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Research Article

The Influence of Block Thickness on the Performance of Asphalt Paving Blocks

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Abstract: Asphalt paving blocks have been known in some places around the world, but there have been very limited research being conducted to assess the influence of block thickness on the structural performance of asphalt paving blocks. This study describes the experimental study to evaluate the performance and properties of asphalt paving blocks placed with different block thicknesses i.e., 70, 80 and 90 mm, respectively. A number of 250 asphalt paving blocks was produced and examined in the laboratory to determine the density, air voids, the compressive load and the rut depth and displacement occurred in the surface of asphalt paving block. The results exhibited that the resistance of asphalt paving block to static loading increased as the block thickness increased. Moreover, the elastic deformation was affected significantly by increasing the block thickness. Meanwhile, the displacement of asphalt block from the pavement was slightly influenced by the block thickness.

Keywords: Asphalt blocks, block thickness, deformation, displacement, pavement

INTRODUCTION

The paving blocks are very unique paving alternative offering many outstanding advantages (Shackel, 1979). The concrete block pavement is the most known type of paving blocks compared to the other types. The main benefits of using the concrete paving blocks are beautiful, easy to be built, have the ability to stand the weightiest loads and are appropriate for steep street (Gencel *et al*., 2012). The asphalt blocks have been introduced for the first time as a road pavement in Canada in 1964 (Baillairgé, 1964) and are still in use in several places in Germany (Hanover, 2011).

Block thickness has a significant impact on performance and behavior of block pavements. In concrete block pavement, many studies have been done to display the effect of block thickness on pavement's resistance to the deformation. A research was carried out by accelerated trafficking test shown that increasing in block thickness has a substantial effect on the performance of block pavement (Shackel, 1979). The same study has established that increasing of block thickness has a greater impact on pavement behaviour than changing in the thickness of road base (Shackel, 1979). On the other side, the economical aspect plays a major role here. A study (Panda and Ghosh, 2012) was done on concrete blocks with different thicknesses i.e., 60, 80 and 100 mm, respectively. The result illustrated that the elastic deformation of pavement reduced as the block thickness increased. Few studies being done to demonstrate the effect of block thickness in asphalt block pavement. A study (Baillairgé, 1964) has recommended a thickness of 80 mm yielded the best results. Another study (Hanover, 2011) has suggested using a block thicknesses range from 60 to 80 mm. However, there have been very limited researches being conducted to prove in detail the effect of using various block thicknesses on the structural performance of asphalt block pavements. The aim of this study is to develop asphalt blocks for road pavement. The objectives of this study are to determine the rut depth and displacements occurred in the surface of asphalt block pavements with varying the block thicknesses i.e., 60, 70 and 80 mm, respectively to ascertain the maximum static load can asphalt block resists and lastly; to examine the properties of asphalt blocks.

MATERIALS USED FOR THE STUDY

Bitumen: The bitumen type involved in this study was a bitumen penetration grade of 60-80. This kind of bitumen is recommended to use for heavy traffic roads as categorized under Malaysia (JKR) Standard (Jabatan, 2008).

Aggregates: Aggregates utilized in the study contain of coarse aggregates, fine aggregates and filler. A 10 mm of aggregate maximum size was used in this study to form the samples.

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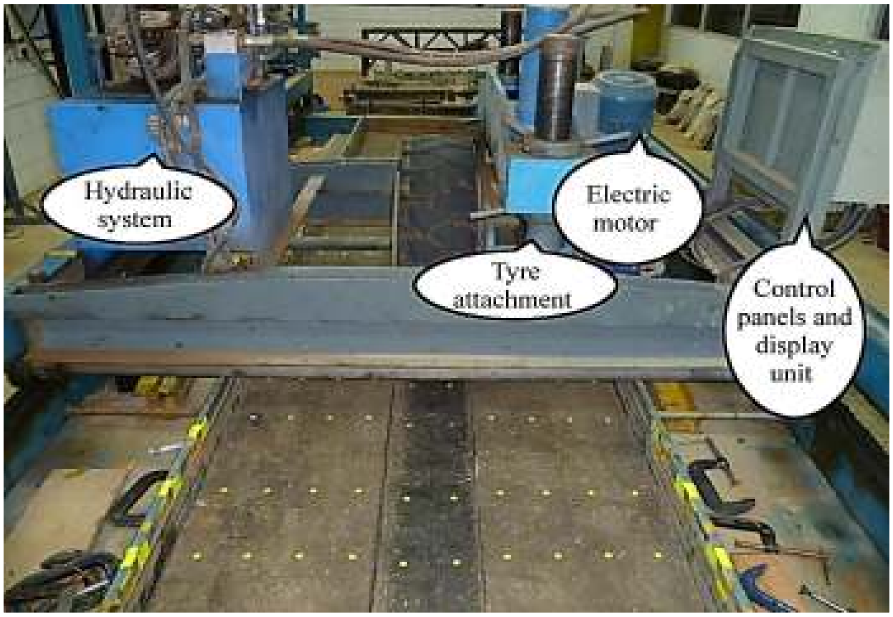

