Cracking and Seating of Concrete Pavement on I-74

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Cracking and seating is becoming a popular technique for reducing reflective cracks in asphalt overlays over deteriorated concrete pavements. Indiana initiated an experimental project on I-74 in the spring of 1984 to study the potential of cracking and seating. The performance of the asphalt overlay is described 5 years after implementing the technique. Cracking and seating prevented at least 75 percent of the reflective cracks that normally occur at 5 years of service life. Adding fibers to the asphalt overlay mixture over cracked and seated sections resulted in further prevention of reflective cracks, maintained the structural strengths both of the pavement and of its support, and may have reduced the formation of blowups. Furthermore, the number of blowups per mile in the cracked and seated sections was reduced by 50 percent over the control sections, which were not cracked and seated.

Many of the nation's highways are constructed with concrete pavements. These concrete pavements deteriorate with age, and resurfacing becomes necessary to restore rideability, structural strength, and skid resistance. Asphalt overlays have been a popular and practical choice for most resurfacing. However, experience has shown that an asphalt overlay usually develops a cracking pattern that reflects the one existing in the old concrete. Such cracks are referred to as "reflective cracks."

Reflective cracks are mainly initiated and propagated by thermally induced and traffic-induced stresses (*1*). Thermal contraction of the underlying concrete causes tensile strains in the asphalt overlay; cracks form whenever the tensile capacity is exceeded. The differential vertical deflections of the concrete pavement at cracks and joints under traffic loads also help propagate reflective cracks.

Preventing, or at least reducing, reflective cracks helps to prolong the service life of an asphalt overlay and reduces maintenance costs. Over the years, many techniques have been developed to try to control reflective cracks. One technique currently used by many states involves cracking and seating the old concrete pavement before overlaying it with asphalt. This technique has potential for reducing reflective cracks. The process of cracking and seating consists of breaking the old concrete slabs into small pieces and pressing these pieces down by rolling with heavy rollers.

The effectiveness of the cracking results from having smaller concrete slabs that undergo reduced thermal length changes and therefore induce smaller thermal strains in the asphalt overlay. Seating the cracked pieces also reduces the differential vertical deflections at cracks.

As a supplementary treatment to further reduce reflective cracks, part of this experiment contains polypropylene fibers in the asphalt overlay. This addition of fibers to the overlay is intended to increase its tensile strength.

A description of roadway conditions following 5 years of service follows. Past experience indicates that development of reflective cracking in overlays, at this point in the pavement's life, has sufficiently stabilized so that the data obtained can be used to evaluate the merit of most crack reduction techniques. However, the previous five winters in Indiana were not severe and reflection cracking in general was slow to develop (*2–4*).

The original condition of the concrete pavement in this study was quite good between joints and cracks, but elsewhere it was in an advanced stage of deterioration because of D cracking. Pavement drainage did not appear to be a general problem, but localized areas with poor drainage did exist. Drainage was upgraded during construction of this contract and can be considered at this time to be good.

OBJECTIVES

The objectives of this experimental study are as follows:

1. To evaluate the effectiveness of the cracking and seating technique in reducing reflective cracks,
2. To determine the optimum asphalt overlay thickness for best crack control and pavement strength,
3. To study the effect of adding fibers to the asphalt overlay on reflective crack intensity and any resulting increase in strength, and
4. To investigate any negative aspects associated with these rehabilitation techniques.

SCOPE

The Indiana DOT initiated this experimental cracking and seating study in the spring of 1984. The project is located on I-74 and runs from SR-39 to 2.0 mi west of the Montgomery-Boone county line. It involves 12.2 mi of centerline concrete pavement originally constructed in 1974. The traffic volume is over 10,000 vehicles per day with about 30 percent trucks.

WORK PLAN

Eight different concrete pavement rehabilitation treatments were used in this study. The details of each treatment, as well as the layout of different sections rehabilitated, are shown in Table 1 and Figure 1, respectively. The two basic rehabilitation techniques used were

1. asphalt undersealing with an asphalt overlay, and
2. cracking and seating the concrete slabs with an asphalt overlay.

