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Kabul-Doshi Road Pavement Rehabilitation Design Review
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Executive Summary

The Louis Berger Group, Inc. and Black and Veatch Special Projects Corporation Joint Venture (LBJV) have prepared rehabilitation plans for a 50.7 km segment of the Kabul-Doshi Road that has experienced pavement rutting and other signs of deterioration since a previous rehabilitation in 2004-2005.

Tetra Tech has reviewed the current rehabilitation plans, related pavement design calculations and the initial pavement coring and Project Report documents that were prepared by LBJV to investigate the pavement deterioration.

A summary of the major points are listed below:

- Tetra Tech is in agreement with the Asphalt Pavement Core Drilling and Laboratory Analysis Report conclusion that the higher than optimum asphalt content was a factor leading to the premature surface rutting observed.

- The design traffic loading measured in Equivalent Single Axle Loads (ESALs) varies from 14.5 to 17.4 million ESALs. Given the limited background information on the ESAL calculations, Tetra Tech is not able to validate the accuracy of the ESAL projections

- An analysis of the existing pavement sections reportedly constructed in 2004-2005, using the traffic loading from LBJV, indicates that the pavement would begin to show signs of cracking and deterioration within 5 years. This is supported by the fatigue cracks, alligator cracking, pavement raveling, pavement shoving and potholes observed in the roadway.

- Tetra Tech also completed and analysis of the proposed pavement rehabilitation. An additional 50mm of asphalt pavement, or a total of 190mm, is required to provide a design life of 10 years based on the reported traffic load. All of the design parameters used by both LBJV and Tetra Tech are within the ranges specified by AASHTO, but the numbers used by Tetra Tech correspond to values typically used and recommended by AASHTO for higher volume arterials and major highways such as the Kabul-Doshi Road

- An alternate “mechanistic” pavement design methodology, currently being incorporated into the new AASHTO Design Guide, was utilized by Tetra Tech and corroborates the recommendation for 50 mm of additional asphalt pavement.

- The asphalt type recommended in the project documents should be satisfactory for the project given the historic maximum and minimum temperatures recorded in the project area. The aggregate gradation specified in the project documents is appropriate. The project documents also specify the aggregate used in the asphalt pavement be ‘durable’ and crushed. A ‘General Note’ to provide a durability specification (such as LA abrasion) and a minimum fractured face percentage for the aggregate is recommended.

- No laboratory testing data or field testing data is currently available to support the assumed values for the strength of the subgrade. It is recommended that USAID discuss this issue with LBJV to confirm their reasons for not sampling and testing the subgrade and base course materials, prior to finalizing the project recommendations.

1.0 Introduction

In 2010, the Louis Berger Group, Inc. and Black and Veatch Special Projects Corporation Joint Venture (LBJV) were contracted by the Islamic Republic of Afghanistan and the United States Agency for International Development (USAID) to complete the design for rehabilitation of a 50.7 km segment of the Kabul-Doshi Road extending from Station 126+95 to 172+895. The subject 50.7 km roadway section was previously rehabilitated in 2004-2005, and has experienced pavement deterioration and pavement failure throughout its length.

Tetra Tech was contracted by USAID to review the pavement design portion of the project. The following information was provided to Tetra Tech and utilized in the review process;

- Asphalt Pavement Core Drilling and Laboratory Analysis Report, prepared by Central Materials Laboratory, Louis Berger Group/Black & Veatch JV, Kabul, Afghanistan, dated January 29, 2009.
- Project Report – Rehabilitation of Kabul-Doshi Road, prepared by Bob S. Nijjar, P.E., dated March 22, 2010
- 2004-2005 Rehabilitation Plan Sheets, Annexure 2.1 (Typical Overlay Sections), 2.2 (Typical Reconstruction Sections with Aggregate Subbase), 2.3 (Typical Reconstruction Sections with Granular Subbase), 2.4 (Typical Raising/New Construction Sections) for the Emergency Transport Rehabilitation Project – Rehabilitation of Kabul-Doshi road. No dates were identified on the plan sheets.
- Rehabilitation of Kabul-Doshi Road Plan Drawings, dated April 10, 2010. Drawings include Plan Sheets KD-GEN-02 through KD-GEN-04 (General Notes) and Plan Sheets KD-TYP-01 through KD-TYP-04 (typical sections) for the proposed rehabilitation of the Kabul-Doshi Road from Station 122+00 to Station 172+76.
- E-mail correspondence between Louis Berger and Black & Veatch and the Khinjin Ministry of Public Works.
- Four pages of handwritten pavement design calculations prepared by Dincer Egin of The Louis Berger Group, Inc., dated April 20, 2010.