Fig. 1: Accelerated trafficking test

Fig. 2: Pull-out test setup

METHODOLOGY

Asphalt mixture design: The dense graded mixture was chosen in this study to manufacture the asphalt paving blocks due to a number of factors for example the dimensions of the blocks used in this study are not very large. Accordingly, it is more proper to have a mixture with smaller aggregate size.

Test method: A series of tests was conducted to ascertain the properties of asphalt blocks i.e., density (AASHTO T166), voids analysis and compressive strength. The structural performance of asphalt block pavement was assessed by using the accelerated trafficking load test and pull-out test:

The accelerated trafficking load test: The accelerated trafficking load test was used to create realistic dynamic wheel loads on the pavement. This test was done to determine the rut depth in the surface of asphalt block pavement. The test was conducted in a big platform with dimensions of 1 m in width and 5.5 m in length. The bedding sand of maximum particle size of 5 and 30 mm thick was placed in the steel platform. Then, the asphalt blocks were placed in stretcher with joint widths of 3 mm between the blocks. Dry sand of a maximum particle size of 2 mm was used to fill the spacing between the blocks. This experiment was carried out on block pavement with different block thicknesses i.e., 70, 80 and 90 mm, respectively. Figure 1 shows the machine used in this study to perform this test. The wheel axle load of 2000 kg with a tire pressure of 600 kPa was set to the loaded wheel to simulate the traffic load. The speed of the wheel was set to 0.2 m/sec throughout the whole test. The test was run up to 20,000 cycles.

Pull-out test: The pull-out test was used to permit single block to be extruded from the block pavement model in order to verify that the neighboring blocks are not being rotated during the extraction process and thereby hold the blocks from being extracted. The test equipment applied its reaction load straight onto the adjacent blocks (Husin, 2001). The uphill load measured by the apparatus in extracting the blocks is considered to be equal to a downhill load (Clifford, 1984). This experiment was conducted on asphalt blocks with different block thicknesses i.e., 70, 80 and 90 mm, respectively. Figure 2 shows the setup of the test and the movements of paving blocks during the extraction process.

EXPERIMENTAL RESULTS AND DISCUSSION

Production and evaluation of asphalt blocks: The optimum bitumen content of asphalt mixture was attained by using the Marshall test. The amount of bitumen of 6.1% of the mixture total weight was found to be the best. The stages of manufacturing the asphalt blocks were done as follows:

- The aggregate was heated to the temperature of 170°C (Asphalt Institute, 1988). The bitumen was then heated to the mixing temperature of 160°C (Liu *et al*., 2010). Additionally, the loose mixture was being made around the optimum bitumen content to calculate the Theoretical Maximum Density (TMD) (Croney and Croney, 1998).The aggregates and bitumen were mixed totally till it is a well-covered to the temperature not further a 163°C (Asphalt Institute, 1988).
- The hot mixtures were poured into a preheated steel mold. Wax discs were also used to keep the mixture from sticking to the base plate. Asphalt blocks have a shape of rectangular with dimensions of 200 mm in length, 100 mm in width.
- The temperature of the mixture was checked and left to cool down to the compaction temperature of 130°C (Mills-Beale and You, 2010). Consequently, the mixture was compacted by the machine as shown in Fig. 3 with a compacting pressure of 32 MPa to keep the air Voids in the Total Mix (VTM) not less than 3% (Taha *et al*., 2013), as most of state highway agencies have acclaimed (Zulkati *et al*., 2013). This percentage is very important to withstand a premature distress such as bleeding (flushing) that is happened as a consequence of an extra compaction by the vehicles (Brown *et al*., 2004).
- The compacted specimens in the steel molds were extruded by using a jack as shown in Fig. 4. The properties and compressive load of asphalt paving blocks are presented in Table 1 and 2, respectively.

