Improvement of Mechanical Interlocking of Non Geometric Interlocking Concrete Blocks

M.K.T.Madhuranga[1] and W.K. Mampearachchi[2]

Department of Civil Engineering, University of Moratuwa, Sri Lanka

ABSTRACT : Today most of the rural roads and sidewalks in urban areas paved with Interlocking concrete blocks. Also non geometric interlocking blocks; cobble shapes are widely used for paving due to aesthetic appearance, availability in various sizes and laying patterns and less manufacturing cost. The mechanical interlocking between these non-geometric interlocking blocks plays a major role in transferring the load to adjacent blocks and finally to the durability of those constructed pavements. It is revealed in the literature survey that no proper study has been done to improve the mechanical interlocking of non-geometric interlocking concrete blocks. In this research several experiments were conducted to investigate the texture of non-geometric interlocking blocks and the filling mediums which contribute to improve the interlocking system. Experiments were conducted with various combination of surface texture, filling material and gap between blocks. Optimum conditions to improve the mechanical interlocking were identified in this study.

1 INTRODUCTION

The rapid demand for better roads and services required the designers and the builders to explore innovative construction methods in order to economize construction as well as increase durability. The last century has seen an intensive process of urbanization which has caused a need for rapid construction of roads and related infrastructure. In most of the countries, high percentages of roads were constructed using concrete or bitumen as the primary material. But concrete roads in general have the following drawbacks such as difficulty to accommodate services such as service ducts, telecom or electricity cables etc in the later stages. In addition the repairs and replacement of a slab or parts of a concrete slab will be very expensive. Bitumen also has several disadvantages as a road construction material in spite of its popularity. Bitumen is a byproduct of crude oil purification. Therefore, the price of bitumen has also increased in parallel with the escalation of crude oil prices, an indication that bitumen may not be a substantial construction material in the future. Therefore, concrete block paving (CBP) technology introduced as an effective alternative to concrete and asphalt. It is considered as a feasible solution for upgrading the rural as well as urban roads in developing countries as it is a labor intensive construction method.

At present Interlocking concrete block paving has become very popular in Sri Lanka. Almost all the rehabilitation of rural roads and paving in urban areas are now paved with interlocking concrete block paving units (ICBP units). And also these blocks are widely used to pave parking lots, gardens, industrial areas, domestic areas religious places etc. Because of the aesthetic appearance, rapid and easy construction, these ICBP units are becoming more and more popular among general public.

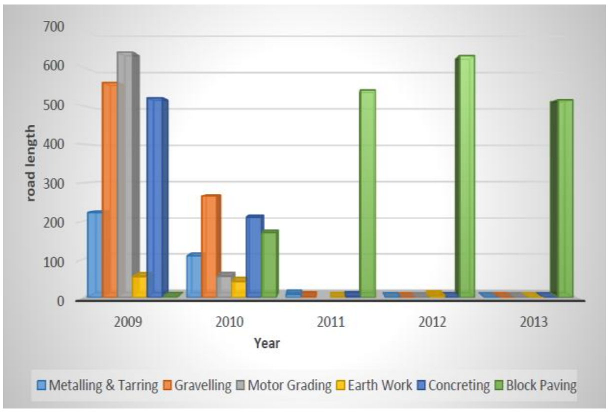

Fig. 1 Use of Different construction materials for paving for Rural Roads

Fig. 1 shows the trend of concrete block paving and other alternative products in rural road construction in Sri Lanka. Therefore, the future demand will be much higher than that of today.

Non geometric interlocking concrete blocks are widely used currently for pavement construction, pave parking lots, gardens, industrial areas, domestic areas, religious places etc. In the literature survey, it was found that no proper study has been done to improve the mechanical interlocking of non geometric interlocking concrete blocks and to find out the optimum conditions that could be

1 Former Student 2 Professor e-mail : wasanthak@uom.lk

adopted in CBP (non geometric) to enhance the interlocking performance.

2 OBJECTIVES

The main objective of the research is to study the effect of surface texture and the filling sand to improve the mechanical interlocking of non-geometric interlocking concrete blocks.

3 METHODOLOGY

The following tasks were executed to achieve the objective of the research.