Following is a summary of Tetra Tech's analysis of the existing pavement failure and the proposed pavement design.

2.0 Analysis of Existing Pavement Failure

Observed Pavement Condition. The project documents state that the following pavement failure has been observed:

- Medium to heavy rutting throughout the road segment.
- Fatigue cracks in the wheelpaths with light to medium alligator cracking observed near the Doshi Bridge and south of Khinjin.
- Pavement raveling and potholes in sharp curve areas and remote potholes and pavement shoving.

Testing of Existing Pavement. An extensive pavement testing process that included taking pavement cores was completed in order to determine the existing pavement thickness and material composition, the findings of the tests are contained in the Asphalt Pavement Core Drilling and Laboratory Analysis Report.

Pavement thickness throughout the project area varies from 71mm to 176mm. The supporting gravel base course below the pavement varies in thickness based on the original design drawings. However, base course and subgrade were not tested.

The average liquid asphalt content in the existing wearing course and binder course pavement sections were approximately 1 percent over the recommended mix design values of 4.92 and 4.25 percent respectively, or an approximate 25 percent increase over the mix design values. The report concludes that the higher than optimum asphalt content was the primary factor leading to the premature surface rutting observed. Tetra Tech agrees with this finding.

Calculation of Pavement Service Life. Pavement service life is determined based on the vehicle axle loading over the design life of the pavement, measured in Equivalent Single Axle Loads (ESALs). The calculation of the ESAL loading in the Project Report is based on a 64 minute traffic count at the project site and a comparison to a similar roadway (K-K Road Section C (Ghazni)). This information produced a 10-year ESAL loading of 17.4 million. The rehabilitation plans and related design calculations refer to a 10 year ESAL loading of 14.5 to 15 million. Given the limited background information on the ESAL calculations, Tetra Tech is not able to validate the accuracy of the ESAL projections.

Tetra Tech completed an independent calculation of the pavement service life for the pavement section constructed in 2004/ 2005. Assuming an ESAL loading of 15 million in 10 years, the results indicate a pavement service life of less than 5 years before the pavement surface would begin to show signs of cracking and deterioration. Therefore the pavement thickness built in 2004/2005 may have also contributed to the existing pavement distress that has been documented. This is supported by the fatigue cracks, alligator cracking, pavement raveling, pavement shoving and potholes reported in the project documents.

3.0 Analysis of Proposed Pavement Recommendations

As per the April 10, 2010 plan drawings 49.2km of the road is proposed to be rehabilitated by milling 25 to 50 mm of the existing surface, then overlaying 80 mm of asphalt concrete binder course and 60 mm of asphalt concrete wearing course. The remaining 1.5km will be subject to complete removal and reconstruction of the asphalt pavement with a 60 mm asphalt concrete leveling course, an 80 mm asphalt concrete binder course and a 60 mm asphalt concrete wearing course.

Review of Pavement Design Calculations. The design method used by the LBJV is not stated in the documents received, but the calculations appear to follow the 1993 AASHTO Guide for Design of Pavement Structures. Tetra Tech believes that this overall methodology is acceptable.

The LBJV design generally includes design parameters that fall within the ranges specified by AAHSTO, but may risk under-designing the pavement thickness given the unknown condition of the roadway subgrade, the uncertainty in projecting ESALs, and the minimum acceptable condition of the roadway surface. The design parameters in question are the

Resilient Modulus, the Reliability, and the Terminal Serviceability. The values used in the LBJV and Tetra Tech designs, the recommended values, and the difference in the resulting pavement thickness are summarized in Table 1.

