Pavement Temperature Prediction Model for Oman Climate Condition

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Asphalt pavement is form an integral part of any transportation system. Temperature is the significant factor that effect on the performance and life span of a pavement. This paper study the relationship between the air temperature and asphalt pavement temperature and using Excel in order to predicate surface asphalt pavement model for Muscat climate. The models were compared with the standard models SHRP and LTPP models [3]. The development models resulted the surface pavement temperature was taken more time in heating cycle than air temperature. When compared the air temperature and surface asphalt pavement temperature with the standards models SHRP and LTPP models. There was difference between them due to the standards models was design for low temperature under zero where in Muscat temperature cannot be under zero [2].

Keywords: Pavement temperature, SHRP, LTPP, regression model

Introduction

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i. Methodology

1.1 Selecting Optimum Place:

Identify the suitable place which the sun is exposed as much as possible from visual monitoring at MEC parking which located in Knowledge Oasis of Muscat city [23]. It should be mention that selection of the site due to easy reach and take reading. Choosing the site in Muscat because the similarity in climate and paving materials [25].

1.2 Data Collection

In order to achieve the major objective of the study and obtained the development model, the temperature data was collected into two cases air temperature and pavement temperature as mention below:

- Measuring the ambient temperature at the target point every two hours and may device take one mint to give the reading [35].
- Measuring surface asphalt pavement temperature by placing the head of weir at the surface pavement every two hours.
- The thermocouple that used in order to measure the temperature was Cobra4 Mobile-Link and it was select as it measures the temperature in all aspects, high accuracy and good sensitivity to temperature [30].

ii. Data analysis

The time of measurement temperature was collected during one month (April) and the reading was taken from 9 AM to 8 PM every day. The temperature was measured every 2 hours (9:00, 12:00, 2:00, 4:00, 6:00 and 8:00) every week. The data was obtained and analysis using Excel [15].

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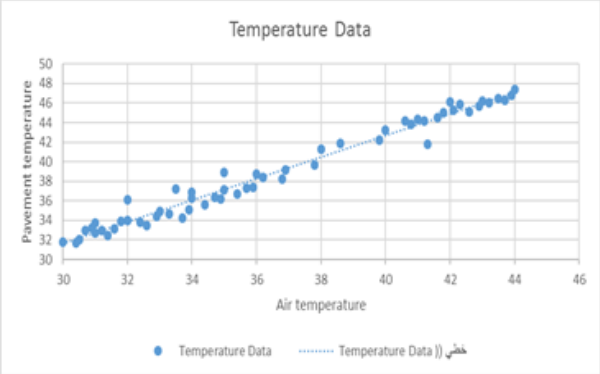

Figure 1: The air temperature and surface asphalt pavement temperature during April month.

Figure 1 shown the variation in minimum and maximum temperature for both air and surface asphalt pavement during April month from 9 AM and 8 PM every week. As can see the linear relationship between air temperature and pavement temperature. The maximum temperature was recorded at 12:00 & 2:00 PM between 40Cº- 44Cº. While, the low temperature was taken at 6:00 & 8:00 PM between 30 Cº -38 Cº[26].

That result because the surface asphalt pavement layer is one of the most sensitive and effect to temperature variations. There is lag time of heating cycle between the maximum air temperature and pavement temperature. In other words, surface asphalt pavement takes more time to heat than air ambient [28].

2.1 Development of high temperature model

The model of high temperature was obtained by using the air temperature as independent variable and the surface asphalt pavement as dependent variable [32]. The model was developed using linear relationship between maximum air temperature and maximum surface asphalt pavement. The model was formed using statistical software SPSS as shown below:

$$T_{sur} = 0.97T_{air} + 4.196$$

Where, Tsur is the maximum surface asphalt pavement, Cº and Tair is the maximum air temperature, Cº [34] The linear relationship and model of maximum temperature data was shown in Figure 2. Where the model was achieved a Goodness of Fit (R^2) of 0.9638.