1. Literature survey of interlocking concrete blocks pavements.
2. Development of an experimental setup to test the block pavers in the laboratory.
3. An experimental investigation to study the effect of block texture on mechanical interlocking of an ICBP pavement constructed with non geometric blocks.
4. An experimental investigation to study the effect of filling material on mechanical interlocking of an ICBP pavement.
5. An experimental investigation to study the combined effect of texture and the filling material.

3.1 *Modeling of Concrete Block Pavement*

A laboratory model of 1m × 1 m was used for the experiment. The test setup was a modified version of the experiment used by Panda and Ghosh (2002b) and it was very similar to Shackel et al (1993) experimental setup. A strong wooden box was used to provide lateral support for the interlocking pavers as used in the experimental study of Mampearachchi and Gunaratne (2010). Two (2) 25cm thick rubber carpet was placed at the bottom of the wooden block to represent the support conditions for the block pavement as per Panda and Ghosh (2002a) and 5cm thick sand layer was laid top of the rubber carpet as a bedding for pavers. Finally, test pavers were laid and all the gaps were filled with bedding sand as per specification.

3.2 *Design of experiments*

Several experiments were designed to achieve the objectives of the research. In all experiments, paving units were placed and load was applied to the center of the pavement with 10kN increments. Loading area is equal to the contact area of a heavy truck. Five dial gauges were placed as per the Fig. 2 and the deflections were noted for each load increment starting from 10kN. In those experiments two parameters were considered for improving the mechanical interlocking of concrete blocks. They were;

1. Side surface texture of the concrete blocks (Rough and Smooth)
2. Texture and shape of Filling material (Sand and Quarry dust)

Experiments were conducted by varying those parameters and deflections were measured at the pre-determined locations shown in Fig. 2. Deflections vs. load graphs were plotted for various combinations of surface texture and filling material.

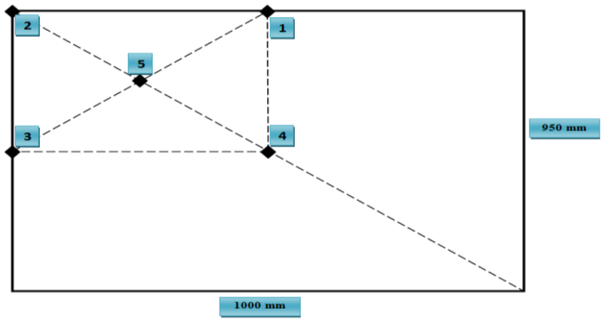

Fig. 2 Placement of dial gauges

3.3 *Experimental Plan*

Four experiments were executed and obtained results. Those 4 experiments were;

Experiment 01: Test for rough side surface textures of non geometric interlocking blocks with sand as filling material

Experiment 02: Test for smooth side surface textures of non geometric interlocking blocks with sand as filling material

Experiment 03: Test for rough side surface textures of non geometric interlocking blocks with quarry dust as filling material

Experiment 04: Test for smooth side surface textures of non geometric interlocking blocks with quarry dust as filling material

4 ANALYSIS

4.1 *Measurement of Pavement Deflection*

Pavement deflection for the center loading was measured by using 5 dial gauges. Due to center loading of the pavement, dial gauges were placed in one quarter of the pavement as shown in Fig. 2 considering the symmetry. Load was measured using 10 ton proving ring and load was increased gradually and relevant deflection was measured. For all 4 experiments, loads vs. deflections were tabulated. Deflection vs. load graphs were plotted for each combination of parameters tested in the study. It is expected to evaluate the effect of following variables on performance of non-geometric interlocking concrete blocks.

- ✓ Best side surface texture
- ✓ Best filling medium

4.2 *Comparison of center Pavement Deflection in first analysis (Test for side texture)*

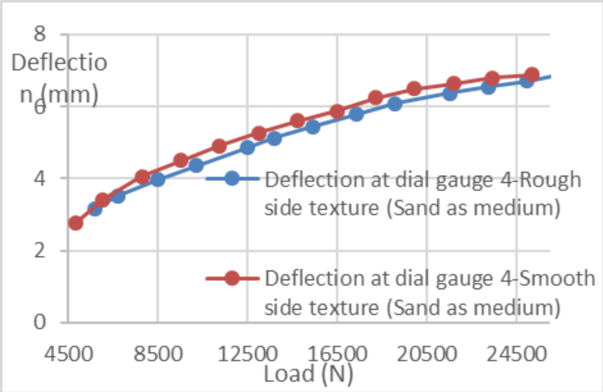

Fig. 3 Effect of surface texture (Sand as filling material)

Fig. 3 shows the deflection vs. load graph plotted for the two side textures selected for the study keeping the sand as filling material. It clearly shows that deflection at the center of the smooth surface is little higher than that of the rough surface. There is no significant effect of side texture on deflection when chosen the sand as filling material.