As shown, the values recommended by Tetra Tech result in the need for an additional 50mm of pavement thickness to support the pavement design load of 15 million ESALs. This additional thickness can be distributed to the binder course and the wearing course based on the desired lift thickness and number of lifts.

Table 1 – Comparison of Pavement Design Parameters and Resulting Pavement Thickness

Design Parameter	AASHTO Specified Range	LBJV Design (*)	Tetra Tech Design	Comments
Resilient Modulus	N/A	82,740 kPa	65,000 kPa	A measure of the material stiffness of the subgrade. Tetra Tech performed a design check based on the CBR value of 8 percent, or 9,400 psi (65,000 kPa), which is based on AASHTO 1993 correlation charts and conversion charts developed after 1993 to convert CBR or R-value to resilient modulus. LBJV performed their design assuming a CBR of 8 percent, and used an empirical relationship developed in 1962 to convert from CBR to resilient modulus. Since 1962, more refined methods of conversion have been developed.
Reliability	85 to 99.9%	90%	95%	The probability that a pavement section will perform satisfactorily for the design period. This factor is used to account for design uncertainties. The less certainty there is in other design parameter such as the subgrade support properties or the projected number of ESALs the higher the reliability factor should be. A value of 95 percent or higher is typically utilized for higher volume roadways to insure the roadway will have a higher chance of performing for the intended service life. A higher number is used to account for factors such as unknown subgrade strength or difficulty projecting ESALs.
Terminal Serviceability	1.5 to 3.0	2.0	2.5	The minimum level of serviceability (surface condition) allowed within the design life of the pavement. A terminal serviceability of 2.5 or greater is recommended by AASHTO for the design of major highways. Allowing the serviceability to reach a lower level during the design life may lead to the need for more intensive rehabilitation or even complete reconstruction in the future.
Required Pavement Thickness		140 mm	190 mm	

* No information is available on how a CBR value of 8 percent was obtained for the LBJV design.

Alternate Pavement Design Check. In addition to the 1993 AASHTO methodology, Tetra Tech also performed a newer “mechanistic” pavement design as a check of the 1993 AASHTO procedure. The new AASHTO Pavement Design Guide currently being developed will incorporate mechanistic analysis to determine recommended pavement thicknesses. The mechanistic design confirmed the results presented above, resulting in a minimum required asphalt pavement thickness of 190 mm or more depending on the criteria used to define failure in the pavement surface.

Review of the Proposed Asphalt Mix Specifications. The asphalt type recommended in the project documents is Performance Grade PG 64-22. Tetra Tech agrees that his grade is satisfactory for the project given the historic maximum and minimum temperatures recorded in the project area.

The aggregate gradation specified in the project documents is appropriate. The project documents also specify the aggregate used in the asphalt pavement be ‘durable’ and crushed. Tetra Tech recommends that the project ‘General Notes’ sheet provide a durability specification (such as LA abrasion) and a minimum fractured face percentage for the aggregate.

Comment on Assumed Sugrade Resilient Modulus Value. The subgrade resilient modulus value is a significant variable in determining the pavement thickness per the AASHTO Design Guide. A CBR value of 8 percent was assumed by LBJV in their pavement design, and by Tetra in their design review, with both firms correlating the CBR value to different resilient modulus values. The CBR value of 8 percent corresponds to a medium strength subgrade material for supporting pavements. No laboratory testing data or field testing data is currently available to support the CBR estimate of 8 percent. Given the 50.7 km length of the subject roadway section, and the varying terrain it traverses through, Tetra Tech would anticipate the subgrade types could vary significantly. We suggest that pavement sections supported on subgrades with a CBR of less than 8 percent could expect to have a service life of less than 10 years.

For a project of this type and size, considerable sampling of the base course and subgrade materials and subsequent laboratory testing would customarily be completed. It is recommended that USAID discuss this issue with LBJV to confirm their reasons for not sampling and testing the subgrade and base course materials, prior to finalizing the project recommendations.