FLEXURAL CRACK WIDTH AT THE BARS IN REINFORCED CONCRETE BEAMS

By

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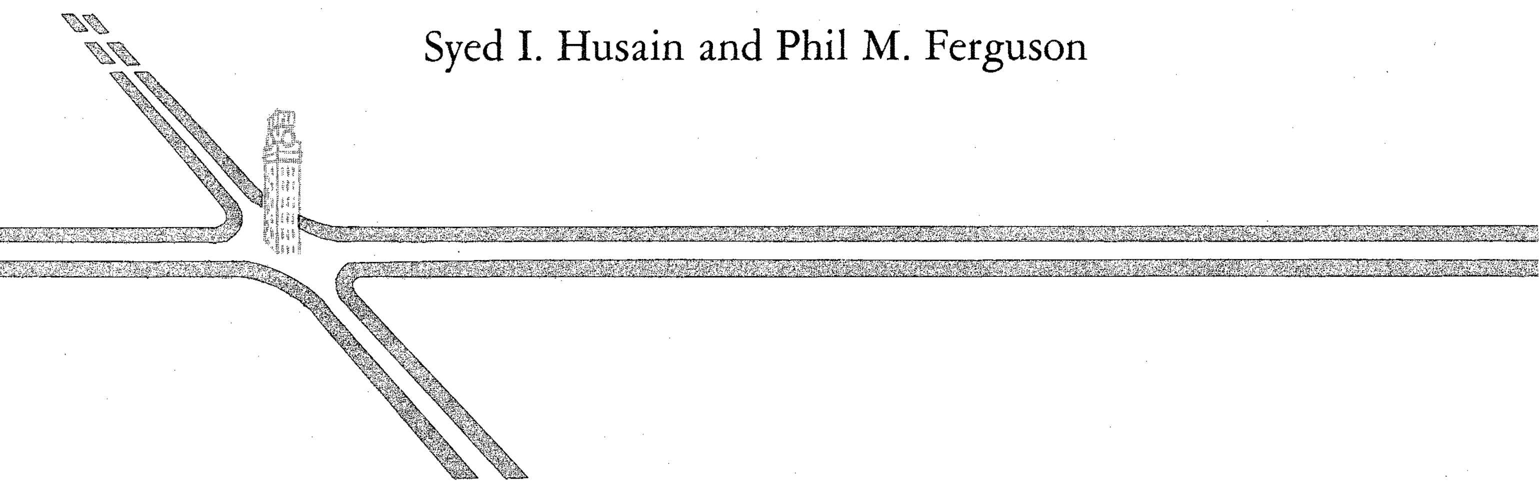

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Corrosion can develop beneath concrete which is uncracked, when it is of poor quality or poorly placed. Cracks have long been a suspected source of corrosion and there has been hesitation to use higher steel stresses because of the wider cracks produced and the supposed increased corrosion hazard.

This investigation of crack width at the face of the *bar,* in contrast to the *surface* crack width, is a preliminary to a study of corrosion, on the theory that any corrosion occurring at a crack must be related to the uncovered part of the bar. It was necessary to develop a technique for sealing flexural cracks while the member was under load and then injecting colored epoxy which would harden before the member was unloaded. After the beam was unloaded the cover over the bars was cut with a diamond point saw into longitudinal strips passing through the cracks. This cutting permitted a detailed examination of the interior cracks. The bar itself was also cut with a torch to permit its removal with its immediate encasement of concrete. This concrete could be stripped from the bar and closely examined with a microscope to establish crack at the bar.

Crack width at the bar varied in a given constant moment length from crack to crack and could best be expressed as an average with the realization that individual widths varied by at least ±50% from this average. At 20 ksi this average width at the bar was always 0.0010 in. or less; at 30 ksi, 0.0022 in. or less, except for one specimen with 3 in. clear cover, 0.0036 in. (another only 0.0022 in.).

