MODIFICATION OF ASPHALT MIXING DESIGN IN AFGHANISTAN THROUGH INTRODUCING LIME STONE POWDER

University of Miyazaki Regular Member ◯Yoshinori Fukubayashi
University of Miyazaki Student Member Abasin Samadi

1. INTRODUCTION

In landlocked Afghanistan, road infrastructure is the major means of transportation as there is no adequate air, rail or marine transport system. Much of the country's road network has been established during the 1960s with assistance from Soviet Union and the United States. After decades of civil wars, the new government has boosted the development of road infrastructure since 2001 with assistance from international donors. However, due to the socio-economic situation and forsake maintenance strategies, plenty of overloaded large vehicles drives and the road surface is severely damaged.

Fig. 1. Kabul – Kandahar Road Section B

As a shortage of qualified and experienced technical expertise, Afghanistan just recently adopted new standards that follow AASHTO and certainly this standard needs to be modified as per condition in Afghanistan. Also, challenges such as lack of proper road maintenance strategy, excessive traffic growth rate, and the overloaded vehicle should be addressed appropriately. Besides the effect of limestone on asphalt pavement has been proven globally, which has significant effects on pavement life. However, in Afghanistan, there are plentiful amounts of limestone but due to lack of technical understanding it's never considered to be used in asphalt pavement constructions.
Surly, for sustainable socio-economic development, it is essential for Afghanistan to properly design, construct and maintain its road network infrastructure. Thus, in this study, the authors aimed to investigate the existing condition of Afghanistan road network, study the performance of newly adopted AASHTO standards in Afghanistan with consideration of adding the limestone powder, ultimately to propose an appropriate pavement design and a practical maintenance strategy considering the challenges.

2. RESEARCH FLOW

To identify the causes of the deterioration of the pavements as shown in **Fig. 1**, literature reviews on the project document of the construction of Kabul-Kandahar Road has been conducted. According to the geotechnical information reported in the documents, the subgrade bearing capacity would be sufficient since the design CBR value is 14 on average. Then, it is assumed that the pavement structure design and their construction method might interpolate the causes of the deterioration. Therefore, the pavement's status survey was conducted on Kabul-Kandahar Road to identify the reasons of these deteriorations. The survey consists of traffic volume count, interviews to truck drivers to know compliance sense on limited loading, pavement surface rating survey and collecting the cores sampled from several deteriorated locations.
Then, in Japan, extraction tests on core samples and Marshall stability tests to know the effect of introducing limestone powders into the new Afghanistan pavement mixture design. The durability reflecting actual wheel load and traffic growth rate would be investigated through a series of laboratory tests, such as wheel tracking tests. By capturing the durability of asphalt mixture stipulated in the new design and modified mix design, maintenance strategy is proposed. This paper illustrates, results of field survey, extraction test and Marshall stability tests for introducing limestone powder into the Afghanistan's new mix design.

3. FIELD SURVEY AND EXTRACTION TEST

Kabul-Kandahar road (483km) is the major link of Afghanistan's national ring road (3200km) which connects the country to its neighboring countries, it connects five main ports and seven provinces to capital city of Kabul and, as of now its critically in its worse conditions. Therefore, this project was set to be the target project. Since its construction in 1966, due to civil wars the project was never subjected to receive proper maintenance, only section A (43km) was rehabilitated by Taliban regime in 1997 and the rest of road (440km) was rehabilitated by USAID and government of Japan in 2004. Where section A also received some minor repairs. For clear comparison of existing deterioration on mentioned road, 49km of recently rehabilitated road adjacent to section A was also included in this survey as section B.
As per the findings from pavement surface rating survey; section A is in good condition compared to section B in terms of serviceability, however section A has developed different types of fatigue cracks, while section B is entirely rutted. The summary of pavement surface rating survey in **Fig. 2** shows that 76% of section A has developed cracks mostly alligator (33%) and longitudinal (30%) cracks. While section B has permanent deteriorations (100% Rutted) by developing severe ruts of 5 to12 cm in depth. As section B was more deteriorated, 7 core samples from different deteriorated and defected locations were collected in 2018 form this section as shown in **Fig. 3** and **Table. 1**. for cause analysis of existing conditions. The result of bitumen extraction test reflects that binder course layer consisted more round aggregate shown in **Fig. 4** and uneven aggregate particle size distribution and the bitumen content from extraction test varied from sample to sample. However, surface course layer had consistent crashed aggregate with stable particle size distribution and bitumen content **Fig. 5**. In terms of aggregate

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Contact address: Gakuen Kibanadai Nishi 1- chome, Miyazaki-Shi, Miyazaki, 889-2192, Japan, Tel: 0985-58-7333

