

The Benefits of Optimization of Asphalt Pavements in the Urban Areas with In-place Recycling

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ABSTRACT

This article is an overview of the new in-place asphalt recycling method and its comparison with the usual methods. The optimization of the existing asphalt layers and surface is significant in many different perspectives including: economic justification, environmental principles and its compatibility with the environment, ergonomic design, reclaiming existing materials and as a result reducing new resource consumption especially the use of quarries and tar. Also the advantages of this method during its application including: the reduction of traffic in the reclaiming areas, the higher speeds of performing this method in comparison to the usual methods, compliance with technical issues such as maintaining alignment with water ducts and sewers and fulfilling the approved quality regulations all prove the necessity of using this method especially in the urban areas. Furthermore, the subject of available technology and how to run them for example: the machinery put to use, additives such as bitumen emulsion and bitumen foam, paving technologies, reclaiming shingles in the damaged layers, how to spread the recycled asphalt, will all be compared with the usual methods of producing new asphalt. It should be noted that the optimization techniques in this method have conformity with the technical and administrative regulations of Iran and international standards of safety and environment and also provides the technical standards of urban areas.

KEYWORDS: Asphalt Recycling; Hot In-Place Recycling (HIR); Cold In-Place Recycling (CIR); Asphalt Optimization; Asphalt Technology; Recycling Urban Pavements; Quality Parameters of Recycling.

INTRODUCTION

Today the development in transportation and its importance in the economic cycle and international trade is known to everyone in such a way that the important characteristics of development in any country are high quality, safe and standard communication routes. However in recent years a number of factors have reduced the quality and the life of many of the routes in our country especially in urban areas. Among the important factors in this area are the dramatic rise in costs related to the production and maintenance of roads, the increase of the volume of traffic, the low load capacity of transport routes compared to the traffic passing through, the long time it takes to recover damaged pavements using the usual methods and also the ineffectiveness of traditional treatment methods according to today's needs[1].

With that being said, the necessity of using a new method which is both economical and also technically and environmentally approved is obvious. In this regard the use of recycling technologies in the production of asphalt is an acceptable and optimal solution. It is the reuse of old asphalt material that is damaged and reduced in technical capability or is declining. Asphalt recycling has many advantages and is known as one of the fastest and most efficient methods for rehabilitation and reconstruction of asphalt coatings[2].

In this study we have tried to enumerate the features and benefits of using recycled asphalt and evaluation aspects in the economic, technical and environmental manner, the importance of taking advantage of this technology and its application in the repair of asphalt coatings, especially in high traffic urban areas.

History

According to some reports and documents the first projects in which reclaimed materials were used were in the early 1915s, but the first efforts for treating pavements took place in the 1930s. In the 1950s along with the economic growth after world war II and after the resumption of construction of new roads and the rehabilitation of the old roads worn-out from the war, asphalt recycling came to attention[1].

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In The United States asphalt recycling started in the 1930s and in 1952 many cases of the airforce airport pavement recycling were seen. In Japan studies on the scientific and industrial aspects of asphalt recycling started in the 1970s and the first recycling plant was built in 1976[3]. In Iran studies on this matter started in 1987 and since then many different studies have taken place.

1. Asphalt Recycling

A general definition of asphalt recycling is the recovery and the reuse of the existing asphalt and its constituent materials for the production of fresh and high quality asphalt in accordance with the plans of the executives. With the use of machines and advanced techniques the inefficient and worn-out asphalt is optimized and by using reclaimed asphalt pavement (RAP) and adding a recycling agent such as bitumen emulsion, a stronger and higher quality asphalt that complies with the regulations and standards can be made[4].

1.1.Asphalt Recycling Methods

1.1.1.Hot-Mix Asphalt Recycling

Hot asphalt recycling is the most common and oldest method for recycling asphalt and many tests and research have taken place on this matter. The results from these many studies show that hot-mix recycled asphalt is worn-out much later and is also more resistant to the effects of water compared to normally made asphalt[5].

