

## **A NEW EXPERIENCE IN REHABILITATION WITH IN-PLANT ASPHALT COLD RECYCLING**

Vahid Ayana , Seyed Masoud Nasr Azadanib , Mukesh C Limbachiya,  
a1 Kingston University, Penrhyn Road, Kingston upon Thames, KT1 2EE, UK, Email:  
V.Ayan@kingston.ac.uk

b Department of Railway Engineering, Iran University of Science & Technology, Tehran, Iran.  
Email:Azadani@iust.ac.ir

c Kingston University, Penrhyn Road, Kingston upon Thames KT1 2EE, UK, E-mail:  
m.limbachiya@kingston.ac.uk

### **1 INTRODUCTION**

Expressways are vital parts of the infrastructure of a country. Construction of an expressway involves huge cost for the authorities and Babaei expressway is not an exception. Babaei expressway was one of the important and strategic expressways of the capital city, which was built as a country road in earlier days. However, it became an urban road in course of time, as a result of development of new towns and organizations around it, and a link between Teheran and the northern cities.

Apart from the conventional alternative maintenance carried out by related organizations, an extensive project has been undertaken during recent years comprising rehabilitation, heavy rehabilitation and reconstruction of the expressway. Each of these activities has been planned individually for different parts of the expressway, after extensive studies depending on the existing defects in different phases. It should be noted that, besides these rehabilitation and reconstruction operations, constructional operations to expand the expressway were undertaken at the same time, e.g. an additional lane in both directions, an auxiliary lane, local access ways, etc.

One of the phases of the project was studied in 2007, involving three kilometer length of the expressway, which necessitated works on the whole asphalt layer (surface, binder and black base) and the lower soil layer including the sub-base and sub-grade of the expressway. Studies and researches carried out by both the contractor and the consultant for the project recommended substructure improvement through stabilization. Cold in-plant recycling method was chosen for sub-base layer for environmental reasons and to suit the urban location of the project. Primary studies included evaluation of pavement distresses and computation of PCI and PSI indices, which resulted in decision on the thickness of cold mix layer. Mix formula of cold in-plant recycling was determined on the basis of reliable codes and standards, and test data, existing as well as that given by the next stage of the work. It should be noted that the construction operation was primarily defined for a section with nearly 3 km length of the whole expressway in both directions, which had significantly more defects compared to the other sections, from both superstructure and substructure points of view. This article deals with studies and construction processes for this section.

### **2 THE PLAN OF COLD RECYCLING MIXED WITH FOAMED BITUMEN**

Reference manual instructions of (1 to 5) have been used for preparing and constructing the asphalt cold recovering layer. Generally, specifications of the mixture under design have been defined on the basis of uniaxial compressive strength (UCS) and indirect tensile strength (ITS).

#### **2/1 Analyzing of RAP**

Test results show that nearly all samples in a particular area are identical. It is also observed that there is no significant difference between the samples related to different areas of the route.

According to the results obtained ,values of aggregates passing through 2 mm sieve is variable between 16 % to 22 %, which should be corrected to the required minimum values., i.e. 25% as per (1) and 18% as per (4).In Fig.1, the curve A shows RAP aggregate. In RAP aggregate, the value of aggregates passing through 0.075 mm sieve is lower than the required minimum, i.e. 3-12% (1) but is in order according to the standard (4), i.e. 0-7%.

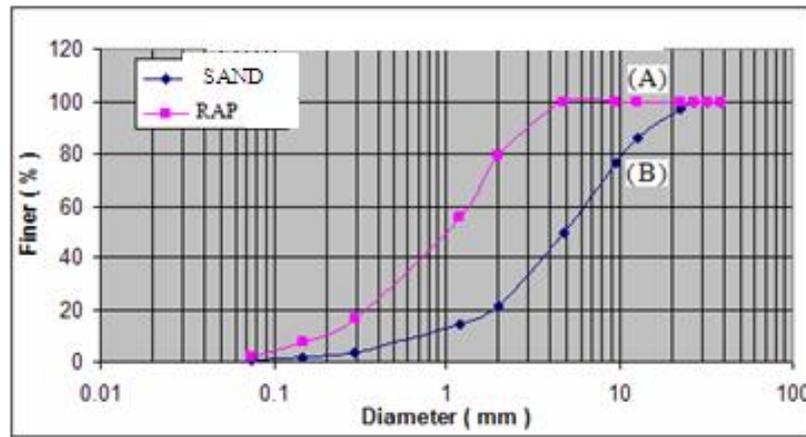


Figure 1. Gradation curve of RAP and sand

### 2/2 Natural and local sand analysis

RAP aggregate gradation results show that sand (0-2mm) is needed to compensate passing from 2mm sieve aggregate deficiency. Unfortunately, no fine aggregate sands (0-2mm) are usually produced in Tehran as well as other parts of the country and (0-6mm) and (0-4mm) are the only sands existed. Sand gradation (0-4mm) is given in Fig.1 as curve B. By composing local sand with 10%, 20% and 25% portions of RAP material, the quality of aggregate were analyzed. This gradation is given in Fig. 2. Test results show that by adding 25% sand (0-4mm) to RAP, gradation is relatively improved, and however, it is tries to prepare sand with more filler.

