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16. Abstract

Many entities currently use recycled asphalt pavement (RAP) and other aggregates as base material, temporary haul roads, and, in the case of RAP, hot mix asphalt construction. Several states currently allow the use of RAP combined with cement for a stabilized base course under both asphalt and concrete pavements. Currently, there is disagreement on what properties are required, and how to test the cement and fly ash treated RAP for both asphalt and concrete pavement structures.

The objective of this study was to determine feasibility of cement and fly ash treated RAP and other aggregates as a structural layer for both portland cement concrete and hot mix asphalt pavement systems. A 610 limestone from Kentucky was used as the reference material. Other materials used in the study include: Mexican 610 limestone, gravel and limestone based RAP, and blended calcium sulfate (BCS). Samples were prepared with three cement and fly ash contents and tested for compression and flexural strength. Length changes specimens were also produced and the resilient modulus was measured.

Mixtures achieving 150 and 300 psi are capable of being produced with 4 to 8 percent portland cement and 10 to 20 percent class C fly ash. The compacted specimens achieved equal to or up to two and a half times greater compressive strength than those samples that were uncompacted. The reference and Mexican 610 limestone's produced much higher strengths compared to the RAP BCS mixtures. The BCS mixtures proved adequate in terms of shrinkage, strength, and did not fall apart when stored in the 100 percent humidity room or underwater for the requisite 14-day cure period for the length change test.

The resilient modulus results were similar across all samples, but no discernible trend could be determined, most likely due to the test containing only one sample for analysis. The results show that cement and fly ash treated RAP and other materials can be used in base course construction.

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Evaluation of Cement and Fly Ash Treated Recycled Asphalt Pavement and Aggregates for Base Construction

by

Tyson Rupnow, Ph.D., P.E.
Patrick Icenogle, E.I.
Scott Reech

Louisiana Transportation Research Center
4101 Gourrier Avenue
Baton Rouge, LA 70808

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ABSTRACT

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ACKNOWLEDGMENTS

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The effort of Randy Young, Matt Tircuit, Kelly Goudeau, Steven Schorr, and Joel Taylor in the concrete laboratory is greatly appreciated. The authors would like to thank Headwaters Resources and Holcim for providing the class C fly ash and the portland cement for the study, respectively. The authors would also like to thank Coastal, Honeywell, Martin Marietta Aggregates, and Vulcan Materials for providing the recycled asphalt pavement, blended calcium sulfate, and base material, respectively.

IMPLEMENTATION STATEMENT

The authors recommend that the Department construct several full-scale base course test sections incorporating stabilized RAP and BCS. One such location has already been determined to be a good pilot project and is located on LA 975 north of Interstate 10. A preliminary laboratory mix design has been completed. A technical assistance report detailing the laboratory results and suggested construction techniques and specifications has been provided to the project engineer.

After successful completion of the implementation project, a full set of specifications can be drafted to be included in standards and specifications for LADOTD construction projects.

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Many entities currently use RAP and other aggregates as base material, temporary haul roads, and, in the case of RAP, hot mix asphalt construction. Several states currently allow the use of RAP combined with cement for a stabilized base course under both asphalt and concrete pavements. Currently, there is disagreement on what properties are required and how to test the cement and fly ash treated RAP for both asphalt and concrete pavement structures.

Literature Review

This section details results obtained by previous work conducted at LTRC. Work completed by others is then presented. The previous work conducted at LTRC generally focused on inclusion of RAP as an ingredient in hot mix asphalt and as a interlayer in asphalt pavement systems. LTRC projects have shown the benefits of using RAP in asphalt pavements [*1*, *2*]. LTRC projects have also shown the benefit of using a RAP interlayer for asphalt pavement systems when testing in the accelerated loading facility (ALF) [*3*]. Another LTRC project noted the benefit of fly ash stabilization of shoulder material [*4*].

Cement Stabilization of RAP for Road Base and Subbase Construction

This study was completed in 2001 and involved cement stabilization of RAP for road bases and subbases. The study took place in the Sultanate of Oman where the recycling of pavement materials is not practiced widely. The objective of the study was to investigate the potential use of Type I portland cement with RAP-virgin aggregate mixtures for road base construction. Test procedures included: physical characterization of the RAP and aggregate mixtures, modified Proctor compaction tests, and unconfined compressive strength tests. Type I portland cement was added to the mixtures at the rate of 0, 3, 5, and 7% by dry weight. Pavement design analysis was also conducted by varying the base properties from laboratory data.

This study, that took place in the Sultanate of Oman, concluded that all RAP-virgin aggregate blends with no cement yield impractical base thicknesses, and RAP-virgin aggregate blends with no cement need a thicker surface course since the RAP percentage increases in the base in order to protect the weak base course. Other results demonstrated that as more cement is used for each mixture, the base course thickness decreases. As the RAP percentage is increased, the thickness of the base course will increase. Conclusions of this study are as follows: optimum moisture content, maximum dry density, and the unconfined compressive strength generally increase as the cement content and virgin aggregate contents increase, 100% RAP aggregate could be used in base construction if stabilized with cement, and RAP aggregate seemed to be a viable alternative to dense graded aggregate in road base and subbase construction [*5*].

Kansas Route 27

Several test sections were constructed and subsequently tested from 1992 to 1996 on Kansas Route 27 [*6*]. A total of 11 test sections were constructed. Three sections were stabilized using a cationic, medium setting polymerized asphalt emulsion; five were constructed using a cationic, medium setting asphalt emulsion; and three were constructed using 13 percent American Society of Testing and Materials (ASTM) class C fly ash as the binder. All layer thicknesses were 4 in., with a 1.5-in. hot mix asphalt overlay.

One conclusion from this study was that cold in place recycled (CIPR) pavements with class C fly ash as a binder reduces the potential of rutting when compared to the other test sections built with conventional binders. The self-cementing fly ash sections consistently showed the lowest surface deflection values for Falling Weight Deflectometer (FWD) testing. Shear strains in the fly ash treated layer were very uniformly distributed across the pavement layers. Lastly, for pavement damage, rutting controlled this project, not fatigue [*6*].

Recycled Pavement, 93rd Street, Shawnee County, Kansas

Constructed in June of 1987, this 1.5-mile section of rural road carries a high volume of truck traffic [*7*]. The surface course varied in thickness from 2 to 6 in. with a 1- to 8-in. granular base overlying a clay subgrade. The design process concluded that 18 percent class C fly ash and 10 percent moisture content was needed to stabilize the material.

The construction process began with recycling the existing pavement and base to a depth of 6 in. and compacting it. The fly ash was deposited in windrows, spread uniformly, and mixed with a Bomag MPH 100 Recycler. For this project, water was added through nozzles in the mixing drum. Initial compaction was completed with a vibratory padfoot roller while final compaction was completed with a smooth drum or pneumatic-tired roller. The surface was kept moist for the five-day cure period. A layer of asphalt was then applied followed by a chip seal wearing surface two months later. Observations four years after construction yield no distress or deterioration [*7*].

Fly Ash Stabilization of RAP, City of Mequon, Wisconsin

This study discussed two test sections 250 m long built on the eastern end of Highland Avenue [*8*]. Both sections had a surface thickness of about 140 mm overlying a 170 mm to 450 mm base course overlying a cohesive subgrade. The project was started and completed in August of 1997.

For construction, both sections were pulverized to a depth of 200 mm. The asphalt emulsion section was repulverized to a depth of 100 mm and emulsified asphalt was added at the rate of 7 L/m2. The section was then graded, compacted, and an 87.5-mm HMA surface was placed. The fly ash section was constructed by placing the ash at 7 percent by dry weight on the RAP and mixing to a depth of 125 mm. The layer was graded and water was applied to the surface to achieve 5 percent moisture content. The stabilized layer was then graded, compacted, and a 100-mm HMA surface was applied. FWD testing shows excellent performance through the first year for the fly ash section due to the increased structural capacity of the pavement [*8*].

Fly Ash Stabilization of RAP, Waukesha County, Wisconsin

This project was undertaken on Highway JK in Waukesha, Wisconsin, and is a ¾-mile county road lying in a low area with very silty subgrade soils. Problems with frost heave have been experienced due to availability of water and the silty nature of the underlying soil. Construction began in October 2001 on the new road base. Fly ash stabilization was used because it was cost effective. The existing asphalt pavement was pulverized to a depth of 6 in., and water was added to the milled material. Then a second pass of the pulvamixer was used to pulverize the material to a depth of 12 in. The target water content for the project was 6 percent, and fly ash was added to the RAP at 8 percent. The final pass of the mixer was then completed. Initial compaction was completed with a vibratory sheepsfoot with a compaction delay of less than half an hour. Final compaction was then completed using a smooth drum roller. The compacted stabilized section was allowed to cure for 24 hours before 5 in. of E-3 Superpave mix was laid down. No frost heave was observed the following winter showing good performance [*9*].

OBJECTIVE

The objective of this project was to determine feasibility of cement and fly ash treated RAP and other aggregates as a structural layer for both portland cement concrete and hot mix asphalt pavement systems.

SCOPE

To complete the objective, two sources of RAP were investigated, limestone based and gravel based. A 610 crushed limestone was used as a reference material. Other aggregates included in the test matrix were Mexican 610 limestone and blended calcium sulfate. The materials were mixed with portland cement and class C fly ash at three levels and tested for strength and shrinkage. Upon determining the optimum level, three percentages (5, 10, and 15 percent) of sand and soil cement were subsequently added to determine their respective effects of strength and shrinkage. Statistical analysis was conducted to determine the optimal combinations, and then the mixtures were duplicated and compacted to better simulate field compaction and construction techniques.

METHODOLOGY

Test Methods

The following test methods were used to determine the respective characteristics of the mixtures and their constituents. Note that x-ray fluorescence (XRF) was used to determine the chemical characteristics for classification of the cementitious materials.

- ASTM C39 [Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens] [*10*]
- ASTM C78 [Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)] [*11*]
- ASTM C136 [Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates] [*12*]
- ASTM C150 [Standard Specification for Portland Cement] [*13*]
- ASTM C157/157M [Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete] [*14*]
- ASTM C618 [Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete] [*15*]

The resilient modulus (M_r) testing was completed using the following test procedure. The sample was pulsed with 50 lb. of load for 200 cycles. A cycle consisted of 0.1 second of load and 0.9 second of rest. The deflections were measured and the last 10 cycles were used in the calculation of the M_r.

Note that compressive strength specimens were cast in triplicate and tested at both 7 days and 28 days of age. Flexural strength specimens were cast in triplicate and tested at 28 days of age. Length change and modulus of elasticity specimens were cast in duplicate and tested at 28 days of age. Resilient modulus samples were tested at 28 days of age.

Note that the test matrix was developed to determine the strength characteristics of a stabilized base course in much the same way a pavement layer is tested.

Test Matrix

The factorial for this study was based on a compressive strength of 300 psi compressive strength commonly found in literature and currently within DOTD specifications. The reference mixture was a #610 limestone from Kentucky. The RAP materials were limestone based and gravel based obtained from local hot mix asphalt producers. Mexican 610 limestone from Mexico and BCS from Honeywell rounded out the materials. The cement used was a Type I/II portland cement from Holcim Theodore, AL, and the class C fly ash used was obtained from Westlake, LA.

All mixtures were all produced with 4, 6, and 8 percent cement and 10, 15, and 20 percent class C fly ash by weight. The water content was kept constant at 6 percent above saturated surface dry (SSD) condition for the respective aggregate source. After determining the hardened characteristics of each mixture, the optimum cement and fly ash contents for the reference and RAP mixtures were then tested to determine the influence of sand and recycled soil cement. The addition rates of sand and soil cement were set at 5, 10, and 15 percent by weight.

DISCUSSION OF RESULTS

Materials Results

The XRF results show that the cementitious materials used in the study are representative of those used in everyday construction projects throughout the state of Louisiana and conform to applicable ASTM, American Association of State Highway Transportation Officials (AASHTO), and LADOTD standards and specifications. Table 1 shows the XRF results for the cementitious materials used in the laboratory test factorial. Note that all values are in percentage of the oxide.

Table 1
XRF results for the cementitious materials used in the laboratory test factorial

Oxide	Type I/II Portland Cement	Class C Fly Ash
SiO_2	20.24	35.04
Al_2O_3	4.45	19.30
Fe_2O_3	3.47	5.32
CaO	63.28	24.98
MgO	3.82	5.48
Na_2O	0.22	1.95
K_2O	0.44	0.46
TiO_2	0.28	1.36
SO_3	2.62	2.81
LOI	1.10	0.60

Figure 1 shows the gradations of each material used in the study. Note that the moisture content at SSD was determined to be 2.10, 2.55, 4.07, 6.29, and 30.64 percent for the reference, limestone RAP, gravel RAP, Mexican 610, and BCS materials, respectively.

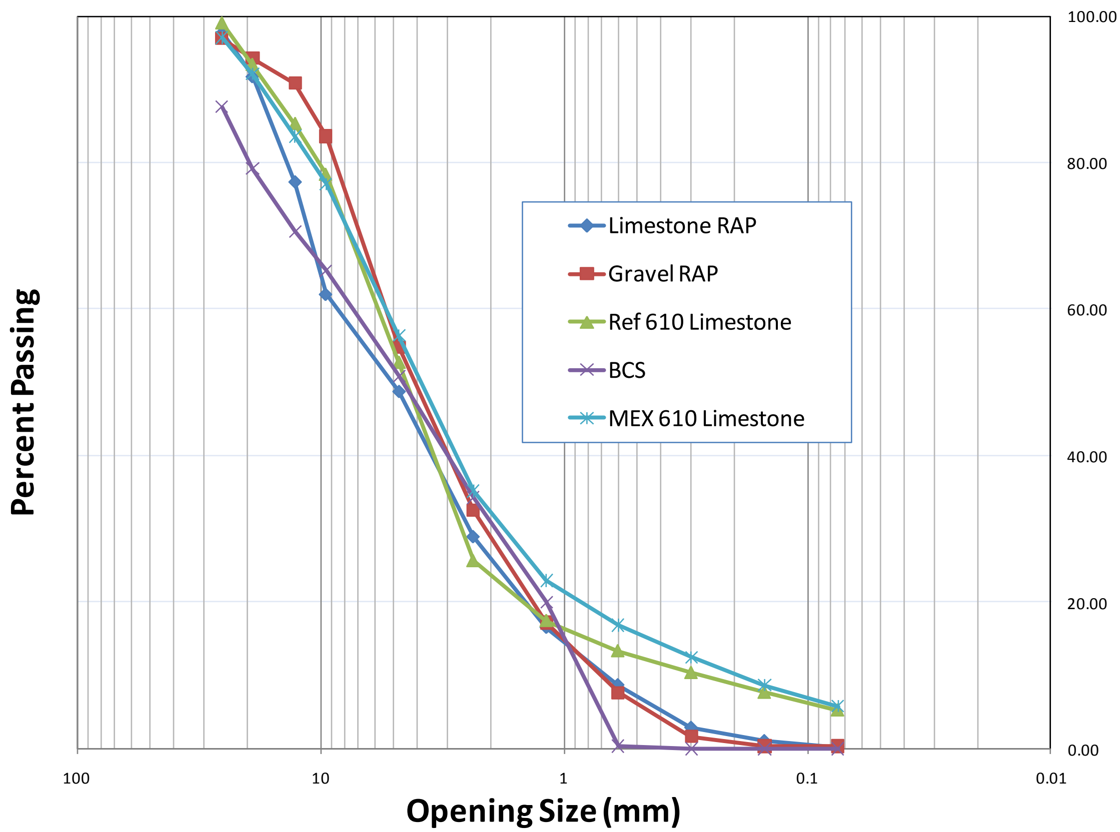

Figure 1
Gradation curves for all materials used in the study

Compressive Strength

The compressive strength gain results are divided into sections based upon primary aggregate type (i.e., reference, limestone or gravel based RAP, Mexican 610, and BCS). A detailed comparison of the results follows.

Reference

The compressive strength gain results for the reference mixture are shown in Figure 2. Note the significant increase in strength when using portland cement versus class C fly ash. Figure 3 and Figure 4 show the influence of sand and soil cement on the compressive strengths of the reference mixture. Note that the addition of sand increased the compressive strengths slightly and the addition of soil cement decreased the compressive strengths by about 30 percent for the portland cement mixtures.

