THE EQUIVALENT LAYER-THICKNESS OF A CONCRETE BLOCK PAVEMENT

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1. INTRODUCTION

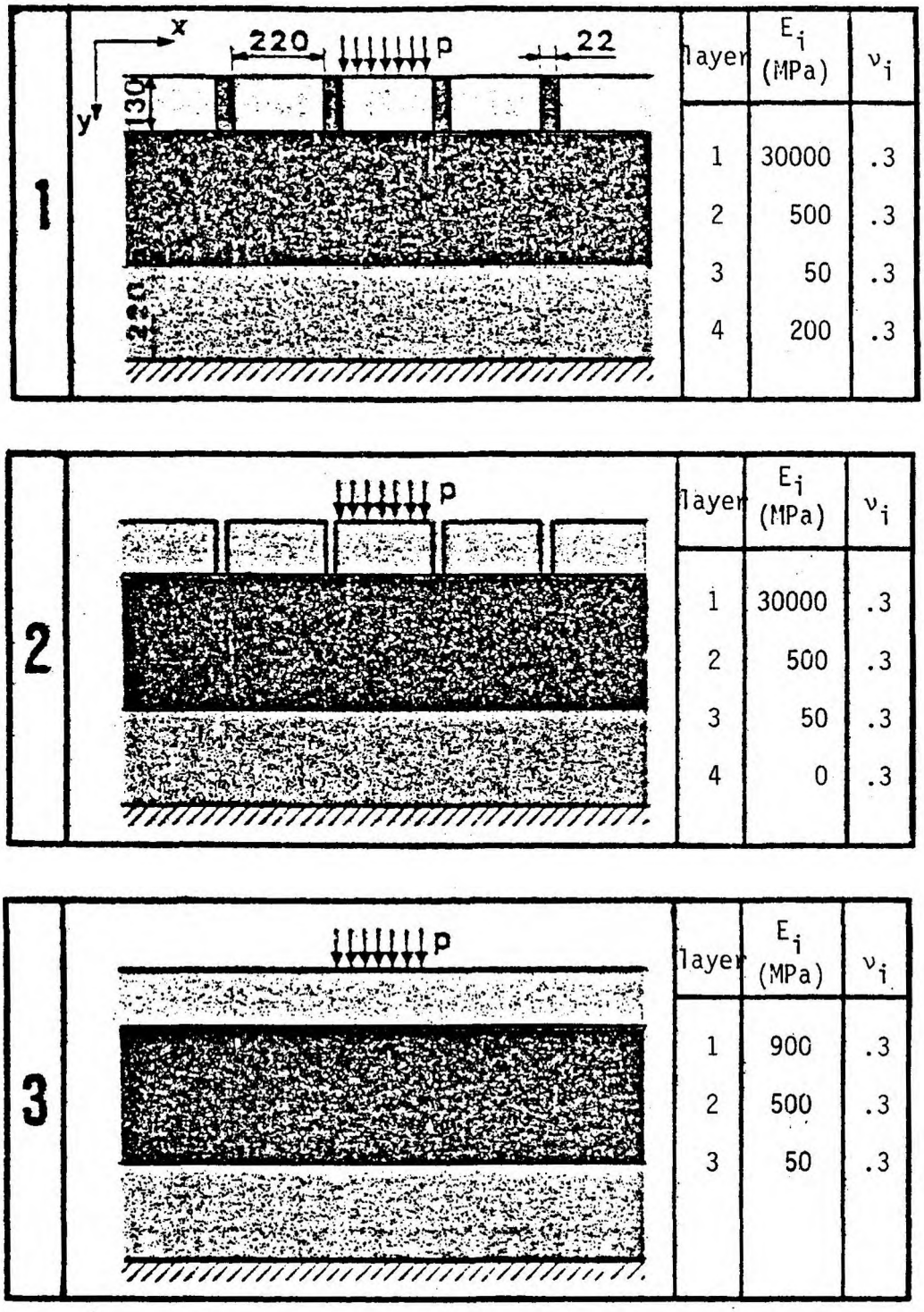
A limited investigation was carried out in order to obtain a better insight into the stress distribution occurring in a concrete block pavement.
To this end a programme was set up enabling the determination of stresses in such a pavement, once the elasticity constants are known; in particular it is possible to simulate the joints between the blocks.
The method of calculation is based upon dividing the solid layer into a network of discrete elements and to derive, by the method of finite differentiation, the displacements of the nodes and from these the stresses.
The pavement structure is supposed to deform in 2 dimensions only according to the Winkler hypothesis.

