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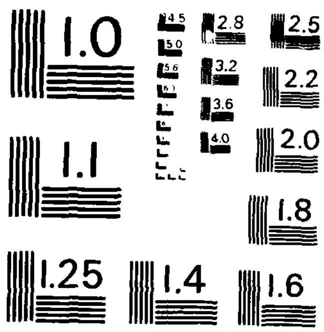

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TECHNICAL MEMORANDUM NO. 6-412

TENSILE CRACK EXPOSURE TESTS

Report 4

STATISTICAL ANALYSIS OF THE LONG-TERM DURABILITY OF SERIES "B" BEAMS

by

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March 1984
Report 4 of a Series

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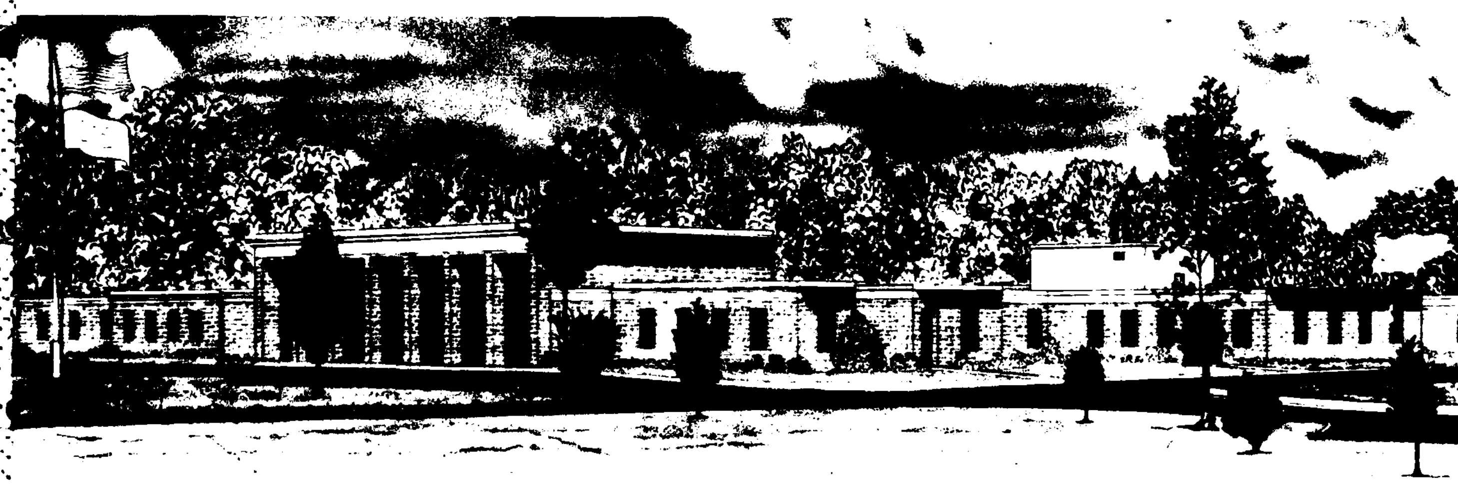

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Concrete cracking	Reinforced concrete	Weathering (concrete)
Concrete exposure	Resonant frequency	
Free-thaw durability	Statistical analysis	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

In November 1954, a long-term durability program was begun to determine the effects of severe natural weathering on reinforced concrete beams loaded to different stress levels and containing reinforcing steel with different types of bar deformations in either top-as-cast or bottom-as-cast positions.

The beams were fabricated, cured, and loaded at the U. S. Army Engineer Waterways Experiment Station (WES) in 1954, then shipped to Eastport, Maine, and
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20. ABSTRACT (Continued).

placed on the beach at the natural weathering exposure station on the south side of Treat Island in Cobscook Bay. The beams were subjected to twice daily tidal cycles exposing them to wetting under considerable head and drying to surface dry conditions. In addition, during the winter months, the beams were subjected to cycles of freezing and thawing with each tide when the air temperature was at or below 28° F (-2.2° C). The beams were inspected annually during the exposure period and evaluated by a team of inspectors rating the degree of deterioration. Nondestructive tests were also performed. Each year data on condition, percent velocity squared (V_U^2), and maximum crack width were collected.

The data which were generated from this study were coded and entered onto the WES IBM 4331 computer for subsequent analyses using the Statistical Analysis System (SAS). An evaluation of the results of these analyses indicates that:

a. Beams with steel in the bottom-as-cast position deteriorate at a slower rate than do beams with steel in the top-as-cast position for both A 305-50T and old-style deformation type, and beams with steel in the bottom-as-cast position exhibited smaller average maximum crack widths (significant at the 50,000-psi stress level).

b. A 305-50T type reinforcement bar deformation exhibited less severe degradation trends than old-style, and A 305-50T deformation type exhibited a significantly larger percent V^2 than did old-style deformation at the 50,000-psi stress level.

c. As stress levels increased, the conditions of the beams generally decreased and the degradation of percent V^2 increased. There were marked increases in maximum crack widths from the 40,000- to 50,000-psi stress levels for all positions and bar deformation types.

d. The more severe exposure conditions of the zero stress (control) beams, i.e., partially covered with sand where a state of higher saturation was maintained, probably affected some anomalous results. Also, the early failure of some 50,000-psi stress level beams containing reinforcement bars with old-style deformations and the subsequent loss of incriminating performance data affected some anomalous results.

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PREFACE

The statistical analysis reported herein was performed on data collected over the years from a test program planned by the Office, Chief of Engineers, in cooperation with the Reinforced Concrete Research Council of the American Society of Civil Engineers. The test program forms a part of Civil Works Research Work Unit 010401/31276 and was approved by the Office, Chief of Engineers, in 2nd indorsement, dated 17 Jan 1951, to basic letter, dated 7 Dec 1950, subject: "Reinforced Concrete Beams for Tensile Crack Exposure Tests," and has been conducted by the Concrete Technology Division (CTD), Structures Laboratory (SL), of the U. S. Army Engineer Waterways Experiment Station (WES).

The statistical analysis was performed as a part of Civil Works Research Work Unit 31132, "Field Exposure Durability Studies." Funds for the publication of this report were provided from Civil Works Research Work Unit 31788, "Special Studies for Civil Works Structural Engineering Problems," and from those made available for operation of the Concrete Technology Information Analysis Center (CTIAC). This is CTIAC Report No. 59. The report was prepared by Mr. Henry T. Thornton, Jr., under the general supervision of Messrs. Bryant Mather, Chief, SL, and John M. Scanlon, Chief, CTD.

Commander and Director of WES during publication of this report was COL Tilford C. Creel, CE. Technical Director was Mr. F. R. Brown.

CONTENTS

CONVERSION FACTORS, NON-SI TO SI (METRIC) UNITS OF MEASUREMENT

Non-SI units of measurement used in this report can be converted to SI (metric) units as follows:

Multiply	By	To Obtain
Fahrenheit degrees	5/9	Celsius degrees or kelvins*
feet	0.3048	metres
inches	25.4	millimetres
pounds (force) per square inch	6894.757	pascals
feet per second	0.3048	metres per second

* To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use the following formula: C = (5/9)(F - 32). To obtain kelvin (K) readings, use: K = (5/9)(F - 32) + 273.15.

TENSILE CRACK EXPOSURE TESTS

STATISTICAL ANALYSIS OF THE LONG-TERM DURABILITY OF SERIES "B" BEAMS

PART I: PHYSICAL FACILITIES AND EXPOSURE CONDITIONS

1. The ultimate test of the durability of concrete is its performance under the exposure conditions in which it is to serve. Although laboratory tests yield valuable indications of probable durability, the potential disrupting influences in nature are so numerous and variable that actual field exposures are highly desirable to assess the durability of concrete when exposed to natural weathering. An exposure station (Figure 1) located at Treat Island in Cobscook Bay near Eastport, Maine,

Figure 1. Exposure rack and beach area where specimens are exposed

has been in use by the U. S. Army Corps of Engineers since 1936. Its location makes it ideal for exposing concrete and concreting materials to severe natural weathering. Its effect is to provide a natural field laboratory where no size limitation is placed on the exposed specimens. The specimens are installed at mean-tide elevation, and the alternating conditions of immersion of the specimens in seawater, then exposure to cold air, provide numerous cycles of freezing and thawing of the concrete during the winter. The effect of the relatively cool summers is to lessen, in general, autogenous healing and chemical reactions in the concrete.

2. In winter, the combination of air and water temperatures creates a condition in which specimens at the mean-tide elevation are thawed to a temperature of about 37° F* when covered with water and are frozen to temperatures as low as -10° F when exposed to air. A recording thermometer, the bulb of which is embedded in the center of a concrete specimen, records these temperatures. A cycle of freezing and thawing consists of the reduction of the temperature at the center of a concrete specimen to below 28° F and the subsequent rise to above 28° F. During an average winter, the specimens are subjected to over 100 cycles of freezing and thawing. In 26 winters, from 1953 to 1979, the number of annual cycles ranged from 71 to 185, with the average being 133.

3. There are currently 36 active research programs in progress at Treat Island involving the exposure of some 1700 concrete specimens. The annual testing and continuous monitoring of these programs yield valuable data on the durability and performance of concrete and concreting materials.

---

* A table of factors for converting non-SI units of measurement to SI (metric) units is presented on page 3.

PART II: SPECIMENS AND TEST PARAMETERS

Tensile Crack Specimens, Series B

4. In November 1954, 76 reinforced concrete beams were installed at half-tide elevation on the beach at Treat Island to compare the relative resistance to weathering of highly stressed, reinforced-concrete beams containing (a) reinforced bars deformed to conform to ASTM A 305-50T* and (b) bars with old-style deformations.

5. The beams were 7 ft 9 in. long and were made of air-entrained concrete with a nominal compressive strength of 2500 psi at 28 days age. All of the beams were reinforced with rail-steel bars; 38 beams contained reinforcement bars which conformed to ASTM A 305-50T and the remaining 38 beams contained reinforcement bars which conformed to the old-style deformations. Of these 76 reinforced beams, 64 of the beams were yoked and stressed by third-point loadings. The loadings ranged from 20,000 to 50,000 psi. The remaining 12 beams were designated as controls and were not loaded. Appendix A lists these specimens and gives their exposure records along with other pertinent information.

Inspection and Testing

6. From 1957 until 1979, the period over which the data for this analysis were collected, the relative resistance to weathering for each of these 76 beams was evaluated annually. Qualitative measurements pertaining to condition were recorded along with the quantitative measurements of pulse velocity and maximum crack width. Due to some midcourse corrections and the lack of concomitant data, the years 1966, 1967, 1973, and 1974 were excluded from this analysis.

Visual inspection and condition rating

7. All exposed specimens are inspected visually by the resident

* American Society for Testing and Materials, Book of ASTM Standards (issued in parts), revisions issued annually, Philadelphia, Pa.

contractor each week during the period that freezing-and-thawing cycles occur, usually October through March. The condition of each specimen is recorded on an inspection form which is forwarded to the laboratory along with the time-temperature history for that week. The inspection form is checked for noteworthy changes that may have occurred, and the number of freezing-and-thawing cycles that occurred during the week are taken from the time-temperature history.

8. During the summer of each year an inspection and testing team from the Structures Laboratory (SL), Waterways Experiment Station (WES), visits the exposure station for the purpose of performing the annual inspection and testing of all specimens by visual and other nondestructive methods. During this annual visit photographs are taken of all programs in progress with special emphasis on programs of particular interest at the time, and of any specimens exhibiting significant or inordinate deterioration.

9. At the same time during the data collection period (1957-1979), a four-man rating team consisting of representatives from WES and the Office, Chief of Engineers (OCE), and one or more from outside government completed condition rating forms on the Tensile Crack Concrete Beam program. Each beam received a score each year resulting from the combined rating forms (see example of form below). The opinions of the observers were remarkably concordant, with very few discrepancies noted over the years.

Inspection Sheets
Formal Inspection, Treat Island, Maine

Tensile Crack Exposure Tests   Date ____________

Instructions

1. Insert in column headed "No. of transverse cracks with spalling" the number of load cracks that have apparently chipped or spalled subsequent to formation when beams were loaded, that now have places in which a pencil can be inserted (about 1/4 in. wide).

2. Measure (Note) the total length of cracking, in inches, appearing over the reinforcing steel.

3. Measure the total length of reinforcement that can be seen through cracks, or that is exposed because concrete has spalled away from it.

4. Measure the total length of cracking bordered by iron stain from the crack.

5. Estimate the total area of visible horizontal and vertical surfaces of concrete that have scaled and make a check under the most appropriate heading on the rating sheet.

Note: Measure to ±1/4 in.

Scoring:

a. Scoring will be done using a numerical system by others after the inspection.

b. Score of zero indicates perfect condition.

c. Light scaling scores 2, medium scaling 4, heavy scaling 8.

d. Numerical score = sum of 4 × number of spalled cracks + length of cracking over steel + 3 × length of visible steel + length of cracking over steel bordering iron-stained areas + appropriate score for scaled area.

10. This score was then converted into a numerical condition rating. The general conversion scheme is shown below:

Condition	Score	Numerical Rating
Negligible deterioration	0	100
Slight deterioration	4	75
More advanced deterioration	104	50
Advanced deterioration, usually with considerable exposure of reinforcing steel	129	25
Disintegrated, incapable of carrying load	629	0

Pulse velocity tests

11. The concrete specimens are subjected also to ultrasonic pulse velocity tests in accordance with CRD-C 51* (ASTM C 597** each year during

* WES. 1949. Handbook for Concrete and Cement, with quarterly supplements, Vicksburg, Miss.
** Op cit.

exposure, unless their size, shape, or exposure condition prevents. The test instrument measures the time of travel of an ultrasonic pulse through a concrete specimen. From the travel time and the path length, values for pulse velocity (V) in the concrete are calculated. The square of the velocity thus determined is expressed as a percentage of the square of initial velocity obtained at installation ($\%V^2$). Example:

V_o = pulse velocity in a certain specimen at installation

V_t = pulse velocity in this same specimen at a later date

Therefore

$$\%V^2 \text{ (at time t)} = \frac{V_t^2}{V_o^2}$$

Since the square of the pulse velocity is related to the dynamic Young's modulus of elasticity, the $\%V^2$ provides an alternate or supplementary parameter by which the progress of deterioration caused by natural weathering can be monitored. The initial velocity (V_o) of each beam was measured in 1954 so that the $\%V^2$ comparison could be made in subsequent years. However, in 1955 and 1956 the velocities were not obtained. For this reason, and because the maximum crack width measurements were not initiated until 1957, the 1957 velocities were used as initial velocities and the statistical analysis was performed over the years 1957 to 1979.

Crack width measurements

12. Before shipment to the exposure station, beams of similar size, with similar stress in steel, and of similar concrete insofar as possible were paired and loaded with third-point flexural loading using spring and yoke devices. Nominal loads (stress in reinforcing steel) were 20,000, 30,000, 40,000, and 50,000 psi. Cracks developed in all of the loaded beams during loading. Beginning in 1957 the maximum width of cracks in the beams was measured annually using a measuring magnifier (least reading of 0.005 in.).

13. In 1963 after nine winters of exposure, comparisons were made of the effects of the variables of steel stress, position of steel at time of casting, and type of steel deformation, using condition rating,

$\%V^2$, and maximum crack width as quantitative measures. The results of these comparisons, as reported by Roshore* were as follows:

> Based on condition rating--
>
> The order of durability from most durable to least durable was zero stress, 20,000-, 30,000-, 40,000-, and 50,000-psi stress.
>
> In 24 of the 45 comparable cases, the beams containing top-positioned steel exhibited greater durability than those containing bottom-positioned steel.
>
> In 29 of the 50 comparable cases, beams containing steel meeting A 305-50T specifications exhibited better durability than those containing steel with old-style deformations.
>
> Increase in crack width over time seemed to correlate with stress level, i.e., crack width increased with increasing stress in steel.
>
> The changes in $\%V^2$ were highly variable from year to year and did not correlate well with results of visual inspections.

14. The objectives of this long-term study were multifaceted. Originally, the study was designed to evaluate the two types of reinforcement bars (A 305-50T and old-style deformations), the five levels of stress (0-, 20,000-, 30,000-, 40,000-, and 50,000-psi stress levels), and the position, as cast, of the steel within each concrete beam (top and bottom); however, subsequent to the initiation of this project and with respect to the constraints mandated by the experimental design, the interactions among these factors, i.e., the independence of factor combinations and the prediction of the measurable response, also became paramount to the successful interpretation of the relative resistance to weathering of these concrete beams.

---

* E. C. Roshore. 1964. "Tensile Crack Exposure Tests; Results of Tests of Reinforced Concrete Beams, 1955-1963," Technical Memorandum No. 6-412, Report 2, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

PART III: ANALYSIS SYSTEM AND PROCEDURE

Statistical Analysis System

15. The Statistical Analysis System (SAS) is a commercially available software package which operates on an IBM or IBM-compatible computer. SAS is one of the most reliable and up-to-date statistical packages available. Since WES has an IBM 4331 which is dedicated to SAS usage, the data generated from this study were keypunched and loaded onto a disk file associated with this minicomputer.

16. The analyses provided in this data report were generated by the MEANS procedure, the CORR procedure, and the ANOVA procedure. The MEANS procedure averages the replicates in each treatment combination. The CORR procedure generates the correlations between the quantitative variables, and the ANOVA procedure generates the analysis of variance tables and subsequent statistics.

Statistical Analysis of the Variables Condition Rating, %V^2, and Maximum Crack Width

17. The data which were generated from the long-term durability study consist of four descriptive factors: steel position (top or bottom of beam as cast), steel deformation type (old-style or A-305), stress (20,000, 30,000, 40,000, and 50,000 psi), and year (1957-1979); and three quantitative variables: condition rating, percent velocity squared (V^2), and maximum crack width. The original plan of study called for four repeated measures on the three quantitative variables for each treatment combination, i.e., position, type, stress, and year.

18. The raw data of this study were coded and entered onto the IBM 4331 computer located at the WES. The data had on-line availability for subsequent analyses using the SAS.

19. The analysis approach to this set of analyses is as follows: averages* of condition rating, %V^2, and maximum crack width per

* Averages were used because the SAS program cannot perform the analysis of variance procedure on interaction effects if an imbalance of replicates exists, or if there are missing replicate values. Both of these conditions exist in these data.

treatment combination. Correlation analysis by position, type of steel, and stress for condition, percent V^2, and maximum crack width, and a four-factor (position, type, stress, and year) analysis of variance for each of the three variables with subsequent mean separations using Duncan's Multiple Range Test for significant main effects, and either John Tukey's or orthogonal mean contrasts for significant interaction effects.

20. The assumptions made for this analysis procedure are:

a. The errors are normally distributed with a population mean of zero and an unknown variance of σ^2 .

b. The effects of the model are fixed.

The assumption pertaining to the normal distribution may be invalid; however, the analysis of variance procedure is robust with respect to this assumption as long as the within-treatment variances are homogeneous.*

21. In order to interpret the meaning of the significant differences, an in-depth multiple comparison of the pertinent treatment combination averages was performed. For the significant main effects the Duncan's Multiple Range Test was used, and for the significant interaction effects either John Turkey's or orthogonal mean contrasts were used. The selection of the latter two as the mean separation test of choice will be discussed during the interpretation of the germane interaction effect. For an in-depth discussion of these multiple comparison procedures, reference Principles and Procedures of Statistics* by Robert G. D. Steel and James H. Torrie or Statistical Methods by George W. Snedecor and William G. Cochran.**

Variable condition

22. The analysis of variance (reference Appendix B) for the variable condition indicates that the effects of position, reinforcement bar deformation, position by reinforcement bar deformation interaction, stress, position by stress interaction, reinforcement bar deformation by stress interaction, position by reinforcement bar deformation by stress interaction, year, stress by year interaction, position by reinforcement

* R. G. D. Steel, and J. H. Torrie. 1980. Principals and Procedures of Statistics: A Biometrical Approach, 2nd ed., McGraw-Hill.

** G. W. Snedecor and W. G. Cochran. 1979. Statistical Methods, 6th ed., Iowa State University Press.

bar deformation by year interaction, and position by stress by year interaction are significant at the 0.05 level of significance.

23. For the second-order interaction effect of position by stress by year, it appears that a linear degradation trend exists for both top and bottom positions at stress levels 0 and 20,000 psi; however, for stress levels 30,000, 40,000, and 50,000 psi, departure from this linear trend exists for both the top and bottom trends (Figures 2-11).

24. For the second-order interaction effect of position by reinforcement bar deformation by year, the assumption of no departure from a linear degradation trend is not too seriously violated (Figures 12-15); however, it is apparent from these figures that the independence assumption, i.e., departure from parallel response relationships, is seriously violated. An in-depth characterization of these response relationships indicates that for the A 305-50T, the top position degrades at a faster rate than the bottom. The same trend is also noticeable for the old-style reinforcement bar deformation.

