Review of Hot In-Place Recycling Work of Asphalt Surface Layer on NH-152


Abstract

Indian road needs urgent rehabilitation for the existing asphalt roads. Overlay is the Conventional corrective maintenance of asphalt pavement in India, which involve a very large capacity of virgin aggregate and bitumen material which results in high mining as well as it lays footprint in ecological deterioration. Chief concerns for this problem are energy prices, aggregate shortages and the global warming. To address above problems several new highly developed techniques are being pursued to conserve energy and mother earth. One of the big names in industry is much trying to repave the present pavement using recycling process known as Hot in place recycling. After successfully completing many projects in India, TATA Eco Resurfaces Private Ltd., alias TERPL, recently successfully finished a highway pavement recycling work of 112 km lane (28km x 4 lanes) of Nh-152, using a Hot In-Place recycler, AR2000 regardless of mechanical, operational and new asphalt supply problems or difficulties which took place during the operation. The existing road surface had been 100% successfully reused and recycled with new mix added as designed. This is the first large scale HIR execution ever done as a single recycling project in Punjab. The AR2000, uses a number of equipment’s arranged in such a manner that all the mechanical work consisting softening of existing layer using hot air followed by scarping of existing layer, mixing and milling with new material repaving and finally compacting the new pavement layer with the help of vibrators ensure on the site recycling possible. Hence it consists number of machines like two numbers of pre-heaters, one number of pre-heater with attached miller and one number of post-heater mixer working one after other forming a train. The heating system rises the existing pavement surface temperature about 600 degrees to soften top layer so that the top layer can be obtained without damaging or crushing aggregates. The big advantage of utilizing AR2000 being that 100% recycling work of desired quality without varying original gradation can be achieved, which has been confirmed by a high quality control checks. The quality control was censured by incorporating, Marshall Test concerning Stability, and Fifth wheel bump indicator test to keep a check on roughness. 96 days were taken for the whole recycling work done by AR2000. The average operation speed was 1.48 km per day, which is far ahead of the speed of work by the conventional manual method. The AR2000 recycling work performed at NH-152 has secured the economic viability of HIR method

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by saving the mother earth from mining operations of about 13350 m³ virgin aggregate and 1698 metric tons of bitumen. In context of structural strength, the marshal load came out to be 1276 kN and roughness value in term of BI scale being 1380 mm/Km which is well above the required benchmarks as per IRC

Keywords: Hot In-place, Recycling, Asphalt, Energy, Aggregate, Speed, RAC, NAC, EAM, NAM, RAM.

Introduction

Poor and damaged pavements can be exemplify by pitiable riding quality and physical agony, like raveling, cracks, ruts and potholes. Pavement gets easily deteriorate by callous climatic conditions, excessive traffic volume and overload as well as due to poor road construction processes and poor maintenance.

The wear and tear of pavements will further be accelerated the start of service but timely remedial techniques such as resurfacing and recycling can help in restoring pavement quality, which greatly lengthen a road’s life.

The topmost layer of pavement is made up of bitumen and virgin aggregates. Generally these materials are available in undersized supply, making them expensive. In present scenario, environment conservation has utmost importance and its well-known fact that the road construction industry requires enormous quantity of natural resources and energy for the construction work. The above mentioned situation can be countered by using the Hot In-place Recycling process. AR2000 as innovative equipment in road recycling work, moreover being environmentally friendly is highly appreciated for conducting such a work. Table 1 shows the comparison among HIR, CIR and conventional overlay in terms of expenditures, Mix design and resources requirement.

<table>
<thead>
<tr>
<th>Requirements</th>
<th>HIR</th>
<th>Surface overlay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing aggregate recycling</td>
<td>Size and form is maintained</td>
<td>Does not recycle</td>
</tr>
<tr>
<td>New Aggregate requirement</td>
<td>Less</td>
<td>Uppermost</td>
</tr>
<tr>
<td>New Binder requirement</td>
<td>Less</td>
<td>Uppermost</td>
</tr>
<tr>
<td>Mix design</td>
<td>No need for Redesign</td>
<td>Redesign</td>
</tr>
</tbody>
</table>

Construction Summary

- A road rehabilitation work was performed by Hot In-place Recycling method at Zirakpur, Punjab State on the national highway 152 between Baldev Nagar and Zirakpur.
- Total length was 112 km of main carriageway, i.e., 28 km x 4 lanes (which exclude the service Road and flyover).
- The Equipment used was AR2000, which recently did successful recycling work in Gujarat. But for the first time in Punjab.
- As is shown in Fig. 1, AR2000 is a train of machines consisting of two Pre-Heaters, which heat and soften the existing pavement surface, the Pre-Heater-Miller, which mills the softened surface while still heating and a Post-Heater Mixer, which mixes for Resurfacing milled materials to be recycled and new admix, to be followed by a conventional paver.

