Journal of Civil Engineering (IEB), 40 (2) (2012) 215-225

Journal of
Civil Engineering
IEB

Mix designing of asphalt concrete with Iterlene IN/400 and Sasobit as additives

Md. Golam Masud and Pawan Karki

Mahrasa Bagi, Shota Rusta Veli, House No. 67, Ganja, Azerbaijan

Received 11 July 2012

Abstract

The intent of this publication is to share ideas that the authors have gained over years in their professional service in Central Asian countries. The CIS countries have their native bitumen sources which differ from that of middle-east countries and other areas in properties. The shortfall in their resources and the climatic factors in the region demand application of additives for bitumen to enhance performance. In Azerbaian the additives Iterlene IN/400 and Sasobit have been applied for construction of 38km long 4-lane Ganja Bypass. The Marshall method of design for hot mix asphalt was applied for base, binder, and surface courses with these additives. Common laboratory approach for determination of Marshall Parameters has been presented.

Keywords: Asphalt, Iterlene, and Sasobit

1. Introduction

In Azerbaijan the road stretching between east and west connecting the capital city of Baku and the border of Georgia is recognized as the principal road which is serving not only the domestic purposes but also the export and import purposes and is of heavy traffic category. Marshall method of mix design is generally followed in Azerbaijan as in many other countries in the world for the hot mix asphalt. It has been found that several sections of East-West highway and other national highway sections along with other interconnecting asphalt roads which were completed during recent past failed prematurely despite of necessary care undertaken in design and construction phases. The Azerroadservice and Transport Ministry are deeply concerned at such premature failure of the rehabilitated/reconstructed national highway sections.

Now-a-days many countries are using Warm Mix Asphalt (WMA) with additives for protection of their environment and for enhancing properties of bitumen. Air pollution due to emission of H_2S gas from hot bitumen is of concern in many countries. In Europe assessment of degree of pollution due to emission of H_2S has been started by this year. However in

Azerbaijan no steps have been taken to counter effect such an environmental hazard. The challenge for Azerbaijan is “overloading” and improvement of local bitumen for the time being.

To cope with such damages due to premature failure of roads the government of Azerbaijan has taken steps for improvement of the construction of roads by introducing additives for modification of bitumen. It was middle of the last decade when such step was undertaken. The 38km long four lane Ganja Bypass funded by ADB is a segment of the East-West road where the liquid additives of ITERLENE IN/400, an Italian product, for all layers and additionally SASOBIT, a solid wax of high molecular weight, for wearing course have been applied with success. Quality Assurance Plan in accordance with UNI EN ISO 9001:2008 was assigned to Impresa, an Italian contractor who has been carrying out construction activities at the site.

2. Purpose

This is an effort to choose additives for bitumen and observe not only the effects in design and construction phases but also conditions in the post construction service and at failure. A summary of laboratory approach is presented with a view to compare with other design and construction and for future reference.

3. Additives used

Iterlene IN/400 has been selected as an anti-stripping agent for all layers. A dose of 0.4% at the lower range was selected from laboratory test results. The stripping test method has been dropped in AASHTO 2007. However, a Turkish method (YFS EK-A) is available and adopted at site. Although this additive has no appreciable effect on parameters for Marshall test its function as an anti-stripping agent is conspicuous from laboratory test results. Marshall test using bitumen without any additives was not carried out or investigated. However, Sasobit wax, on the other hand with a recommended minimum dose of 1.5% and Iterlene of 0.4% ,from laboratory results, both by weight of bitumen, has an appreciable effect on increasing the Marshall density and consequent changes to other parameters have been noticed (TABLE -1 and TABLE-2).

4. Bitumen binder

Native source of 50/70 grade is used throughout the country. Laboratory tests on bitumen signify that penetration, softening point, loss on heating, and solubility are within AASHTO Specification. However, a wide difference of test results on ductility has been observed and in most cases the results are significantly below the specification limit (TABLE-3). In TABLE-4 and TABLE-5 effects of Sasobit wax on properties of bitumen have been shown where the softening point is increasing and penetration decreasing due to its addition.

5. Aggregates

A plenty of quarry sources of aggregates were available at the construction area. Both fine and course aggregates were produced at crusher plants and used. Routine tests were made on these materials and consistent results were obtained at all times. Representative values are given in Table 6. Table 7 shows stripping test results that served as a guide for selecting the dose of anti-stripping agent Iterlene IN/400.