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TABLE 1 REHABILITATION TREATMENTS

Treatment	Description	Overlay Thickness (in.)	Overlay Contents (lb./sq.yd.) Surface	Binder	Base
A	asphalt underseal with asphalt overlay	4.25	70	150	250
A1	as A with fiber reinforced asphalt base layers	4.25	70	150	250
A2	as A with fiber reinforced asphalt base and binder layers	4.25	70	150	250
B	cracked and seated with asphalt overlay	5.00	70	150	330
B1	as B with fiber reinforced base layer	5.00	70	150	330
B2	as B with fiber reinforced asphalt base and binder layers	5.00	70	150	330
C	cracked and seated with asphalt overlay	6.50	70	150	510
D	cracked and seated with asphalt overlay	8.50	70	150	700

An asphalt overlay thickness of 4.25 in. was used for the control sections. These control sections were also undersealed with asphalt. Overlay thicknesses of 5.0, 6.5, and 8.5 in. were used on the cracked and seated sections. Fibers were added both to the base and binder mixtures on one control section and on one cracked and seated section. Fibers were also added to the base layer only for one control and one cracked and seated section.

To determine the performance of these treatments for various sections, the following actions were conducted:

1. Transverse reflective cracks were counted by visual survey each year for each section over a 5-year period (1985 to 1989).
2. Deflections were measured using the Dynaflect each year for all sections.
3. Blowups were counted for each section by visual survey.
4. Ruts in the wheel path were measured for all sections using a 4.0-ft straightedge.

RESULTS

Reflective Cracks

Reflective crack intensities for different treatments over the 5-year period were plotted in Figure 2. The reflective crack development on the control sections was high in the beginning and increased at a fast rate. Most reflected cracks show considerable compounding and meandering, probably because of the D cracking in the old pavement. Adding fibers to the mixtures in the control sections did not help to control the occurrence of high crack reflection in the first 2 years; however, crack development progressed more slowly afterwards. Reflective crack development on the cracked and seated sections was low in the first 3 years and thereafter increased slowly. Cracking and seating reduced reflective cracks by at least 75 percent over those occurring in the uncracked control sections. A further reduction of reflective cracking on the cracked and seated sections was obtained by the addition of fibers to the asphalt mixture. It was observed that increasing asphalt overlay thickness on the cracked and seated sections from 5.0 to 6.5 in. reduced the number of reflection cracks by about 25 percent. As expected, overlaying with 8.5 in. of asphalt reduced reflective cracks even more. Also, adding the fibers to the asphalt mixture delayed the onset of reflective cracks and reduced their rate of development.

Road Structural Strength

Deflections for all the different sections were collected annually using the Dynaflect. In Figures 3 to 6, the maximum and minimum Dynaflect readings taken in 1984 and 1988 (or 1989)

