Environment Friendly Asphalt in Industrial Roads
(Green Roads)
[Engineer. Muhammed Hussain Sheariya]

Yanbu Industrial City is located 350 Kilometers north west of Jeddah. It possesses tourism features due to its location on a coastal line the red sea and hijaz hills. The red sea with its crystal water and attractive coral reefs welcomes the people who visit and frequent it for marine picnics, diving and several types of water sports. In this young city – just over 40 years became a center for modern industries. It plays a major role in Kingdom’s gross national income.

Yanbu port includes the facilities that enable it export more than three (3) million barrels / day while its location near the Suez channel makes it an excellent access to European markets and the developing markets in Affric and Middle East. Yanbu, moreover is located in the middle of the distance between America and the countries of the pacific ocean.

The main objective of Yanbu Industrial City Economic review is to gain better and current understanding of the city wide economic performances. The specific objectives are:

- To monitor / keep track of City’s economic trends on a quarterly basis.
- To understand the changes in the economic structure of the city over the period of time.
- To generate economic awareness.

The Royal Commission vision is “The best choice for investors in petrochemical and energy-intensive industries and the leading contributor to the Kingdom’s growth.

The Royal Commission Mission is “Plan, promote, develop & manage petrochemical and energy intensive industries through successful focus and partnerships with investors, employees, communities and other stakeholder
The Royal Commission’s strategic objectives are:
- Growth: Expand industrial base through growth in number of cities and industrial output.
- Tenant Portfolio: Optimize tenant portfolio by attracting investments of added value.
- Cities of Excellence: Gain recognition as one of the top industrial cities globally.
- Distinctive Staff: The best in attracting distinctive human resources in the Kingdom.
- Financial: Gradually develop financial sustainability and increased efficiency.

Royal Commission at Yanbu Industrial City, Saudi Arabia was keen to raise the efficiency of its main & secondary roads network in Industrial Yanbu due to its strategic location in the kingdom’s map and its association with neighboring countries. Our goal is to provide a safe roads network with high quality specifications without defects, that includes the study for an advanced asphalt mix design system where Industrial Yanbu will expand significantly in industrial, urban and investment field.

The Royal Commission conducts studies to overcome the asphalt pavement deformation problems for intersections and industrial roads and end up with three (3) major solutions:
1) Use of marshal Mix Design
2) Use of Reinforced Concrete pavement instead of asphalt
3) Use of Superpave Mix Design

In 2014, the Royal Commission for Yanbu bought an Equipment for the Evaluation of the roads to establish maintenance priorities. Condition data such as roughness, rutting, cracks and surface distress, and deflection are used to establish the projects most in need of maintenance and rehabilitation. Once identified, the projects in the poorest condition are more closely evaluated to determine repair strategies (See Figure # 2).

### Table: Type of Road

<table>
<thead>
<tr>
<th>Type of road</th>
<th>Kilometer</th>
<th>meter</th>
<th>Square meter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highway (TAMA &amp; Bypass Road)</td>
<td>124</td>
<td>124,300</td>
<td>3,395,600</td>
</tr>
<tr>
<td>Primary Streets (Main Roads)</td>
<td>102</td>
<td>101,400</td>
<td>2,183,000</td>
</tr>
<tr>
<td>Secondary Streets</td>
<td>101</td>
<td>100,950</td>
<td>1,736,350</td>
</tr>
<tr>
<td>Tertiary Streets</td>
<td>195</td>
<td>195,350</td>
<td>1,707,950</td>
</tr>
<tr>
<td>Parking Area</td>
<td>-</td>
<td>-</td>
<td>296,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>522</td>
<td>522,000</td>
<td>9,318,900</td>
</tr>
</tbody>
</table>

The roads in Yanbu Industrial City were frequently damaged due to the extensive use of overloaded trucks without using control or balance weight, mainly on highway and roads in heavy & light industrial park areas, resulting in asphalt rutting, cracks, bleeding, etc. (See Figure # 1).

Construction of asphalt pavement using Marshall mix design method is relatively economical but it has some major drawbacks (See Figure # 3 & 4).
1) Less pavement strength.
2) Low resistance of rutting and cracking.
3) Short service life.
4) Requires regular maintenance, so uneconomical.
Due to the increment in traffic volume, especially heavy trucks and trailers, the Royal commission decided to go through the second method that was Rehabilitation of Roads using Reinforced Concrete pavement instead of asphalt. The application was limited to intersections with rutting problem (See Figure # 5).

The advantages of this method are:
1) Improved skid resistance compared with traditional type of asphalt pavement.
2) Better visibility at night time and less glare.
3) Long Service life.

The disadvantages are:
1) High construction cost.
2) Less resistance of transverse cracking compare with Marshall mix design.
3) Increase pavement noise due to expansion joints and type of surfacing pattern (transverse thinking).

