RECYCLED GLASS UTILIZATION IN HIGHWAY CONSTRUCTION

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Disclaimer

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ABSTRACT

The utilization of recycled glass in highway applications has been occurring over the past couple of decades. In recent years, the discovery of several economic and environmental benefits could increase the use of recycled glass in highway construction, making the evaluation of the engineering properties of glass and aggregate mixes necessary. The uses of recycled glass have varied widely, depending on the specific application. Crushed recycled glass, or cullet, has been used independently, and has also been blended with natural stone construction aggregate at different replacement rates. This research provides an evaluation of the potential use of glass cullet when used in combination with natural base course aggregate for roadway construction. This research studied the strength and moisture/density characteristics of different glass and aggregate blends to examine the effects of blending glass cullet into base course aggregate. Two sources of natural aggregate were tested: one being crusher run and very angular in nature; and the other being pit-run and rounded in nature. The glass was introduced into the aggregate at replacement rates of 10%, 20%, and 30%. Four different maximum glass cullet sizes were also tested, with maximum sizes ranging from 3/4" to 3/8". The strength of the glass-aggregate blends was evaluated using the AASHTO T190-Resistance R-value Test. Analysis of the data showed that glass cullet mixed with the more angular crusher run aggregate (LAF) performed more consistently than when the cullet was combined with the rounded natural aggregate (STAR) for all sizes and replacement rates. The LAF glass-aggregate blends had average strength values above or slightly lower than the control mix across all replacement rates and maximum cullet sizes. The STAR blends exhibited a decrease in strength as both cullet size and replacement rate increased. The moisture-density relationships were determined in accordance with the AASHTO T99-Standard Proctor Test. The maximum size of glass cullet used was shown to be insignificant in determining the optimum moisture content and maximum density of the blends. The replacement rate had a significant effect on both the compaction properties. As the cullet content increased, the optimum moisture content increased, and the maximum density decreased.

1. BACKGROUND AND INTRODUCTION

As recycling continues to grow as a means of utilizing waste materials in today's world, more markets must be established for products containing recycled materials. Specifically, glass continues to be one of the principal waste products generated by the public and recovered by the recycling industry. In 2003, 10.7 million tons of waste glass was generated in the U.S., and 2.35 million tons, or 22%, was recycled. [1] Recovered recycled glass is crushed and becomes what is known as glass cullet. Glass cullet is the basic product that is reused for most recycling applications.

The major market for the glass cullet is the container industry, but the use of glass cullet in glass container production batches is limited due to color contamination and transportation costs. [2] Glass cullet, which is reused for containers, must be well sorted according to color and must also be relatively free of debris. This required sorting and cleaning costs time and money. Transportation costs associated with recycled glass are often high because of the geographic concentration of glass plants near urban areas. [3] This makes it more difficult to use glass cullet produced in rural locations for the purpose of making new containers. For example, the glass suppliers for this project send shipments of cullet hundreds of miles to out-of-state processors. Transportation costs range from $20-$35 per ton, while the cullet receives $50 per ton for brown glass and only $20 per ton for clear when delivered. For an average shipment, the higher price paid for the brown glass barely covers the shipping cost of the clear glass. If another market for the clear or mixed glass existed, the cullet could be used more economically.

Over the past few decades, another market for cullet has been developing within many states, including Texas, Minnesota, California, Washington, Oregon, New York, and several others. The use of glass cullet as a construction aggregate is becoming more widespread as the results of research and laboratory testing studies on glass cullet become better known. When glass is used as construction aggregate, there is less need to sort and separate by color, and less need for the cullet to be free of contaminants. The need for transporting the cullet long distances to container glass manufacturing facilities can also be eliminated. Glass cullet has the potential to be used in aggregates for structural or drainage applications. Some of the structural applications include base and subbase, embankments, structural fills, and utility backfill. Drainage blankets, French drains, and various waste medias are the possible drainage applications. [4]

Several studies have been conducted regarding the use of glass cullet as construction aggregate. The largest study to date concerning the use of glass cullet is probably the Clean Washington Center's "Glass Feedstock Evaluation Project," completed by Dames and Moore, Inc. This study included replacement rates of 15%, 50%, and 100%, and mix gradations of 3/4" minus and 1/4" minus. [6] Several tests were conducted to determine whether the cullet and aggregate mixtures were suitable from the engineering and environmental standpoints. The study found that the addition of glass cullet had no negative effects to the soils it was combined with. [5] Another study conducted by the Texas Department of Transportation found similar results. TxDOT concluded that the addition of glass up to 20% didn't have significant effects on the engineering properties of the mixture. [7]

Several states have developed specifications for using glass cullet for construction purposes. Most studies have indicated that glass cullet would be a suitable substitute for natural aggregate at lower replacement rates. In a survey conducted by the TxDOT, most states that indicated using glass cullet specified replacement rates of 5%-20%. [7] The Minnesota Department of Transportation has had several counties that have implemented the use of glass cullet in their roadways. MnDOT specifications include the use of 10% reclaimed glass in aggregate material for road base. [8] Otter Tail County used 10% glass in road base on a 4-mile section of county road. No specialized equipment was needed for placement and compaction, and county officials were pleased with the results. [8]

The use of glass cullet by state DOTs is becoming more common, but the lack of supply or quantity needed for larger projects may force more city and county agencies to consider using glass cullet as construction aggregate. This may be more beneficial for a couple of reasons. Cities and counties are responsible for disposing of the glass and are therefore, less reluctant to consider its use. Also, city and county construction projects tend to be smaller in nature therefore, the quantity of glass needed could be obtained without lengthy stockpiling times or without the cost of hauling cullet over long distances to the project. Whether larger state DOTs or small city and county agencies adopt standards for using glass cullet, the engineering properties of the glass and glass blends must be evaluated.

2. RESEARCH OBJECTIVES

While use of recycled glass in roadway construction is increasing, many agencies are still reluctant to consider cullet as a suitable substitute for materials already being used. This is mainly due to unfamiliarity with the engineering properties of cullet and a lack of suitable sources that supply glass cullet. This research will examine several properties of glass cullet through laboratory testing. Specifically, this study will investigate the strength and moisture-density characteristics of glass cullet blended with natural aggregates for use as road base material. This study will provide recommendations on the maximum particle sizes and associated replacement rates at which glass cullet can effectively be used.

3. LABORATORY TESTING

Laboratory testing was done at the University of Wyoming and the Wyoming Department of Transportation (WYDOT) Central Laboratory. All the testing was conducted according to AASHTO and WYDOT specifications. The WYDOT performed the Resistance R-value testing, and all other testing was conducted at the University of Wyoming.

