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Development of Asphalt Pull out Tester for Investigation of Tack Coat Adhesiveness

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Abstract. Tack coat is a bituminous product applied to provide sufficient bond between pavement layers in which the bond strength maybe quantify through shearing, tensile or torsional mechanism. A system capable to determine the quality of tack coat in term of the tensile property is always interested for the adhesion study. A prototype device using tensile mechanism was developed to evaluate the quality of the bituminous product. The objective of the work is to examine the developed system in performing laboratory testing on tack coat applications. Two asphalt binders (PEN80/100 and PG76) were evaluated using the developed device at 3 application rates (low, medium and high), 2 contact plate diameters (50mm and 100mm) and 2 confinement loads (6kg and 12kg) on the resulting tensile strength. For the tested variables, the ANOVA test results indicated that all variables possessed significant effect on the resulting tensile strength except for confinement load. The F-statistic of the ANOVA test further concluded that specimen diameter was the most significant factor followed by application rates and the binder types. The tensile strength tested on 50mm specimen was generally higher than 100mm specimen. For binder PG76, reduction in tensile strength was observed with increasing amount of dosage while for binder PEN80/100, maximum tensile strength appeared at minimum dosage application. For this trend however, it was worthwhile to note that from the mass loss analysis, it was found that binder PG76 failed due to adhesive failure, and that the determined tensile strength do not reflect the true tensile strength of the material.

1. Introduction
The use of tack coat in construction of pavements is important to provide sufficient bond between pavement layers. Tack coat is a thin application of asphaltic products (normally asphalt emulsion, straight asphalt or cutback asphalt) between wearing course and binder course to achieve good bonding. The bond ensured the structural integrity of the overall pavement to withstand traffic and environmental stresses. Studies had indicated that pavement interface failure maybe attributed to shear failure, tensile failure or combination of both cases [1, 2]; the test mechanism includes direct shear, direct tension and torsional test. This study focused on to develop a prototype device which is capable to perform the pull out test of the tested bituminous materials. Similar devices like ATACKer [3, 4] and UTEP pull out test [5] have been developed and documented. Having the devices, the tensile strength of tack coat was investigated taking into considerations the following variables: tack coat

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types; tack coat application rates; temperature; setting time; and compressive load. At the same time, standard test procedure on pull out test was also authenticated [6]. In Malaysia, the construction of asphalt pavement also adopted the usage of tack coat to enhance pavement interface bond strength. Thus, the objective of this reported work is to examine the developed system in performing laboratory testing on tack coat applications. The tested parameters include compressive load, plate diameter, tack coat types and application rates.

2. Materials and Method

Two asphalt binders of penetration grade PEN80/100 and performance grade PG76 were selected as the tack coating material in this work. Binder PEN80/100 has a penetration of 84.7, softening point at 41°C and viscosity of 470cP at 135°C; and binder PG76 has penetration of 46.4, softening point at 76.6°C and viscosity of 800cP at 135°C. Meanwhile, the design of the asphalt pull out tester is presented in Fig. 1.

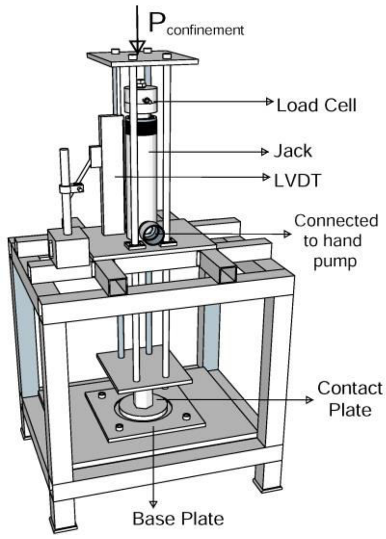

Figure 1 The prototype design of asphalt pull out tester.

The device is basically consisted of a frame with several other components like load cell, LVDT, jack, contact plate, base plate, hand pump and a data acquisition system. The overall design concept is to apply a compressive load that will push the contact plate to the base plate and a pulling force is introduced to pull apart the two plates. The tested variables using this system are summarized in Table 1. Prior, the tack coat was applied as evenly as possible on the base plate accordingly to the desired dosage. The contact plate was later released to touch the tack coat and confined for 5 minutes with the tested compressive load. The pull out test then commenced by applying an uplift force using a hand pump soon after the confinement has reached to an end. Tensile stress (reported in N/mm^2) was further calculated by dividing the peak recorded tensile force over the contact surface area.

Table 1 Test factors and levels.

Factors	**Levels**
Plate diameter	50mm, 100mm
Compressive load	6kg, 12 kg
Tack coat types	PEN80/100, PG76
Tack coat application rates	0.25*l*/m^2, 0.40*l*/m^2, 0.55*l*/m^2

3. Results and Discussions

3.1. **Tensile stress**

The tensile stress results of binder PEN80/100 and PG76 were presented in Fig. 2. The error bars of standard deviation were also plotted. On average, PG76 generally possessed higher tensile stress compared to PEN80/100; and tensile stress of specimens tested using 100mm diameter contact plate were lower than 50mm contact plate. To investigate the effects of the tested variables on the resultant shear stress, the general liner model of analysis of variance (ANOVA) was carried out at 95% confidence interval. The tested result was presented in Table 2. It was identified that all variables have significant effect on the resultant tensile stress except for the compressive loads. Contact plate diameter was found to be the most significant, followed by application rates and binder types accordingly to the F-statistic.