The experiment two was conducted using quarry dust as the filling material and two type of side textures were tested as in experiment 1. Fig. 4 shows the effect of side texture with quarry dust as filling material.

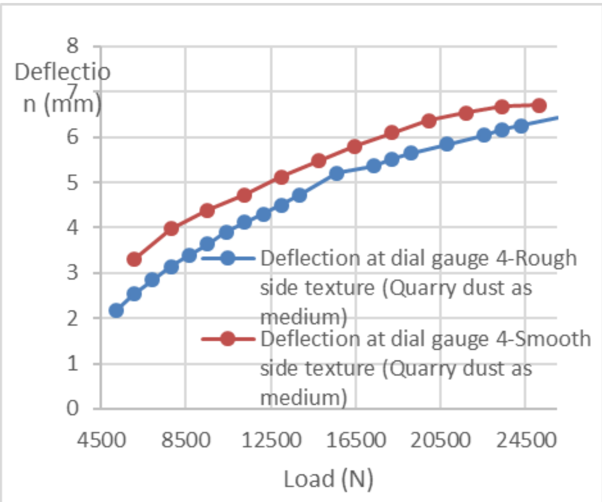

Fig. 4 Effect of surface texture (Quarry dust as filling material

It clearly indicates that deflection at the center of the smooth surface is much higher than that of the rough surface when the medium of the filling is quarry dust. As direct shear strength is much higher in quarry dust than sand, the interlocking of the blocks has enhanced Therefore the filling medium play a significant role in improving the vertical interlocking of the block. Material with higher direct shear strength (rough surface texture) promotes the interlocking ability of rough texture blocks.

4.3 *Comparison of center Pavement Deflection in second analysis (Test for filling medium)*

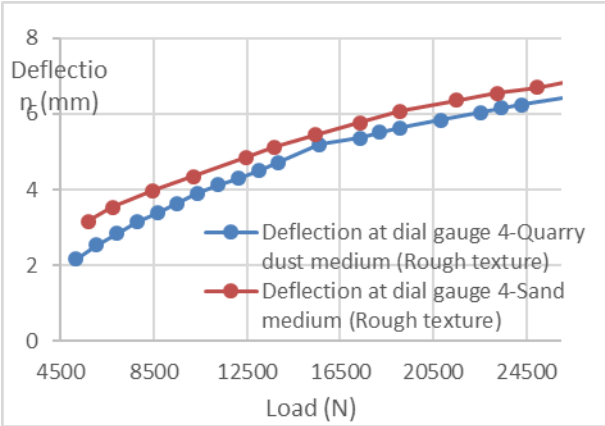

Fig. 5 Effect of filling material (Rough texture for concrete blocks)

Fig. 5 shows deflection at the center of the pavement with filling medium. Two filling materials; sand and quarry dust were used. For rough surface texture, quarry dust filling materials shows better performance than sand. Therefore, quarry dust filling medium significantly improve the mechanical interlocking performance of rough texture concrete blocks. So, mechanical interlocking performance increases when quarry dust is used as the filling medium rather than sand as filling medium.

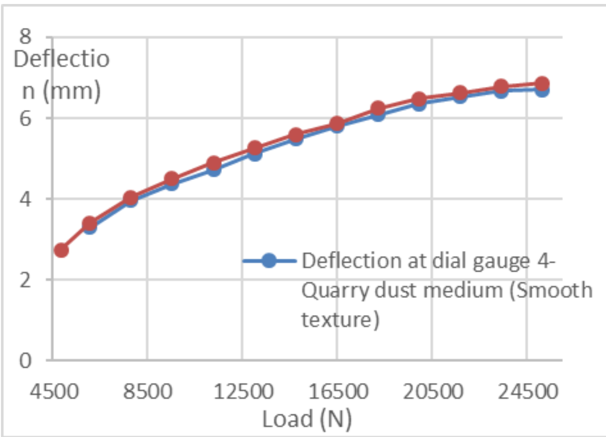

Fig. 6 Effect of filling material (Smooth texture for concrete blocks)

Fig. 6 shows deflection at the center of the pavement with filling medium. Two filling materials; sand and quarry dust were used. For smooth surface texture, quarry dust filling materials has less deflection than that of sand as filling material. Therefore, quarry dust filling medium has a little influence on mechanical interlocking performance of smooth texture concrete blocks.