3.1 Research Variables

The effects of three variables were studied in the testing process. The variables included were type of aggregate, size of glass cullet, and glass replacement rate. The test matrix for this research is shown in Table 1. Several other variables, including debris content or contamination level in the cullet and glass color, were considered but eventually omitted. This research aimed to find alternate uses for glass cullet that allowed a more flexible screening process, and these variables are two of the more stringent requirements for recycled glass to be used in the bottling manufacturing process. As found in the case studies mentioned in the previous section, debris content or contamination level can be significantly important for the bottling manufacturing process as well as for use in highway road base applications. The decision to omit debris content was made because it was this research's goal to evaluate the glass cullet as received from the recycling centers with the debris levels that were accepted by the majority of recycling centers. Glass color was not considered a variable, because for construction purposes, glass would not have to be sorted by color. This section will discuss each of the variables and why they were selected for the research.

Table 1 Test Matrix for Each Source of Aggregate

		Replacement Rate		
		10%	20%	30%
Maximum Glass Size	3/4"	3	3	3
	5/8"	3	3	3
	1/2"	3	3	3
	3/8"	3	3	3

The first variable that was considered was type of aggregate. The type of aggregate variable was included because it was hypothesized that glass cullet would perform differently when combined with different types of aggregate. It was reasonable to assume this because the addition of any foreign material could affect the natural materials in many different ways. By selecting natural aggregates with at least one dissimilar material property, analysis on the affect of glass cullet on that property can be accomplished. Two different types of base course aggregate were used separately for the testing of the aggregate and glass blend samples. Further discussion of the properties of these aggregates is in the Materials section of this chapter.

The size of glass cullet, which was blended with the aggregate, was the second variable tested. The glass cullet was collected from local recycling centers and was separated into four different maximum sizes ranging from 3/4" to 3/8". The four maximum sizes used were 3/4", 5/8", 1/2", and 3/8". A maximum size of 3/4" indicates that all glass particles pass a 3/4" sieve. These four particle sizes were chosen based on previous research discovered during the literature review and also by visual inspection. There were definite visual differences in size of glass cullet particles occurring between the four sizes chosen. The most difference can be see between sizes with greater than 1/8" difference in size (i.e., 3/4" vs. 1/2"). Figures 1 through 4 illustrate the differences in size among the four sizes of cullet tested.

Figure 1 Glass Cullet 3/4" Maximum Size

Figure 2 Glass Cullet 5/8" Maximum Size

Figure 3 Glass Cullet 1/2" Maximum Size

Figure 4 Glass Cullet 3/8" Maximum Size

The third variable tested was glass cullet replacement rate. Glass cullet replacement rate is the rate at which glass cullet will be substituted for aggregate in the glass-aggregate blends. For example, a replacement rate of 10% indicates that 10%, by weight, of aggregate in the blend is replaced with glass cullet making the blend 90% aggregate and 10% glass cullet by weight. Replacement rates of 10%, 20%, and 30% were evaluated during this study. These values were chosen based on previous studies as explained in the literature review and also were based on the practical limits of the local statewide supply of crushed recycled glass. The properties of all the glass-aggregate blends were compared to control samples made up of 100% natural base course aggregate.

3.2 Materials

Base course aggregate was used for all testing. The aggregate was donated by two local sources. Aggregate 1 was obtained from STAR Aggregates of Cheyenne, Wyoming, and will be referred to as STAR. Aggregate 2 was obtained from Lafarge North America, Inc., and will be referred to as LAF.

Aggregates properties for both aggregates can be found in Table 2. As shown, STAR was a pit-run aggregate, while LAF was crusher run. The two aggregate were very similar in nature, except for a couple of properties. STAR aggregate particles were more rounded in nature, whereas, LAF particles were very angular. Both aggregates were classified as non-plastic according to Atterberg Limit tests, but LAF exhibited significantly more cohesion than STAR by visual inspection. The WYDOT classification of the material was base grading 'W'. The gradation specification for base 'W', along with the gradation of the material used for blending, is shown in Table 3.

Table 2 Aggregate Properties of the Two Sources Tested

Aggregate Sources	Type	Liquid Limit	Plasticity Index	Fine Agg. Angularity (%)	Coarse Agg. Angularity (%)	Bulk Specific Gravity		Absorption	
						FA	CA	FA	CA
STAR	Pit-Run Base	0	Non-Plastic	47.3	74 / 35	2.601	2.621	0.806	0.776
LAF	Crushed Base	0	Non-Plastic	46.7	99 / 96	2.57	2.616	0.969	0.715

Table 3 Aggregate and Glass Gradations

AGGREGATE AND GLASS GRADATIONS USED FOR BLENDING			
Sieve Size	Aggregate Gradation	Glass Gradation	WYDOT Base Grading 'W'
	Percent Passing		
1 1/2"	100	100	100
1"	98	88	90 - 100
3/4"	91	74	--
5/8"	--	63	--
1/2"	73	48	60 - 85
3/8"	63	32	--
#4	46	12	45 - 65
#8	36	6	33 - 53
#30	20	2	10 - 30
#200	9.0	0.5	3 - 12

The recycled glass cullet used for all testing was obtained from three sources in Wyoming. Two recycling centers donated glass cullet that was crushed by a crusher. The other source had a unique policy in place at the landfill in which a designated area was used to store all glass brought in and was then crushed by a dozer. The intent of using this source was to compare the effects of different crushing techniques. The glass was not sorted by color for the testing because, when used for construction purposes, color sorting would not be necessary. The type of glass accepted for use was bottles, jars, and other container glass, while cathode-ray tubes (CRT) and other hazardous glass were discarded. This sorting occurred only at the recycling centers and was monitored at the landfill operation.

3.3 Gradations

Gradation tests were conducted to determine the size distribution of both the natural aggregate and glass cullet. Testing was in accordance with AASHTO T11 – Materials Finer than No. 200 Sieve in Mineral Aggregate by Washing and AASHTO T27 – Sieve Analysis of Fine and Coarse Aggregate. Aggregate from both sources had very similar gradations, therefore, the aggregate gradation used for all blends was an average of both source gradations. For the same reason, an average of the glass gradations from the two glass crushers was used for all blends. The gradations of the aggregate and glass cullet used for all blends are shown in Table 3.

3.4 Resistance R-Value

The strength and moisture susceptibility of the aggregate glass blends were determined in accordance with AASHTO T190 – Resistance R-value and Expansion Pressure of Compacted Soils. This test consists of three separate components: Exudation Test, Swell Pressure Test, and Stabilometer Test. The range of the results of the R-value test is 0-100, with a practical range of 5-85.A material with an R-value of 5 is a very weak material, while a value of 85 indicates a high strength material. A minimum R-value of 75 for base and 60 for subbase is required by WYDOT.

