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Standard Practice for Use of Foundry Sand in Structural Fill and Embankments[1]

This standard is issued under the fixed designation D7765; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice covers methods to use foundry sand as embankment and structural fill.

1.2 It includes recommended construction (Section 5), compaction control (Section 6), and freeze-thaw durability (Section 7) practices.

1.3 The engineer should be aware that foundry sand is a by-product of metal casting industries. Various state, county, and local environmental laws and regulations may apply if foundry sand is used as an alternative embankment or fill material. It is advised that foundry sand users contact state, county, and local environmental regulators to determine what requirements or limitations may exist.

1.4 This standard applies to both green foundry sand and chemically bonded foundry sand.

1.5 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.7 *This guide offers an organized collection of information or a series of options and does not recommend a specific course of action. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this guide may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C837 Test Method for Methylene Blue Index of Clay

D653 Terminology Relating to Soil, Rock, and Contained Fluids

D698 Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft^3 (600 kN-m/m^3))

D1556 Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method

D1557 Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3))

D1883 Test Method for CBR (California Bearing Ratio) of Laboratory-Compacted Soils

D2216 Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass

D2974 Test Methods for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils

D4327 Test Method for Anions in Water by Suppressed Ion Chromatography

D5080 Test Method for Rapid Determination of Percent Compaction

D5918 Test Methods for Frost Heave and Thaw Weakening Susceptibility of Soils

D6026 Practice for Using Significant Digits in Geotechnical Data

D6938 Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

G51 Test Method for Measuring pH of Soil for Use in Corrosion Testing

G187 Test Method for Measurement of Soil Resistivity Using the Two-Electrode Soil Box Method

3. Terminology

3.1 For definitions related to geotechnical properties, see Terminology D653.

[1] This practice is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.14 on Geotechnics of Sustainable Construction.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *active clay content, n*—the clay fraction that still can be hydrated.

3.2.2 *binders, n*—additives used to hold the sand in the required shape during the casting process. Binders may be inorganic, such as bentonite clay and sodium silicate, or organic such as phenolic-urethanes and epoxy-resins.

3.2.3 *chemically bonded sand, n*—foundry sand that contains non-bentonite binders.

3.2.4 *foundry sand, n*—a narrowly graded fine sand with subangular to rounded grains that is a by-product of the steel and aluminum casting industry.

3.2.5 *green foundry sand, n*—a mixture of foundry sand, bentonite and seacoal. Most of foundry sand generated is green foundry sand that contains bentonite clay and carbonaceous additives, such as seacoal. Bentonite content of the green foundry sands is the key characteristics affecting their behavior.

3.2.6 *seacoal, n*—a carbonaceous material added to foundry sand to provide a reducing environment during casting and to help ease the release of the cooled metal from the mold.

4. Significance and Use

4.1 Earthwork associated with highway construction provides an opportunity for high volume reuse of green foundry sands discarded by the foundry industry. This practice covers methods and recommendations to use of foundry sand as embankment and structural fill.

4.2 This practice describes the unique construction considerations that may apply to foundry sands. The behavior may vary due to specific composition of the material and local conditions.

4.3 The use of foundry sand in embankment and structural fill may be regulated by state and local codes. These codes should be consulted.

4.4 This practice is intended for use with green foundry sands where bentonite is used as the binder. It may not be applicable for chemically bonded foundry sands.

5. Construction Practices

5.1 The following practices are recommended when constructing foundry sand embankment and structural fill.

5.1.1 Foundry sand should be conditioned for dust control and to prevent erosion by the addition of from 10 to 15 percent water by mass at the source site prior to delivery. This conditioning may include subsequent storage (stockpiling) of the foundry sand for a period of 24 h or more, after the addition of water, until the water is evenly dispersed. If the supplier can demonstrate that water is evenly distributed throughout the foundry sand, then stockpiling may not be required.