TABLE- 1 Properties of Compacted Hot-Mix Prepared by Marshall Method of Wearing Course with 0.4% Iterlene IN/400 and without SASOBIT

(Test Method AASHTO T245)

RFI No		Specific Gravity of Bitum Gb =	0.983	Lab Ref No	
Description of Materials	Crushed Materials	Effective SG of Aggrgate Gse =	2.699	Date of Sample	06/09/11
Sample Location	IMPRESA Asphalt Plant Ch: 29+000 R	Bulk SG of Aggregates Gsb =	2.658	Date of Test	07/09/11
Type of layer	Bituminous Wearing Course	Apparent SG of Aggrega Gsa =	2.741	Tested By	Jointly
Sample,gr	1200	Optimum Bitumen Conte Wb =	4.60		

Sl No	% Bitumen of total mix	Thickness mm	Weight in Air g	Weight in water g	Weight in Air, SSD g	Volume cc	Bulk Density of the Mix g/cc	Max Sp.Gr. of Mix Gmm	Air Voids %	VMA %	VFA %	Stability & Flow: Dial reading	Stability KN	Factor	Corrected Stability KN	Flow mm
1	4.00	64.0	1187.9	681.5	1191.1	509.6	2.331					1.28	13.9	1.00	13.9	3.52
2		63.8	1194.4	684.1	1195.7	511.6	2.335					1.30	14.2	1.00	14.2	3.38
3		63.8	1195.1	686.3	1197.4	511.1	2.338					1.33	14.5	1.00	14.5	3.56
4		63.8	1185.4	681.5	1188.2	506.7	2.339					1.18	12.8	1.04	13.3	3.12
Average							**2.336**	**2.523**	**7.41**	**15.64**	**52.60**				**14.0**	**3.40**
5	4.50	63.3	1190.9	684.2	1191.3	507.1	2.348					1.21	13.2	1.04	13.7	3.67
6		63.4	1189.8	684.4	1190.3	505.9	2.352					1.19	13.0	1.04	13.5	3.25
7		63.4	1197.8	689.5	1198.7	509.2	2.352					1.30	14.2	1.00	14.2	3.82
8		63.1	1191.4	685.2	1191.9	506.7	2.351					1.31	14.3	1.04	14.9	3.55
Average							**2.351**	**2.502**	**6.05**	**15.53**	**61.03**				**14.1**	**3.57**
9	5.00	62.9	1178.7	679.7	1179.1	499.4	2.360					1.28	13.9	1.04	14.5	3.40
10		63.1	1202.5	694.5	1202.8	508.3	2.366					1.26	13.7	1.00	13.7	3.63
11		62.9	1184.8	684.1	1185.5	501.4	2.363					1.19	13.0	1.04	13.5	3.85
12		63.0	1194.0	690.3	1194.5	504.2	2.368					1.17	12.7	1.04	13.2	3.75
Average							**2.364**	**2.482**	**4.76**	**15.50**	**69.31**				**13.7**	**3.66**
13	5.50	62.9	1179.1	680.9	1179.4	498.5	2.365					1.25	13.6	1.04	14.1	3.35
14		63.1	1196.4	690.3	1196.8	506.5	2.362					1.20	13.1	1.04	13.6	4.02
15		63.0	1182.6	681.9	1183.1	501.2	2.360					1.05	11.4	1.04	11.9	3.50
16		62.9	1191.1	687.3	1191.5	504.2	2.362					1.22	13.3	1.04	13.8	3.85
Average							**2.362**	**2.463**	**4.07**	**16.01**	**74.58**				**13.4**	**3.68**
17	6.00	63.0	1173.7	675.8	1174.1	498.3	2.355					1.10	12.0	1.04	12.5	3.55
18		63.0	1194.9	688.0	1195.2	507.2	2.356					1.18	12.8	1.04	13.3	4.10
19		62.8	1191.1	686.5	1191.4	504.9	2.359					1.14	12.4	1.04	12.9	4.75
20		62.6	1181.9	678.3	1182.2	503.9	2.346					1.17	12.7	1.04	13.2	3.75
Average							**2.354**	**2.443**	**3.65**	**16.75**	**78.22**				**13.0**	**4.04**
Specefication Limit									**4 ~ 6**	**14 ~ 16**	**65~75**				**>9000 N**	**3 ~ 5**

6. Approach to Marshal method of design

Conventional Marshall method of design was followed to obtain optimum bitumen content and the Job Mix Formula with and without the additives. Project specification was followed and the procedure in accordance with MS-2 of American Asphalt Institute. Fig.1 through Fig.3 represent combined grading of aggregates and filler followed by Marshall results (Fig.4 through Fig.6) at the laboratory.