The compaction percentages and air voids analysis of asphalt blocks as shown in the tables have met the standard specification of highway state agencies (Asphalt Institute, 1988). Table 2 showed that as the block thickness increases, the asphalt block resistance to static (compressive) load increases. Furthermore, asphalt paving blocks proved that they have the capability to resist a static loadas a little as 156.6 kN. In accordance to AASHO Road Test and other studies (Shackel, 1994), the heaviest permitted axle load in the U.S and other countries is an 80 kN equivalent single axle load (Garber and Hoel, 2009). Consequently, Asphalt paving blocks are suitable enough to carry a static vehicle axle load.

Accelerated trafficking load test: The accelerated trafficking load test was run up to 20,000 cycles in order to ascertain the deformation (rutting) happened in the surface of the pavement. As exposed previously in Fig. 1, the main rutting occurred lengthways the loaded wheel path. Figure 5 illustrates the rut depth in asphalt

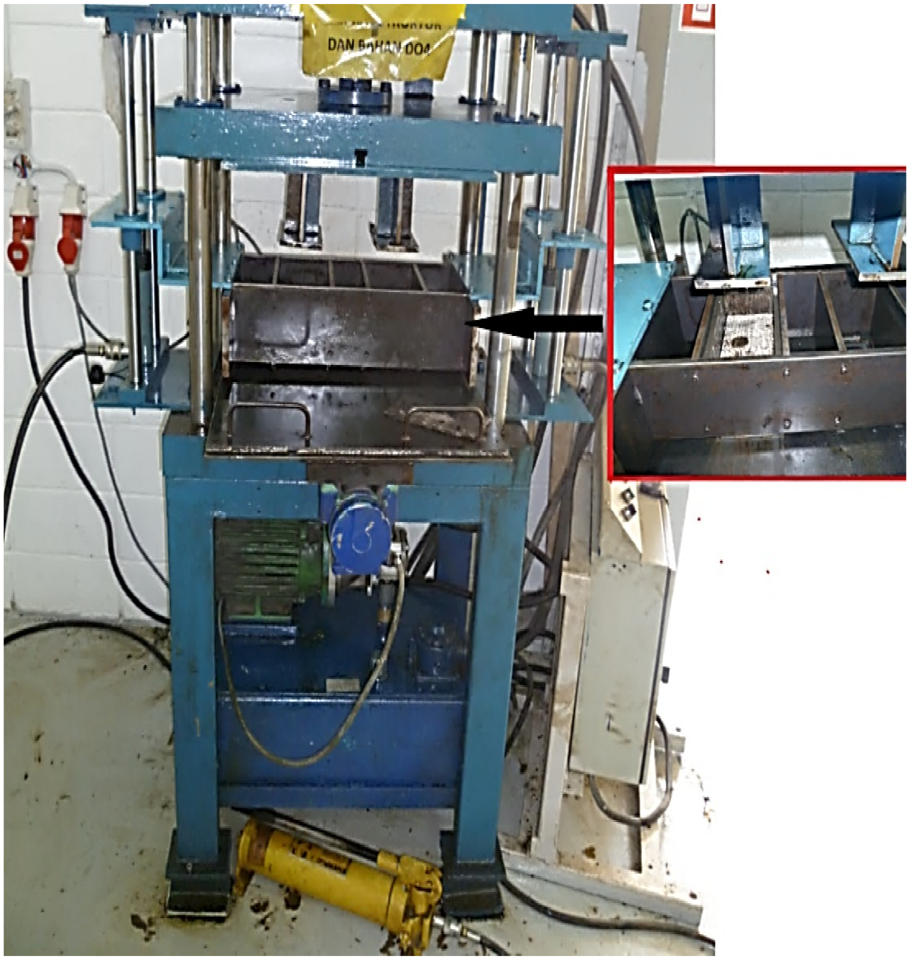

Fig. 3: A machine used to manufacture the blocks

Fig. 4: Extruding of asphalt block from steel mold by a jack

Table 1: The density and voids analysis of asphalt paving blocks

Bitumen types used in block mixture	Density (g/cm³)	Compaction (%)	VTM (%)	VMA (%)	VFA (%)
Bitumen grade of 60-80	2.291	96.1	3.1	12.8	75.8

