



Best Practices in Glass Recycling

Typical Geotechnical Parameters of Glass Aggregate

Material: Recycled Glass

Issue: For engineers specifying natural aggregate, geotechnical parameters and requirements for specific types of construction applications are generally available in published information and design manuals, as well as from the engineer's personal knowledge of material behaviors and properties. With new materials, however, parameters are often derived from laboratory test results. Even when lab tests are performed, it is always desirable to have a range of typical values for comparison. Glass aggregate is a relatively new construction aggregate material. In general, glass aggregate is durable, strong, and easy to place and compact. This best practice presents typical geotechnical parameters for aggregate consisting of 100% glass as well as mixtures of glass and natural aggregate.

Best Practice: The geotechnical parameters of cullet aggregate are largely dependent upon the percentage of glass content, gradation and compaction level, and to a lesser degree on the type or source of glass. The experience gained from construction and lab results indicates that moisture and debris content (within reasonable ranges) have a relatively minor effect on the geotechnical performance. The insensitivity to moisture content is likely due to the fact that glass aggregate is more free-draining than most natural aggregate. This is for two reasons: first, glass has a smooth, non-porous surface that does not retain water; second, glass aggregate contains no clay materials to hinder drainage. Hence, only a limited amount of moisture can be retained by the cullet. In the case of debris content, the insensitivity is due to the fact that the debris content by weight is much lower than a two dimensional visual judgment would suggest. This is because the typical contaminants; paper labels, plastic rings, and metal caps, have much lower densities than glass and tend to lie flat on a stockpile, presenting their largest face. Because the debris content appears to be much greater than it actually is, load rejections are likely to occur before the contamination reaches a point of actually affecting the engineering performance.

One hundred percent cullet fill is typically used in lightly loaded or non-loading applications in which it should be compacted to about 90% to 95% of the maximum dry density as determined using the ASTM D698 (Standard Proctor) test method. As indicated previously, the parameters for natural aggregate are typically available in published information. For mixtures of cullet and natural aggregate, some parameters such as unit weight can be linearly interpreted based on the mix percentage. The ranges of typical values presented here take into account the effects of gradation and compaction level. For non-critical structures or applications, high range values can be safely assumed. For critical structures or applications, the parameters should be confirmed by laboratory testing. Geotechnical parameters should always be selected or interpreted by qualified engineering personnel.

Unit Weight The unit weight of a compacted, 100% cullet fill can range from 95 to 115 pounds per cubic foot (pcf). The unit weight generally increases with decreasing cullet size. Also, well-graded cullet has a higher unit weight than poorly-graded cullet. Every piece of glass processing equipment generates a somewhat different shape and gradation of glass aggregate. Glass aggregate processors should test the unit weight of their products and keep it on file for potential users.

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Bearing Capacity The bearing capacity is a function of loading geometry, embedment depth, unit weight of fill, and the strength of the fill. Cullet aggregate with 100% cullet can be used for support of light loads. For small load areas such as footings or piers, typical bearing capacities of 1,000 to 1,500 pounds per square foot (psf) can be considered for glass. For large loading areas such as mat or rigid pavement, a subgrade reaction modulus in the range of 100 to 200 pounds per cubic inch (pci) can be considered.

Lateral Pressures Lateral pressures are required for the design of retaining structures. These pressures are functions of unit weight, material strength, and the deflection of the retaining structure. For 100% cullet fill, the following parameters can be used for design purposes:

<u>Lateral Pressure</u>	<u>Equivalent Fluid Density (pcf)</u>
Active	25 to 30
Passive	250 to 300
At-Rest	35 to 45

Note that these parameters do not include hydrostatic pressure that must be taken into account if drainage is not provided. Also, the passive values include a safety factor of 1.5.

Angle of Repose A high angle of repose is desirable so that temporary excavation can be sloped without shoring. The angle of repose will largely depend on the gradation, compaction level, and the weather condition. Typically, a 100% cullet can be stable at a slope angle of 2H: 1V. (2 horizontal to 1 vertical). Temporary slopes (less than a few weeks in general) can be excavated at 1H:1V. The slope must be flattened if the material is under groundwater. Also, the excavation must be in conformance with local safety regulations.

Permeability Cullet fill has a medium to high permeability depending mainly on the gradation. The permeability values typically range from 0.05 to 0.25 cm/sec. These parameters compare favorably with those of natural sand and gravel.

Implementation: The parameters presented in this Best Practice reflect some of the research performed on glass aggregate to date. This information can be a starting point for qualified geotechnical engineers to make their own judgments based on local conditions and availability of processed material.

Benefits: Dissemination of the information presented herein should help geotechnical engineers, contractors and permitting authorities become familiar with glass aggregate fill materials and ultimately to increase their use in construction.

Application Sites Design offices, construction sites, and testing laboratories.

Contact: For more information about this Best Practice, contact CWC, (206) 443-7746, e-mail info@cw.org.

References:

Aggregate. Report GL-93-5. ReTAP, Clean Washington Center, 1994.

Glass Feedstock Evaluation Project: Evaluation of Cullet as A Construction

Shin, C. J., Civil Engineer, S&EE, Inc., Bellevue, WA

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