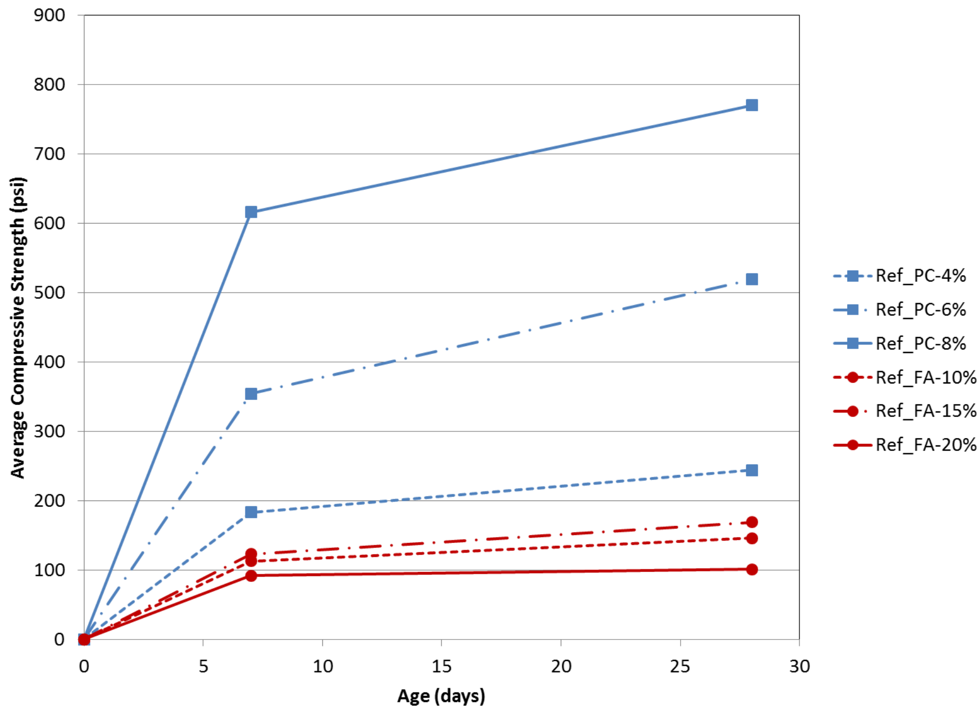

Figure 2
Compressive strength gain results for the reference mixture

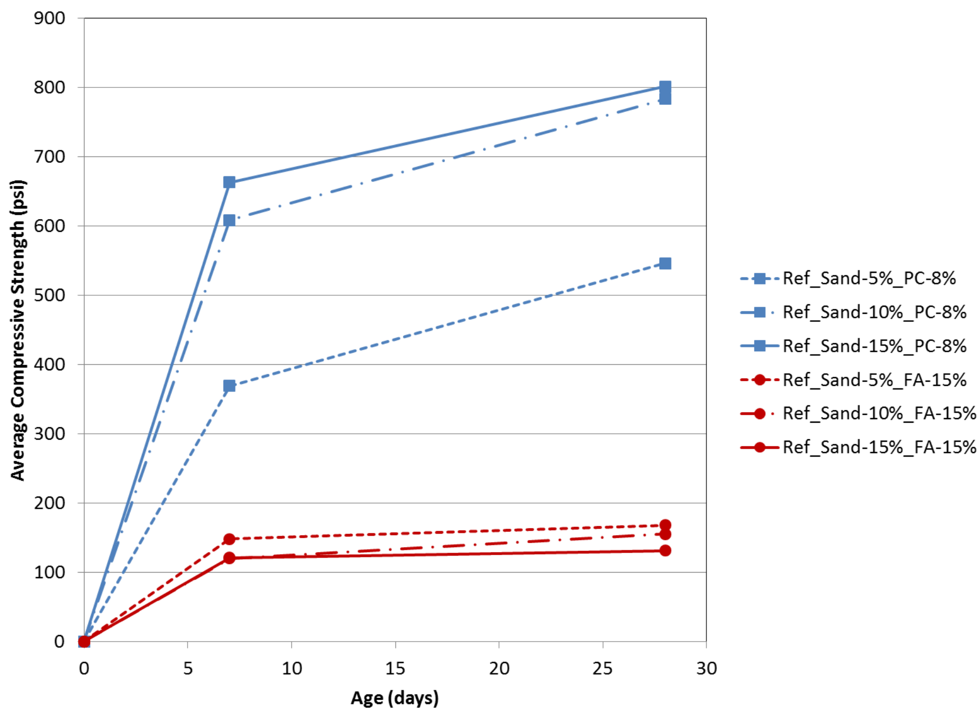

Figure 3
Compressive strength gain results for the reference mixture containing sand

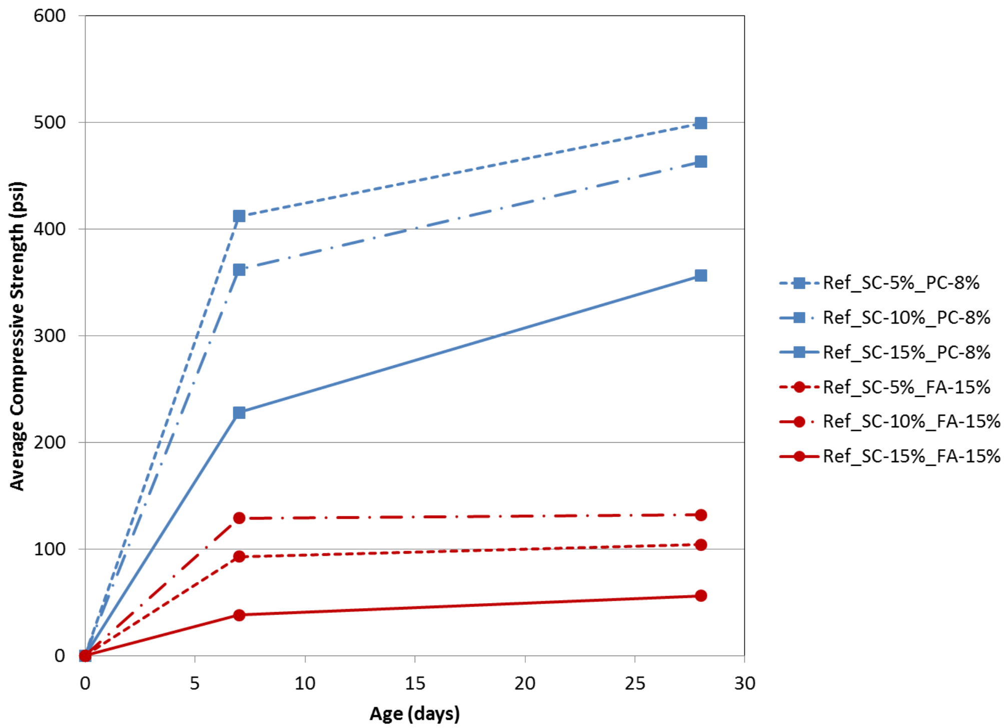

Figure 4
Compressive strength gain results for the reference mixture containing soil cement

Limestone Based RAP

The compressive strength gain results for limestone based RAP mixtures are shown in Figure 5 to Figure 7. Note an increase in compressive strength when incorporating sand and soil cement into the mixture. The limestone based RAP mixtures also show that when incorporating sand into the mixture, the effect of portland cement and fly ash are about the same. This would prompt the use of fly ash, which is generally about half the price of portland cement on a per ton basis.

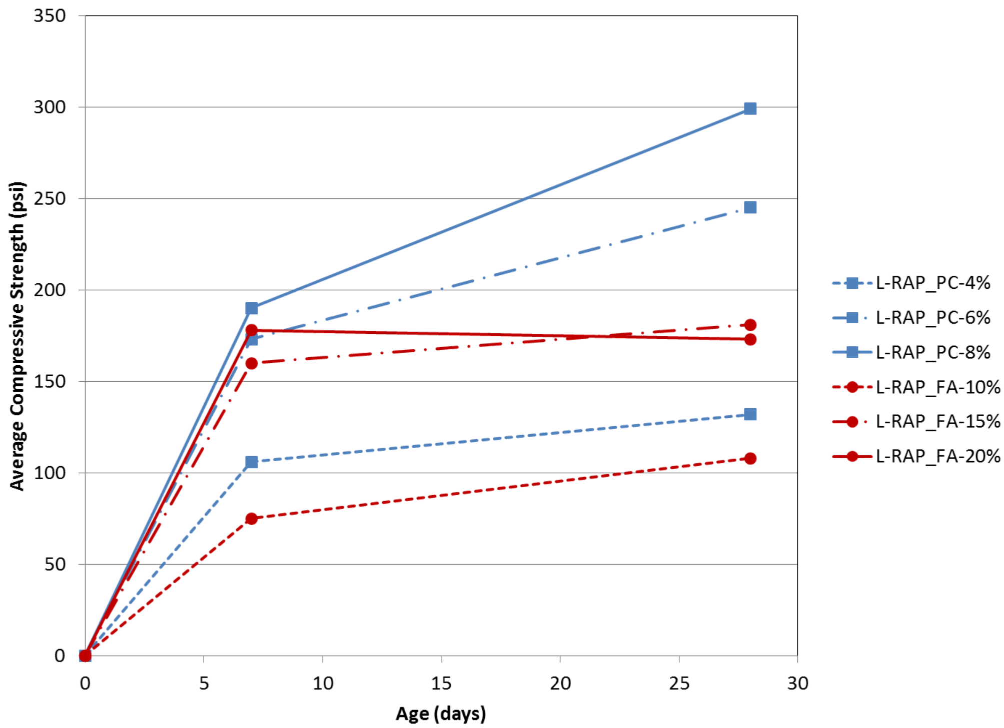

Figure 5
Compressive strength gain results for limestone based RAP mixtures

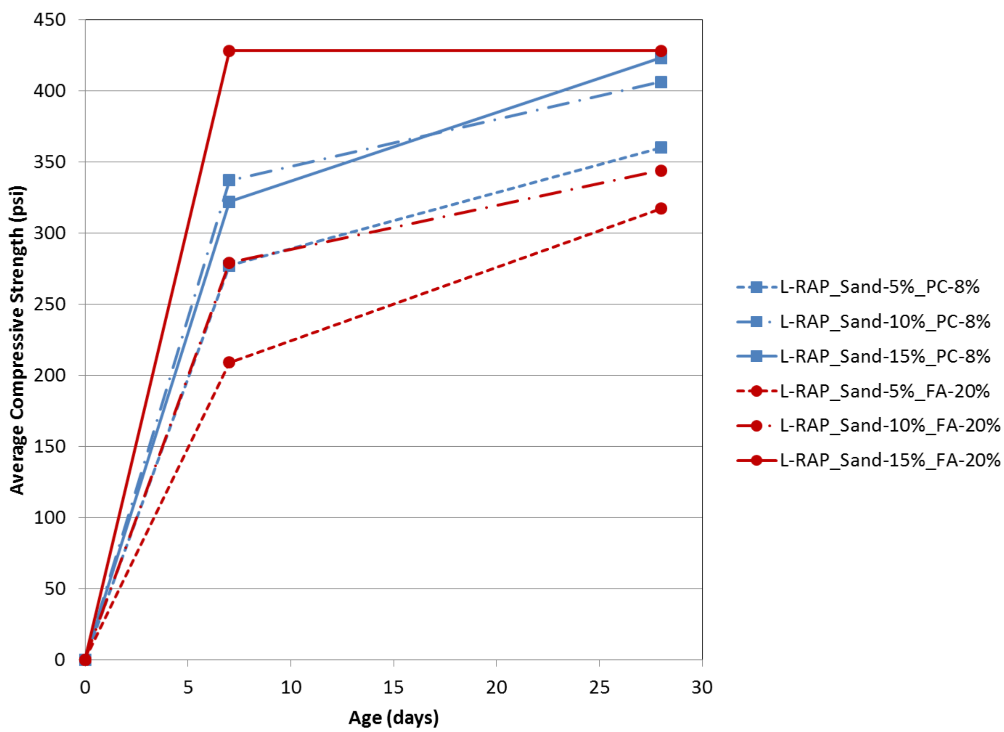

Figure 6
Compressive strength gain results for limestone based RAP mixtures containing sand

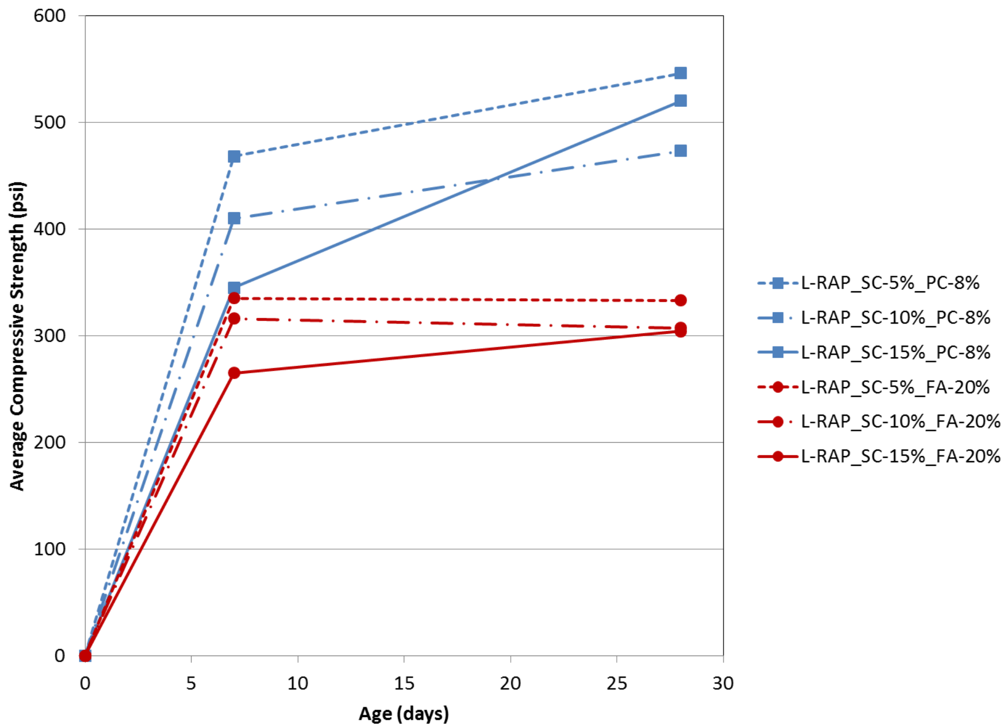

Figure 7
Compressive strength gain results for limestone based RAP mixutres containing soil cement

Gravel Based RAP

The compressive strength gain results for gravel based RAP mixtures are shown in Figure 8 to Figure 10. Note the increase in compressive strength when incorporating sand and soil cement for gravel based RAP mixtures. Though the results show relatively weak strengths (i.e., less than 300 psi), the addition of sand to the mixtures can bring the strengths above the more desirable 300 psi, especially when using portland cement as the cementitious material.