### 2/3 Active filler

It should be noted that mastic mixture is very suitable for mixing with foamed bitumen. In foamed bitumen mixtures, only fine aggregates could be coated completely with a bitumen film but this is not the case with all aggregates, particularly the coarse aggregates. The amount of filler (aggregates passing through sieve 0.075 (No.200)) is insufficient for the RAP material and an addition of 25% sand (0-4mm) to the RAP could improve its gradation. However, it would still not reach the desirable limit in reference (1). Active fillers like cement or lime are required to be added to the mixture, therefore, in order to reduce its susceptibility to moisture, increase its strength and stiffness, and improve cohesion of bitumen with the aggregates. Addition of such fillers would also result in increased proportion of filler in a mixture. When active filler is added to the mixture, the time between addition of filler and foamed bitumen to the aggregates should be kept to the minimum both in laboratory and during recycling operation. Active filler reaction begins immediately after its contact with the surface of wet stone and causes fine-grained aggregates to stick together, which can result in bad dispersion of the binder through the aggregate and coating of aggregates. Tests have showed that adding cement to RAP material as active filler, with 2 to 2.5 % portions considerably reduces filler deficiency. Fig. 3 shows RAP with 25 % sand (0-4mm) and 2.5 % cement.

### 2/4 Anti-stripping additive

Babaei expressway is located in a damp environment with relatively high rainfall. Its drainage does not work properly, due to trees in the central reserve and the surrounding forest. It is necessary; therefore, that bitumen anti-stripping chemical additive should be used for recycling. For good quality aggregate, usage of only one percent active filler could be sufficient. As will be mentioned in the following paragraph, 2.5 % cement has been used in the case under discussion.

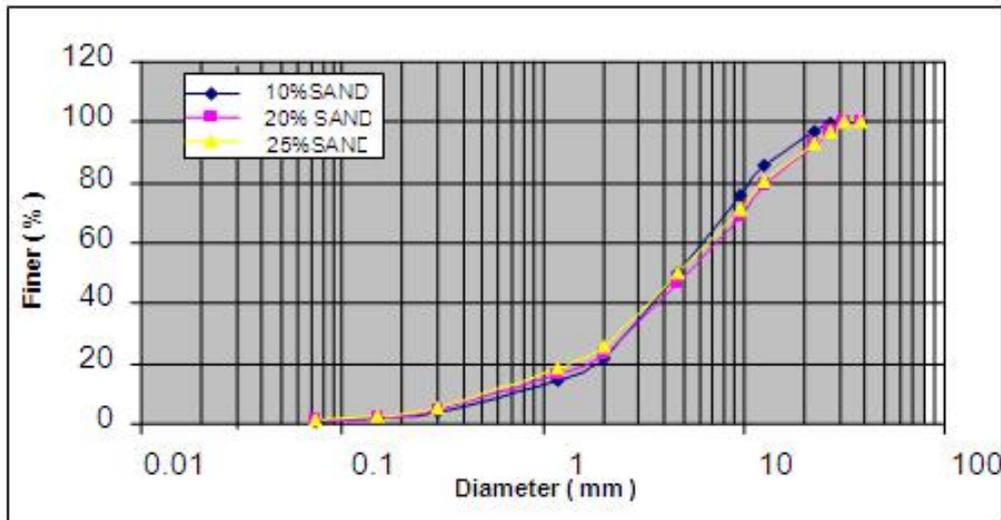


Figure 2. Gradation curve of adding sand to RAP

#### 2/5 Foamed bitumen

Conventional foamed bitumen from 60-70 type was produced by adding 2-4 % bitumen by weight and under 3 bar pressure. Bitumen temperature was between 160-180o C and air was blown in the expansion chamber of the device KMA 150. Foamed bitumen temperature was around 80-100° C during its letting out of the tank. The following main parameters were considered and tested in foamed bitumen production quality:

- Bitumen temperature:

Foamed bitumen properties are improved with increase in the bitumen temperature.

- Water content:

Generally, foamed bitumen volume is related to the amount of water added to the hot bitumen. However, it should be noted that its half-life would be reduced.

- Bitumen compression

Low compression causes low explosion as well as reduction in half-life.

Generally, foamed bitumen produced with minimum expansion ratio of 10 times and half-life of minimum 10 seconds is considered as suitable.

#### 2/6 Results of recycling layer laboratory production

In order to determine optimum amounts of cement and bitumen, Indirect Tensile Strength (ITS) tests were performed during 7th day of recycling layer production. Samples were produced according to the manuals [1] by adding 25% sand to RAP and in the forms of 2%, 2.5% and 3.5% bitumen, keeping cement content as 2% and 2.5 %.The test results are given in Tables 1 and 2.

