# The Effect of Paver Joint Width on the Construction of Concrete Block Pavement on Sloping Road Section

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***Abstract -*** This research presents the construction of concrete block pavement (CBP) on sloping road section that influences the joint width between blocks. The effect of load transfer on the CBP behavior is discussed. The results of a series of tests conducted in laboratory with horizontal force test. The horizontal force testing installation was constructed within the steel frame 2.00 x 2.00 meter and forced from the side until CBP failure (maximum horizontal creep). The optimum joint width between blocks is 3 mm. For joint widths less than the optimum, the jointing sand was unable to enter inside between blocks. A large amount of sand remained outside the joint showing sand heaps on the block surface. The effect of the degree of slope on concrete block pavements on sloping road section area is significant with friction between blocks and thrusting action between adjacent blocks at hinging points is more effective with thicker blocks. The spacing of anchor beam will be increases with decreasing joint width.

***Keywords*:** *Optimum, Joint width and Horizontal Creep.*

## 1. Introduction

The construction of Concrete Block Pavement (CBP) on steep slopes poses particularly interesting challenges for road engineers. The horizontal (inclined) forces exerted on the road surface are severely increased due to traffic accelerating (uphill), braking (downhill) or turning. These horizontal forces cause distress in most conventional pavements, resulting in rutting and poor riding quality. Experience has shown that CBP performs well under such severe conditions. Although CBP performs well on steep slopes, there are certain considerations that must be taken into account during the design and construction of the pavement.

Due to the steepness of the slope, normally vertical traffic loading will have a surface component exerted on the blocks in a downward direction. This force is aggravated by traction of accelerating vehicles up the hill and breaking of vehicles down the hill. If uncontained, these forces will cause horizontal creep of the blocks down the slope, resulting in opening of joints at the top of the paving and weaving on the concrete block pavement.

The objectives of the study are: (1) To study the performance of CBP deformation (horizontal creep) that is affected by horizontal force with variables joint width between blocks. (2) To define the spacing of anchor beam on sloping road section based on joint width between blocks.

## 2. Literature Review

The sand was used in bedding course with a 50 mm thickness for all of these experiments. Figure 1. shows the response of pavement for design joint widths of 2 mm, 3 mm, 5 mm, 7 mm and 9 mm with same quality of sand (Rachmat Mudiyono and Hasanan, 2004). As the joint width decreases, the deflection of the pavement also decreases of jointing sand.

