

Synthesis of Optimal Usage of Available Aggregates in Highway Construction and Maintenance

Introduction

In recent years, the South Carolina Department of Transportation (SCDOT) has experienced a situation in which South Carolina quarries have had an overabundance of certain sized aggregates in supply while having lesser amounts of other, premium-sized aggregates available. This issue arose during the “27 in 7” campaign, in which 27 years of roadway construction was completed in 7 years. Some of these aggregates currently have limited demands in highway construction and maintenance while others have numerous applications in highway construction and are consequently in higher demand.

During times of aggregate utilization imbalance, the SCDOT No. 7 and 789 stone were in high demand, but production to meet this demand resulted in excessive amounts of screenings that led to an imbalance in available aggregate supply. In fact, 60% of the mix is composed of two sizes that are only 11% of the production. According to the SCDOT in a 2005 presentation, the state requires approximately 80% of the 1/2-inch material produced. This, in turn leaves producers with excess crusher run and fines. Because many construction and maintenance operations involve the use of aggregates, SCDOT could potentially be paying more for projects than what is possible with a better balance of aggregate production and use. The aim of this research, conducted in partnership with industry, was to investigate possible additional ways the various aggregate sizes being produced could be used in highway projects and where the use of premium-sized aggregates can potentially be reduced (i.e., achieving mass balance) without sacrificing the final product’s performance, quality, cost, or expectations.

Research Objectives

The ultimate goal of this research was to identify possible ways to achieve aggregate mass balance by optimizing existing material specifications and usage to efficiently utilize available aggregate supplies—all without sacrificing the final product’s performance, quality, or expectations. The specific tasks of this study were to

- ✓ Conduct a literature review of previous research addressing this topic
- ✓ Evaluate the aggregate specifications and usage in South Carolina and other states
- ✓ Evaluate the potential benefits of using more abundantly available aggregate sizes in lieu of premium-sized aggregates in highway construction and maintenance materials (e.g., concrete, asphalt, soils, base courses, etc.)
- ✓ Provide recommendations for implementation and/or additional in-depth research

Research Methodology and Summary of Results

Survey responses from 25 of the 50 state DOTs were collected and analyzed to better understand the issue of aggregate imbalance across the country. Only six of the respondents had experienced an imbalance, but of those six, five of them experienced it as a recurring problem, which is what makes this

research of particular importance and interest. The majority of the effects were seen in pavement construction primarily hot mix asphalt, asphalt surface treatments, and concrete pavements. In addition, a database of specifications was constructed to compare gradations of specific sieve sizes. From this database, a number of particular sieve sizes in hot mix asphalt gradations were identified as having great variance when South Carolina was compared to other states. It was these sieves that this research suggests should be examined to determine if there is a way to better optimize the available aggregates. The analysis also compared aggregate property specifications across the country. Finally, information about aggregate balance and recommendations for promoting balance was solicited from South Carolina aggregate producers.

Conclusions

The survey results and the aggregate specification database have made it possible to come to a number of conclusions concerning the aggregate mass imbalance, or the over- or under-utilization of particular aggregate sizes.

Survey Conclusions

- ✓ 6 of the 25 state DOT respondents had encountered an aggregate imbalance.
- ✓ Of the six states that have experienced an imbalance, 5 have experienced a recurring aggregate imbalance.
- ✓ The timing and duration of the imbalances varied widely across the responding states.
- ✓ High construction volume had slight to severe effects on the aggregate imbalance in all states that responded as having experienced an aggregate imbalance.
- ✓ Times of high volume construction are a major factor in aggregate imbalance.
- ✓ Roadway construction and maintenance, specifically hot mix asphalt, Portland cement concrete, and asphalt surface treatments was believed to contribute most to the aggregate imbalance.
- ✓ Specifically in South Carolina, the 3/8-inch and 1/2-inch aggregates are most over-utilized, while screenings and crusher run aggregates are most under-utilized.

The survey of the Nation’s state DOTs supports the thought that times of high volume construction, similar to that experienced in South Carolina during the “27 in 7” campaign certainly contributed to the aggregate imbalance. However, of the states that experienced an aggregate imbalance, the majority experienced it as a recurring problem. So although the “27 in 7” campaign is completed and a similar boom in construction may or may not be occurring again, it is important to take precautions to avoid a recurring aggregate mass imbalance as it ultimately results in further depletion of valuable resources and creates an intensified demand that results in costs much higher than what it would be with a mass balance amongst aggregate sizes. The high volume of construction greatly contributed to the current aggregate imbalance, but although the “27 in 7” campaign is over, the importance and need to maintain aggregate mass balance should continue to be considered.