Hot in-place recycling can only be used to treat surface damage, thus the implementation of this method requires the existing underlayers to have appropriate strength and load capacity so that the reclaiming and treatment can be done at a depth of 5cm. Some of the surface disorders that can be treated with this method are:

1. Slippage cracks
- 2.Temporary removal of reflective cracks
- 3.Reformation the rising of bitumen of roads
- 4.Reformation of roads transverse slope and surface drainage
- 5.Modifying the size and quality of asphalt
- 6.Rehabilitation of existing oxidized asphalt bitumen using emulsion without increasing the bitumen in asphalt

The asphalt recycling and reclaiming association (ARRA) classifies hot in-place recycling in three major groups:

1. Surface Recycling
- 2.Repaving method
- 3.Remixing method

The differences between the three groups are the differences in the use and operation of them.

1.1.2.Cold-Mix Recycling

In the cold in-place recycling method that is more common than the cold plant recycling, all the reclaiming is done in-place using special machinery. This method reclaims part or all of the asphalt layers and cuts and crushes it. Then the crushed material is graded and bitumen is added. Using this method we can build up to 30cm in depth. In many of the states of America the cold in-place recycling method has took place alongside hot asphalt paving[6].

Although cold recycling does not have a long history, it has a high speed and performance quality but is less common compared to hot recycling. With this method worn-out and injured asphalt in the surface or underlayers can be strengthened with the restoration of its aggregates and bitumen materials. Although the implementation of this method saves in energy consumption, reduces overall costs and improves conservation of natural resources due to its high operating speeds, it is suggested to use this method only when the volume of recycled materials for the project is high[7].

2.Recycling Technology

In this section the existing technologies, including a variety of production methods and characteristics of each method, machinery used for hot and cold recycling and technical assessment methods will be mentioned.

2.1.Production Features

This section will show the specific features of both hot and cold in-place recycling.

1.The important features of hot asphalt production[4]:

- Increasing the strength of the pavement without or with little change to its volume
- Repairing surface damage such as bitumen corrosion, the phenomenon of separation of aggregates from the asphalt surface, track disability and deformation
- Maintaining the surface levels or with minor change in the levels thus adapting with the roads geometry
- Increased swing sliding-restrained
- Adjustment of the physical and chemical features of bitumen using emulsion
- Increasing the durability of asphalt pavement and improve its fatigue-restrained
- Repairing the cracks caused by the loads on the road

2.The important features of cold asphalt production[8]:

- Optimizing all the asphalt layers including the bitumen layers
- Optimizing the base and sub-base layers and repairing the sub-grade layer
- Short time gaps between mixing and compacting the layers
- The ability to modify the layers of non-cohesive aggregate pavement
- Increasing the quality of pavements without increasing the volume
- Consolidation and strengthening of aggregates and asphalt through the addition of bitumen emulsion and materials
- Removing the reflective cracks and the thermal cracks of the pavement
- Increased pavement resistance to moisture and icing

2.2.Machinery and Technologies For Recycling

2.2.1.Hot In-Place Recycling

General classification of equipment and machinery used for hot in-place recycling is shown below:

- 1.Heating systems
- 2.Crushing unit
- 3.Emulsion adding system
- 4.Mixers
- 5.Finishers
- 6.Rollers

The super recycler (AR2000) is one of these machinery. This machine is a portable hot recycling plant which consists of two pre-heaters, a hot miller and a post-heater, drier and a mixer. For spreading and compacting the recycled asphalt, finishers, rubber-tired rollers and vibratory rollers are used in conventional methods. The advantages of this machine include[9]:

- 1.Environmentally friendly
- 2.Saves time and reduces costs
- 3.Daily recycling capacity of 6000 to 10000 square meters for 10 hours work
- 4.Exclusive compressed hot air heating system
5. Diesel fuel
- 6.Optimization of fuel consumption saves upto 50% energy
- 7.Exclusive pre-heater, post-heater and mixer system
- 8.Pugmill units for adding additives
- 9.Easy to transport and easy to connect to truck tractors

2.2.2.Cold In-Place Recycling Machinery

A classification for equipment and machinery for cold recycling is shown below:

- 1.One-part machinery
- 2.Two-part machinery
- 3.Multi-part machinery

The MCR250 is one of these machinery. The MCR250 is a train like machine used to recycle worn-out asphalt using cold in-place recycling. This machine is equipped with a mechanical vacuum to clean up the edges of the work area and a prime and tack coat spraying system and is able to add emulsion bitumen, polymer bitumen and foam bitumen to the cut off aggregate and make a uniform asphalt mix in the mixer. The advantages of this machine are as below[10]:

- 1.The mixture of aggregate is done by weight not volume
- 2.The mixture of materials in the mixer is not dependent on the machines speed
- 3.Moisture tests are performed before the mixture
- 4.Material screening, separation and breaking the materials is done without error
- 5.Clearing capabilities, plated surface and penetrating emulsion
- 6.Recycling of asphalt using bitumen foam and cement

2.3.Mix Design

If the reclaimed asphalt pavement (RAP) materials in the hot asphalt mixture is 20% or less no changes should be done to the specifications of the pure bitumen used. But mixture that are made of more than 20% reclaimed asphalt surface, a pure bitumen with a one degree softer fineness modulus specification should be used so that the high viscosity of the oxidized bitumen would amend. Although studies show that in many countries the same bitumen is used regardless of the RAP[4].

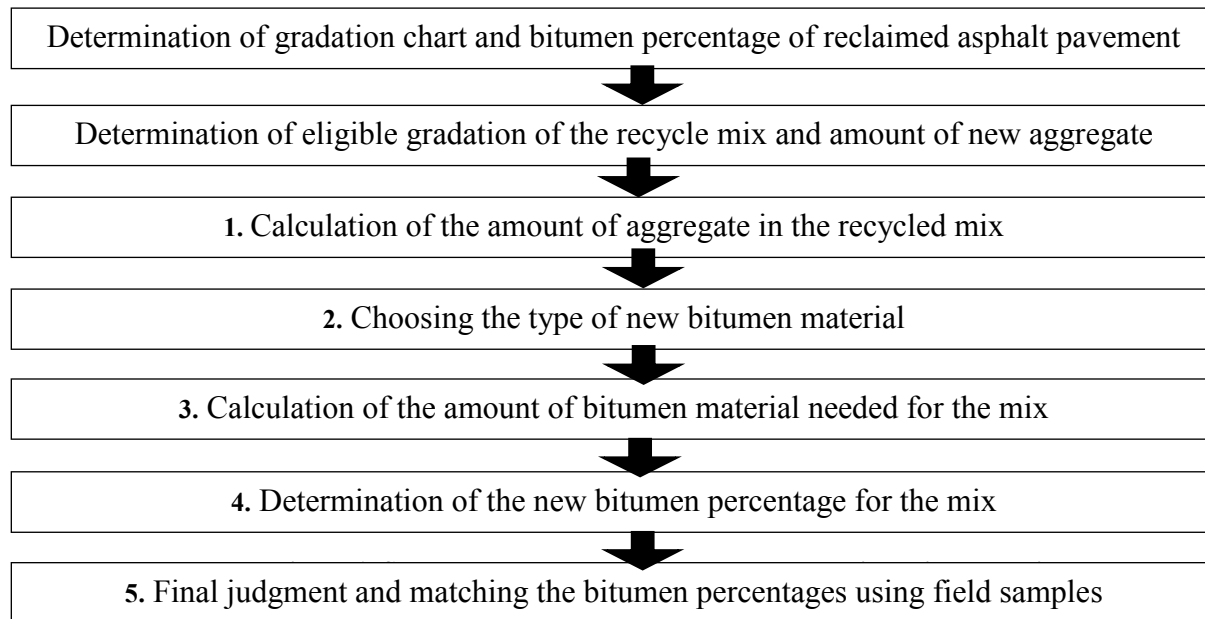
The complete specifications and design of cold recycling mixes is in the ASTM standards. With help from figure (1) we can classify the mixture methods for cold recycling, both in-place and using a recycling plant, into five classifications as the ARRA proposes[8]. In this method the mixture of bitumen materials such as cement, fly ash, or new aggregate if

needed, to produce a new asphalt with high specifications. This method takes place in the ambient temperature without the use of heating machines[11].

2.4. Control Tests

The ASTM can be pointed out as a reference for control tests on the hot recycling method mixture design[12]. In many countries the marshal mixture design[2] or hveem[13] are used to determine bitumen and RAP percentage for the hot asphalt recycling method as is used for the usual method[14].

