GEOTECHNICAL CHARACTERISATION OF DREDGED MATERIALS.

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Abstract: Concern over environmental effects of dredging, disposal of dredged material, and the increasing unavailability of suitable disposal sites, has put pressure for characterization of this material as a resource for various beneficial applications. Its mineralogy and Geotechnical properties qualify it for use in the manufacture of high value, beneficial use products. Therefore, comprehensive laboratory and field investigations are conducted to determine the engineering properties of the dredged material. The study shows how dredged material can be effectively used in bulk as a resource for various applications.

Keywords: Dredging; Material; Rock; characterization; Grain size; Atterberg Limits.

I. INTRODUCTION

Dredging of the Rivers and Lakes generates dredged material in bulk. The issues surrounding the disposal of this very large quantity of material will have a significant impact on both economic developments in the region and the environment. Current plans are to dispose of the uncontaminated sediments from these water bodies on shoreline in filling low lying areas surrounding them, both of which face opposition from environmental groups. The movement of large volumes of sediment from one location to another disrupts existing 'habitats' at both the dredging location and the disposal site.

Consequently, the environmental effects must be carefully evaluated in the light not just of the proposed benefit for one particular restoration goal but in terms of the habitats that are lost or replaced by the dredging or material placement. With the large amount of dredged sediments being generated, there is a dire need to consider reuse alternatives to disposal. Development of economically viable beneficial use alternatives have several attractions including reducing the need for aquatic disposal with attendant environmental advantages. The various uses could include fill for highway construction and capping material for brown-fields remediation projects. For all above uses/applications, Geotechnical characterization of dredged material forms an important consideration, which will help in proper use of this unwanted material.

II. DREDGED MATERIAL AND ITS SOURCES

Dredging is simply the removal of sediments from a body of water that have accumulated due to upland erosion in order to maintain a desired depth, as in a reservoir, lake, dam, shipping berth, navigation channel. Dredged materials exhibit properties similar to those of undisturbed native soil and rock materials in a subaqueous environment, but when excavated, removed, remoulded, or redeposited, the properties change accordingly as the original material structure changes. High water contents, low dry densities, and low shear strengths typify remoulded and deposited fine-grained dredged materials. Dredged material is categorised into various sediment types such as- Rock, gravel and sand, consolidated clay, silt or soft clay and a mixture of rock, sand silt and soft clay. Rock may range from soft marl like sandstone and coral to hard rock like granite and basalt. Depending on its size and quantity rock can be a valuable construction material. Gravel and sand are perhaps the most...
valuable resource and are routinely used for beach nourishment, wetland restoration and many other purposes. Consolidated clay, if the water content is low, can be used for engineering purposes. Silt and soft clay usually come from maintenance dredging, are rich in nutrients and thus are good for agricultural purposes such as topsoil and for wildlife habitat development. Mixed materials are somewhat more restricted in use options but may still be used for filling, and improvement and topsoil. Using dredged material as a resource is important, one could almost say urgent, because use – rather than disposal has broad societal, environmental and financial benefits. It contributes to global sustainability. The potential uses for dredged material depend on the type of dredged material, where it is dredged, how it is dredged and its overall acceptability. Two broad categories of proposed uses are often distinguished: Engineering uses and environmental uses.

III. USES OF DREDGED MATERIALS

Engineering uses of dredged material include: Construction including landfill and foundation materials; Isolation of contaminated sites; Flood and coastal protection, such as beach nourishment; Land improvement; and Placement on riverbanks. Environmental enhancement using dredged material includes: Habitat creation and improvement; Water quality improvement; Aquaculture; Agriculture; Recreation; Sustainable relocation; and pit filling. In both cases, criteria are to be established that ensure that extensive testing is done for suitability of materials, that the potential use site is in reasonable proximity to where the dredging is planned and that a thorough physical and chemical evaluation is done. Beneficial use of dredged material is an integral and necessary part of the dredge material management process. Dredged material can be beneficially used in upland, wetland, and aquatic environment.

IV. CHARACTERISATION OF DREDGED MATERIAL

Characterization of the dredged material is initiated by an evaluation of its physical properties including (a) grain-size distribution, (b) particle shape, (c) texture, (d) water content, (e) permeability, (f) plasticity, and (g) organic content. The engineering properties are used to determine the compactability, consolidation, and shear strength of the dredged material. An assessment of chemical properties can indicate the actions required to (a) obtain the desired pH or salinity, (b) determine a liming requirement to enhance buffering capacity or nutrient availability for plant growth, (c) improve texture, and (d) determine if inorganic (e.g., metals) or organic contaminants are present. Finally, the biological properties must be assessed to (a) evaluate the bioavailability of contaminants to plants and animals, (b) determine the potential for adverse environmental impacts, and (c) determine if control measures or restrictions are required to prevent adverse environmental impacts.

V. CHARACTERISATION TESTS USEFUL IN DETERMINING PHYSICAL PROPERTIES

Grain size and particle shape are useful in determining the stability, resistance to shear, permeability, compressibility, and compactability of the dredged material. Grain-size distribution and particle shape significantly impact on the weight-bearing capacity of soil or dredged material. Angular particles tend to interlock, forming a stable dense mass capable of bearing more weight than rounded particles, which tend to slide or roll past each other. Dense soils have greater weight-bearing capacities than loose soils. The strain required to reach failure is approximately twice as large for angular-shaped particles as that required to reach failure for spherical particles.