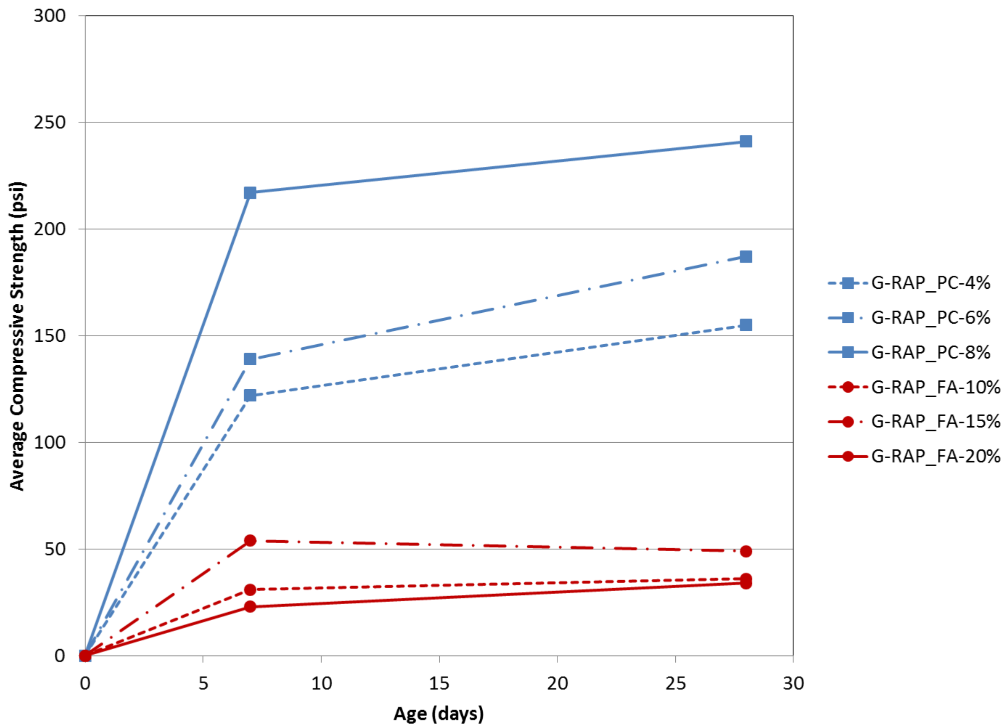

Figure 8
Compressive strength gain results for gravel based RAP mixtures

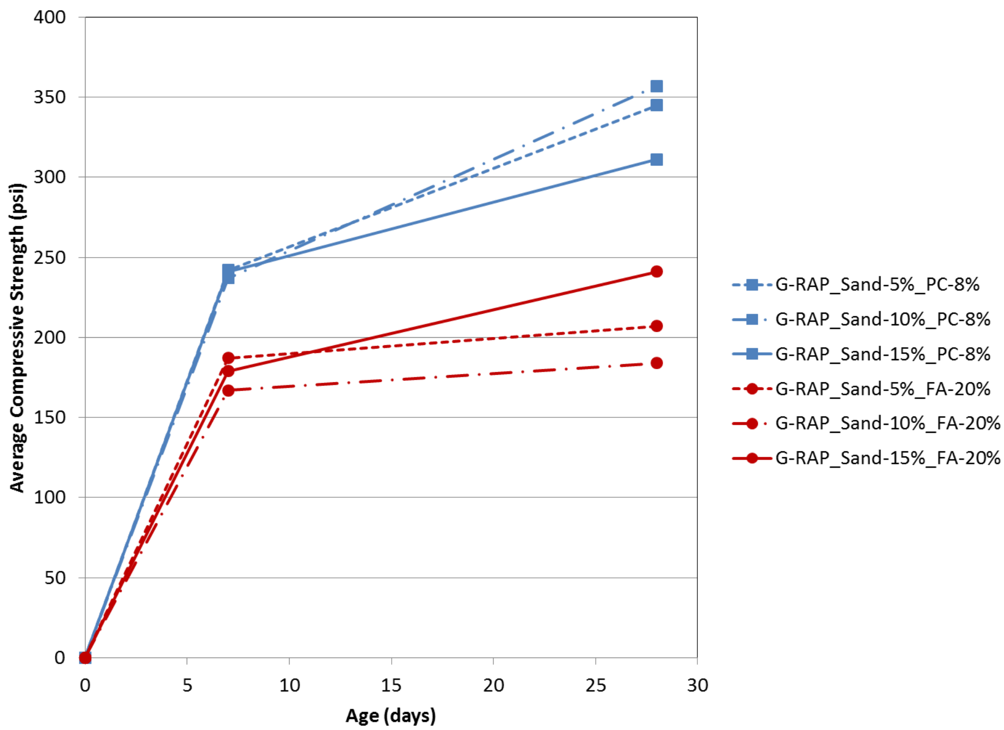

Figure 9
Compressive strength gain results for gravel based RAP mixtures containing sand

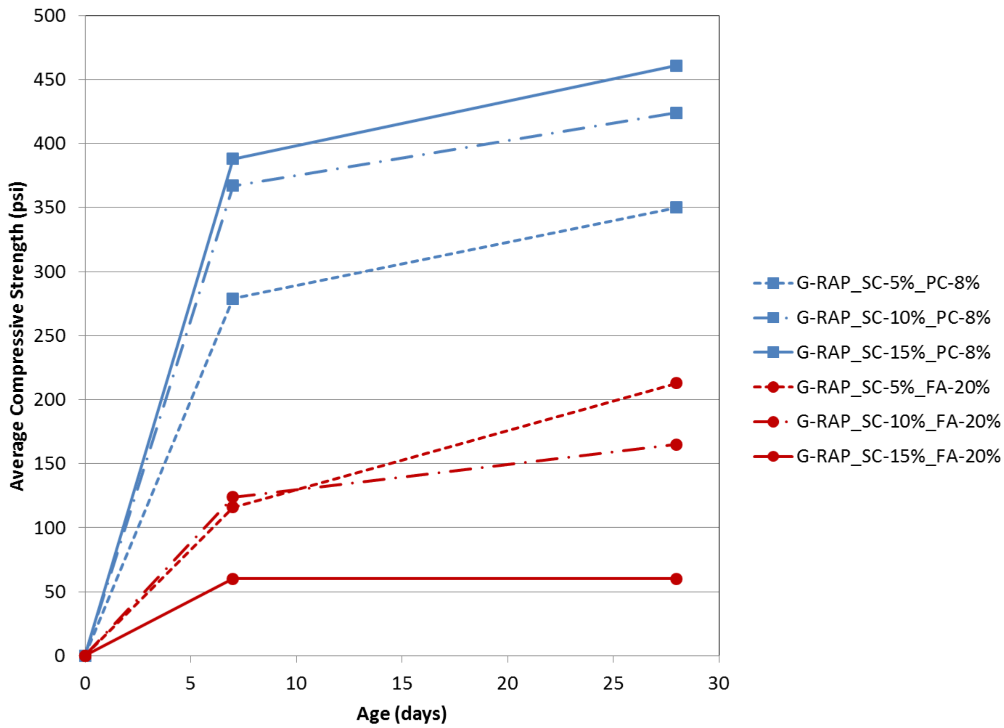

Figure 10
Compressive strengh gain results for gravel based RAP mxitures containing soil cement

Mexican 610 Limestone

The compressive strength gain results for Mexican 610 limestone mixtures are shown in Figure 11. Note the results are similar to the reference material as is expected due to the materials both being a 610 gradation.

BCS

The compressive strength gain results for BCS mixtures are shown in Figure 12. Note the results show that BCS performs adequately when incorporating 6 percent portland cement or greater.

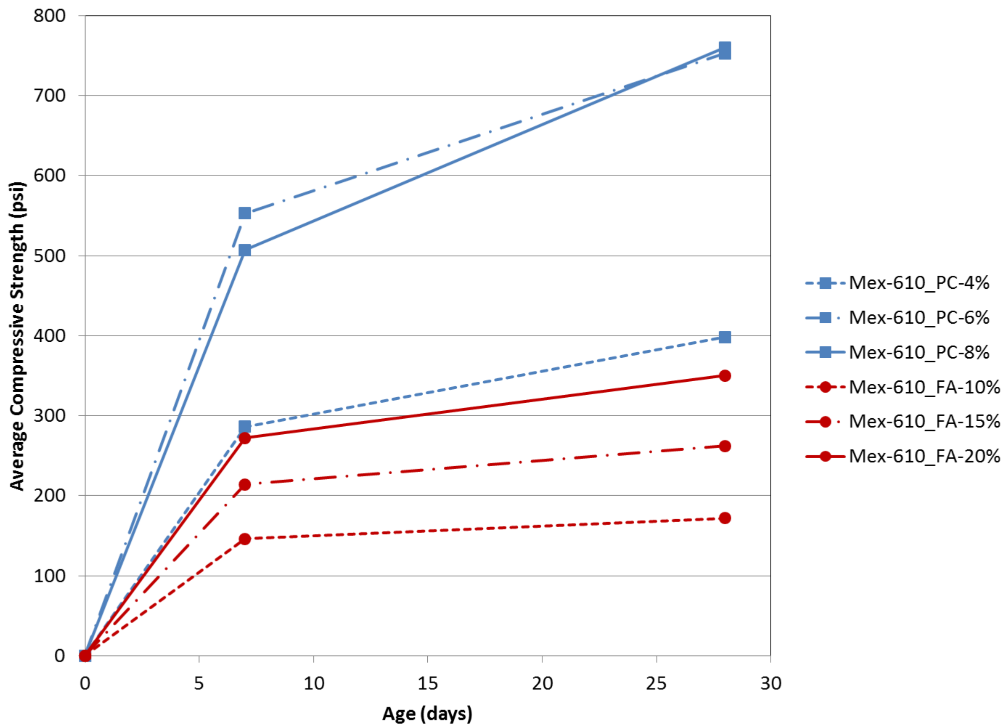

Figure 11
Compressive strength gain results for Mexican 610 limestone mixtures

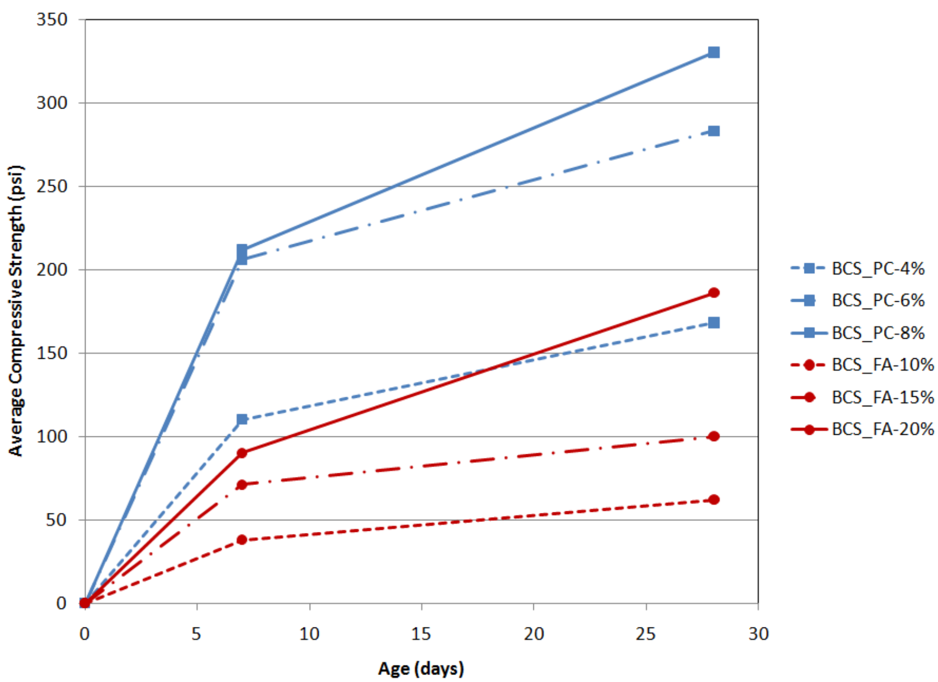

Figure 12
Compressive strength gain results for BCS mixtures

Mixture Comparison

Figure 13 shows the comparative average 28-day compressive strengths for all material types containing portland cement. Note the bar for reference is the minimum strength for soil cement construction in Louisiana and as the cement content increased, the compressive strength increased. The reference mixture, a 610 limestone, and the Mexican 610 limestone mixtures performed the best followed by the BCS, limestone RAP, and gravel RAP. Although the RAP mixtures did not perform as well as the others, they still meet minimum strengths for construction of bases in Louisiana.

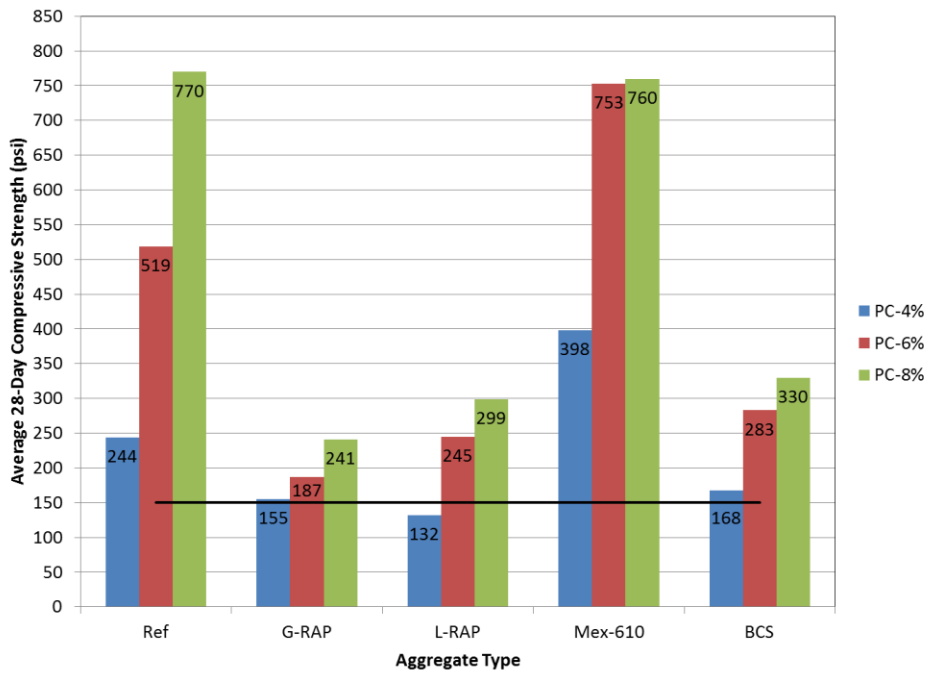

Figure 13
Comparison of the average 28-day compressive strength for all mixtures containing portland cement

Figure 14 shows the comparative average 28-day compressive strengths for all material types containing class C fly ash. The Mexican 610 limestone mixtures performed the best followed by the BCS, limestone RAP, and the reference 610 limestone. The use of fly ash significantly reduces the compressive strengths compared to portland cement, but adequate strengths can still be achieved with a greater percentage of fly ash use on the order of 15 to 20 percent by weight.

Figure 15 and Figure 16 show the effect of sand addition on 28-day compressive strengths. Note the addition of sand increased the compressive strengths, most likely due to a better gradation and a more dense structure. The mixtures also all met the greater threshold of 300 psi for base course construction in Louisiana. BCS was not produced with sand due to the material readily breaking down in the mixer. The Mexican 610 mixtures were not produced with sand due to the similar results found without the sand addition when comparing the reference 610 and the Mexican 610. Comparable increases from the reference 610 mixture can be expected for the Mexican 610.

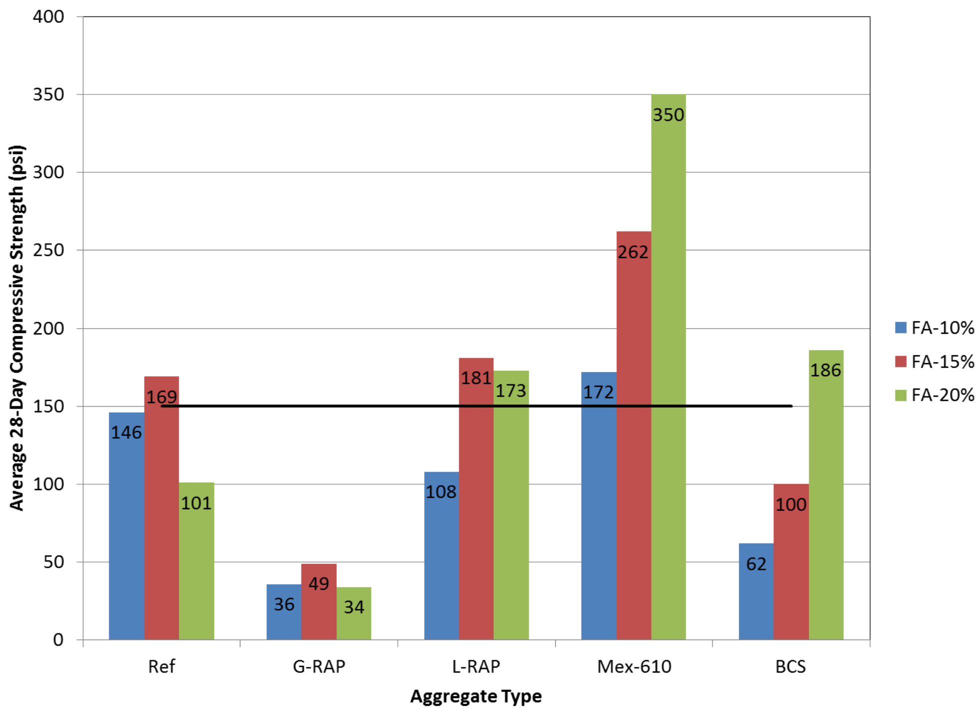

Figure 14
Comparison of the average 28-day compressive strength for all mixtures containing fly ash

Figure 17 and Figure 18 show the effect of soil cement addition on 28-day compressive strengths. Although the addition of soil cement generally decreased the strengths, the results show that a little bit of soil cement will not affect the end result of 150 psi. This is important to consider especially when the reclamation and stabilization of an old roadway is being completed in a one-pass operation. Although these results are consistent with in-place mixing, a pug mill may be used for mixing on future construction projects.