In addition to strength, an idea about the moisture sensitivity of the material can be gained from conducting the R-value test. WYDOT classifies a material as moisture sensitive if on a graph of exudation pressure versus R-value the curve of R-values at different moisture contents has a difference in value greater than 5 between the 300 psi and 200 psi exudation pressure.

The blends for the testing were mixed at the University of Wyoming, while the Resistance R-value tests were conducted by WYDOT. The glass was blended with the natural aggregate as a percentage by dry weight of the total amount needed to conduct the test. As a requirement of the test all material was first "scalped" on the 3/4" sieve. The material passing the 3/4" sieve was used to prepare the test blends. All aggregate and glass were separated according to particle size then blended back according to average gradations. When blended, the proportioning of the particle sizes for the aggregate and glass separately were held constant throughout testing according to the average gradations found from the gradation testing. Therefore, the gradations for each blend were slightly different depending on the maximum size of glass used.

3.5 Moisture-Density Relationships

The moisture-density relationships were determined from compaction tests conducted in accordance with AASHTO T99 – Standard Proctor Test. The optimum moisture content at which the maximum density can be achieved is obtained from this testing. The standard Proctor test uses a 5.5 lb rammer dropped from 12 inches. A mechanical compactor was used during testing to ensure uniform compaction of all test blends.

Each blend was prepared in the same fashion used for the R-value testing and then compacted. Moisture content versus dry density curves were then produced for each blend.

4. DATA ANALYSIS AND RESULTS

4.1 Gradation

There were two objectives for conducting the gradation testing. The first was to determine the particle size distributions for all the sources of aggregate and glass. In doing this, a common or average gradation for the aggregate and a common or average gradation for the glass could be established. These average gradations were used for proportioning all of the aggregate-glass blends and remained constant throughout the research. The decision was made to use the average of the glass gradations that were already being produced from the glass sources rather than specifying a new gradation. In doing this, readily available recycled glass cullet could be used in practice without having to implement major changes in the glass crushing procedure. The gradations for the aggregate and glass that were used for blending are shown in Table 3.

The glass gradation resulted in a relatively even distribution of particle sizes over the range of sieve sizes 1" (25mm) to 3/8" (9.5mm). This provides constant shifts in the particle size distribution when blended with other materials. Also notice the very low amount of glass cullet passing the #4 (4.75mm) sieve. An average of only 12% of the glass cullet from crushers passed the #4 (4.75mm) sieve; therefore, the addition of glass cullet from a crusher will have the most effect on the larger sieve sizes. It is possible to increase the amount of fine material passing the #4 sieve by using glass pulverizers rather than glass crushers. Glass pulverizers can produce cullet 3/8" and smaller, while glass crushers produce cullet 2" and smaller. The amount of fine particle size cullet is minimal if obtained from a glass crusher. A glass pulverizer should be considered if it is desired to supplement the fine aggregate properties such as plasticity.

The second objective was to determine whether the glass gradation produced from glass crushers was different from the gradation produced by the dozer crushing. This comparison was made mainly for smaller agencies to determine the feasibility of using dozer crushed glass if commercial crusher cullet is not available. Using the particle size distribution curves in Figure 5, it can be shown that gradations for one of the crushers and the dozer were very similar. In fact, there was a greater difference between the two crushers than between the crushers and the dozer. Between the crushers, there was up to a 15% difference in the amount passing on the 1/2" (12.5mm) sieve and, 10% difference passing the 5/8" (15.9mm) and 3/8” (9.5mm) sieves. On the other hand, the one crusher and the dozer differed 4% on material passing the 1/2" sieve (12.5mm), and had 0% or 1% difference in the percent passing all other sieves. The difference in gradations between the crushers is most likely due to an adjustment that can be made to the steel roller that crushes the glass. It also should be noted that, when the dozer was used to crush the glass, whole bottles were visible in the pile even after the dozer had passed over it. The unbroken bottles were excluded from the gradation testing.