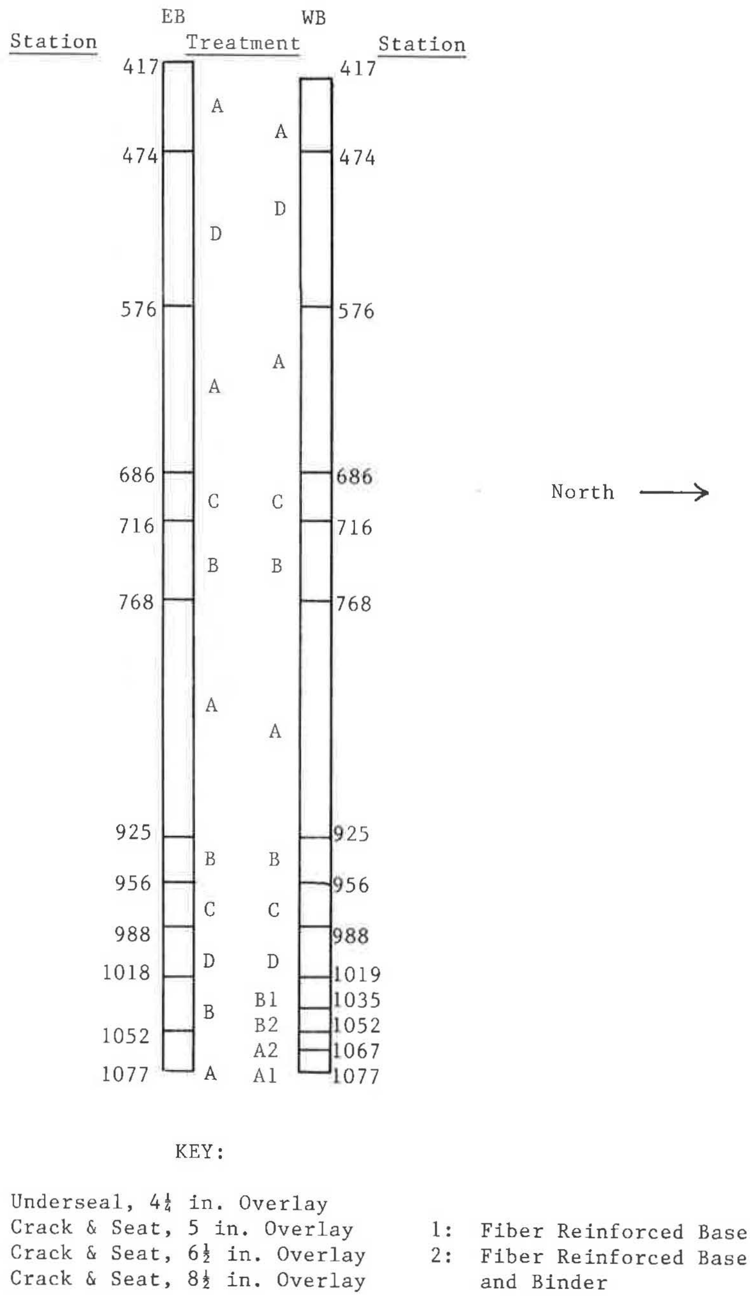


FIGURE 1 Treatment locations.

were plotted for all different treatments. The deflection data were adjusted to the standard temperature of 70°F according to Majidzadeh and Kumar (*5*). Maximum deflections indicate the relative strength of the pavement section, whereas minimum deflections give an indication of the relative strength of the pavement support. Satisfactory maximum deflection for overlaid concrete pavement is 0.50 mils, whereas the unsatisfactory value starts at 0.70 mils. Satisfactory minimum deflection is under 0.30 mils. Anything over 0.30 mils represents poor pavement support (*5*).

The 4.25-in. overlay on the uncracked control section is similar in strength to the 8.50-in. overlay on the cracked and seated section. Both of these sections have undergone less than 15 percent strength decrease in 5 years. However, the cracked and seated sections with 5.0- and 6.5-in. overlays have deteriorated in strength as much as 50 percent. As can be seen in Figures 4 and 6, the addition of fibers to the overlay mix improved or at least maintained the total pavement strength and the pavement support strength with time. The addition of fibers to either the base (fb) or binder, or both (fbb), improved or maintained the pavement strength similar to uncracked pavement with 4.25 in. overlay or to the cracked and seated pavement with 8.50-in. overlay.

Ruts and Blowups

Ruts were measured in the wheel path on all pavement sections using a 4.0-ft straightedge in 1989. Ruts for all fiber mix overlay sections were approximately $1/16$ in. and for all other