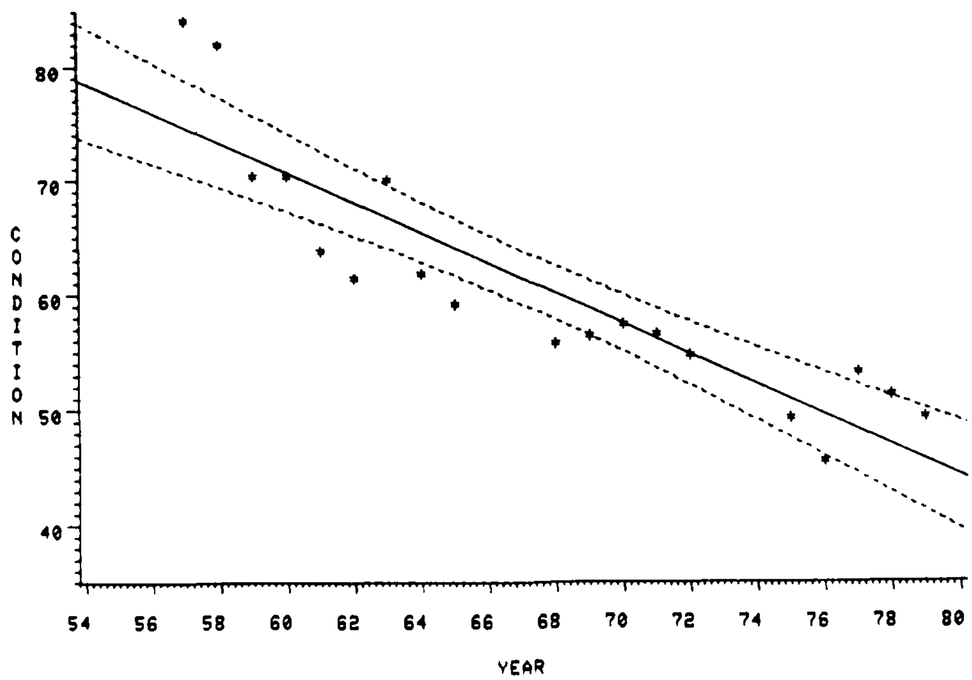

Figure 2. Condition average over reinforcement types. Position, bottom; stress 0 psi

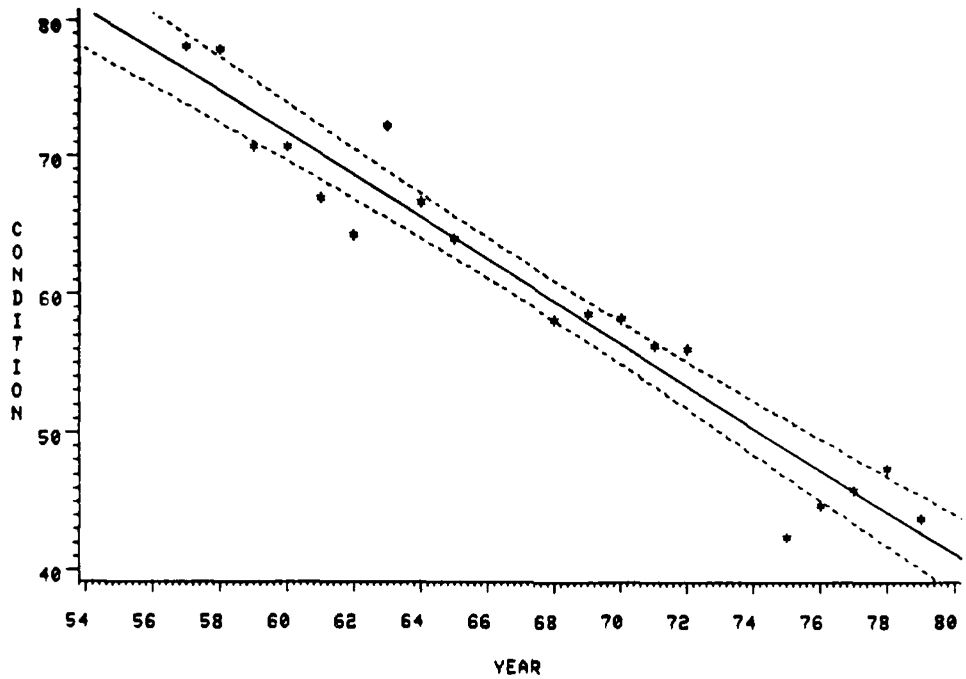

Figure 3. Condition average over reinforcement types.
Position, top; stress, 0 psi

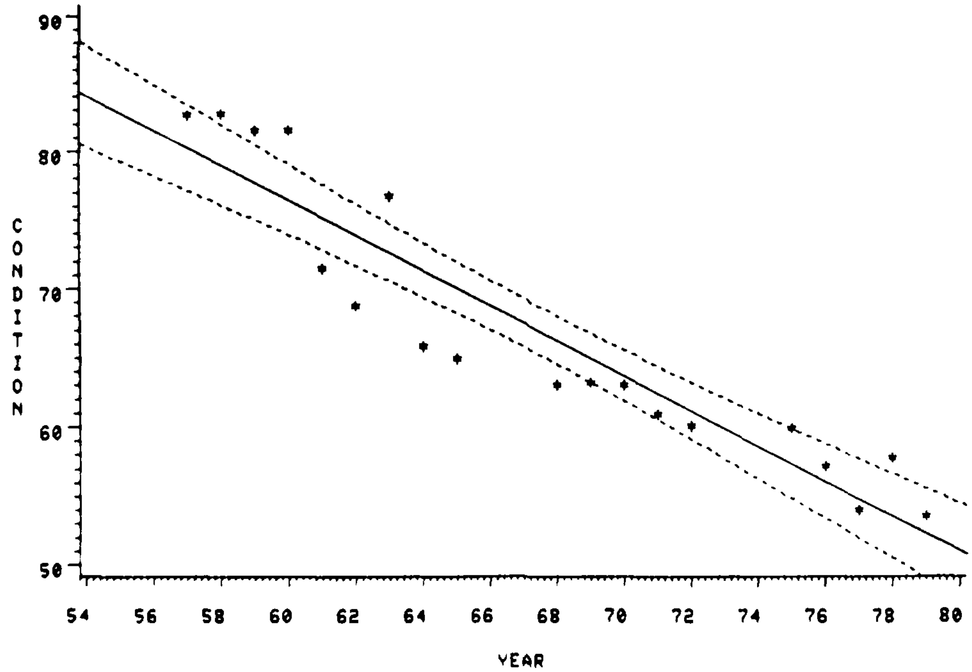

Figure 4. Condition average over reinforcement types.
Position, bottom; stress, 20,000 psi

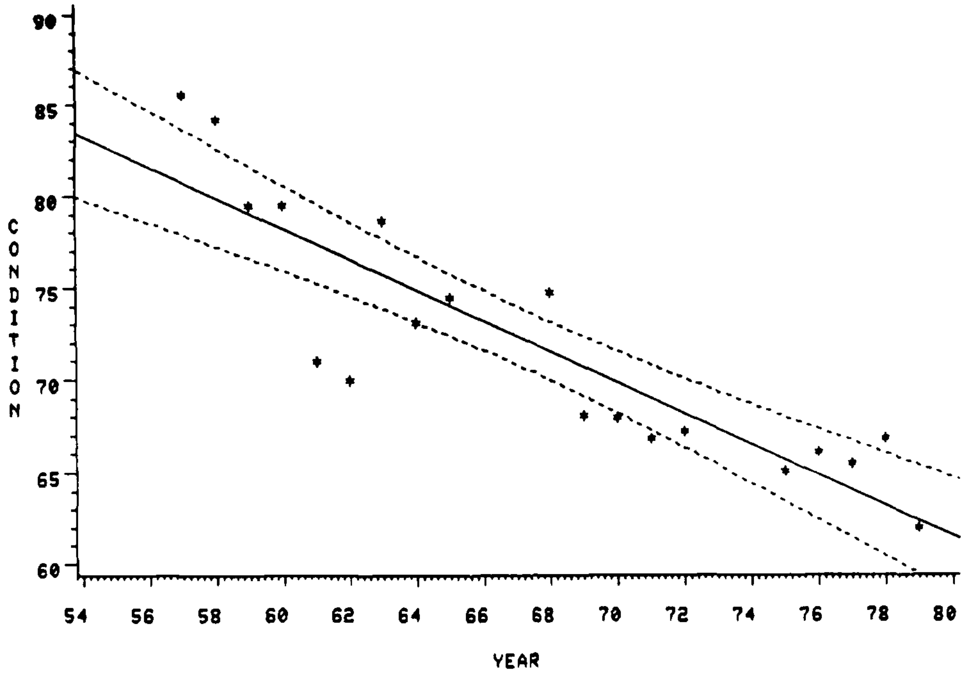

Figure 5. Condition average over reinforcement types.
Position, top; stress, 20,000 psi

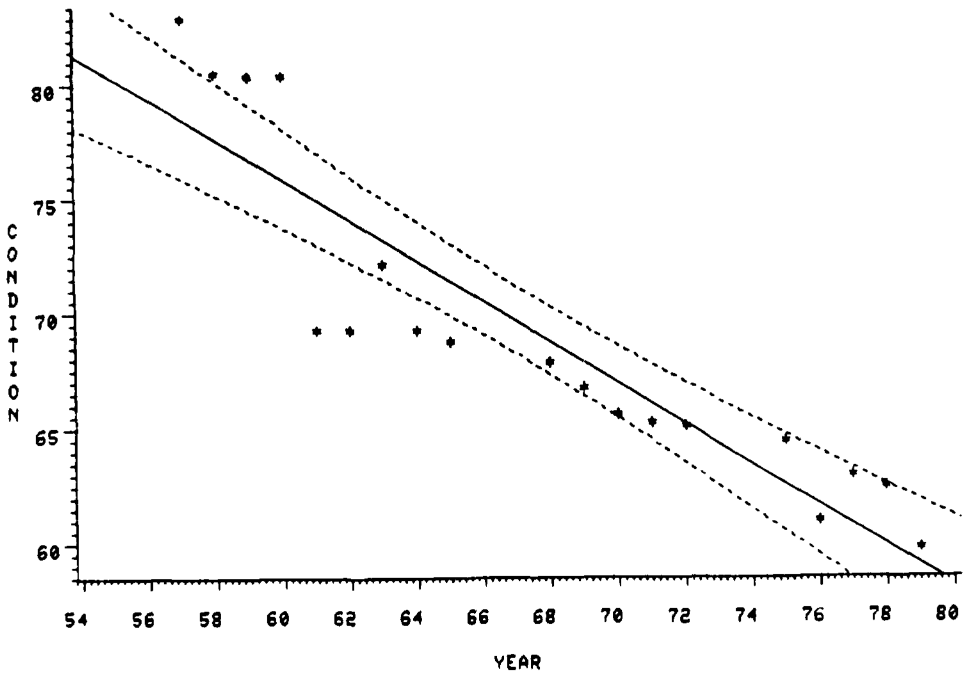

Figure 6. Condition average over reinforcement types.
Position, bottom; stress, 30,000 psi

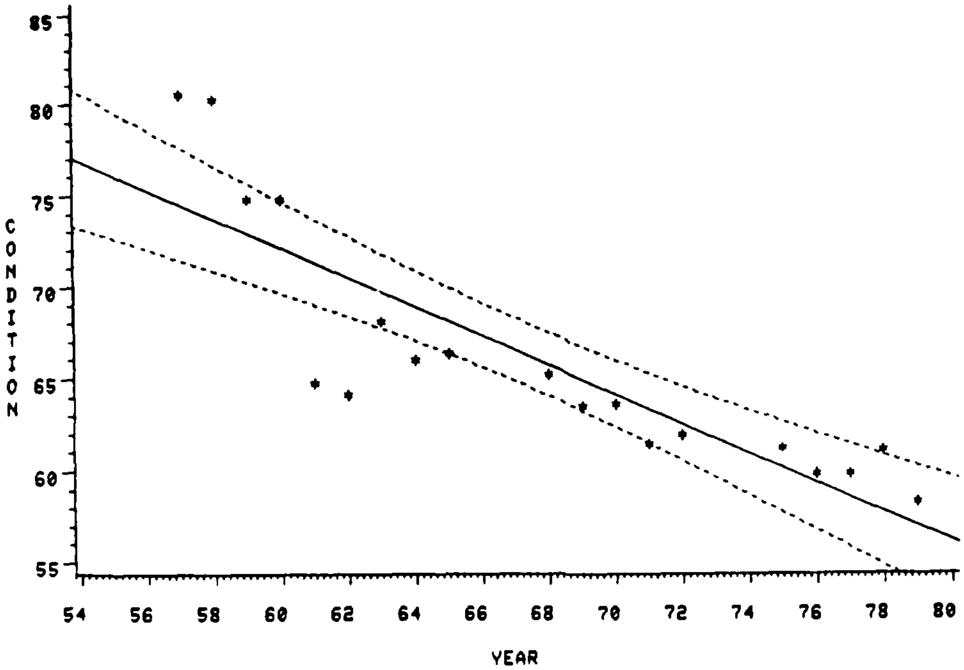

Figure 7. Condition average over reinforcement types. Position, top; stress, 30,000 psi

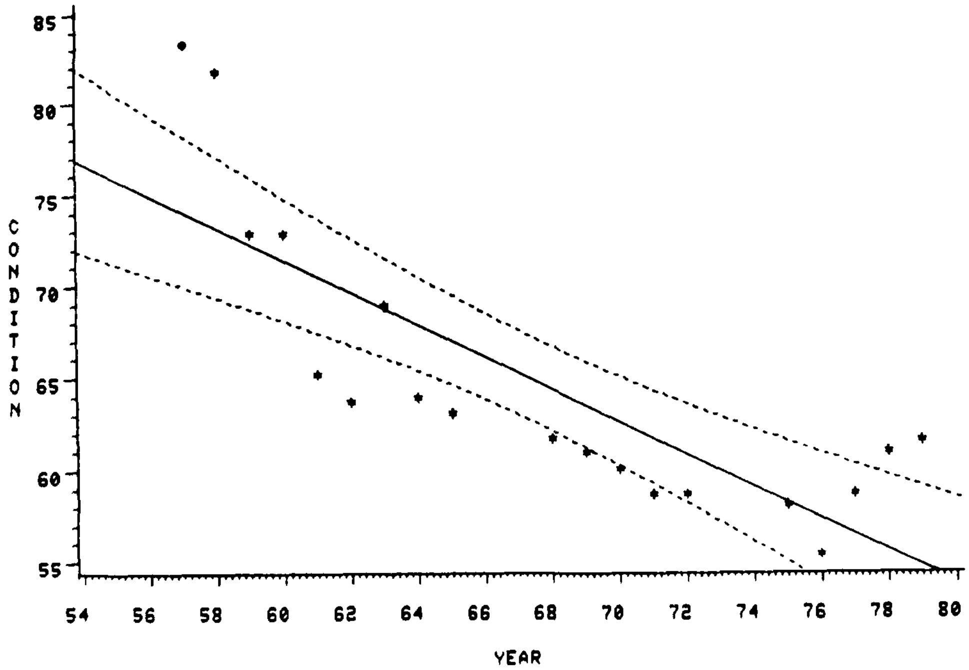

Figure 8. Condition average over reinforcement types. Position, bottom; stress, 40,000 psi

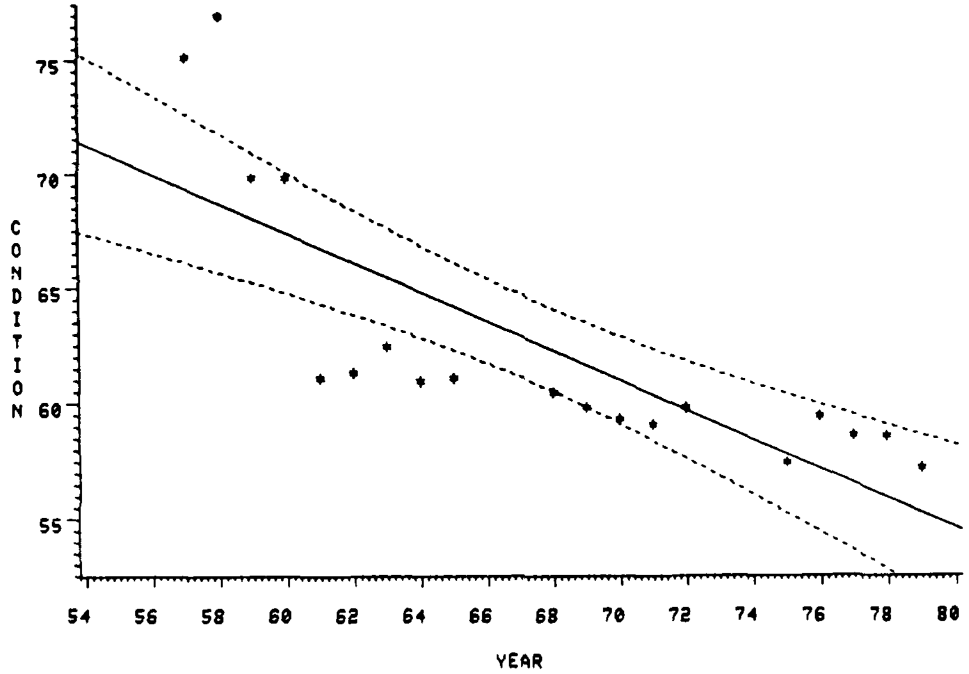

Figure 9. Condition average over reinforcement types.
Position, top; stress, 40,000 psi

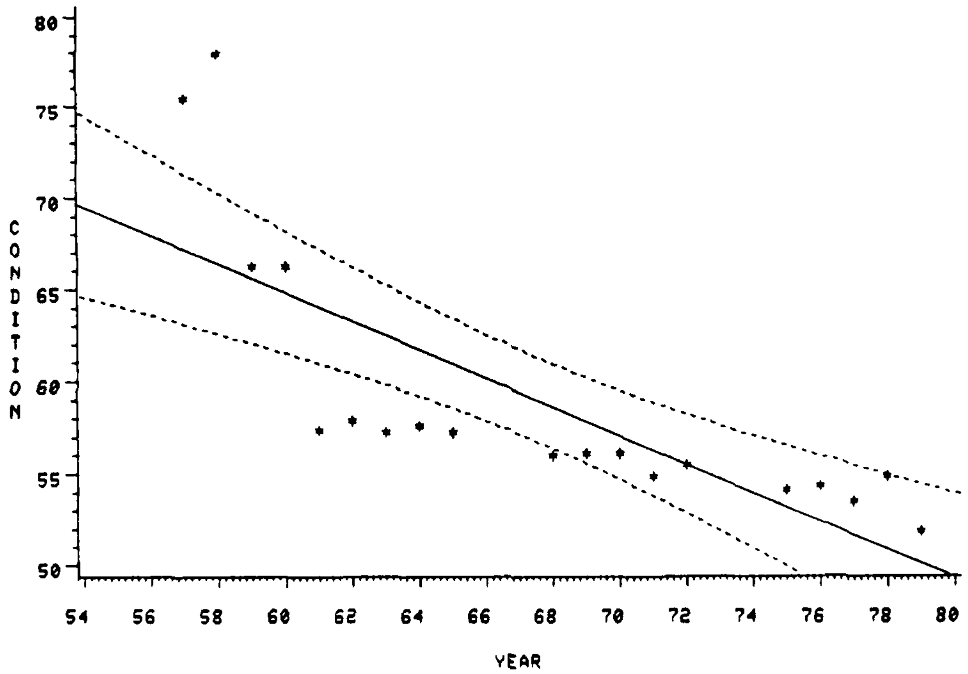

Figure 10. Condition average over reinforcement types.
Position, bottom; stress, 50,000 psi

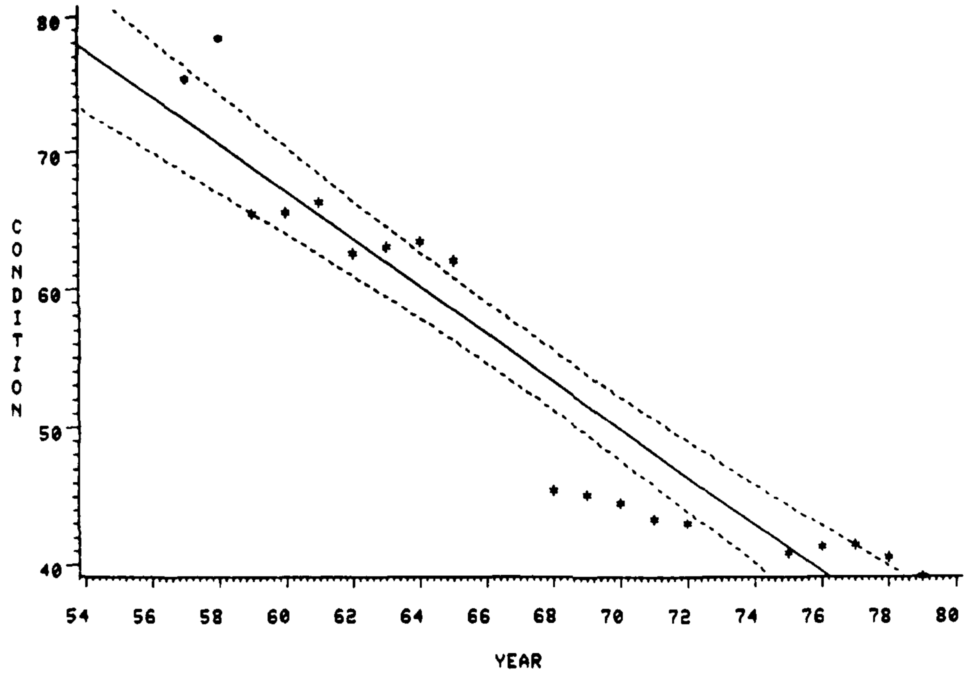

Figure 11. Condition average over reinforcement types. Position, top; stress, 50,000 psi

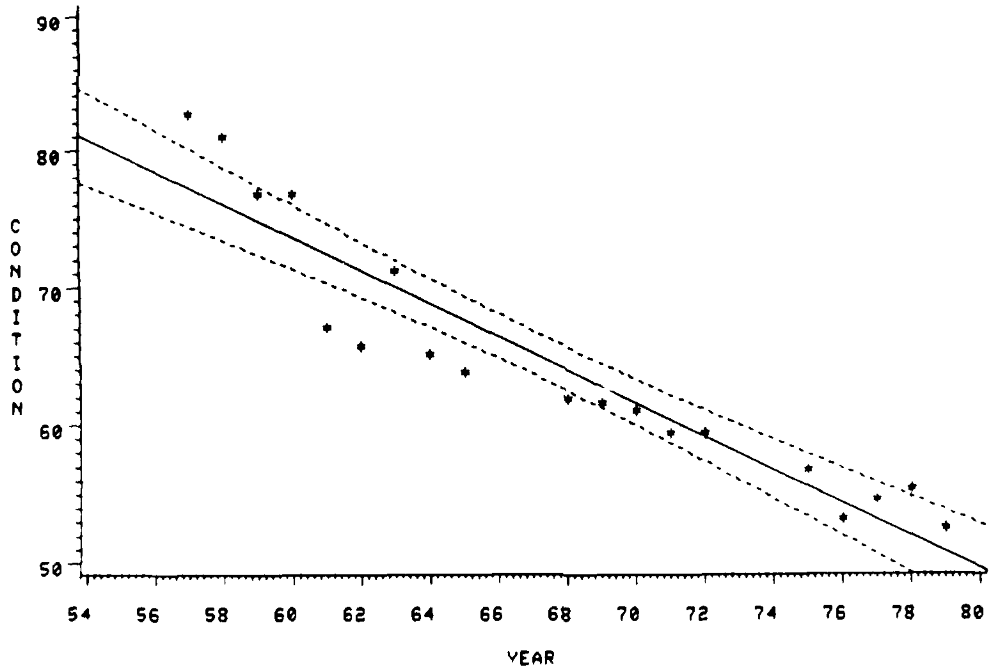

Figure 12. Condition average over stress levels. Position, bottom; type, A-305

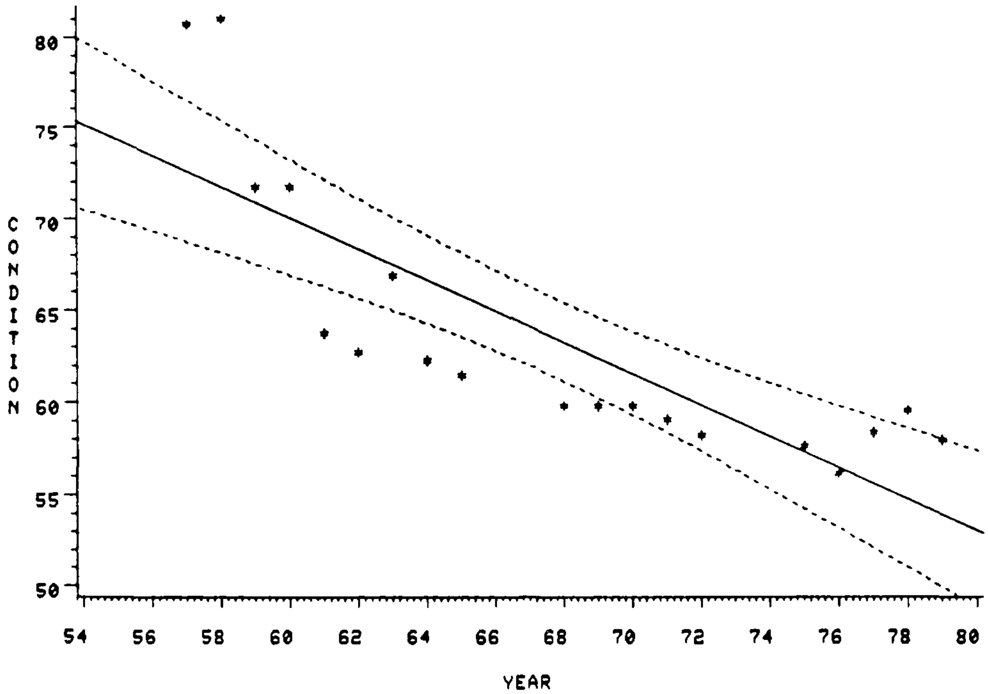

Figure 13. Condition average over stress levels.
Position, bottom; type, old-style

