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Flexible Pavement Construction

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Hot-mix asphalt (HMA) plays a vital role in the U.S. transportation system, and will continue to do so into the new millennium. Thus it is important to examine both the state of the art of and future prospects for HMA in a number of key areas, including the role of the user agency or owner, materials, processing, transportation, lay-down procedures, testing for quality and performance, work zone safety and traffic control, and training.

ROLE OF USER AGENCY

Public agencies purchase hot-mix materials from producers and use them to patch potholes, produce thin surface overlays, and perform other tasks designed to extend the life of existing pavement. This work utilizes a substantial proportion of all HMA now produced in the United States and will probably continue to do so. State agencies are likely to focus research and rehabilitation efforts on pavement preservation applications. The American Association of State Highway and Transportation Officials (AASHTO) defines this emphasis as a planned strategy of applying cost-effective treatments to existing roadway systems and their appurtenances to preserve the system, retard future deterioration, and maintain or improve the functional condition of the system without increasing structural capacity. Contract maintenance is being used by some agencies at present and will probably increase as maintenance budgets decrease.

The approach of basing a contract award on the lowest and best bid from a qualified contractor prevails among both public and private owners today. Use of this approach is expected to continue into the future. On large projects, however, there are good reasons to consider a design–build procedure, which will probably be applied more frequently for such projects in the future.

Warranties are being used in some areas of the United States to place more responsibility on the contractor—not only to guarantee higher-quality construction, but also to expedite work schedules. Some states are employing incentives to complete projects in less time and thus more quickly restore full use of the facilities involved for the benefit and safety of the traveling public.

In the new millennium, growing numbers of heavily loaded trucks will demand a higher-quality, rut-resistant pavement structure. States are increasingly using Superpave® mixes for heavy-duty thoroughfares and interstate-type dual roadways. According to an AASHTO survey, in 1997, 15,524,043 metric tons of Superpave was used for 355 projects, representing 4 percent of all such projects and 12 percent of total metric tons of paving material. This figure was expected to increase to 44,257,900 metric tons in 1998. One goal for Superpave implementation is for all states to be using the mixes by the year 2000.

MATERIALS

Existing local sources will continue to be used for the selection of aggregates whenever possible, so that the mix designs developed will support estimated traffic loads under a wide range of conditions. Restrictions increasingly being placed on the availability of high-quality, inexpensive aggregates as a result of environmental and zoning laws make it difficult to locate processing plants and obtain economical products. This will be an important concern into the 21st century, especially in urban areas. There will be a growing need for recycling of existing pavement materials.

Both stone matrix asphalt and Superpave mixes demand aggregates with certain essential properties. More angularity in the coarser fractions and clean, angular fine aggregate will be required to obtain mixes that will provide extended performance under increasingly heavy traffic loads. It may be necessary to depart from previous standard designs by using an acceptable performance test to predict the behavior of a mix. To meet the need for aggregate angularity, more of the natural material will be wasted in production, further impacting supply.

Asphalt binders are improving with implementation of the Superpave performance-graded specifications. Modifiers, including elastomers, plastomers, fibers, and pulverized rubber, will be used to produce mixes with enhanced potential to withstand climatic stresses, support heavier loads, and extend pavement life.

The introduction of reclaimed asphalt pavement (RAP) into HMA mixes has reduced the cost of pavements and will continue to do so. With this material, however, more intensive laboratory analysis may be required to achieve a satisfactory mix design. The incorporation and performance of RAP and modified asphalt binders in mixtures will be the subject of Superpave implementation research as the new century begins.

PROCESSING

Continuous or drum HMA plants are being improved for greater productivity and portability. However, the environmental problems associated with dust, noise, and appearance have resulted in more restrictive laws and limitations on available plant sites. The control of dust emanating from stockpiles, plant operations, and truck traffic is becoming increasingly difficult for urban plant operators, and is especially critical when there is a need to expand operations to improve production. Restrictions on particle size and the quantity of allowable dust emissions are becoming increasingly stringent.

