Continuously-Reinforced Concrete Pavement in California After Eight Years Service

BAILEY TREMPER, Supervising Materials and Research Engineer,
California Division of Highways

An experimental continuously-reinforced concrete pavement one mile in length was constructed in California in 1949. After eight years of heavy traffic, it remains in good condition. Adjacent sections of non-reinforced jointed pavement constructed at the same time are also in relatively good condition, with the exception of a moderate amount of faulting at a few joints. The experimental pavement has not reached sufficient age to warrant comparison with non-reinforced pavement on an economic basis.

● IN 1949, the California Division of Highways constructed a test section of continuously-reinforced portland cement concrete pavement one mile in length as part of a project involving non-reinforced pavement with weakened-plane joints at 15-ft intervals. In both the regular and experimental sections the pavement was 24 ft wide and 8 in. thick, constructed lane-at-a-time. The pavement forms one side of a four-lane divided expressway. The experimental section was divided into two equal lengths containing, respectively, 0.50 and 0.62 percent of reinforcement consisting of ½-in. round, deformed billet-steel bars. The reinforcement was continuous through the two portions.

A detailed description of the test project, its instrumentation, and the observed results up to the end of the first year, was reported by Stanton (1). The purpose of the present report is to record the comparative condition of the experimental section and the adjacent non-reinforced sections after eight years of service.

In 1949 the total traffic over the section in one direction was 6,000 vehicles of all types per day. In 1956 the total traffic in one direction was 9,000 vehicles per day, of which 14 percent consisted of heavy trucks and buses. Legal load limits in California are 18,000 lb per single axle and 32,000 lb for tandem axles.

The average uncracked slab length in the outer lane of Section 2 of the reinforced pavement was 4.2 ft in 1950. By 1957 the average length had decreased to 3.2 ft. All of the cracks appear to be tight, with little or no spalling. None shows evidence of pumping. Figure 1 shows one of the most prominent cracks in the reinforced section. Figure 2 shows a typical weakened-plane joint in the section adjacent to the reinforced section. Figure 3 shows a random crack in the non-reinforced pavement.

Movement of the pavement in a longitudinal direction has been measured several times. The results are summarized in Table 1. Longitudinal movement has been confined to a distance of about 400 linear ft at each end.

In June 1957, the reinforced section was 0.98 in. longer than in June 1950. The change took place in about 800 linear ft of pavement. Such an increase could be attributed entirely to thermal expansion only if the pavement temperature in June 1957 was about 18 degrees higher than in June 1950. The actual pavement temperatures are not known. The effects would have been difficult to evaluate, because the entire series of measurements required several days to complete. It must be recognized as a possibility that at least part of the observed increase in length was permanent.

Terminal joints 4 in. wide were constructed of multiple plies of preformed expansion joint filler. The joints have been sealed a number of times and remain in good condition.

Closure of the terminal joints was always greater than the increase in length of the reinforced pavement. This indicates that pressure was being exerted against the jointed pavement at each end. Measurements indicate that the jointed pavement was shortened through a distance of about 300 linear ft from the terminal joint.

Random cracks did not form between installed gage points and no record of their width is available. There were, however, eight pairs of gage points that were installed to span weakened-plane joints and their movement may be considered to be representative of

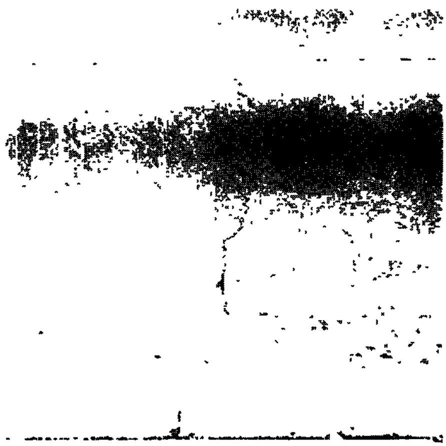

Figure 1. A prominent crack in the continuously-reinforced pavement.