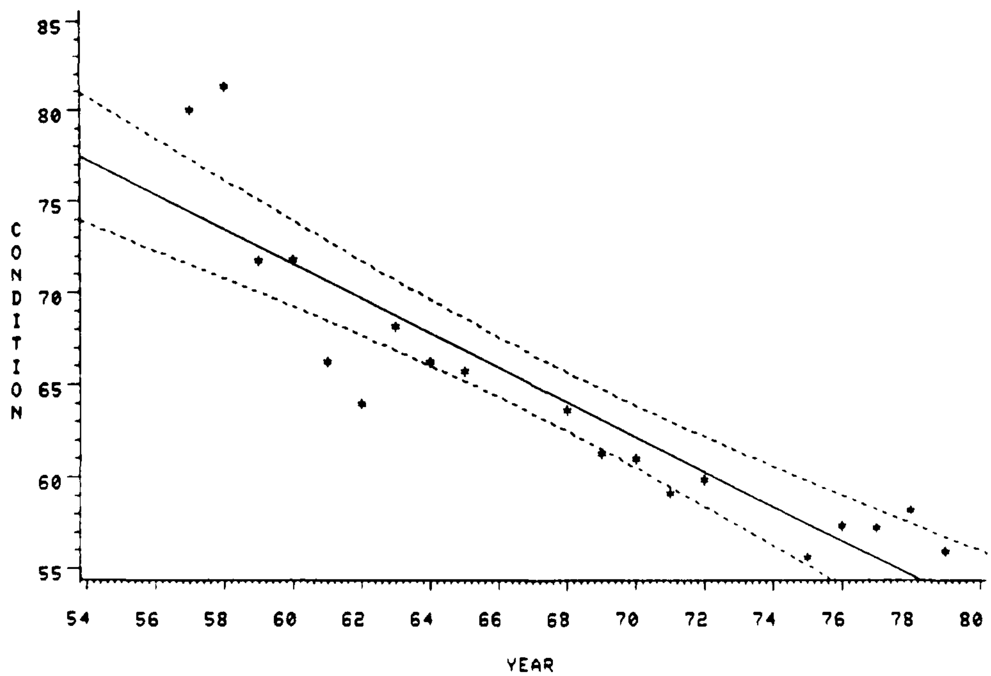

Figure 14. Condition average over stress levels.
Position, top; type, A-305

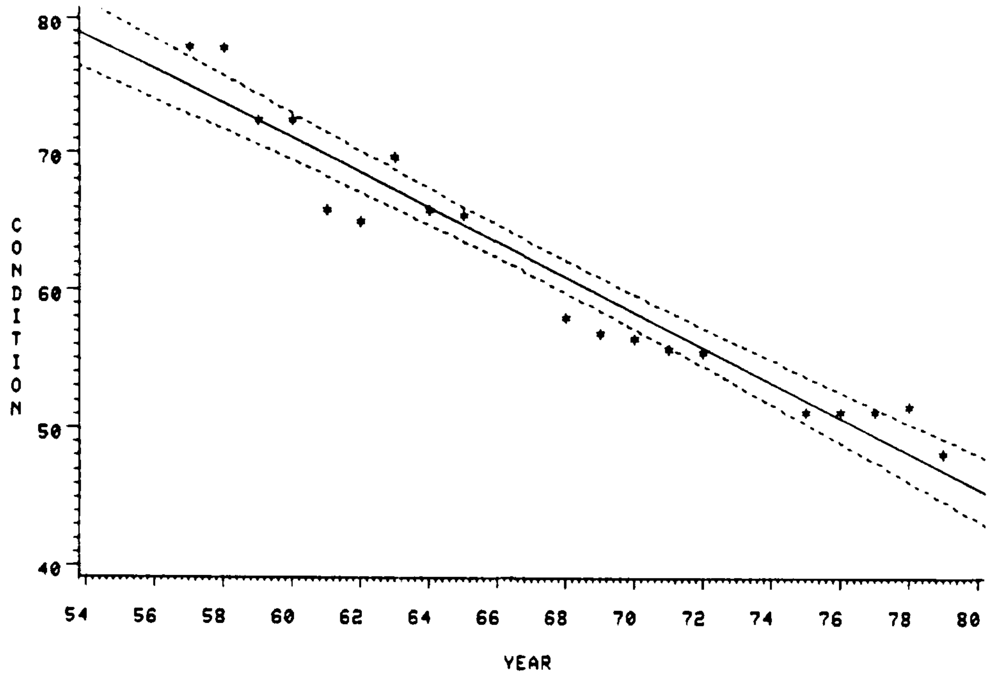

Figure 15. Condition average over stress levels.
Position, top; type, old-style

25. For the first-order interaction effect of stress by year, Table 1 displays the pertinent cell means.

Table 1

Stress by Year, Condition Ratings

	Stress at				
Year	0 (Control)	20,000 psi	30,000 psi	40,000 psi	50,000 psi
57	81	84	82	79	75
58	80	83	80	79	78
59	71	81	78	71	66
60	71	81	78	71	66
61	65	71	67	63	62
62	63	69	67	63	60
63	71	78	70	66	60
64	64	70	68	63	61
65	61	70	68	62	60
68	57	69	67	61	51

(Continued)

Table 1 (Concluded)

Year	Stress at 0 (Control)	20,000 psi	30,000 psi	40,000 psi	50,000 psi
69	58	66	65	60	51
70	58	66	64	60	50
71	57	64	63	59	49
72	56	64	64	59	49
75	46	63	63	58	48
76	45	62	60	57	48
77	50	60	61	59	48
78	49	62	62	60	48
79	47	59	59	59	46

26. The John Tukey w-procedure was used to compare the five cell means within a year category. This multiple comparison procedure uses the error mean squares from the analysis of variance table, the number of observations within each cell mean, and the upper percentage points of the studentized range which is a tabular value found in most statistical methods tests. The w-procedure utilizes the following:

$$w = Q(t,df)\sqrt{(\text{error mean squares})/N}$$

where $Q(t,df)$ is the tabular studentized range value, t is the number of means being compared, and df is the degrees of freedom of the error mean squares. It was found that the critical difference among five means composed of four observations was 7.49. Utilizing this critical difference, one may readily observe that the stress levels 20,000, 30,000, and 40,000 psi behave similarly and are significantly higher than the stress levels of 0 and 50,000 psi which behave similarly. The zero stress level (control) beams were not kept out of the sand (Figure 16) as were the yoked beams. The fact that drying could not readily occur probably accounts for the poor performance of the control beams as shown in Table 1.

27. For the second-order interaction effect of position by reinforcement bar deformation by stress, the pertinent cell means are displayed in Table 2.

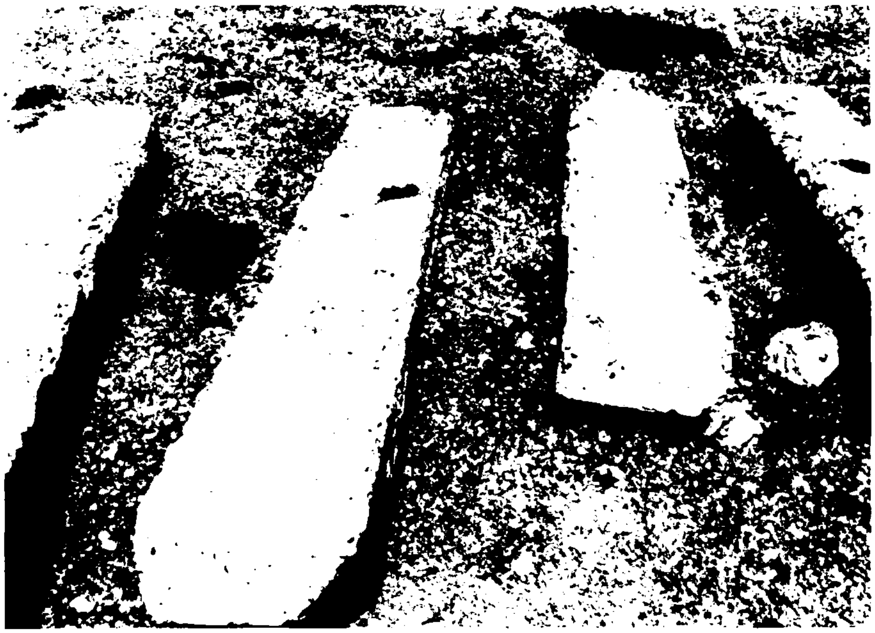

Figure 16. Zero stress (control) specimens after excavation of sand

Table 2

Position by Reinforcement Bar

Deformation by Stress, Condition Ratings

		Stress at				
		0 (Control)	20,000 psi	30,000 psi	40,000 psi	50,000 psi
Bottom	A 305-50T	66.30	62.72	70.92	62.91	60.01
	Old-Style	55.14	70.93	67.42	66.70	57.93
Top	A 305-50T	61.05	73.30	65.24	58.43	64.30
	Old-Style	59.33	70.54	66.97	66.75	43.91

28. The John Tukey w-procedure was used to simultaneously compare the five cell means within position and reinforcement deformation type, and it was found that the critical difference is 3.44. This in essence means that if any two cell means within the position and deformation type differ by more than 3.44, then these two means are significantly

different. Duncan's Multiple Range notation was used to arrange these means in the following order.

		30,000	0	40,000	20,000	50,000
Bottom	A 305-50T	70.92	66.30	62.91	62.72	60.01
		20,000	30,000	40,000	50,000	0
	Old-Style	70.93	67.42	66.70	57.93	55.14
		20,000	30,000	50,000	0	40,000
Top	A 305-50T	73.30	65.24	64.30	61.05	58.43
		20,000	30,000	40,000	0	50,000
	Old-Style	70.54	66.97	66.75	59.33	43.91

Means underscored by the same line are not statistically different; the permutation or arrangement of the cell means in Table 2 exhibits consistent patterns. Resultant from this, the interaction of position by reinforcement type became significant when considered by stress level.

29. Again, the poor exposure condition, i.e., partially covered with sand so that drying could not readily occur, is thought to account for the poor showing of the zero stress level beams.

30. For the first-order interaction effect of reinforcement bar deformation type by stress, the pertinent cell means are displayed in Table 3 and graphically in Figure 17.

Table 3

Reinforcement Bar Deformations by Stress Levels, Condition Ratings

	Stress at				
	0 (Control)	20,000 psi	30,000 psi	40,000 psi	50,000 psi
A 305-50T	63.68	68.01	68.08	60.67	62.16
Old-style	57.24	70.74	67.20	66.72	50.92

31. John Tukey's w-procedure was used to compare the five cell means within deformation type, and it was found that the critical

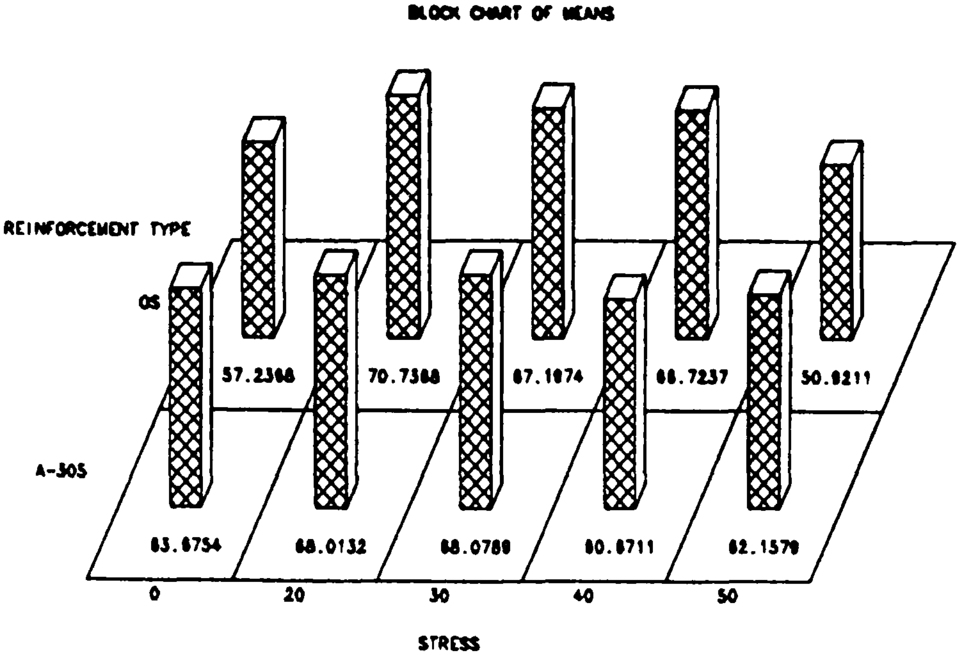

Figure 17. Condition average over years. Reinforcement types, old-style and A-305

difference is 2.28. Therefore, for the A 305-50T reinforcement bar deformation type, it is readily seen that the condition ratings of the concrete beams show a significant increase from the 0 stress level to the 20,000-psi stress level which is similar to the 30,000-psi stress level, and then the condition decreases from the 20,000- and 30,000-psi stress levels to the 40,000- and 50,000-psi stress levels, which are also similar. The old-style reinforcement bar deformation exhibited a similar pattern. Within this reinforcement deformation type, the condition of the concrete beams increased from the 0 stress level to the 20,000-psi stress level, then decreased from the 20,000- to the 30,000- and 40,000-psi stress levels, which were similar, and then exhibited a marked decrease for the 50,000-psi stress level. It is also worth noting that for the A 305-50T reinforcement type, the 0 stress level is similar to the 50,000-psi stress level; whereas with the old-style reinforcement deformation type, the 50,000-psi stress level was significantly smaller than the 0 stress level. In fact, it displayed an 11.04 percent decrease.

32. For the first-order interaction effect of position by stress, the pertinent cell means are displayed in Table 4 and graphically in Figure 18.

Table 4

Position by Stress, Condition Ratings

	Stress at				
	0 (Control)	20,000 psi	30,000 psi	40,000 psi	50,000 psi
Bottom	60.72	66.83	69.17	64.80	58.97
Top	60.19	71.92	66.11	62.59	54.11

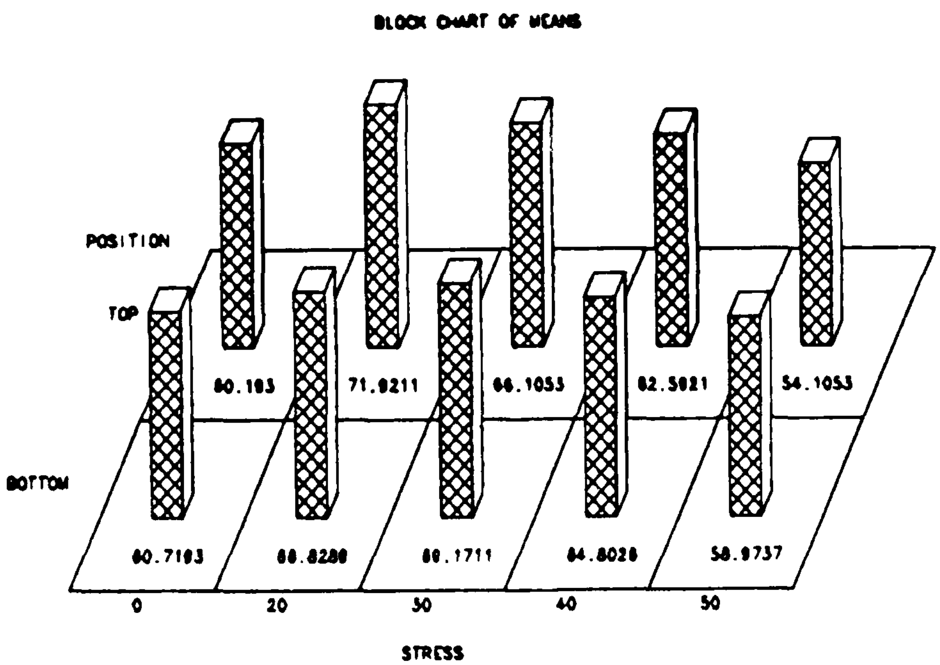

Figure 18. Condition average over years. Positions, top and bottom

33. The John Tukey w-procedure calculation, as in the interpretation of the reinforcement bar deformation type by stress interaction, yields a critical difference of 2.28. In Table 4 similar patterns are exhibited over stress levels within the bottom position; the condition

ratings of the concrete beams increase from the 0- through the 30,000-psi stress level and then decreases from the 30,000-psi stress level through the 50,000-psi stress level, with 0- and 50,000-psi stress levels exhibiting similar condition measures. Within the top position, the condition ratings increase from 0 to 20,000 psi and then decrease through the 50,000-psi stress level, with the 50,000-psi stress level exhibiting a significant 10.10 percent decrease from the 0 stress level.

34. For the first-order interaction effect of position by reinforcement bar deformation type, the pertinent cell means are displayed in Table 5.

Table 5

Position by Reinforcement

Bar Deformation, Condition Ratings

	A 305-50T	Old-Style	Δ
Bottom	64.57	63.62	0.95
Top	64.47	61.50	3.20

35. Orthogonal contrasts were used to compare independently the cell means within position; the critical difference is 0.77. Hence, it is readily seen that the A 305-50T reinforcement bar deformation concrete beams are exhibiting significantly larger average condition rating values than the old-style reinforcement bar deformation concrete beams.

36. For the main effect of stress, Duncan's Multiple Range test produces the following pattern.

Stress at				
20,000 psi	30,000 psi	40,000 psi	0 (Control)	50,000 psi
69.38	67.34	63.70	60.46	56.54

As can readily be seen, all stress levels are significantly different with the dominating pattern of increasing from 0 to 20,000 and decreasing from 20,000 through 50,000. The zero stress level performance is considered to be anomolous and is probably the result of the more severe exposure conditions mentioned before, i.e., being partially covered with sand so that drying could not readily occur (Figure 16).

37. For the main effect of reinforcement bar deformation type, the A 305-50T exhibited a significantly larger average condition value (64.52) than the old-style (62.56). Also, with the main effect of position, the bottom position exhibited a significantly larger average condition rating value (64.10) than the top position (62.99).

38. Reference Appendix B for the detailed computer analysis for this data set.

39. For the response variable condition rating, the data from this investigation indicate that degradation patterns over time changed as stress levels increased. It appears that a linear degradation trend is present for the 0- and 20,000-psi stress levels; however, for the 30,000-, 40,000-, and 50,000-psi stress levels a curvilinear degradation trend is present. Also, it appears that A 305-50T reinforcement bar deformation type exhibits less severe degradation trends which do not deplete as rapidly as does the old-style reinforcement type.

Variable $\%V^2$

40. The analysis of variance for the variable $\%V^2$ indicates that the effects of reinforcement bar deformations, stress levels, position by stress level interaction, reinforcement bar deformation by stress level interaction, position by reinforcement bar deformation by stress level interaction, year, and stress by year interaction are significant at the 0.05 level of significance.

41. For the first-order interaction effect of stress by year, the pertinent cell means are displayed in Table 6. All stress levels displayed a linear degradation trend through 1972; however, an increase occurred from 1972 through 1977. Since this pattern was consistent across all stress levels, it was assumed to be an anomaly within all data sets, and was probably due to either operator differences or instrument changes or both. Regardless of the reason for the apparent anomalies, if a linear degradation response is assumed through time, then from the graphs

Table 6

Stress by Year, $\%V^2$

(Rounded to the nearest whole percent)

	Stress at				
Year	0 (Control)	20,000 psi	30,000 psi	40,000 psi	50,000 psi
57	100	100	100	100	100
58	102	102	103	104	102
59	96	97	98	100	95
60	99	85	84	88	78
61	105	101	96	103	96
62	100	104	99	104	96
63	73	67	67	69	69
64	80	69	65	70	70
65	61	58	51	52	51
68	56	50	48	49	42
69	25	23	22	23	18
70	39	40	36	34	30
71	35	35	34	32	27
72	30	26	27	27	20
75	60	42	42	37	24
76	61	46	46	40	34
77	59	41	44	40	29
78	35	30	35	32	21
79	50	48	46	45	34

depicted in Figures 19-28, one readily sees that the least squares regression equation shows a more rapid degradation process the higher the stress level. It is this departure from parallelism which is generating the significant stress by year interaction effect.

42. For the second-order interaction effect of position by reinforcement bar deformation by stress, the pertinent cell means are displayed in Table 7.

43. To interpret the cell means, John Tukey's w-procedure was used within each position and deformation type so that comparisons across stress levels could be performed.

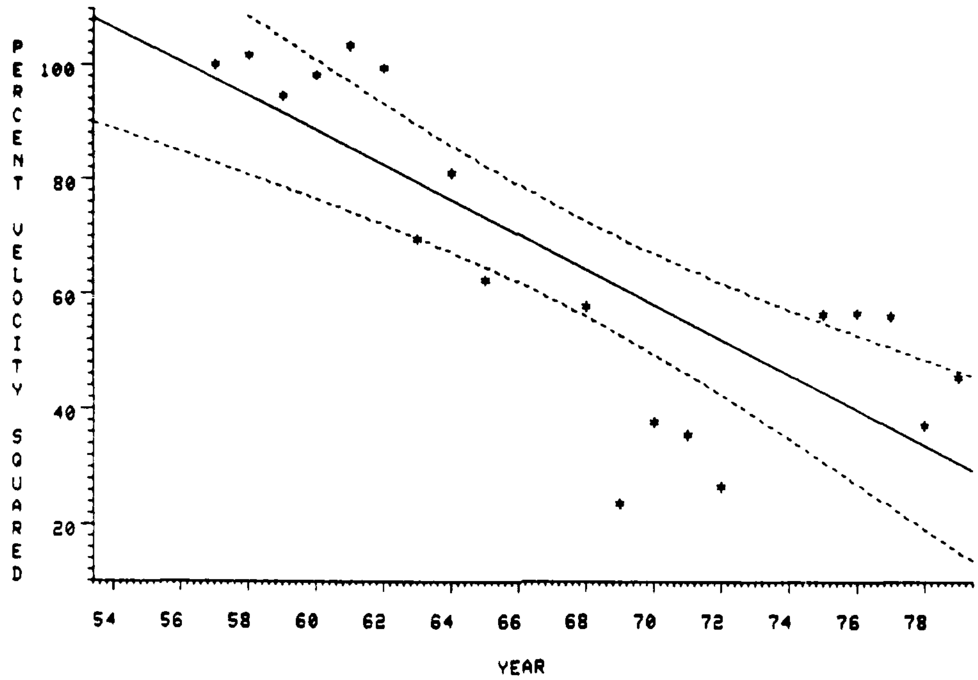

Figure 19. Percent V^2 average over reinforcement types. Position, bottom; stress, 0 psi

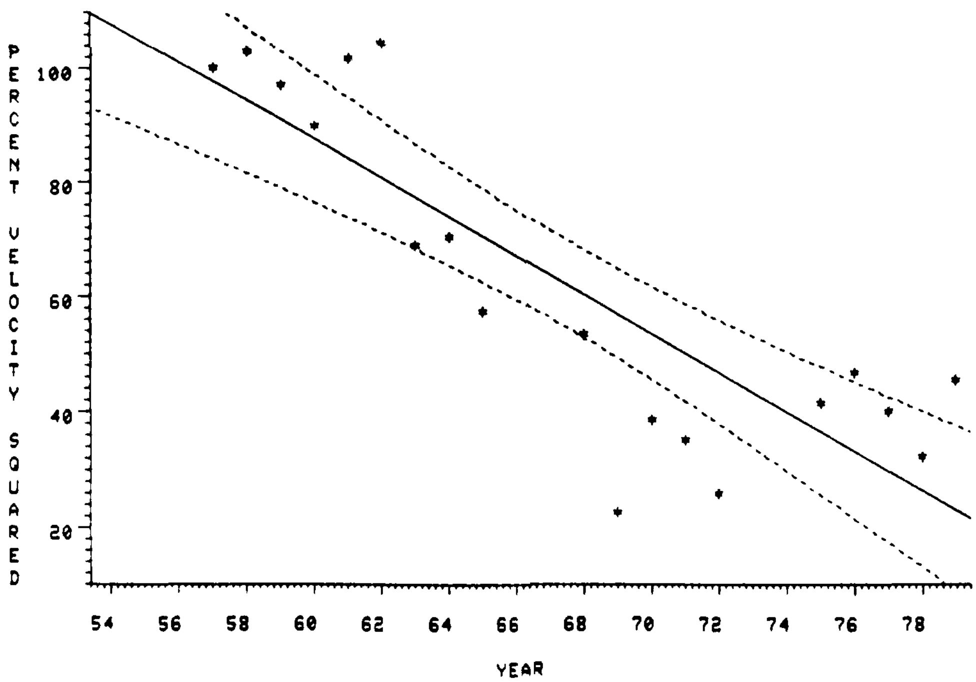

Figure 20. Percent V^2 average over reinforcement types. Position, bottom; stress, 20,000 psi