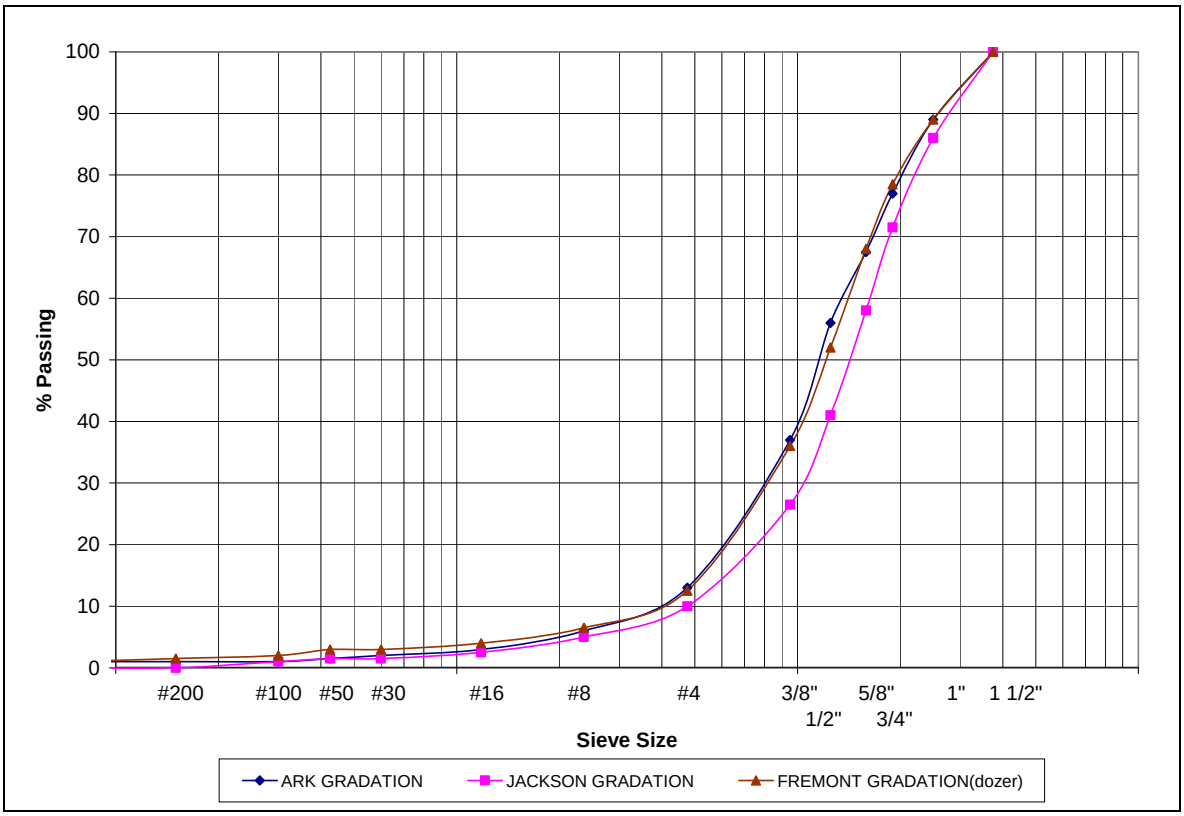

Figure 5 Glass Crusher and Dozer Gradation Comparisons

4.2 Resistance R-Value

The objective of conducting the Resistance R-value test was to study the effects that adding glass cullet to base course material had on strength and moisture susceptibility. The strength and moisture susceptibility of a base course can be directly related to the performance of the overlaying pavement therefore, knowledge of the effects of the addition of glass on these two engineering properties is essential. The test was performed three times for each blend, except for the two control mixes with 0% glass. These were only conducted twice because numerous existing data on the material matched the two test results for each aggregate. The R-value was averaged across the three tests for each blend.

The first aggregate tested was the STAR material. The STAR base course material had a control R-value (0% glass) of 78. This is above the WYDOT specifications of 75 for base course material. The results of the R-value test for the STAR aggregate are shown in Figure 6. The addition of glass cullet at a 10% replacement rate shows no significant effect for the maximum glass sizes of 3/8" and 1/2", but significantly lowered the strength at sizes of 5/8" and 3/4" to an average of 72. At a 20% replacement rate, the 3/8" size material still performed above the required specification with a value of 76. The 1/2" size dropped significantly from 79 to 71 at 20% replacement. At the larger sizes of glass, the samples began falling apart in the stabilometer, which produced varying results. The larger glass particles were most likely breaking as the load was applied, causing the layers inside the sample to move and break apart. The same behavior was observed when 30% glass cullet was used. The 3/8" size again slightly decreased, and the larger sizes showed unusual testing behavior. Testing with the rounded STAR particles was very inconsistent at higher replacement rates and larger glass sizes.

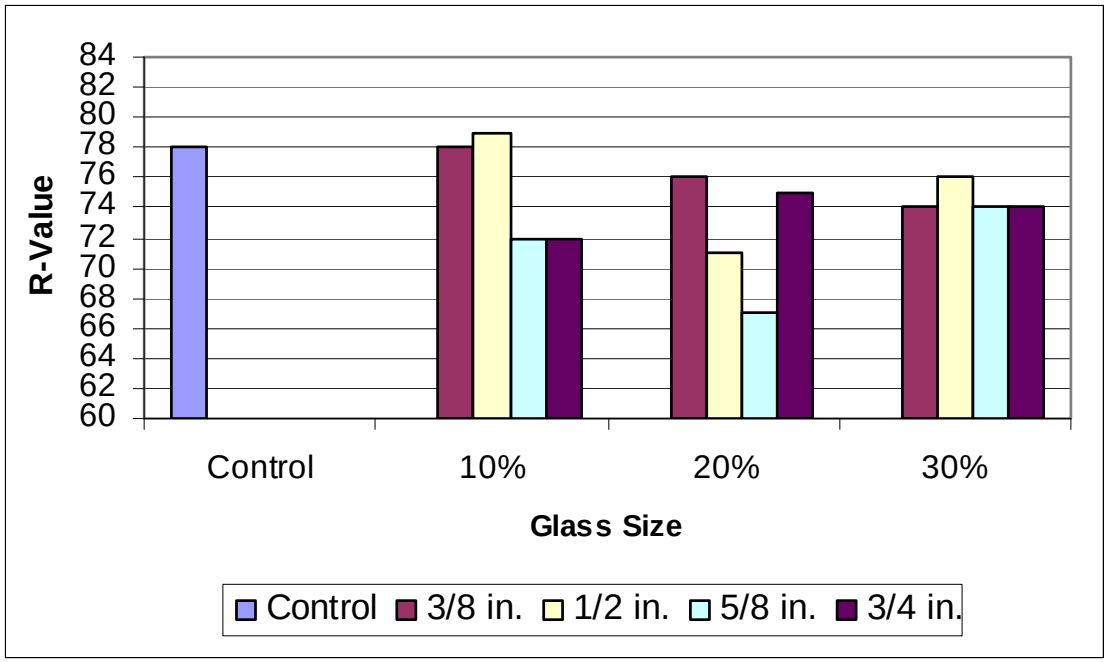

Figure 6 STAR R-value Results

The second aggregate tested was the LAF material. The LAF base course had a control R-value of 80. This is again above WYDOT specifications for base course material. LAF material showed very consistent behavior across all testing. The results for the LAF R-value test are shown in Figure 7. Nine of the 12 blends had average R-values above the control of 80. The three blends that did not increase in value had an average of 79. This consistency could be due to the fact that the aggregate material is very angular in nature, as is the glass cullet at all the sizes. The glass cullet behaved better when used with a more angular aggregate possibly because interlocking of the particles can still easily occur. With the rounded particles from the STAR material, the glass cullet can slip when it come in contact with the rounded particles.

Statistical analysis of the R-value data indicates that of the three variables tested, only aggregate type and cullet size are statistically significant factors in predicting the strength of the glass-aggregate blends. Replacement rate was not shown to significantly affect the strength of the blends. This may be true because of the inconsistent results at the higher replacement rates for the STAR aggregate as strength is expected to decrease at higher cullet contents. The scatter plot shown in Figure 8 shows the relationship between R-value or strength and cullet size. The squares indicate the LAF source of aggregate, while the circles represent the STAR aggregate. The predicted regression indicates a downward trend in R-value as cullet size increases for both the STAR and LAF aggregate.