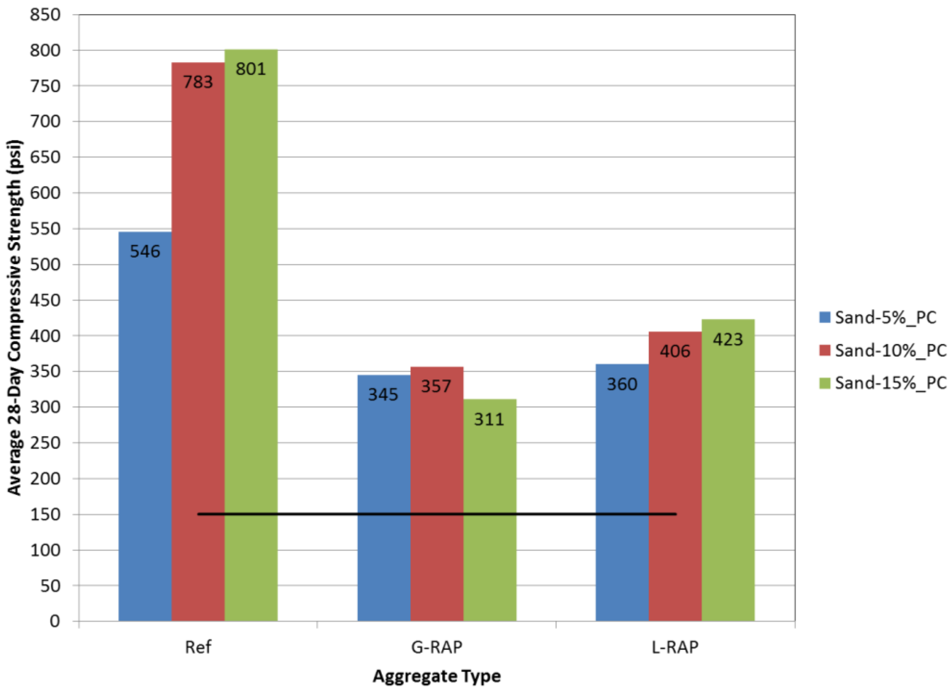

Figure 15
Comparision of the average 28-day compressive strength for all mixtures containing portland cement and sand

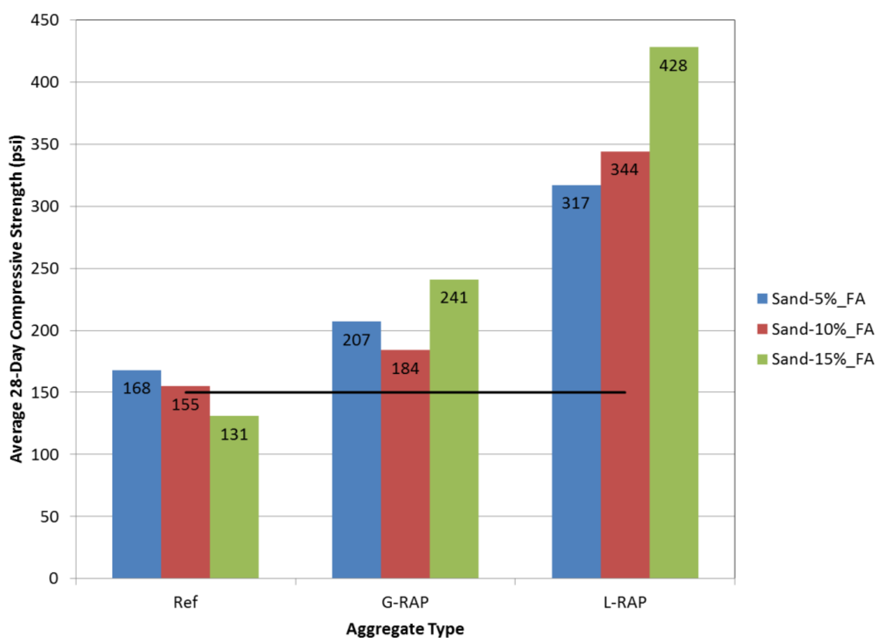

Figure 16
Comparison of the average 28-day compressive strength for all mixtures containing fly ash and sand

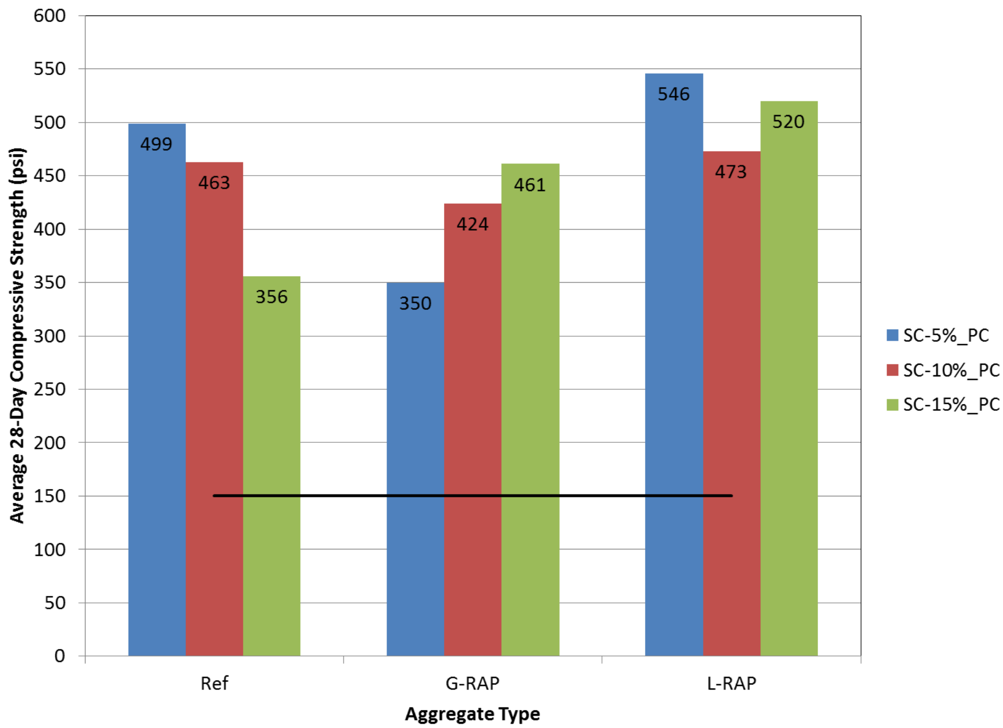

Figure 17
Comparison of the average 28-day compressive strength for all mixtures containing portland cement and soil cement

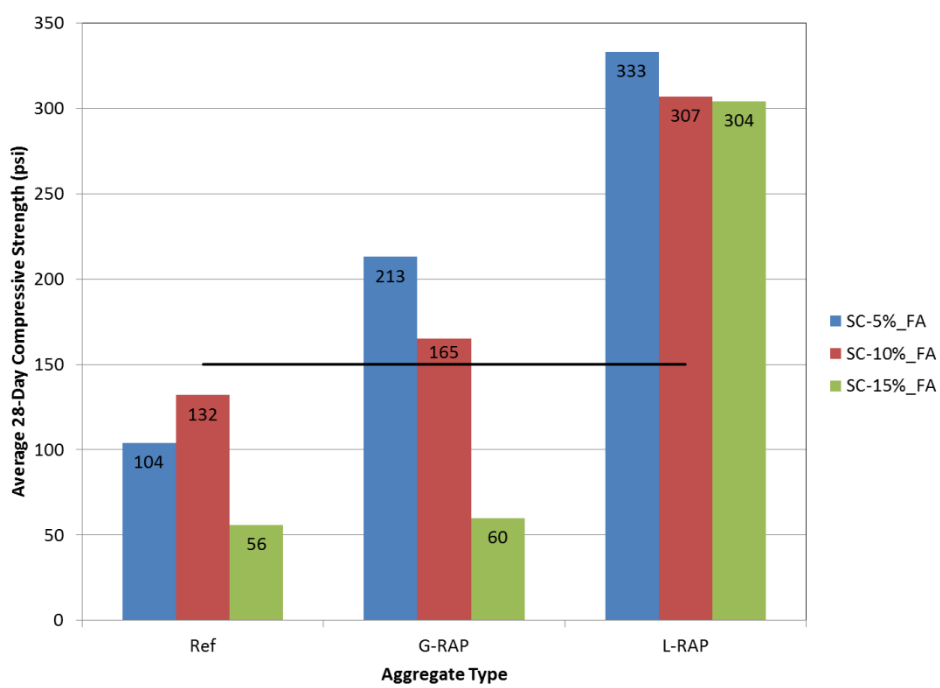

Figure 18
Comparison of the average 28-day compressive strength for all mixtures containing fly ash and soil cement

Flexural Strength

The average 28-day flexural strength results are shown in Figure 19 to Figure 24. The flexural strength results follow the same trend as the compressive strength results. An increase in the cement or fly ash content generally increases the flexural strength. The addition of sand and soil cement affected the flexural strength considerably. Note that an increase in the percentage addition of soil cement led to a reduction in flexural strength.

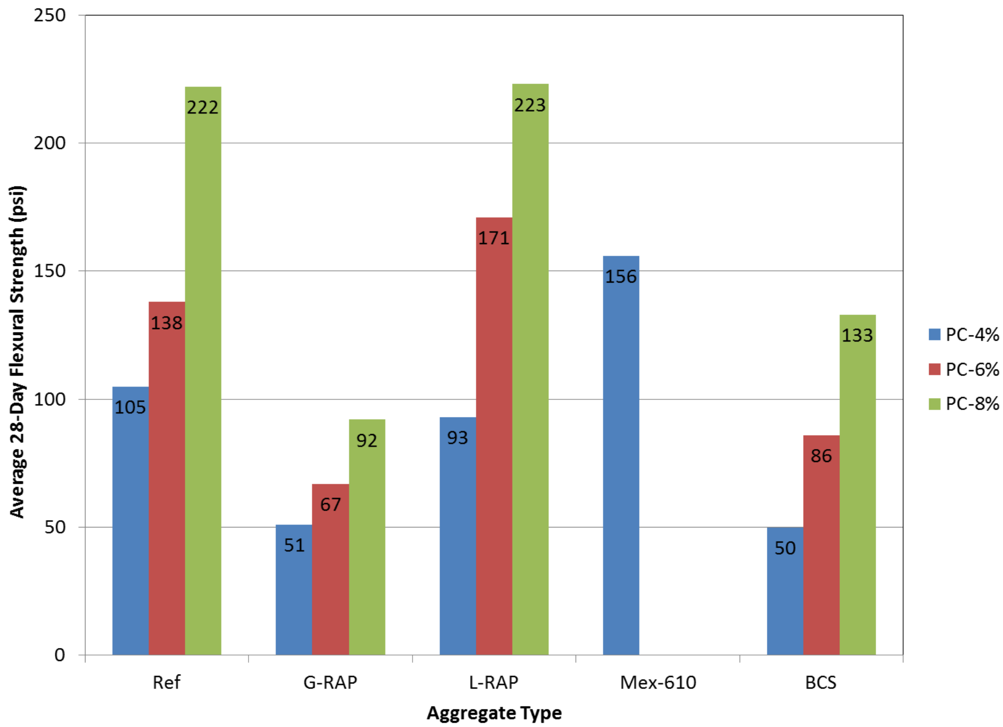

Figure 19
Comparison of the average 28-day flexural strength results for mixtures containing portland cement

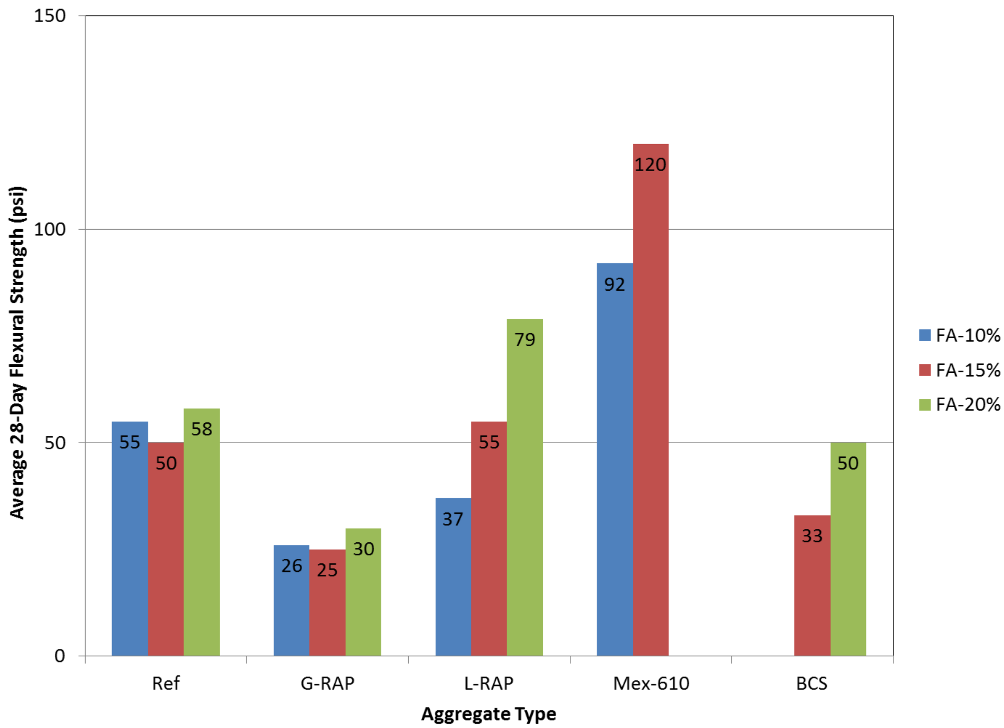

Figure 20
Comparision of the average 28-day flexural strength results for mixtures containing fly ash

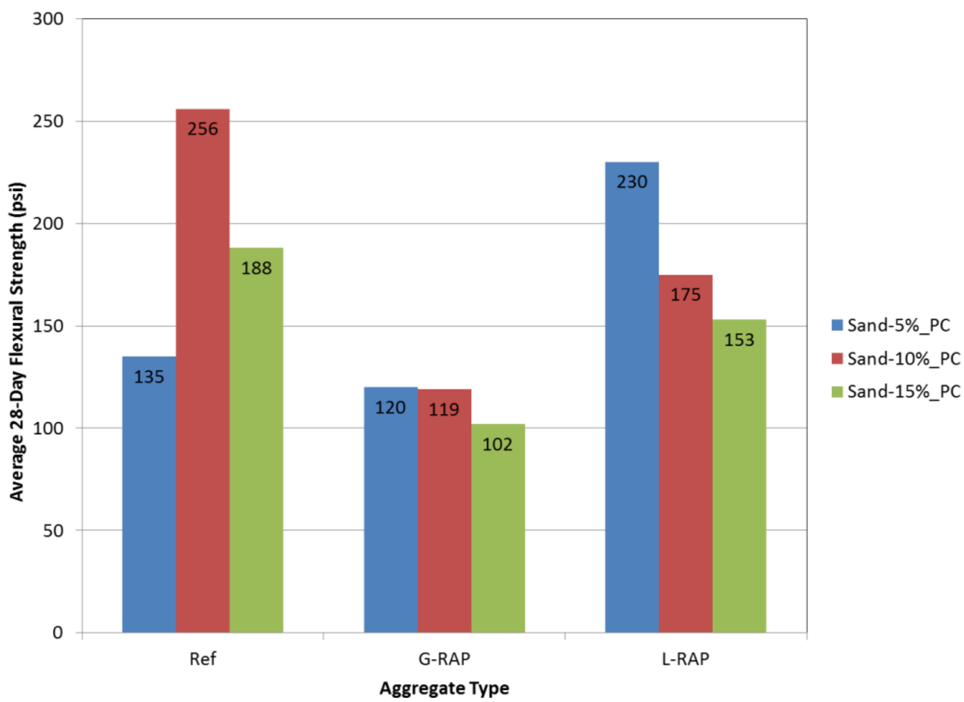

Figure 21
Comparison of the average 28-day flexural strength results for mixtures containing portland cement and sand