Therefore the quality of all the materials used in hot plant recycling or hot in-place recycling must match and comply with the regulation standards of hot asphalt recycling in Iran[15,16].



In cold asphalt recycling quality control, the results of each test must match the technical criteria, including: the gradation of recycled mix, bitumen material and additives, the amount of water added to the recycled mix, the remaining water of the compacted mix, the strength quality of the bitumen foam mix, compaction of the layers, determination of the voids in the mix, calibration of the equipment and etc[10].

3. Pavement Layer Optimization Through Recycling

The most important parameters of recycling is its feasibility and its justification which include: significant reduction in production costs, economic savings in projects, observance of environmental principles and the reduction of resource consumption including bitumen and aggregate.

Among the most significant and environmental characteristics of asphalt recycling are[8]:

- Accomplishment of reconstruction and development goals
- The preservation of natural resources due to the reuse of pavement materials
- Reduction in the costs of operation and maintenance of the routes
- Reduction of environmental pollution
- Reduction in the costs of production and transportation of raw materials and energy savings (bitumen, diesel, electricity, etc.)
- Increase in speed and efficiency of operations
- Decline in traffic due to open operating routes during the recycling

RESULTS

In this section which is linked to the articles title, we get to know the conclusions of this method. Without doubt any kind of pavement will eventually get worn-out and lose its full operating specifications and will need a new overlay[17]. According to what was said in this article, if urban road pavement construction and repairing takes place using the usual methods, the technical, economic and speed of implementation of the work would be obsolete compared to the recycling methods (both hot and cold). The schematic diagram below is a comparison between the methods and practices conducted by the usual and recycling methods, in terms of speed as well as the economic point of view:

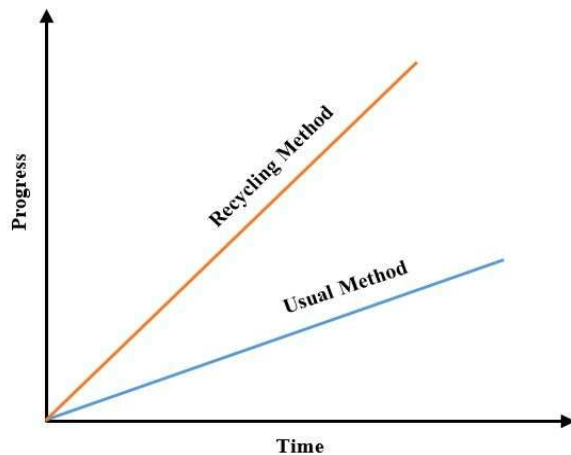


Figure2. Comparison of operating speed

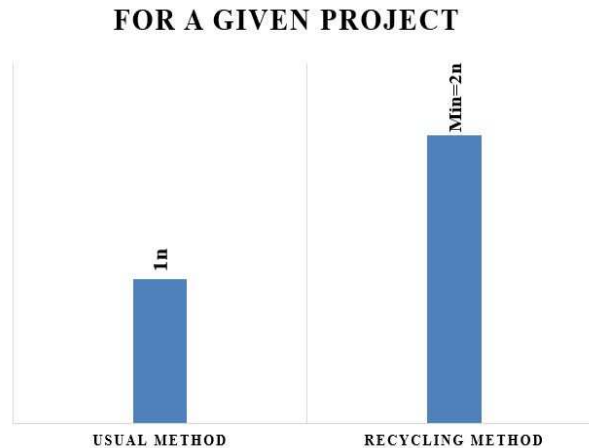


Figure3. Comparison of economic benefit

Another important aspect is the technical and administrative aspects of pavements which comes to consideration, especially in urban areas. For example the guidance of water ducts, sewers and surface water can fully comply with the mandatory levels due to the technology and machinery used in recycling[12].

CONCLUSION

It can be concluded that pavement recycling has many positive parameters compared to the usual methods, that have been pointed out in this article (economic, environmental, technical, etc.). The important point is to achieve the ideal conditions and optimization of the recycled mix, which can be achieved according to the environmental characteristics of the project.

Another goal in this paper was to evaluate the optimization of road repairs using in-place recycling and the proper use of this method in large-scale urban projects. We have tried to explain the reasons in the text and all options to verify this topic, including technical and economical verification.

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