6.1 140mm Thick Asphalt Base Course

Constructed in two layers on top of subbase layer made of crushed aggregate the base course has an optimum binder content of 4.4% and 0.4% of anti-stripping agent. The additive was mixed at site in tanks of hot bitumen in circulatory motion. The properties of the mix are enumerated below (Fig.4):

6.2 80mm Thick Asphalt Binder

It was constructed in single layer made of optimum binder content of 4.6% and 0.4% of anti-stripping agent mixed with hot circulating bitumen in tanks at the site. Summary of Marshall results are as follows (Fig.5):

TABLE- 2 Properties of Compacted Hot-Mix Prepared by Marshall Method of Wearing Course With 0.4% Iterlene IN/400 % & 1.5% of SASOBIT

(Test Method AASHTO T245)

RFI No		Specific Gravity of Bitumen Gb =	0.983	Lab Ref No	
Description of Materials	Crushed Materials	Effective SG of Aggrgates Gse =	2.694	Date of Sample	20/09/11
Sample Location	IMPRESA Asphalt Plant Ch: 29+000 R	Bulk SG of Aggregates Gsb =	2.660	Date of Test	21/09/11
Type of layer	Bituminous Wearing Course	Apparent SG of Aggregates Gsa =	2.744	Tested By	Jointly
Sample,gr each	1200	Optimum Bitumen Content Wb =	4.90		

Sl No	Bitumen, % of total mix	Thickness mm	Weight in Air g	Weight in water g	Weight in Air, SSD g	Volume cc	Bulk Density of the Mix g/cc	Max Sp.Gr. of Mix Gmm	Air Voids %	VMA %	VFA %	Stability & Flow				
												Dial reading	Stability KN	Factor	Corrected Stability KN	Flow mm
1	4.00	63.3	1187.9	686.8	1189.2	502.4	2.364					1.51	16.5	1.04	17.2	3.10
2		63.2	1195.9	692.6	1196.7	504.1	2.372					1.62	17.6	1.04	18.3	2.00
3		63.2	1194.0	690.7	1194.9	504.2	2.368					1.76	19.2	1.04	20.0	3.60
4		63.4	1197.2	690.7	1198.4	507.7	2.358					1.73	18.8	1.04	19.6	2.90
Average							**2.366**	**2.519**	**6.07**	**14.62**	**58.48**				**18.7**	**2.90**
5	4.50	63.1	1187.2	689.0	1187.4	498.4	2.382					1.58	17.2	1.04	17.9	3.10
6		63.1	1195.1	693.6	1195.7	502.1	2.380					1.65	18.0	1.04	18.7	2.90
7		63.5	1195.1	691.2	1195.9	504.7	2.368					1.48	16.1	1.04	16.7	2.60
8		63.5	1191.2	687.7	1191.5	503.8	2.364					1.49	16.2	1.04	16.8	3.50
Average							**2.374**	**2.498**	**4.98**	**14.78**	**66.24**				**17.6**	**3.03**
9	5.00	63.0	1195.1	692.8	1195.6	502.8	2.377					1.54	16.8	1.04	17.5	3.40
10		62.5	1189.4	691.3	1189.6	498.3	2.387					1.51	16.4	1.04	17.1	2.90
11		62.8	1190.6	690.1	1190.9	500.8	2.377					1.48	16.1	1.04	16.7	3.40
12		62.5	1195.9	694.6	1196.2	501.6	2.384					1.52	16.6	1.04	17.3	3.00
Average							**2.381**	**2.478**	**3.91**	**14.95**	**73.83**				**17.1**	**3.18**
13	5.50	62.0	1184.0	688.4	1185.1	496.7	2.384					1.56	17.0	1.04	17.7	3.20
14		62.0	1190.7	693.7	1191.5	497.8	2.392					1.39	15.1	1.04	15.7	3.40
15		62.3	1181.1	686.2	1182.1	495.9	2.382					1.42	15.5	1.04	16.1	3.90
16		62.4	1208.0	702.7	1208.5	505.8	2.388					1.33	14.5	1.04	15.1	3.80
Average							**2.386**	**2.459**	**2.94**	**15.22**	**80.70**				**16.1**	**3.58**
17	6.00	62.1	1186.4	690.1	1187.2	497.1	2.387					1.37	14.9	1.04	15.5	3.80
18		62.3	1186.4	688.8	1187.1	498.3	2.381					1.34	14.6	1.04	15.2	4.20
19		62.2	1184.2	686.5	1184.4	497.9	2.378					1.23	13.4	1.04	13.9	3.50
20		62.4	1184.4	685.4	1185.1	499.7	2.370					1.31	14.3	1.04	14.9	3.90
Average							**2.379**	**2.439**	**2.47**	**15.93**	**84.50**				**14.9**	**3.85**
Specefication Limit									**3 ~ 5**	**14 ~ 16**	**65~75**				**>9000 N**	**≤ 5**

Table 3
Summary of Test Results of 50/70 Bitumen

Name of tests		Results	Spec.
Specific gravity (AASHTO T 228)		0.982	
Softening point (AASHTO T 53)	^{0}C	49	46 ~ 54
Penetration (ASHTO T 49)	0.1mm	58	50 ~ 70
Ductility (AASHTO T 51)	cm	67	100 min
Flash point	^{0}C	235	230 min
Fraas breaking point	^{0}C	-12	-8 max
Solubility	%	99.2	99 min
Loss on heating AASHTO T 47)	%	0.04	0.5, max
Softening point after hardening	^{0}C	51	
Retained Penetration	%	52	50 min
Ductility after hardening	cm	55	
Paraffin Content	%	2.1	2.0 max