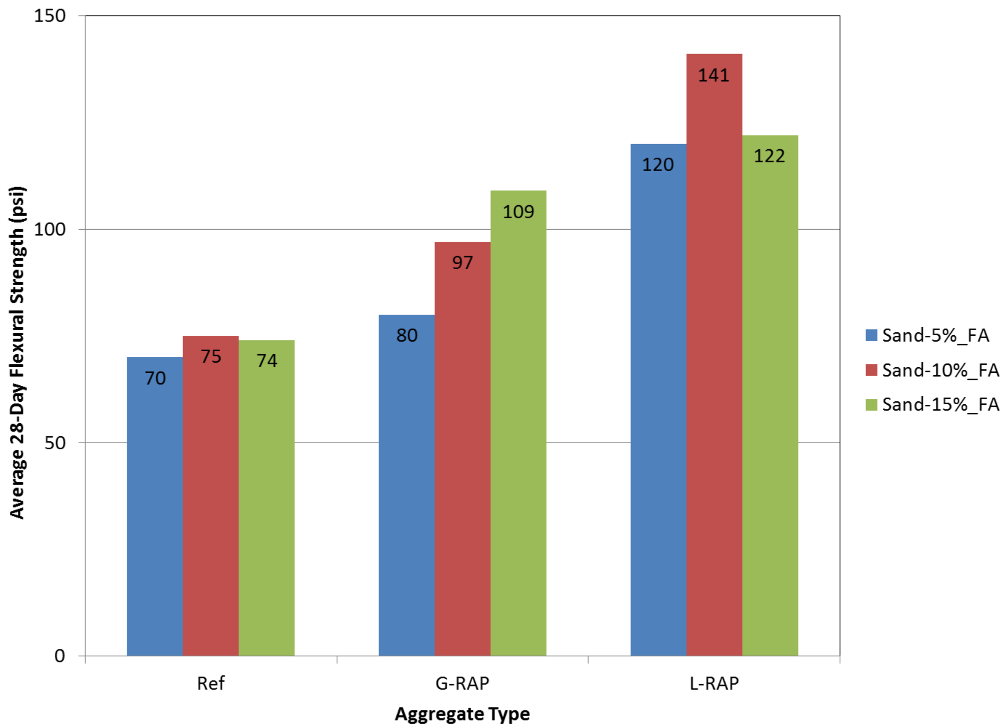

Figure 22
Comparison of the average 28-day flexural strength results for mixtures containing fly ash and sand

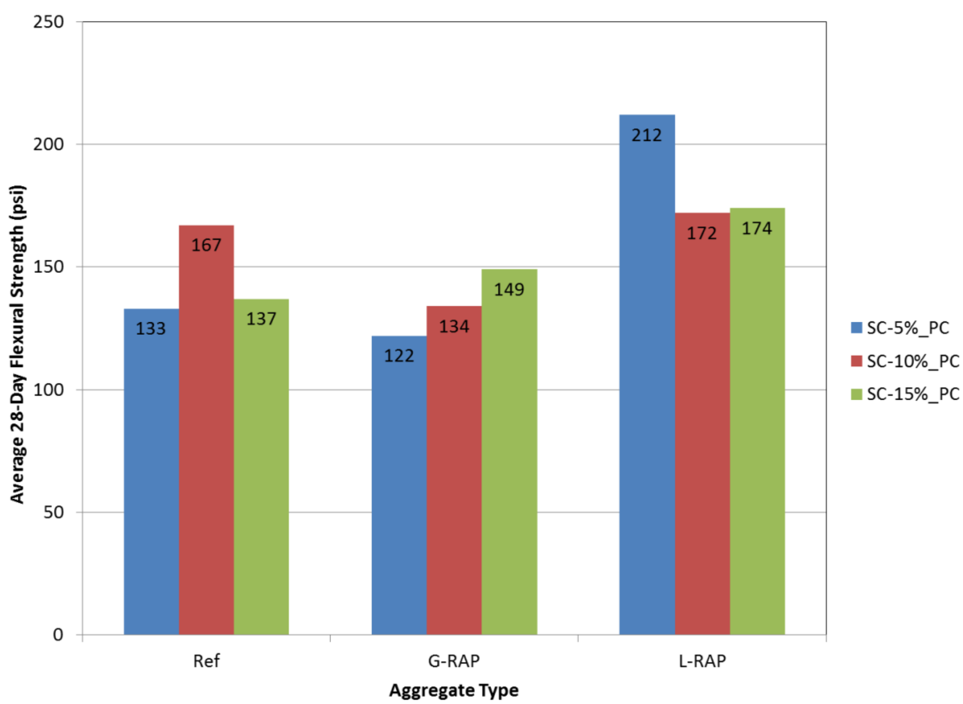

Figure 23
Comparison of the average 28-day flexural strength results for mixtures containing portland cement and soil cement

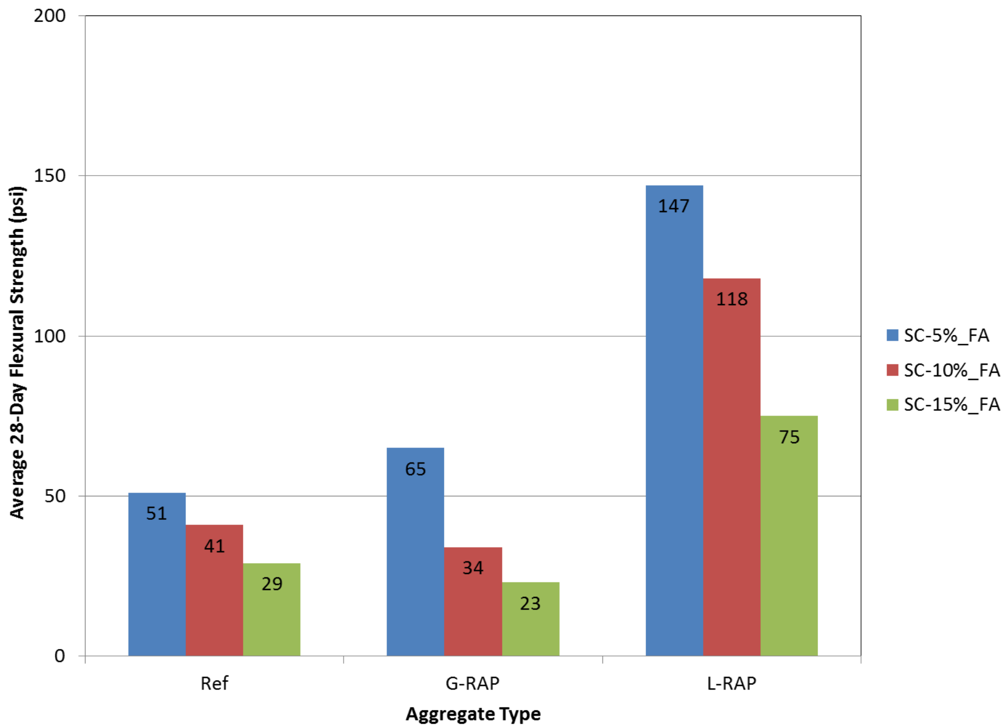

Figure 24
Comparison of the average 28-day flexural strength results for mixtures containing fly ash and soil cement

Length Change

The average length change results are shown in Figure 25 to Figure 30. Note that the length change results are an average of two specimens. The length change results for the BCS are comparable to the reference mixture.

The fly ash length change specimens (Figure 26) performed considerably better than those containing portland cement (Figure 25) across all material types. These results indicate that the use of fly ash as a stabilizer in lieu of portland cement for base course construction may reduce the occurrence of reflective cracking in an asphalt pavement. The results shown in Figure 27 and Figure 28 indicate that the inclusion of sand does not influence the length change significantly. The effect of soil cement is positive though with the exception of one outlier that expanded, leading to a reduction in the shrinkage.

An attempt was made by the authors to compare the length change of specimens produced in this study to that of soil cement specimens. After an exhaustive literature search, comparable results were not able to be found. Future work in this area should include soil cement specimens for comparison purposes.

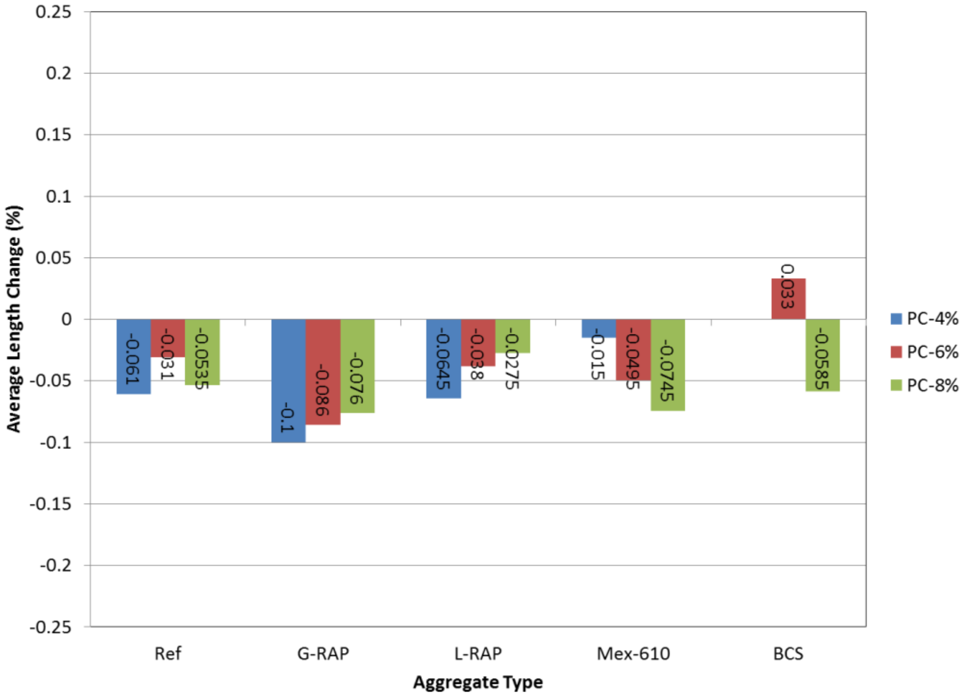

Figure 25
Comparison of the average length change results for mixtures containing portland cement

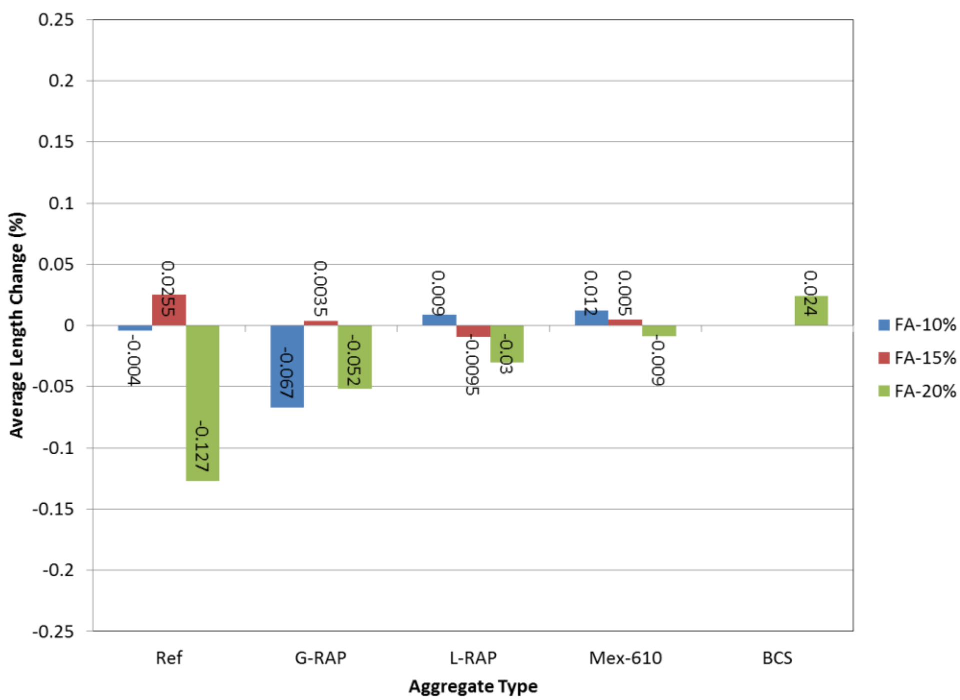

Figure 26
Comparison of the average length change results for mixtures containing fly ash

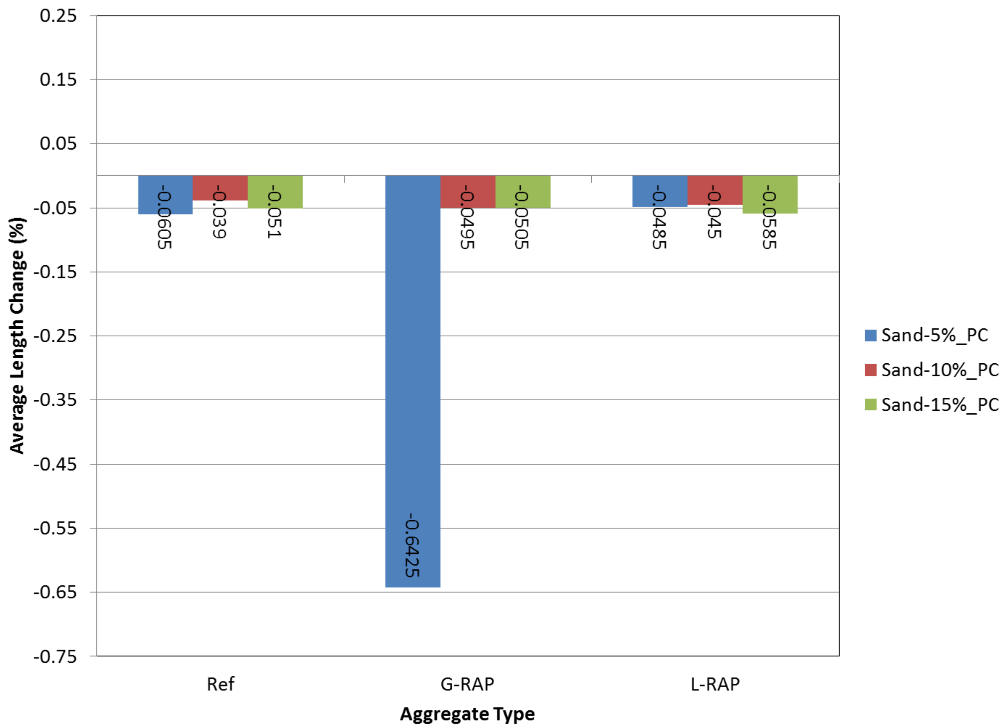

Figure 27
Comparison of the average length change results for mixtures containing 8 percent portland cement and sand

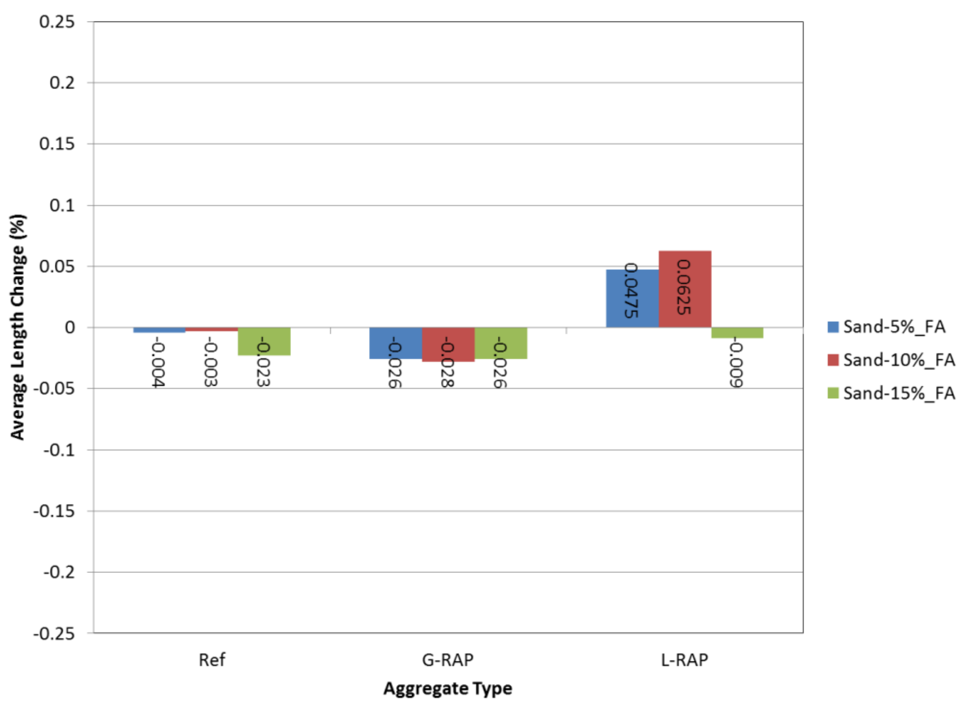

Figure 28
Comparison of the average length change results for mixtures containing 20 percent fly ash and sand