The average crack widths at bar and at beam

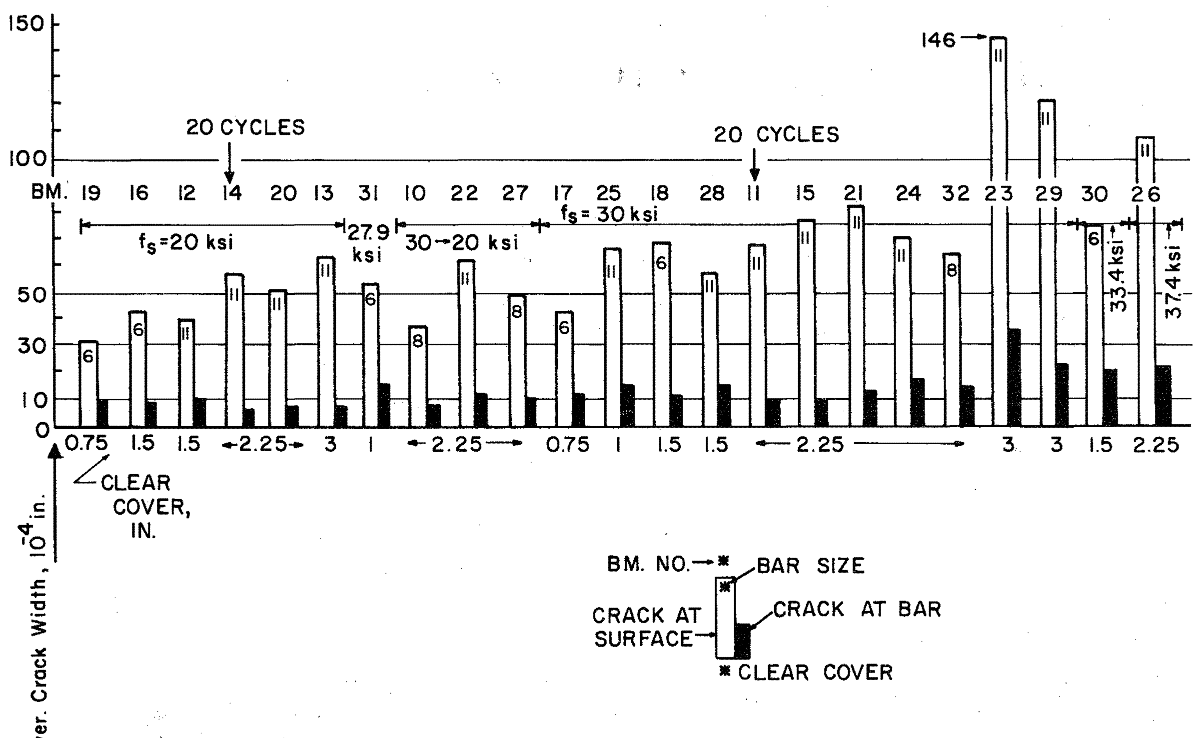

Fig. 10. Average crack width (for cracks successfully injected).

surface are shown in the bar chart of Fig. 10. The ratio of average crack width at bar to that at the surface is given in Fig. 15.

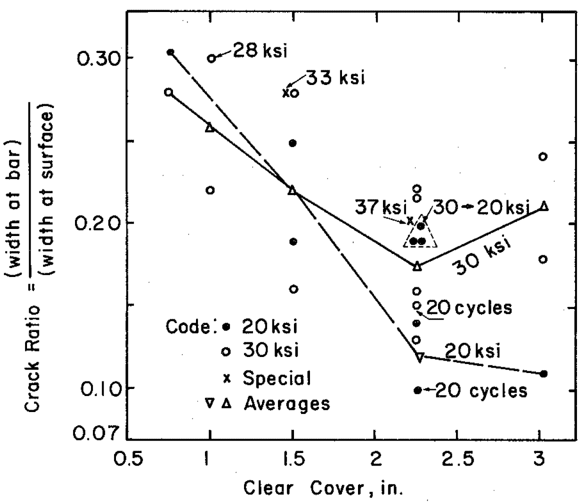

Fig. 15. Variation of crack ratio with clear cover over bars, for cracks successfully injected.

Conclusions

A new technique has been developed for measuring the width of cracks within the concrete covering the bars. The tests have clarified the relation between crack width at the bar and at the surface and have given some measure of the width variation within the cover.

With this technique the following crack characteristics have been noted.

1. The crack spacing and the crack width at any level vary from average values by at least ±50%. Average widths are used here for comparisons between cases.
2. Steel stress was the most important variable influencing crack width at the bar.
   (a) Average crack widths at the bar surface at 20 ksi steel stress range downward from 0.0010 in., the smaller values being associated with thicker bar cover.
   (b) At 30 ksi the average crack width at the bar is about 50 percent greater than at 20 ksi, except that at a cover of 3 in. the average jumps suddenly to 0.0029 in. Since no such increase occurs at a cover of 2.25 in. (where the average is only 0.0013 in.), it appears that the extra heavy cover is not actually helpful insofar as cracking is concerned.
3. For other conditions equal, crack width at the beam tension face varied almost linearly with the cover. However, at 30 ksi and 3 in. cover the width was greater than this ratio would suggest.
4. Surface crack width at 30 ksi was (very roughly) 50 percent greater than at 20 ksi, except that at 3 in. cover it was more than doubled.
5. The ratio of crack width at the bar to that at the surface varied from 0.10 to 0.31, being largest in a shallow member with clear cover of 0.75 in.
6. The crack thickness from bar to surface plotted approximately as a trapezoid, except that shallow members had relatively greater widths at middepth of the cover. A similar nearly linear variation in crack width existed laterally from the bar to the edge of the beam, with slightly smaller crack widths (possibly because nearer the beam neutral axis).
7. Repetitions of load for 20 cycles had no noticeable influence on measured crack dimensions.