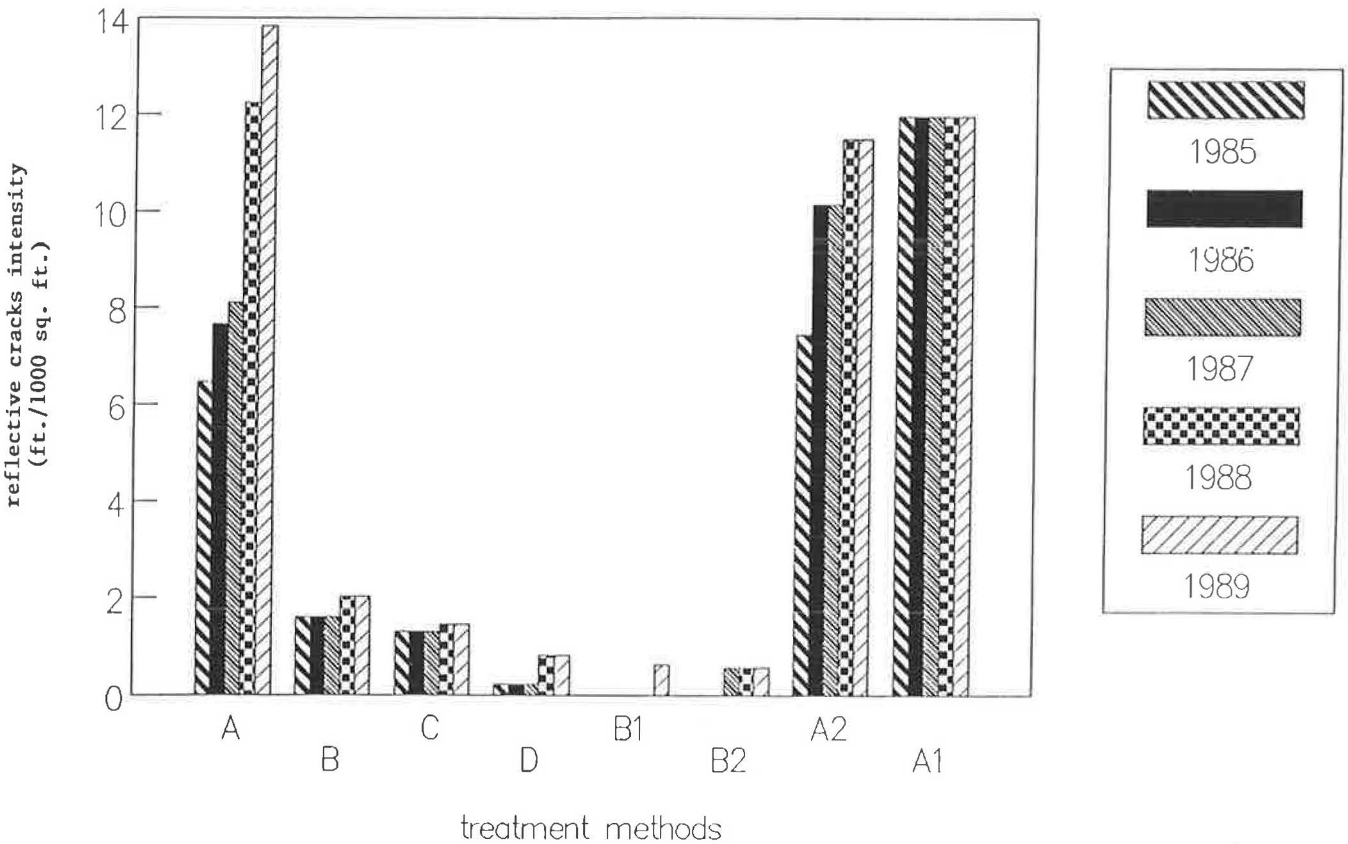


FIGURE 2 Development of reflective cracks with time for several treatments.

sections they were about ⅛ in. The slight difference in rutting is attributed to the fiber reinforcement of the overlay mix, as expected. In both cases, however, rut depths are lower than one would expect on bituminous pavements after 5 years of service.

Blowups were surveyed visually for different treatments in 1989. The blowup intensities (number of blowups per mile) are shown in Figure 7. Blowup intensities in cracked and seated sections are less than on the uncracked control sections by about 50 percent. Also, on the sections with added fibers, no blowups have been observed. Blowups, as defined here, are all sharp pavement protrusions that develop over the joints and which grow with time and eventually need to be milled or burned off. Blowups are relatively rare events, so the observed differences may not be significant.

VISUAL OBSERVATIONS

The severity of reflective cracks for the different treatments has been visually surveyed. Cracks in control sections containing fibers were compounded and more severe than those elsewhere, as shown in Figures 2 and 8.

Most blowups were not severe, except one that now is rough and should be milled or ground off to restore rideability. Several other blowups have been milled off during the past 5 years.

Some longitudinal surface cracks were observed in the wheelpath. The reason for the formation of such cracks is not understood. They appear to be related to the surface mixture only.

CONCLUSIONS

Cracking and seating techniques reduced reflective cracks by at least 75 percent over those occurring in the uncracked control sections.

Adding fibers to the asphalt overlay mix over cracked and seated sections reduced reflective cracking by 85 percent over cracks occurring in the control sections. The fibers also improved the pavement strength and support conditions by about 15 percent over sections without fibers. Fiber addition did not significantly reduce reflective cracking for sections that were not cracked and seated.

The 5.0-in. asphalt overlay with fibers gave the best performance among all treatment combinations with respect to reflective cracking and maintaining pavement strength.

Generally, blowup intensity on the cracked and seated sections was observed to be less than that in control sections by at least 50 percent. Reinforcing the asphalt overlay with fibers reduced rutting slightly and may have prevented blowups from developing.