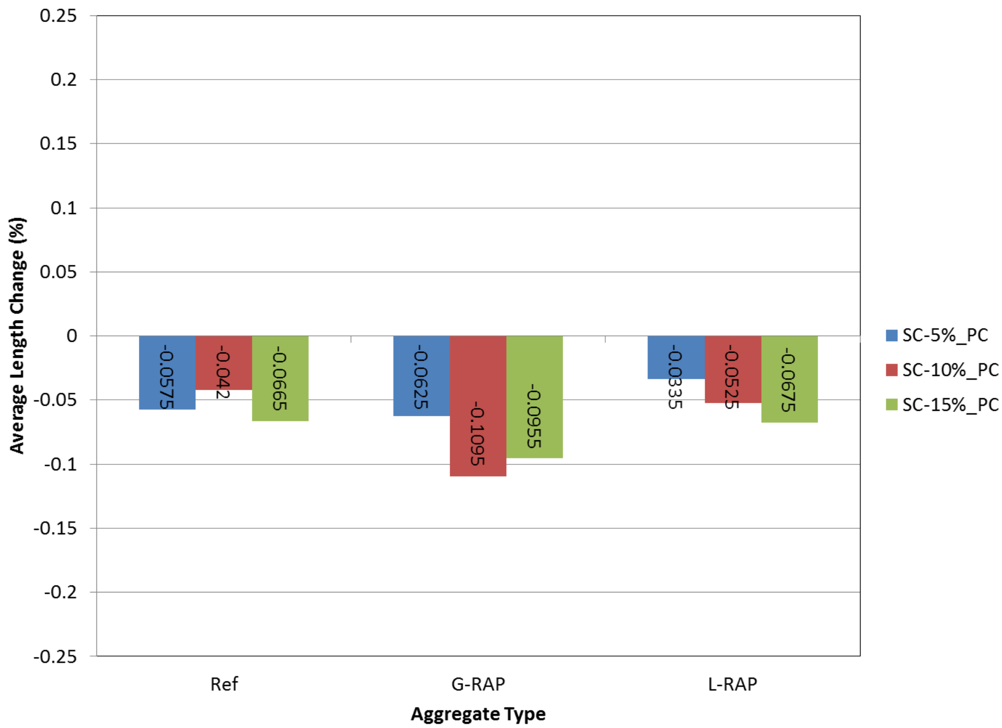

Figure 29
Comparison of the average length change results for mixtures containing 8 percent portland cement and soil cement

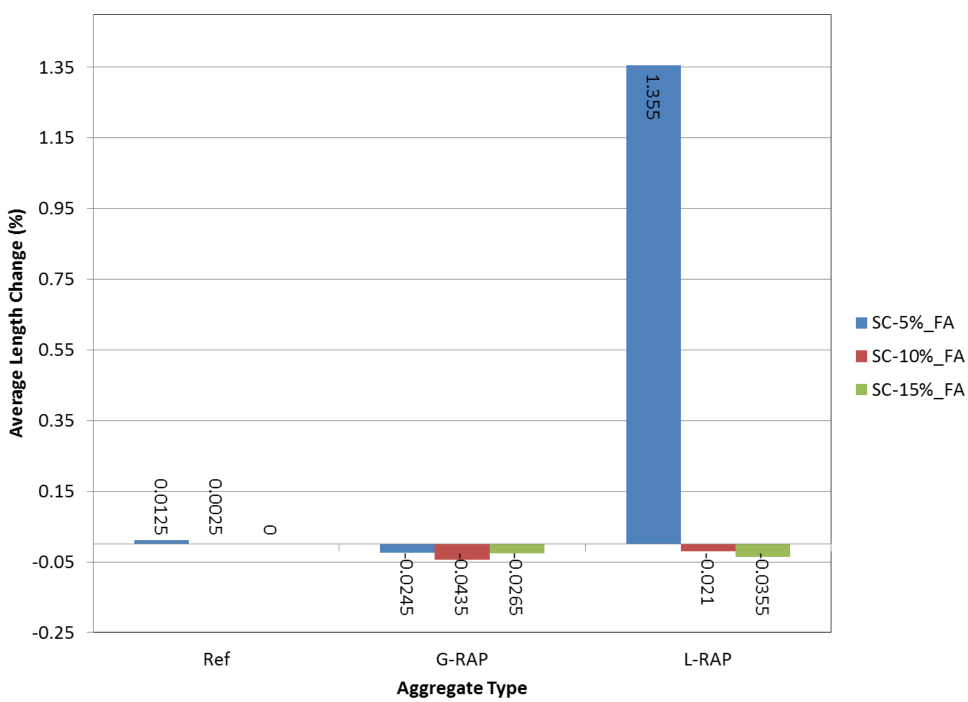

Figure 30
Comparison of the average length change results for mixtures cotnainig 20 percent fly ash and soil cement

Resilient Modulus

The resilient modulus results are shown in Figure 31 to Figure 36. The mixtures as a whole were nearly equal when comparing the results for the portland cement. The results are counterintuitive as when the portland cement content is increased, the resilient modulus tends to decrease. The biggest effect on the resilient modulus is due to the addition of sand and soil cement to the mixtures. These additions give a slightly larger resilient modulus.

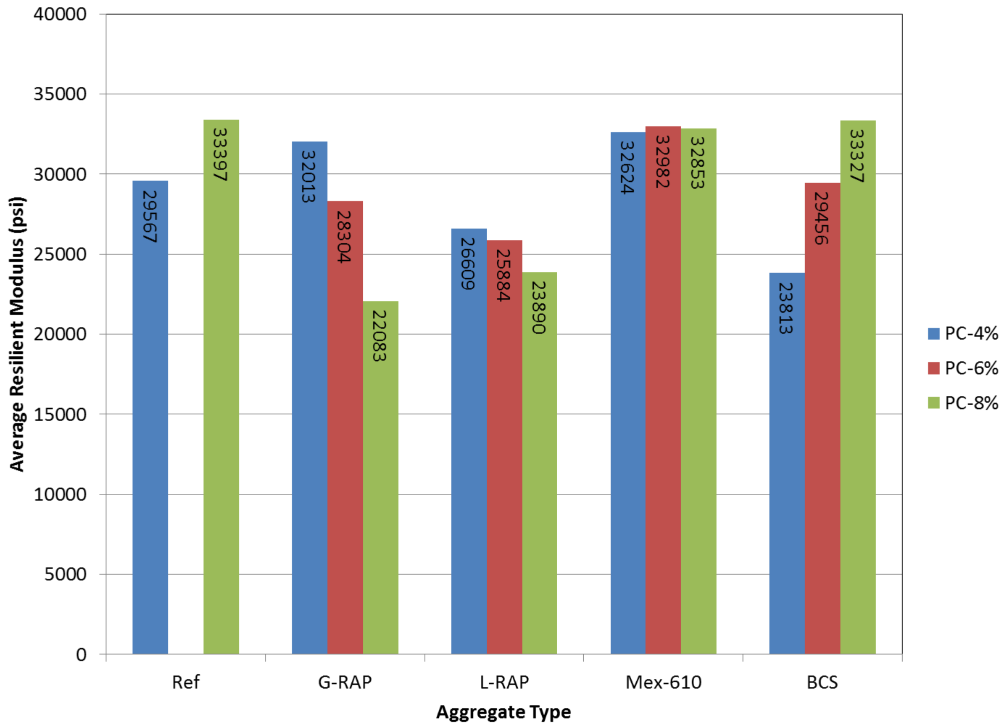

Figure 31
Comparison of resilient modulus results for mixtures containing portland cement

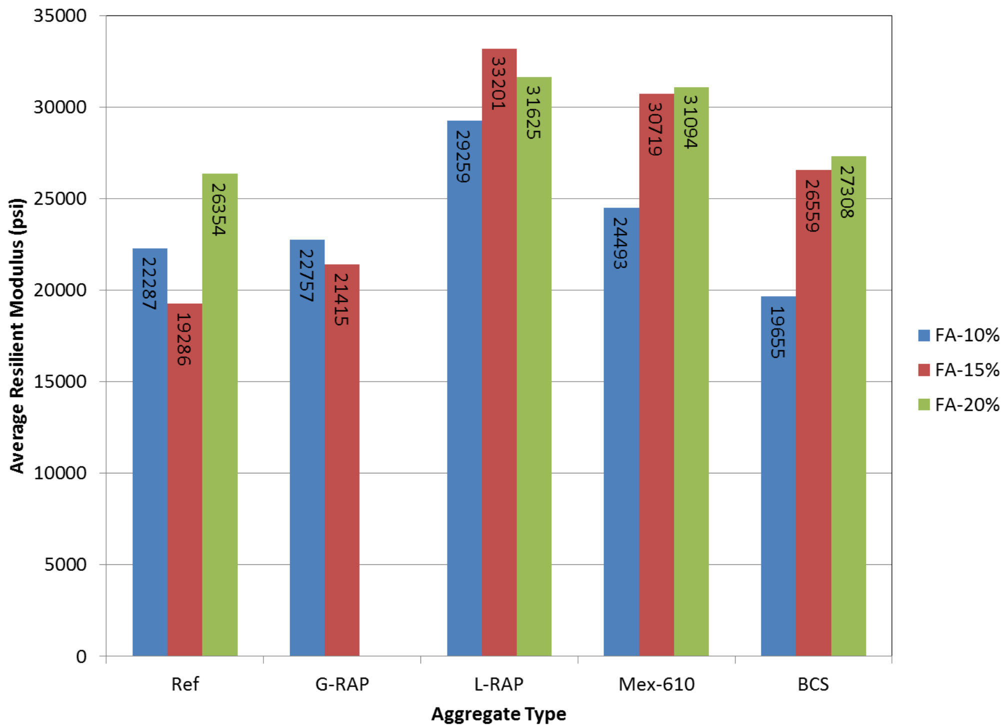

Figure 32
Comparison of resilient modulus results for mixtures containing fly ash

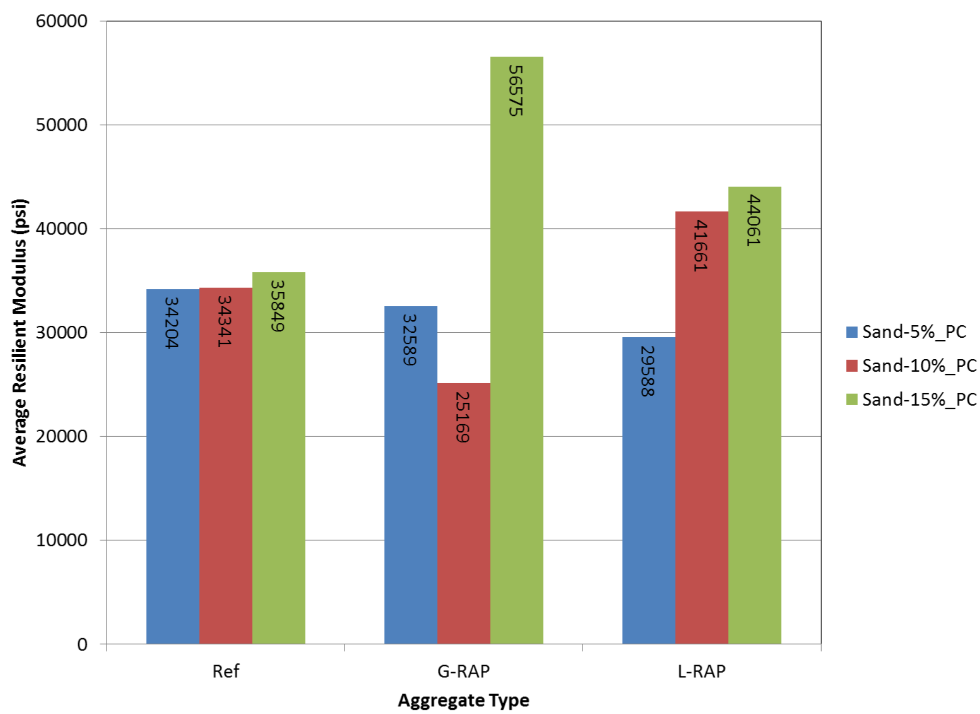

Figure 33
Comparison of resilient modulus results for mixtures containing 8 percent portland cement and sand

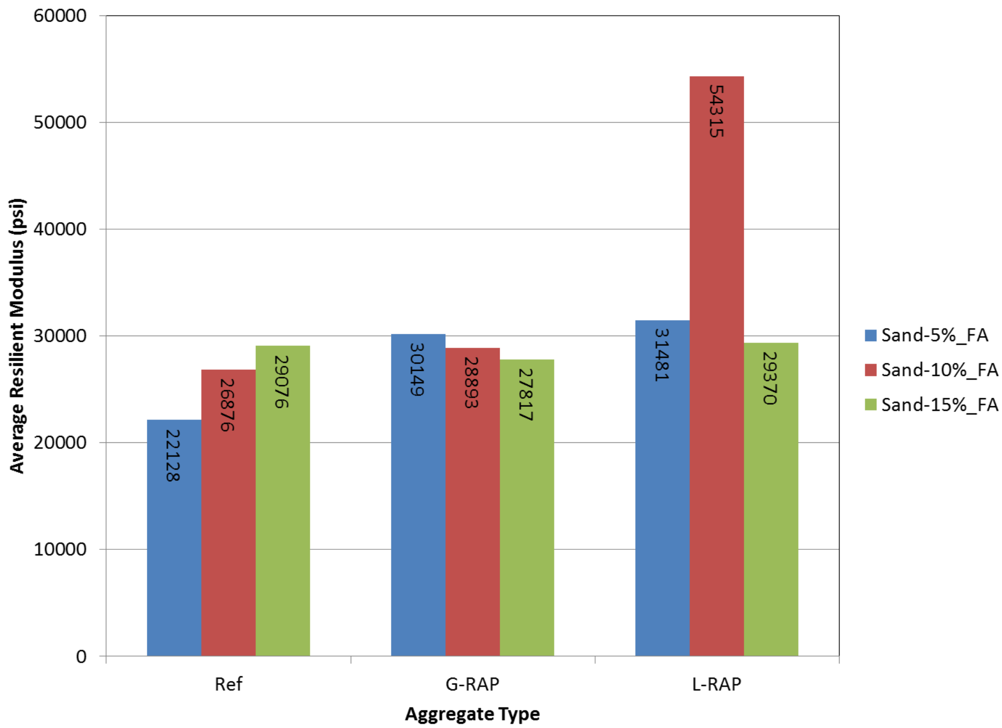

Figure 34
Comparison of resilient modulus results for mixtures containing 20 percent fly ash and sand

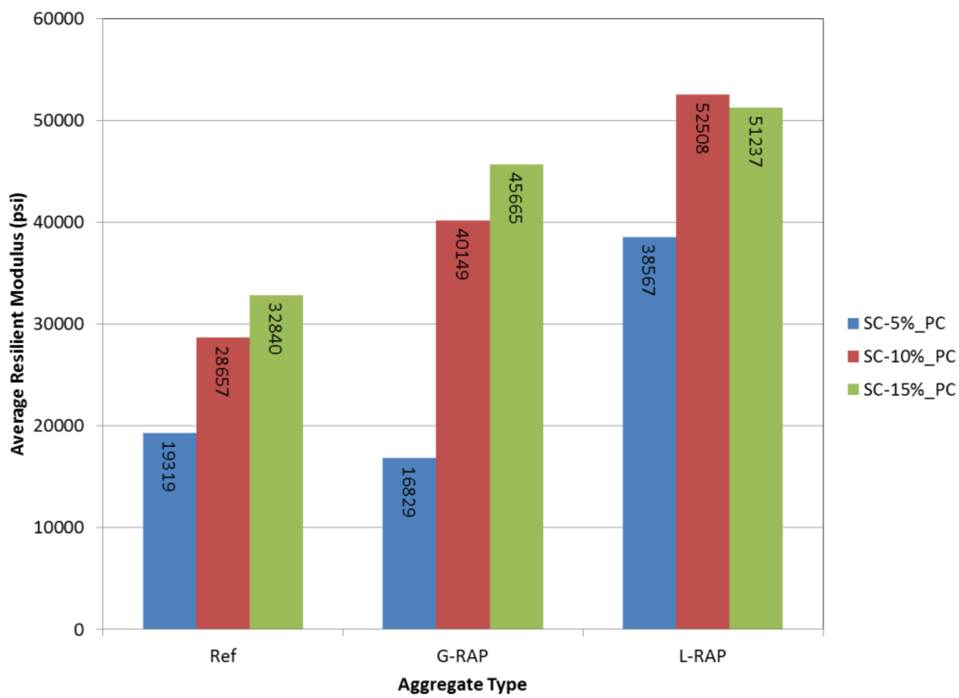

Figure 35
Comparison of resilient modulus results for mixtures containing 8 percent portland cement and soil cement