Equipment Details

AR2000 was developed by a famous Canadian company, Martec and has been manufactured with the globally patented technology. The technological benefit of the AR2000 lies in more efficiency which allows 100% recycling of the existing asphalt blend on-site without crushing aggregates in use.
Characteristics of the Equipment’s Work

This technology is intended and manufactured to operate close to emission-free recycling work.

i. It uses a hot jet air circulation structure utilized to soften the asphalt pavement plane, avoiding direct flames. This results in more environmentally friendly work.

ii. The deafening noise allied with conventional exhuming due to friction among milling pig and hard pavement surface is drastically reduced through softening top pavement surface.

iii. Existing asphalt pavement is 100% recycled, spawning no waste from the site.

iv. Speedy work due to on the spot recycling.

Generous Time Saving

i. The average operation speed was 2.18 km per day or 1.51 m/min. Depending on the operational conditions, the highest speed was over 2.5 m/min., which can hardly be achieved by the conventional resurfacing process.

ii. As compared to the conventional overlaying method, HIR method greatly reduces the construction time.

Operation of Each Machine

Pre-Heating Machine

Two Pre-Heaters, operating one after one, tenderly heat and softens the existing pavement surface. By using the Hot Air Heating System, air is heated up to 600 degrees Celsius. System is enclosed by a metallic cover that prevents loss of circulation as well as guards workers from the hot air expulsion.

Pre-Heater-Miller Machine

It applies additional heat over pavement, which helps out to easily mill and grate the softened pavement. The mechanized depth controller permits pavement removal to a preferred depth depending on a rehabilitation design and the operating milling heads can be adjusted to a functioning range from 3.3 m to 4.0 m.

The Post-Heater Mixer Equipment

It consists a series of devices to be used to continuously mix the mill asphalt mixture and to expose the mixture to hot air.

The asphalt mixture is brought from the pounded pavement surface and transferred to the twin-shaft pug-mill, where transferred mixture and new admix as required by a blend design adopted are mixed. This Post Heating and Mixing Process, helps detailed and consistent heating of the recycled asphalt mix and also remove the surplus moisture from the mix.

The Paver

RAM is moved from the pug mill to hopper of a paver for laying road surface.


The Pneumatics Rollers

Compaction is done by pneumatic and vibratory rollers.

Mix Design

A mix design was made in a way to assure the quality requirements adopted as the pavement standard in India with respect to the quality of RAM composed of blend of recycled existing material and of the virgin admix.

In case of NH-152 pavement recycling work several material test were executed for the mix design. 25 numbers of samples were collected from the site to study the existing pavement material properties.

Gradation Design

The mix proportioning selected for recycled mix consist 75% of EAM and 25% of NAM. The resulting mix met gradation limits as specified in codes. Table 2 illustrates the gradation of mix along with prescribed limits.

### Table 2. Combined Gradation of Recycled Asphalt Mixture

<table>
<thead>
<tr>
<th>Mix proportion (%)</th>
<th>EAM</th>
<th>NAM</th>
<th>Combined gradation</th>
<th>Gradation limits in India</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pass %</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25 mm</td>
<td>75</td>
<td>25</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>20.0 mm</td>
<td>71.5</td>
<td>24.5</td>
<td>96</td>
<td>90-100</td>
</tr>
<tr>
<td>10 mm</td>
<td>52.8</td>
<td>18.5</td>
<td>71.3</td>
<td>56-80</td>
</tr>
<tr>
<td>4.75 mm</td>
<td>38.3</td>
<td>14.8</td>
<td>53.1</td>
<td>35-65</td>
</tr>
<tr>
<td>2.36 mm</td>
<td>25.4</td>
<td>9.5</td>
<td>34.9</td>
<td>23-49</td>
</tr>
<tr>
<td>0.3 mm</td>
<td>6.8</td>
<td>2.45</td>
<td>9.25</td>
<td>5-19</td>
</tr>
<tr>
<td>0.075 mm</td>
<td>2.1</td>
<td>1.2</td>
<td>3.3</td>
<td>2-8</td>
</tr>
</tbody>
</table>

Bitumen Content

Minimum bitumen content required was determined in accordance to IRC requirement. The bitumen content was taken 5.2% from the previous experience and lab results given by marshal test. Table 3 shows required asphalt percentage.

