A2J03: Committee on Mineral Aggregates
Chairman: D. Stephen Lane

Mineral Aggregates

D. STEPHEN LANE, Virginia Transportation Research Council
STEPHEN FORSTER, Federal Highway Administration

The aggregate industry has a number of concerns with regard to the use of aggregates, including those synthesized from mineral or other sources, in the construction of transportation facilities. The issues of concern include aggregate properties, mineralogy, physical and chemical characteristics, degradation, testing for quality control, quality assurance, sources of current and future supply, production, distribution, environmental and safety consequences of production and distribution operations, and subsequent uses of the land after depletion of the aggregate resources. These issues are salient for both the current state of the practice and future directions of the aggregate industry.

CURRENT ISSUES

Aggregate Resources

A continuing concern of the transportation industry is the availability of the materials needed to maintain or increase the supply of high-quality, economical aggregates to meet demand. There are two major influences on the availability of these materials—depletion of current production sites and establishment of new sites. Many of the existing sites for aggregate production have been in use for some time and are running out of reserves, because either the quality or type of source material is changing, specifications for aggregate materials have changed, or the boundaries of the site are being approached. Increased demand for aggregates is creating pressure to explore and develop new sites. The development of new sites is subject to difficulties, however, including the need to comply with environmental and zoning restrictions and regulations (particularly in urban areas) and the public perception of aggregate production facilities. These same difficulties can also impact expansion into undeveloped reserves at existing sites.

Aggregate Production

Various factors influence the equipment and processes used to produce aggregate. The principal factors are the nature and characteristics of the raw materials, the local market demand for specific aggregate products, and the technology available to produce the desired product from the available raw materials. Because the capital investment in resources and production facilities is quite large and the return rate is low, the producer needs to maximize the saleable products produced from the given reserves.

User interest in aggregate products is driven by the need for the material to provide satisfactory performance in a given application. Current research into the properties and characteristics that enhance the performance of aggregate materials in particular applications is leading to refinements in specification requirements aimed at optimizing performance. For each application area (e.g., asphaltic- or hydraulic-cement concrete mixtures, base material, ballast), there may be one or more sets of requirements (e.g., grading, particle shape, surface texture, durability, abrasion resistance) intended to ensure optimal performance. In attempting to produce materials that meet more exacting requirements, aggregate producers must often confront a growing inventory of material that has no current market and consequently may drive up the cost of marketable products.

An example of this issue is the almost universal production of excess fines at aggregate plants. This problem is likely to grow more acute given the trend toward more tightly specified particle shapes, because the crushing processes used to produce more equidimensional particles generate higher percentages of fines. Since current thinking on most bound aggregate applications tends to limit the fine aggregate fraction, this material represents a loss to the aggregate producer in terms of both reserve and, potentially, the cost of disposal. Current federal highway funding under the Transportation Equity Act for the 21st Century will increase demand for aggregate by approximately 16 percent. Most of this demand will be for “clean” or “washed” products. There will also be growing competition among different applications for the same sizes of materials. Both of these factors exacerbate the fines issue. Continuing research is needed to determine the actual benefit to performance and ultimate cost of tighter aggregate specifications, and to develop innovative uses for the excess materials of production.

Aggregate Testing for Quality and Performance

The issue of aggregate testing is closely related to the production issue discussed above. As knowledge of the mechanistic, as opposed to empirical, behavior of aggregates in various applications increases, there is a concomitant increase in the need to better define and measure the relevant characteristics and properties of the aggregate to ensure quality and predict performance. The industry must also wrestle with moving targets in the areas of both quality and performance, which can vary widely depending on the application, climate, and expected performance involved. The engineer needs sound guidance to help determine the quality and performance tests that should be conducted, as well as the proper acceptance levels in those tests for the particular application. The increasing pressure to use recycled, waste, and by-product materials as aggregate further increases the need to provide a means of defining and testing for quality and performance.

FUTURE ISSUES

Specifications

As the shift toward end-result (or performance-related) specifications takes place, the relationships among the specifying agency, the contractor, and the aggregate supplier will change. The specifying agency will have to cede the traditional role of recipe specifications and delegate these decisions to the contractor, as is now occurring to varying degrees. The contractor and aggregate supplier will have to work together to achieve performance standards and meet warranty provisions. Doing so will require setting performance standards for testing and acceptance that can be applied quickly and economically in both the laboratory and the field. It will also be necessary to develop and maintain a keen understanding of the processes in the field that impact on performance so the performance level specified for a particular application will be realistic. Better resource management can be achieved by avoiding the specification of performance levels for factors that will never be encountered on a particular project. For example, if the possibility of freezing is negligible on a project, the aggregates should not be required to be frost-resistant. Applying a rational-needs approach to the writing of specifications could greatly increase the pool of available materials.

Increasing emphasis on the construction concept of “get in, get out, and stay out” will require contractors to work faster and more safely while delivering better quality. This requirement will drive the pursuit and development of better materials and processes that will allow construction to proceed more expeditiously.

As the producers of asphaltic- and hydraulic-cement concrete change their processes, they will place new demands on their suppliers. For example, the use of more cold feeds will potentially lead to fractionated aggregate plants. Another aspect of the specification issue is the need to define performance and quantify the contribution to that performance of the various components (including aggregate). Doing so has not been easy, as evidenced by the case of Superpave®. With Superpave, extensive resources have been applied in an attempt to model performance, and, then, to use testing procedures and materials specifications for evaluating the properties of unbound materials so the ultimate performance of the pavement can be predicted.

Role of Aggregates

Currently in most transportation construction, aggregates make up the majority of the material placed and are by far the least expensive of the materials used. Aggregate is therefore likely to remain the principal ingredient used in construction. The challenge for the future is to integrate increasing knowledge of the role played by aggregates in the performance of the end-product with approaches to resource management, and to use systems that enhance aggregate supplies, improve production techniques, and control quality during the production process in order to ensure the required performance.

In the future, an increasing percentage of aggregate supplies may come from recycled or waste materials. This may be especially true in urban areas, where opportunities for exploration and development of new quarries are few, and disposal problems for waste, by-product, and recyclable materials are many. The challenge will be to process and test these materials so there is no decrease in the quality and performance of the end-products in which they are used. Production equipment and processes may change greatly. Whereas production now involves basically crushing, sizing, and perhaps washing and storage/handling, future production operations may routinely include, in addition, high-temperature processing, metal extraction (physically or chemically), and beneficiation. Future operations are also likely to include recycling within the production process, so that unacceptably low-quality or out-of-specification material can be recycled back into the process immediately to yield products of acceptable quality. Furthermore, the production process may have to take place at the job site in order to conserve energy by eliminating transportation costs.

With these new aggregate sources and production processes will come the additional challenge of developing tests to measure their quality and predict their end-use performance. A goal for the aggregate community is to reach the point at which quality can best be defined in terms of several fundamental chemical, physical, and mechanical characteristics of the material that accurately reflect performance.