Table 4
Summary of test results of 50/70 bitumen with 0.4% of Iterlene IN/400

Name of tests		with 0.4% of Iterlene IN/400
Specific gravity (AASHTO T 228)		0.983
Softening point (AASHTO T53)	^{0}C	48
Penetration (ASHTO T 49)	mm	55
Ductility (AASHTO T 51)	cm	72
Loss on heating (AASHTO T 47)	%	0.04
Softening point after hardening	^{0}C	52
Retained Penetration	%	74
Ductility after hardening	cm	54

Table 5
Summary of test results of 50/70 bitumen
with 0.4% of Iterlene IN/400 and 1.5% of Sasobit

Name of tests		Results
Specific gravity (AASHTO T 228)		0.983
Softening point (AASHTO T 53)	^{0}C	56
Penetration (ASHTO T 49)	mm	42
Ductility (AASHTO T 51)	cm	40
Loss on heating (AASHTO T 47)	%	0.04
Softening point after hardening	^{0}C	57
Retained Penetration	%	84
Ductility after hardening	cm	29

Table 6
Physical and strength properties of Aggregates and filler

Name of test		Results
Specific gravity, bulk, of course aggregate		2.688
Water absorption of coarse aggregate	%	0.88
Specific gravity, bulk, of fine aggregate		2.644
Water absorption of fine aggregate	%	1.4
Specific gravity of filler		2.754
TFV	kN	250
ACV	%	14
LAA (B-grading)	%	12
LAA (C-grading)	%	15

Table-7
Stripping test results for Bitumen-Aggregate Mixtures
(Turkish Road Specification YFS EK-A)

Ingredients	Test Results (% Area Coated)
Bitumen	40
Bitumen + 0.2% of Iterlene IN/400	52
Bitumen + 0.3% of Iterlene IN/401	65
Bitumen + 0.4% of Iterlene IN/402	82