The basic components of today’s HMA plants are essentially the same as those of many years ago. However, the plants have become larger, more productive, and more sophisticated. Greater attention is being paid to stockpile management aimed at reducing segregation. In addition, there is a trend toward the use of enclosures to maintain uniform moisture in the aggregate and eliminate neighborhood complaints about dust, particularly in urban areas. Placement of the various sizes of aggregate into multiple feeder bins (to provide the desired proportions to the rotating drum dryer or other drying equipment) also requires efforts to control segregation. Current vibrating, reciprocating, and belt feeders will be enhanced with better controls and electronic weighing systems.

Most asphalt plants today have one or more hot storage bins or silos to accommodate maximum plant production capability. Having more than one bin allows simultaneous availability of multiple mixes for delivery to various customers. The trend is toward increasing the number of bins to meet more diverse mix demands. Operation of the bins is simple enough, although care is needed to control segregation and temperature. There have been few changes in mixer technology. Exceptions are improved methods of liquid measurement, more durable and efficient mixer components and liners, and more sophisticated timing devices.

TRANSPORTATION

The evolution of hauling equipment has been dramatic in recent years. Use of heavy-duty equipment with insulated beds, multiple axles carrying heavier loads, and automatic covers to control heat loss from the mix has lowered the costs of transportation. Two-way radios and mobile telephones have enabled improved truck fleet management, and further improvements may be realized through use of the Global Positioning System (GPS). The ability of GPS to provide location-specific information will enable logistical analyses that can reduce time lost in transit when plant stoppages occur or job requirements change.

In areas of lower traffic volume or large projects, cost savings can be realized through the use of bottom-dump or conveyor-flow semi-trailers carrying significantly more tons per load. Bottom-dump trailers deposit the HMA on the existing pavement in a windrow; a pickup or transfer device is required to deliver the mix to the paver. Trailers with conveyors can unload directly into the paver or into a load transfer device. The size of loads will not increase greatly in the future because of restrictive laws governing maximum axle loads and total vehicle weight.

LAY-DOWN PROCEDURES

At the job site, it is essential to address the temperature-segregation relationship. To this end, truck fleet management coordinated with paver speed can be used to avoid strings of trucks waiting to unload. On a large job, load transfer devices can smooth out the paver operation and permit faster truck unloading. These machines not only transfer the material, but also reduce segregation through their remixing action.

Pavers are becoming more productive and sophisticated. Computerized controls using microchips regulate the various paver functions from the hopper to the screed. Smoother mats are being obtained through use of a rolling beam or sensing instruments. These screed controls reduce human error in the placement of the material.

There is a trend today toward the use of tandem-drum vibratory rollers for compaction. Tests have shown that it is necessary to have one or two breakdown rollers operating immediately behind the paver to achieve maximum density before heat is lost from the mix. Intermediate roller patterns often incorporate a pneumatic or rubber-tired roller to obtain further density. When tender mix behavior is encountered, as has been the case with some Superpave mixtures, the intermediate roller is often removed from the compaction train. A finish roller is then used to smooth the mat. The ability to achieve specified densities may vary among mixtures. The combination of lower asphalt content and higher crushed particle sizes in some HMA mixes presents workability problems associated with the mix design.

TESTING FOR QUALITY AND PERFORMANCE

After the pavement has been constructed, it is checked for compliance with quality requirements specified by the purchasing agency. In the past, agencies have conducted both quality control (QC) and quality assurance (QA) testing. In recent years, contractors have assumed a much larger role in this activity—a trend that will continue. Contractors are often asked to submit their QC plans, and agencies sometimes integrate all or part of the QC test results in their QA strategy. This practice has required contractors to establish field laboratories. It is likely that in the future, all hot-mix facilities will be required to maintain high-caliber testing laboratories.