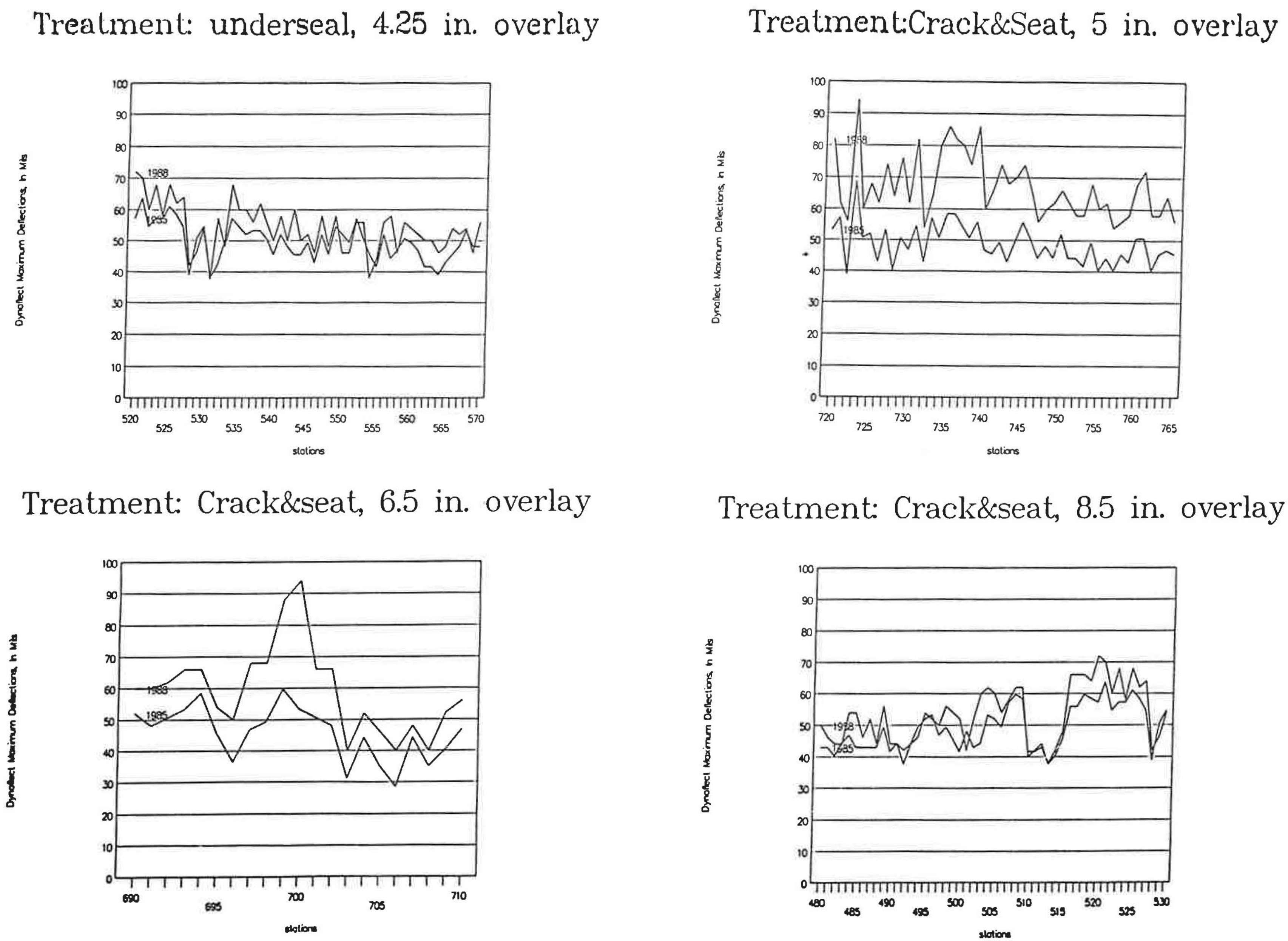
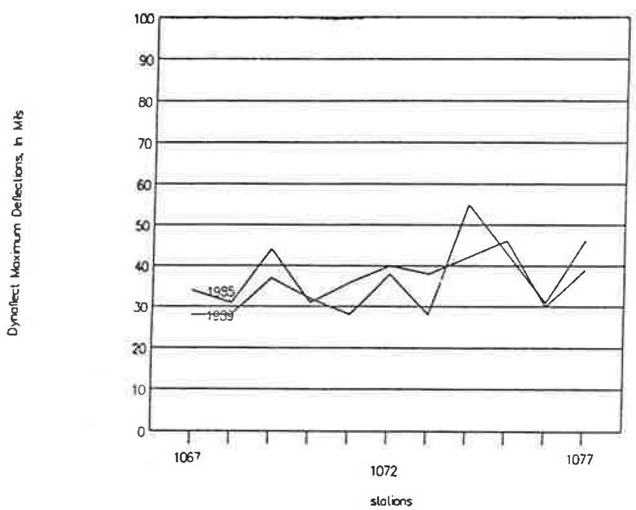


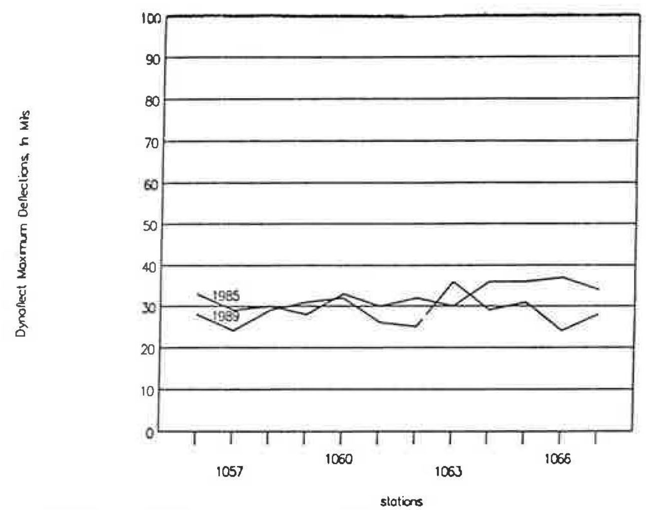
FIGURE 3 Dynaflect maximum deflections.

