THE NAMUR TEST ROAD: BEHAVIOUR OF VARIOUS TYPES OF CONTRACTION JOINTS AFTER 17 YEARS OF TRAFFIC

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1. INTRODUCTION

During the application of a concrete overlay on an existing bituminous pavement of State road N 4 (Brussels-Luxemburg) in the Belgian province of Namur, a part of the job site was reserved for conducting an experiment to be monitored by the PIARC Technical Committee on Concrete Roads (1).

The object of this experiment is to compare the behaviour in time of various types of contraction joint on the same site, in a region with varying and sufficiently severe seasonal weather conditions.

The test site consists of 4.5 km of road with two separate two-lane carriageways. At the time of opening (November 1979), daily traffic consisted of 17,000 vehicles, including 2,500 heavy vehicles. This volume increased to 20,000 vehicles/day in December 1988, but then dropped by about 50 % as a result of the opening of the nearby motorway E 411.

Many observations and measurements were performed by the Belgian Road Research Centre, mainly to assess the behaviour of the joints under traffic at different ages of the pavement (1, 2, 3). This paper briefly redescribes the 1979 experiment and presents the main conclusions that can be drawn after 17 years of traffic. Although the structural behaviour of the pavement can be assessed as excellent, it has been overlaid in 1996, mainly for rolling noise reduction, by a porous asphalt wearing course.

2. DESCRIPTION OF THE EXPERIMENT

The main object of the experiment is to compare the behaviour of various types of contraction joint over a period of time.

Six different types of joint were constructed :

- joints with evenly spaced dowels, both sealed and unsealed ;
- joints with variably spaced dowels, both sealed and unsealed ;
- undowelled joints, both sealed and unsealed.

All transverse joints are of the contraction type and were made by sawing a crack inducer 4 mm wide and between 75 and 80 mm deep. The dowelled joints are perpendicular to the road centre line, whereas the undowelled joints were skewed to 80° in order to avoid the simultaneous passage of wheels mounted on the same axle.

Combining the variables led to the construction of twelve different test sections, each 750 m long. Their main characteristics are summarized in Table I. It should be noted that on about half of the sections, those marked "B", an extra half a metre was added to the width of the outer slabs. This extra width has been kept free of traffic by suitable road markings.

In order to avoid the retention of water seeping in under the slabs or the hard shoulder, a thick course of porous lean concrete was laid under that shoulder. This course is about 20 cm thick and provided with outlets every 10 m. It is highly

permeable to water (15 to 20 % of voids) and confined between two impervious courses in bituminous concrete : the overlying layer is a wearing course in asphalt concrete (about 5 cm thick), while the underlying layer is a 6 cm thick course in dense bituminous macadam finished to the level of the old pavement of the carriageway and thus also to that of the base of the new concrete slabs. A cross section of the structure is presented in figure 1. Figure 2 illustrates the lay-out of dowels with even or variable spacings.

3. OBSERVATIONS AND MEASUREMENTS

3.1 Joint Activity - Opening And Closing Movements

Periodic measurements of opening and closing movements were carried out in the first few years after opening to traffic on 20 consecutive joints in each test section ; they showed that only some of the joints were active. The location of the active joints does not show any regularity in occurrence. In contrast, there is a satisfactory correspondence between the location of the active joints and that of the joints which were observed to crack a few days after concreting.

The average value observed for all the sections and whatever the type of joint is 35 % of active joints or, roughly speaking, one active joint in three. This leads to the conclusion that exact predictive calculations of joint opening and closing movements are illusory with such structures. However, the sum of the movements of 20 consecutive joints, i.e. over a pavement length of 100 m, is more or less constant in the various sections and corresponds with the thermal expansion and shrinkage of the concrete. As a result, the openings of the active joints are sometimes wider than expected and this is bound to affect the transfer of shearing actions exerted by passing loads, as well as the life of the seals.

3.2. Slab Rocking At The Joints

a) Method Of Measurement

Determining the amplitude of the vertical displacements of the slab ends when subjected to the passage of a heavily loaded axle makes it possible to assess the effectiveness of load transfer at the joint and to draw conclusions about the foreseeable development of the pavement under traffic.

