A Historical Perspective of Hot Mix Recycling

Summit on Increasing RAP Contents in Asphalt Mixes

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The concept of recycling reclaimed asphalt concrete (RAP) pavement is not new. The fact is there has never been a reason not to use RAP material as a component of Hot Mix asphalt. More than anything else the interest in the use of RAP has always been tied primarily to its economic value.

In 1972 when the nation was hit with the oil embargo, I was in charge of the asphalt research for the Florida Department of Transportation. At that time we were not using RAP nor were we doing any research relative to its use. We did shortly after that time, however, begin to consider utilizing salvaged pavement materials.

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The problem we encountered was very simple. The cost involved in removing sections of pavement and crushing for reuse was not cost competitive with virgin materials.

Then in 1974 cold milling began to be developed in the state and the economics of reclamation started to change. Up to that time when a flexible pavement was scheduled for rehabilitation, the conventional approach had consisted of a leveling course and an additional thickness of asphalt concrete to restore the structural integrity of the pavement system. This process resulted in raising pavement grades, changing existing drainage facilities and adding material to the shoulders to maintain transverse profiles. With cold milling we could remove existing distressed pavement quickly and efficiently. This resulted in having a supply of salvaged materials that could be reintroduced as a material component of the new pavement layer.

As we began to study the process, we were faced with a number of obstacles. Besides not having an abundant supply of RAP material, the majority of hot mix plants were batch plants which posed the problem of how to introduce the RAP and how to bring it to an acceptable mix temperature. We needed to resolve gradation control issues, mix temperature and coating concerns as well as reassuring ourselves that we could produce a mix that met all quality requirements. This included being able to place and compact the recycled hot mix asphalt so that the long term performance equaled or exceeded that of conventional mixtures.

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A number of changes were coming together at the same time that were ultimately to play a role in the development and acceptance of RAP as a mix component and recycled hot mix asphalt as a design alternative.

During the 1970's the Florida DOT was evaluating all of their construction and materials specifications. As a part of this process, we were starting to adopt contractor quality control requirements and transferring mix design responsibilities to the contractor. This resulted in the industry being more informed about materials management and more focused on the blending of various aggregates to produce the most cost competitive hot mix. As quality control programs were implemented at the aggregate quarries, it became easier to utilize drum mix plants. The development of drum mix plants made it easier to introduce higher percentages of RAP and to better control mix temperatures.

Combine this with the fact that these plants produced higher volumes and operated much more efficiently, it was obvious the hot mix industry was positioned to enter a new era.

The Florida DOT constructed its first hot mix recycled project in early 1977. This initial beginning was accomplished utilizing materials salvaged from an old runway at the Palm Beach International Airport. The old pavement was crushed and 15 % 1/2 inch minus RAP material was used in the paving mixture. A batch plant was used for this first project and the RAP was introduced directly into the mixer. With the mixing time being increased in order to achieve the desired temperature, there were some minor problems with steam because of moisture in the RAP, but overall the project went very well with very few problems.

Data from this project was used to develop specifications for a second project located on a section of four lane roadway on US 441 near Ocala, Florida. This resulted in an eight-mile long test road for the evaluation of removal and replacement of asphalt concrete pavement through the milling and recycling process. The contract specifications required the use of a drum mix plant and permitted the use of up to 60 % RAP material in the new hot mix asphalt.

Using data obtained from that project, specifications were developed and refined through construction of subsequent pavements over the next three-year period.

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In mid-1980 the Florida Department of Transportation began state-wide implementation of hot mix recycling as a standard design alternative to be included as a consideration for all rehabilitation projects.

Numerous technical reports and documentation summaries were produced by the Department's Bureau of Materials and Research in Gainesville, concerning the efforts expended in developing this process for use.

The Federal Highway Administration (FHWA) provided financial support for much of the field and laboratory evaluations associated with the development efforts. Subsequently, the FHWA distributed a number of Florida's reports for use by others. In addition, "Guidelines for Hot Mix Recycling of Asphalt Pavements," developed for use in Florida were reproduced and distributed nationally.

As I began preparing this presentation, I reviewed several articles that I had written during the late 1970's and 1980's pertaining to the research work we had done relative to recycling.

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In particular I found a paper I prepared for presentation at the Recycling Institute meeting March 20-21, 1985 in New Orleans, Louisiana. The paper was entitled "An Overview of Recycling – Florida's Experience". After reviewing my comments at that time, I thought it would be enlightening to share them with you since I think they are just as appropriate nearly 25 years later.

The following are some of the excerpts from that paper:

Since 1977, the Florida Department of Transportation had constructed a number of hot mix recycled asphalt concrete pavements. Each of these has been carefully evaluated to insure that the quality of the pavement is maintained. The results of these performance studies have shown these pavements are performing in a manner equal to and, in some cases, exceeding that of similar conventional paving processes.

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By utilizing the recycling alternative, we have found the cost of the project is 15 – 30 % less than the conventional paving approach. In addition, the energy demand measured in terms of BTU's is reduced by 25 – 45 % when compared to the conventional method.