Treatment: Underseal–4.25 in. – fb



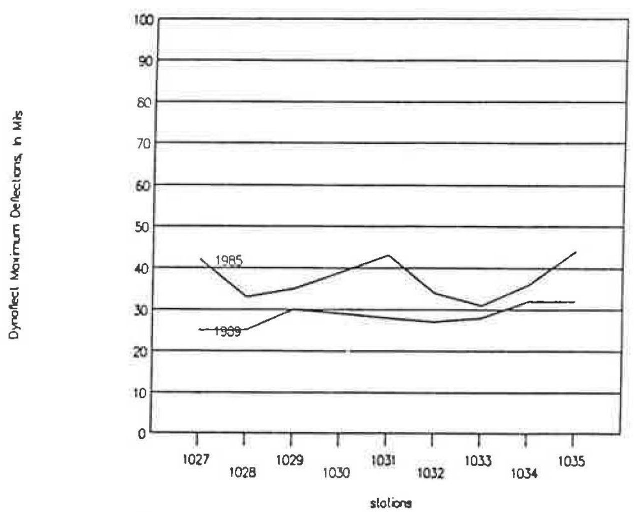
fb: fibers are added to asphalt base layer

Treatment: Underseal–4.25 in. – fbb



fbb: fibers are added to both asphalt base and binder layers

Treatment: Crack&seat – 5.0 in. – fb



Treatment: Crack&seat – 5 in.– fbb

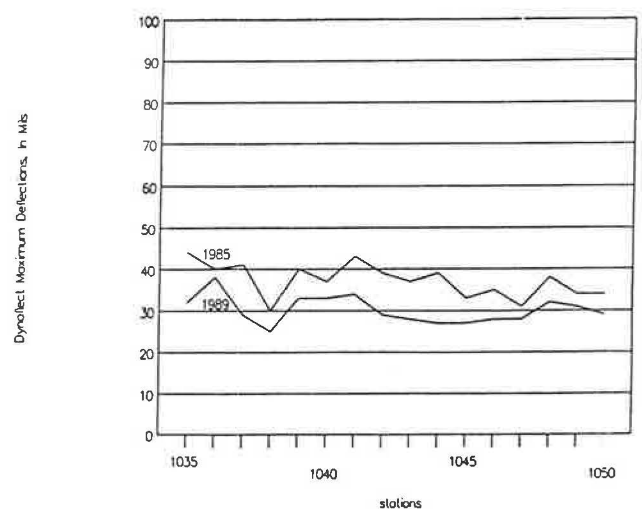


FIGURE 4 Dynaflect maximum deflections with fibers added.