This experimental technique makes it possible to distinguish between concrete pavement construction variants without having to wait for the appearance of clear signs such as the development of stepping, pumping at the joints, cracking or breaking of slabs, etc.

The technique used on the N 4 State road consists of placing an apparatus comprising a vertical displacement sensor on both sides of the joint to be examined, and allowing an axle loaded to 13 t to pass slowly over the joint. After appropriate processing, the electric signal from the displacement sensor is recorded on tape for later use (4).

The displacement determined by this procedure is thus the displacement of the end of one slab with respect to the opposite end of the adjacent slab (figure 3)

- with the axle stopped on the upstream slab (position A), the displacement measured is $Z_{1A} - Z_{2A} = l_1$
- with the axle stopped on the downstream slab (position B), the displacement measured is $Z_{2A} - Z_{1B} = l_2$

When the axle passes over the joint, a measurement is made of slab rocking $b = l_1 + l_2$.

The amplitude of slab rocking thus obtained at a given moment does not represent an invariable characteristic of the pavement but is subject to a series of more or less significant factors, such as :

- the extent to which the crack in the joint is open, which is related to the mean temperature of the concrete
- the presence of any curvature in the slabs, related to the existence of a vertical temperature gradient in the slab
- the distance of the load from the edge of the slab

The first two factors should be accommodated by making measurements only under favourable conditions, i.e. at air temperatures lower than 10°C. Continuous measurements of opening and closing movements of the joints have shown that gradual blockage occurs when the temperature measured at mid-depth in the slab exceeds 20°C (2).

Practical experience has indicated that slab rocking amplitudes :

- of 0.1 mm or less correspond to pavements giving no reason to harbour any fears with regard to their immediate future
- between 0.1 and 0.25 mm are observed on pavements in good general condition
- of the order of 0.5 mm or more correspond to defective pavements requiring maintenance work

b) Results And Conclusions

The results of slab rocking measurements carried out in March 1996 on 20 consecutive joints in each test section are presented in figure 4. It should be mentioned that the temperature at mid-depth in the pavement, measured by means of thermocouples embedded in the concrete, varied between 0 and 5°C.

Table II shows the average value of slab rocking for each section, as well as the numbers of joints where slab rocking is greater than 0.01 and 0.02 mm, respectively.

The following conclusions can be drawn :

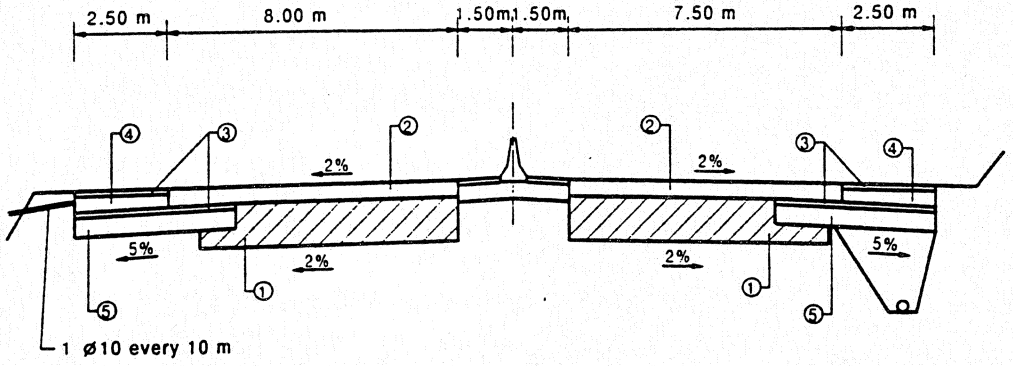
1. The amplitudes of slab rocking measured after 17 years of traffic remain extremely low on all the test sections. With only a few exceptions, slab rocking is lower than 0.1 mm for all the joints examined. In view of the criteria set above, the behaviour of the pavement can be considered as excellent regardless of the structural variant of the joints, whether they were dowelled or not, sealed or not, etc.

2. This conclusion should - it must be added - be related to the design of this thick concrete overlay (20 to 23 cm) on a still sound bituminous pavement, and the provision of efficient drainage of infiltrated water by a porous concrete base under the hard shoulder.