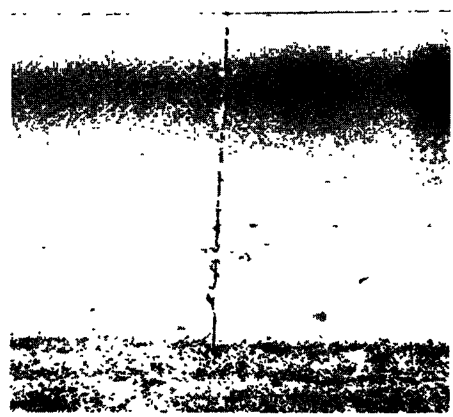

Figure 2. A typical joint in the non-reinforced pavement.

that of the random cracks. Average measured openings are given in Table 2. It will be noted that the joints were not closed as tightly in June 1957 as in June 1950. This finding may afford confirmation of the possibility that the reinforced section has increased permanently in length, as discussed in connection with longitudinal movement.

The condition of the continuously-reinforced pavement after eight years of service appears to be excellent. A comparison of its performance with other pavements of the same age and subjected to the same traffic is afforded by profilograph records of the reinforced section and adjacent portions of the non-reinforced jointed sections placed under the same contract. Throughout the length of the entire pavement there are a number of surface irregularities due to settlement of fills adjacent to culverts. Such portions have been eliminated from consideration.

Figure 3. One of a very few random cracks in the non-reinforced pavement.

Stanton included profilograms (1, Fig. 20) showing short sections of reinforced and non-reinforced pavement. The 10-ft profilograph used at that time (1950) has been superseded by one of 25-ft wheelbase. The shape of the trace produced by the two instruments is somewhat different and simple comparisons are difficult to make.

Short sections of profilograms obtained during the afternoon of June 25, 1957, are shown in Figure 4. These sections include those shown in Stanton's Figure 20. They are fairly representative of the entire reinforced and non-reinforced sections other than those affected by settlement at cross culverts. It will be noted that a moderate amount of faulting is indicated at a few of the joints in the non-reinforced section.

Faulting less than 0.1 in. cannot be

TABLE 1

SUMMARY OF PAVEMENT LONGITUDINAL MOVEMENT MEASUREMENTS

Date	Age (months)	Change in Length of Reinf Section (in.)	Change in Combined Width of Terminal Joints (in.)
May 1949	0	0	0
Dec. 1949	7	-0.50	-0.16
June 1950	13	+0.69	-1.22
Nov. 1950	18	-0.08	-1.72
Jan. 1951	20	-0.41	-0.99
Mar 1952	34	-0.09	-1.35
June 1957	97	+1.67	-3.62

measured accurately from profilograms and only those of greater magnitude are considered in the following discussion. Such faulting has developed only in the non-reinforced section lying east of the reinforced section. In this portion, faulting of 0.10 in. or more has developed in the outer (driving) lane at 17 percent of the joints. The average faulting at these joints is 0.14 in. This faulting and random cracks in 6 percent of the slabs are the only evidence of distress in the non-reinforced pavement.

TABLE 2

AVERAGE MEASURED CRACK OPENINGS

Date	Crack Opening (in.)
Dec. 1949	0.013
June 1950	0.003
Nov. 1950	0.009
Jan. 1951	0.014
Mar. 1952	0.009
June 1957	0.009

Individual opinions as to the relative riding comfort of the two types of pavement are not entirely consistent, probably because of the influence of settlements and because both pavements would be rated as "smooth". An effort has been made to develop a numerical measure of riding comfort from profilograms. Tentatively it has been concluded that noticeable discomfort is felt by automobile passengers only when profilograms show deviations in excess of 0.2 in. from a plane established by the moving wheelbase of the profilograph.