Figure 7 LAF R-value Results

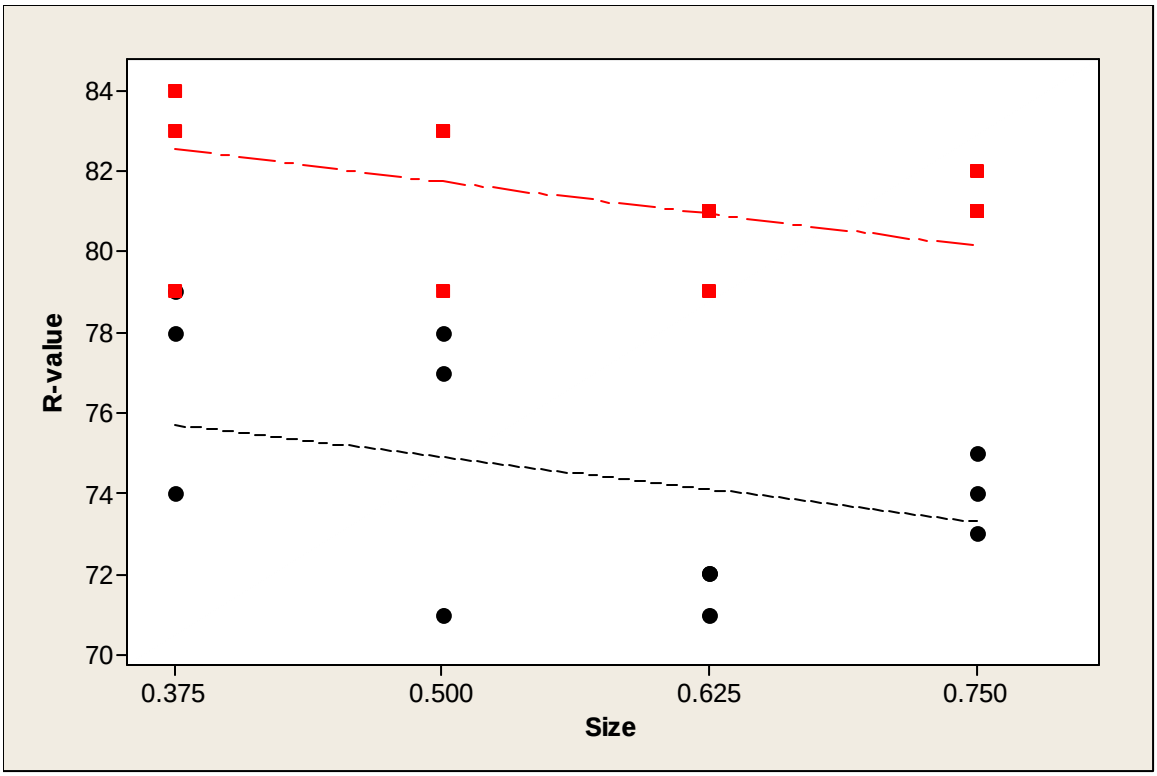

Figure 8 Scatter Plot of Median R-value vs. Size

4.3 Moisture-Density Relationships

To determine the moisture-density relationships of the glass-aggregate blends, the standard proctor test was performed. Moisture-density curves were developed to determine the optimum moisture content and maximum dry density for each glass-aggregate blend. The moisture-density curves for each source are shown in Figures 9 and 10. Each figure shows the cullet size and the corresponding curves for the control and 10%, 20%, and 30% replacement rates.

