Recycling Bituminous Pavements

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This paper is a summary report on a research project entitled "An Investigation of Recycling Bituminous Pavements," an HPR Research Project conducted by the JHRP staff at Purdue University. The research was performed by James L. McKinney, Graduate Instructor in Research, under the direction of Professors Donn E. Hancher and Leonard E. Wood. Copies of the final report are available through the JHRP, Civil Engineering Building, Purdue University, West Lafayette, Indiana 47907.

INTRODUCTION

Asphalt pavement recycling is a viable method that can be used to maintain, rehabilitate, and reconstruct asphalt pavements. One of the major problems facing transportation agencies is the need to maintain and upgrade the level of service that highways provide, while copies with rapidly escalating costs and a nearly fixed level of highway funding. Asphalt pavement recycling can be a part of the solution to this multi-faceted problem. A significant portion of the highways in this country are constructed with asphaltic materials. Asphalt recycling reuses these materials in the rehabilitation or reconstruction process. As such, recycling not only conserves natural resources, but can be an economical, as well as an energy efficient rehabilitation alternative.

RECYCLING METHODS

Asphalt pavement recycling is one of many alternative methods that can be used to rehabilitate or reconstruct flexible pavements. However, there are many different ways in which asphalt pavements can be recycled. Basically asphalt recycling can be classified into three major areas: surface recycling, central plant recycling, and in-place recycling.

Surface Recycling

Surface recycling is one of the most widely used forms of asphalt pavement recycling. This method is used primarily to correct or rehabilitate the surface layer of flexible pavements. Surface recycling is particularly well suited for treating or correcting surface deficiencies, as

well as pavement geometry problems. Most surface-related defects can be attributed to the oxidation of the pavement binder that occurs in the upper layer of the pavement surface. Surface recycling either removes this layer of aged material or rejuvenates the material, so that near original binder properties can be restored to the pavement surface. Successive new material overlays can cause problems with vertical clearances, roadway cross-slopes, curb reveal, utility covers, and drainage structures. Removing excess surface material, with surface recycling techniques, before a new material overlay can eliminate these problems.

Surface recycling can be classified into two major groups: *hot surface recycling* and *cold surface recycling*. Hot surface recycling utilizes thermal energy to heat the pavement surface material to facilitate the removal process. Several different machines can be used to accomplish this operation: heater-planers, heater-scarifiers, and hot millers. The major problem associated with the use of hot surface recycling techniques is the development of the proper level of thermal energy. Excessive temperature can damage pavement materials, as well as generate excessive atmospheric pollutants. Inadequate temperature can seriously retard the pavement removal process or impede the surface recycling operation.

Cold surface recycling, rather than depending on thermal energy to aid in the pavement removal process, utilizes mechanical energy to plane or mill the pavement surface. The most prevalent type of cold surface recycling equipment is a cold milling machine which utilizes a rotating drum equipped with cutting teeth to remove the pavement surface material. Temperature related degradation of the asphalt binder and associated hydrocarbon emissions are eliminated. In general, cold millers are capable of removing more material per pass, with greater cutting accuracy, while consuming less energy per unit of material removed than hot surface recycling equipment.

Central Plant Recycling

Paving contractors and asphalt producers have shown the most interest in central plant recycling. Central plant recycling usually involves removing the existing asphalt-bound pavement material, full depth, and transporting the salvaged material to a central plant where additional new materials may be added to the salvaged materials during a hot mixing operation. The recycled material is then put back on the roadbed with conventional paving equipment. A significant improvement in the structural capacity of the existing pavement can be achieved during this recycling operation. The base/subbase can be reconstructed after the asphalt pavement materials are removed. The salvaged asphalt materials can be rejuvenated and upgraded during central plant mixing operations.

The salvaged material must be crushed and sized prior to recycling in the central plant. Usually, the salvaged asphaltic pavement material is crushed at the central plant site using conventional aggregate crushing equipment, although the material may be crushed in-place, on the roadbed, using mobile equipment.

Central plant recycling can be classified into two major groups: drum mixer recycling and batch plant recycling. The major problem associated with the use of central plant equipment for recycling asphaltic materials is that the hydrocarbon emissions are generated when the salvaged binder is ignited by the dryer flame.

Drum-mixer recycling utilizes a dual-feed process to control hydrocarbon emissions. Uncoated aggregate is used to protect the salvaged asphaltic material from the high temperature of the drum mixer's burner. The uncoated aggregate also acts as a heat transfer medium that raises the temperature of the salvaged pavement materials.

Batch plant recycling also utilizes a dual-feed process to eliminate hydrocarbon emissions. Uncoated aggregate is superheated in a conventional dryer, while the salvaged pavement material is introduced directly into the batch plant tower, bypassing the dryer. The salvaged pavement material is heated by the superheated, uncoated aggregate in the batch plant weigh hopper and pugmill, totally eliminating the generation of any hydrocarbon emissions. Modification components or add-on recycling kits are available for both types of central plants so that conventional equipment can be used for central plant recycling.