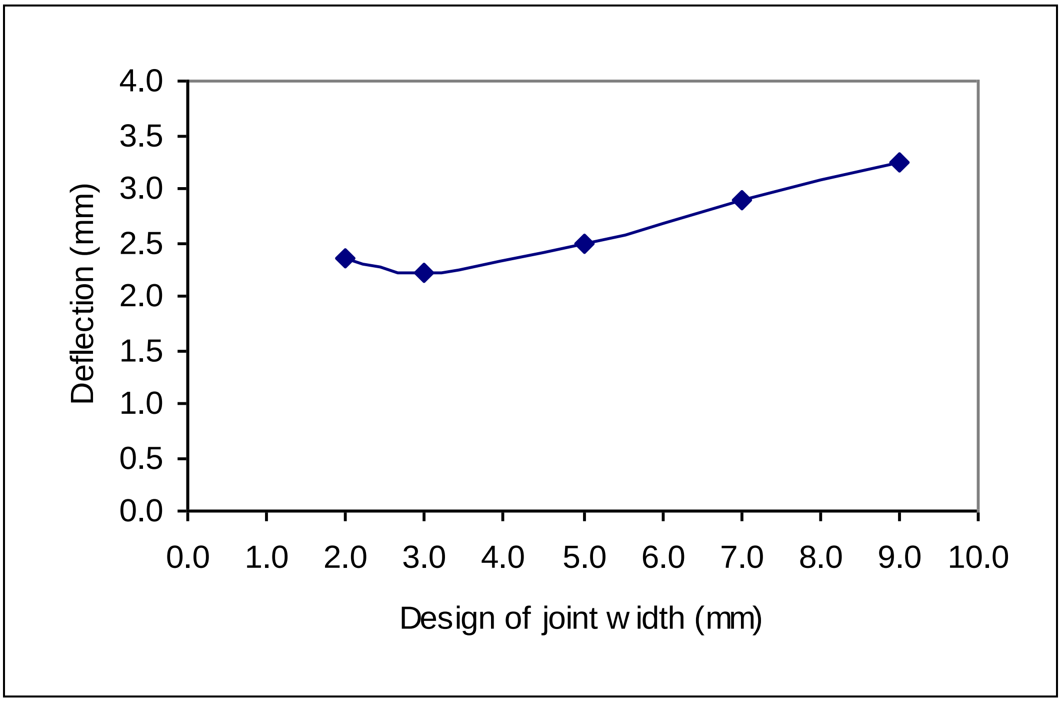


Figure 1. The response of pavement deflection for design joint widths

The results that decrease in joint width increases the pavement performance and the concept of optimum joint width well agree with that of a series of static load tests.

The deflection of pavement decreases up to a certain point and then slightly increases with decrease in joint width, i.e., there is an optimal joint width. The optimum joint widths for these experiments are 3 mm, respectively.

- The higher the thickness, the lesser the normal stiffness of the joint will be. This will lead to more rotations and translations of blocks. Thus, there will be more deflection under the same load for thicker joints.
- For joint widths less than the optimum, in a slight increase in deflections was observed. Some of the grains coarser than the joint width were unable to enter inside. This has been observed during filling sand in joints. A large amount of sand remained outside the joint showing sand heaps on the block surface. The coarse grains of sand choke the top surface of joints and prevent movement of other fine grains in to joint. There might be loose pockets or honeycombing inside the joint. The joint stiffness decreases and in turn reflects slightly higher deflections.

## 3. Filling of Jointing Sand

The compaction might not be fully effective for a higher thickness of bedding sand during vibration. The bedding sand rises through the joints to small heights and wedges in between the blocks. Figure 2. shows the rise of sand through the design joints width of 3 mm, 5 mm and 7 mm with varying thickness of bedding sand. The rise of sand increases with increase in thickness of bedding sand. The wedging of these sands absorbs the major part of applied vibration energy and transfers less to the bedding sand below. As a result, the bedding sand is not fully compacted for higher thickness (Shackel, 2003).

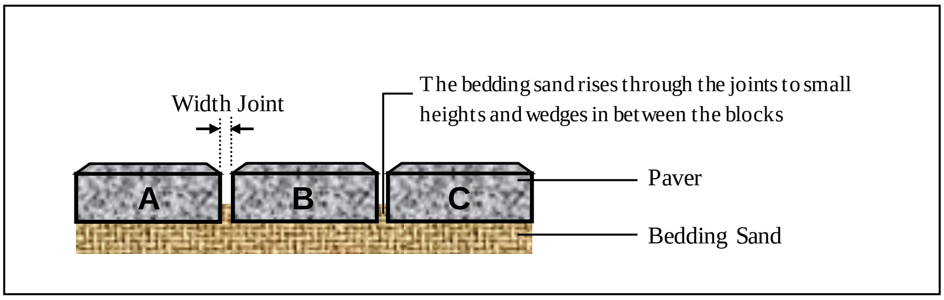


Figure 2. The rises of bedding sand between the blocks

Consequently, some compaction of bedding sand takes place under load and thus shows more deflection in the test pavements. The higher the bedding sand thickness, the more the deflection will be.