As hot mix asphalt is the primary aggregate consumer in the state, which was supported by the construction type to have largest effect of aggregate imbalance in the survey, it must be specifically investigated to determine if it can be updated to better obtain aggregate balance. This approach will be further discussed in the aggregate gradation specification section of the conclusions to follow.

Aggregate Gradation Specifications Conclusions

The following is a summary of the comparison of the aggregate gradation specifications of South Carolina to those around the nation.

- ✓ For bases, the 1.5-inch, No. 4, and No. 200 sieves produced the most differences.
 - 1.5-inch sieve: The majority of other state specifications were finer or broader. Of 25 specifications, 14 were finer and narrower.
 - No. 4 sieve: The majority of other state specifications varied. Of 38 specifications, 19 were finer, 8 were coarser, and 4 were broader.
 - No. 200 sieve: The majority of other state specifications were similar or tighter. Of 40 specifications, 15 were narrower, and 12 had no difference within tolerance.
- ✓ For hot mix asphalt Type A/B surface courses, the 3/8-inch and No. 8 sieves had the most differences.
 - 3/8-inch sieve: The majority of other state specifications were broader or coarser. Of 41 specifications, 19 were broader and 14 were coarser.
 - No. 8 sieve: The majority of other state specifications were finer. Of 38 specifications, 30 were finer.
- ✓ For hot mix asphalt Type C surface courses, the 3/8-inch, No. 4, and No. 8 sieves had the most differences.
 - 3/8-inch sieve: The majority of other state specifications were finer and narrower. Of 36 specifications, 21 were finer and narrower, while 8 were coarser.
 - No. 4 sieve: The majority of other state specifications were broader or coarser. Of 35 specifications, 17 were broader and 16 were coarser.
 - No. 8 sieve: The majority of other state specifications were broader and/or coarser. Of 35 specifications, 15 were broader and coarser and 14 were coarser.
- ✓ For hot mix asphalt Type A/B intermediate courses, the 1/2-inch and No. 8 sieves had the most differences.
 - 1/2-inch sieve: The majority of other state specifications were broader or varied. Of 35 specifications, 19 were broader, 11 were coarser, and 4 finer.
 - No. 8 sieve: The majority of other state specifications were finer. Of 41 specifications, 32 were finer.
- ✓ For hot mix asphalt base courses, the 1-inch, 3/4-inch and No. 8 sieves had the most differences.
 - 1-inch sieve: The majority of the other state specifications were coarser and broader. Of 33 specifications, 22 were coarser and broader and 7 were coarser.
 - 3/4-inch sieve: The majority of other state specifications were coarser. Of 28 specifications, 24 were coarser, 5 were narrower, and 4 were broader.
 - No. 8 sieve: The majority of other state specifications were coarser. Of 34 specifications, 30 were coarser.

The fact that South Carolina generally has tighter allowable gradation bands in this aggregate size grouping is not necessarily a bad thing as the tightness of gradation can be directly

proportional to pavement function and performance, and it is imperative that if any specifications are to be modified that they maintain the same level of performance. However, from an aggregate mass balance perspective, tight specifications limit the opportunities to utilize aggregate sizes that are typically under-utilized.

- ✓ For asphalt surface treatments, South Carolina had allowable aggregates that covered the full range of aggregate sizes used across the nation. However, there is currently a Special Provision requiring the use of lightweight aggregate in asphalt surface treatments.

The surface treatments were identified as a possible contributor to the aggregate mass imbalance, but no clear difference was seen between South Carolina gradations and other states in the allowable aggregates. In fact, South Carolina's range of allowable aggregate gradations was consistent with the range of all states cumulatively and in addition, provided more detail on specific application, which could be beneficial from a performance perspective. The main factor with respect to aggregates for surface treatments is the requirement of lightweight material which limits the availability to one out of state supplier.

Los Angeles Abrasion Value Conclusions

The Los Angeles Abrasion specifications across the country were recorded for various roadway applications and then compared. South Carolina had the highest allowable percent loss value in all applications. The fact that South Carolina aggregates, particularly in the upstate, could have significantly higher percent loss values than other places around the country likely has a large impact on the specified gradation and the actual gradation due to aggregate breakdown.

Recommendations

Based on the results of this study, the following general recommendations have been made:

- ✓ Test broader or varying HMA gradation ranges in the particular sieve sizes.
- ✓ Test breakdown of high abrasion loss aggregates both in production and construction.
- ✓ Determine the effects of using the maximum allowable dust to binder ratio of 1.6.
- ✓ Examine the possibility of base substitution, specifically in HMA pavements replacing the HMA base with a graded aggregate base.
- ✓ Examine the use of screenings as backfill or soil replacement.
- ✓ More effective planning and communications with producers.

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