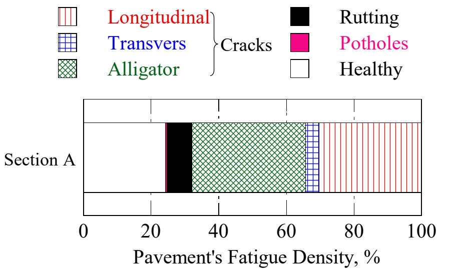

Fig. 2. Pavement surface inspection summary

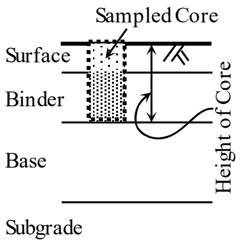

Fig. 3. Core Layers

Table. 1. Kabul - Kandahar Core Samples for Extraction Test

No #	Location	Type of Defects	Height, cm	Bitumen %
#1	81+100	No Defects	20	4.25
#2	81+100	Deep Transverse Cracks	20	4.03
#3	77+200	Transverse Cracks	20	Not Tested
#4	68+200	Rutted	12	4.83
#5	55+100	Rutted	17	Not Tested
#6	69+500	Rutted with Alligator Crack	17	2.99
#7	59+300	Rutted with Alligator Crack	10	5.24

size and gradation curves, core sample #6 has coarser aggregates and the gradation curve also don't possess smoothness, as a result the bitumen content is the lowest at 2.99% in sample #6 among all samples.

Samples #4 and #7 poses the highest contents of bitumen where aggregate gradation curve is finer. Fine aggregates are subjected to higher surface areas which results in higher bitumen contents. Sample #1 which is healthier compare to other samples, possess a smoother aggregate gradation curve having more coarse aggregates. Remaining 2 samples will be subjected to be analyzed by nondestructive tests using optical imaging or X-ray analysis to find the gradations curves and also to confirm the actual status of air voids in these samples.

Aggregate gradation can influence all the performances for asphalt mixture, for fine and rounded gradations, the inner friction angle is smaller compared to the coarse gradation. Thus, the shearing resistance will weaken, and further causes rutting (Fang et al. 2018).

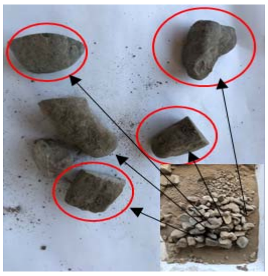

Fig. 4. Round Aggregate

4. MARSHALL STABILITY TEST

Considering the traffic problems in Kabul–Kandahar road the government proposed new asphalt mix design for its repairing work which is followed from AASHTO standards. Authors acknowledged that the new asphalt mixture design consists of 50mm maximum aggregate size which is twice the size of maximum aggregate size in existing pavement, now to verify the performance of newly proposed asphalt mix design, it was needed to recreated the samples in Japan, the aggregate size, quality and other properties in Japan were similar to the aggregates in Afghanistan. Marshall test results shows that stability, flow, unit weight and other parameters are same as results from Afghanistan. While added limestone powder, with increase of limestone powder content the air void value significantly reduced and the flow values has been increased and there were no significant changes in stability of the specimens **Fig. 6.** Limestone can increase the pavement performance life up to 3 years (Sebaaly et al).

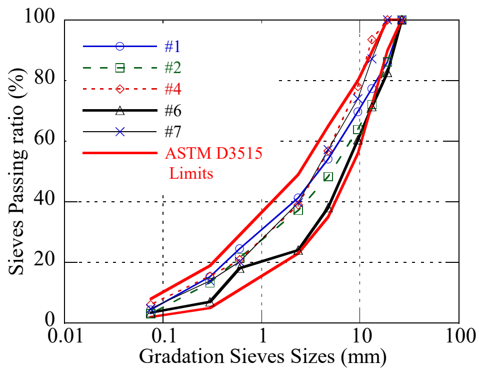

Fig. 5. Aggregate gradation from extraction test

5. CONCLUSIONS

From the asphalt extraction test, the surface texture of aggregate and its gradation curve fluctuations may result in premature failure of the asphalt pavement. The results also emphasis the importance of strict quality control measures in construction phases which seems to be neglect in Kabul-Kandahar road project.

From the Marshall stability test, the specimens with 5.5% asphalt exhibits high values of density and stability, while mixed with limestone powder the value of density increased and the value of air voids decreased significantly. As new asphalt mixture design consists of large aggregate sizes which are has relatively higher percentage of air voids it's essential for the asphalt mix designs in Afghanistan to possess the less air voids contents to avoid moisture failure during freezing seasons in Afghanistan. The moisture stability dramatically decreases when air voids exceed 7% (Mansour et al. 2012).

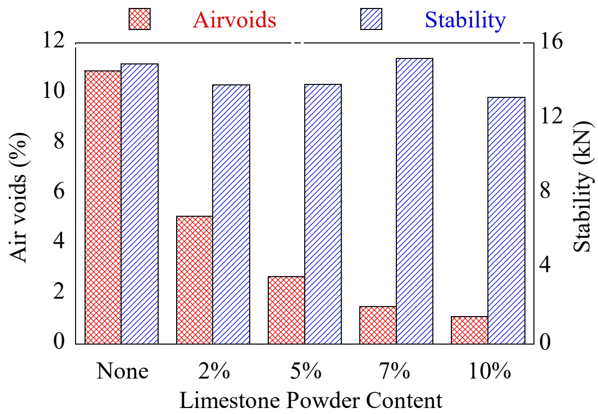

Fig. 6. Limestone effects on Air voids

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