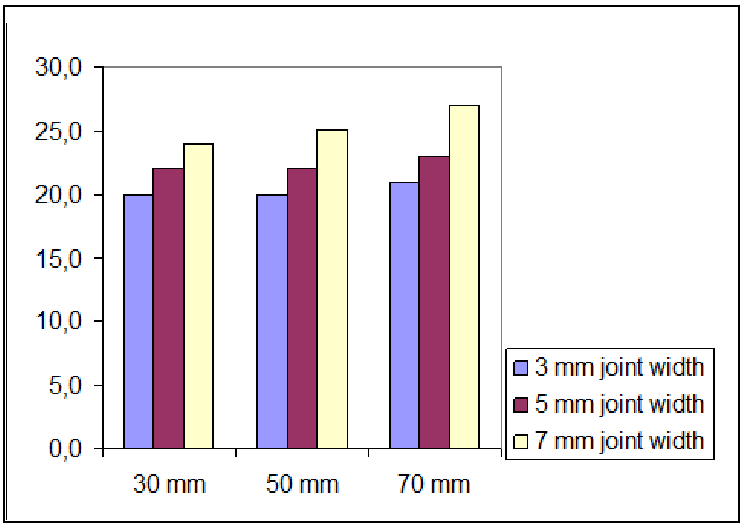


Figure 3. The comparison bedding sand rises in various widths joint with bedding sand thickness (Knapton and O'Grady 1983).

The findings of this study are contradictory to those reported by Knapton and O'Grady (1983). Knapton and O'Grady (1983) have found an increase in bedding sand thickness produced a proportionate increase in load-carrying capacity of pavement. As the pavement response is nearly for 50 mm thickness of bedding sand can be recommended to use in the field. But this depends on other factor, such as required level in sub-base tolerance and rise of bedding sand through the joints.

## 4. Methodology

This research begins by studying the interactions that can develop between adjacent blocks and between blocks (surface course) with the bedding and jointing sands especially on sloping road section. A series of tests conducted to investigate the effects of changing parameters of joint width between blocks. A laboratory-scale model was to study the behaviour of concrete block pavement testing to highlight i.e. horizontal force test to find the maximum horizontal creep. It can be shown that these horizontal forces can be significant to define the spacing of anchor beam that used in construction of CBP on sloping road section

The horizontal force testing installation was constructed within the steel frame 2.00 x 2.00 metre. In this study, the effects of changing of laying pattern, joint width, block shape and block thickness are investigated. The steel frame as edge restraint was placed on the concrete floor and welded to the concrete floor.