2. CALCULATION RESULTS

The three pavement structures that were compared are shown in figure 1.
In the structures 1 and 2 E_i $(i = 1,2,3)$ and ν_i $(i = 1,2,3)$ represent the elastic moduli and Poisson coefficients of concrete paving blocks, sub-base and subgrade respectively. E_4 and ν_4 represent the same quantities for the jointing sand; the second structure has no jointing sand between the blocks.
The third structure is a pavement structure consisting of three continuous layers, where the upper layer has a modulus that is much lower than that of the concrete paving blocks themselves, but is often used as an equivalent modulus for the discontinuous layer of paving blocks and joints.

The data that result from the calculations are the maximum tensile stress, both the main stresses, the sum of the main stresses, the orientation of the main stresses and the stresses in the x- and y-direction.
Since many authors consider the stress in the x-direction at the bottom of the sub-base layer as the decisive criterion for design, the distribution of stress σ_x for the different composing materials of the 3 different structures is shown.
Then the equivalent layer-thickness for the upper layer of a three-layered system is considered. To this end the horizontal stress σ_x in the sub-base near the boundary between sub-base and subgrade is determined.

Figure 2 shows the important tensile stresses occurring in pavement structure 1 both at the bottom of the loaded paving blocks and at the bottom of the sub-base.
Figure 3 indicates that in pavement structure 2 the tensile stresses at the bottom of the sub-base have strongly increased (punching through of the single block).
Figure 4 indicates that in pavement structure 3 the tensile stresses occur as well at the bottom of the upper layer as at the bottom of the sub-base.



	layer	E_i (MPa)	ν_i
1	1	30000	.3
	2	500	.3
	3	50	.3
	4	200	.3
2	1	30000	.3
	2	500	.3
	3	50	.3
	4	0	.3
3	1	900	.3
	2	500	.3
	3	50	.3

Figure 1. Calculated concrete block pavement structures.

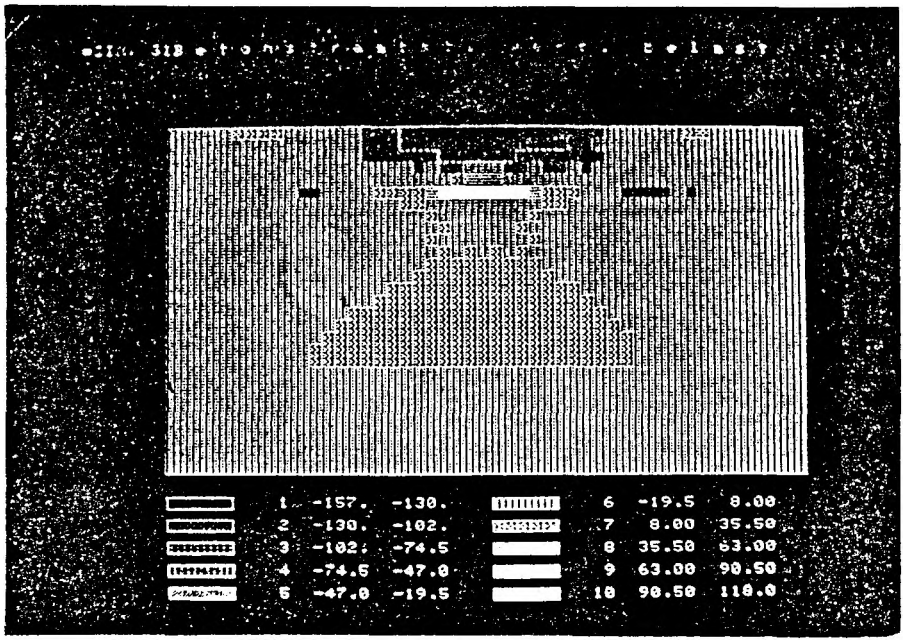


Figure 2. Stresses σ_x in pavement structure 1 (upper layer 130 mm).