3. Careful examination of the results measured on carriageway A shows a significant but logical difference in behaviour between the sections with undowelled joints and those with evenly or variably spaced dowels in the joints. Although the observed values are very low in all cases and therefore have no immediate effect on pavement performance, there clearly seems to be a difference in the effectiveness of load transfer between the three types of joint. This difference is marked both by the average amplitude of measured slab rocking movements and by the number of joints where slab rocking is greater than 0.01 and 0.02, respectively.

4. A similar trend can be observed on carriageway B. In spite of the presence of an extra width, and hence reduced stresses at the edge of the pavement, the amplitude of slab rocking is in the same range as on carriageway A. It can be noted that, among the sections with dowelled joints, the greatest movements were observed on section VIB where the slabs are between 5.5 and 6 m long. Without allowing definite conclusions in this respect - the amplitude of the movements measured is too low - these observations could point to an influence of slab length and hence, the average opening width of the joints on slab rocking. However, the values measured on section VB where slab length varies between 3 and 4 m, are in the same range as those on the other sections which were constructed with undowelled joints.

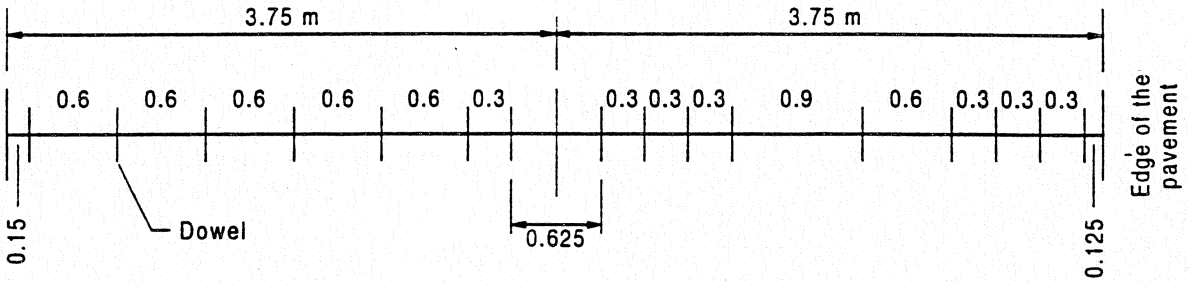
5. A comparison between similar sections with sealed and unsealed joints does not reveal any influence of sealing on pavement behaviour. This finding should however be related, on the one hand, to the adhesion between the bituminous base and the concrete overlay, and, on the other, to the effective drainage of water seeping in through the unsealed joints.



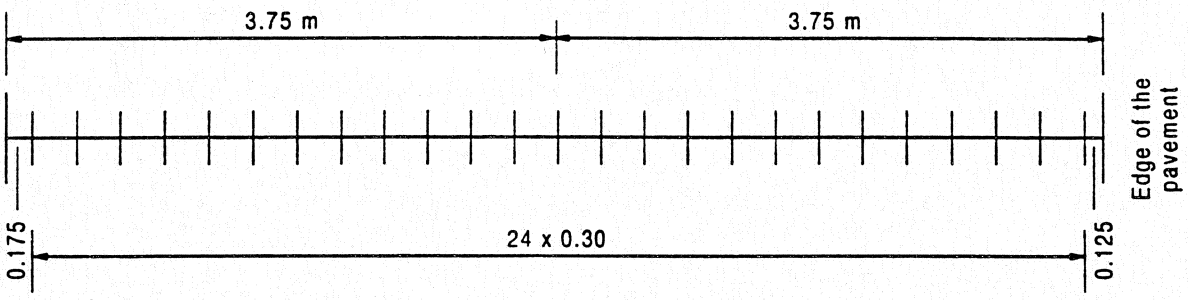
1. Existing bituminous pavement
2. Concrete pavement (20 or 23 cm)
3. Bituminous surfacing 5 cm
4. Lean porous concrete
5. Lean concrete (20 cm)