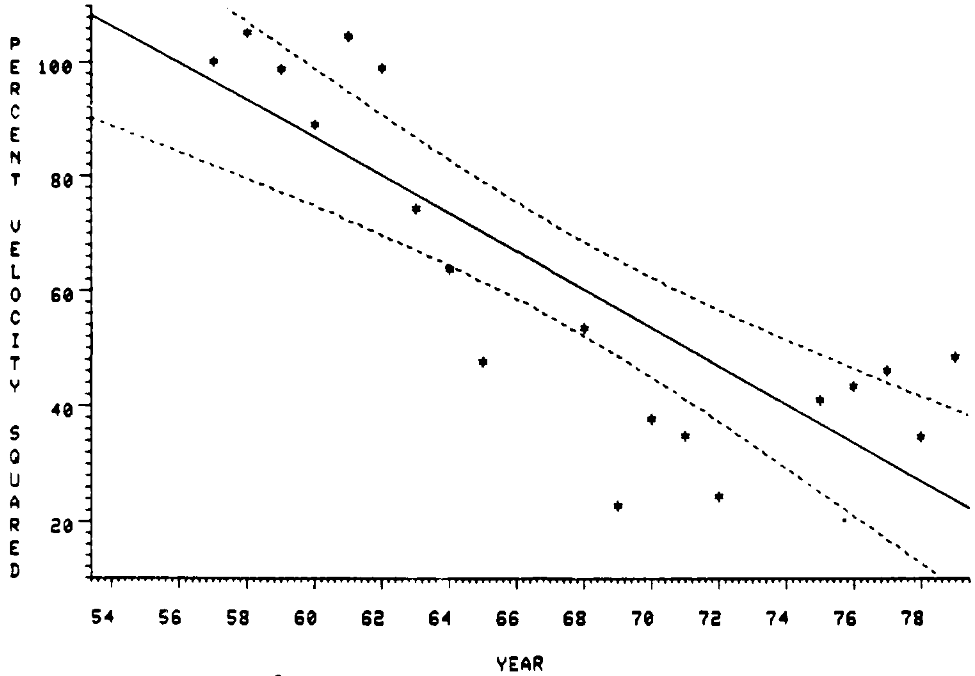

Figure 21. Percent V^2 average over reinforcement types. Position, bottom; stress, 30,000 psi

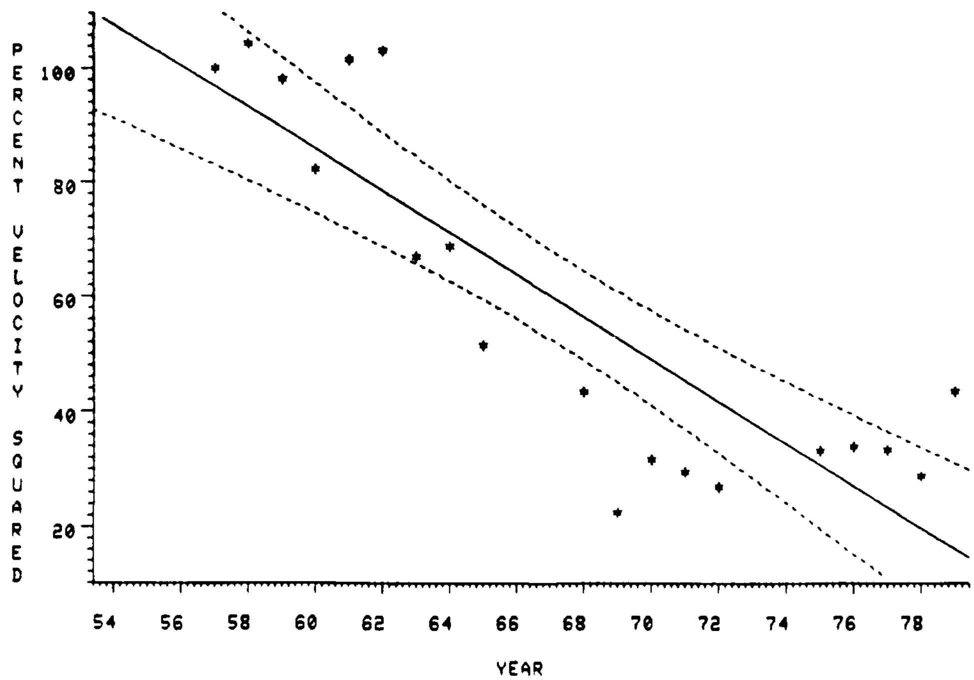

Figure 22. Percent V^2 average over reinforcement types. Position, bottom; stress, 40,000 psi

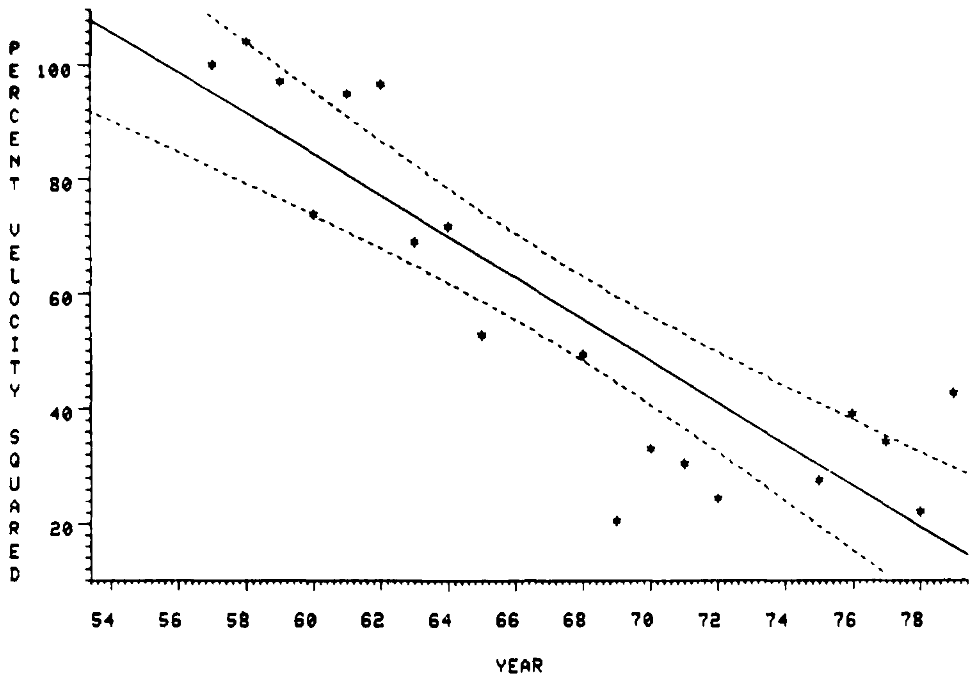

Figure 23. Percent V^2 average over reinforcement types. Position, bottom; stress, 50,000 psi

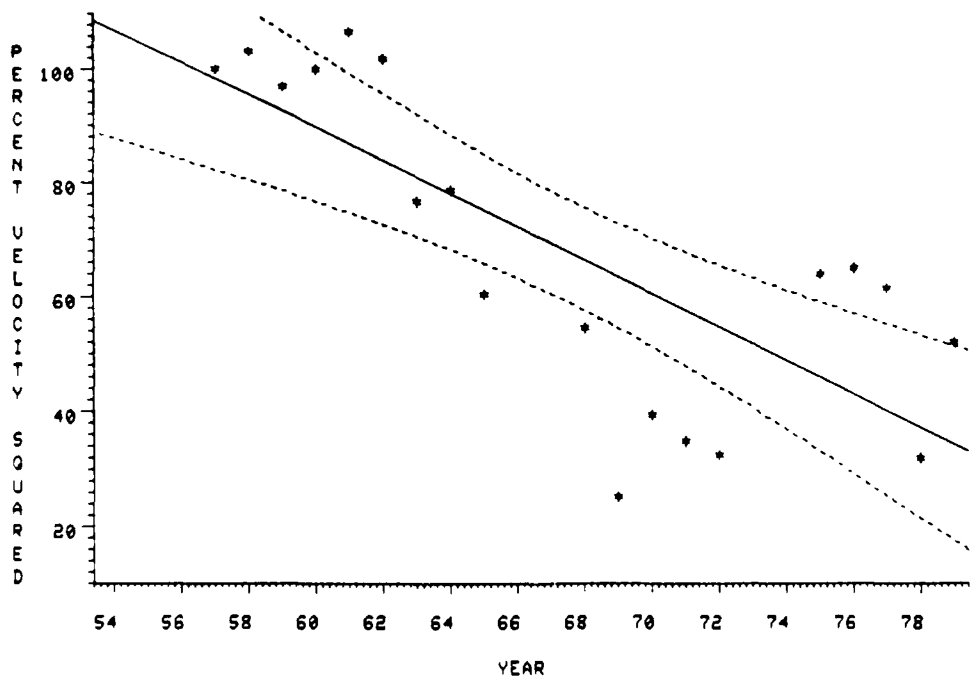

Figure 24. Percent V^2 average over reinforcement types. Position, top; stress, 0 psi

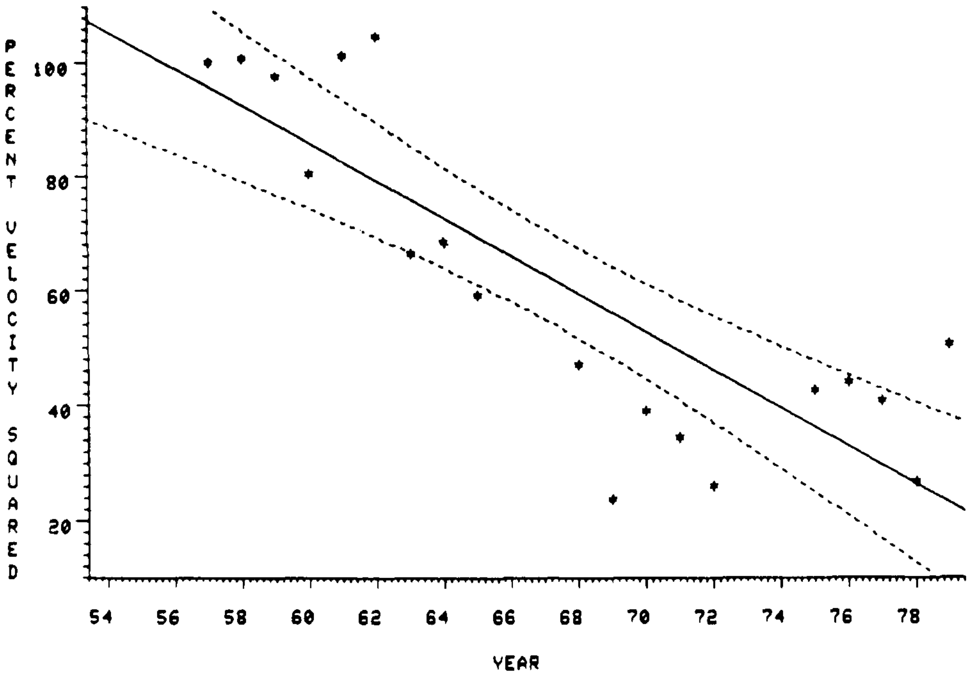

Figure 25. Percent V^2 average over reinforcement types. Position, top; stress, 20,000 psi

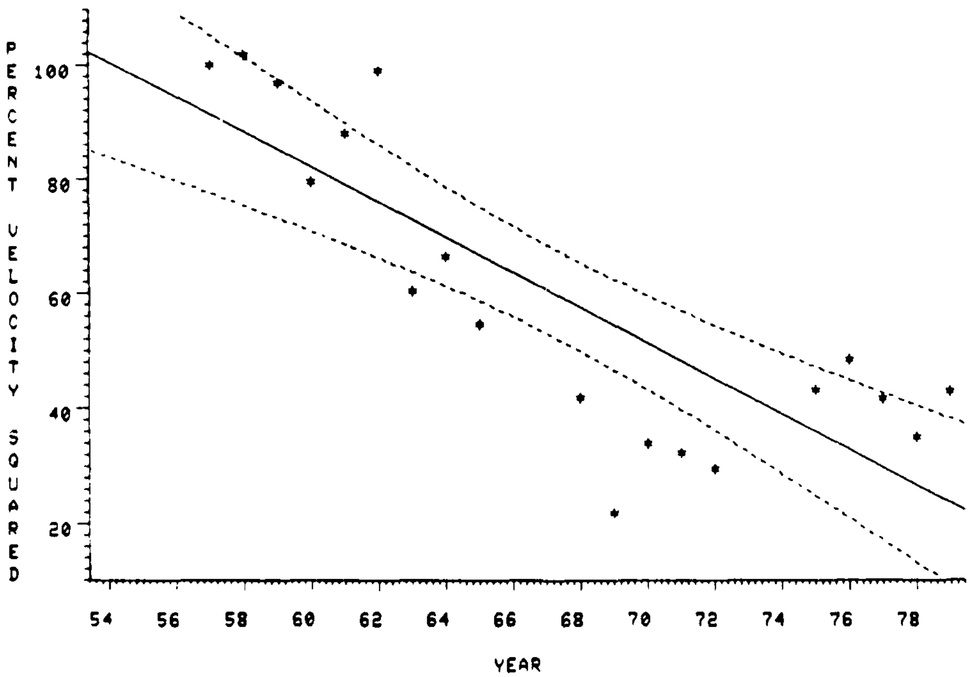

Figure 26. Percent V^2 average over reinforcement types. Position, top; stress, 30,000 psi

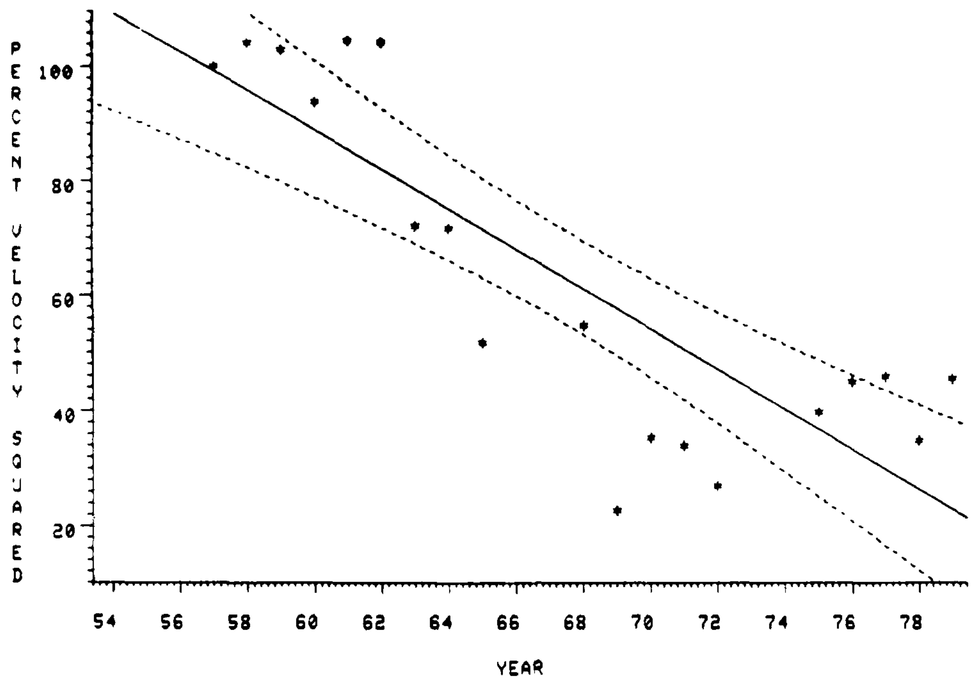

Figure 27. Percent V^2 average over reinforcement types. Position, top; stress, 40,000 psi

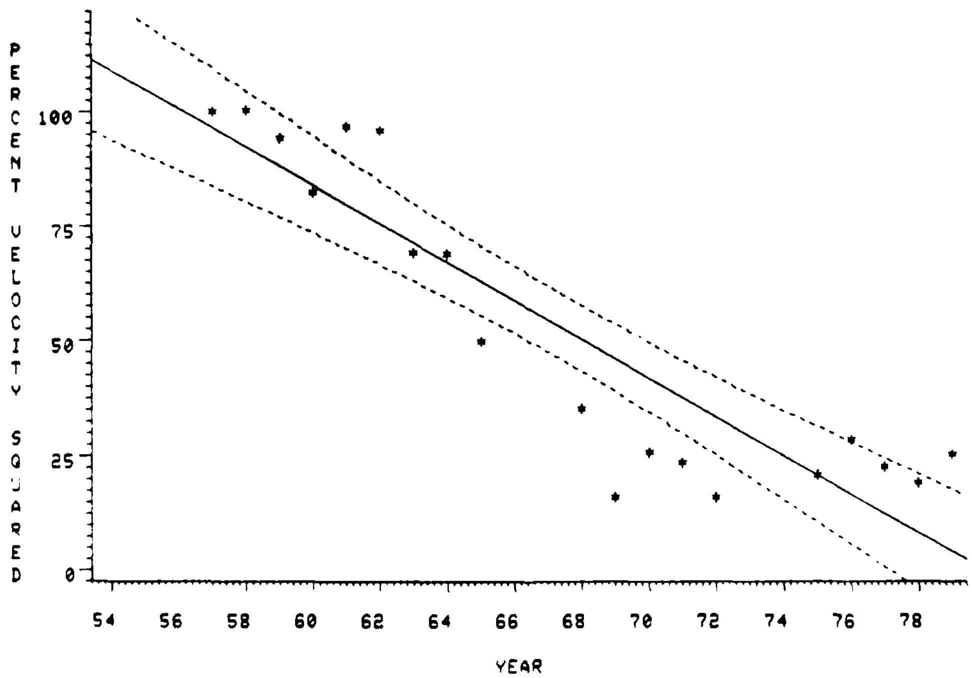

Figure 28. Percent V^2 average over reinforcement types. Position, top; stress, 50,000 psi

Table 7

Position by Deformation Type by Stress

$\%V^2$

	Stress at				
	0 (Control)	20,000 psi	30,000 psi	40,000 psi	50,000 psi
Bottom					
A 305-50T	66.34	63.14	62.04	59.28	55.11
Old-Style	64.27	60.55	60.97	56.97	58.90
Top					
A 305-50T	67.13	60.18	59.35	60.73	58.77
Old-Style	68.16	61.34	58.26	64.57	45.49

For these particular cell means, the critical value of w is 4.79. This value of w produces the following statistical patterns.

	0	20,000	30,000	40,000	50,000
Bottom: A 305-50T	66.34	63.14	62.04	59.28	55.11
Bottom: Old-Style	64.27	60.55	60.97	56.97	58.90
Top: A 305-50T	67.13	60.18	59.35	60.73	58.77
Top: Old-Style	68.16	61.34	58.26	64.57	45.99

In order to represent the last category, the cell means must be reordered as follows:

0	40,000	20,000	30,000	50,000
68.16	64.57	61.34	58.26	45.49

Note: Means underscored with the same line are statistically equivalent.

44. From this type of synopsis, the changes in the significance patterns are readily seen. Since these changes are prevalent in this set of data, the interaction term became significant. From this set of cell means one would conclude the following.

a. For the A 305-50T deformation type.

(1) Within the bottom position, the 0 stress level has a significantly higher $\%V^2$ than the 50,000-psi stress level; furthermore, the 20,000-, 30,000-, and 40,000-psi stress levels yield similar $\%V^2$ values.

(2) Within the top position, the 0 stress level has a significantly larger $\%V^2$ than the 20,000-, 30,000-, 40,000-, and 50,000-psi stress levels which exhibit a similar $\%V^2$ pattern.

b. For the old-style deformation type.

(1) Within the bottom position, the 0, 20,000-, and 30,000-psi stress levels exhibit similar $\%V^2$ values; however, the 20,000-, 30,000-, 40,000-, and 50,000-psi stress levels also exhibit similar $\%V^2$ values. Therefore, the primary conclusion would be that 0 stress level produces a significantly larger $\%V^2$ than the 40,000- and 50,000-psi stress levels.

(2) Within the top position, the pattern is more complex; however, the conclusions that the 0 stress level exhibits significantly larger $\%V^2$ than the 20,000- and 30,000-psi stress levels and that the 20,000- and 30,000-psi stress levels exhibit significantly larger $\%V^2$ than the 50,000-psi stress level can be inferred.

45. For the first-order interaction effect of reinforcement bar deformation by stress, the pertinent cell means are displayed in Table 8. A three-dimensional block chart of the cell means is presented in Figure 29.

Table 8

Reinforcement Bar Deformation by Stress Levels, $\%V^2$

Reinforcement Type	Stress at 0 (Control)	20,000 psi	30,000 psi	40,000 psi	50,000 psi
A 305-50T	66.88	61.66	60.94	60.01	56.94
Old-Style	66.21	60.94	59.61	60.77	52.20
Difference	0.67	0.72	1.33	-0.76	4.74

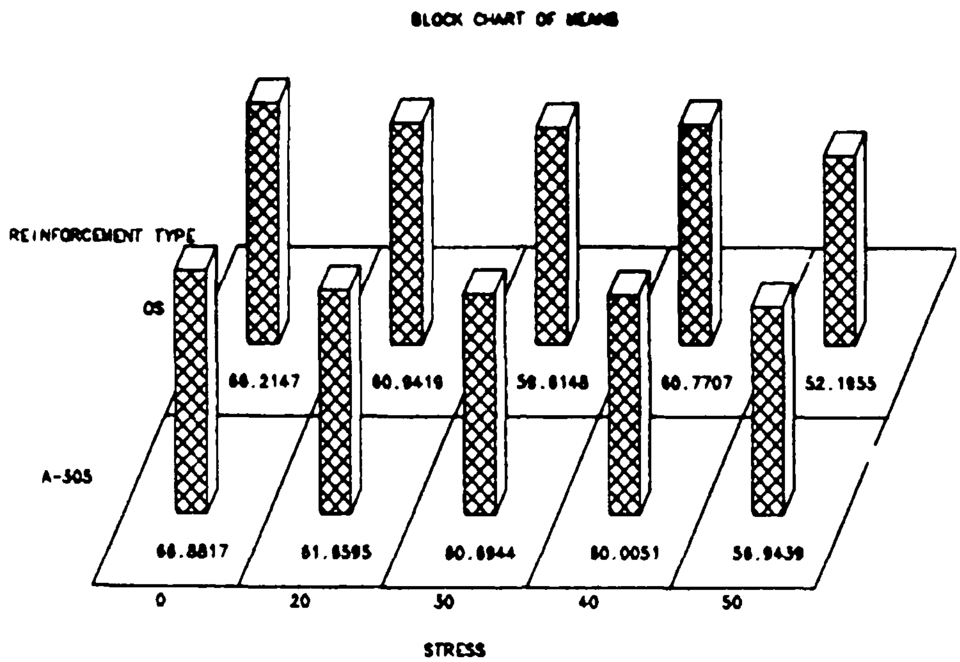

Figure 29. $\%V^2$ average over years by deformation type

The multiple comparison procedure known as orthogonal comparisons was used to determine the critical difference between any two cell means within stress levels; the critical difference is 1.81, which is obtained by

$$\text{Critical difference} = t(p,df)\sqrt{(\text{error mean squares})/N}$$

This equation is used for independent or orthogonal contrasts, where $t(p,df)$ is the tabular point from the t-distribution with degrees of freedom (df) and confidence level $(1 - p)$. N represents the number of observations comprising each cell mean. With 1.81 as the defined critical difference, the only significant difference occurs at the 50,000-psi stress level, where the A 305-50T reinforcement deformation type exhibits a significantly larger $\%V^2$ value than the old-style deformation type.

46. For the first-order interaction effect of position by stress, the pertinent cell means are displayed in Table 9 and are graphically depicted in Figure 30.