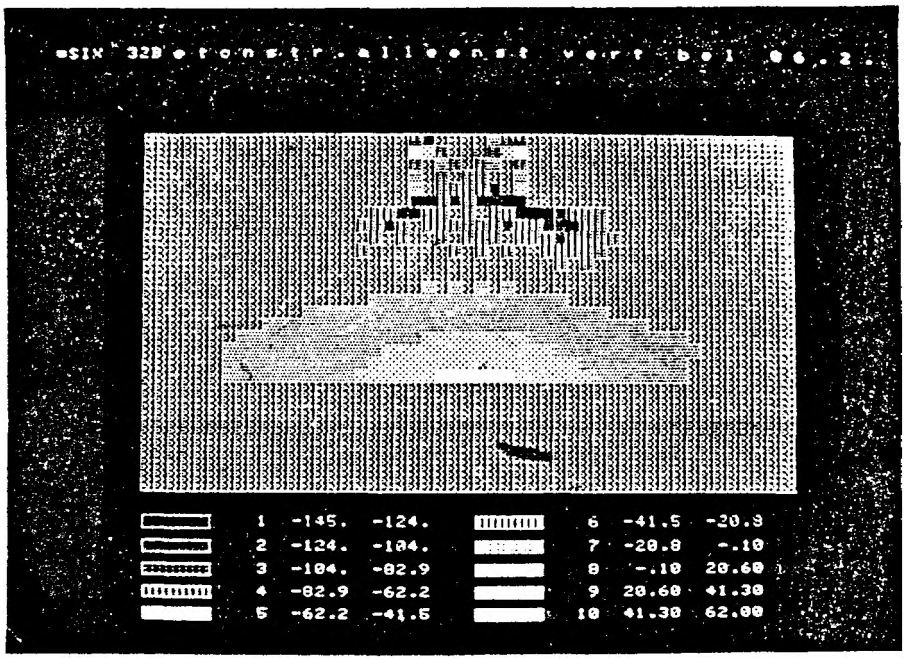


Figure 3. Stresses σ_x in pavement structure 2 (upper layer 130 mm).

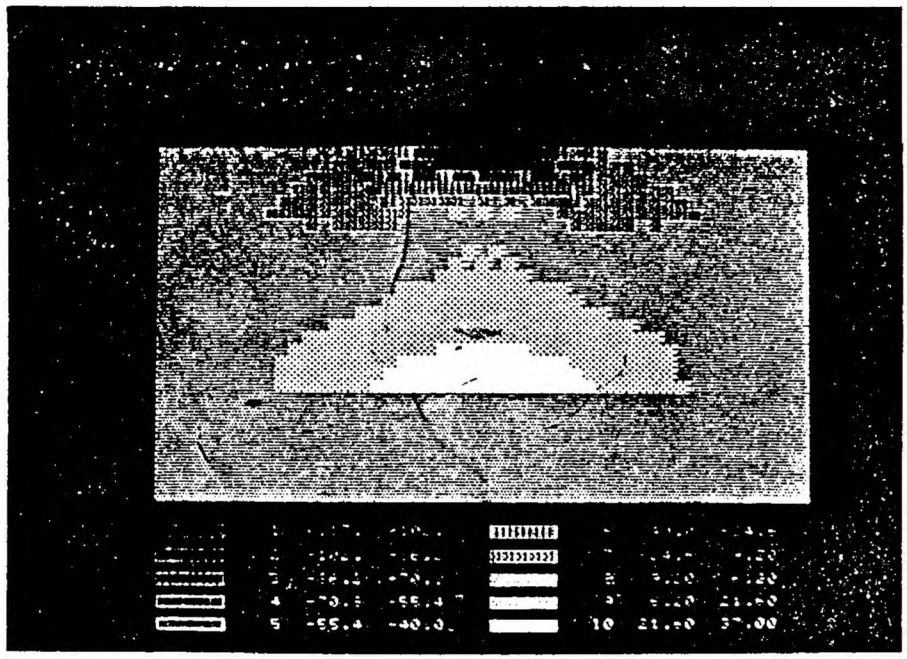


Figure 4. Stresses σ_x in pavement structure 3 (upper layer 130 mm).

In order to obtain an even clearer picture of the stress distribution, in figure 5 the stresses along the axis of symmetry for the three pavement structures are shown.