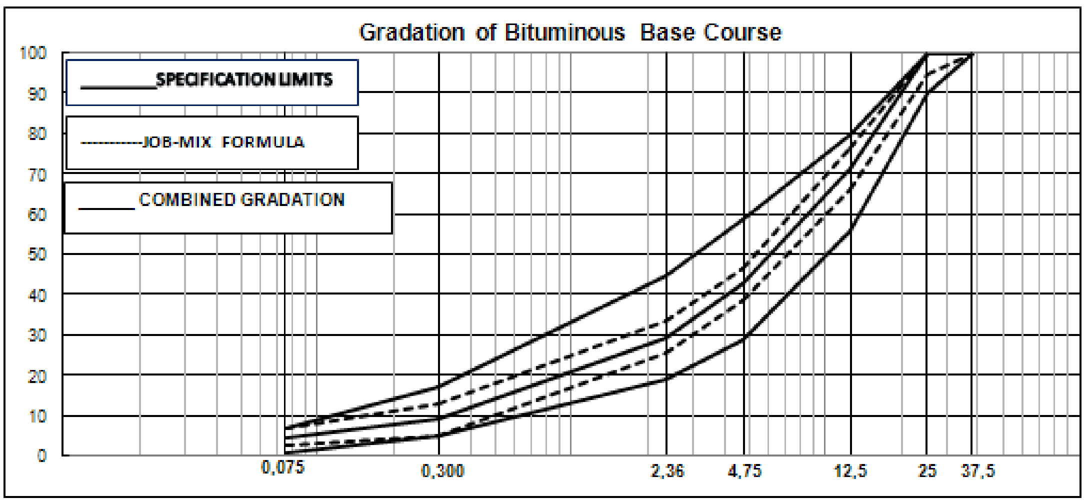

Fig. 1

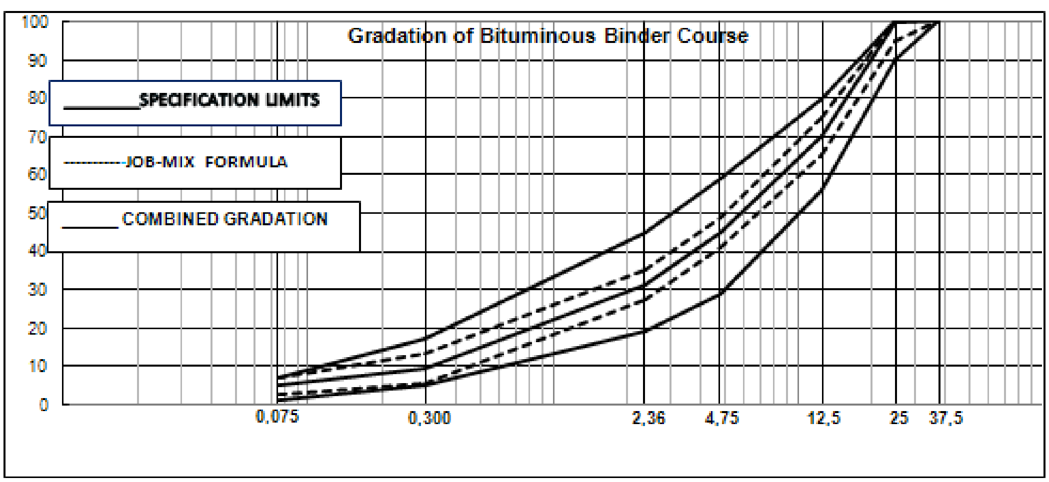

Fig. 2

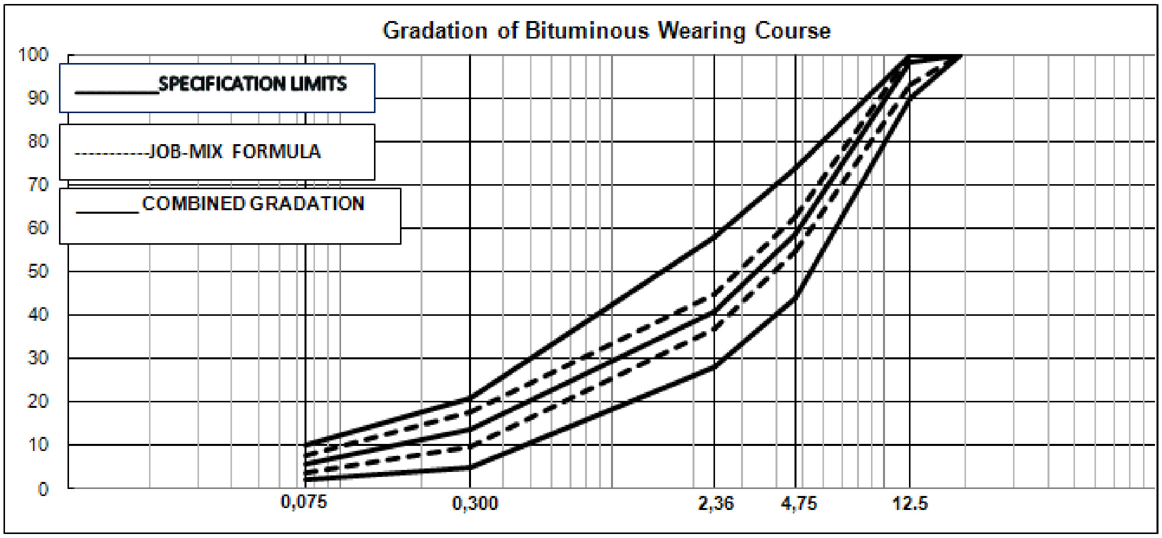

Fig. 3

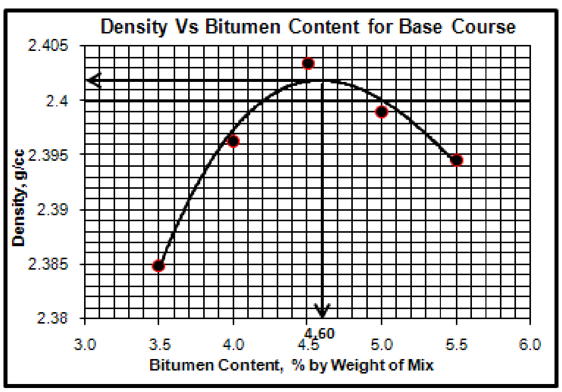

Fig. 4A

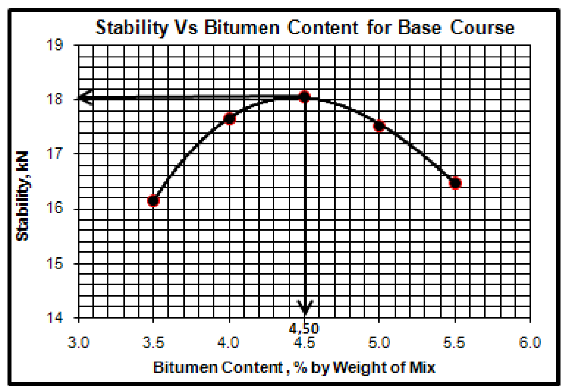

Fig. 4B

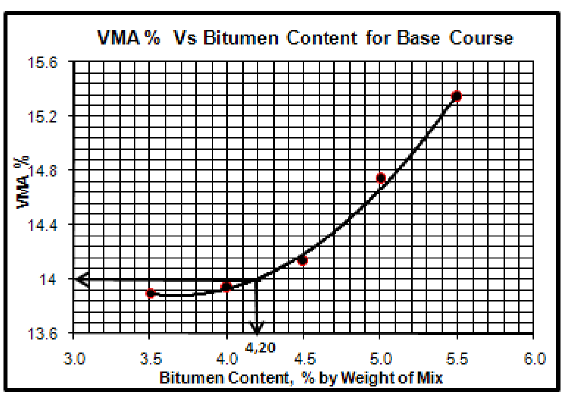

Fig. 4C

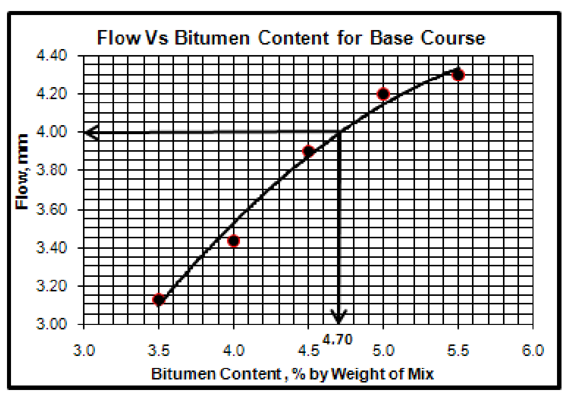

Fig. 4D

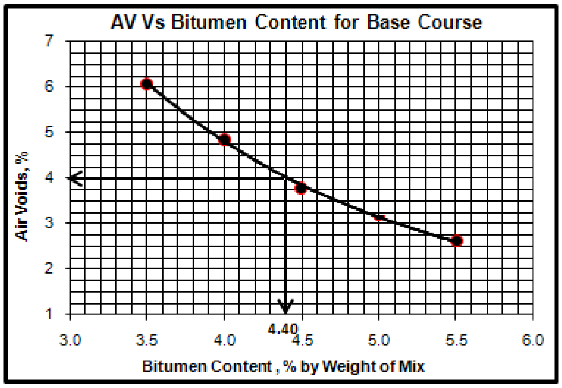

Fig. 4E

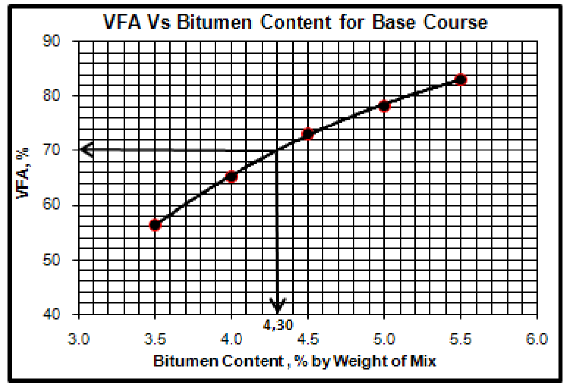

Fig. 4F

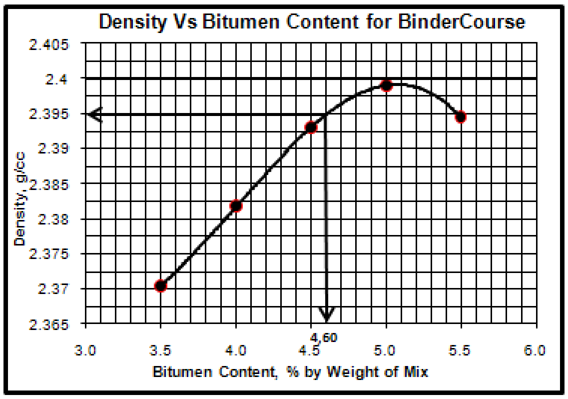

Fig. 5A

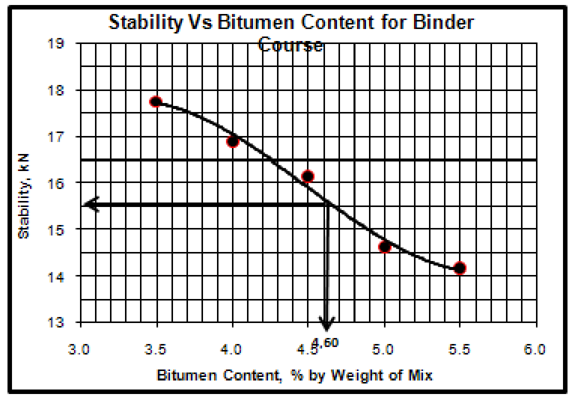

Fig. 5B

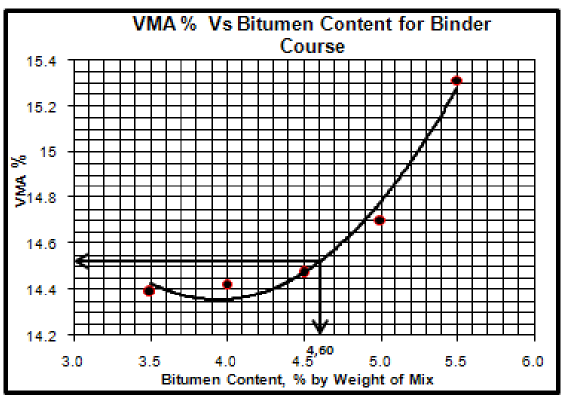

Fig. 5C

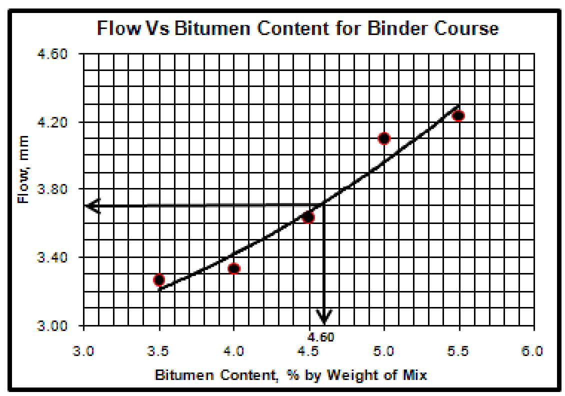

Fig. 5D

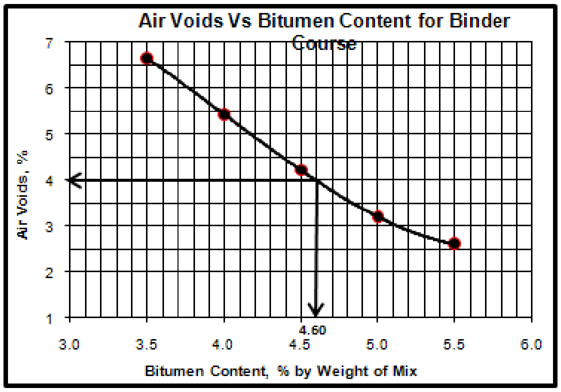

Fig. 5E

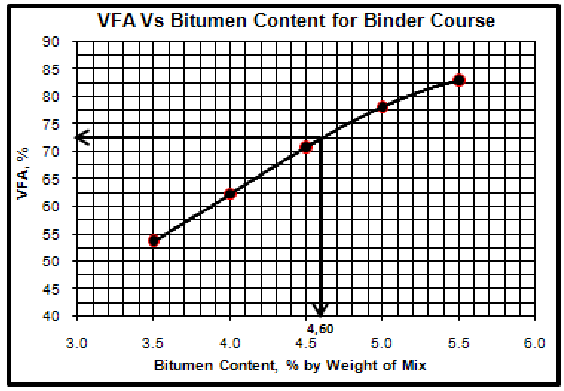

Fig. 5F

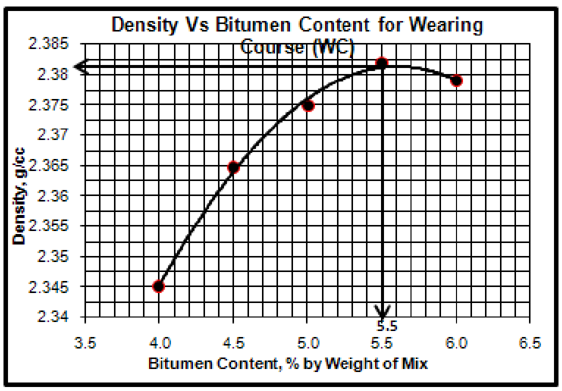

Fig. 6A

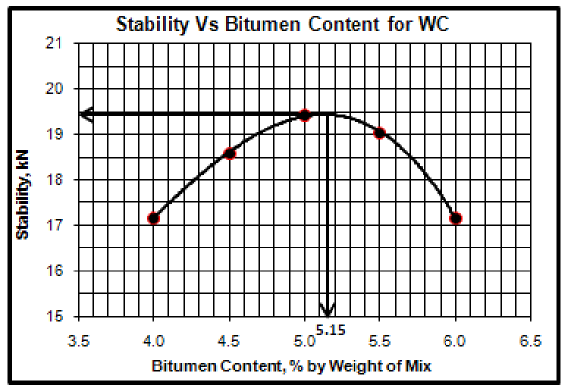

Fig. 6B

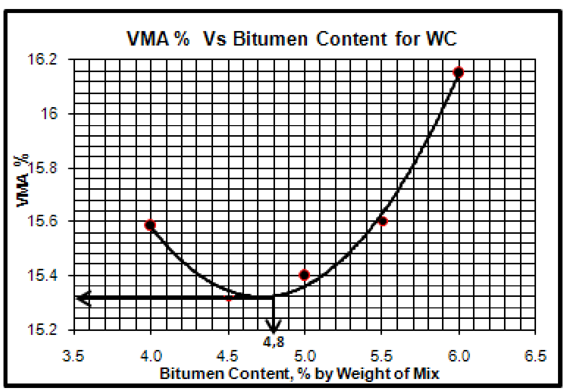