Table 9

Position by Stress, $\%V^2$

Position	Stress at 0 (Control)	20,000 psi	30,000 psi	40,000 psi	50,000 psi
Bottom	65.45	61.84	61.51	58.12	57.01
Top	67.64	60.76	58.80	62.65	52.13
Difference	-2.19	1.08	2.71	-4.53	4.88

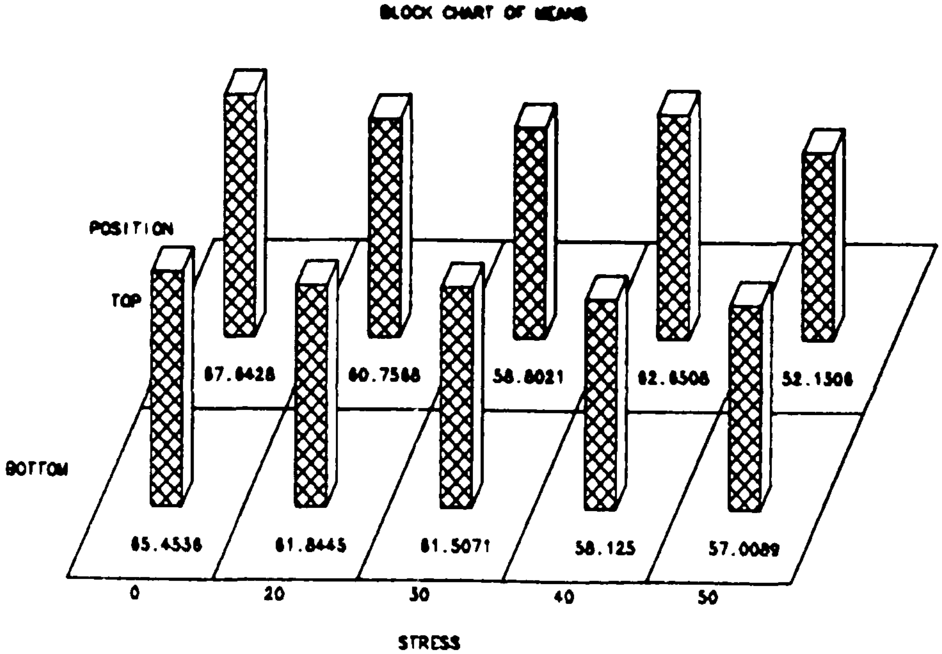

Figure 30. $\%V^2$ average over years by position

47. The absolute critical difference for this set of cell means is 1.81. As can be seen from Table 9, it can be concluded that at the 0 stress level the top position exhibited a significantly larger $\%V^2$ than the bottom position; no significant differences are exhibited at the 20,000-psi stress level; at the 30,000-psi stress level, the bottom position exhibits a significantly larger $\%V^2$ than the top position; at the 40,000-psi stress level, the top position exhibits a significantly

larger $\%V^2$ than the bottom position; and at the 50,000-psi stress level, the bottom position exhibits a significantly larger $\%V^2$ than the top position.

48. For the main effect of stress, Duncan's Multiple Range test indicates that the 0 stress level exhibits a significantly larger $\%V^2$ than the 20,000-, 30,000-, and 40,000-psi stress levels which in turn are significantly larger than the 50,000-psi stress level.

Stress at				
0 (Control)	20,000 psi	30,000 psi	40,000 psi	50,000 psi
66.55	61.30	60.39	60.15	54.57

Reference Appendix B for the detailed computer analysis of this data set.

49. For the main effect of reinforcement deformation type, the A 305-50T deformation type exhibits a significantly higher $\%V^2$ than the old-style.

A 305-50T	Old-Style
61.24	59.95

Reference Appendix B for the detailed computer analysis for this data set.

50. For the response variable $\%V^2$, the data from this investigation indicated that the degradation rate of $\%V^2$ increases as stress levels increase (exhibited by the significant stress by year interaction); the mean $\%V^2$ averaged over time indicated that the average $\%V^2$ decreased as stress increased, and that the primary difference between the A 305-50T and the old-style deformation types occurred at the 50,000-psi stress level where the A 305-50T deformation type exhibited a significantly larger $\%V^2$.

Variable
maximum crack width

51. For the variable maximum crack width, the 0 stress level was omitted due to the absence of measurable cracks. However, with stress levels of 20,000, 30,000, 40,000, and 50,000 psi, the analysis of

variance procedure indicated that the following factors were significant: stress levels, reinforcement deformation type by stress interaction, position by reinforcement deformation type by stress interaction, year, and stress by year interaction. Subsequent analyses of these significant effects are described below.

52. For the first-order interaction effect of stress by year, the data are graphically displayed in Figures 31-38. From these plots it is readily seen that maximum crack width tends to increase linearly with age for the stress levels of 20,000, 30,000, and 40,000 psi; however, for the 50,000-psi stress level there is definitely a nonlinear relationship. Maximum crack widths within the 50,000-psi stress level group display a fairly smooth linear trend until 1975, and then a more rapidly linear increasing trend through 1979.

53. For the second-order interaction effect of position by deformation type by stress level, the data are displayed in Table 10. As is readily observed from this table, maximum crack width displays a slight

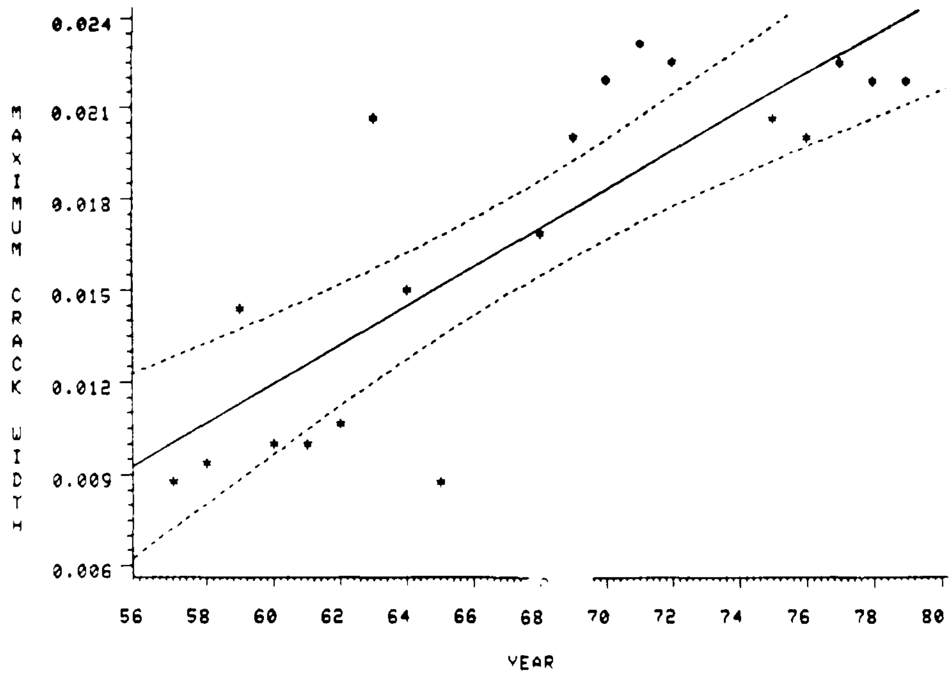

Figure 31. Maximum crack width average over reinforcement types. Position, bottom; stress, 20,000 psi

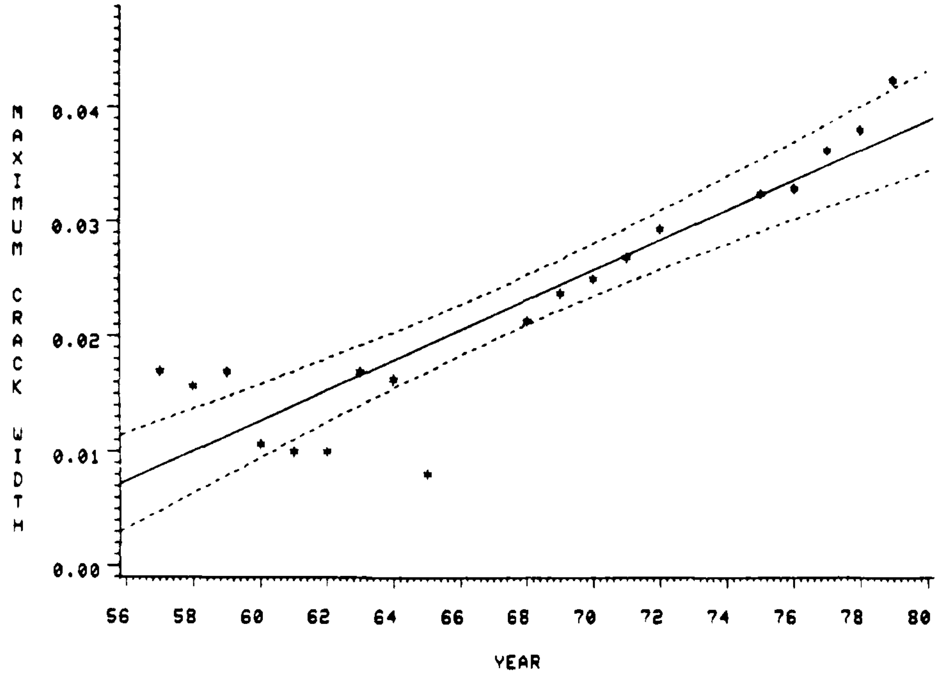

Figure 32. Maximum crack width average over reinforcement types. Position, top; stress, 20,000 psi

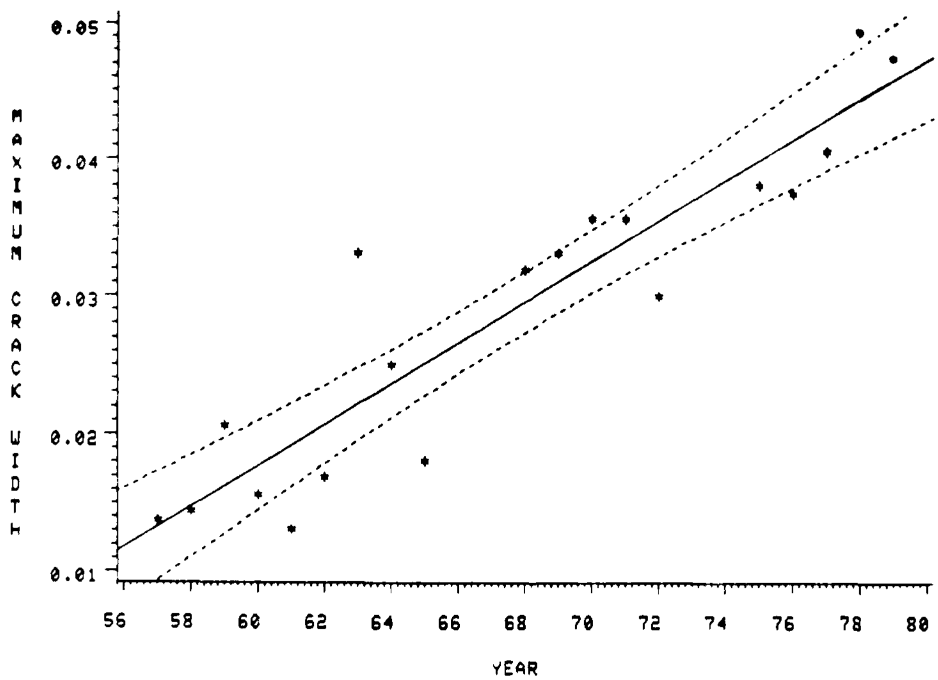

Figure 33. Maximum crack width average over reinforcement types. Position, bottom; stress, 30,000 psi

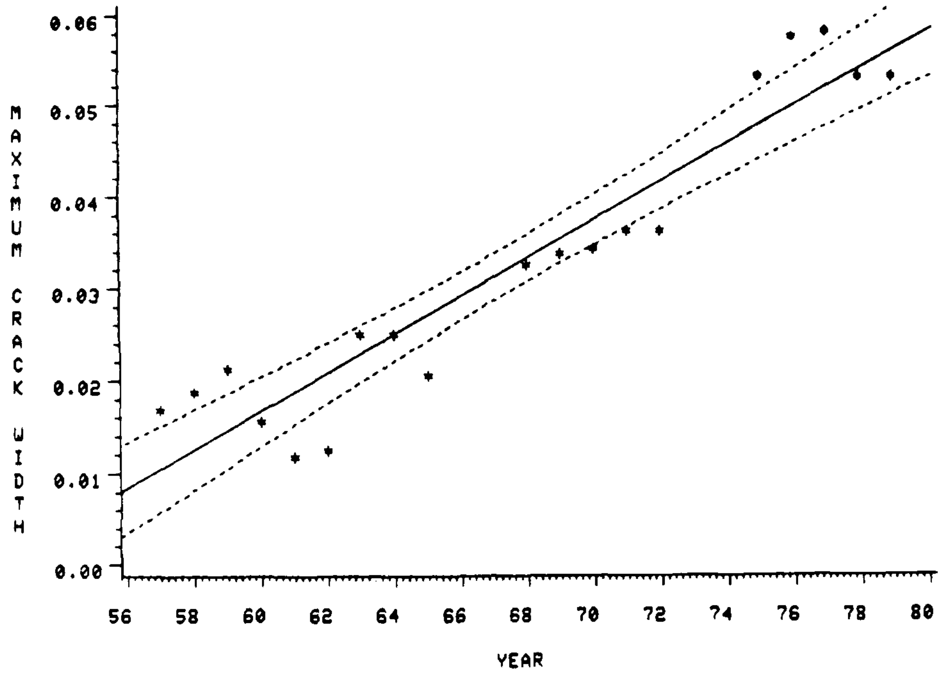

Figure 34. Maximum crack width average over reinforcement types. Position, top; stress, 30,000 psi

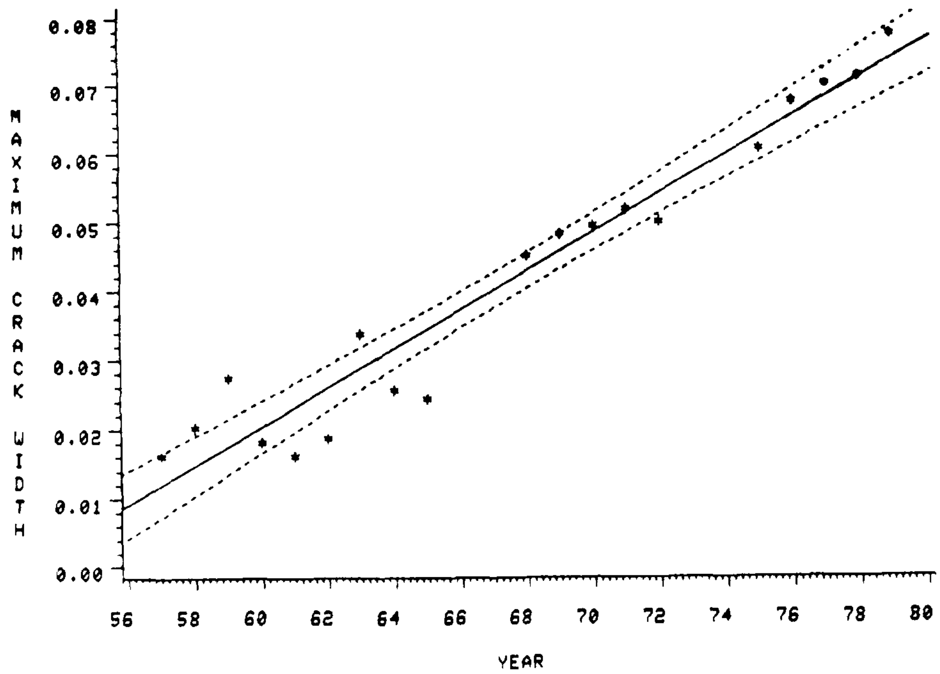

Figure 35. Maximum crack width average over reinforcement types. Position, bottom; stress, 40,000 psi

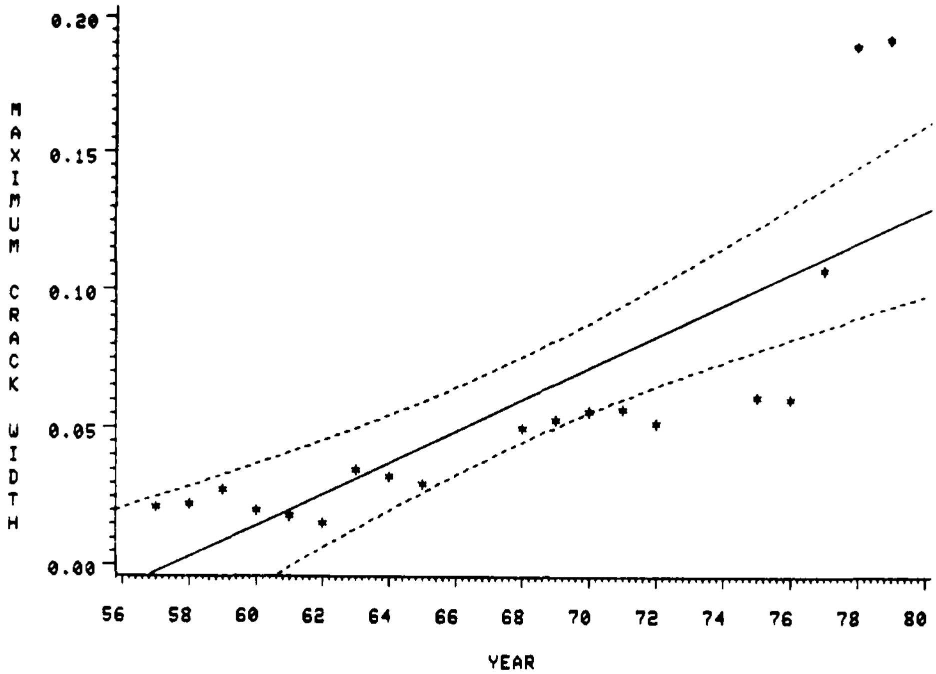

Figure 36. Maximum crack width average over reinforcement types. Position, top; stress, 40,000 psi

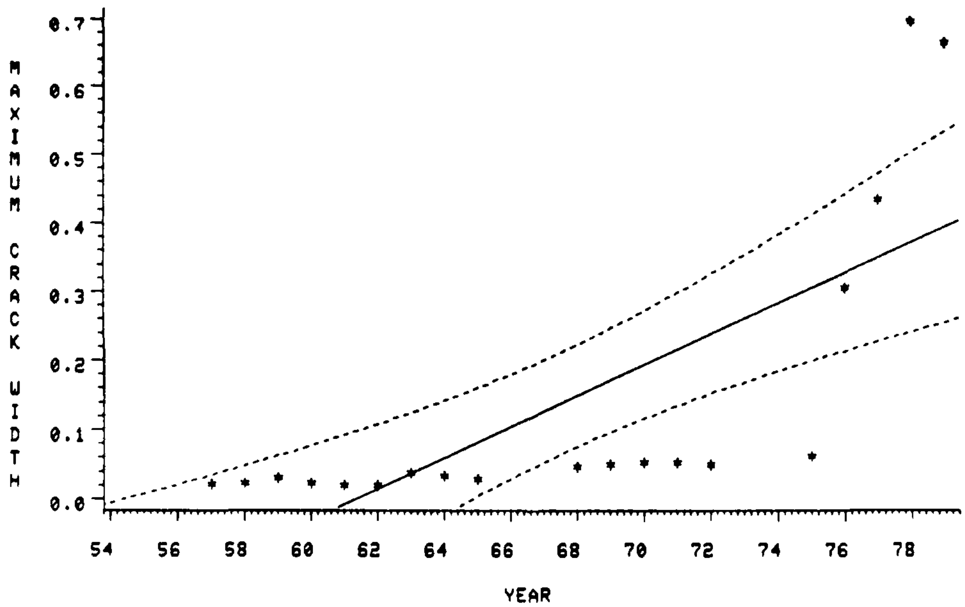

Figure 37. Maximum crack width average over reinforcement types. Position, bottom; stress, 50,000 psi

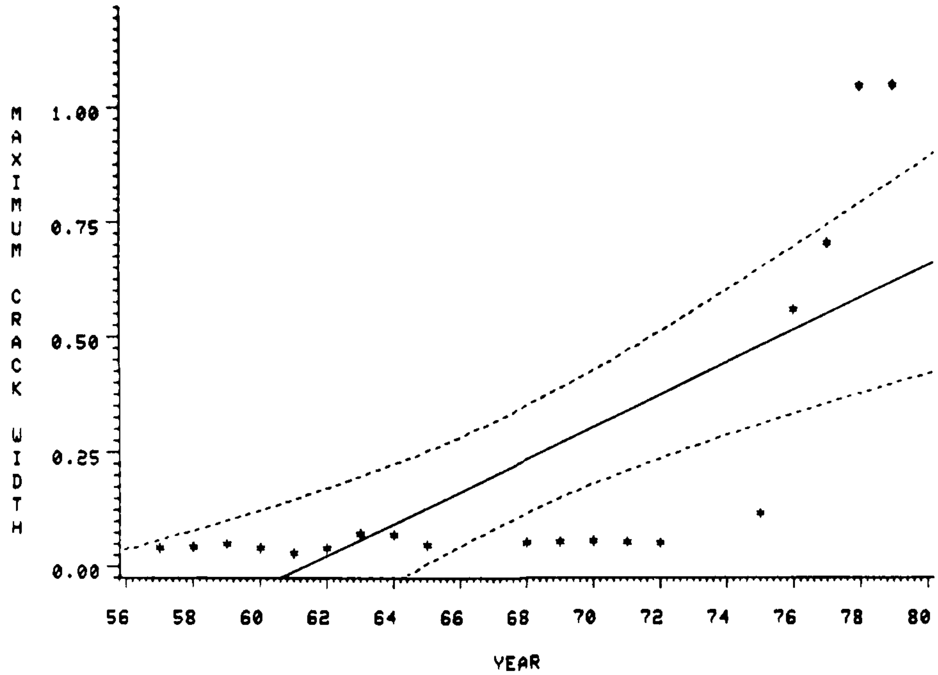

Figure 38. Maximum crack width average over reinforcement types. Position, top; stress, 50,000 psi

Table 10

Position by Stress by Reinforcement Bar Deformation, Maximum Crack Width (in.)

	Stress at			
Position/Type	20,000 psi	30,000 psi	40,000 psi	50,000 psi
Bottom				
A 305-50T	0.01546	0.02232	0.03754	0.12724
Old-Style	0.01809	0.03559	0.04586	0.15217
Top				
A 305-50T	0.02066	0.03072	0.04855	0.31664
Old-Style	0.02458	0.03408	0.06737	0.12395

linear increasing trend from 20,000 to 40,000 psi; however, a 261.23 average percent increase occurs from the 40,000- to the 50,000-psi stress level; whereas, a 152.98 percent increase occurs from the 20,000- to the 40,000-psi stress level.

54. For the first-order interaction effect of reinforcement bar deformation type by stress, the pertinent data are displayed in Table 11 and graphically in Figure 39. Orthogonal comparisons were made of

Table 11

Reinforcement Bar Deformation by Stress Level, Maximum Crack Width (in.)