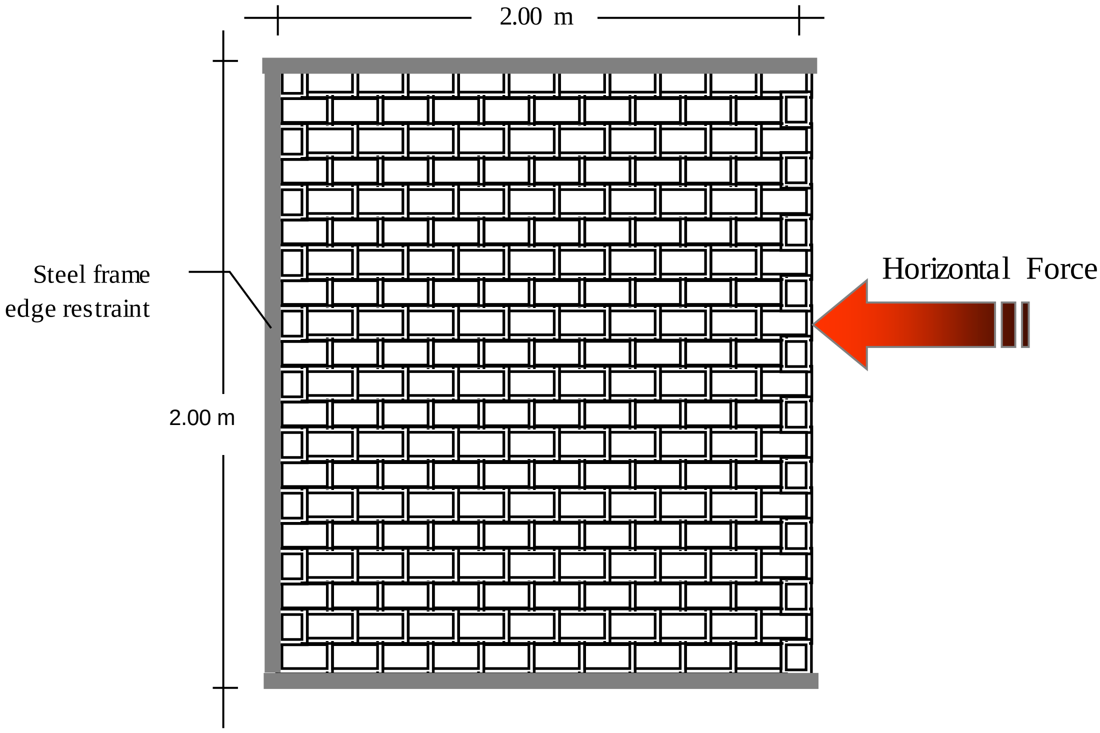


Figure 4. Stretcher bond laying pattern

## 5. Analysis

Figure 5. show the response of pavement for design joint widths of 3 mm, 5 mm and 7 mm with varying block thickness and bedding sand thickness. As the joint width decreases, the deflection of the pavement also decreases. The higher of block and bedding sand thickness, the lesser the normal stiffness of the joint will be. This will lead to more rotations and translations of blocks. Thus, there will be more deflection under the same load for thicker joints. Some of the grains coarser than the joint width were unable to enter inside. This has been observed during filling sand in joints. A large amount of sand remained outside the joint showing sand heaps on the block surface. The coarse grains of sand choke the top surface of joints and prevent movement of other fine grains into the joint. There might be loose pockets or honeycombing inside the joint. The joint stiffness decreases and in turn reflects slightly higher deflections. At the optimum joint width, there is the maximum chance that single grains of average size, close to the joint width, will be retained in the joints during joint filling.

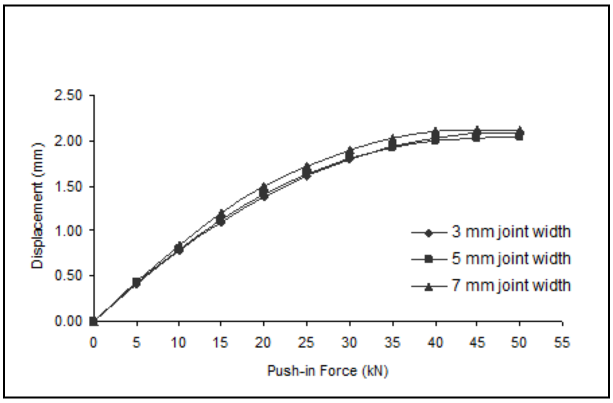


Figure 5. Relationship between push-in forces with displacement on CBP: rectangular shape, 60 mm block thickness and 30 mm bedding sand thickness

## 6. General Discussion

The width of joints in block paving is more important than that perhaps been realized in the past. A serious disadvantage of pavements laid in this way is that joints of less than 2 mm in width often contain little of no jointing sand. This would obviously reduce the contribution of individual blocks to the structural properties of the pavement. Width use the individual blocks move is relation to one another which results in spelling of the edges. Although this is not structurally damaging, the overall appearance of the pavement is less desirable and the small piece of broken corners could cause problems if not swept away.

Blocks laid to a poor standard were seen where joint widths of more than 5 mm were common. The amount of sand required to fill the joints was too great to allow intimacy between blocks forming the joint to develop. The shear strength of the jointing sand would be the limiting factor in the structure of the pavement. The increase of joint width between blocks and degree of slope, decrease the friction resistant between blocks. Thus, the result is an increase of the displacement.

The optimum joint width between blocks is 3 mm. For joint widths less than the optimum, the jointing sand was unable to enter inside between blocks. A large amount of sand remained outside the joint showing sand heaps on the block surface.

## 7. Conclusion

The experimental work performed in this study leads to the following applicable conclusions:

- The joints in between blocks should be properly filled with sand. The optimum joint width between blocks is 3 mm. For joint widths less than the optimum, the jointing sand was unable to enter between blocks. A large amount of sand remained outside the joint showing sand heaps on the block surface.
- A block pavement may present various types of mechanical behaviour when submitted to a horizontal force, depending on the joint width between blocks.
- The horizontal force test with rectangular block shape and stretcher laying pattern, which is parallel to the continuing lines of the joints, shows that the cohesion of such a plate is near to zero whatever the restraining of the edges. Indeed, far a relatively low value of the applied force, the line of loaded blocks moves monolithically, the friction forces which are the only ones capable of reacting on the continuous lines being too weak to perform this role.

