NONDESTRUCTIVE SEDIMENT BULK DENSITY MEASUREMENTS FROM X-RADIOGRAPHY

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Abstract Cohesive sediments factor into many marine and riverine engineering works such as navigation, remediation of contaminated sites, and ecosystem restoration. Erosion is a key process in describing cohesive sediment behavior. Unlike non-cohesive sediments, cohesive sediment erosion is dependent upon multiple physicochemical parameters such as mineralogy, pore water chemistry, organic content, bulk density, and gas content among others. Given these complex interactions and present state of knowledge, cohesive sediment erosion experiments require site- and sediment-specific characterization with a cohesive sediment erosion device, such as Sedflume. Sedflume is a device designed to measure and quantify surface and subsurface erosion rates. Bed density is one of the primary factors influencing cohesive sediment erosion. Considerable variation in bed density is often found within the upper portion of the sediment bed, and consequently, high-resolution, high-accuracy methods are desired to relate bed density to erosion. Additionally, since the sediment cores are to be eroded in the Sedflume, a nondestructive method is required. Previous methods for determining bulk density for cohesive sediment erosion studies include physical sampling (destructive, low resolution) and nuclear density profiling (non-destructive). This paper will demonstrate a nondestructive method for determining in-situ density of sediment cores using an x-radiography density profiler that offers many advantages over previous methods.

Similar to nuclear density methods, X-rays are attenuated when transmitted through a particular material. This relationship is best described using the basic Beer's Law equation:

$$I = I_o e^{-\mu\rho d}$$

where
I_o = incident x-ray intensity
I = detected x-ray intensity
μ= mass attenuation coefficient
ρ = density of sediment sample
d = thickness of sample material

Solving for density

$$\rho = \frac{-1}{\mu d}\ln\left(\frac{I_o}{I}\right)$$

To determine the sample density, the system is calibrated to a mass attenuation coefficient representative of sedimentary minerals. Results from the system calibration and verification experiments will be presented.

The x-radiography system includes a 160 keV x-ray source, high performance x-ray detector, a single unit multi channel analyzer (which includes an amplifier and digital pulse processor), and tungsten and brass collimators. The components are controlled by motor controllers in order to

perform vertical and rotating scans. Experimental results indicate that the system provides approximately 1-mm vertical resolution with nominally 1% accuracy in bed density.

The x-radiography density profiler has been applied to several erosion experiments involving dredged material and contaminated sediment capping materials. These applications have enabled more accurate determination of in-situ density profiles and erosion rates for application in modeling studies. Results and comparisons for these applications will be presented.