical properties and carbonation of mortars produced with construction and demolition waste" Construction and Building Materialshttps://doi.org/10.1016/j.conbuildmat.2017.11.08