The texture of a soil is its appearance or “feel” and depends on the relative size and shape of the particles, as well as the range or distribution of those sizes. Soil texture is affected by the mineral content, organic matter, soil aggregates, and moisture present in the soil. Soil texture contributes to the water-storage capacity, water-infiltration rates, aeration, fertility, and ease of tilling, as well as
compressibility. The texture of dredged material can limit its beneficial uses. For example, predominantly sandy dredged material can be used as a fill material or in dike construction, but might not be suitable for vegetation establishment because of its low nutrient content and water-holding capacity.

Water content and permeability are interrelated and have a significant influence on the suitability of a dredged material for use as a fill, subgrade, or foundation material. Water content ($w$) is one of the most important factors affecting the properties and behavior of dredged material. Soil must be compacted to obtain the required strength and density while the water content is maintained at the optimum level during construction projects (e.g., embankments, highway subgrades). The behaviour of fine-grained soils, like silt or clay, is influenced by the water content. Permeability is one of the factors that determine shear strength and is a measure of water or air movement through the dredged material. Permeability is determined by mineralogical composition, particle size and distribution, void ratio, degree of saturation, and pore fluid characteristics. Very fine-grained materials (clayey) generally have low permeability rates to water, and this is a desirable feature when dredged material is used as fill or foundation material in landfills. However, if the material is to be used for revegetation projects, coarse-grained material would need to be added to clayey material to enhance aeration and root penetration.

Plasticity tests are conducted on dredged material that is finer than 0.425 mm to determine the range of water content in which plasticity is exhibited. The types and amounts of clay particles present and water content, as well as the physicochemical interactions of clay particles, determine the plastic behaviour of a dredged material. The Atterberg Limits consist of the liquid limit (LL) and plastic limit (PL) and can be used to assess the amount of dewatering needed before a dredged material can be handled and processed. The Atterberg Limits, either individually or with other soil properties, can be correlated to other properties such as compactability, compressibility, shear strength, or permeability. The water content above which a dredged material is in a semiliquid state is its LL. The water content that is the lower limit of the plastic state and the upper limit of the semisolid state is the PL. If the water content of the dredged material is below its PL, it becomes brittle and breaks into fragments when remolding is attempted.

The organic content in a soil can contribute to high plasticity, high shrinkage, high compressibility, permeability, or low strength. Soils with significant amounts of organic matter generally have lower shear strength and higher compressibility than those composed mainly of inorganic minerals. An organic soil is one where the LL of the oven-dried soil is <75 percent of the LL of the soil before it was dried. While a certain amount of organic material can be desirable (e.g., enhanced buffering capacity, immobilizing contaminants), it can make characterization of dredged material more difficult since there are many forms of organic materials, and, depending on the origin, each has distinctive attributes.

**VI. BENEFICIAL USES OF DREDGED MATERIAL**

There are many potential beneficial uses of processed dredged material in upland, wetland, or aquatic environments. The properties, as well as the types and bioavailability of contaminants, will determine the beneficial uses of a dredged material and the amount of processing needed to reduce adverse environmental impacts. In addition, waste materials such as fly ash, alkaline wastes, and spent lime can be added to dredged material to engineer a soil product that can meet specifications required for a particular beneficial use. Examples are impermeable caps for landfills, superfund sites, and brownfields.
While habitats will develop from placement of dredged material into disposal sites, the enhancement and development of high-quality habitats require the utilization of sound management strategies. Dredged material is an underutilized resource that can be used in a beneficial manner once appropriate physical, engineering, chemical, or biological properties are determined. Over 2,000 man-made islands have been created in the Great Lakes and coastal and riverine areas by the U.S. Army Corps of Engineers. These islands, along with additional ones, can provide nesting areas, protection from terrestrial predators, and the seclusion from humans needed by migratory or colonial nesting waterbirds and threatened or endangered species (e.g., pelicans, spoonbills, gulls, herons, terns). Additional beneficial uses in aquatic environments include habitat creation (reefs, tidal flats, sea grass meadows), erosion control (underwater berms made of geotextile tubes filled with dredged material, beach and shoreline nourishment), and construction (dikes). Dredged material can be used to augment decreasing wetland resources including freshwater and saltwater marshes, biofilters for landfill leachate, constructed wetlands for wastewater treatment, or fill for sloughs in riverine areas or denuded reservoir banks. There are a vast number of beneficial uses in upland areas including construction of roads or airport runways, landscaping (manufactured soil products), parks and recreational area development, cemetery development, and others. All products made from dredged material will have to meet the performance specifications established for existing material and will have to be cost competitive, available in a timely manner, and tested for performance.

VII. PHASED APPROACH FOR TESTING OF DREDGED MATERIAL

A phased approach to testing should be employed in determining suitability for beneficial uses. It may not be necessary to conduct all of the characterization tests. First, the beneficial use needs and/or opportunities should be determined for the specific location. Next, an evaluation of the physical suitability of material for the proposed uses needs to be conducted using appropriate characterization tests for determining the physical and engineering properties. If the physical properties do not meet desired specifications, processing the dredged material by addition of available materials such as spent lime, fly ash, or kiln dust should be considered. Many times the dredged material can be conditioned to meet desired specifications. Next, the logistical and management requirements are considered. The evaluation of environmental suitability is then considered. If there is reason to believe the dredged material is contaminated, either the chemical or biological or both characterization tests should be conducted. If the results of the chemical/biological screening tests indicate the potential for adverse impacts, the dredged material should be treated and then retested for adverse impacts. If adverse impacts are no longer indicated, or if there is no reason to believe the dredged material is contaminated, the beneficial uses can be realized, and the evaluation of socioeconomic, technical, management, and other environmental considerations, either as an Environmental Assessment or an Environmental Impact Statement, is conducted. If adverse impacts are still indicated, the dredged material should not be used for beneficial purposes.

REFERENCES