Fig. 6C

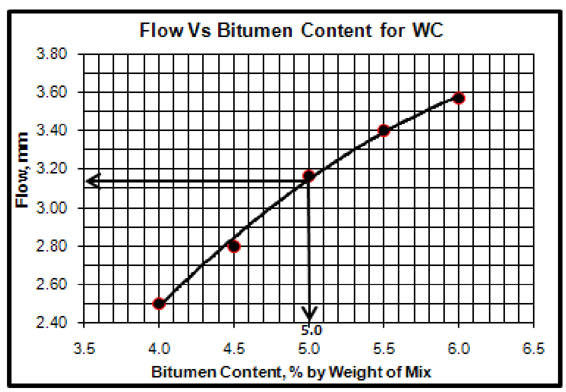

Fig. 6D

6.3 50mm Asphalt Wearing Course

It was also constructed in single layer consisted of 5.0% of optimum binder, 0.4% of anti-stripping agent, and 1.5% of Sasobit. The additive Sasobit had been carefully mixed with hot circulating bitumen beforehand in Baku and then shifted to the site before application. Properties are mentioned in the form of graphs below (Fig.6):

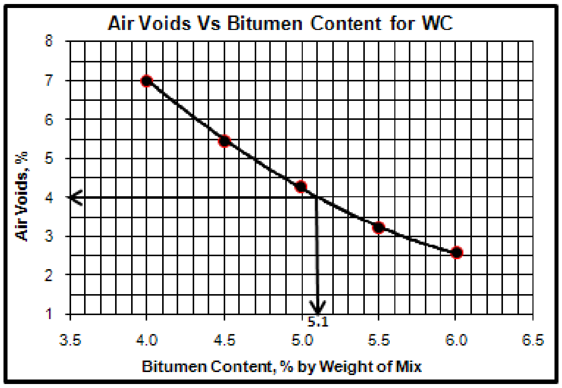

Fig. 6E

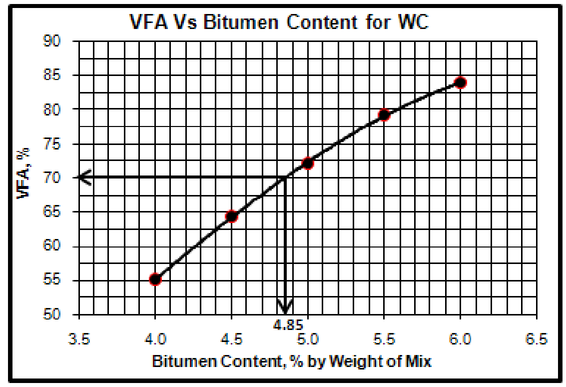

Fig. 6F

Fig.7. Photograph of a Sasobit mixing plant in Baku, Azerbaijan

7. Conclusions and Recommendations

1. Apparently the selected additives Iterlene and Sasobit have been found effective in respect of reducing stripping problem and increasing softening point and stability values.