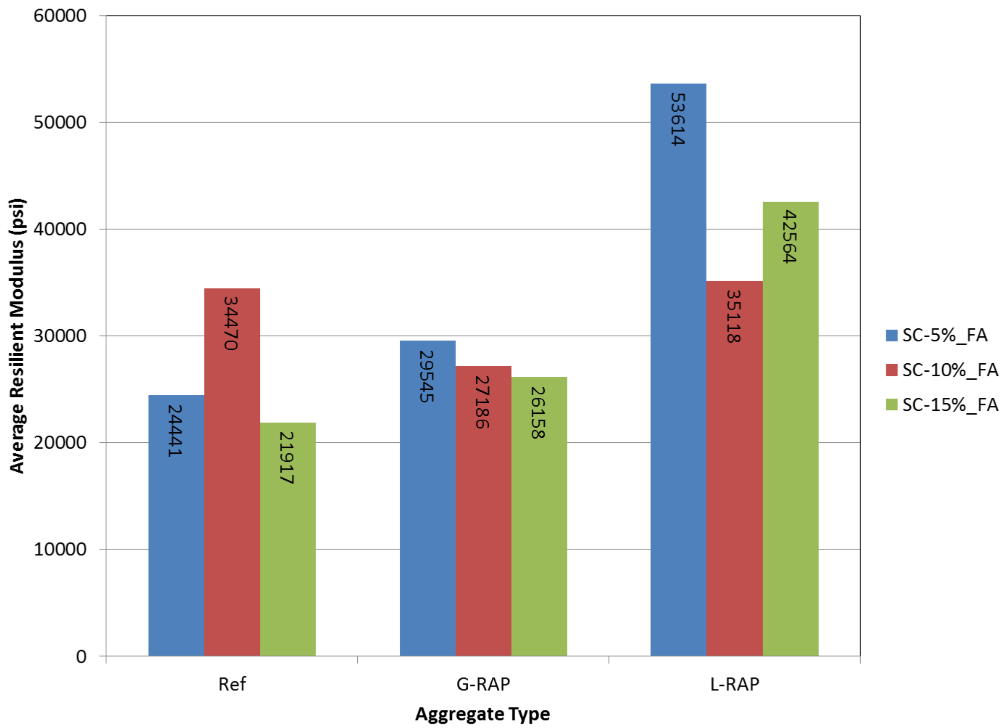

Figure 36
Comparison of resilient modulus results for mixtures containing 20 percent fly ash and soil cement

Compacted Sample Comparisons

After determining the physical properties of the mixtures, samples were then re-prepared and compacted using standard Proctor energy to determine the effects of compaction. The authors believe that the compacted sample results are more indicative of field construction techniques. The authors note that the mixtures were not compacted in earlier stages of the test matrix due to the large amount of mixtures to be tested and that the uncompacted sample results would be conservative due to the unconsolidated nature of the specimens.

The comparison of the uncompacted and compacted sample results for mixtures containing the reference material are shown in Figure 37 to Figure 39. The compacted mixtures are generally twice the strength than the uncompacted mixtures. The compacted samples containing soil cement are generally three times the uncompacted strengths due to the better particle packing when using compactive effort.

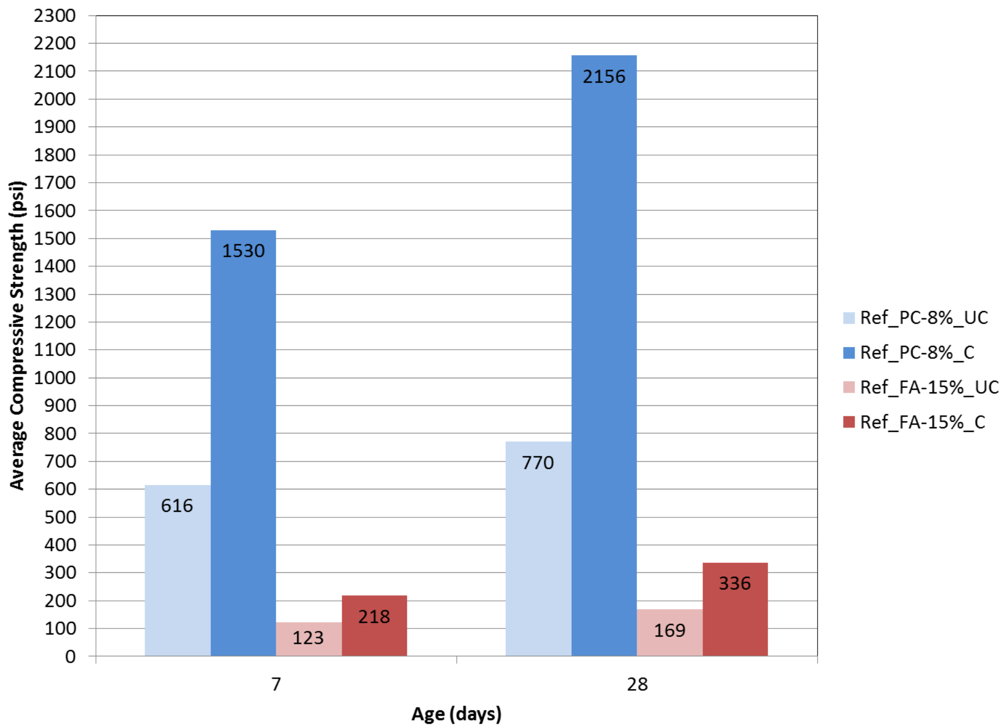

Figure 37
Comparison of compacted and uncompacted compressive strengths for the reference mixtures

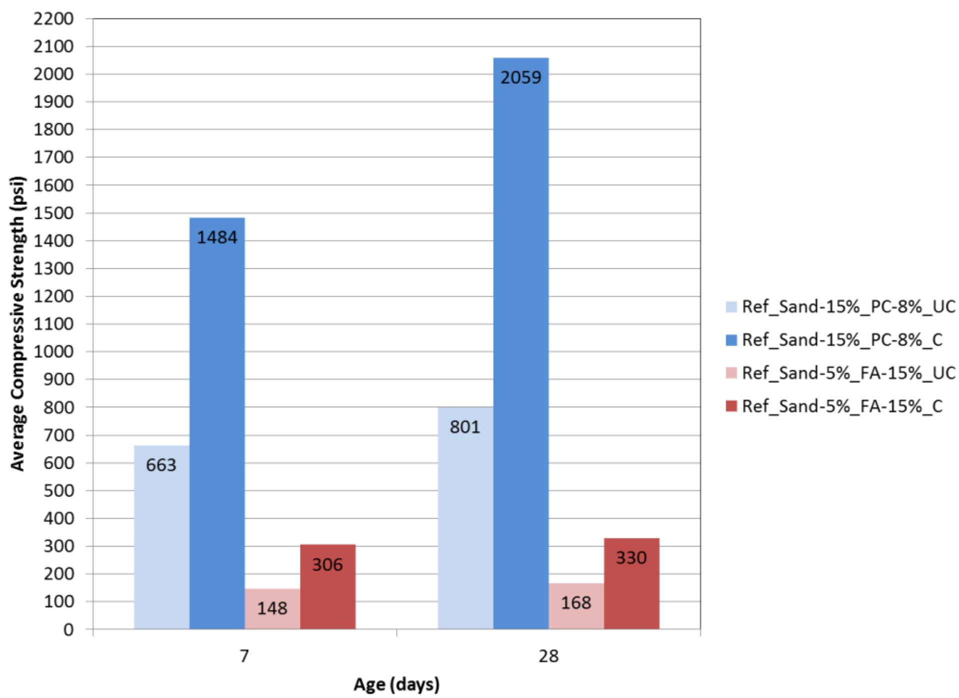

Figure 38
Comparison of compacted and uncompacted compresive strengths for the reference mixtures incorporating sand

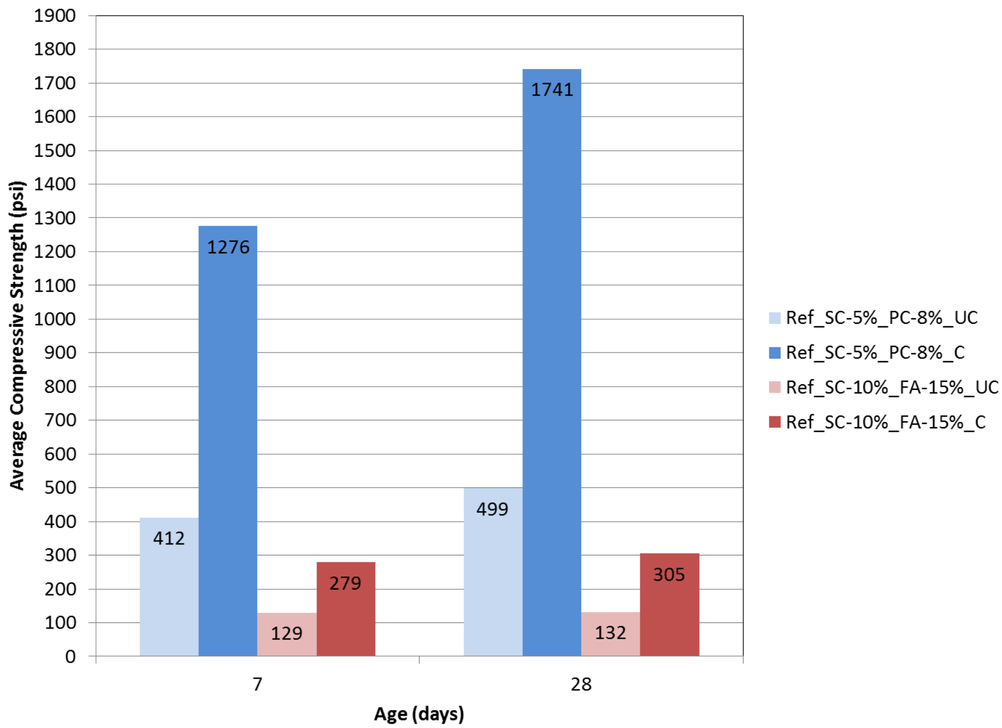

Figure 39
Comparison of compacted and uncompacted compresive strengths for the reference mixtures incorporating soil cement

The comparison of the uncompacted and compacted sample results for mixtures containing limestone and gravel based RAP are shown in Figure 40 to Figure 42 and Figure 43 to Figure 45, respectively. The compacted limestone RAP mixtures were generally twice the strength than the uncompacted mixtures except for those samples containing soil cement, where they were equal when using portland cement and higher using fly ash.

The compacted gravel based RAP mixtures were generally two to three times the strength than the uncompacted mixtures. This trend holds true even for those samples incorporating soil cement.

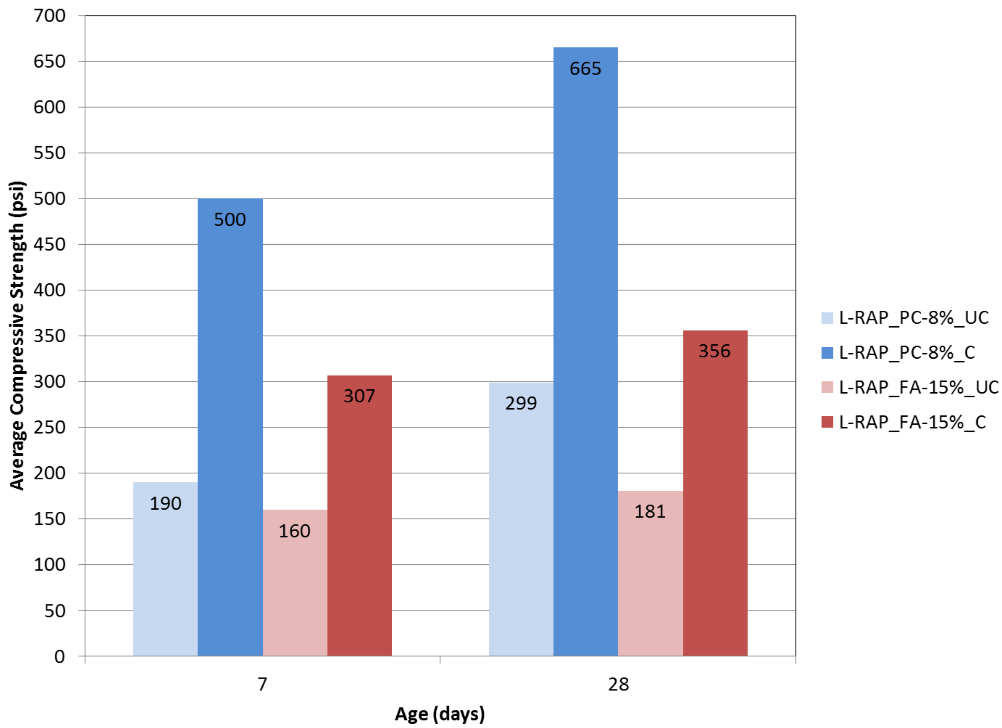

Figure 40
Comparison of compacted and uncompacted compresive strengths for the limestone RAP mixtures

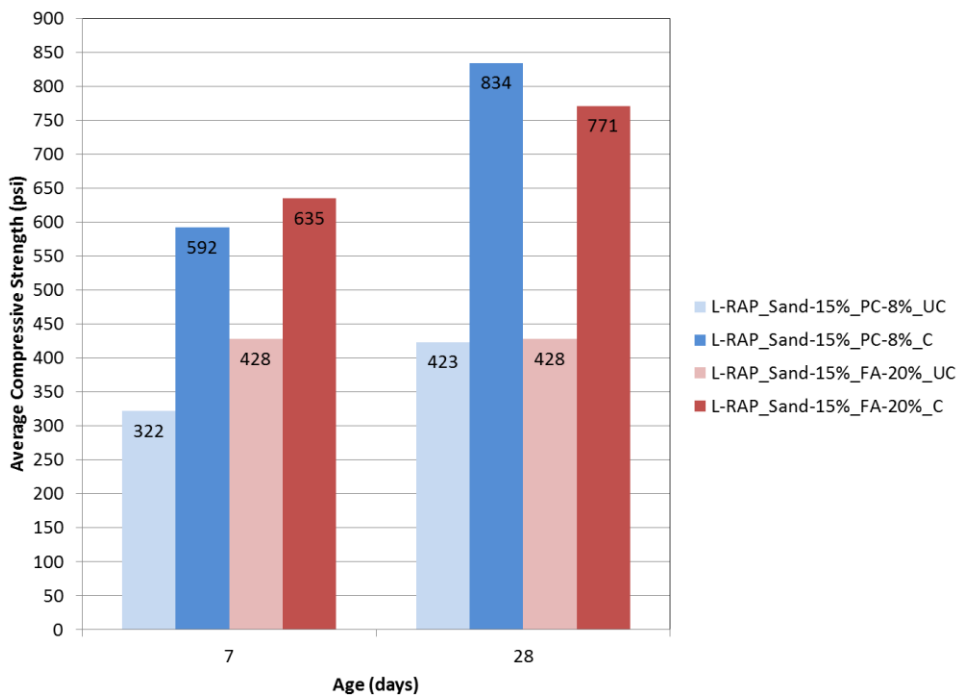

Figure 41
Comparison of compacted and uncompacted compresive strengths for the limestone RAP mixtures containing sand