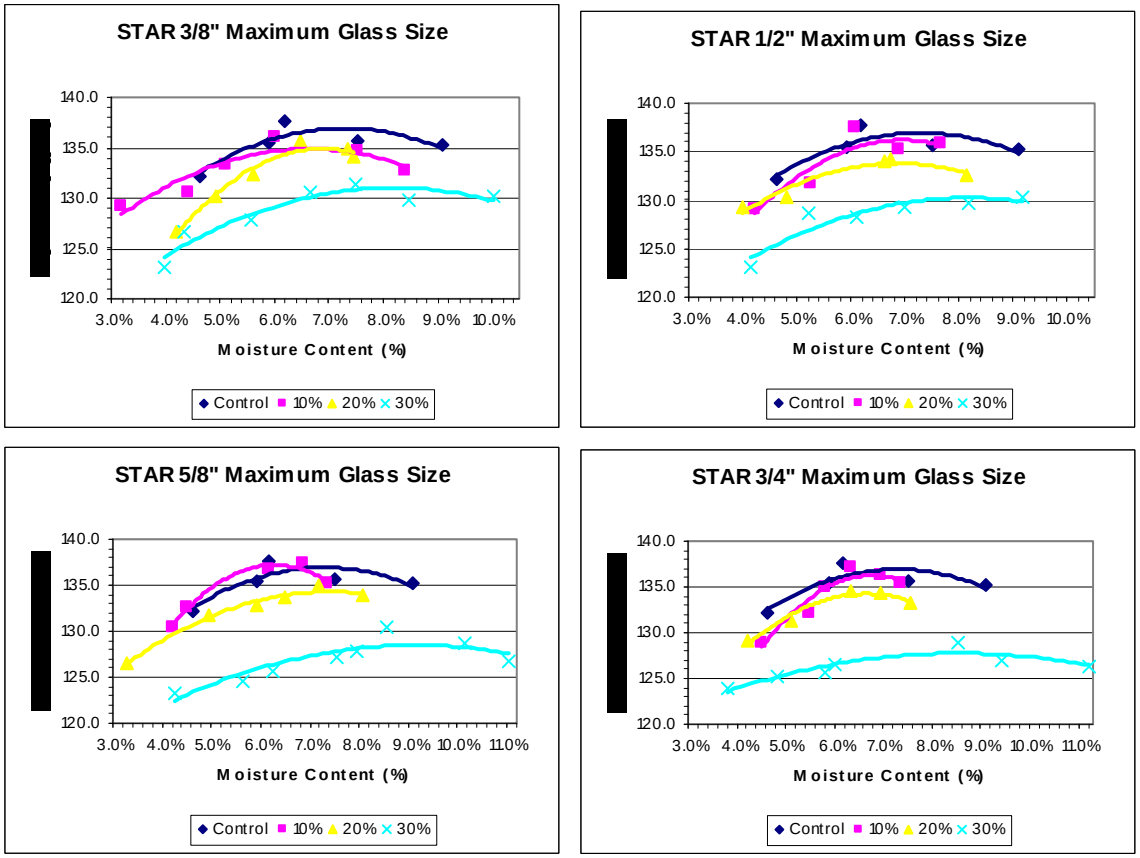

Figure 9 STAR Aggregate Moisture Density Curves

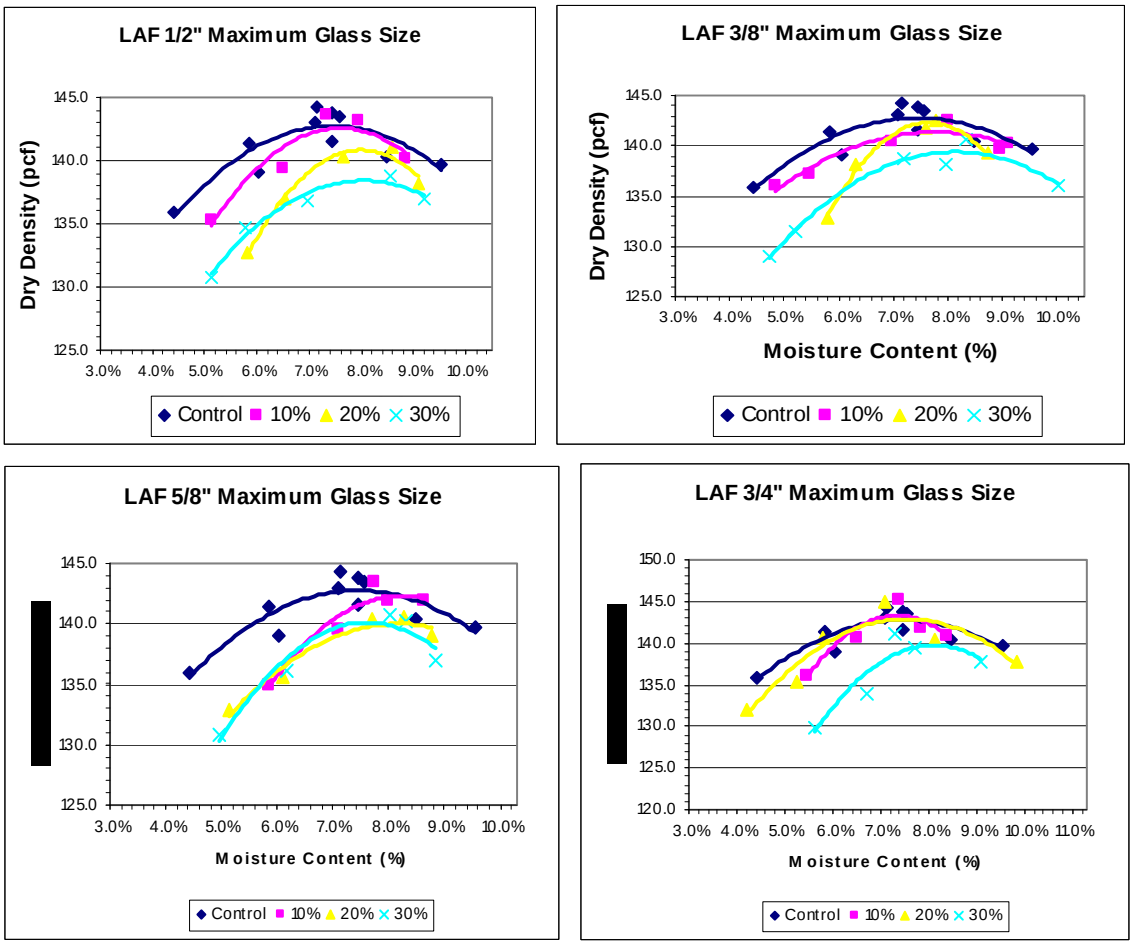

Figure 10 LAF Aggregate Moisture Density Curves

The maximum density of the blends will be discussed first. Statistical analysis of the curves show that type of aggregate and replacement rate are significant factors in determining the maximum density of a blend. As shown in Figure 11, the maximum density decreases as more cullet is introduced into the blend. This is true for both sources tested. The decrease in density was slightly greater for the rounded STAR aggregate versus LAF aggregate. At a 10% replacement rate, STAR aggregate remained at 99% of the density found for the control mix. An approximately 2% additional decrease occurred at replacement rates of 20% and again at 30%. At the highest replacement rate tested, the density was still found to be 95% of the control mix. Since most specifications allow compaction at approximately 95% of maximum, this implies that cullet used at the highest replacement rate tested would still meet this requirement. LAF aggregate performed very similar, but at higher maximum densities. LAF exhibited only a slight decrease (0.3%) when combined with 10% glass and only a 3% decrease in density from the control at 30% glass.

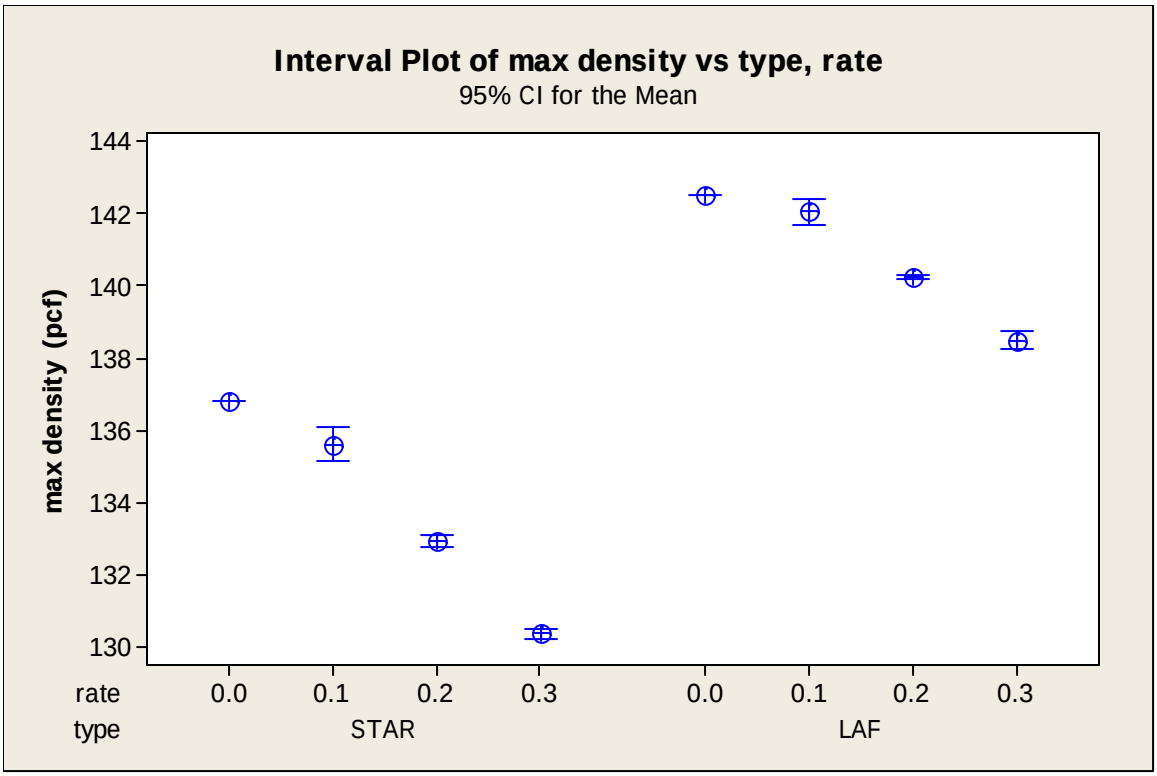

Figure 11 Interval Plot of Maximum Density vs. Replacement Rate

The average maximum densities versus size are shown in Figure 12. The 95% confidence intervals overlap across all sizes tested. This shows that size of cullet used does not significantly affect the density that can be achieved. This is true for both sources of natural aggregate tested. The confidence intervals are much larger for the size factor compared with the replacement rate factor because it encompasses values of maximum density across the three rates tested. Since the replacement rates of glass significantly affects density, the three values for one size of glass are significantly different leading to larger intervals. The same is true for the confidence intervals of optimum moisture content.

