Use of polluted sediments in road construction

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Introduction: Every year, a large amount of sediments is dredged from harbours and river in the North of France (approximately 4 million m^3) [1]. Legislation about dumping at sea tends to protect the environment. Hence, the management of sediments led to develop them as materials in various domains (Civil engineering, Agriculture …) in accordance to technical, economical and environmental criteria.

The *Ecole des Mines* of Douai aims to develop methodology to use marine and river sediments in the Civil Engineering. This study shows the physical as the mechanical characteristics of the polluted marine sediments of Dunkirk harbour intended to be used as sub-base material.

Methods: The aim of this study is to extend the result obtained on low polluted sediments [2] [3]. The methodology adopted includes:
- The study of raw polluted sediments (from marine and river): physical, environmental, mineralogical characteristics and mechanical behaviour.
- The design of materials to be used as sub-base by adding sand and binder (lime and cement). Sand and binder additives allow to obtain the good granular skeleton and the interesting mechanical behaviour. This study is carried out on cylindrical samples (Φ=5cm, h=10cm), characteristics of these samples are fixed according to the optimal content of water, dry density and the bearing capacity. Measured parameters are compressive strength, the modulus of elasticity, the tensile strength, and the potential outputs of pollutants (test leaching). These parameters are very important for the use of materials in road structure because they allow obtaining an optimized granular arrangement and enough strength to support machines traffic during the roadwork.

Results: This article shows the characteristics of the polluted marine sediments from Dunkirk harbour, the results of Proctor test, index CBR immediate (CBRi) and mechanical behaviour in long term on four mixes. Granular skeleton of these mixes is made of fine sediments and dredged sand. For two mixes, career sand has been used.
Mixes have been treated with cement or a mix of cement and lime. According to the mix, fine sediment proportion has been fixed to 33 % in dry mass.
On table 1, the results of physical characteristics of low polluted and polluted marine sediments from the same harbour are shown.

	Polluted marine sediment	Low polluted marine sediment [2]
% < 2μm (Clay)	7.4	5.4
2μm < % < 63μm (Silt)	56.4	57.8
63μm < % (Sand)	36.2	36.8
% MO (by ignition)	8.6	4.5
ρ_s (kg/m^3)	2530	2530
VBs	3.4	3.1
W_L (%)	92.4	97.4
W_P (%)	37.4	45.0
I_P (%)	55	52.4

Table 1: Summary results of physical analyses on raw sediments

The results of Proctor perform on four mixes w% ≈ 10 to 11%; $\rho_d \approx$ 1900 to 2000 kg/m^3 and CBRi ≥ 65.

Discussion: The physical characteristics of two types of sediments are almost similar. The studied sediments contain a high quantity of organic matters (MO = 8.6%), that can be considered as organic materials, and this study has shown a big influence of these organic matters on the behaviour of sediments [2].
The formulas give high dry density and index CBR immediate (CBRi max = 91.1 and CBRi min = 65.4) allowing to ensure the traffic of machine on the road building (the minimal recommended value of IPI for the sub-base mustn't be lower than 45 [4]). The index CBR immediate increases with presence of career sand.

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