Title: Reuse of dredged sediments for geotechnical applications

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Research program

The reuse of dredged sediments represents an important challenge since the increasing interest in the development of sustainable methods to convert them from problematic waste into added-value construction materials.

Sediments are regularly dredged from the bottom of seas, lakes and rivers to ensure the navigability of waterways, prevent silting of reservoirs and remediate contaminated waterbeds. These sediments are treated as waste and dumped in diked containment areas that retain solids while allowing the carrier water to drain. About 100-200 million cubic metres of sediments are dredged every year in Europe, including 5-6 million in Italy alone, which constitute an enormous amount of material to be disposed of, posing significant environmental problems to local authorities worldwide.

Many of the above challenges could be overcome if sediments, instead of being treated as waste, were valorized and used in industrial applications. This would not only lessen the need of disposal facilities, but it would also create a low-cost resource for fabricating new products in line with the circular economy strategy promoted by the European Commission and the United Nations.

The use of dredged sediments as construction materials requires the prior improvement of their mechanical characteristics via compaction and/or chemical treatment. In the case of chemical treatment, the presence of contaminants inside the sediments may interfere with the binding reactions and, therefore, limit the effectiveness of the treatment.

The aim of the research project is to study the effect of organic matter (OM) (always found in dredged sediments) on the mechanical performance of the treated material by performing a wide campaign of geotechnical and geophysical tests. In construction applications, dredged sediments are often mixed with cement or lime to enhance their mechanical properties. OM is always present in dredged sediments and may alter the chemo-physical evolution of the stabilising reactions. As an example, OM may delay or even inhibit the hydration of pozzolanic binders by reducing the pH of the pore water solution and reacting with calcium to form insoluble products (Mohd Yunus et al. 2011).

To explore this aspect, pozzolanic reactions will be triggered by adding conventional binders (e.g. Portland cement, lime) to a low-reactive clay soil, which will be mixed with different amounts of OM to create a proxy of dredged sediments. This reference material will be subjected to a multiscale experimental investigation to highlight: a) the interaction between OM and calcium during the pozzolanic reactions, b) the key factors controlling the mechanical improvement of sediments and c) the time scale of the stabilisation process.

The investigation will then move to the natural sediments with their native OM content. Natural sediments will be initially tested to determine the amount and composition of OM together with the mineralogical constitution of their inorganic part. The sediments will then be treated with the same binders of the reference material to assess the impact of their organic and inorganic fractions on the observed mechanical improvement. Information about the effects of OM on the development of the pozzolanic reactions will be drawn from the comparison between the reference and natural materials. A similar methodology will be employed for studying the effects of OM on other chemical stabilisation treatments.

Proposal for a PhD position

The Department of Earth Science, Environment, and Resources of the University of Naples, Federico II invites applications for one PhD position in Earth Sciences. The research project will start from a systematic study of cement and lime stabilisation of dredged sediments by exploring the potential interference of the organic matter with the hydration reactions of the binders. The objective of this study is to provide a scientific interpretation to the observed performance of current stabilization treatments on sediments. The research methodology is based on multi-scale approach, involving investigation at particle, microstructure and representative volume scale levels. The experimental activities will be carried out at DiSTAR, where the PhD student will have the opportunity to acquire technical skills related to several experimental techniques at different scales of investigation. Furthermore, the proposed experimental activity requires a multidisciplinary approach due to the complexity of the analysed processes. Training courses of the Doctoral School will be available for the PhD student, in order to improve his knowledge on different topics. The work program will include a period of about 6 months to be carried out in one or more UNINA's research partner, in order to allow the PhD student to learn different experimental methods and to compare herself /himself with other scholars, also in order to have the possibility to further develop her/his career.

The research project will be funded with departmental funds from the Applied Geology and Geotechnical Group.