	Stress at			
Deformation Type	20,000 psi	30,000 psi	40,000 psi	50,000 psi
A 305-50T	0.01806	0.02652	0.04305	0.22194
Old-style	0.02134	0.03484	0.05661	0.13806

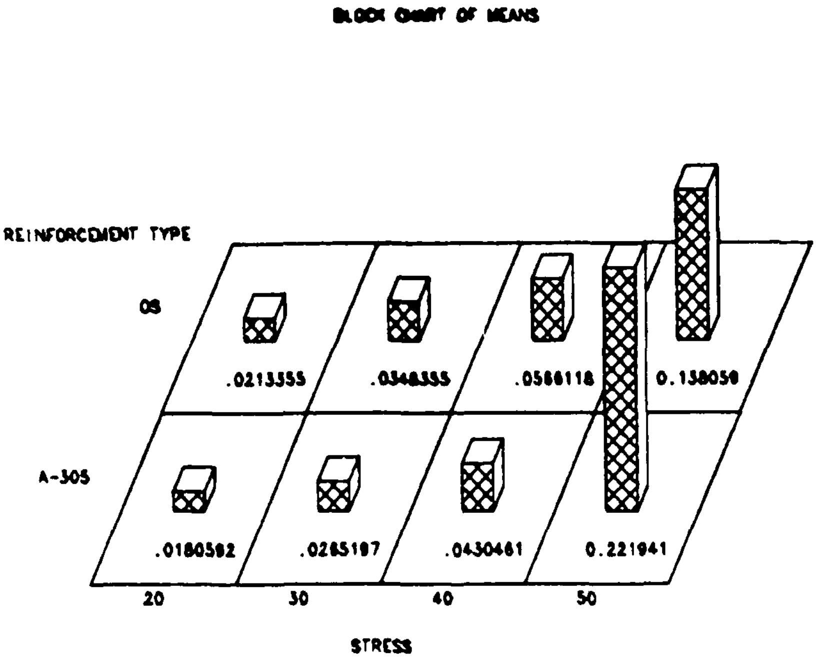

Figure 39. Maximum crack width average over years by reinforcement type

reinforcement bar deformation types within stress levels; the critical difference in maximum crack width was found to be 0.0544 in. As is observed from Table 11, the only difference which exceeds this critical difference is at the 50,000-psi stress level where the A 305-50T reinforced concrete beams exhibited a significantly larger average maximum crack width than the old-style reinforced concrete beams. One (beam 149) of the four beams which provided data for the top position, A 305-50T deformation type, 50,000-psi stress level treatment combination experienced failure of one of its two reinforcing bars during the winter of 1973-1974 (see Figures 40 and 41 and Appendix A). The loss of approximately one-half of its tensile load-bearing capacity resulted in the

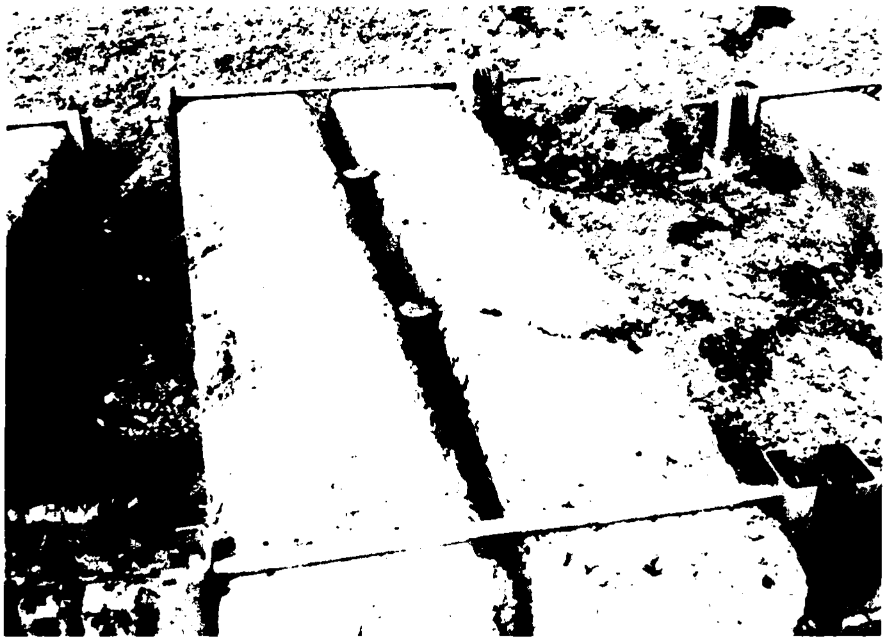

Figure 40. Beam 149 experienced failure of one of two reinforcing bars during winter of 1973-1974

formation of a very large transverse crack which increased in width through subsequent years. Beam 147, one of the four data sources for the top position, old-style deformation type, 50,000-psi stress level treatment combination, experienced the abrupt failure of both reinforcing bars in 1968. This failure completely severed beam 147 and damaged its companion beam, No. 148. Consequently, only two beams (151 and 152) remained for data collection in this treatment condition (top, old-style, 50,000-psi stress). Because of the relatively early failure and

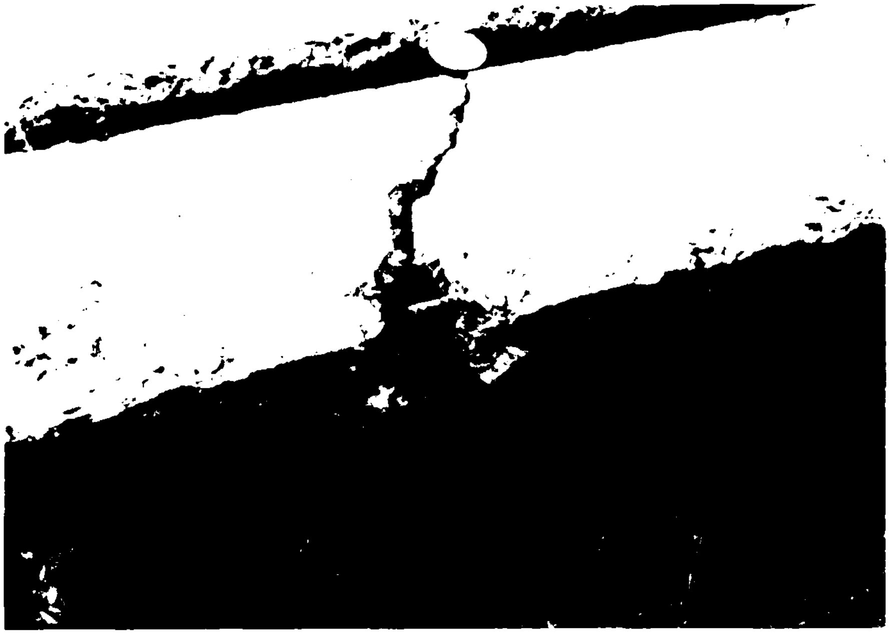

Figure 41. Close-up of beam 149. Note severed rebar

discontinuance of data collection on beams 147 and 148, these data were excluded from the analysis; whereas beam 149, having experienced partial failure, continued to produce crack width data of very large magnitudes. The early failure of the old-style beams and subsequent loss of "incriminating" performance data from the analysis seriously affects the validity of conclusions that might be drawn on the basis of the numbers shown in Tables 10 and 11 concerning deformation type at the 50,000-psi stress level.

55. For the first-order interaction effect of position by stress, the data are displayed in Table 12 and Figure 42. Since these means are based on the same number of observations (n = 38), the critical difference between average maximum crack width within stress levels remains at 0.0544 in. Consequently, the only stress level exhibiting a difference larger than 0.0544 in. is the 50,000-psi stress level where the top position exhibits an average maximum crack width of 0.2203 in. and the bottom position exhibits an average maximum crack width of 0.13970 in.

Table 12

Position by Stress,

Maximum Crack Width (in.)

Position	Stress at 20,000 psi	30,000 psi	40,000 psi	50,000 psi
Bottom	0.01678	0.02895	0.04170	0.13970
Top	0.02262	0.03240	0.05796	0.2203

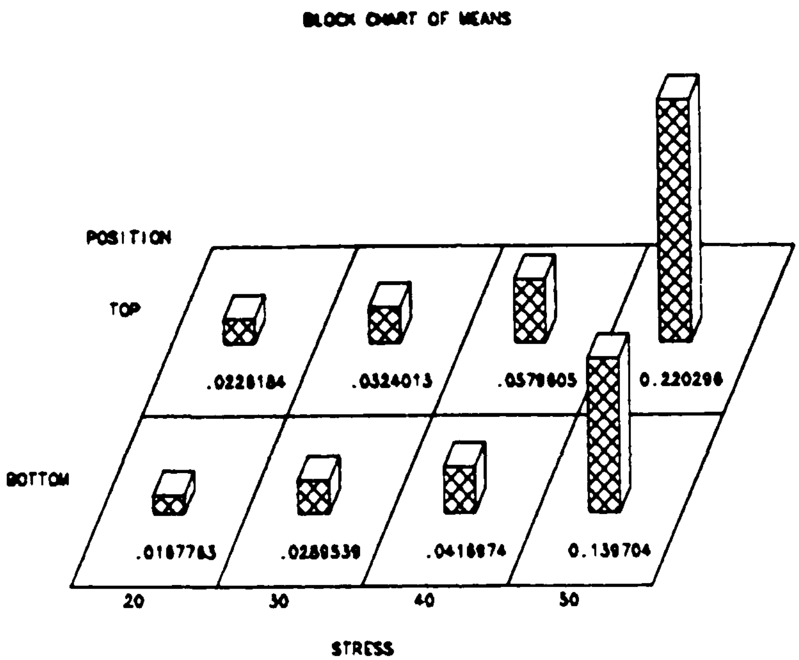

Figure 42. Maximum crack width average over years by position

56. For the first-order interaction effect of reinforcement bar deformation type and position, the pertinent data are displayed in Table 13. Orthogonal comparisons showed the critical difference between A 305-50T and old-style reinforcement bar deformation to be 0.03866 in. As is observed from Table 13, the two average maximum crack widths which will exceed this critical difference occur at the top position where the A 305-50T exhibited an average maximum crack width of 0.10414 in. and the old-style exhibited a maximum crack width of 0.06249 in. As mentioned

Table 13

Reinforcement Bar Deformation by Position,

Maximum Crack Width (in.)

	A 305-50T	Old-Style
Bottom	0.05064	0.06293
Top	0.10414	0.06249

in the previous discussion of Tables 10 and 11, it is felt that these numbers do not represent actual performance of A 305-50T deformation versus old-style deformation considering the omission of the early failure of old-style beams and subsequent loss of performance data.

57. For the main effect of stress, the pertinent data are exhibited in Table 14. Tukey's w-procedure was used to compare all four means simultaneously. It was found that the average maximum crack widths for stress levels 20,000, 30,000, and 40,000 psi were not significantly different; however, the 50,000-psi stress level exhibited an average maximum crack width which was significantly larger than the 20,000-, 30,000-, and 40,000-psi stress levels.

Table 14

Stress Levels,

Maximum Crack Width (in.)

20,000 psi	30,000 psi	40,000 psi	50,000 psi
0.01970	0.03068	0.04983	0.1800

58. For the response variable maximum crack width the data from this investigation indicated that maximum crack width increased linearly for stress levels 20,000, 30,000, and 40,000 psi, and nonlinearly for stress level 50,000 psi. Furthermore, this linear trend when averaged over time showed a marked increase from the 40,000- to the 50,000-psi stress level for all positions and deformation bar types. The largest

increase between the 40,000- and 50,000-psi stress levels occurred for the A 305-50T deformation type with the top position. However, it is felt that the old-style deformation type would have shown a similar trend if data from the beams which failed had been included in the analysis. Beams with the A 305-50T deformation bar type displayed smaller maximum crack widths than the old-style deformation bar type for stress levels of 20,000, 30,000, and 40,000 psi; however, the opposite was true for the 50,000-psi stress level. Again, this reversal in trend is probably due to omission of performance data on the old-style beams which failed.

Linear Models

59. Linear regression analyses of condition, $\%V^2$, and maximum crack width were done for each combination of position, stress, and reinforcement bar deformation over time. The results are shown in Appendix C. The correlation coefficient and the mathematical equation describing each regression line are given for each combination of position, stress, and reinforcement bar deformation over time. In the equations the predictor is the year and the criterion measures are condition rating, $\%V^2$, and maximum crack width.

PART IV: CONCLUSIONS

60. An evaluation of the results of the statistical analysis leads to the following conclusions:

a. Beams with steel in the bottom-as-cast position deteriorate at a slower rate than do beams with steel in the top-as-cast position for both A 305-50T and old-style deformation type, and beams with steel in the bottom-as-cast position exhibited smaller average maximum crack widths (significant at 50,000-psi stress level).

b. A 305-50T type reinforcement bar deformation exhibited less severe degradation trends than old-style, and A 305-50T deformation type exhibited a significantly larger $\%V^2$ than did old-style deformation at the 50,000-psi stress level.

c. As stress levels increased, the conditions of the beams generally decreased and the degradation of $\%V^2$ increased. There were marked increases in maximum crack widths from the 40,000- to 50,000-psi stress levels for all positions and bar deformation types.

d. At the 50,000-psi stress level the A 305-50T reinforced concrete beams exhibited a significantly larger average maximum crack width than the beams containing old-style deformation bars.*

61. For further clarification of some apparent anomalies, it should be noted here that the zero stress level (control) beams were more difficult to support than the yoked pairs (stressed) of beams. Consequently, they were tossed and moved around during winter storms and became partially covered with sand. The partial covering with sand during most of their exposure time affected a more saturated condition of these beams which resulted in inordinate deterioration due to freezing and thawing. It is felt that this more severe exposure condition adversely affected the performance of the zero stress level beams as reflected in the analysis results of the variable "condition."

* As previously discussed, it is felt that the early failure of one pair of old-style, 50,000-psi stress level beams, and the subsequent loss of "incriminating" performance data seriously affect the validity of conclusions drawn concerning performance of deformation type at the 50,000-psi stress level. With this in mind, and in view of conclusion b above, the data seem to indicate that beams containing bars with A 305-50T deformation performed better than beams containing old-style type bars.

APPENDIX A: EXPOSURE RECORDS OF SPECIMENS

Table 1-TC-B

Record of Observation and Testing of Large-beam Tensile Crack Specimens,

Series B, 1954- (Installed Nov 1954)

Beach Row 1

Beam No.	Nominal Stress psi	Steel Position*	Type** Steel Deformation	1954-1958 Readings: 0 Cycles, 1954 Condition	0 Cycles, 1954 Pulse Veloc fps	0 Cycles, 1954 %V²	143 Cycles 1955 Condition	310 Cycles 1956 Condition	454 Cycles, 1957 Condition	454 Cycles, 1957 %V²	454 Cycles, 1957 Max Crack Width† 1/1000 in.	525 Cycles, 1958 Condition	525 Cycles, 1958 %V²	525 Cycles, 1958 Max Crack Width† 1/1000 in.
83	20,000	B	A-305	Sound	10,890	100	100	91	87	173	10	[illegible]	173	10
84	20,000	B	A-305	Sound	11,150	100	100	91	88	168	5	84	170	10
85	20,000	B	OS	Sound	11,7[illegible]	100	100	90	84	157	10	[illegible]	153	10
86	20,000	B	OS	Sound	11,470	100	100	87	82	170	10	84	155	10
87	20,000	B	A-305	Sound	10,640	100	100	82	74	171	5	77	183	5
88	20,000	B	A-305	Sound	10,470	100	100	84	76	175	10	77	200	10
89	20,000	B	OS	Sound	11,255	100	100	84	77	162	10	77	167	10
90	20,000	B	OS	Sound	11,300	100	100	83	83	160	10	77	169	10
91	30,000	B	A-305	Sound	11,540	100	93	90	79	146	10	76	151	15
92	30,000	B	A-305	Sound	11,540	100	100	90	82	161	10	81	166	10
93	30,000	B	OS	Sound	12,120	100	100	87	86	151	15	80	152	15
94	30,000	B	OS	Sound	11,605	100	100	87	82	145	20	80	169	20
95	30,000	B	A-305	Sound	11,905	100	100	92	84	154	10	80	156	10
96	30,000	B	A-305	Sound	11,195	100	100	90	86	162	10	80	174	10
97	30,000	B	OS	Sound	11,385	100	100	86	86	152	15	86	154	15
98	30,000	B	OS	Sound	11,385	100	100	90	85	149	20	87	159	20
99	40,000	B	A-305	Sound	10,290	100	100	88	87	190	15	84	202	15
100	40,000	B	A-305	Sound	10,435	100	100	88	57	190	10	[illegible]	198	15
101	40,000	B	OS	Sound	10,400	100	98	82	82	195	15	79	191	20
102	40,000	B	OS	Sound	10,455	100	100	84	82	167	20	81	203	20
103	40,000	B	A-305	Sound	8,915	100	95	83	80	228	10	77	246	20
104	40,000	B	A-305	Sound	8,585	100	94	82	78	248	25	[illegible]	269	25
105	40,000	B	OS	Sound	9,230	100	100	86	91	246	10	[illegible]	237	20
106	40,000	B	OS	Sound	9,435	100	100	80	80	236	25	74	238	30
107	50,000	B	A-305	Sound	10,310	100	100	86	80	195	15	[illegible]	191	15
108	50,000	B	A-305	Sound	11,385	100	98	86	77	147	20	[illegible]	156	20
109	50,000	B	OS	Sound	8,915	100	91	74	72	274	20	[illegible]	273	20
110	50,000	B	OS	Sound	10,170	100	92	74	77	199	25	[illegible]	201	25
111	50,000	B	A-305	Sound	9,130	100	99	79	74	251	20	76	252	25
112	50,000	B	A-305	Sound	9,160	100	100	86	86	242	20	[illegible]	[illegible]	25
113	50,000	B	OS	Sound	8,850	100	93	70	64	243	25	[illegible]	[illegible]	25
114	50,000	B	OS	Sound	8,525	100	100	77	77	250	30	[illegible]	[illegible]	30
115	None	B	A-305	Sound	12,985	100	96	86	84	115	0	[illegible]	122	0
116	None	B	A-305	Sound	13,015	100	100	88	84	110	0	[illegible]	111	0
117	None	B	A-305	Sound	13,245	100	100	94	93	114	10	[illegible]	11[illegible]	10
118	None	B	OS	Sound	13,250	100	98	76	65	111	0	[illegible]	119	[illegible]
119	None	B	OS	Sound	13,130	100	100	91	90	119	0	[illegible]	11[illegible]	[illegible]
120	None	B	OS	Sound	13,185	100	100	88	89	115	0	[illegible]	11[illegible]	[illegible]
121	20,000	T	A-305	Sound	9,600	100	96	77	80	213	35	[illegible]	[illegible]	35
122	20,000	T	A-305	Sound	9,570	100	96	87	76	237	10	[illegible]	[illegible]	[illegible]
123	20,000	T	OS	Sound	9,870	100	100	86	[illegible]	205	10	[illegible]	[illegible]	10
124	20,000	T	OS	Sound	9,675	100	100	94	86	216	10	[illegible]	[illegible]	15
125	20,000	T	A-305	Sound	12,960	100	100	86	86	120	15	[illegible]	1[illegible]	15
126	20,000	T	A-305	Sound	13,160	100	100	79	80	122	35	[illegible]	1[illegible]	[illegible]
127	20,000	T	OS	Sound	13,3[illegible]	100	100	94	90	132	10	[illegible]	1[illegible]	1[illegible]
128	20,000	T	OS	Sound	13,015	100	100	92	90	135	10	[illegible]	1[illegible]	1[illegible]
129	30,000	T	A-305	Sound	9,755	100	97	8[illegible]	75	[illegible]34	15	74	[illegible]	[illegible]
130	30,000	T	A-305	Sound	9,820	100	[illegible]	8[illegible]	[illegible]	230	20	77	[illegible]	[illegible]
131	30,000	T	OS	Sound	11,675	100	96	81	76	136	20	75	1[illegible]	[illegible]
132	30,000	T	OS	Sound	11,675	100	[illegible]	77	76	159	30	80	1[illegible]	[illegible]
133	30,000	T	A-305	Sound	13,070	100	[illegible]	88	[illegible]	115	10	[illegible]	1[illegible]	10
134	40,000	T	A-305	Sound	12,820	100	[illegible]	[illegible]	[illegible]	1[illegible]	1[illegible]	[illegible]	1[illegible]	1[illegible]
135	30,000	T	OS	Sound	12,875	100	[illegible]	87	[illegible]	141	1[illegible]	[illegible]	14[illegible]	[illegible]
136	30,000	T	OS	Sound	11,340	100	[illegible]	[illegible]	[illegible]	1[illegible]	10	[illegible]	149	1[illegible]
137	40,000	T	A-305	Sound	10,[illegible]	100	[illegible]	[illegible]	[illegible]	14[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

(Continued)

* [illegible] of beam.
[illegible]
** [illegible]
[illegible]
† [illegible]
[illegible]

Table 1-TC-B (Continued)

Beach Row 1

				1954-19[illegible] Readings										
				0 Cycles, 1954			143 Cycles 1955	310 Cycles 1956	454 Cycles, 1957			525 Cycles, 1958		
Beam No.	Nominal Stress psi	Steel Position	Type Steel Deformation	Condition	Pulse Veloc fps	fV^2	Condition	Condition	Condition	fV^2	Max Crack Width 1/1000 in.	Condition	fV^2	Max Crack Width 1/1000 in.
138	40,000	T	A-305	100	10,490	100	92	[illegible]	74	177	25	78	182	25
139	40,000	T	OS	100	12,095	100	88	7[illegible]	7[illegible]	132	1[illegible]	75	150	15
140	40,000	T	OS	100	12,225	100	90	76	71	129	15	74	148	15
141	40,000	T	A-305	100	9,275	100	99	84	7[illegible]	24[illegible]	15	70	241	20
142	40,000	T	A-305	100	9,570	100	100	85	76	228	15	78	227	20
143	40,000	T	OS	100	9,375	100	94	82	76	224	25	84	234	25
144	40,000	T	OS	100	9,390	100	95	80	[illegible]	231	40	84	238	40
145	50,000	T	A-305	100	9,435	100	96	82	82	243	40	84	253	40
146	50,000	T	A-305	100	9,345	100	94	81	79	238	30	81	255	30
147	50,000	T	OS	100	8,970	100	86	66	68	272	85	72	249	85
148	50,000	T	OS	100	8,900	100	82	67	67	260	75	70	260	75
149	50,000	T	A-305	100	9,105	100	99	8[illegible]	75	225	40	88	235	40
150	50,000	T	A-305	100	9,175	100	100	82	82	235	25	86	259	30
151	50,000	T	OS	100	11,130	100	92	80	76	180	15	72	164	15
152	50,000	T	OS	100	10,655	100	88	78	72	195	25	74	181	25
153	None	T	A-305	100	12,475	100	94	86	74	120	0	72	121	0
154	None	T	A-305	100	12,795	100	100	92	87	117	0	88	132	0
155	None	T	A-305	100	12,875	100	100	90	86	115	0	80	120	0
156	None	T	OS	100	13,045	100	100	91	90	120	0	82	118	0
157	None	T	OS	100	12,630	100	98	86	80	120	0	75	124	0
158	None	T	OS	100	12,710	100	99	78	61	120	10	70	119	15

Beach Row 1

				1959-1961 Readings								
				675 Cycles, 1959			746 Cycles, 1960			887 Cycles, 1961		
				Condition	fV^2	Max Crack Width 1/1000 in.	Condition	fV^2	Max Crack Width 1/1000 in.	Condition	fV^2	Max Crack Width 1/1000 in.
83	20,000	B	A-305	84	161	15	84	180	10	7[illegible]	19[illegible]	1[illegible]
84	20,000	B	A-305	86	161	20	86	159	10	77	179	1[illegible]
85	20,000	B	OS	91	143	15	91	158	10	7[illegible]	1[illegible]	[illegible]
86	20,000	B	OS	82	150	15	82	137	10	[illegible]	1[illegible]	[illegible]
87	20,000	B	A-305	72	176	15	72	128	10	61	[illegible]	1[illegible]
88	20,000	B	A-305	73	181	10	7[illegible]	133	10	[illegible]	[illegible]	1[illegible]
89	20,000	B	OS	86	160	15	86	152	10	7[illegible]	[illegible]	1[illegible]
90	20,000	B	OS	73	158	10	78	147	10	7[illegible]	[illegible]	1[illegible]
91	30,000	B	A-305	80	140	15	80	107	10	71	1[illegible]	1[illegible]
92	30,000	B	A-305	80	154	10	[illegible]	162	10	67	[illegible]	1[illegible]
93	30,000	B	OS	80	152	30	80	108	20	71	1[illegible]	1[illegible]
94	30,000	B	OS	75	198	25	75	112	30	[illegible]	15[illegible]	[illegible]
95	30,000	B	A-305	[illegible]	144	25	[illegible]	142	15	[illegible]	1[illegible]	1[illegible]
96	30,000	B	A-305	85	162	20	85	167	15	[illegible]	1[illegible]	1[illegible]
97	30,000	B	OS	78	147	20	77	133	10	[illegible]	16[illegible]	1[illegible]
98	30,000	B	OS	7[illegible]	145	20	[illegible]	152	15	[illegible]	1[illegible]	1[illegible]
99	40,000	B	A-305	77	139	25	77	124	15	[illegible]	[illegible]	1[illegible]
100	40,000	B	A-305	78	179	25	[illegible]	107	15	[illegible]	[illegible]	[illegible]
101	40,000	B	OS	70	181	35	[illegible]	13[illegible]	20	[illegible]	1[illegible]	[illegible]
102	40,000	B	OS	6[illegible]	188	45	[illegible]	1[illegible]	[illegible]	[illegible]	190	15
103	40,000	B	A-305	72	233	25	7[illegible]	197	1[illegible]	6[illegible]	204	1[illegible]
104	4[illegible]	B	A-305	[illegible]	250	25	[illegible]	2[illegible]	[illegible]	[illegible]	243	20
1[illegible]	4[illegible]	B	OS	[illegible]	234	[illegible]	[illegible]	1[illegible]	15	[illegible]	[illegible]	15
1[illegible]	4[illegible]	B	OS	[illegible]	203	[illegible]	[illegible]	158	15	[illegible]	[illegible]	1[illegible]
1[illegible]	50,[illegible]	B	A-[illegible]	[illegible]	1[illegible]	[illegible]	[illegible]	[illegible]	15	[illegible]	190	15
1[illegible]	[illegible]	B	A-3[illegible]	[illegible]	1[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	14[illegible]	1[illegible]
1[illegible]	[illegible]	B	OS	[illegible]	[illegible]	35	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11[illegible]	[illegible]	B	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	141	[illegible]
111	[illegible]	B	A-[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11[illegible]	[illegible]	B	A-[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1[illegible]