#### 2/7 Evaluation of laboratory test results

Required ITS rate was obtained on the basis of reference (1) for 2.5% cement and 3.5%bitumin.Since the value of ITS obtained for all samples on the basis of reference (4),it was recommended that the rate of 2.5%cement and 3%bitumin to be considered as mix design. To prepare samples, given water content in mix design was considered 5%.

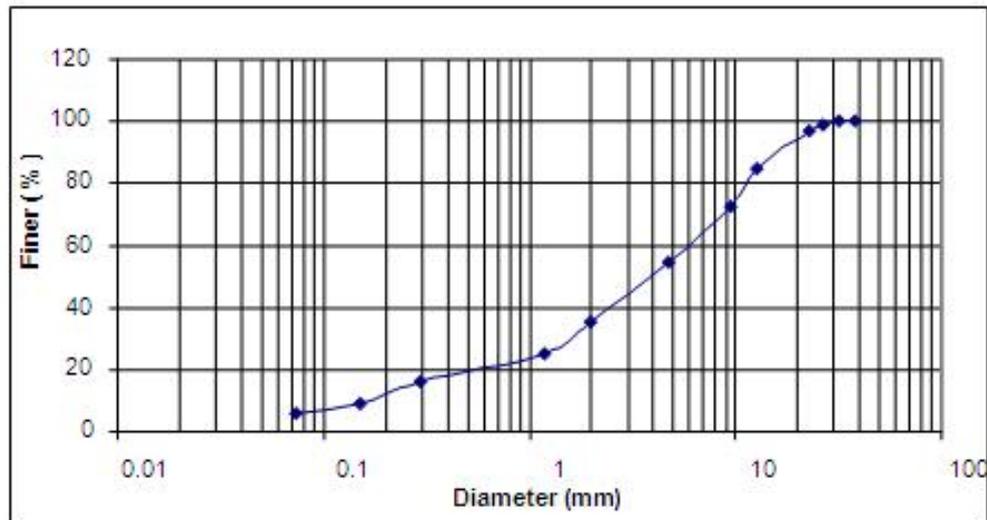


Figure 3. Gradation curve with (2.5% cement +25% sand +RAP)

### 3 STAGES OF EXECUTING IN-PLANT COLD RECYCLING OPERATION

Stages of the project execution include followings, respectively:

- Asphalt milling and carrying to the workshop
- Regarding (add virgin aggregate)
- Cold recycling production with machine KMA150
- Placing and compaction
- Curing
- Surfacing

Table 1. Laboratory test results of recycling layer with 2% cement

Sample Production		Sand 25%+RAP 75%			Requirements
Cement Content	%	2	2	2	-
Bitumen Content	%	2.5	3	3.5	-
Water Content	%	5	5	5	-
Dry Density	gr/cm <sup>3</sup>	2.072	2.057	2.060	-
Mix Density	gr/cm <sup>3</sup>	2.530	2.489	2.468	-
Air Content	Vol.%	18	17.6	16.5	8-15 Vol.%
ITS in 7 <sup>th</sup> day	N/mm <sup>2</sup>	0.3	0.35	0.42	Acc.[1] >0.50 N/mm <sup>2</sup> Acc.[4] >020 N/mm <sup>2</sup>

Table 2. Laboratory test results of recycling layer with 2.5% cement

Sample Production		Sand 25%+RAP 75%			Requirements
Cement Content	%	2.5	2.5	2.5	-
Bitumen Content	%	2.5	3	3.5	-
Water Content	%	5	5	5	-
Dry Density	gr/cm <sup>3</sup>	2.076	2.069	2.103	-
Mix Density	gr/cm <sup>3</sup>	2.535	2.529	2.521	-
Air Content	Vol.%	17.9	16.5	16.2	8-15 Vol.%
ITS in 7 <sup>th</sup> day	N/mm <sup>2</sup>	0.35	0.42	0.52	Acc.[1] >0.50 N/mm <sup>2</sup> Acc.[4] >020 N/mm <sup>2</sup>

## 8 CONCLUSIONS

The road rehabilitation project has met all the objectives mentioned in Section 3, including their technical and economical aspects justifying the use of modern plant and machinery. This is seen from results of the quality control tests, which were carried out in respect of technical objectives such as improvement in pavement quality, increase in its strength and removal of defects. Economic objectives have also been met, e.g. reduction in costs of operation and maintenance of the road. Savings have been achieved as applicable to costs of materials and human resources. Additionally, the project has succeeded in bringing about energy conservation and environment protection. Accelerated construction operation has been made possible by readily accessible materials and use of modern plant and machinery, which have led to economy of the project. Clearly, heavy rehabilitation at this level will have a vital role in reducing the ongoing costs of conventional and alternative maintenance in future.

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