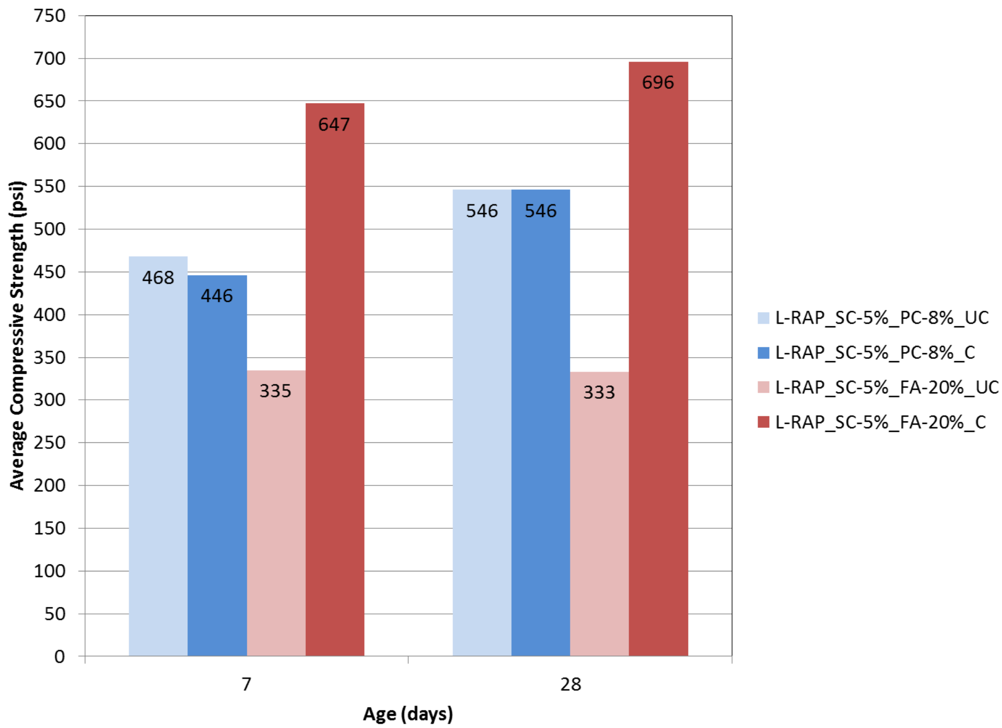

Figure 42
Comparison of compacted and uncompacted compresive strengths for the limestone RAP mixtures containing soil cement

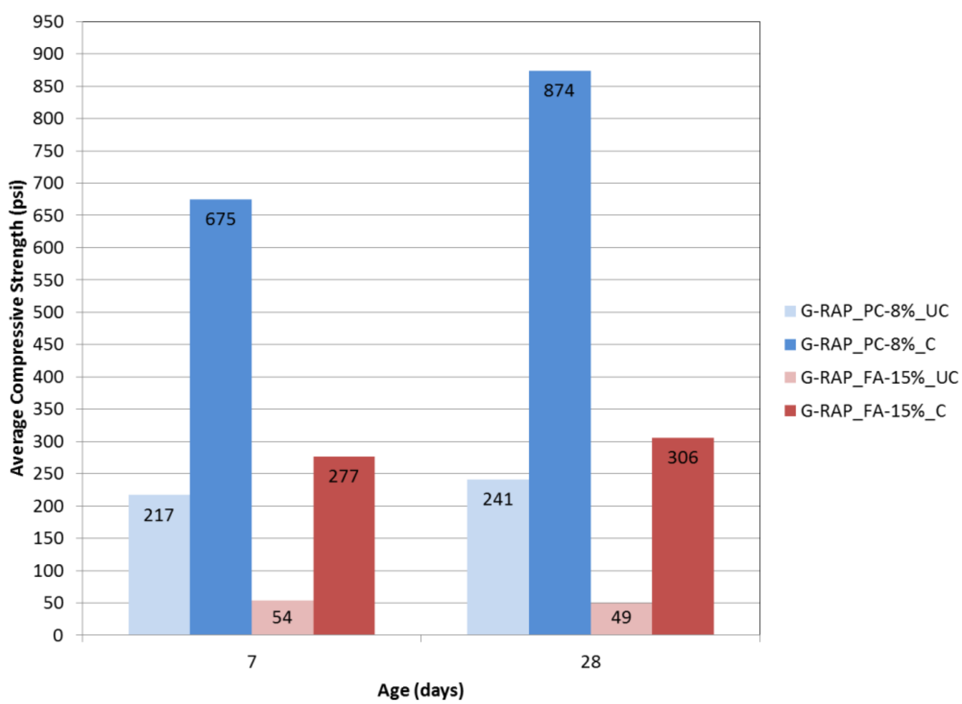

Figure 43
Comparison of compacted and uncompacted compresive strengths for the gravel RAP mixtures

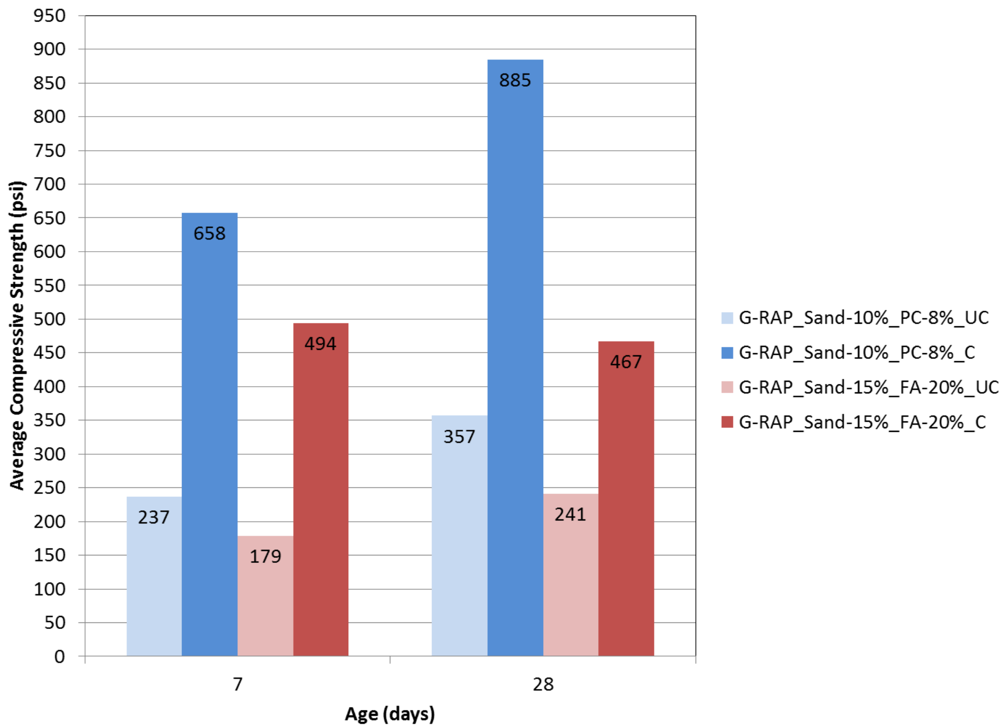

Figure 44
Comparison of compacted and uncompacted compresive strengths for the gravel RAP mixtures containing sand

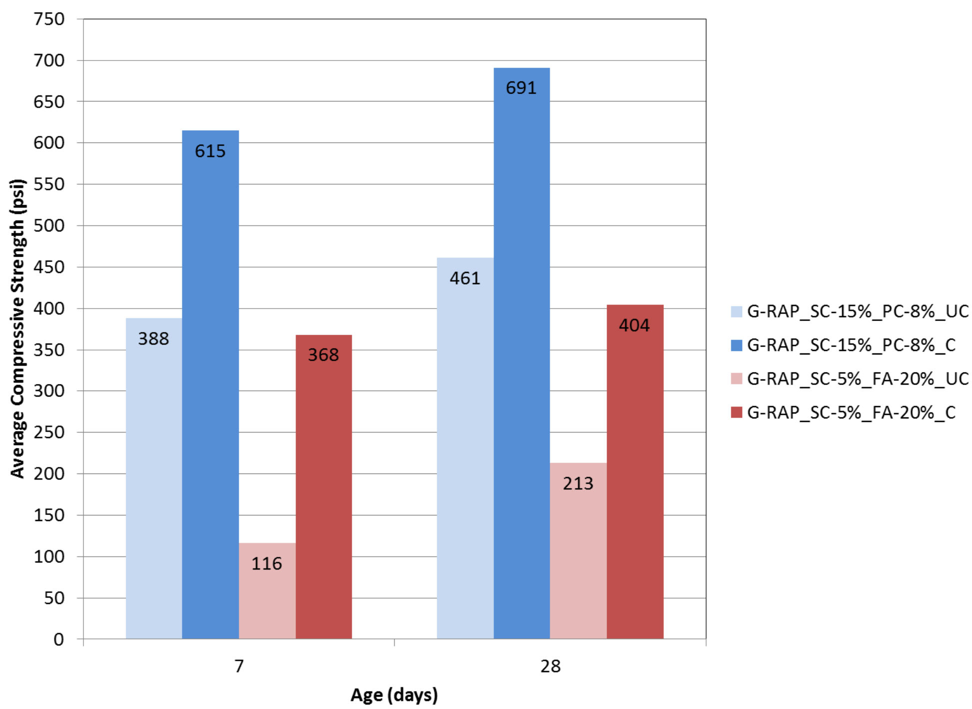

Figure 45
Comparison of compacted and uncompacted compresive strengths for the gravel RAP mixtures containing soil cement

The comparison of the uncompacted and compacted sample results for mixtures containing Mexican 610 and BCS are shown in Figure 46 and Figure 47, respectively. The compacted Mexican 610 mixtures were 2 – 2½ times the strength when using portland cement, but only 2 times the strength when using fly ash. The BCS results show a slight improvement from compactive effort for the portland cement mixtures, but a great improvement, up to twice the strength, when using class C fly ash.

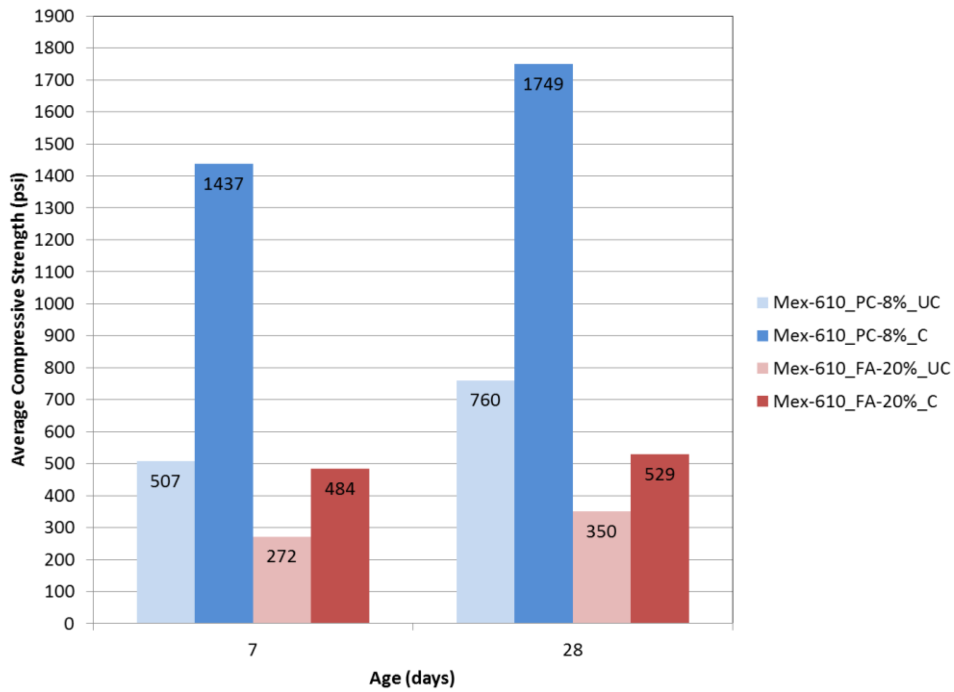

Figure 46
Comparison of compacted and uncompacted compressive strengths for the Mexican 610 mixtures

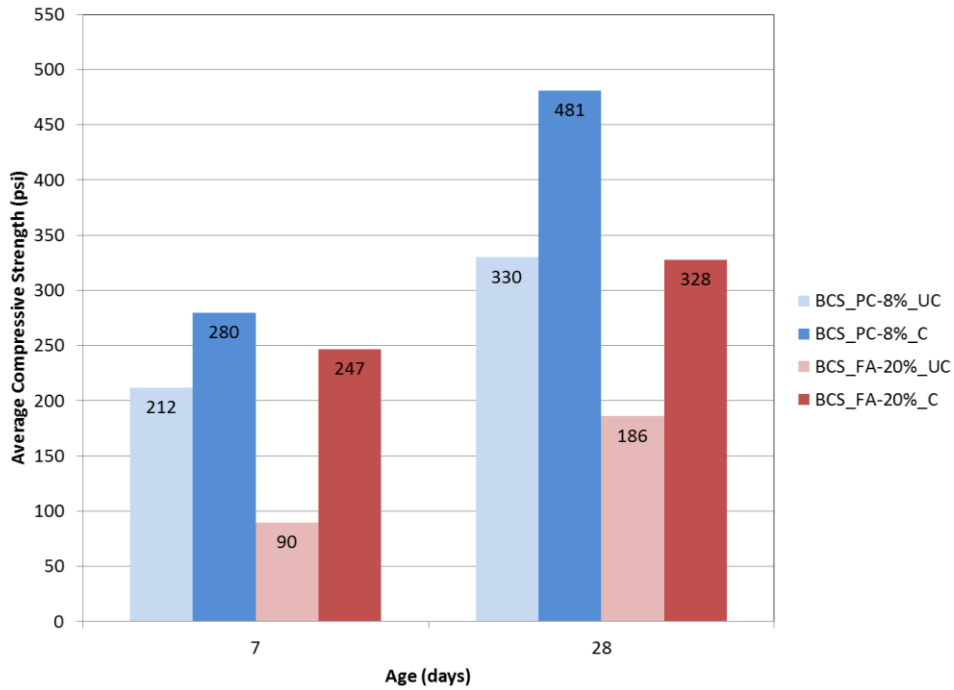

Figure 47
Comparison of compacted and uncompacted compressive strengths for the BCS mixtures

The compacted compressive strength results are especially positive in that the minimum cement or fly ash content needed to achieve a minimum compressive strength, whether that is 150 or 300 psi, can probably be reduced. Nearly all mixtures met the 300 psi for the stronger soil cement specifications after compaction. For those mixtures greater than 1000 psi, the binder contents can be greatly reduced.

The compacted compressive strength results show that about half of these mixtures are nearing or exceeding lean stabilized base strengths, especially those mixtures that are greater than 1200 psi. These lean stabilized bases are easily constructed at minimal cost.

CONCLUSIONS

The results of this study warrant the following conclusions. Mixtures achieving 150 and 300 psi are capable of being produced with 4 to 8 percent portland cement and 10 to 20 percent class C fly ash. The compacted specimens achieved equal to or up to two and a half times greater compressive strength than those samples that were uncompacted.

The reference and Mexican 610 limestone mixtures produced much higher strengths compared to the RAP and BCS mixtures. The BCS mixtures proved adequate in terms of shrinkage and strength and did not fall apart when stored in the 100 percent humidity room or underwater for the requisite 14-day cure period for the length change test.

The resilient modulus results were similar across all samples, but no discernible trend could be determined, most likely due to the test containing only one sample for analysis.

The results show that cement and fly ash treated RAP and other materials can be used in base course construction.

RECOMMENDATIONS

The authors recommend that the Department construct several full-scale base course test sections incorporating stabilized RAP and BCS. One such location has already been determined to be a good pilot project and is located on LA 975 north of Interstate 10. A preliminary laboratory mix design has been completed. A technical assistance report detailing the laboratory results and suggested construction techniques and specifications has been provided to the project engineer.

An investigation should be made into the value of shrinkage and flexural strength of typical soil cement sections for LADOTD projects. This data would provide valuable insight into mitigation of reflective cracking.

ACRONYMS, ABBREVIATIONS, AND SYMBOLS

AASHTO	American Association of State Highway Transportation Officials
ALF	Accelerated Loading Facility
ASTM	American Society of Testing and Materials
BCS	blended calcium sulfate
CIPR	cold in place recycling
FHWA	Federal Highway Administration
FWD	falling weight deflectometer
LTRC	Louisiana Transportation Research Center
LADOTD	Louisiana Department of Transportation and Development
M_r	resilient modulus
psi	pounds per square inch
RAP	Recycled Asphalt Pavement
SSD	saturated surface dry
XRF	x-ray fluorescence

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