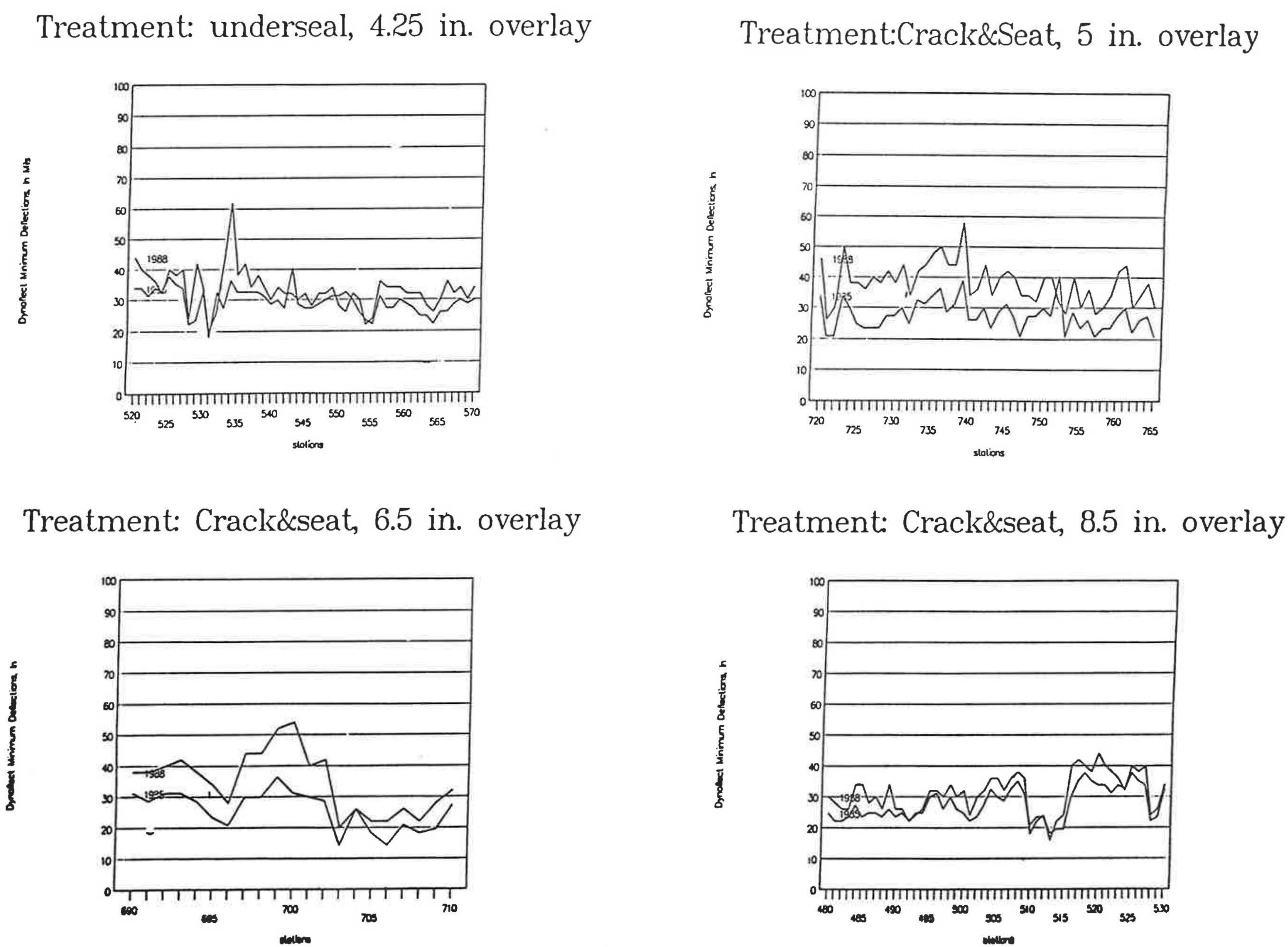


FIGURE 5 **Dynaflect minimum deflections.**

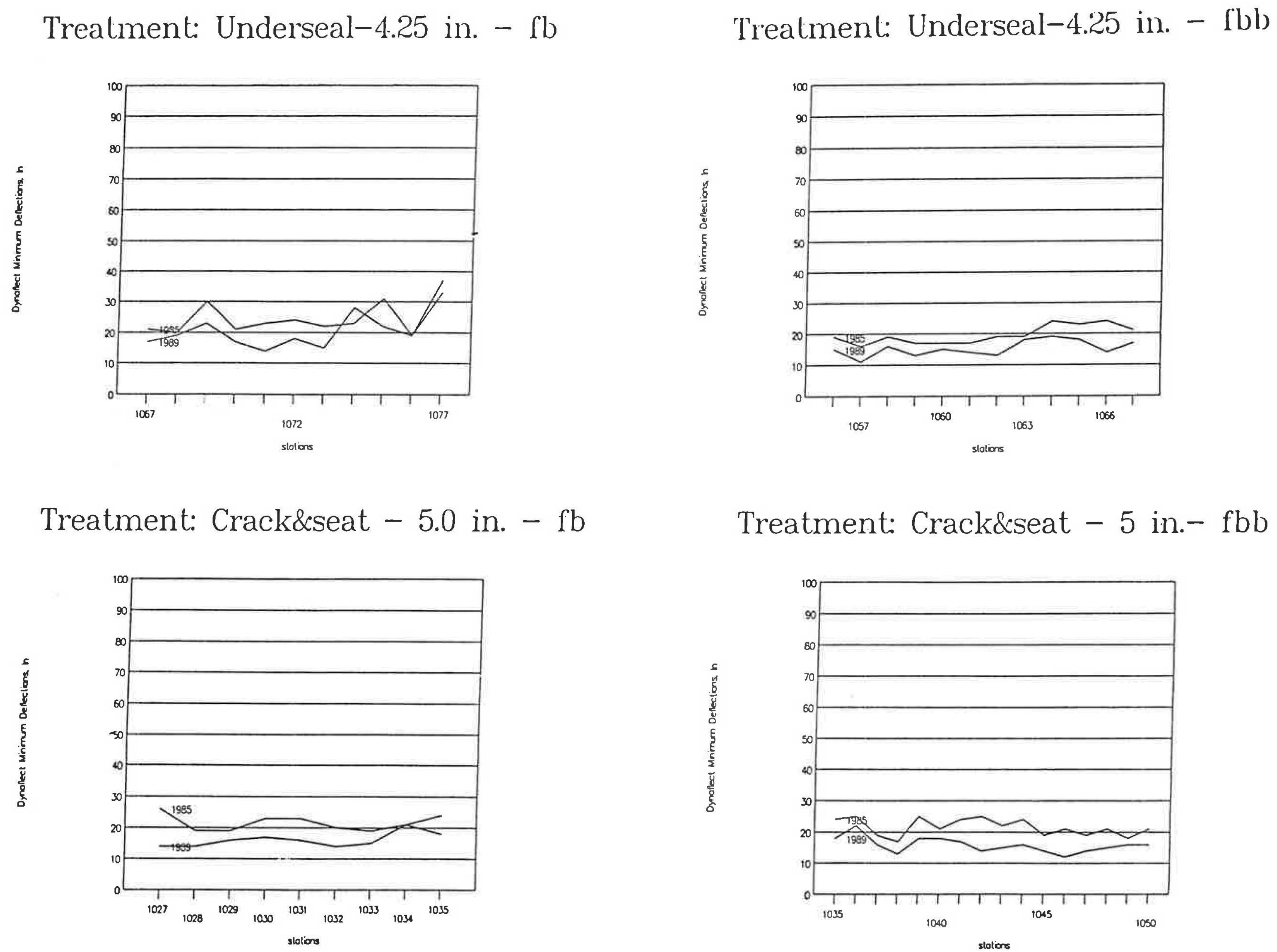


FIGURE 6 Dynaflect minimum deflections with fibers added.

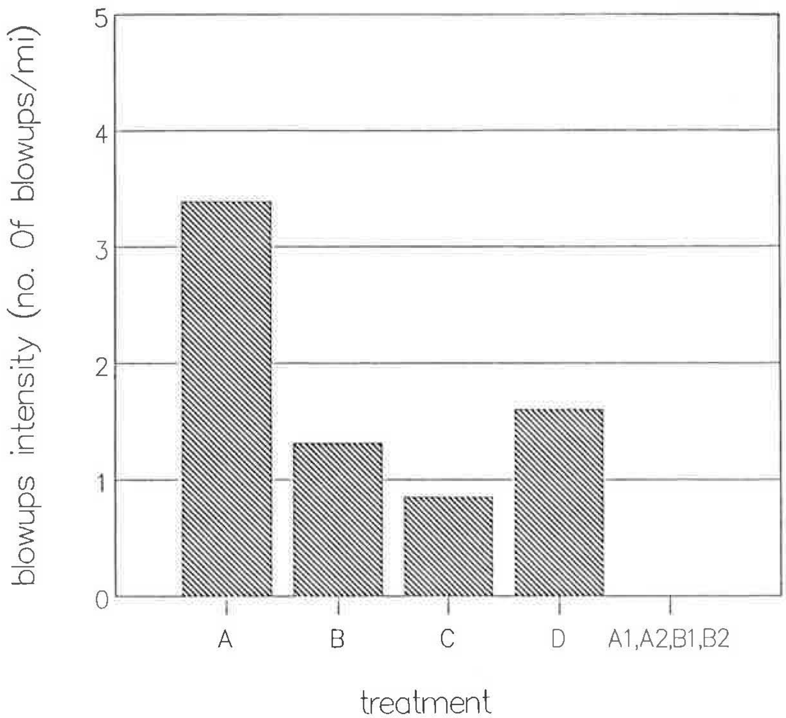


FIGURE 7 Blowup intensities (1989).

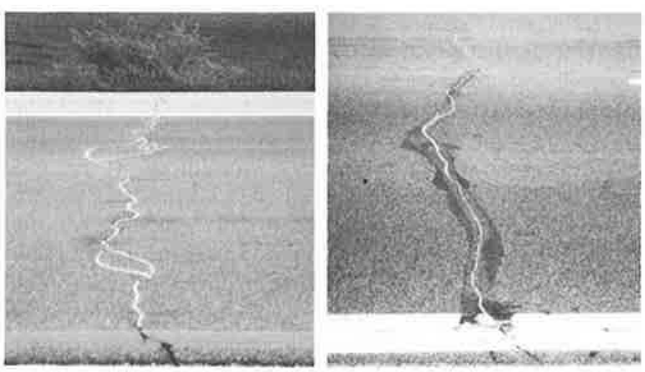


FIGURE 8 Typical reflective crack (*left*) in fiber section and (*right*) elsewhere.

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