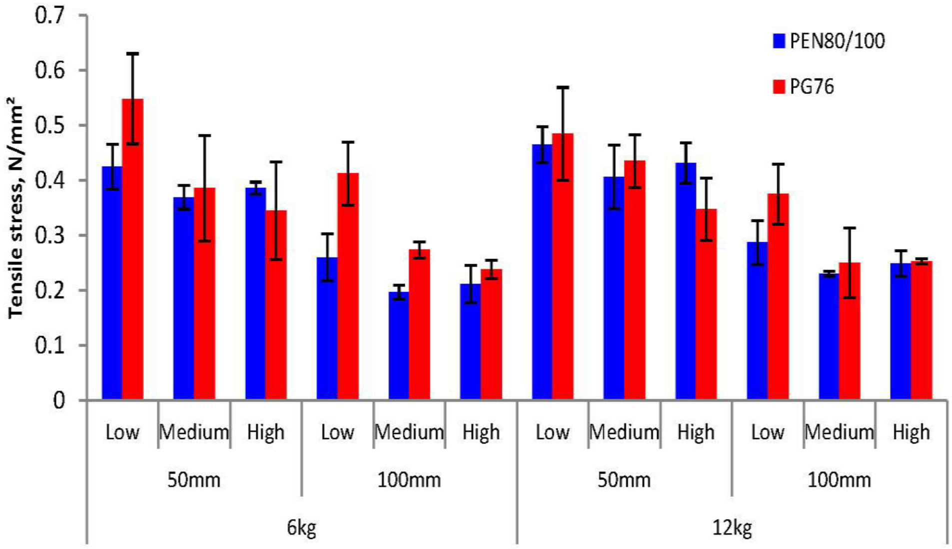

Figure 2 Tensile stress of binder PEN80/100 and PG76.

Table 2 Analysis of variance results for tensile stress.

Source	F	Sig.
Binder types	9.210	0.004
Application rates	28.370	0.000
Plate diameter	158.891	0.000
Compressive load	1.305	0.259

3.2. **Mass loss**

It was observed that regardless of binder types and the application rates, the tensile stress is at the highest when the application rate is the lowest. This trend agrees with works done by Buchanan and Woods [4]. Such observation might have indicated the possibility of slippage of the binder upon confinement which indirectly reduced the shear stress, especially when the dosage is at the maximum. Alongside the testing, the tested specimen was also weighed for the respective mass before and after testing. The data was manipulated to obtain the mass loss (i.e. the difference) which has been presented in Figure 3.

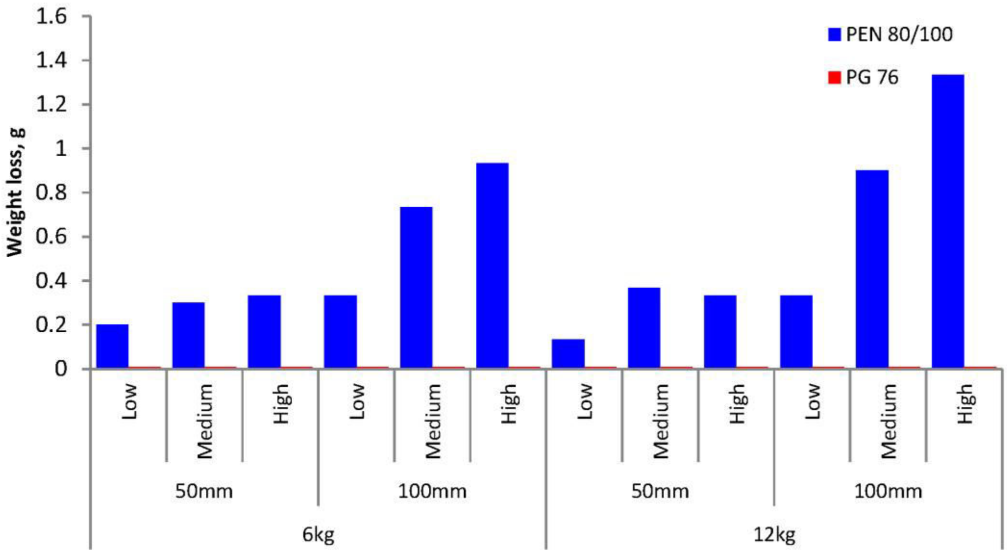

Figure 3 Mass loss of binder PEN80/100 and PG76.

It is interesting to note that for every test configuration of binder PEN80/100 and PG76, there existed no mass loss for binder PG76. Binder PEN80/100, however, generally possessed mass loss increment with increasing application rates. These findings reveal that the measured tensile stress of binder PG76 was an adhesive failure but not cohesive failure. The measured tensile stress therefore, is not representable for the material tensile stress. The reverse, however, applies to binder PEN80/100.

4. Conclusions and Recommendations

Two different binders were tested using the developed prototype asphalt pull out tester. It was concluded that the device is able to distinguish between adhesive and cohesive failure of the tested specimen. Binder PEN80/100 was found to fail in cohesion while binder PG76 failed in adhesion, indicating that the reported tensile stress of binder PG76 reported herein does not reflect the exact tensile stress of the material. Maximum tensile stress appeared at lowest application rate; and increasing mass loss was observed with increasing application rate. To improve in this work, it is recommended to investigate further on the capability of the device to determine the cohesive failure tensile stress. Also, the use of rotor attached to the device for constant pulling rate is also recommended to ensure uniformity of the test results.

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