Fig. 7 shows the various combination of filling material and texture of blocks. The lowest deflections can be seen with rough surface texture with quarry dust as filling material and the height deflection can be seen with smooth surface texture with sand as filling material.

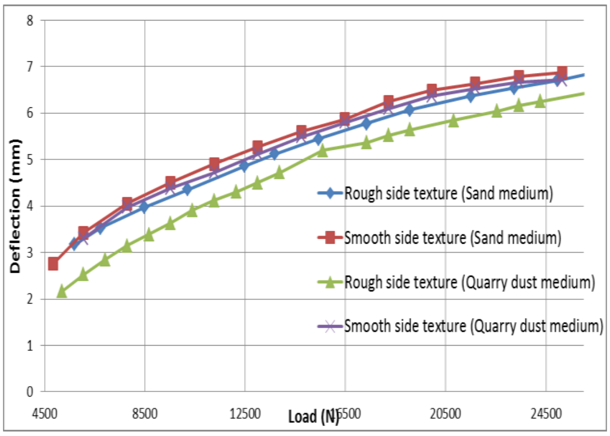

Fig. 7 Comparison of various combination of filling material and texture of blocks

5 DISCUSSION

5.1*Properties of sand and quarry dust*

- ✓ Quarry dust has rough, sharp and angular particles, and as such causes a gain in strength due to better interlocking
- ✓ Sand is usually not graded properly and has excessive silt, while quarry rock dust does not contain silt or organic impurities and can be produced to meet desired gradation and fineness as per requirement
- ✓ Quarry dust exhibits high shear strength than sand
- ✓ It has a good permeability and variation in water content does not seriously affect its desirable properties

The mechanical interlocking of non geometric concrete blocks can improve quarry dust as quarry dust has rough, sharp and angular particles. The above properties of quarry dust will improve better interlocking between particles and interlocking between concrete blocks. Also quarry dust has higher direct shear strength than sand. Hence quarry dust can withstand much higher loads than sand does. This will also result the better interlocking between concrete blocks. Therefore as a filling medium, quarry dust is more suitable than sand to improve the mechanical interlocking of non geometric interlocking concrete blocks.

6 CONCLUSION

As the side surface texture of non-geometric interlocking concrete blocks get roughen the mechanical interlocking is improved. Therefore a better interlocking between paving blocks can be achieved by making the side texture of blocks rougher.
Also quarry dust can improve the mechanical interlocking between non geometric concrete blocks than sand .Quarry dust has rough, sharp and angular particles, and as such causes a gain in strength due to better interlocking. Quarry dust exhibits high shear strength than that of sand. Sand is usually not graded properly and has excessive silt, while quarry dust does not contain silt or organic impurities and can be produced to meet desired gradation and fineness as per requirement. It is confirmed that quarry dust is a better filling medium than sand.

Rough surface texture alone does not significantly improve the interlocking of block. The filling medium of gaps plays a significant role in enhancing the mechanical interlocking of rough textured blocks.

REFERENCES

Mampearachchi, W. K., and Gunaratne, W. P. H.(2010)" Finite Element Model Approach to Determine Support Conditions and Effective Layout for Concrete Block Paving" Journal of Materials in Civil Engineering-ASCE, October, 2010

Panda, B. C., and Ghosh, A.K. (2002 a). Structural Behavior of Concrete Block Paving I: Sand in Bed Joints. Journal of Transportation Engineering @ ASCE, 128 (2), 123-129.

Shackel, B. (1980). ''The performance of interlocking block pavements under accelerated trafficking.'' Proc., 1st Int. Conf. on Concrete Block Paving, Newcastle-upon-Tyne, U.K., 113–120

Panda, B. C., and Ghosh, A.K. (2002 b). Structural Behavior of Concrete Block Paving II: Concrete Blocks. Journals of Transportation Engineering @ ASCE, 128 (2), 130-135.