XV International Conference on Durability of Building Materials and Components
DBMC 2020, Barcelona
C. Serrat, J.R. Casas and V. Gibert (Eds)

Concrete Durability Probed Using Compressive Strength, Chloride Penetration and Porosity Measurements on CEMII and CEMV Concretes Incorporating Mollusc Shell Spares in Artificial and Natural Seawaters

Marine D. Georges[1], Amel. Bourguiba[1], Nassim. Sebaibi[1], Daniel. Chateigner[2] and Mohamed. Boutouil[1]

[1]COMUE Normandie Université, Laboratoire ESITC - ESITC Caen, rue Pierre et Marie Curie 1, 14610 Epron, France, marine.georges@esitc-caen.fr

[2]Normandie Université, CRISMAT UMR CNRS n°6508, ENSICAEN, Université de Caen Normandie, boulevard Maréchal Juin 6, 14050 Caen, France, daniel.chateigner@ensicaen.fr

Keywords: *Flat Oyster Larvae, Marine Infrastructure, Concrete, Bio-Colonisation, Durability.*

1 Introduction

This study is carried out within the framework of the European Marineff project. One of this study's objectives is the design of maritime infrastructures for flat oysters (*Ostrea edulis* Linnaeus, 1758) restoration in the Channel. Indeed, the flat oyster is an endangered species. One of the solutions could therefore be the design of bio-receptive and sustainable concrete for the implementation of these infrastructures. Concrete immersed in the marine environment will undergo chemical, physical and biological attacks that can lead to its deterioration (Bastidas-Arteaga *et al*., 2008). It is therefore important to design concrete that is as durable as possible in order to ensure its sustainability in its immersion environment.

Using a combination of laboratory and field experiments, we aimed to: (1) develop and optimize of concrete formulations by varying the type of cement and introducing shellfish by-products into their composition (2) determine which concrete formulation is the most sustainable to colonization of marine organism.

2 Methodologies

For this study, four concrete mix design were designed with 2 types of cement (CEMII and CEMV). A substitution of 20% of the aggregates by oyster shell was carried out. After the characterization of the materials, the concrete optimization was carried out in accordance with EN 206-1. The immersion was carried out during 3 months in natural seawater to study the colonization of samples by marine organisms. Durability (chloride ion diffusion, porosity accessible to water) and resistance strength tests (compressive test) were carried out on these samples in comparison with control samples (after a 90-days cure at 100% humidity) and immerged in artificial seawater.

3 Results

The samples were colonized by marine organisms (sessile fauna and some macro-algae) after 3 months of immersion in Natural SeaWater (NSW). The compressive strength increases for all concretes except for CEMV without shells immersed in NSW compared to the reference concrete. This increase is larger for concretes containing shell aggregates, with approximately 35% larger strengths for CEMII with shells and 24% without. The registered enhancement, is more important when the concrete contains shell aggregates. In artificial seawater (ASW, Figure 1A and B, solid lines), the presence of shells in the concrete (Figure 1B) tends to enhance chloride content by a factor of nearly 2 in the first millimeters. This tendancy is not observed for immersions in NSW (Figure 1A and B, dotted lines). The reason for such a behaviour could be seen in partial dissolution of shell pieces, which is more pronounced in artificial seawaters.

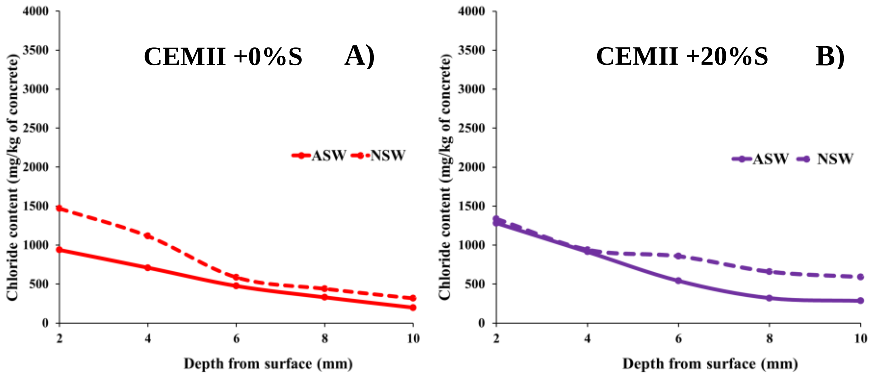

Figure 1. Chloride content after an immersion of 1 month in an Artificial SeaWater (ASW) (solid line) and after 3 months in Natural SeaWater (NSW) (dotted line) for concrete CEMII without (A) and with Shell (S) (B).

Measurements of porosity accessible to water indicate that, except for a slight increase in porosity of around 0.1-0.2%, the two concrete formulations made with CEMII remain stable after immersion for 3 months in NSW. The shell-containing CEMV concrete however exhibit less porosity decrease compared to such a concrete without shells.

4 Conclusion

Our results indicate that the CEMII concrete formulations are the more resilient to chloride penetration in ASW and NSW than CEMV concretes. The incorporation of shell aggregates does not significantly modify chloride penetration in NSW but increases it in ASW.

Calcium carbonates partial dissolution is more pronounced in ASW, and combined with an increased chloride ion penetration inside the first millimeters of the materials.

ORCID
Nassim Sebaibi: http://orcid.org/0000-0002-1241-2745
Daniel Chateigner: http://orcid.org/0000-0001-7792-8702
Mohamed Boutouil: http://orcid.org/0000-0002-2752-8265

References

Bastidas-Arteaga, E., Sánchez-Silva, M., Chateauneuf, A. and Silva, M.R. (2008). Coupled reliability model of biodeterioration, chloride ingress and cracking for reinforced concrete structures. Struct. Saf. *30*, 110–129.
NF EN 206+A1, Concrete - Specification, performance, production and conformity, 2016.