CRR-OCW WR 17145

Figure 1 : Standard cross section of the pavement



b/ at variable spacing



a/ at constant spacing

CRR-OCW WR 14808

Figure 2 : Lay-out of dowels (Ø = 25 mm, l = 60 cm)

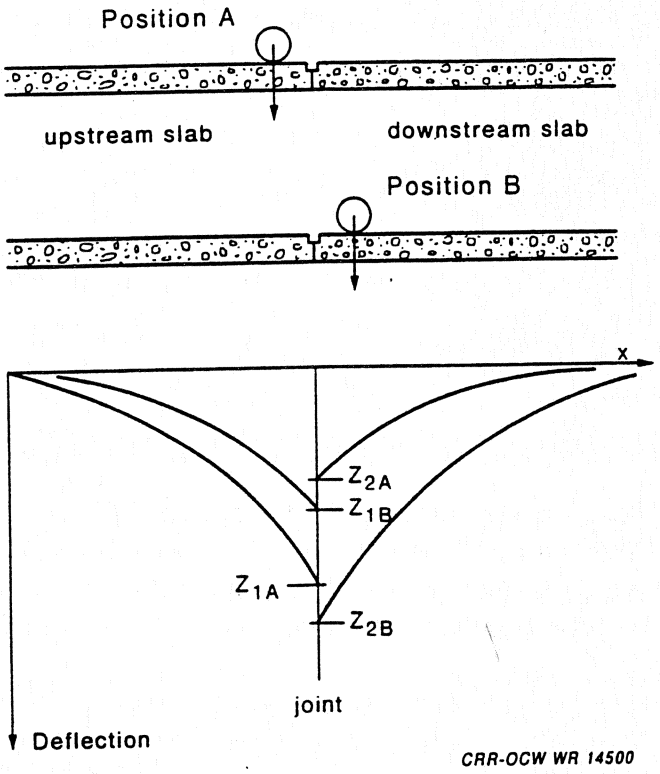


Figure 3 : Deflection of slabs at the passage of a load

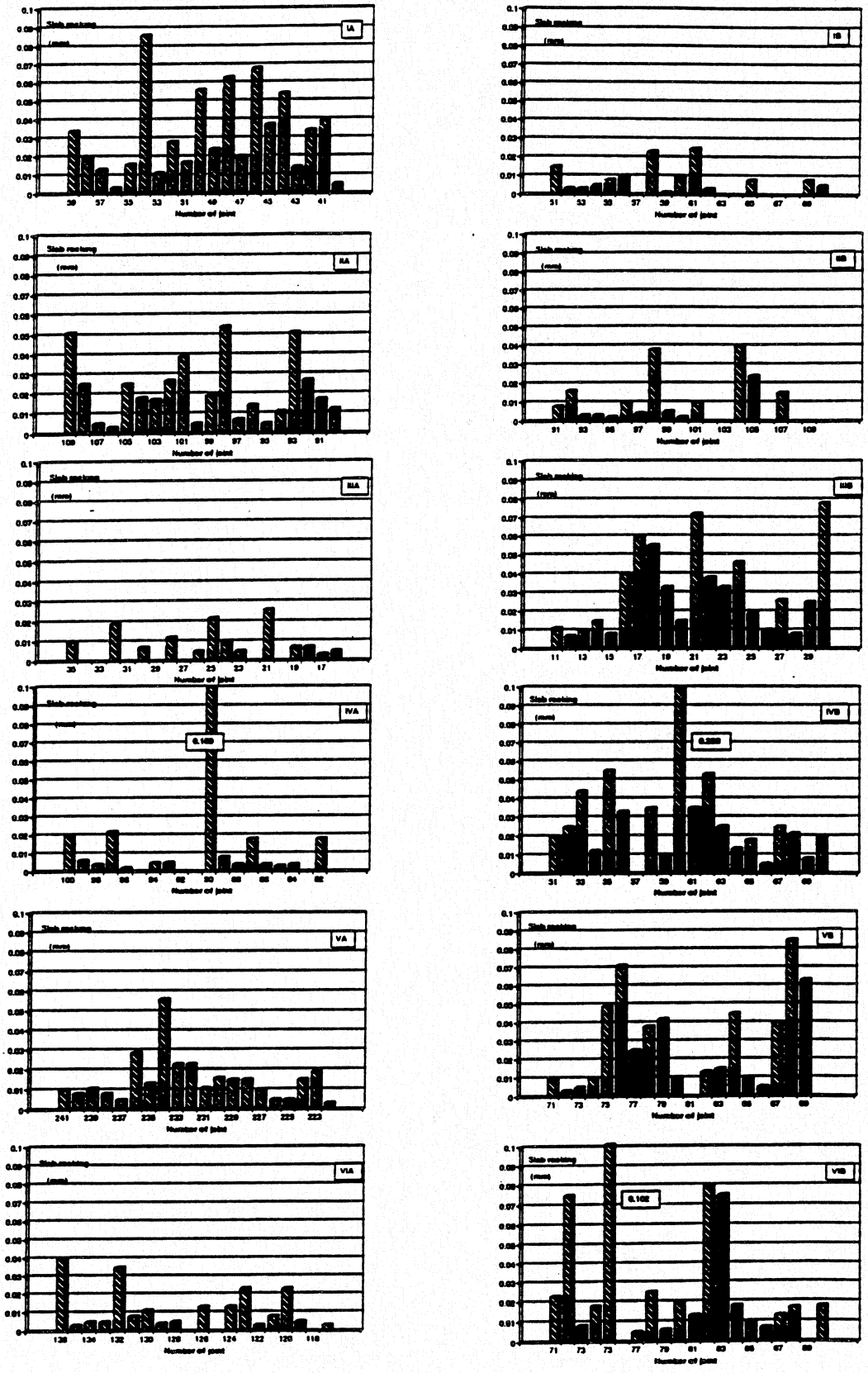


Figure 4 : Slab rocking (March 1996)

TABLE I : Geometric characteristics of the test sections on the N 4 State road at Assesse

Section No.	Slab width (m)	Slab length (m)	Slab thickness (cm)	Type of joint	Joint seal
I A	2 x 3,75	5	min. 23	undowelled	sealed
II A	2 x 3,75	5	min. 23	undowelled	unsealed
III A	2 x 3,75	5	min. 20	evenly spaced dowels	sealed
IV A	2 x 3,75	5	min. 20	evenly spaced dowels	unsealed
V A	2 x 3,75	5	min. 20	variably spaced dowels	sealed
VI A	2 x 3,75	5	min. 20	variably spaced dowels	unsealed
I B	3,75 + 4,25	5	min. 20	evenly spaced dowels	sealed
II B	3,75 + 4,25	5	min. 20	evenly spaced dowels	unsealed