([illegible])

Beach Row 1

Beam No.	Nominal Stress psi	Steel Position	Type Steel Deformation	[illegible]-1961 Readings: 975 Cycles, 1959 Condition	$\%V^2$	Max Crack Width 1/1000 in.	746 Cycles, 1960 Condition	$\%V^2$	Max Crack Width 1/1000 in.	887 Cycles, 1961 Condition	$\%V^2$	Max Crack Width 1/1000 in.
113	50,000	B	OS	60	238	30	66	173	25	59	229	20
114	50,000	B	OS	64	255	35	64	192	25	64	265	20
115	None	B	A-305	78	113	0	78	112	0	69	131	0
116	None	B	A-305	80	107	0	80	114	0	[illegible]	117	5
117	None	B	A-305	70	[illegible]	20	60	109	10	[illegible]	117	[illegible]
118	None	B	OS	55	111	0	55	112	0	46	104	0
119	None	B	OS	70	104	0	70	111	0	67	123	0
120	None	B	OS	59	105	0	59	112	0	59	119	0
121	20,000	T	A-305	80	201	15	80	165	10	77	230	[illegible]
122	20,000	T	A-305	85	217	15	83	156	10	70	236	10
123	20,000	T	OS	77	216	20	77	[illegible]	10	[illegible]	241	[illegible]
124	20,000	T	OS	80	217	20	82	176	15	[illegible]	[illegible]	[illegible]
125	20,000	T	A-305	70	174	20	70	99	10	[illegible]	[illegible]	[illegible]
126	20,000	T	A-305	77	118	10	77	94	10	77	[illegible]	[illegible]
127	20,000	T	OS	80	121	15	76	[illegible]	10	[illegible]	[illegible]	[illegible]
128	20,000	T	OS	82	120	20	82	133	10	[illegible]	[illegible]	[illegible]
129	30,000	T	A-305	65	214	15	65	135	10	[illegible]	[illegible]	[illegible]
130	30,000	T	A-305	81	213	15	81	202	10	[illegible]	[illegible]	[illegible]
131	30,000	T	OS	75	144	15	75	114	15	[illegible]	[illegible]	[illegible]
132	30,000	T	OS	72	147	25	72	115	[illegible]	[illegible]	[illegible]	[illegible]
133	30,000	T	A-305	77	119	20	77	118	15	[illegible]	[illegible]	[illegible]
134	30,000	T	A-305	78	122	25	78	[illegible]	15	[illegible]	[illegible]	[illegible]
135	30,000	T	OS	73	134	30	73	96	20	[illegible]	[illegible]	[illegible]
136	30,000	T	OS	77	148	25	77	112	20	[illegible]	[illegible]	[illegible]
137	40,000	T	A-305	64	173	35	64	154	30	[illegible]	[illegible]	[illegible]
138	40,000	T	A-305	68	171	40	68	135	30	[illegible]	[illegible]	[illegible]
139	40,000	T	OS	75	139	35	75	145	[illegible]	[illegible]	[illegible]	[illegible]
140	40,000	T	OS	70	139	30	70	149	15	[illegible]	[illegible]	[illegible]
141	40,000	T	A-305	68	231	25	68	213	25	[illegible]	[illegible]	[illegible]
142	40,000	T	A-305	73	208	20	73	195	15	[illegible]	[illegible]	[illegible]
143	40,000	T	OS	66	223	20	66	169	15	[illegible]	[illegible]	[illegible]
144	40,000	T	OS	75	206	25	75	171	20	[illegible]	[illegible]	[illegible]
145	50,000	T	A-305	70	236	25	70	170	25	[illegible]	[illegible]	[illegible]
146	50,000	T	A-305	64	235	30	64	173	20	[illegible]	[illegible]	[illegible]
147	50,000	T	OS	61	132	105	61	221	100	[illegible]	[illegible]	[illegible]
148	50,000	T	OS	64	242	110	64	258	90	[illegible]	[illegible]	[illegible]
149	50,000	T	A-305	70	228	30	70	164	15	[illegible]	[illegible]	[illegible]
150	50,000	T	A-305	66	240	35	66	[illegible]	25	[illegible]	[illegible]	15
151	50,000	T	OS	[illegible]	155	30	[illegible]	176	25	[illegible]	[illegible]	[illegible]
152	50,000	T	OS	61	173	35	61	197	30	[illegible]	179	[illegible]
153	None	T	A-305	55	116	0	[illegible]	[illegible]	0	[illegible]	[illegible]	[illegible]
154	None	T	A-305	80	114	0	80	122	0	77	[illegible]	[illegible]
155	None	T	A-305	77	116	0	77	[illegible]	0	[illegible]	[illegible]	[illegible]
156	None	T	OS	[illegible]	111	0	[illegible]	117	0	[illegible]	[illegible]	[illegible]
157	None	T	OS	77	115	0	76	113	0	[illegible]	[illegible]	[illegible]
158	None	T	OS	[illegible]	117	20	[illegible]	[illegible]	15	[illegible]	173	[illegible]

[illegible]

Beam No.	Nominal Stress psi	Steel Position	Type Steel Deformation	[illegible] Readings: [illegible] Cycles, 19[illegible] Condition	$\%V^2$	Max Crack Width 1/1000 in.	[illegible] Cycles, 19[illegible] Condition	$\%V^2$	Max Crack Width 1/1000 in.	[illegible] Cycles, 19[illegible] Condition	$\%V^2$	Max Crack Width 1/1000 in.
[illegible]	[illegible]	B	A-[illegible]	[illegible]	140	10	[illegible]	131	20	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	B	A-[illegible]	[illegible]	174	10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	B	[illegible]	[illegible]	[illegible]	15	[illegible]	101	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	B	[illegible]	[illegible]	109	10	[illegible]	112	[illegible]	[illegible]	[illegible]	[illegible]
87	[illegible]	B	A-[illegible]	[illegible]	174	10	[illegible]	127	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	B	A-[illegible]	[illegible]	[illegible]	10	[illegible]	137	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	B	[illegible]	[illegible]	[illegible]	15	[illegible]	114	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	100	[illegible]	[illegible]	[illegible]	[illegible]
91	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	A-[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

(Continued)

[illegible]

(Revised Aug 1965)

Table 1-TC-B (Continued)

Beam No.	Nominal Stress psi	Steel Position	Type Steel Deformation	970 Cycles, 1962 Condition	970 Cycles, 1962 $\%V^2$	970 Cycles, 1962 Max Crack Width 1/1000 in.	1082 Cycles, 19[illegible] Condition	1082 Cycles, 19[illegible] $\%V^2$	1082 Cycles, 19[illegible] Max Crack Width 1/1000 in.
93	30,000	B	OS	71	136	20	70	10[illegible]	[illegible]
94	30,000	B	OS	69	163	25	69	133	[illegible]
95	30,000	B	A-305	79	148	15	[illegible]	10[illegible]	[illegible]
96	30,000	B	A-305	69	162	20	81	1[illegible]	[illegible]
97	30,000	B	OS	64	147	10	[illegible]	10[illegible]	[illegible]
98	30,000	B	OS	64	154	15	6[illegible]	111	[illegible]
99	40,000	B	A-305	62	180	15	[illegible]	13[illegible]	[illegible]
100	40,000	B	A-305	64	212	15	75	143	[illegible]
101	40,000	B	OS	64	184	25	[illegible]	1[illegible]	[illegible]
102	40,000	B	OS	67	206	20	66	14[illegible]	[illegible]
103	40,000	B	A-305	59	210	15	[illegible]	14[illegible]	[illegible]
104	40,000	B	A-305	66	258	25	[illegible]	1[illegible]	
105	40,000	B	OS	72	258	20	[illegible]	1[illegible]	
106	40,000	B	OS	[illegible]	244	15	[illegible]	1[illegible]	
107	50,000	B	A-305	[illegible]	194	15	[illegible]	1[illegible]	
108	50,000	B	A-305	59	134	15	[illegible]	[illegible]	
109	50,000	B	OS	[illegible]	192	25	[illegible]	[illegible]	
110	50,000	B	OS	55	197	25	[illegible]	[illegible]	
111	50,000	B	A-305	[illegible]	[illegible]	25	[illegible]	[illegible]	
112	50,000	B	A-305	66	[illegible]	15	[illegible]	[illegible]	
113	50,000	B	OS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
114	50,000	B	OS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
115	None	B	A-305	[illegible]	113	[illegible]		[illegible]	
116	None	B	A-305	70	112	[illegible]	[illegible]	[illegible]	
117	None	B	A-305	[illegible]	120	10	[illegible]	[illegible]	
118	None	B	OS	[illegible]	[illegible]	[illegible]			
119	None	B	OS	[illegible]	1[illegible]4	[illegible]		[illegible]	
120	None	B	OS	[illegible]	1[illegible]4	[illegible]			
121	[illegible]	T	A-305	[illegible]	[illegible]	1[illegible]		[illegible]	
122	[illegible],000	T	A-305	[illegible]	[illegible]	1		[illegible]	
123	[illegible],000	T	OS	[illegible]	[illegible]	1[illegible]		[illegible]	
124	[illegible],000	T	OS	[illegible]	[illegible]	[illegible]		[illegible]	
125	[illegible],000	T	A-[illegible]	[illegible]	1[illegible]	[illegible]			
126	[illegible],000	T	A-[illegible]		1[illegible]	[illegible]		[illegible]	
127	[illegible],000	T	[illegible]		[illegible]	[illegible]			
128	[illegible],000	T	[illegible]		1[illegible]	[illegible]			
129	30,000	T	A-[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
130	30,000	T	A-[illegible]	[illegible]	[illegible]	[illegible]			
131	30,000	T	[illegible]	[illegible]	1[illegible]	[illegible]			
132	30,000	T	[illegible]	[illegible]	1[illegible]	[illegible]		[illegible]	
133	30,000	T	A-[illegible]	[illegible]	1[illegible]	1[illegible]			
134	30,000	T	A-[illegible]	[illegible]	1[illegible]	[illegible]			
135	30,000	T	[illegible]	[illegible]	1[illegible]	[illegible]			
136	30,000	T	[illegible]	[illegible]	1[illegible]	1			
137	[illegible]	T	A-[illegible]	[illegible]	1[illegible]				
138	[illegible]	T	[illegible]	[illegible]	[illegible]				
139	[illegible]	T	[illegible]	[illegible]	[illegible]				
140	[illegible]	T		[illegible]	[illegible]	[illegible]			
141	[illegible]	T	A-[illegible]		[illegible]	[illegible]			
142	[illegible]	T	A-[illegible]	[illegible]	1	[illegible]			
143	[illegible]	T							
144	[illegible]	T	[illegible]	[illegible]	[illegible]				
145	[illegible]	T	A-[illegible]		[illegible]				
146	[illegible]	T	A-[illegible]		[illegible]				
147	[illegible]	T	[illegible]		[illegible]	[illegible]			
148	[illegible]	T		[illegible]	[illegible]	[illegible]			
149	[illegible]	T	[illegible]						
[illegible]	[illegible]	T	A-[illegible]	[illegible]	[illegible]				
[illegible]	[illegible]	T	[illegible]	[illegible]	1[illegible]				
[illegible]	[illegible]	T	[illegible]	[illegible]	1[illegible]				

Table 1-PC-B (Continued)

Beach Row 1

Beam No.	Nominal Stress psi	Steel Position	Type Steel Deformation	1965-1967 Readings: 1360 Cycles, 1965: Condition	V^2	Max Crack Width 1/1000 in.	1510 Cycles, 1966: Condition	V^2	Max Crack Width 1/1000 in.	[illegible] Cycles, 1967: Condition	V^2: Before Unloading	V^2: Not Loaded	V^2: After Reloading	Max Crack Width 1/1000 in.: Before Unloading	Max Crack Width 1/1000 in.: Not Loaded	Max Crack Width 1/1000 in.: After Reloading
133	30,000	T	A-305	*	59	15	63	**	15	*	82		52	10		15
134	30,000	T	A-305		83	15	72		20		84		[illegible]	10		15
135	30,000	T	OS		75	15	67		25		65		44	30		30
136	30,000	T	OS		89	25	65		30		79		58	30		35
137	40,000	T	A-305		73	40	51		55		91		72	[illegible]		70
138	40,000	T	A-305		83	40	57		50		98		97	50		75
139	40,000	T	OS		57	20	67		30		70		61	30		35
140	40,000	T	OS		70	20	64		35		74		56	40		35
141	40,000	T	A-305		106	30	55		30		155		93	30		45
142	40,000	T	A-305		116	30	59		35		135		93	35		40
143	40,000	T	OS		143	25	65		25		119		111	25		30
144	40,000	T	OS		118	35	62		45		107		95	45		60
145	[illegible]	T	A-305		139	30	70		45		103		88	45		70
146	50,000	T	A-305		120	30	53		35		114		75	40		45
147	50,000	T	OS		98	100	53		125		162		98	115		125
148	50,000	T	OS		115	55	64		100		157		137	100		120
149	50,000	T	A-305		147	35	64		50		124		60	45		50
150	50,000	T	A-305		150	40	65		40		145		65	35		50
151	50,000	T	OS		71	35	57		35		111		64	35		45
152	50,000	T	OS		82	35	54		45		102		70	40		45
153	None	T	A-305		96	0	44		0			74			0	
154	None	T	A-305		75	0	67		0			73			0	
155	None	T	A-305		67	0	77		0			70			0	
156	None	T	OS		74	0	66		0			69			0	
157	None	T	OS		64	0	60		0			87			0	
[illegible]	None	T	OS		53	15	52		10			68			10	

Beach Row 1

Beam No.	Nominal Stress psi	Steel Position	Type Steel Deformation	1968-1972 Readings: 1951 Cycles, 1968: Condition	V^2	Max Crack Width 1/1000 in.	2005 Cycles, 1969: Condition	V^2#	Max Crack Width 1/1000 in.	[illegible] Cycles, 1970: Condition	V^2#	Max Crack Width 1/1000 in.	2127 Cycles, 1971: Condition	V^2	Max Crack Width 1/1000 in.	[illegible] Cycles, 1972: Condition	V^2	Max Crack Width 1/1000 in.
[illegible]	[illegible]	B	A-305	65	116	15	62	40	15	59	69	15	60	[illegible]	15	[illegible]	[illegible]	10
[illegible]	[illegible]	B	A-305	68	75	15	68	37	20	67	71	20	66	61	15	64	[illegible]	10
[illegible]	[illegible]	B	OS	72	61	20	72	28	20	71	53	25	70	61	25	63	52	[illegible]
[illegible]	[illegible]	B	OS	66	84	15	66	35	20	64	57	20	[illegible]	[illegible]	[illegible]	62	36	25
[illegible]	[illegible]	B	A-305	52	[illegible]	20	53	41	25	52	62	25	47	[illegible]	30	47	[illegible]	[illegible]
[illegible]	[illegible]	B	A-305	56	84	20	54	44	25	59	72	35	51	68	40	51	34	[illegible]
[illegible]	[illegible]	B	OS	64	75	20	67	42	20	68	[illegible]	20	68	[illegible]	25	66	[illegible]	30
[illegible]	[illegible]	B	OS	63	104	10	64	37	15	65	61	25	62	[illegible]	30	60	[illegible]	[illegible]
1[illegible]	[illegible]	B	A-305	70	85	20	70	35	20	70	55	25	69	[illegible]	25	69	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	A-305	70	66	20	67	35	20	67	55	20	66	61	25	67	47	[illegible]
[illegible]	[illegible]	[illegible]	OS	68	53	40	56	32	40	64	51	40	64	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	64	78	50	66	35	50	[illegible]	[illegible]	55	62	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	A-305	72	100	[illegible]	72	34	55	68	[illegible]	40	68	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	A-305	68	104	30	67	41	35	[illegible]	68	35	65	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	67	76	30	64	34	[illegible]	61	[illegible]	35	61	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	97	35	62	54	30	[illegible]	58	[illegible]	61	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	A-305	[illegible]	110	35	60	[illegible]	35	59	58	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	A-305	[illegible]	75	[illegible]	63	37	[illegible]	[illegible]	[illegible]	35	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	60	[illegible]	[illegible]	70	61	59	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8	50	64	53	[illegible]	64	[illegible]	55	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	A-305	71	[illegible]	45	53	50	50	53	[illegible]	[illegible]	61	61				
[illegible]	[illegible]	[illegible]	A-305	[illegible]	[illegible]	45	[illegible]	51	50	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	
[illegible]	[illegible]	[illegible]	OS	71	111	[illegible]	[illegible]	56	45	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	81	50	54	46	45	56	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	
1[illegible]	[illegible]		A-305	[illegible]	[illegible]	40	52	[illegible]	45	[illegible]	54	40	[illegible]		[illegible]		[illegible]	[illegible]

* In 1965 and 1966 the condition of specimens was not rated by panel of observers.
** [illegible] pulse velocity readings were not obtained in 1966 due to malfunction of testing equipment.
[illegible]
\# [illegible] readings obtained in [illegible] are not believed to be valid due to [illegible] equipment; these [illegible] values are therefore questionable.

Table 1-TC-B (Concluded)

Beach Row 1

Beam No.	Nominal Stress psi	Steel Position	Type Steel Deformation	1968-1972 Readings: 1851 Cycles, 1968 Condition	$\%V^2$	Max Crack Width 1/1000 in.	2005 Cycles, 1969 Condition	$\%V^2$#	Max Crack Width 1/1000 in.	2158 Cycles, 1970 Condition	$\%V^2$#	Max Crack Width 1/1000 in.	23[illegible] Cycles, 1971 Condition	$\%V^2$	Max Crack Width 1/1000 in.	24[illegible] Cycles, 1972 Condition	$\%V^2$	Max Crack Width 1/1000 in.
108	50,000	B	A-305	57	73	40	57	26	45	57	41	45	[illegible]	43	45	56	37	50
109	50,000	B	OS	66	149	50	66	59	50	66	99	55	66	41	[illegible]	66	[illegible]	[illegible]
110	50,000	B	OS	55	117	50	55	56	50	55	95	55	[illegible]	81	50	56	47	[illegible]
111	50,000	B	A-305	53	91	50	55	52	50	56	79	50	61	[illegible]	50	[illegible]	65	[illegible]
112	50,000	B	A-305	63	93	40	63	50	45	63	76	45	62	71	40	63	65	[illegible]
113	50,000	B	OS	49	103	55	49	53	55	48	92	60	48	86	60	[illegible]	[illegible]	65
114	50,000	B	OS	53	180	55	52	42	65	52	64	65	50	62	70	[illegible]	64	70
115	None	B	A-305	59	68	0	54	26	0	58	43	0	56	39	0	[illegible]	[illegible]	[illegible]
116	None	B	A-305	65	58	[illegible]	67	25	0	67	38	0	66	[illegible]	0	[illegible]	[illegible]	[illegible]
117	None	B	A-305	65	68	0	65	28	0	65	43	0	67	40	0	[illegible]	30	[illegible]
118	None	B	OS	40	66	0	39	27	0	43	43	0	44	41	0	36	44	[illegible]
119	None	B	OS	52	67	0	53	30	0	56	49	0	52	47	0	51	41	[illegible]
120	None	B	OS	54	69	0	56	27	0	56	43	0	55	41	0	54	37	[illegible]
121	20,000	T	A-305	57	41	25	74	49	25	74	79	25	71	73	25	74	86	[illegible]
122	20,000	T	A-305	62	55	25	70	52	30	69	81	25	67	77	20	66	[illegible]	[illegible]
123	20,000	T	OS	72	119	30	61	47	35	61	76	40	61	74	45	[illegible]	51	[illegible]
124	20,000	T	OS	71	111	35	65	59	40	65	98	40	65	92	45	[illegible]	51	[illegible]
125	20,000	T	A-305	64	45	20	60	34	20	59	59	25	58	53	[illegible]	[illegible]	[illegible]	30
126	20,000	T	A-305	77	63	20	77	34	25	76	60	25	77	[illegible]	[illegible]	76	[illegible]	[illegible]
127	20,000	T	OS	76	68	10	69	28	10	70	42	10	68	[illegible]	20	66	[illegible]	[illegible]
128	20,000	T	OS	69	60	5	69	27	5	70	47	10	68	43	15	67	[illegible]	25
129	30,000	T	A-305	60	90	20	55	50	25	55	77	30	53	73	35	55	[illegible]	40
130	30,000	T	A-305	71	84	35	66	45	35	65	69	35	62	66	35	63	54	35
131	30,000	T	OS	74	56	50	73	34	50	74	52	50	72	47	55	72	53	50
132	30,000	T	OS	61	84	40	61	35	50	61	54	50	58	51	50	58	[illegible]	40
133	30,000	T	A-305	63	45	20	63	26	25	63	44	30	61	[illegible]	30	61	[illegible]	30
134	30,000	T	A-305	66	61	25	66	28	25	66	47	25	64	45	25	65	[illegible]	30
135	30,000	T	OS	62	53	35	61	28	30	61	44	30	61	42	35	[illegible]	[illegible]	[illegible]
136	30,000	T	OS	65	63	35	63	33	30	64	50	25	61	45	25	[illegible]	[illegible]	[illegible]
137	40,000	T	A-305	51	89	70	49	##	70	49	50	70	[illegible]	50	75	49	47	70
138	40,000	T	A-305	57	106	70	56	37	70	56	60	75	[illegible]	56	70	56	[illegible]	60
139	40,000	T	OS	67	92	35	67	26	40	66	29	45	66	38	45	66	[illegible]	40
140	40,000	T	OS	69	82	35	70	29	40	68	53	40	67	49	40	65	30	40
141	40,000	T	A-305	55	99	55	54	52	55	54	91	60	[illegible]	94	60	53	67	60
142	40,000	T	A-305	59	111	50	58	50	55	57	90	60	57	[illegible]	65	62	53	60
143	40,000	T	OS	65	116	30	64	48	35	64	74	35	64	71	30	64	61	25
144	40,000	T	OS	61	115	55	61	51	60	61	80	65	61	73	70	61	61	60
145	50,000	T	A-305	68	101	65	66	50	70	65	94	65	56	79	65	54	63	60
146	50,000	T	A-305	52	98	50	51	68	55	49	116	55	48	96	55	47	55	60
147	50,000	T	OS	Failed§§														
148	50,000	T	OS	Damaged ‖														
149	50,000	T	A-305	68	126	45	68	50	55	68	83	60	67	77	55	68	60	50
150	50,000	T	A-305	65	142	50	65	62	50	64	86	50	65	80	50	65	54	50
151	50,000	T	OS	57	79	50	58	30	50	57	49	55	57	45	55	57	39	50
152	50,000	T	OS	54	111	50	54	40	55	54	66	55	54	63	50	54	31	50
153	None	T	A-305	44	72	0	44	30	0	46	48	0	43	45	0	44	33	0
154	None	T	A-305	61	64	0	62	29	0	62	45	0	55	44	0	57	34	0
155	None	T	A-305	[illegible]	63	0	65	30	0	66	44	0	66	40	0	65	[illegible]	0
156	None	T	OS	66	74	0	[illegible]	29	0	63	[illegible]	0	66	31	0	66	35	0
157	None	T	OS	60	[illegible]	0	60	29	0	60	46	0	56	44	0	[illegible]	[illegible]	0
158	None	T	OS	[illegible]	67	10	53	[illegible]	10	53	[illegible]	10	52	[illegible]	[illegible]	[illegible]	66	10

§§ Beam failed but left under exposure.

‖ Damaged when beam 147 failed, but left under exposure.