An expression termed the "profile index" is obtained by using a 0.2-in. blanking band on the profilogram, totaling all deviations in excess of this amount, and expressing the result in terms of inches per mile. A composite of personal impressions of many miles of both asphaltic and portland cement pavements indicates that a profile

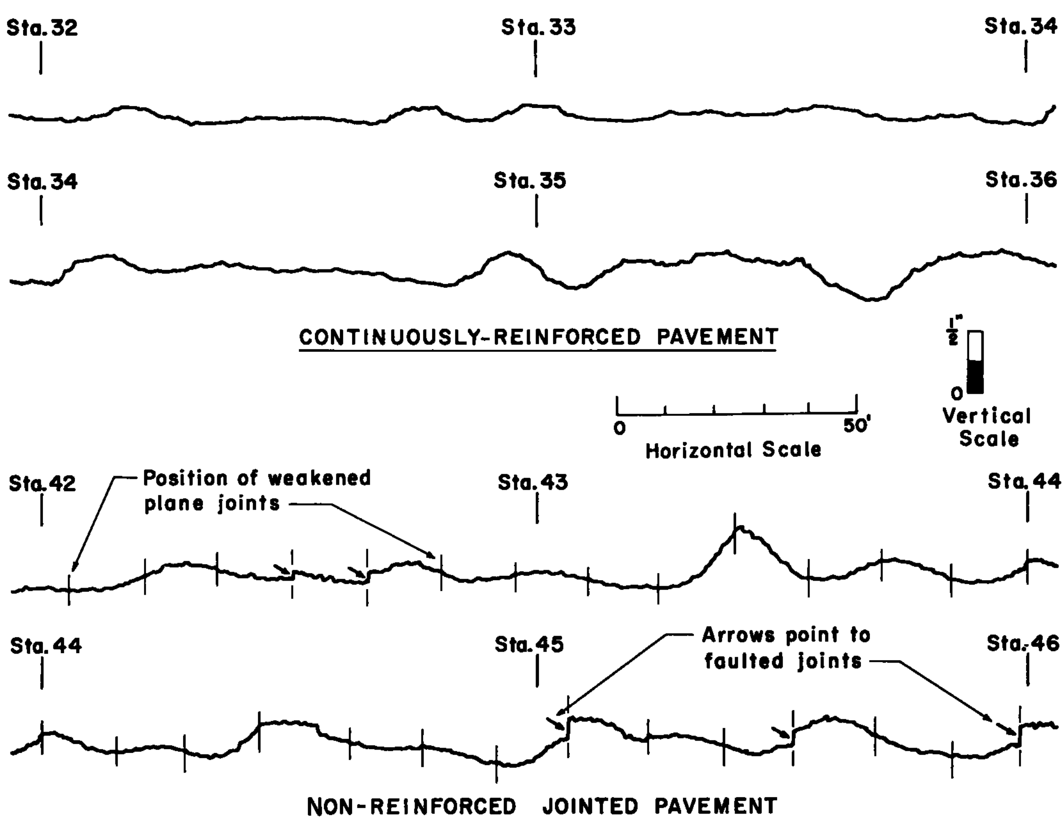

Figure 4. Profilograms of outer (driving) lane taken afternoon of June 25, 1957, temperature 103 F; Fairfield test section.

index of 10 in. or less is typical of well-finished new pavements or of older pavements that have remained exceptionally smooth. If the profile index is greater than 40, the pavement is rated as unquestionably rough and uncomfortable to passengers in automobiles. Present profile indices for the pavements in question, after eliminating irregularities due to local settlements, are 12.6 for both the reinforced and non-reinforced sections. The index does not take account of the moderate faults that have developed in portions of the non-reinforced pavement, some of which may be noticed by more sensitive passengers.

From the standpoint of riding comfort, it cannot be concluded that at present the reinforced section is definitely superior to the non-reinforced pavement. Structurally there is some evidence that the non-reinforced pavement is deteriorating at a slightly greater rate, but at present the difference in performance is not of sufficient magnitude to warrant a conclusion as to the economic value of the continuous reinforcement. It will be recognized, of course, that the comparison is made between pavements of equal thickness supported on presumably equal subgrades, not between pavements of comparable cost.

REFERENCE

1. Stanton, T. E., "Reports on Experiments with Continuous Reinforcement in Concrete Pavements—California." HRB Proc., 30:28 (1950).