Table 2: The compressive load of asphalt block with different thicknesses

Block thickness (mm)	Compressive load (kN)
70	156.6
80	160.0
90	163.8

block pavement with varying of asphalt block thicknesses i.e., 70, 80 and 90 mm, respectively.

Figure 5 revealed that the elastic deformation (rutting) occurred in asphalt block pavement is considerably affected by the block thicknesses. The

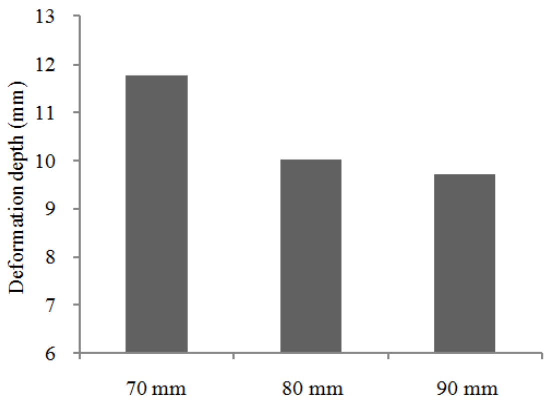

Fig. 5: Deformation (rutting) depth occurred in the surface of asphalt block pavement after a repetition of 20,000 cycles

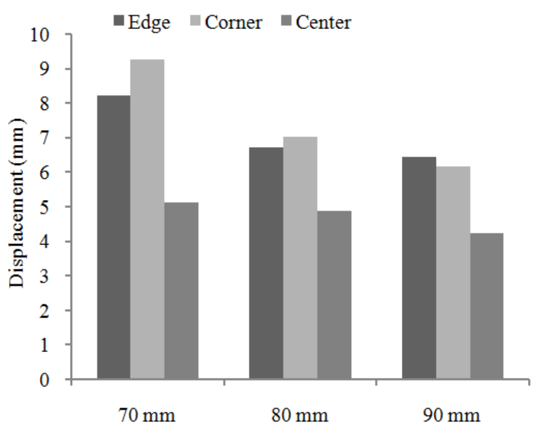

Fig. 6: The displacement occurred in the block pavement

results show that as asphalt block thickness increases, the elastic deformation decreases. Asphalt paving blocks with a thickness of 90 mm yields the best resistance to the deformation.

Pull-out test: Pull-out test was carried out at three different locations i.e., edge, corner and center.

Figure 6 shows the final displacement occurred in the block pavement as a result of extracting a unit of paving block from pavement model.

As shown in Fig. 6, the behavior of asphalt block pavement during extraction process is not significantly affected by the block thickness and that may due to the interactions between asphalt block with neighboring ones are very high thus, the block thickness does not play a significant role here.

CONCLUSION

This research investigated the effect of block thickness on the structural performance of asphalt paving blocks. As stated formerly in the introduction, the aim of this study was to evaluate pavement resistance to rutting and displacement. The following conclusions were drawn:

- The resistance of asphalt paving block to static load decreased as the block thickness decreased. The minimum block thickness in this study resisted a static vertical load as little as 156.6 kN.
- The elastic deformation occurred in this surface of asphalt block pavement increased as the block thickness decreased. Meanwhile, the block thickness of asphalt block has a slight effect on the displacement of asphalt paving block from the pavement model.

The deformation happened in asphalt paving block is considerably higher compared to normalasphalt pavement and that may due to existing of further layer under the paving blocks (bedding sand layer). On the other hand, the normal asphalt pavement is built by using heavy machines. In this manner; it would be useful to have an unconventional method of paving, especially for narrow streets where the heavy paver cannot go through. To conclude, a similar study should be done by varying some of variables such as the block dimensions and the bedding sand and assess their influence on the structural performance of asphalt paving blocks.

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