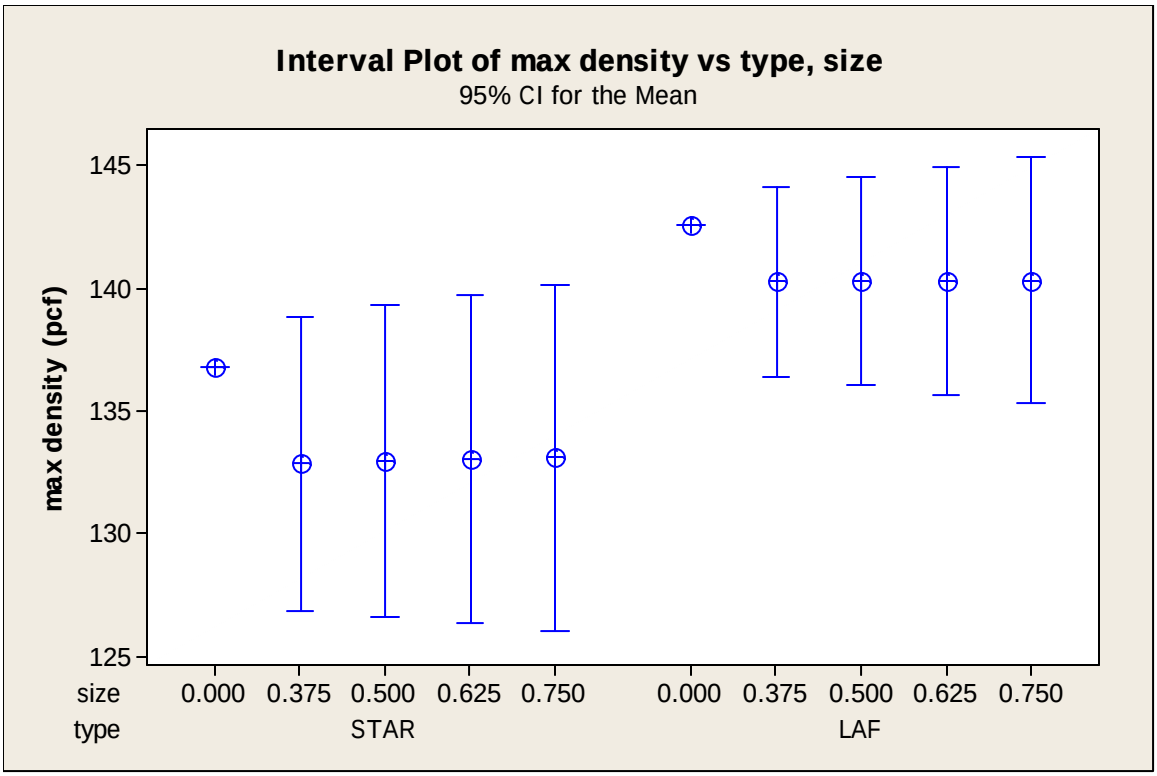

Figure 12 Interval Plot of Maximum Density vs. Cullet Size

The addition of glass cullet affected the optimum moisture content as well. The type of aggregate and replacement rate are significant factors in determining optimum moisture content, and again, cullet size is not. Figure 13 illustrates the relationship of moisture content and replacement rate, and Figure 14 shows the relationship between moisture content and glass particle size. It was expected that as the glass content increased the optimum moisture would decrease, but this was not observed. As cullet content increased the moisture content at which maximum density could be achieve also increased. This means that by adding glass, compaction or maximum density of mix is slightly harder to achieve.

Again, the addition of glass with the rounded aggregate had greater affect on the behavior of the material than it did when added to the angular aggregate. The optimum moisture content for STAR aggregate increased approximately 7% from the moisture content of the control when 10% glass was blended with the natural aggregate. The increase was approximately 13% for 20% glass and 19% for 30% glass. The moisture content for LAF aggregate increased approximately half as much as STAR for the same replacement rates. The increase was approximately 3% when 10% cullet was added, 6% when 20% cullet was added, and 9% when 30% cullet was added. The increase in optimum moisture content as a function of replacement rate is shown in Figure 13.

The average optimum moisture contents versus size are shown in Figure 14. Again, the 95% confidence intervals overlap across all sizes tested. This shows that size of cullet used does not significantly affect the optimum moisture content that is required to achieve maximum density. This is true for both sources of natural aggregate tested.