III B	3,75 + 4,25	5	min. 23	undowelled	sealed
IV B	3,75 + 4,25	5	min. 23	undowelled	unsealed
V B	3,75 + 4,25	3 an 4*	min. 23	undowelled	unsealed
VI B	3,75 + 4,25	5,5 and 6 altern.	min. 20	evenly spaced dowels	sealed

* repeated sequences : 3 - 3,5 - 3,2 - 4 - 3,8 - 3 - 4 - 3,5 - 3,8 - 3,2 m

TABLE II : N 4 State road at Assesse - Slab rocking (March 1996)

Carriageway	A						B					
Section nr	I	II	III	IV	V	VI	I	II	III	IV	V	VI
Characteristics Dowels (1) Sealing (2) Slab length in m	UD S 5	UD US 5	ED S 5	ED US 5	VD S 5	VD US 5	ED S 5	ED US 5	UD S 5	UD US 5	UD US 3-4	ED S 5,5&6
Average slab rocking in mm (20 consecutive joints)	0,032	0,022	0,007	0,006	0,015	0,010	0,006	0,009	0,030	0,024	0,027	0,027
Slab rocking > 0,01 mm (number of joints)	18	15	6	5	14	7	5	7	17	17	15	14
Slab rocking > 0,02 mm (number of joints)	13	8	2	3	4	4	2	3	11	13	9	7

(1) ED = evenly spaced dowels; VD = variably spaced dowels; UD = undowelled

(2) S = sealed; US = unsealed

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