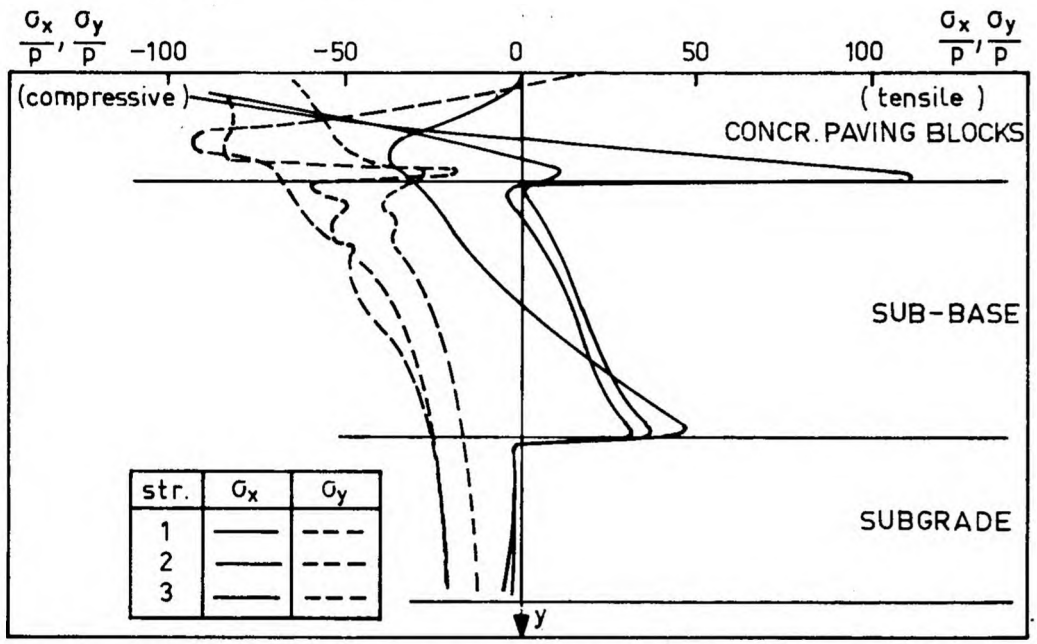


Figure 5. Stresses σ_x and σ_y in structures 1, 2 and 3 along the axis of symmetry.

From figure 5 it is concluded that the stresses at the bottom of the sub-base are well comparable for the structures 1 and 3 but, however, this does not hold for the stresses at the bottom of the paving blocks

and the equivalent upper layer respectively.
With the aim to determine the equivalent thickness of the upper layer, the calculations were made again for different thicknesses of the upper layer, in order to obtain the same distribution of stresses at the bottom of the sub-base, more in particular on the axis of symmetry.
This is even more clearly illustrated by comparing the stress distribution for σ_x in structure 1 (figure 2) and that for the equivalent structure type 3 with an upper layer of 195 mm (figure 6).

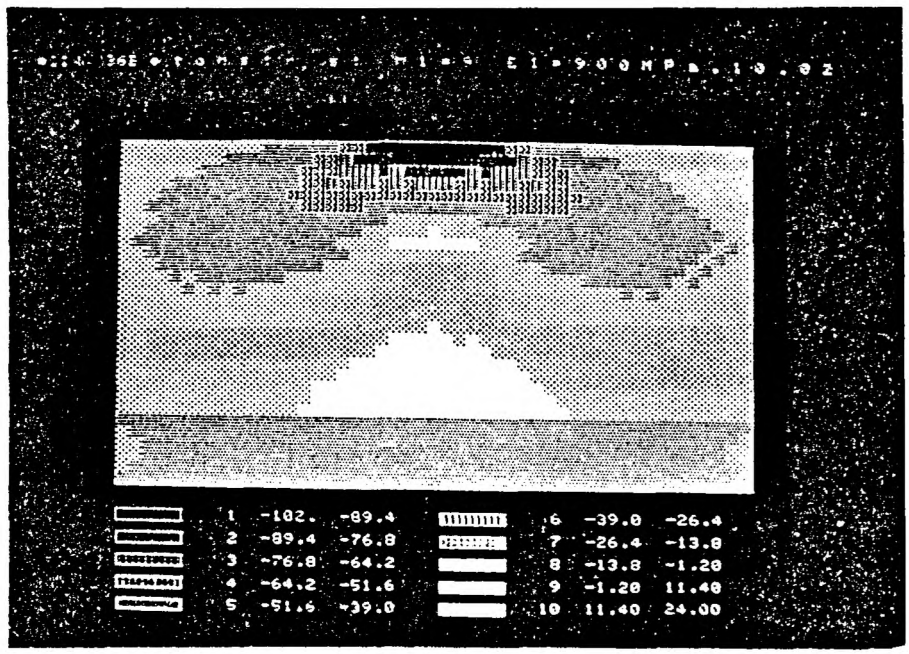


Figure 6. Stresses σ_x in pavement structure 3 (upper layer 195 mm).

3. CONCLUSIONS

It is possible to simulate by means of a computer programme the influence of the transfer of stresses occurring between concrete paving blocks and to determine, theoretically, the equivalent layer thickness of the upper layer in a three-layered system.

REFERENCE

U.K. Research into Concrete Block Pavement Design
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