In-Place Recycling

In-place recycling is the third major form of asphalt pavement recycling. A variety of equipment and construction techniques can be used to recycled asphaltic pavement materials in-place. Normally, the product produced by this recycling method is a cold mixed in-place stabilized base. Usually, a new material overlay or an asphalt surface treatment is applied to protect the recycled layer from traffic action, to waterproof the recycled materials, and to add increased structural strength to the recycled pavement.

In-place recycling is normally accomplished using conventional road building equipment. Costly transportation operations are eliminated since the asphaltic material is recycled in-place on the roadbed. In-place recycling consumes less energy per unit of material processed than the other two major forms of recycling. The major disadvantage associated with some in-place recycling operations is the inability to control the quality of the product that is produced. Because of the fact that such a wide variety of construction equipment and techniques are used to recycle the materials in-place, the variability associated with the final product is much greater.

The primary operations required for recycling an asphalt pavement in-place are: removal of the existing pavement; crushing and pulverization of the salvaged pavement materials; mixing of the salvaged material with additional materials (as needed); and laydown and compaction of the recycled product.

Many different types of equipment, ranging from the simple to the relatively complex, can be used to accomplish these operations. The type of new binder incorporated in the recycled mixture will control the type of mixing, laydown, and compaction equipment that can be used. The quantity and quality of the existing pavement will dictate, in large part, the proper choice of equipment for removal and crushing operations. The type of equipment chosen, in turn, controls the in-place recyling rate of production, as well as greatly influencing the unit cost associated with recycling operations.

RECYCLING GUIDELINES

The major problem associated with the use of asphalt recycling as a pavement rehabilitation or reconstruction technique is one of determining whether a pavement is a suitable candidate for recycling. The recycling guidelines developed in this research project establish a formal evaluation and investigation procedure that can be used to identify possible recycling candidates.

A pavement investigation program, composed of a field survey program, a historical records investigation, and a materials testing program, is used to characterize the existing pavement. The field survey program outlines a formal method for evaluating the existing structure and determining its rehabilitation needs. The geometric adequacy, surface condition and structural adequacy of the existing pavement is investigated as part of the field survey program. The historical records investigation is conducted using design, construction, and maintenance records to determine what should exist in the field. The materials testing program uses field samples to substantiate or refuse the findings of the historical records investigation, as well as to characterize the material properties of the existing subgrade, base and bituminous concrete. The existing pavement is fully characterized, and its rehabilitation needs can be identified when the results of the field survey program, the historical records investigation, and the materials testing program are combined. These programs also allow the probable cause of pavement distress or failure to be determined. This determination is used to identify feasible alternatives, recycling and conventional, that can be used to rehabilitate the pavement. The existing condition of the pavement structure, the distress manifestations that are evident in the existing structure, and the distress mechanisms producing the problems are used to identify rehabilitation alternatives.

No quantitive values have been assigned to any of the decision criteria contained within the Recycling Guidelines. It is anticipated that each transportation agency implementing these guidelines will select appropriate values that would be based upon past experience and local conditions. These then could be used to identify the proper rehabilitation alternative(s) for the extent and severity of pavement distress encountered.

The recycling guidelines also comment on *mix design procedures* that can be used for the major forms of asphalt pavement recycling. some procedures are outlined for designing recycled mixes that incorporate additional binder, virgin or salvaged base aggregate, and reclaiming agents.

Finally, the recycling guidelines comment on the *design of the recycled pavement structure*. Procedures are outlined so that the proper thickness of the pavement structure, the recycled layer, as well as the conventional material components, can be selected for anticipated traffic and climatic conditions, as well as for the types of materials that will be used.

CONSTRUCTION GUIDELINES

A specific recycling system must be selected in order to implement the rehabilitation alternative generated by the recycling guidelines. *Construction Guidelines* were developed in this research project to provide insight and guidance into the process of selecting the component pieces of equipment that will make up the recycling system. The performace of both the system and the system components can be evaluated once the specific recycling system is identified. Anticipated rates of production, unit costs, and unit rates of energy consumption should be calculated. The specific recycling system should be compared to an equivalent conventional system on the basis of life cycle costs, total energy consumption, and various environmental considerations.

The construction guidelines also provide a means to analyze the proposed recycling project prior to the start of actual construction. Recycling process variability, project management decisions, and potential problem areas are identified for the specific recycling system proposed for use.

Finally, *Guide Specification* for the major forms of recycling are provided in the construction guidelines. The forms of recycling that are covered by the specifications are: heater-planing, hot milling, heater-scarification, cold milling, central plant recycling, and in-place recycling. The guide specifications are intended to supplement existing specifications or to provide guidance as to how existing specification should be modified or revised to account for recycling operations.

SUMMARY

Asphalt pavement recycling is a viable method for maintaining, rehabilitating, or reconstructing existing asphalt pavements. However, thorough engineering analyses are essential to identify pavements which can be economically recycled. Also, considerable engineering input is required for the redesign of the pavement, identification of the construction methods to be used, and specification of the construction requirements. The research project summarized in this paper addressed these important issues and recommended procedures were identified to resolve these issues.