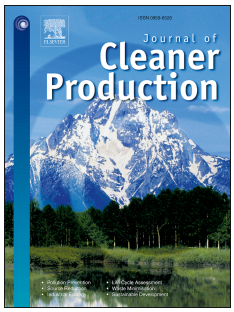
Accepted Manuscript



Reuse of Tunisian marine sediments in paving blocks: Factory scale experiment

Imen said, Amel Missaoui, Zoubeir Lafhaj

PII: S0959-6526(15)00532-6

DOI: 10.1016/j.jclepro.2015.04.138

Reference: JCLP 5508

To appear in: *Journal of Cleaner Production*

Received Date: 8 July 2014

Revised Date: 24 April 2015

Accepted Date: 24 April 2015

Please cite this article as: said I, Missaoui A, Lafhaj Z, Reuse of Tunisian marine sediments in paving blocks: Factory scale experiment, *Journal of Cleaner Production* (2015), doi: 10.1016/j.jclepro.2015.04.138.

Reuse of Tunisian marine sediments in paving blocks: Factory scale experiment

Imen SAID[a,*], Amel Missaoui[a], Zoubeir Lafhaj[b]

[a]*Université de Tunis El Manar, Ecole Nationale d'Ingénieurs de Tunis, LIG LR14ES03, 1002, Tunis, Tunisie.*
[b]*Ecole Centrale de Lille, Villeneuve d'Ascq, France*.

ABSTRACT

Important volumes of sediments are dredged periodically worldwide in order to maintain harbors commercial activities. Finding a new solution for managing these dredged marine sediments becomes a challenge for harbors managers. This research aims at demonstrating the practical reuse of the Rades harbor's non polluted sediments into paving blocks production. Thus, a full-scale industrial experiment test was carried at a paving blocks factory located in the north of Tunisia. Sediments already characterized in the laboratory were introduced in the mix-design with a substitution ratio of 19% as a partial replacement of quartz sand. Approximately 300 factory sediment-amended paving blocks (FSPB) were produced. The latters were then subjected to the main qualification tests (splitting tensile strength, water absorption, leaching test). The results showed that the substitution of quartz sand by sediments gave a splitting tensile strength (3.58 MPa) very close to the standards as well as a lower water absorption ratio (4.05%) than ordinary paving blocks. Moreover, leaching tests-results showed that the quantities of heavy metals leached from crushed paving blocks were within the regulatory limits. Thus, FSPB can be considered as non-hazardous materials. Finally, this research has led to a new use case of sediments recycling in manufacturing environment.

Keywords: sediment, marine, characterization, reuse, paving blocks, industrial scale.

1. Introduction

Over the years, high amounts of materials are needed and nearly all natural aggregates come from excavation of riverbeds or quarries, leaving the open spaces with deep holes and damaging the ecosystems (Dubois et al., 2009). On one hand, the natural aggregates are becoming scarce and expensive, and as governmental pressure is increasing to find innovative solutions, new resources should be found. Therefore, the need to extend the durability of materials in construction has resulted in the implementation of new recycled construction materials (Nguyen et al., 2013). On the other hand, the accumulation of sediments in harbors, channels, and rivers can prevent boat traffic and disrupt the physico-chemical balance of water masses (Boutin, 1999). To overcome the latter problems, dredging operations are necessary to maintain inland waterways and harbors. The increasing amount of these dredged sediments, about 600 M m^3 each year worldwide (Dubois, 2006), raises several problems such as finding the best ways to manage them especially if they are polluted and harmful to the environment. After extraction, sediments are either dumped at sea or disposed in lands. These operations are constrained by national and international regulations and conventions such as European commission (Bray, 2008; European Parliament and Council, 2008), OSPAR convention (1992), London convention (1972, 2013), Barcelona convention (UNEP and MAP, 2011), Helsinki convention (HELCOM, 2008).
In Tunisia, large amounts of sediments are dredged to ease circulation of ships in harbors. Tunisian administrations try to choose the suitable discharge sites, in order to manage dredged sediments while respecting the technical, environmental and economic criteria (CJB and EAM, 2007). According to the volumes of sediments and taking into account the frequency of dredging operations, the total volume of dredged sediments from all Tunisian commercial harbors is about 8 M m^3 per year (CJB and EAM, 2007). Around 2.5 M m^3 (32% of the total volume) of these sediments are dredged from the complex of harbors Rades –La Goulette located in the bottom of the Gulf of Tunis, on the northeast coast of Tunisia as shown in Fig. 1 (CJB and EAM, 2006). According to these large volumes of sediments, new solutions should be found, in addition to sea deposit and landfilling so as to dispose dredged materials. In order to choose the efficient alternative to manage and discharge marine sediments, Tunisian administration compares the results of environmental analyses to Netherlands standards in the absence of local legislation specific to the country (CJB and EAM, 2006; Eisma, 2000). Owing to the high cost of alternative solutions, such as terrestrial disposal that requires special treatment and large areas (LIFE, 2002), the development of beneficial use strategies of dredged sediments is therefore necessary. One of the strategies could be the reuse of dredged sediments in several applications such as erosive

Corresponding author. Tel.: +216 22 14 66 34 ; fax: +216 71 872 729
E-mail address: imensaid2@gmail.com (I.Said).