### Table 3. Asphalt Content

<table>
<thead>
<tr>
<th>Mix proportion (%)</th>
<th>EAM</th>
<th>NAM</th>
</tr>
</thead>
<tbody>
<tr>
<td>RAM binder content (%)</td>
<td>3.57</td>
<td>1.63</td>
</tr>
<tr>
<td>Total binder content (%)</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

Work Management

Quality Management

The following tests were performed to ensure plenty quality control; Temperature Management, Marshall Stability, Sieve Analysis, Roughness determination test. Roughness was determined in five stretches using CRRI prescribed fifth wheel bump indicator and results were computed in terms of BI scale and then compared with IRS SP: 16. The test results of which are shown in Fig. 2 to Fig. 4 and Table 4 - Table 5.

Temperature Management

The heat level of existing pavement heated by Pre-Heaters is essentially important for the efficiency of milling, mixing and compaction. Fig. and Table 2 shows the average temperature results at the specific measurement points.
The temperature of new pavement exactly after paving work done by an asphalt paver was about 126 degrees Celsius, which was well within prescribed limit. Therefore the heating capacity of AR2000 has been found to be safe and sound for good quality work.

**Table 4. Temperature Details at Various Stages**

<table>
<thead>
<tr>
<th>Measuring point</th>
<th>Detailed position</th>
<th>Average temperature (in °C)</th>
<th>Measuring point</th>
<th>Measuring point</th>
<th>Average temperature (in °C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Existing surface</td>
<td>36</td>
<td>4.</td>
<td>Pounded asphalt mix</td>
<td>145</td>
</tr>
<tr>
<td>2.</td>
<td>Surface after first pre-heater</td>
<td>115</td>
<td>5.</td>
<td>New Asphalt mix</td>
<td>152</td>
</tr>
<tr>
<td>3.</td>
<td>Surface after second pre-heater</td>
<td>141</td>
<td>6.</td>
<td>After paving</td>
<td>126</td>
</tr>
</tbody>
</table>

**Marshall Stability**

Marshall stability test was performed after each 6 days of work with every new batch of mixes.

Figure 3 shows the variation of Marshall Stability for the first five trials. The average result was 1,276 kg which is well beyond the standard figure of 820 kg.
Gradation

The gradation test results were quite close to the Standard Gradation and fell within the range of allowable gradation. Results are shown in Fig. 4.

![Figure 4. Particle Size Distributions](image)

Economical and Ecological Aspect

About 75% material was saved in this project. Apart of material quantity of fuel for hauling huge amount of material, operation and maintenance of hauling equipment’s and human resources was quite large, reduction of which helps in kerb overall expenditures on project.

<table>
<thead>
<tr>
<th>S.no</th>
<th>Particular Subdivision</th>
<th>Quantity</th>
<th>Saving</th>
<th>Saving in percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bitumen VG-30</td>
<td>Overlay</td>
<td>HIR</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2214 MT</td>
<td>516 MT</td>
<td>1698 MT</td>
</tr>
<tr>
<td>2</td>
<td>Aggregate</td>
<td>&lt;=6 mm</td>
<td>10393.6</td>
<td>2494.464 cum</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6-16 mm</td>
<td>4480 cum</td>
<td>1097.6 cum</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16-24 mm</td>
<td>2688 cum</td>
<td>631.68 cum</td>
</tr>
<tr>
<td>3</td>
<td>Filler OPC Grade</td>
<td>358.4 cum</td>
<td>100.352 cum</td>
<td>258.048 cum</td>
</tr>
</tbody>
</table>

Roughness Determination

Roughness of asphalt surface was determined using CRRI’s recommended fifth wheel bump indicator. The test was performed in three phases, i.e. before HIR, after HIR, after one year of construction by HIR. F Test lane was selected from lalru toll-tax to 5 km towards Dera bassi.

Speed of Work

This methodology ensures speedy and safe construction and helps to shorten the conventional work duration. Skilled labor and technicians are required to operate and maintain the construction machinery. The average maneuver speed was found to be 1.48 km per day or 1.02 m/min.
Conclusion

The Zirakpur-Ambala NH-152 rehabilitation work done by HIR method has proven:

1. The Surface laying work results meet the Requirement of MORTH.
2. The work proves to be quite environmentally graceful, whether it is about the net energy use, bitumen and aggregates use or in terms of net gas discharge.
3. The work was found to be economically cost effective, by saving up the total construction expenses, duration of work, virgin aggregates and bitumen demand etc.
4. Mother earth was saved from mining operation of about 13350 m$^3$ virgin aggregate and 1698 metric tons of bitumen.
5. Average operation speed was observed to be 1.48 km per hour which is above standard speed of 1 km per day, which was satisfactory
6. Roughness index result shows increase in riding quality of road. Roughness before HIR is 1842 to 1932 and after HIR it reduces to range from 1308 to 1476 (in mm/Km).

References