In 2016, many studies and site visits were conducted including the road survey analysis by Royal Commission’s Road Evaluation Equipment which can provide the detailed reports like type of deformation of asphalt layers, degree of damage in asphalt layer, cracks, rutting, etc. Moreover, the Royal Commission Roads Department was coordinated and discussed with several consultants around the globe to find out the right solution to avoid deformation in asphalt pavement at the industrial roads. Furthermore, Roads Department conducted site visits in all batch plants in Yanbu in order to check the quality of the materials used for mix design. Based on the thorough evaluation results, The Royal Commission decided to execute the third method as trial, since the previous methods are not suitable for the industrial city being un-efficient and un-economical. We applied the wearing course by superpave mix design on the existing asphalt base course having Marshall Mix design. This procedure established the precedent in the world. This method is called environment friendly asphalt layer in Industrial Roads (Green Roads).

The Royal Commission decided to execute the third method (superpave mix design) at the critical locations, including:
- Applying super pave mix design in light industrial area
- Applying super pave mix design at intersections along King Abdulaziz highway (TAMA)

The Royal Commission Roads Department was executed the following steps:
Step # 1 : Count the number of vehicles and Trucks using Yanbu industrial city Roads (see Figure # 9).

The Super pave mix design Evaluation Criteria includes the following:
1) Specimen heights  
2) Mixture volumetric  
   a. Air voids  
   b. Voids in mineral aggregate (VMA)  
   c. Voids filled with asphalt (VFA)  
   d. Mixture density characteristics  
3) Dust proportion  
4) Moisture sensitivity

The Crushed Fragments in Gravels used as aggregate shall have the following characteristics:
1) Quarried materials always 100% crushed minimum two sides of aggregate (See Figure # 12).
2) Minimum values depended upon traffic level and layer (lift).
3) Defined as percentage mass with one or more fractured faces.

Crushed face aggregates helps to reduce shear plane slides and mass deformation of the pavement structure.

Step # 2 : Compare with standards (see Figure # 10).

Step # 3 : Determine Super pave Mix Design requirements (see Figure # 11).

The Super pave mix design method was designed to replace the Hveem and Marshall methods. Final product of the 1987-1993 FHWA Strategic Highway Research Program to investigate better pavement materials & design methods. The Super pave (Superior Performing Asphalt Pavements) mix design method ties asphalt binder and aggregate selection into the mix design process, and consider traffic and climate as well. The compaction devices from the Hveem and Marshall procedures have been replaced by a gyratory compactor and the compaction effort in mix design is tied to expected traffic.

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**Figure # 9; RTMS Data**

**Figure # 10; ESAL and traffic Designation**

**Figure # 11; Steps of Super pave mix design**

**Figure # 12; Crushed fragments in gravel**

**Figure # 13; Super pave asphalt binder grading system**

**Figure # 14; The grading system is based on Climate in KSA**
Asphalt cement is a viscoelastic material and its behavior depends on the following:
1) Temperature
2) Time of loading
3) Aging (properties change with time)

Step # 4: Site visit to Asphalt patch plant:
Visiting of asphalt patch plant is important step to check How we can apply and requirement of super pave mix design (see figure # 15).

Step # 5: Preparation of super pave mix design in patch plant (see figure # 16).

Step # 6 (a): Applying super pave mix design in light industrial area (see figure # 18)

Figure # 17: Condition of asphalt layers at light industrial park before the application of super pave

Figure # 18: Rehabilitation of roads in light industrial parks

Figure # 19: Condition of asphalt layers at light industrial park after the application of superpave

Step # 6 (b): Applying super pave mix design at intersections along King Abdulaziz highway (TAMA)
The advantages of superpave asphalt mix design are:
1) Reduced the amount and severity of pavement distresses.
2) Improved stability to prevent rutting.
3) Improved flexibility to prevent cracking.
4) Improved durability to prevent potholes/weathering.
5) Long service life.
6) Low maintenance cost.
7) Less pavement noise.
8) Provide excellent riding quality.

The Royal Commission experiment for using the Superpave asphalt mix design in operation & maintenance and construction projects offers:
1) Sufficient asphalt to ensure a durable pavement.
2) Sufficient stability under traffic loads.
3) Sufficient air voids.
4) Upper limit to prevent excessive environmental damage.
5) Lower limit to allow room for initial densification due to traffic.
6) Sufficient workability and sufficient skid resistance.

By this way the Royal Commission can provide to the motorist an Environment friendly asphalt industrial roads calling (green roads).

Authors and Affiliations:

Engineer. Muhammad Hussain Sheariya
Civil Engineer, Associate Value Specialist (AVS)
Classify Professional Engineer from Saudi Council of Engineers
Manager, Roads Planning, Studies & Contracts Section
Roads Department, Royal Commission for Yanbu.

References:
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- American Society for Testing and Materials (ASTM):
- Saudi Arabian Standard - Ministry of Transport (MOT) Standard Specifications for Road and Bridge Construction: