FWD-BASED STRUCTURAL EVALUATION OF HEAVY-DUTY ILB PAVEMENTS

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ABSTRACT

In the construction of ports and airports, in which pavements must be often laid before ground settlement is completed, interlocking block (ILB) pavements are sometimes used, as they easily follow the ground settlement. In addition, the blocks are able to sustain heavy load because they are composed of cement concrete, and can be easily repaired. ILB pavements are, however, seldom used in ports and airport in Japan due to a lack of performance data against heavy loading conditions.
In this study, the structural capacity of the ILB pavements was evaluated with the use of Falling Weight Deflectometer (FWD). Two series of experimental pavements were constructed for both new construction and rehabilitation. FWD deflections were measured on the experimentally constructed pavements, and their structural properties were back-calculated. The main conclusions are: (1) In the structural design of ILB pavements for new construction purposes, the design principle for asphalt pavements can be used, but the ILB layer is not structurally equivalent to asphalt concrete layer, so a proper correction factor should be introduced. (2) Blocks can be used in concrete pavement rehabilitation where concrete overlay design principle can be used with a proper correction factor in the adhered construction case, while the design principle of pavements might be used in the sand intervening construction case.

1. INTRODUCTION

Many airports are planned and constructed on ground reclaimed from the sea. The pavements in these airports, as well as those in sea ports, are influenced by settlement due to subsoil consolidation. Interlocking block (ILB) pavements are sometimes used, as they will easily follow the settlement. In addition, they will sustain heavy loads well because they are manufactured with cement concrete, and can be easily repaired. Nevertheless, they are seldom used in Japan due to a lack of performance data against heavy loading conditions.

To encourage their application to these facilities, the structural capacity, one of the most important characteristics, must be revealed. As destructive testing procedures are not only costly but time-consuming, Falling Weight Deflectometer (FWD), one of the nondestructive testing instruments for pavements, is used. FWD can apply load up to 200 kN to pavements through the loading plate with a radius of 225 mm. Pavement deflections caused by this load are measured at seven points, of which the distances from the load center are 0, 30, 40, 600,

900, 1,500, and 2,500 mm. The load is produced by dropping a mass of 450 kg from the given height. The FWD deflections used here are those obtained in the case of the 150 kN load.

Loading tests with FWD have been conducted on two series of experimental pavements ; one, which is aimed at new construction, the other for rehabilitation. The former is planned and implemented to utilize the structural design methods of asphalt pavements for the ILB pavements, and the latter to develop construction procedures of ILB layers.

In this paper, the deflection data measured with FWD on the experimental pavements are described, and their structural properties are then estimated by back-calculating the deflection bowls. As a result, both the structural design principle of ILB pavements and the repair method using ILB layer are mentioned through these analyses.

2. EXPERIMENTAL PAVEMENTS

Two experimental pavement projects were implemented, as mentioned above.

The objective of the first project was to confirm the structural design principle of ILB pavements for port yards [1]. The applicability of the asphalt pavement design method to ILB pavements is mainly considered. In this project, both an ILB section and an asphalt section, which had identical subgrade conditions and base course and subbase structures as shown in Figure 1, were constructed. In the ILB pavement, a 20 mm thick sand bed and 100 mm thick blocks, of which the total thickness was equal to the surface course thickness in asphalt pavement, were placed on a lean concrete layer.

A 143kN wheel load was applied over these two sections up to 22,000 times. After the repeated loading, FWD was used to measure the deflections at and away from the wheel path in the interior and at joints in the lean concrete layer.

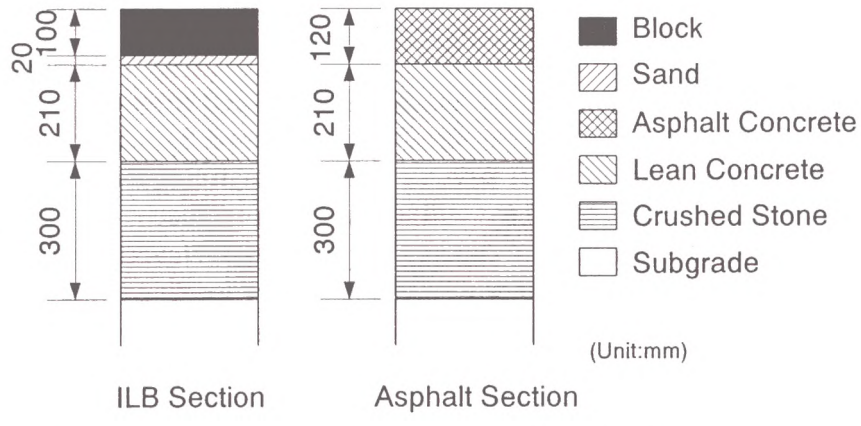

Figure 1 Experimental Pavements for New Construction

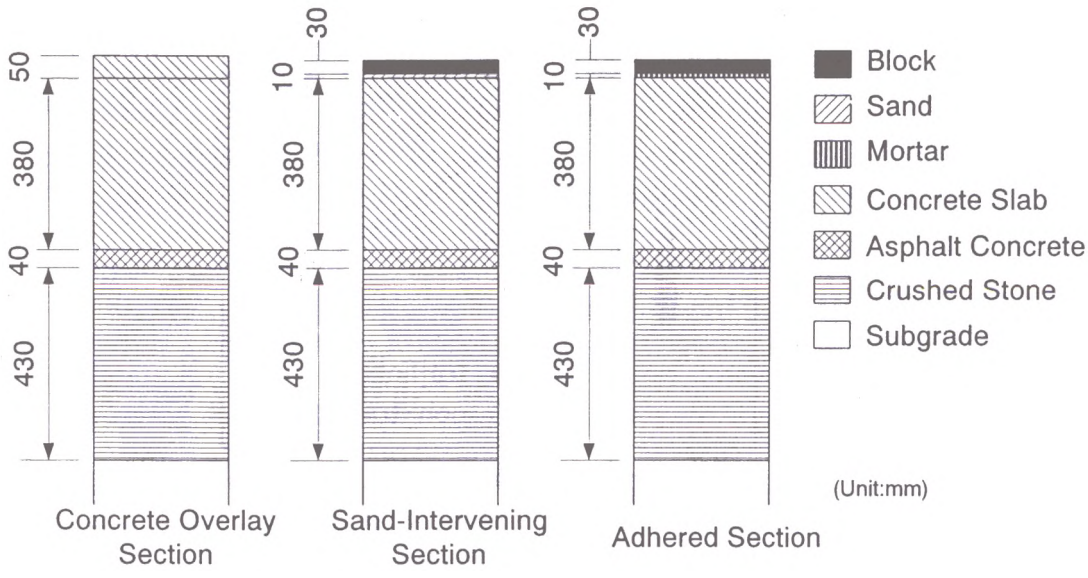

Figure 2 Experimental Pavements for Rehabilitation

The second project was planned to ascertain rehabilitation measures mainly for adjusting the formation of concrete pavements when ground subsidence occurs [2]. Thin blocks are needed not to support the heavy loads but to adjust the formation. ILB layers are constructed on the concrete pavements, of which concrete slab is 380 mm thick, as shown in Figure 2. As the procedure for placing blocks on concrete layers has not been established, two kinds of ILB layer construction procedures were tried; that is, to place blocks after laying sand on the concrete slab, and to paste blocks onto the concrete slab with cement mortar.

A repetitive loading test was conducted on the pavements up to 5,000 times using a loading cart with the landing gear of B-747 aircraft. During the test, the deflections were measured with FWD and the structural capacity was evaluated.

3. NEW CONSTRUCTION

Figure 3 shows deflections at the center of loading plate of FWD, D_0, in three loading points; that is, in the interior, at expansion joints and at contraction joints of the lean concrete base course. The deflections at the contraction joints are similar to those in the interior positions, although the deflections at the expansion joints are larger than those at other points. The deflections in the interior positions might not be influenced by traffic loading applied here.

The linear elastic layered theory is used to analyze the loading tests as the design procedure of asphalt pavements can be adapted to that of ILB pavements for port yards. Figure 4 shows the elastic modulus of ILB layer back-calculated with the LMBS computer program [3]. In this analysis, the ILB layer is supposedly composed of both block and sand layers. As opposed to D_0, the modulus does not largely vary with loading positions in trafficked areas. The traffic loading seemingly increases the structural integrity of the ILB layer from a viewpoint of modulus.

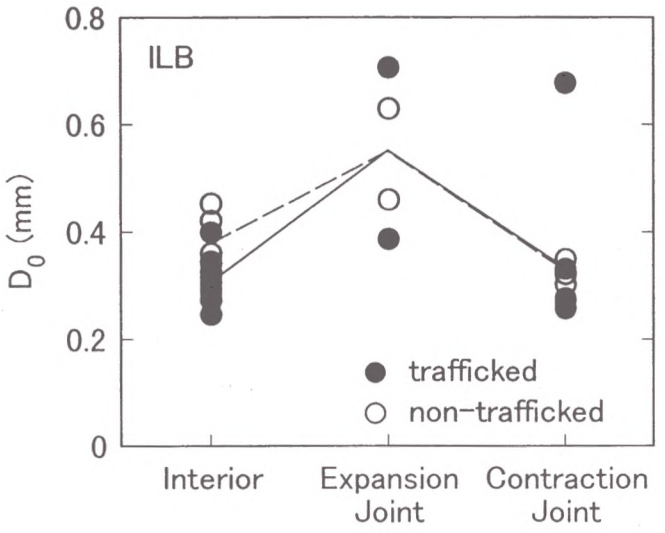

Figure 3 Comparison of D_0 at three positions.

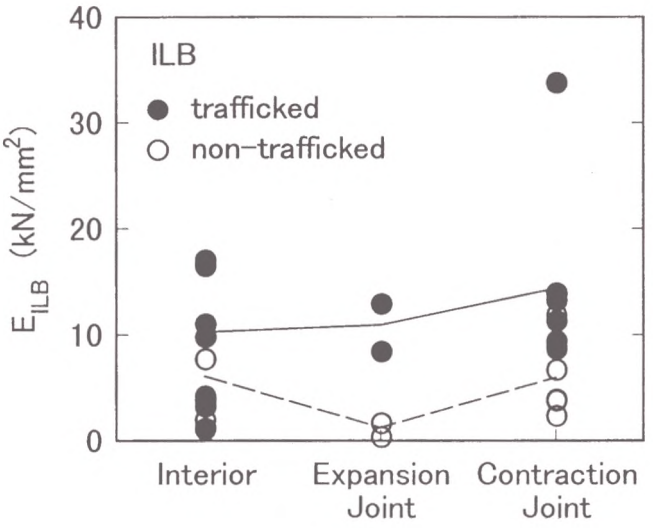

Figure 4 Elastic Modulus of ILB layers

From the above two figures, expansion joints should not be constructed in lean concrete base course. This is corroborated by the fact that the temperature changes within the layer are not so large.

The structural condition of ILB pavements should next be compared with that of asphalt pavements. The relationship of the modulus of surface layer to that of subgrade is expressed in Figure 5. Supposing that the ILB pavement is designed as asphalt pavement, the ILB layer itself might not be structurally equivalent to asphalt concrete layers and a proper correction factor should be introduced. The other layers and subgrade, however, will be designed in accordance with the stipulations for asphalt pavement [4].

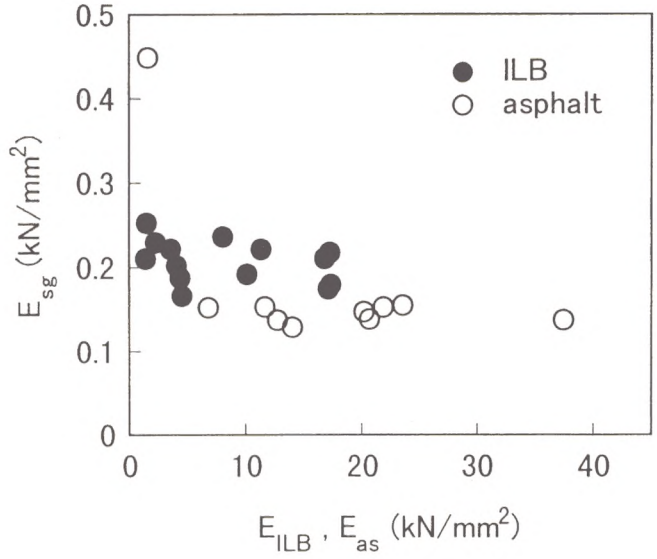

Figure 5 Modulus of Surface Layer and Subgrade

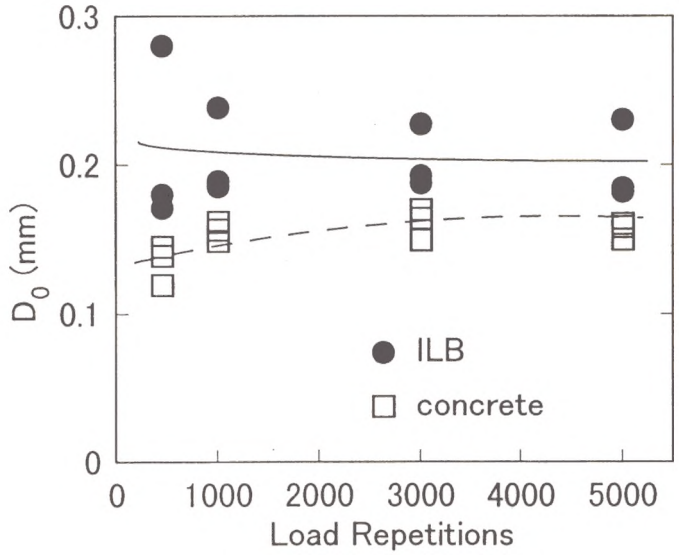

Figure 6 Difference of D_0 in Rehabilitation Procedures

4. REHABILITATION

The maximum deflections measured with FWD, D_0, are different in rehabilitation procedures, as is shown in Figure 6. That is, D_0 at ILB overlay is larger than that at concrete overlay. D_0 does not, however, vary with load repetitions practically.

Through a preliminary analysis of measured deflections, the concrete slab with an overlay layer ought to be considered as a monolithic layer and be presumably supported by Winkler foundations. Thus, the back-calculated method developed by the authors [5] was adapted, of which the results are shown in Figure 7. As estimated from D_0, the elastic modulus of ILB

overlaid slab is smaller than that of concrete overlaid slabs.

A difference in structural capacities due to construction procedures must be defined, as the above figures contain the data obtained at differently constructed sections. As indicated in Figure 8, showing the ratio of D_0 at sand intervening section to that at adhered section, the ratio is larger than 1.0, but decreases with load repetitions. Thus, the structural condition becomes stable after the load repetitions.

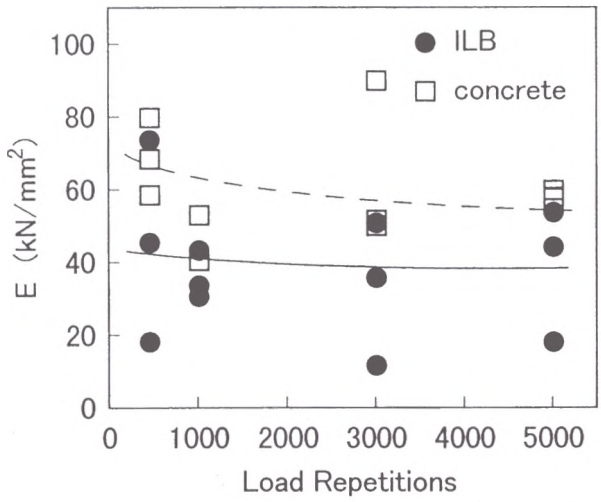

Figure 7 Difference of Elastic Modulus in Rehabilitation Procedures

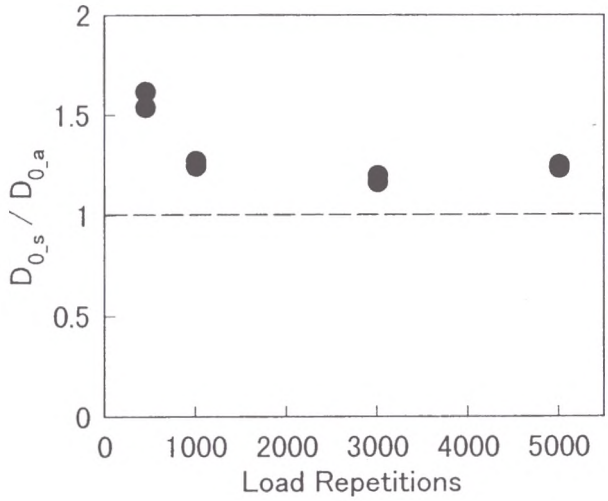

Figure 8 Ratio of D_0 at Differently Constructed ILB Sections

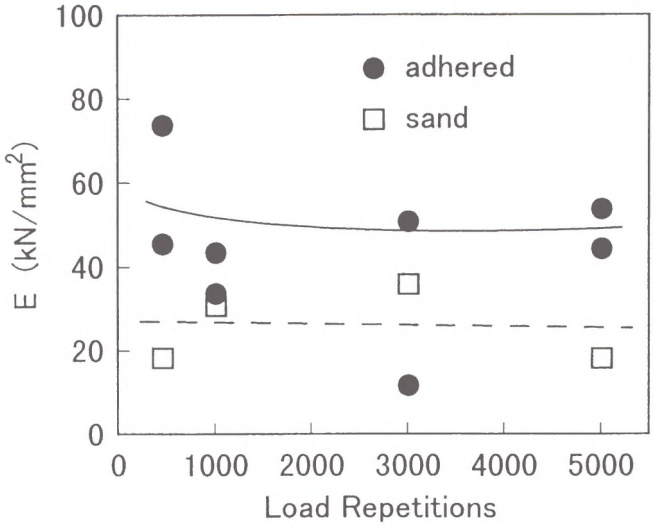

Figure 9 Elastic Modulus at Differently Constructed ILB Sections

The difference in construction procedures influences the back-calculated elastic modulus of layer. From Figure 9, the modulus of adhered section is larger than that of the sand intervening section. This results from the fact that the former is presumably same as bonded overlay, while the latter is an unbonded overlay. The durability of both procedures against repeated loading was verified through this test.

Blocks can be used to rehabilitate concrete pavements, especially when they subside due to ground settlement. In the case of the adhered ILB overlay, the structural design principle should not be the same as that for the bonded concrete overlay[6], as its structural capacity is not equivalent to that of concrete overlay. Thus, a proper correction factor should be introduced in the overlay case. In the case of the sand intervening ILB overlay, the design principle of asphalt pavements might be used, as its mechanical behavior is completely different from that of concrete pavements.

5. CONCLUSION

The structural capacity of ILB pavements for both new constructions and rehabilitations are evaluated by using FWD in this study. The main conclusions are as follows.

(1) In the structural design of ILB pavements for new construction, the design principle for asphalt pavements can be used. ILB layer is not, however, structurally equivalent to the asphalt concrete layer, in which case a proper correction factor should be introduced.

(2) Blocks can be used in concrete pavement rehabilitation. In the case of the adhered construction, the concrete overlay design principle can be used with a proper correction factor, while the design principle of pavements might be used in the case of in the sand intervening construction.

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