5.1.2 Delivery of foundry sand should be in closed or covered trucks.

5.1.3 Large-scale storage (stockpiling) of foundry sand at the site is permissible provided that the water content is maintained at 10 to 15 percent by mass for dust control.

5.1.4 Foundry sand material should be spread into loose lifts of approximately 20 cm thickness. The engineer may consider thicker lift dimensions if it can be satisfactorily demonstrated with a test section that adequate compaction can be achieved over the full depth of the thicker lift.

5.1.5 If necessary for proper compaction, water should be added to the foundry sand by the use of water distribution tank trucks. The water and foundry sand should be mixed using a rototilling mixer or other approved method. At the time of compaction, the foundry sand should have a moisture content that will result in an after compaction dry density that complies with the requirements of the project specifications. The dry density is a function of the clay content.

5.1.6 The first pass in the compaction process should be accomplished by the method known as tracking. This involves the use of a bulldozer track to accomplish initial compaction. The bulldozer is moved progressively across the foundry sand until the entire area is tracked.

5.1.7 The foundry sand should subsequently be compacted using pneumatic tired compaction equipment. Smooth steel drum and vibratory steel drum compactors are not as effective as pneumatic tired compactors for compacting foundry sand.

5.1.8 The foundry sand embankment should be compacted as required by the specifying agency. The dry density is a function of the clay content. Foundry sand with no clay should have a dry density equal to or greater than 1602 kg/m^3 with an optimum water content of approximately 9 %. Increasing clay content will increase dry density and optimum water content.

5.1.9 At the completion of each day's work, the surface of the foundry sand embankment should be sealed. This means that it should be graded after compaction to the specification requirement and rolled with a smooth steel roller so that rain will flow off the foundry sand instead of puddling.

5.1.10 The contractor should use water or other dust palliatives, if necessary, to control the generation of dust due to drying of the foundry sand.

6. Compaction Control

6.1 The use of foundry sand as structural fill and embankment material can present compaction-related issues that may be different from those encountered with conventional sandy materials. Bentonite content of the green foundry sands is the key characteristics affecting their constructability and performance behavior. The active clay content can be determined by using methylene blue titration following Test Method C837. A description of the issues and recommended practices for mitigation are presented below.

6.1.1 The moisture-density relationship for foundry sand will vary depending on the sand type and the amount of clay. Hydration of dehydrated clay in foundry sands takes at least 1 week.[3] Accordingly, in performing laboratory tests for index, compaction, and mechanical property, these characteristics should be recognized and an appropriate hydration time should be allowed after adding water to simulate the expected condition in the field. Green sand compacted according to Test

[3] Kleven, J. R., Edil, T. B., and Benson, C. H. "Evaluation of Excess Foundry System Sands for Use as Subbase Material," *Journal of the Transportation Research Board*, No. 1714, National Research Council, Washington D. C., 2000, pp. 40-48.

Methods D698 with the exception of extending the hydration period to 1 week from 24 h will give a moisture density curve with a well-defined maximum dry density peak with an optimum water content between 9 and 14 percent.[3] The expected maximum dry density will fall between 1602 kg/m^3 and 1860 kg/m^3 using Test Methods D698.[3] It is recommended that the water content be within 1 % of the optimum water content to achieve densities greater than 95 % standard proctor or 90 % modified Proctor. Chemically bonded foundry sand and green sand with no clay will have similar dry densities to the green sand with clay, but the moisture density curve is comparatively flatter with a poorly defined peak. The optimum water content will be between 10 and 15 percent. While the water content is not as critical for compaction, it is still recommended that the field water content be maintained within 1 % of the optimum water content.

6.1.2 Compaction techniques may vary among jurisdictions. However, a loose lift thickness for foundry sand of 20 cm is generally preferred. A defined and effective rolling pattern should be developed. Foundry sand is best compacted using pneumatic tired compaction equipment. Smooth steel drum and vibratory steel drum compactors are not as effective as pneumatic tired compactors for compacting foundry sand.