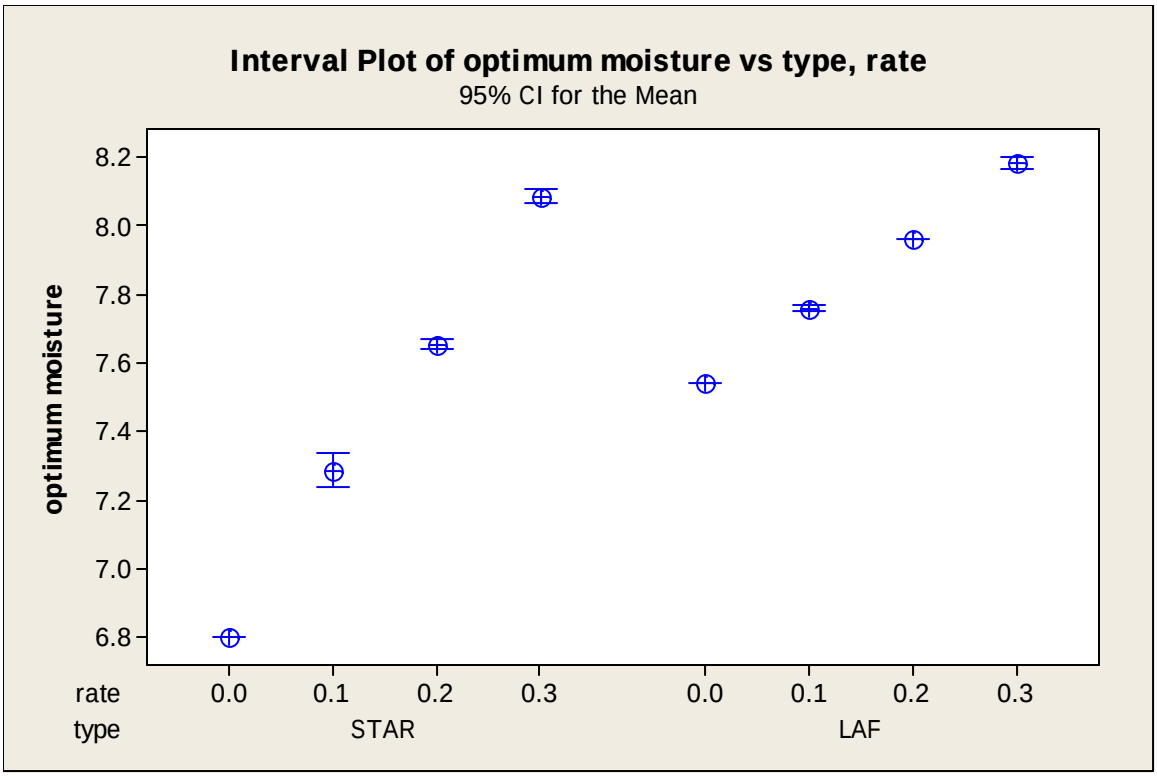

Figure 13 Interval Plot of Optimum Moisture Content vs. Replacement Rate

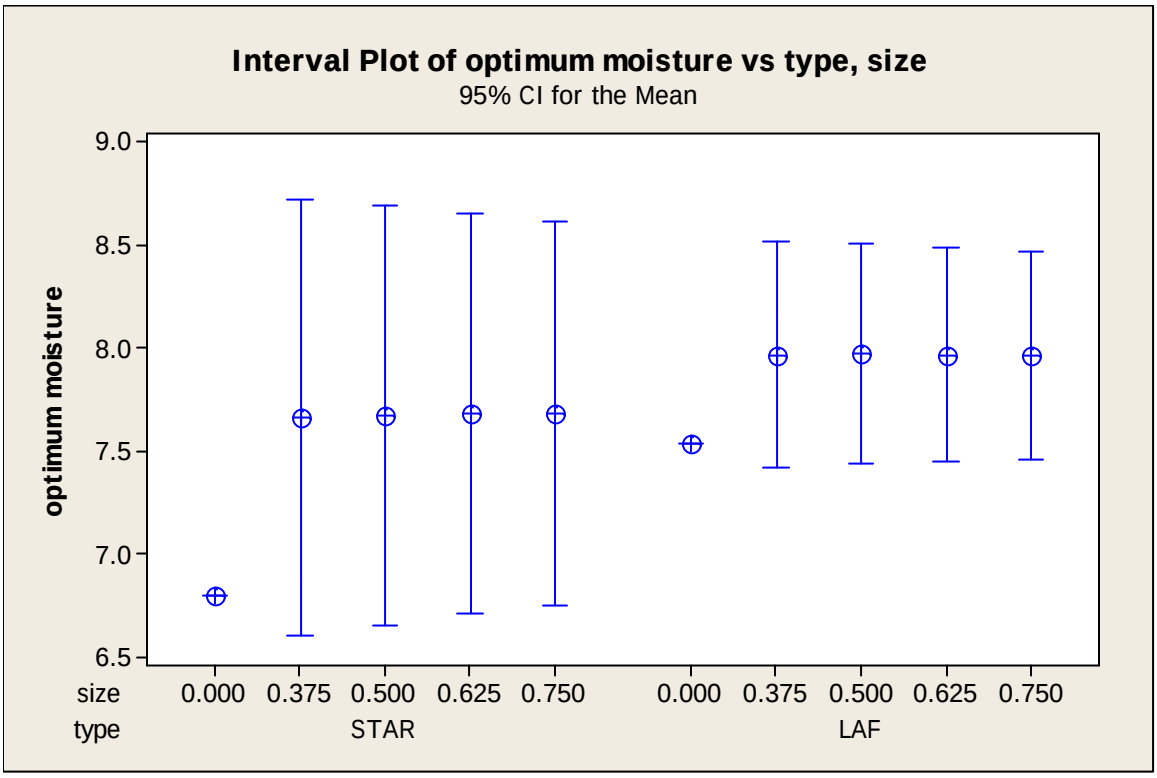

Figure 14 Interval Plot of Optimum Moisture Content vs. Cullet Size

5. CONCLUSIONS AND RECOMMENDATIONS

The objectives of this study were to evaluate the strength and moisture susceptibility and also the moisture-density relationships of natural aggregate and glass cullet blends. Two different sources of aggregate, three cullet replacement rates, and four maximum cullet sizes were evaluated. Analysis of the data indicated the following conclusions:

- A dozer is an acceptable alternative to a glass crusher in terms of producing similar glass gradations.
- Aggregate type has a significant effect on engineering properties of glass-aggregate blends. Specifically, the angularity of the natural aggregate will influence the behavior of the mix. More angular aggregate performs better when combined with glass cullet.
- Strength of the glass-aggregate blend is dependent on the size of glass cullet used in the mix and the aggregate type. The strength of the blend will decrease as the cullet size increases when combined with either aggregate.
- Cullet replacement rate is a significant factor in determining the maximum density and optimum moisture content of glass-aggregate blends.
- The addition of glass cullet decreases the maximum density that can be achieved by the blend. Ninety-five percent of the control maximum density is still obtained at all replacement rates tested.
- The optimum moisture content is significantly affected by the addition of glass cullet. An increase in optimum moisture content occurs as total cullet content in the blend increases.

After conducting this evaluation of the glass-aggregate blends, it can be concluded that crushed recycled glass, or cullet, can be used as a supplement to natural road base material. This study recommends that the use of cullet be limited to a 20% maximum replacement rate and a maximum size of 1/2". It is more feasible to use glass cullet with crushed, angular aggregate since it performs more consistently than when blended with rounded natural aggregate.

Utilization of cullet mixed with natural aggregate could prove to be very economically beneficial, especially for rural locations. The feasibility and exact economic benefits of using glass cullet for construction purposes should be considered on an individual basis by agencies that are considering its use. Nonetheless, based on this study, the strength and compaction properties of glass-aggregate blends are comparable to those of natural road base material. The addition of glass to road base, at the recommended levels, does not compromise the properties of the aggregate it is combined with and provides additional environmental and economic benefits.

6. REFERENCES

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