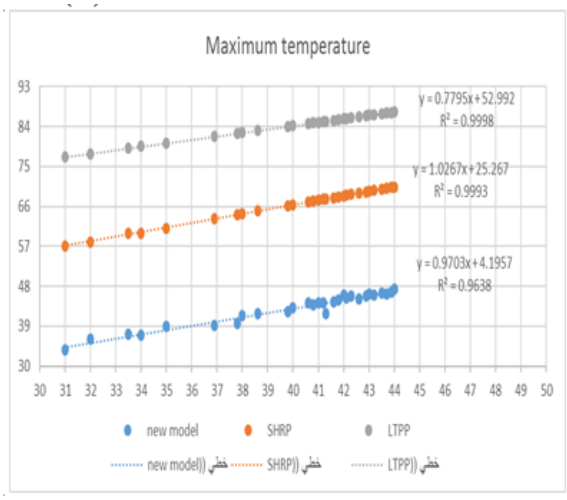

Figure 2: The development model of high temperature model.

2.2 Development of low temperature model

The low temperature model was formed using low air temperature as an independent variable and high surface asphalt pavement as dependent variable. The development model was obtained as following below:

$$T_{sur} = 0.99\ T_{air} + 1.65$$

Where, Tsur is the maximum surface asphalt pavement temperature, Cº and Tair is the maximum air temperature ,Cº. Where the model was achieved Goodness of Fit (R2) of 0.9463, as shown in Figure 3 below.

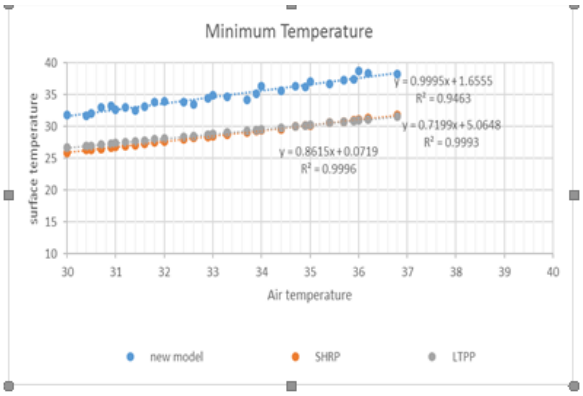

Figure 3: The development model of low temperature model.

2.3 Comparison of developed models with SHRP and LTPP standard models

There two main standard models which they become popular to use nowadays as following below [35]:

2.3.1 High Pavement Temperature Model

As shown in Figure 2 the comparison between the development model and SHRP and LTPP standard

models in order to prediction model for the low surface asphalt pavement temperature. There is big difference between the prediction model and the standard around 20 Cº – 30 Cº. The SHRP and LTPP standard models for the high pavement temperature at surface are given as following [39]:

For SHRP model $T_{sur} = T_{air} – 0.00618\ Lat^2 + 0.2289\ Lat + 24.4$

For LTPP model $T_{pav} = 54.32 + 0.78\ T_{air} – 0.0025\ Lat^2$

2.3.2 Low Pavement Temperature Model

As can see from Figure 3 the comparison between the development model and the standard models SHRP and LTPP for the lower temperature surface pavement. Also, there is difference between the new model and the standard models about 6 Cº- 10 Cº. The formula of SHRP and LTPP standard models that use as following below [28]:

For SHRP model $T_{sur} = 0.589\ T_{air} + 0.17$
For LTPP model $T_{pav} = -1.56 + 0.72\ T_{air} – 0.004\ Lat^2 + 6.26\ \log_{10}$ (25).

iii. Conclusion

The temperature pavement was measured on Middle East College Parking pavement due to easy to reach the place. Where the data collection was referred to the predication model for surface pavement temperature. In addition, the surface pavement temperature takes more time to heat than the air ambient need [22].
The predication model of surface pavement temperature of MEC Packing was obtained by making the air temperature as an independent variable. The model achieved Goodness of Fit R2 of 0. 968 and 0.946[25].

The high temperature model was compared with standard models SHRP and LTPP, showed that the two standard models provided higher estimate for the surface pavement temperature compared with the developed model.
The low temperature model was showed that two standard models higher than the development models in order to evaluate the surface pavement temperature compared with the predication model [31].
Where the standard models SHRP and LTPP was formed in American which has different climate than the climate in Oman so, the development model is suitable for Oman's climate only and its regions [17].

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