\# Some pulse velocity readings obtained in 1969 and 1970 are not believed to be valid due to the power limitations of the test equipment; these $\%V^2$ readings are therefore questionable.

\## A pulse velocity reading was not obtained on this specimen.

(Sheet 7)

Table 1-TC-B (Continued)

				1973-1976 Readings: 2624 Cycles, 1973			2760 Cycles, 1974			2872 Cycles, 1975			3018 Cycles, 1976		
Beam No.	Nominal Stress psi	Steel Position	Type Steel Deformation	Condition	ΣV^2	Max Crack Width 1/1000 in.	Condition	ΣV^2	Max Crack Width 1/1000 in.	Condition	ΣV^2	Max Crack Width 1/1000 in.	Condition	ΣV^2	Max Crack Width 1/1000 in.
83	20,000	B	A-305	59	**	10	53	**	5	59	74	10	46	66	15
84	20,000	B	A-305	63		10	67		10	65	67	15	64	74	25
85	20,000	B	OS	72		25	71		20	71	72	25	66	73	20
86	20,000	B	OS	66		20	66		20	66	66	20	63	65	20
87	20,000	B	A-305	46		15	48		15	45	70	20	47	105	20
88	20,000	B	A-305	50		10	49		15	49	68	20	51	69	15
89	20,000	B	OS	64		20	66		20	65	76	25	64	76	25
90	20,000	B	OS	61		20	60		20	60	60	30	57	97	20
91	30,000	B	A-305	69		20	68		20	67	56	30	68	55	25
92	30,000	B	A-305	67		15	66		15	66	83	20	51	80	20
93	30,000	B	OS	64		25	66		40	64	53	35	64	53	50
94	30,000	B	OS	67		55	67		70	64	57	70	61	65	70
95	30,000	B	A-305	68		20	68		15	67	78	25	62	77	25
96	30,000	B	A-305	65		20	66		20	67	73	25	62	80	20
97	30,000	B	OS	63		40	63		30	61	59	50	62	58	40
98	30,000	B	OS	59		50	58		50	60	63	50	58	62	50
99	40,000	B	A-305	59		50	59		60	59	57	50	57	58	60
100	40,000	B	A-305	58		40	56		30	57	73	50	53	71	50
101	40,000	B	OS	58		60	60		70	60	53	75	58	52	75
102	40,000	B	OS	61		60	63		60	63	46	70	59	49	100
103	40,000	B	A-305	50		60	51		60	48	89	60	47	94	60
104	40,000	B	A-305	57		60	58		50	58	76	55	57	81	55
105	40,000	B	OS	69		50	70		50	68	110	55	64	108	70
106	40,000	B	OS	52		50	52		50	52	63	70	48	66	70
107	50,000	B	A-305	51		50	51		60	51	38	55	51	38	(1-in. spall)
108	50,000	B	A-305	55		50	52		50	54	37	55	57	38	(1/2-in. spall)
109	50,000	B	OS	66		60	66		70	66	62	60	64	126	(1-1/2 in. spall)
110	50,000	B	OS	55		60	55		60	53	57	60	55	100	75
111	50,000	B	A-305	51		40	50		50	51	83	50	49	92	75
112	50,000	B	A-305	63		60	62		70	58	74	60	61	103	75
113	50,000	B	OS	48		80	48		80	48	75	80	47	76	(1/4-in. spall)
114	50,000	B	OS	51		70	52		60	52	71	75	51	138	100
115	None	B	A-305	63		0	57		0	56	79		47	79	
116	None	B	A-305	65		0	58		0	57	82		55	79	
117	None	B	A-305	43		0	45		0	48	42		35	42	
118	None	B	OS	34		0	35		0	38	61		35	65	
119	None	B	OS	56		0	49		0	49	40		50	43	
120	None	B	OS	53		0	54		0	48	83		52	80	
121	20,000	T	A-305	74		30	72		25	72	97	35	72	98	25
122	20,000	T	A-305	69		20	68		15	67	90	25	69	102	30
123	20,000	T	OS	60		50	61		50	60	90	50	60	103	60
124	20,000	T	OS	64		40	64		40	62	86	50	61	81	50
125	20,000	T	A-305	60		25	59		20	56	55	30	57	56	30
126	20,000	T	A-305	76		25	77		25	74	57	30	75	58	30
127	20,000	T	OS	65		15	67		20	66	57	20	67	56	20
128	20,000	T	OS	58		10	67		10	64	61	20	68	59	15
129	30,000	T	A-305	54		50	52		40	54	75	50	52	98	50
130	30,000	T	A-305	63		50	63		50	63	70	60	61	111	65
131	30,000	T	OS	72		60	72		60	70	62	70	72	62	75
132	30,000	T	OS	59		60	59		60	58	71	60	51	83	75
133	30,000	T	A-305	60		50	61		50	58	83	50	57	78	50
134	30,000	T	A-305	64		60	64		50	64	60	65	62	61	75
135	30,000	T	OS	61		40	61		40	61	50	40	61	46	40
136	30,000	T	OS	65		20	65		30	62	82	30	63	86	30
137	40,000	T	A-305	49		80	50		70	49	66	85	49	67	90
138	40,000	T	A-305	56		75	55		80	56	68	75	55	67	75
139	40,000	T	OS	66		50	65		60	65	92	50	64	68	50
140	40,000	T	OS	67		45	67		40	67	65	55	66	67	60
141	40,000	T	A-305	53		60	53		60	52	75	60	58	105	60
142	40,000	T	A-305	53		40	59		50	54	70	50	61	86	50
143	40,000	T	OS	64		40	63		40	62	78	50	64	114	75
144	40,000	T	OS	61		60	61		70	55	72	65	59	91	(1/4-in. spall)
145	50,000	T	A-305	60		80	54		80	52	68	80	54	116	125
146	50,000	T	A-305	46		50	48		60	44	72	70	46	84	80

** Satisfactory pulse velocity readings were not obtained in 1973 and 1974.

(Sheet 8)

Table 1-TC-B (Continued)

Beam No.	Nominal Stress psi	Steel Position	Type Steel Deformation	3095 Cycles, 1977: Condition	3095 Cycles, 1977: ΣV²	3095 Cycles, 1977: Max Crack Width 1/1000 in.	3242 Cycles, 1978: Condition	3242 Cycles, 1978: ΣV²	3242 Cycles, 1978: Max Crack Width 1/1000 in.	3335 Cycles, 1979: Condition	3335 Cycles, 1979: ΣV²	3335 Cycles, 1979: Max Crack Width 1/1000 in.
83	20,000	B	A-305	22	80	15	47	78	15	34	85	15
84	20,000	B	A-305	60	74	25	64	47	30	64	72	30
85	20,000	B	OS	68	88	[illegible]	66	40	20	59	68	20
86	20,000	B	OS	65	69	25	67	58	25	63	70	25
87	20,000	B	A-305	46	66	20	46	52	20	44	71	20
88	20,000	B	A-305	51	53	20	53	52	20	46	97	20
89	20,000	B	OS	63	46	25	64	56	25	61	95	25
90	20,000	B	OS	58	59	25	56	49	20	58	56	20
91	30,000	B	A-305	68	60	25	69	38	30	68	98	30
92	30,000	B	A-305	65	84	25	66	39	25	64	62	25
93	30,000	B	OS	63	51	55	65	44	60	64	72	60
94	30,000	B	OS	63	68	70	65	60	75	60	55	75
95	30,000	B	A-305	60	76	25	46	63	20	42	63	20
96	30,000	B	A-305	64	86	25	65	60	96	63	99	30
97	30,000	B	OS	62	76	50	63	66	40	62	75	40
98	30,000	B	OS	59	63	50	61	54	50	55	70	100
99	40,000	B	A-305	56	92	60	59	54	75	59	56	75
100	40,000	B	A-305	56	72	55	56	41	50	43	81	100
101	40,000	B	OS	56	54	80	57	43	80	56	63	80
102	40,000	B	OS	58	53	100	56	58	125	54	65	125
103	40,000	B	A-305	47	86	60	47	57	60	46	139	60
104	40,000	B	A-305	64	62	60	58	73	75	56	124	75
105	40,000	B	OS	65	82	75	65	88	80	88	117	80
106	50,000	B	OS	66	69	70	90	76	(1/4-in. spall)	91	97	(1/4-in. spall)
107	50,000	B	A-305	50	46	(1-in. spall)	51	55	(1-in. spall)	49	83	(1-in. spall)
108	50,000	B	A-305	53	44	(5/8-in. spall)	54	33	(5/8-in. spall)	49	53	(3/8-in. spall)
109	50,000	B	OS	65	115	(1-1/2 in. spall)	64	54	(2-in. spall)	56	97	(2-in. spall)
110	50,000	B	OS	53	94	75	55	62	100	53	109	100
111	50,000	B	A-305	50	68	75	55	43	100	49	88	100
112	50,000	B	A-305	59	67	75	61	50	(1-in. spall)	62	90	(1-in. spall)
113	50,000	B	OS	47	79	(1/4-in. spall)	48	48	(1/4-in. spall)	46	106	(1/4-in. spall)
114	50,000	B	OS	51	101	100	51	56	(1/2-in. spall)	51	151	(1/2-in. spall)
115	None	B	A-305	51	78		49	43		46	58	--
116	None	B	A-305	57	76		57	25		62	61	--
117	None	B	A-305	59	44		53	45	30	52	61	30
118	None	B	OS	44	64		42	22		39	20	--
119	None	B	OS	55	43		52	70		45	63	--
120	None	B	OS	54	79		55	50		53	49	--
121	20,000	T	A-305	70	92	35	73	52	30	71	146	30
122	20,000	T	A-305	67	97	35	69	60	30	67	140	30
123	20,000	T	OS	59	65	60	59	51	100	52	71	100
124	20,000	T	OS	63	71	60	63	47	60	63	98	60
125	20,000	T	A-305	57	54	30	59	30	25	57	86	25
126	20,000	T	A-305	75	54	30	76	37	25	74	54	25
127	20,000	T	OS	66	68	20	68	61	20	55	57	20
128	20,000	T	OS	67	65	20	68	35	15	57	53	50
129	30,000	T	A-305	52	93	50	54	96	60	53	92	60
130	30,000	T	A-305	60	83	60	61	69	75	56	78	75
131	30,000	T	OS	70	49	75	72	60	75	72	79	75
132	30,000	T	OS	54	53	75	56	60	(1/4-in. spall)	47	64	(1/4-in. spall)
133	30,000	T	A-305	58	91	50	58	47	50	[illegible]	[illegible]	50
134	30,000	T	A-305	62	70	75	64	54	50	63	45	50
135	40,000	T	OS	61	43	40	61	29	40	60	60	40
136	40,000	T	OS	[illegible]	59	40	63	49	50	58	[illegible]	50
137	40,000	T	A-305	49	79	100	50	37	110	47	[illegible]	110
138	40,000	T	A-305	[illegible]	77	75	56	[illegible]	[illegible]	54	[illegible]	[illegible]
139	40,000	T	[illegible]	[illegible]	80	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
140	[illegible]	T	OS	[illegible]	81	[illegible]	[illegible]	[illegible]	65	[illegible]	57	[illegible]
141	[illegible]	T	A-305	[illegible]	94	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	54	[illegible]
142	40,000	T	A-305	[illegible]	86	[illegible]	62	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	T	[illegible]	[illegible]	81	[illegible]	63	[illegible]	75	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	T	[illegible]	[illegible]	93	([illegible]-in. spall)	[illegible]	[illegible]	(1-in. spall)	52	117	([illegible]-in. spall)
[illegible]	[illegible]	T	A-305	[illegible]	[illegible]	[illegible]	50	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	T	A-305	[illegible]	73	[illegible]	47	[illegible]	[illegible]	[illegible]	113	[illegible]

(Continued)

Table 1-TC-B (Continued)

Beach Row 1

Beam No.	Nominal Stress psi	Steel Position	Type Steel Deformation	1973-1976 Readings: 26[illegible]4 Cycles, 1973: Condition	$\%V^2$	Max Crack Width 1/1000 in.	2760 Cycles, 1974: Condition	$\%V^2$	Max Crack Width 1/1000 in.	2872 Cycles, 1975: Condition	$\%V^2$	Max Crack Width 1/1000 in.	3018 Cycles, 1976: Condition	$\%V^2$	Max Crack Width 1/1000 in.
148	50,000	T	OS		##		Unloaded	##	--	--	--	--	--	--	--
149	50,000	T	A-305	68		75	66		500¶	61	73	500	61	100	(4-in. spall)
150	50,000	T	A-305	65		60	65		70	62	61	70	64	104	75
151	50,000	T	OS	57		70	58		70	57	62	60	56	63	(1/2-in. spall)
152	50,000	T	OS	54		60	54		55	51	52	50	53	52	50
153	None	T	A-305	44		0	36		0	16	50		26	52	
154	None	T	A-305	55		0	54		0	54	84		55	81	
155	None	T	A-305	76		0	65		0	61	82		65	81	
156	None	T	OS	52		0	27		0	25	83		22	81	
157	None	T	OS	52		0	51		0	49	83		50	90	
158	None	T	OS	51		0	50		0	50	74		51	79	(2-in. spall)

Beam No.	Nominal Stress psi	Steel Position	Type Steel Deformation	1977- Readings: 3095 Cycles, 1977: Condition	$\%V^2$	Max Crack Width 1/1000 in.	3242 Cycles, 1978: Condition	$\%V^2$	Max Crack Width 1/1000 in.	3341 Cycles, 1979: Condition	$\%V^2$	Max Crack Width 1/1000 in.
148	50,000	T	OS	--	--	--	--	--	--	--	--	--
149	50,000	T	A-305	64	67	(4-in. spall)	62	50	(6-in. spall)	61	93	(6-in. spall)
150	50,000	T	A-305	63	65	75	63	60	75	62	90	75
151	50,000	T	OS	53	63	(5/8-in. spall)	45	32	(1-in. spall)	45	54	(1-in. spall)
152	50,000	T	OS	53	67	50	54	33	50	52	96	50
153	None	T	A-305	29	53		26	35		19	55	--
154	None	T	A-305	55	74		61	24		59	--	--
155	None	T	-305	65	82		66	53		65	52	--
156	None	T	OS	23	82		23	52		21	56	--
157	None	T	OS	54	80		57	28		49	82	--
158	None	T	OS	50	68		52	36	(2-in. spall)	50	74	(2-in. spall)

Note: [illegible] of these beams was discontinued after [illegible]
Satisfactory pulse velocity readings were not obtained in 1973 and 1974.
¶ One rebar failed during winter of [illegible].

(Sheet [illegible])

APPENDIX B: ANALYSIS OF VARIANCE

TENSILE CRACK, SERIES B REINFORCED CONCRETE
LONG-TERM DURABILITY TEST
1957-1979
ANALYSIS OF VARIANCE

ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: COND CONDITION

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	307	46874.57529240	152.68591300	10.78	0.0001	0.978714	5.9220
ERROR	72	1019.47324561	14.15935063		STD DEV		COND MEAN
CORRECTED TOTAL	379	47894.04853801			3.76289126		63.54122807

SOURCE	DF	ANOVA SS	F VALUE	PR > F
POSIT	1	116.27368421	9.35	0.0051
TYPE	1	363.51603187	25.67	0.0001
POSIT*TYPE	1	96.67597661	6.83	0.0109
STRESS	4	8313.21739766	146.78	0.0001
POSIT*STRESS	4	1101.40394737	19.45	0.0001
TYPE*STRESS	4	3674.97441520	64.89	0.0001
POSIT*TYPE*STRESS	4	2719.54697661	48.02	0.0001
YEAR	18	24744.06367690	97.09	0.0001
POSIT*YEAR	18	285.87976901	1.12	0.3504
TYPE*YEAR	18	53.91794590	0.21	0.9997
STRESS*YEAR	72	2035.76593567	2.00	0.0019
POSIT*TYPE*YEAR	18	758.94616228	2.98	0.0005
POSIT*STRESS*YEAR	72	1753.43910819	1.72	0.0110
TYPE*STRESS*YEAR	72	857.94919591	0.84	0.7670

TENSILE CRACK, SERIES B REINFORCED CONCRETE
LONG-TERM DURABILITY TEST
1957-1979
ANALYSIS OF VARIANCE

ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: PCT_V2 PERCENT VELOCITY SQUARED

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	307	320842.32062233	1045.08899226	33.51	0.0001	0.993050	9.2165
ERROR	72	2245.42290232	31.18642920		STD DEV		PCT_V2 MEAN
CORRECTED TOTAL	379	323087.74352465			5.58448110		60.59252754

SOURCE	DF	ANOVA SS	F VALUE	PR > F
POSIT	1	14.49264059	0.46	0.4976
TYPE	1	158.09393300	5.07	0.0274
POSIT*TYPE	1	13.72148568	0.44	0.5092
STRESS	4	5508.58302128	44.16	0.0001
POSIT*STRESS	4	1079.27180721	8.65	0.0001
TYPE*STRESS	4	321.91921536	2.58	0.0443
POSIT*TYPE*STRESS	4	1671.55722861	13.40	0.0001
YEAR	18	302071.13714371	538.11	0.0001
POSIT*YEAR	18	236.31290117	0.42	0.9779
TYPE*YEAR	18	207.07128304	0.37	0.9898
STRESS*YEAR	72	5354.36678237	2.39	0.0001
POSIT*TYPE*YEAR	18	546.37984539	0.97	0.4986
POSIT*STRESS*YEAR	72	1940.10150044	0.86	0.7317
TYPE*STRESS*YEAR	72	1712.30683448	0.76	0.8735

TENSILE CRACK, SERIES B REINFORCED CONCRETE
LONG-TERM DURABILITY TEST
1957-1979
ANALYSIS OF VARIANCE

ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: MAX_C   MAXIMUM CRACK WIDTH

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	249	8.76019698	0.03518151	2.51	0.0001	0.920434	169.0487
ERROR	54	0.75726185	0.01402337		STD DEV		MAX_C MEAN
CORRECTED TOTAL	303	9.51745883			0.11842030		0.07005099

SOURCE	DF	ANOVA SS	F VALUE	PR > F
POSIT	1	0.05351685	3.82	0.0559
TYPE	1	0.01638024	1.17	0.2846
POSIT*TYPE	1	0.05528257	3.94	0.0522
STRESS	3	1.26034329	29.96	0.0001
POSIT*STRESS	3	0.07578940	1.80	0.1564
TYPE*STRESS	3	0.12232046	2.91	0.0422
POSIT*TYPE*STRESS	3	0.17069319	4.06	0.0114
YEAR	18	1.96758102	7.79	0.0001
POSIT*YEAR	18	0.12692738	0.50	0.9454
TYPE*YEAR	18	0.10778392	0.43	0.9753
STRESS*YEAR	54	3.84614699	5.08	0.0001
POSIT*TYPE*YEAR	18	0.19226323	0.76	0.7327
POSIT*STRESS*YEAR	54	0.19090252	0.25	1.0000
TYPE*STRESS*YEAR	54	0.57226592	0.76	0.8469

APPENDIX C: LINEAR REGRESSION ANALYSES

Condition

Position	Type Rebar	Stress kips	Correlation Coefficient	Regression Equation
Bottom	A-305	0	-0.95	Condition = 166.42 - 1.48 * Year
Bottom	A-305	20	-0.94	Condition = 164.56 - 1.51 * Year
Bottom	A-305	30	-0.93	Condition = 134.95 - 0.947 * Year
Bottom	A-305	40	-0.91	Condition = 140.37 - 1.15 * Year
Bottom	A-305	50	-0.79	Condition = 122.14 - 0.919 * Year
Bottom	OS	0	-0.78	Condition = 132.39 - 1.14 * Year
Bottom	OS	20	-0.91	Condition = 140.55 - 1.03 * Year
Bottom	OS	30	-0.83	Condition = 122.70 - 0.82 * Year
Bottom	OS	40	-0.60	Condition = 107.63 - 0.606 * Year
Bottom	OS	50	-0.75	Condition = 100.47 - 0.629 * Year
Top	A-305	0	-0.95	Condition = 156.23 - 141 * Year
Top	A-305	20	-0.83	Condition = 117.27 - 0.65 * Year
Top	A-305	30	-0.83	Condition = 125.84 - 0.90 * Year
Top	A-305	40	-0.71	Condition = 106.36 - 0.709 * Year
Top	A-305	50	-0.90	Condition = 134.21 - 1.03 * Year
Top	OS	0	-0.96	Condition = 169.81 - 1.63 * Year
Top	OS	20	-0.89	Condition = 139.14 - 1.02 * Year
Top	OS	30	-0.88	Condition = 113.68 - 0.691 * Year
Top	OS	40	-0.88	Condition = 106.12 - 0.568 * Year
Top	OS	50	-0.93	Condition = 207.22 - 2.42 * Year

Percent V^2

Bottom	A-305	0	-0.77	PCT - V^2 = 270.94 - 3.02 * Year
Bottom	A-305	20	-0.85	PCT - V^2 = 299.35 - 3.50 * Year
Bottom	A-305	30	-0.82	PCT - V^2 = 277.33 - 3.91 * Year
Bottom	A-305	40	-0.86	PCT - V^2 = 312.28 - 3.75 * Year
Bottom	A-305	50	-0.88	PCT - V^2 = 310.77 - 3.78 * Year
Bottom	OS	0	-0.82	PCT - V^2 = 269.71 - 3.04 * Year
Bottom	OS	20	-0.84	PCT - V^2 = 282.08 - 3.28 * Year
Bottom	OS	30	-0.83	PCT - V^2 = 291.73 - 3.41 * Year
Bottom	OS	40	-0.85	PCT - V^2 = 299.03 - 3.58 * Year
Bottom	OS	50	-0.86	PCT - V^2 = 289.65 - 3.41 * Year
Top	A-305	0	-0.80	PCT - V^2 = 281.15 - 3.17 * Year
Top	A-305	20	-0.79	PCT - V^2 = 260.93 - 2.97 * Year
Top	A-305	30	-0.81	PCT - V^2 = 264.87 - 3.04 * Year
Top	A-305	40	-0.84	PCT - V^2 = 294.72 - 3.46 * Year
Top	A-305	50	-0.88	PCT - V^2 = 296.11 - 3.61 * Year

(Continued)

Percent V^2 (Continued)

Position	Type Rebar	Stress kips	Correlation Coefficient	Regression Equation
Top	OS	0	-0.71	PCT - V^2 = 246.35 - 2.64 * Year
Top	OS	20	-0.86	PCT - V^2 = 304.80 - 3.60 * Year
Top	OS	30	-0.82	PCT - V^2 = 268.19 - 3.11 * Year
Top	OS	40	-0.83	PCT - V^2 = 299.00 - 3.47 * Year
Top	OS	50	-0.91	PCT - V^2 = 375.29 - 4.88 * Year

Maximum Crack Width

Position	Type Rebar	Stress kips	Correlation Coefficient	Regression Equation
Bottom	A-305	20	0.80	Max crack width = -0.0227 + 0.000565 * Year
Bottom	A-305	30	0.70	Max crack width = -0.0336 + 0.000827 * Year
Bottom	A-305	40	0.95	Max crack width = -0.1297 + 0.00247 * Year
Bottom	A-305	50	0.72	Max crack width = -1.28 + 0.0208 * Year
Bottom	OS	20	0.80	Max crack width = -0.0299 + 0.000711 * Year
Bottom	OS	30	0.96	Max crack width = -0.1084 + 0.00213 * Year
Bottom	OS	40	0.97	Max crack width = -0.167 + 0.00315 * Year
Bottom	OS	50	0.75	Max crack width = -1.47 + 0.024 * Year
Top	A-305	20	0.75	Max crack width = -0.0370 + 0.000853 * Year
Top	A-305	30	0.93	Max crack width = -0.129 + 0.00236 * Year
Top	A-305	40	0.96	Max crack width = -0.1562 + 0.00303 * Year
Top	A-305	50	0.75	Max crack width = -3.53 + 0.0570 * Year
Top	OS	20	0.91	Max crack width = -0.0950 + 0.00177 * Year
Top	OS	30	0.93	Max crack width = -0.0862 + 0.00178 * Year
Top	OS	40	0.70	Max crack width = -0.504 + 0.00845 * Year
Top	OS	50	0.61	Max crack width = -0.766 + 0.013 * Year

END

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