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Examples of savings realized when using the recycling process as compared to the conventional process are shown in Table 1:

TABLE 1

SAVINGS WHEN COMPARED TO CONVENTIONAL PROCESS

					Savings Compared to Conventional Mixtures			
Year	Recycled Asphalt Mix (Tons)	Total Asphalt Mix (Tons)	Percent Recycled	Lane Miles	Energy (Billion BTU's)	Asphalt (Gallons)	Aggregate (Tons)	Cost (Dollars)
1979	75,098	n/a	n/a	67.1	20.7	529,441	37,548	591,960
1980	9,077	n/a	n/a	19.2	2.5	63,993	4,539	71,549
1981	120,964	n/a	n/a	95.2	33.3	852,796	60,482	953,499
1982	288,168	3,088,739	9.3	246.6	79.2	2,032,584	144,084	2,271,484
1983	545,461	2,886,000	18.9	340.6	150.2	3,845,500	272,731	4,299,596
1984	1,771,311	3,721,950	47.6	1,876.4	487.1	12,487,742	885,656	13,962,359
TOTALS	2,810,109	9,696,689	75.8	2,645.1	773.0	19,811,966	1,405,040	22,150,447

The data presented were obtained by documenting actual costs and available fuel consumption records. The dollar savings are obvious, and as we expand our use of the recycling alternative, we can significantly extend the construction dollar.

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…… hot mix recycling cannot be approached as a means of using a waste product but rather from the standpoint that a paving mixture of equal or superior quality will result. To insure the quality of the final product, we must use the same approach as we would on any conventional paving project. The primary problem exists in the fact that we have been using conventional procedures for so long that we have lost touch with the evolutionary development of all of the quality control measures employed in association with the component parts of the final mixture.

Many engineers have failed to view the salvaged asphalt and aggregate combination as another commercial component that must be monitored and controlled in a fashion similar to any of the other materials composing the final asphalt concrete paving mixture.

As is the case with conventional asphalt paving, the type of quality control measures adopted for the final mixture is worth very little if there is no assurance that the component parts are produced under similar circumstances.

The current specifications permit two basic approaches in utilizing reclaimed asphalt pavement in the new flexible pavement layers.

First, projects that are designed including a requirement for pavement removal and then the option to utilize this material as a part of the asphalt concrete mix in the rehabilitated pavement system; and second, the option of the contractor to utilize recycled asphalt pavement as an aggregate alternate in any asphalt concrete pavement layer with the exception of friction courses.

Specifications for both of these approaches contain a number of key elements that past experience has indicated play a major role in providing realistic bids as well as insuring a high quality flexible pavement layer.

In either approach, present bid documents provide for no minimum amount of recycled asphalt pavement for inclusion in the final job mix formula. However, an upper limit of 60 % has been established. This provides the materials engineer with latitude to adjust gradations, asphalt contents, and viscosity levels of the recycled mixture.

There have been no special gradations developed for recycled mixtures. Rather, current standard gradations and Marshall design requirements are specified for these as well as conventional mixtures.

After construction is begun, the quality control and acceptance testing required is very similar to that of conventional paving mixtures. Gradation analyses of aggregate component stockpiles are monitored daily along with extractions of the salvaged asphalt concrete stockpiles. These tests are performed by the contractor's quality control technician as a part of his plan control program.

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The established mix temperature at the time of discharge at the asphalt plant must be in a range of 240°F to 300°F (115°C to 149°C). Our experience has shown that this operating range can be uniformly maintained, and as long as the viscosity level is controlled within specification limits, the mix can be handled in the field in the same manner as any other conventional paving mixture.

There have been no revisions made to the Department's standard placement and compaction specifications that relate specifically to recycled asphalt concrete mixtures. We have made every effort to comply with the same standards of quality expected in conventional mixtures. If this is accomplished, it follows that the placement and compaction specifications should be no different than would be utilized with any similar paving mixture.

Hot mix recycled asphalt concrete pavements have been in use in Florida for nearly eight years. To date, the performance from all of these pavements has been excellent. In fact, the pavement sections have equaled or exceeded the performance of similar roadway sections constructed by the conventional process.

The data obtained from field cores indicate that the in-service hardening rate of the recycled asphalt is somewhat less than that of comparable standard asphalt cements. At the present time, firm conclusions cannot be drawn, but these trends are being monitored so that an analysis can be made to confirm our assumptions.

In areas where the pavement is in an advanced stage of cracking, and the asphalt concrete layer is removed entirely for reprocessing, the performance has far exceeded the conventional leveling and resurfacing approach. To date, this has been the most efficient rehabilitation used by the State, and a major reason has been the elimination of the reflective cracking potential.

The following is the summary of conclusions from that paper:

As of January 1, 1985, the same quality assurance specifications utilized for conventional mixtures are used for control of recycled asphalt concrete mixtures. Our experience to date has shown that a high quality pavement can be constructed incorporating salvaged asphalt materials. The following appear to us to be key points related to this type of construction process:

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1) The same general gradation requirements and design properties should be used when specifying recycled asphalt concrete mixtures.

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2) Design strength equivalencies used in the pavement design process should be the same as those that would be assigned to the same standard mix produced by conventional processes.

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3) Recoveries of the asphalt cement from recycled asphalt concrete mix should be made at the plant site at regular intervals during the production process. Viscosity measurements should be performed at 140°F (60°C) at 4,500 ± 1,500 poises.

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4) Placement and compaction requirements should not deviate from standard construction requirements used in conjunction with normal asphalt paving projects.

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5) No lower limit should be placed on the percentage of salvaged material incorporated into the final design; however, an upper limit of 60 % is suggested. This limitation permits more design latitude and uniformity of the mix during production.

As I said earlier, these comments were taken directly from a paper I wrote nearly 25 years ago. For a number of reasons from the late 1980's and into the 1990's we lost our momentum with regard to the implementation and further refinement in the use of RAP materials.

What I think is most important for us to take away from this meeting is that we don't have to duplicate research that has already been done. We should build on this knowledge and utilize today's improved processing techniques and quality control procedures to expand the use of a proven material. Failure to do so impacts the hot mix industry's competitive position and costs the taxpayers millions of dollars each year.

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