To define the spacing of anchor beam of CBP on sloping road section must be computation factors of degree of slope joint width between blocks. The increase of degree of slope will cause shorter spacing of anchor beam. The increase of joint width between blocks will cause shorter spacing of the anchor beam.

## References


Akpinar, M. V. *Defining Roller Compactor Position and Slope of Tapered Surface in a Longitudinal Joint Construction Using 2-D Finite Element Model*. Ph.D. Thesis, Kansas State University, Manhattan; 2001

Beaty A. N. S. and Raymond G. P.(1995). *Concrete Block Road Paving*. Journal of Concrete International, March: 16-20

Chatti, K.(1992). *Dynamic Analysis of Jointed Concrete Pavements Subjected to Moving Transient Load*, Ph.D. Dissertation, Institute of Transportation Studies, University of California at Berkeley.

Clifford, J.M. (1984). S*egmental Block Pavement – Optimizing the joint Width and Joint Material*. Proc. Second Int. Conf. On Concrete Block Paving, Delft.

Concrete Manufacturers Association, (2000). *Concrete Block Paving For Steep Slopes* Technical Note. CMA

Emery, J. A. (1993). *Stabilization of Jointing Sand in Block Paving*. Journal of Transportation Engineering, Vol. 119, No. 1-3: 143-147.

Hasanan Bin Md Nor.(1999). *Good Practice for Concrete Block Pavement*. Seminar Kejuruteraan Awam. Universiti Teknologi Malaysia.

Hasanan Bin Md Nor and Rachmat Mudiyono. (2005). *The Development and Application of Concrete Block Pavement*. International Seminar and Exhibition on Road Construction (ISERC), 26th May 2005, Semarang – Indonesia.

Houben, L. J. M. (1996). *Eflect of the Use of Half-Blocks in Mechanical Block Paving*. Proc. 5th Int. Conference on Concrete Block Paving, Tel-Aviv: Israel, 213-222.

Knapton, J., and O'Grady, M. (1983). *Structural Behavior of Concrete Block Paving*. Journal Concrete Society: 17–18.

Rachmat Mudiyono and Hasanan Bin Md Nor (2004). *The Effect of Changing Parameters of bedding and Jointing Sand on Concrete Block Pavement*. Seminar Penyelidikan Kejuruteraan Awan (SEPKA), UTM.

Panda, B. C., and Ghosh, A. K. (2001). *Structural Behavior of Concrete Block Paving. I: Sand in bed and joints*. Journal of Transportation Engineering, USA ASCE, 128(2): 123–129.

Panda, B.C. and Ghosh, A.K.(2001). *Source of Jointing Sand for Concrete Block Pavement*. Journal of Transportation Engineering. ASCE, USA: Vol. 13, No. 3.

Panda, B.C. and Ghosh, A.K.(2002). *Structural Behavior of Concrete Block Paving II: Concrete Blocks*. Journal of Transportation Engineering. USA: ASCE

Rohleder, M., (2002). *Horizontal Shiftings of Paving Surfaces and Their Visualization*. PhD Thesis, Institute for Highways Constructions Bochum.

Shackel, B. (1985). *Evaluation, design and application of concrete block pavements*. Proc., 3rd Int. Conf. on Concrete Pavement Design and Rehabilitation, Purdue University, West Lafayette: Ind., 113–125.

Shackel, B. (1983). *An Experimental Investigation of the Roles of the Sand Bedding and Jointing Sand in the Performance of Interlocking Concrete Block Pavements Subjected to Traffic*. Journal Concrete: 5-15.

Shackel, B., and Lim, D. O. O. (2003). *Mechanisms of Paver Interlock*. Proceeding 7th *International* Conference on Concrete Block Paving, South Africa.