Structural Evaluation of Block Pavements using Light Weight Deflectometer

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Abstract :

The block pavement has been widely used in urban area of Korea to mitigate the heat island effect, enhance the drainage function, and improve the aesthetic feature of city. Recently, the local government is willing to extend the application of block pavement to the roadway. For this purpose, the structural capacity of block pavement should be considered in design and construction stage for better performance and longer life. This study is intended to evaluate the structural capacity of block pavements using light weight deflectometer (LWD). The seasonal variation of surface deflection in block pavement hasbeen assessed using the field LWD testing results. Test results indicate that the deflections measured in block pavement 15 times higher than those in asphalt pavement. The structural capacity of subbase and subgrade in block pavement is generally low because of lack of compaction effort and low quality of materials. It is also found that the seasonal variation of LWD deflection in block pavement seems to be very high compared to asphalt pavement. This fact is because the materials used in subbase and subgrade is sensitive to seasonal change, the water can easily infiltrate into unbound layer through the block gap, and temperature change inside block pavement is very high.

Key Words : Block Pavement Structural Capacity Light Weight Deflectometer; Deflection

1. Introduction

The block pavement has been widely utilized in the sidewalk to mitigate the heat island effect, enhance the drainage function, and improve the aesthetic feature of city. Recently, the local government is willing to extensively apply block pavement to the roadway. Since a heavy loading of vehicle is applied in the block pavement, it is necessary to improve the strength of block and support of base and subgrade layer. For this purpose, the structural capacity of block pavement should be considered in design and construction stage for better performance and longer life. The objective of this study is to compare the deflection characteristics and seasonal variation of block and asphalt pavements using the Light Weight Deflectormeter (LWD) and Falling Weight Deflectometer (FWD).

2. Falling Weigth Deflectometer (FWD) and Light Weight Deflectometer (LWD)

FWD and LWD are the field testing equipments that can assess the structural integrity of pavement by applying a load to the pavement surface and measuring the resulting deflections. These equipments are normally used to determine the stiffness of pavement materials and evaluate the structural condition. Since the LWD is easy to operate and small enough to be used at any place, it is used to evaluate the structural capacity of block pavement in this study.A load can be applied up to 15kN using falling weights and deflections can be measured using geophones. It requires no reference and can be tested on both bound and unbound layers.

3. Comparision of Deflection Characteristics in Asphalt and Block Pavement

A FWD testing was conducted to figure out the general characteristics of FWD deflection in one asphalt and two block pavement sections. A 4 ton of loading was applied inthe 10 locations with 10 meter interval. Seven geophone sensors located at different distance from the loading plate were used to measure the surface deflections.

Figure 1 shows the profile of FWD center deflections at different locations. As shown in this figure, the average center deflections in the asphalt and block pavements are 218 micrometer and 2974 micrometer, respectively. The center deflections in block pavement are 15 times higher than those in asphalt pavement. Figure 2 presents the comparion of FWD deflection basins obtained from asphalt and block pavements. It is observed from this figure that the deflection slope in block pavement is very high compared to the asphalt pavement indicating that the stiffness of unbound layer in block pavement is too low. According to backcalculation analysis, the modulus of unbound layer in block pavements range from 25 to 35 MPa. These modulus values belong to poor condition in unbound layer of asphalt pavement based on the pavement design guide in Seoul Metropolitan Government.



Figure 1. Falling Weight Deflectometer Testing in Block Pavement



Figure 2. Light Weight Deflectometer Testing in Block Pavement

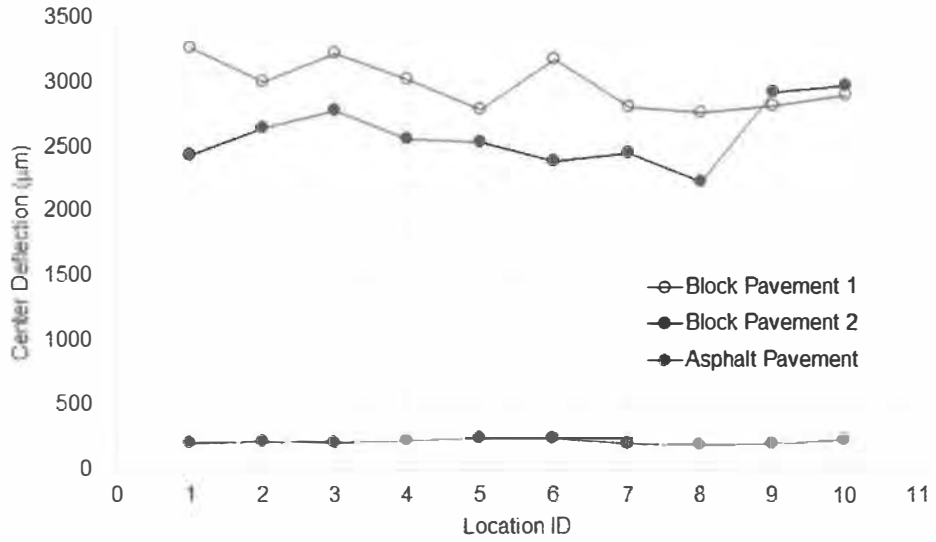


Figure 3. FWD Center Deflection Profile in Block and Asphalt Pavements

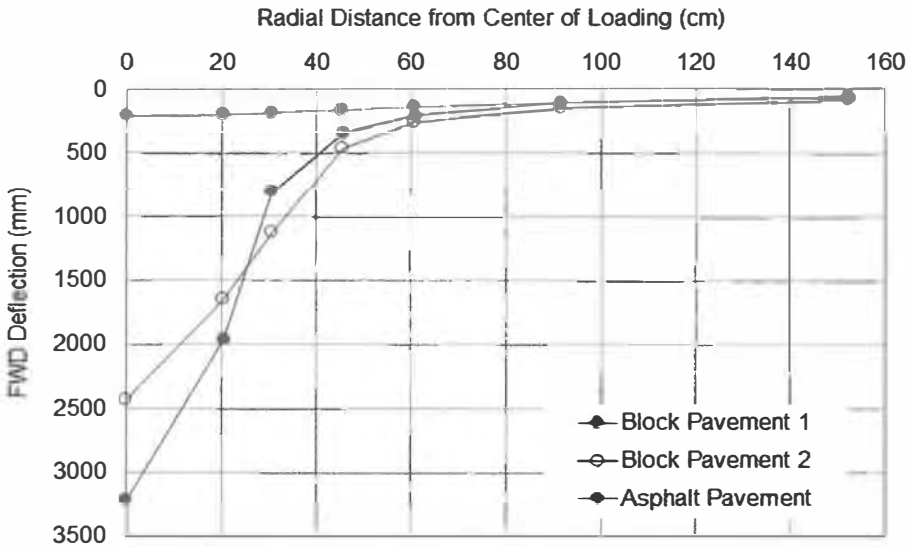


Figure 4. FWD Deflectin Basins in Block and Asphalt Pavements

4. LWD Testing Results in Block Pavement

The LWD testing was conducted on a total of ten block pavement sections to evaluate the structural capacity of block pavements. To analyze the seasonal variation of stiffness characteristics, this testing was performed on October 2016, January 2017, and March 2017. The average air temperatures at the time of testing are 20, 4, and 17oC. A total of 10 LWD drops were applied to measure the surface deflection at each location, and last three deflections were averaged and used for representative value for each location. For comparision purpose, the FWD testing was also conducted on asphalt pavements near the block pavement section.

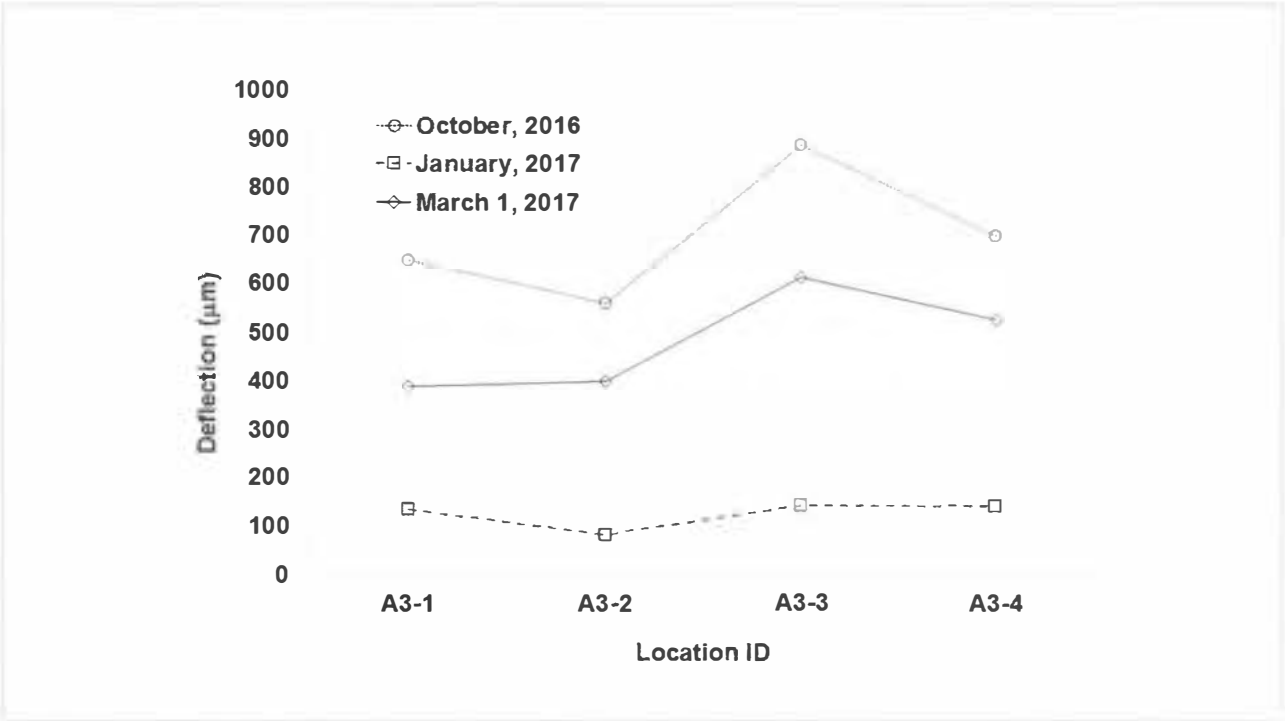


Figure 5. LWD Deflection Profile in Block Pavement (A3)

Figure 5 shows the LWD deflection profile collected in three different seasons in A3 block pavement section. It is found from this figure that the LWD deflection can identify the location with weak condition (A3-3) within the block pavement section. The deflection in A3-3 is 200mm higher than other locations in October, 2016 indicating that the unbound layer inthis location is in poor condition. Similar trend can be observed in deflection profiles measured in other seasons. It is also observed that the average deflection is about 125mm in freezing season and 480mm in thawing season. The large change in deflection due to seasonal variation can have a bad influence on the pavement performance.

5. Seasonal Variation of Deflection in Block and Asphalt Pavements

Figures 6 and 7 present the average deflection data seasonally measured in block and asphat pavement sections. It is noted that the LWD and FWD testing were conducted on block and asphalt pavements, respectively. As shown in Figure 6, the deflection tends to dramatically decrease as the air temperature decreases based on the comparision between surface deflections measured on October and January. It is found from this observation that LWD deflections were decreased by about 65 to 90% as air temperature drops from 20 to 4°C. The degree of reduction in block pavement seems to be significant when comparedwith asphalt pavements which show the 25 to 50% of deflection reduction. This deflection reduction is mainly due to the freezing effect in subbase and subgrade layers. The overall stiffness of block pavement is more sensitive to the air temperature change since the block thickness is relatively thin (60~80mm) and there is no heat absorption in the block. The water infiltation througth block gap can increase the water content in the unbound layer and induce the freezing effect during winter season. The higher fine content in unbound layers is also major factor affecting the degradation of stiffness.

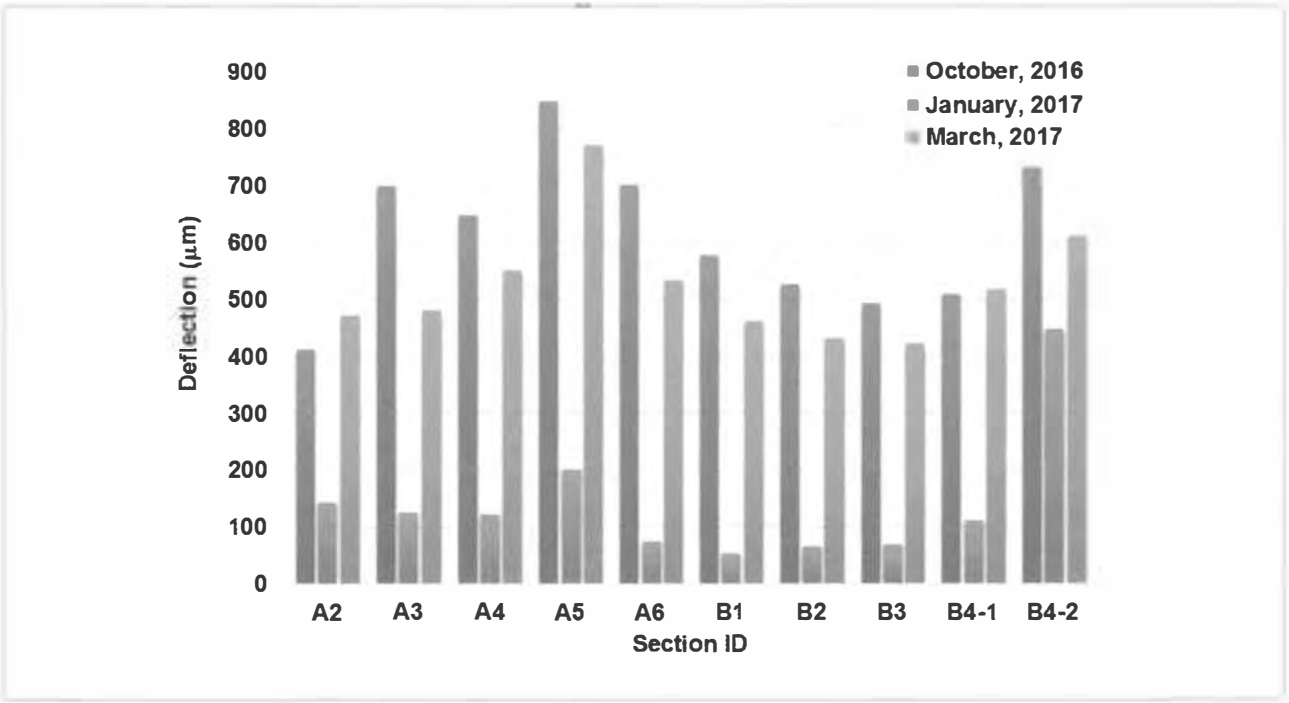


Figure 6. LWD Deflections in Block Pavement Sections

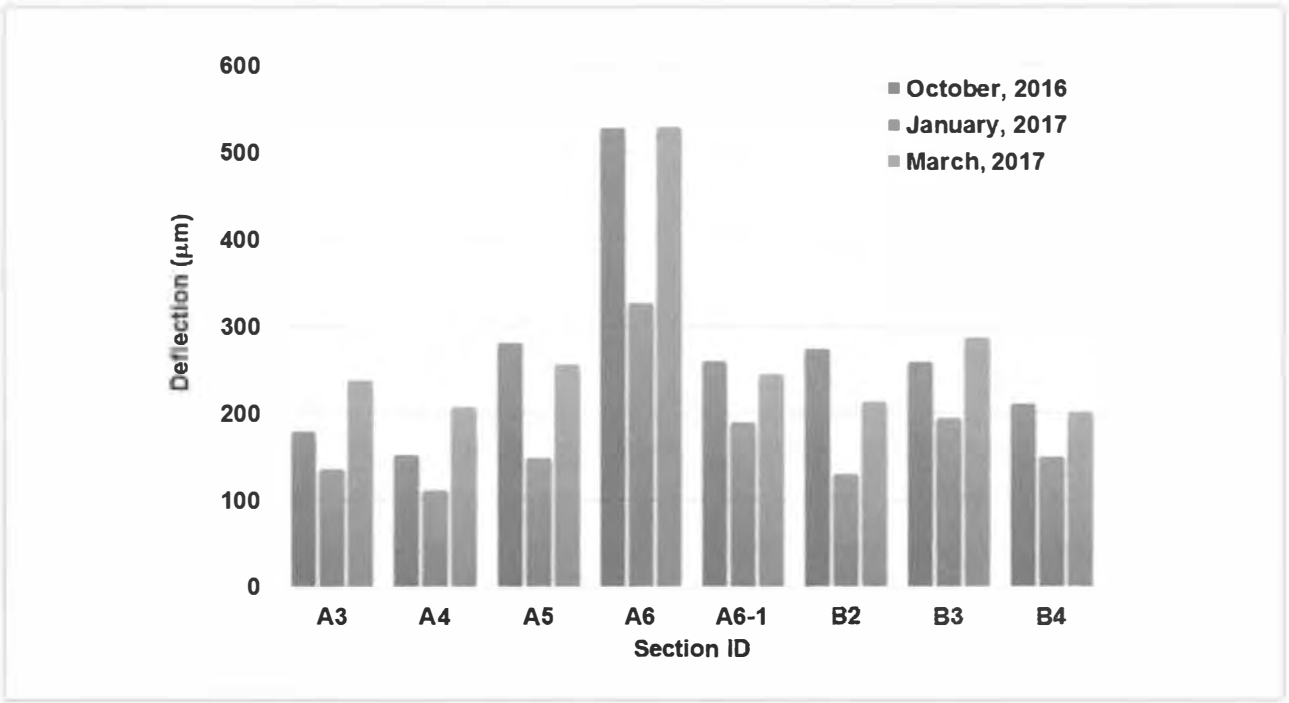
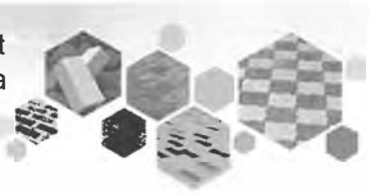


Figure 7. FWD Deflections in Asphalt Pavement Sections

6. Conclusions

It is concluded from this study that the deflections measured in block pavement are muchhigher than those in asphalt pavement because of low structural capacity of subbase and subgrade layer in block pavement. It is also found that the seasonal variation of LWD deflection in block pavement seems to be very high compared to asphalt pavement because thematerials used in subbase and subgrade layer of block pavement are sensitive to seasonal change.



When the block pavement system is applied in the roadway, the structural capacity of pavement system should be considerd in the stage of design and constuction. In block pavements, the use of low quality material and insufficient compaction in base and subgrade layer can induce not only reduction of structural capacity but only frequent repair work. The reinforcement technique underneath block layer will be a good alternative to improve the structural support for extend the service life.

References

[1] Park, H. M., Kim, Y. T., and Lee, S. H. An Analysis on the Nonlinear Behaviour of Block Pavements using Multi-Load Level Falling Weight Deflectometer Testing. International Journal of Highway Engineering 2017, Vol. 18 No. 6, 35-40.

[2] Uzan, J. Characterization of granular materials. Transportation Research Record 1985, Transportation Research Board, Washington, D. C., 52-59.

[3] Park, H. M., Kim, Y. R., and Park, S. W. Assessment of pavement layer condition with use of multiload-level falling weight deflectometer deflections, Transportation Research Record 2005,Transportation Research Board, National Research Council,Washington D.C., 107-116.