6.1.3 Acceptance of each lift should be based on in-place density as a percentage of maximum dry density at ±1 % of optimum water content as determined by Test Method D1556 or D6938, or an equivalent method. It should be noted that a nuclear density gauge calibrated for well graded sand will likely give an inaccurate value for foundry sand due to its narrow range of particle sizes. It is recommended that Test Method D6938 and other tests be carried out to determine a correction factor for the nuclear density gauge, or that the gauge be recalibrated for foundry sand both for moisture and density using Test Method D2216 and Test Method D1556, respectively. From a practical point of view, the nuclear density gauge will be used on other materials besides foundry sands, so a correction factor is the preferred method. The usual value for the acceptance of the lift is 95 percent of the maximum dry density as determined by Test Methods D698 or 90 percent of the maximum dry density as determined by Test Methods D1557.

6.1.4 When the contractor demonstrates a consistent ability to achieve acceptable compaction as demonstrated by repeatable percent compaction measurements in accordance with Test Method D5080, the engineer may elect to allow a procedural acceptance technique to be used. In this approach a test strip is established and the strip or lift is compacted. After each pass, where a pass is defined as all areas of the lift being compacted by the compaction equipment one time, a test of the density of the lift is made. The actual density of the lift is compared with the maximum dry density value as determined by Test Methods D698 or Test Methods D1557.

6.1.5 If other materials are blended with the foundry sand, it is likely that the gradation will change, and that this will result in changes to the moisture-density relationships. An effective method of offsetting this variability problem is to use Test Method D5080 for rapid determination of percent compaction. This test method describes the procedure for rapidly determining the percent compaction and the variation from optimum moisture content of an in-place soil for use in controlling construction of compacted earth. These values are obtained by developing a three-point compaction curve at the same moisture content as the in-place soil without knowing the value of the moisture content. The soil used for the compaction curve is normally the same soil removed from the location of the in-place density test. On a given day, when an in-place density test is performed, a companion sample of foundry sand is taken. The acceptance of the compaction for the day's production is based on these values. If there is a high degree of variability in the foundry sand, it may be necessary to establish a practice of performing rapid percent compaction on a morning and afternoon basis, or even more frequently.

6.2 Appropriate testing for strength and other design-related parameters as dictated by the intended end-use considerations should be made on foundry sands and the foundry sands blended with other materials at the specified field densities.

7. Electrochemical Limits

7.1 Durability of metallic inclusions in the fill, such as metallic pipes and steel reinforcement elements, requires that the fill material does not exceed certain electrochemical limits. The recommended electrochemical limits are as follows:[4]

Property	Standard	Test Procedure
Resistivity	Ohm-cm > 3000	Test Method G187
pH	>5 <10	Test Method G51
Organic Content	≤1 %	Test Methods D2974
Chloride	<100 ppm	Test Method D4327
Sulfates	<200 ppm	Test Method D4327

8. Freeze-Thaw Durability

8.1 The potential for frost susceptibility may be evaluated in the laboratory by the use of Test Method D5918. This test method involves the compaction of a soil specimen and then freezing it at one end while free liquid water is in contact with the other end of the specimen. The specimen is subjected to a conditioning cycle and then two freeze-thaw cycles. The specimen is measured for heave and then it is tested for California Bearing Ratio (Test Method D1883) after freeze-thaw cycling. The California Bearing Ratio value is compared with a control test where the specimen is not subjected to freeze-thaw. The reduction in the CBR due to freeze-thaw can be used as a guide to adjust the structural properties used in design.

9. Keywords

9.1 compaction; embankment; fly ash; foundry sand; freezing; structural fill

[4] Corrosion/Degradation of Soil reinforcements for Mechanically Stabilized Earth Walls and Reinforced Slopes, Federal Highway Administration Publication No. FHWA-NHI-00-044, September 2000.