Technology Brief

Quality Control for Recycled Concrete as a Structural Fill Material

The use of recycled concrete as a structural fill material, in lieu of natural aggregate, has recently been increasing. In some regions, recycled concrete aggregate may cost 20 % to 30 % less than natural aggregate. This technology brief summarizes the results of testing two modifications of conventional aggregate testing procedures, specifically adapted for potential use in compaction specification of recycled concrete aggregate.

Key Words	
Materials:	Recycled concrete aggregate.
Technologies:	Nuclear densometer field testing; Modified Proctor laboratory testing (ASTM D-1557).
Applications:	Structural fill applications.
Market Goals:	Develop simple quality control methods for field verification of compaction level.
Abstract:	Modification of conventional aggregate compaction specification testing procedures (1¼inch & ¾inch minus).

Background

On-site quality control during the placement of structural fill is typically maintained through verification of compaction level by measurement of in-situ moisture and density. Nuclear densometers are commonly used for these quality control measurements, because densometers provide quick and reasonably accurate field measurements of moisture content and density for natural soils and aggregates. The nuclear densometer measures wet density and moisture content of a fill material, from which the dry density is calculated through the following relationship:

$$g_d = g_t / (1+w)$$

where: g_d = *Dry Density*
g_t = *Wet Density*
w = *Moisture Content (%)*

Compaction level is then calculated as the ratio of field-measured to laboratory-measured dry density:

$$\text{Percent Compaction} = g_{d\,(field)} / g_{d\,(laboratory)}$$

Because of the prevalent use of nuclear densometers for compaction specification of natural aggregate, it is desirable to develop quality control procedures for recycled concrete that also use nuclear densometer measurements. The nuclear densometer, however, provides an inaccurate moisture content measurement for recycled concrete, since it measures moisture based on the hydrogen content of the tested material. Because water is the sole source of hydrogen in most natural aggregates, the densometer provides a reasonably accurate measurement for these materials. However, for hydrogen rich materials, such as recycled concrete or organic soils, the densometer measures a moisture content that is higher that the actual content. This leads to the calculation of a dry density that is lower than the actual value, and in turn a lower compaction level. Thus, existing in-situ moisture and density testing procedures must be modified in order to accurately measure the characteristics of recycled concrete.

Test Description

This study explores the viability of two conventional aggregate testing procedures that are modified for recycled concrete aggregate.

COMPACTION SPECIFICATION USING WET DENSITY:

The first modified testing procedure examines the potential of using wet density for compaction specification of recycled concrete. The moisture-density relationships (Modified Proctor curves) are

#CDL-97-5

plotted for two recycled concrete samples, 1¼ inch minus and ¾inch minus.

The wet and dry density curves indicate a relatively high degree of non-linearity, yielding two substantially different wet-density based compaction levels, one for the dry-of-optimum condition and one for the wet-of-optimum condition.

COMPACTION SPECIFICATION USING MOISTURE CONTENT CORRELATION CURVES (FIELD-MEASURED VS. LABORATORY-MEASURED):

The second modified testing procedure examines the potential of using a correlation between field-measured (nuclear densometer) moisture content and laboratory-measured moisture content for compaction specification of recycled concrete. Moisture content correlations are developed for two recycled concrete samples, 1¼ inch minus and ¾ inch minus, each laid in six inch thick layers as subgrade of slab-on-grade. Results indicate that the field-measured moisture content varies between 9% and 20% while the laboratory measured moisture content varies between 4% and 11%. For samples with relatively low moisture content, the nuclear densometer measurements are approximately two times greater than the actual (laboratory) values. The difference in field and actual values decreases with the increase in moisture content.

Test Results

Test results indicate that fill control using moisture content correlation curves is a more promising technique than fill control using wet density.

COMPACTION SPECIFICATION USING WET DENSITY:

The two samples in this study showed a significant non-linearity between dry and wet densities. The materials are sufficiently moisture sensitive so that for a constant, dry-density based compaction level, there are two substantially different wet-density based compaction levels for the dry-of-optimum and wet-of-optimum conditions. Thus, for fill control using wet density, field personnel would be required to distinguish the moisture state (i.e., dry or wet-of-optimum) and apply the correct corresponding compaction level. Consequently, this methodology should be used with care, because it requires both a high level of field experience, as well as a thorough evaluation of dry and wet density compaction curves.

COMPACTION SPECIFICATION USING MOISTURE CONTENT CORRELATION CURVES (FIELD-MEASURED VS. LABORATORY-MEASURED):

The collected data indicates that the moisture content measured by nuclear densometer in the field is approximately twice that of the actual moisture content measured in the laboratory. Since it appears that the difference in measured and actual moisture content varies only with the actual moisture content, a correlation curve of laboratory measured moisture content versus field measured moisture content can be established. Using this correlation curve, nuclear densometer measurements in the field can be used to estimate actual moisture content. This estimated actual moisture content can then be used to calculate the dry density and corresponding compaction level with reasonable accuracy. This method is easily applied in practice since the correlation between the measured and actual moisture contents can be established prior to the fill control program. The fill control program should involve confirmation samples for every 250 to 500 cubic yards of material.

These conclusions, however, are based on a very small sample size, and sensitivity of the correlation to other variables (such as gradation, material sources, and compaction method) has not been established. Therefore, prior to extensive use, this methodology should be further investigated and confirmed using a larger database.

Acknowledgements

This testing program was developed and performed by Soil and Environmental Engineers, a civil engineering firm in Seattle, Washington. Recycled concrete aggregate was supplied by Renton Concrete Recyclers, Renton, Washington.

Fact Sheet Issue: *January 1998*

For More Information

For more information on this fact sheet, contact CWC at (206) 443-7746, email info@cwc.org, or visit the CWC Internet Website at www.cwc.org. This technology brief was prepared by **CWC**, Managing Partner of the **Recycling Technology Assistance Partnership (ReTAP)**. ReTAP is an affiliate of the national Manufacturing Extension Partnership (MEP), a program of the U.S. Commerce Department's National Institute of Standards and Technology. ReTAP is also funded by the U.S. Environmental Protection Agency and the American Plastics Council.

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