Past and present QC and QA testing involves measuring HMA component and other physical properties. A recent trend has been toward laboratory compaction of field-produced mix and use of the resulting volumetric properties for QC and QA. Although the recent trend has been toward greater reliance on mix volumetrics and less on component analyses for QC and QA testing, the expanded use of asphalt ignition ovens has led agencies and material suppliers to reincorporate component analyses into their QC and QA plans. Whether volumetric or component requirements are used, it must be recognized that these properties are only indicators of mix performance.

Various research efforts now under way are aimed at developing new laboratory procedures that will augment or replace current methods of QC and QA testing. These procedures involve the use of test equipment to evaluate the performance properties of as-produced HMA. Some of this equipment measures mixture engineering properties, which are believed to be better indicators of true mix performance than volumetric or component analyses. Examples include creep and shearing tests. Yet other types of equipment measure empirical strength properties as indicators of performance; various wheel-tracking tests are the best examples of such testing, and could be adapted for field use. In any case, there remains an urgent need for inexpensive, reliable, performance-related tests to support QC and QA activities.

Presently, the most common strategies used in accepting finished HMA pavement are based on in-place density, usually determined with a core or nuclear density gauge. While this approach will continue to be employed, there has recently been a rapid growth in the use of asphalt pavement smoothness specifications. Profilometers and profilographs are the most common means of measuring pavement smoothness. Because of training issues in the use and interpretation of the results obtained, smoothness devices used for QC and QA will need to be updated with automatic data collection. Automated devices will allow critical measurement data to be sent via electronic links to central locations, which will have the capability of monitoring many job sites. It will be possible to make immediate decisions at these centers and communicate them back to project personnel. Advanced decision-making procedures and systems will allow contractors to respond to problems in real time, which will in turn result in improved construction efficiency and roadway quality.

Ultimately, contractors will play a far greater role that will result in the elimination of classical QC and QA testing. Contractors will be expected to guarantee or warrant the performance of pavements they construct for a longer period of time, perhaps 20 to 30 years. This approach will allow use of innovative materials and design methodologies, which are currently not employed under low-bid specifications.

WORK ZONE SAFETY AND TRAFFIC CONTROL

Although not part of the HMA process, safety in roadway work zones is receiving increasing emphasis as the next century approaches. Passage of the 6-year Transportation Equity Act for the 21st Century dramatically increased the level of funding available for the core highway program. Some estimates indicate a 66 percent increase in construction zones nationwide. In some areas, construction zones may appear as frequently as every 30 to 40 miles.

Each year there are more than 700 people killed and 37,000 injured while traveling in construction areas. The presence of unexpected traffic queues due to lane closures, the close proximity of barriers and construction equipment, and a lack of properly maintained traffic control devices may all contribute to the high rate of accidents in work zones. Worker safety is also a major concern within roadway work zones. Worker deaths at roadway construction sites account for 15 percent of all work-related deaths nationally. Recent studies have indicated that the risk of death among workers engaged in highway and street construction is at least seven times greater than that of the general U.S. workforce.

Numerous strategies and technologies currently exist and are being developed to combat the safety risks associated with roadway work zones. Improved traffic management and control techniques provide better positive guidance and emphasize driver awareness. Innovative construction techniques allow work to be completed more quickly. Increased reliance on night and weekend paving reduces the probability that traffic lanes will be closed during peak periods.

Work zone safety and traffic control have become an increasingly expensive element of the paving contract. These costs will continue to rise as a percentage of total contract costs in the future unless better techniques for handling increasing traffic loads are developed.

TRAINING

Throughout the process of HMA preparation and installation, people make the difference. It is critical that each person involved in the process be appropriately trained to accomplish his or her assigned task. Equipment manufacturers provide training that covers the proper maintenance and use of their equipment. Many state and national associations, such as the National Asphalt Pavement Association and the Asphalt Institute, conduct training programs as well. The National Center for Asphalt Technology trains university professors in both laboratory and design procedures that they can take back to their classrooms. Such efforts will increasingly be needed to qualify both owners and contractors to meet future demands for smoother and longer-lasting pavements.

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