2. The method of construction differs from plain asphalt in that the additives are to be added to bitumen in a prescribed way. Proper mixing must to be ensured before application.
3. Advantage of using additives is not questionable but it needs further research to see whether any other additives or modifiers could give better results/performance. Research can also be made on selecting optimum doses for additives.
4. Some trial sections with different type of additives or modifier are recommended to find the appropriate additives giving best performance.
5. Performance of pavement and its life should be carefully monitored. A team can work for this.

6. Cost-benefit ratio should be made on the basis of increased cost of additives. Life expectancy should be compared with the asphalt concrete with no additives.
7. Environmental impact assessment should be strengthened.

References

AASHTO Standard Specifications for Transportation Materials and Methods of Sampling and Testing. Part-2. Tests, 27th Edition 2007.

ASTM C 131 Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.

BS 812 Testing Aggregate. Part 105. Methods for determination of Particle Shape. Section 105.1 Flakiness Index, 1989. Section 105.2 Elongation Index of coarse aggregate, 1990. Part 110. Methods for determination of aggregate crushing value (ACV), 1990. Part 111. Methods for determination of ten percent fines value (TFV), 1990.

Contract Documents Volume IB, December 2008, Contract 01/2008AZE, ADB Loan 2433AZE, Reconstruction of Ganja Bypass, Azerroadservice, Ministry Of Transport, Azerbaijan Republic.

Roberts, Freddy L. et al, Hot Mix Asphalt Materials, Mixture Design, and Construction, 1st Ed. 1991, NAPA Education Foundation, Lanham, Maryland, USA.

MS-2 Sixth Ed., For Asphalt Concrete and Other Hot-Mix Types, American Asphalt Institute.