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IOWA STATE HIGHWAY COMMISSION

Materials Department — Date February 6, 1975

Attention George Calvert — REFER TO: 772.0720

From Stephen E. Roberts

Dept. Research

Subject Corrosion of Steel in CRCP, Research Project HR-1004
HR-1004

The Materials and Research Departments cooperated in planning and performing Research Project HR-1004 during the summer of 1974. The Research Department agreed to accept responsibility for the final report; it has been delayed because of our efforts to obtain a maximum amount of information from the data by means of various statistical analyses.

This memorandum contains all of the data, hopefully in a manner that will permit you to proceed with your consideration of an experimental project using cathodic protection for the CRCP steel. A more detailed report will be prepared at a later date.

Project HR-1004 involved the measurement of electrical potential at 5 test locations on each of 14 CRCP pavements on Interstate routes. The projects were selected by the Materials Department, and the 5 test locations per project were selected by the field crew.

All test locations were to the right of the midpoint of the righthand lane. At each location, a core was drilled to expose one of the longitudinal reinforcing bars on which an electrical connection was made. Corrosion readings were then made on the pavement surface directly over the bar at 20 transverse cracks fore and 20 cracks aft of the electrical connection. Readings were also obtained between most of the cracks. This provided a total of 350 to 375 corrosion readings per CRCP project.

Concrete samples for chloride determination were obtained at 2 points on cracks and 2 points between cracks at each of the 5 test locations per project.

The CRCP projects are identified in Table 1.

The average corrosion readings, chloride content, and crack spacing for each of the 70 (14 x 5) test locations are summarized in Tables 2-1 through 2-14. The chloride content for I-80 project, Dallas, I-80-3(14)109, has not yet been reported by the laboratory.

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In Tables 2-1 through 2-14, the average of the corrosion readings at each test location is shown, along with the standard deviation. From statistical theory, we would expect 95 percent of all possible readings from a test location to be within a range of the average plus or minus two standard deviations.

A complete list of all corrosion readings is contained in Appendix "A", which accompanies this memorandum.

Corrosion readings above 0.35 v were observed on the following projects:

Project	Station (Test Location)	No. Readings Over 0.35 v	Total Readings
Dallas, I-80-3(14)109	685	7	69
	680	16	67
	585	21	77
	532	10	74
	514	6	67
Decatur, I-35-1(21)5-01-27	412	2	71
	600	2	72
Hamilton, I-35-5(16)134-01-40	656	2	74
Cerro Cordo, I-35-7(12)198-01-17	1096	2	75
	1197	17	73
Cerro Gordo, I-35-7(11)193-04-17	901	2	69
	977	6	75
	983	2	70

For bridge decks, both the FHWA and the California Division of Highways have set the following interpretation.

Electrical Potential	Condition of Reinforcing Steel
0 to 0.29 v	Passive (corrosion unlikely)
0.30 to 0.35 v	Unknown
0.35 v or more	Active corrosion probable

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In a paper presented at the January 1975 Transportation Research Board meeting, R. F. Stratfull stated that California experience indicates that only 1.0 pound of chlorides per cubic yard of concrete is sufficient to produce corrosion of the steel under favorable conditions.

Tables 2-1 through 2-14 show the average chloride content at cracks and between cracks at a depth of 3-4 inches in the concrete. This is the approximate level at which the steel was found in the core holes drilled for the electrical connections. Chloride content averages of 1.00 pound per cubic yard or more were found on 9 CRCP projects from samples obtained at cracks. Chloride content averages of 1.00 pound or more were not found on any CRCP projects from samples obtained between cracks. (Note that chloride contents have not been reported for project I-80, Dallas, I-80-3(14)109.)

Coarse aggregate source was one of the considerations in selecting the 14 projects for testing. It was suspected that coarse aggregate from some sources may facilitate a greater or lesser accumulation of chlorides in the concrete.

A statistical analysis of the relationship between coarse aggregate source and chloride content was found to be impossible because there was no way to separate out the effects of fine aggregate and concrete mixture. The possibility that a relationship exists is suggested, but not proved, by the figures in Table 3.

It may be argued that visual observation of the steel in concrete is the only positive method of corrosion detection. Since this requires that cores containing reinforcing steel be drilled from bridge decks or CRC pavements, we prefer to use halfcell potential and/or chloride measurements to give a reasonable estimate as to whether or not active corrosion of the steel is taking place. R. F. Stratfull of California is generally regarded as the best authority on the use of such measurements for estimating the corrosion of steel in reinforced concrete bridge decks.

Mr. Stratfull has stated that a halfcell potential of -0.35 volts is indicative of active corrosion and that 1.0 pound of chloride per cubic yard of concrete is sufficient to cause corrosion. The use of this criteria must be tempered with the recognition that these symptoms are not infallible. This is discussed by Stratfull in his report given at the recent TRB meeting. The following is quoted from that report.

> "The corrosion of steel in concrete is a dynamic process. There is a continual replenishment of oxygen; conversion of iron to its final form of rust; polarization effects; variations in the halfcell potential due to oxygen, chloride, and hydrogen-ion concentrations; and variations in the moisture content of the concrete which affects its resistivity and ability to act as an electrolyte.
>
> "If the preceding is ignored, then the interpretation of the influence of particular variables such as half-cell potential values and chloride content of the concrete, can lead to erroneous conclusions. For example, when the chloride-ion content of the concrete is greater than say 1.0 lb./cu. yd. (0.59 Kg/m^3), there is no reason to believe that there <u>always</u> is an automatic and irrevocable start of the corrosion process. A corrosion threshold of amount of chloride is only a point in the concentration where corrosion can begin.
>
> "Once corrosion begins, it is time dependent in that it becomes more extensive as time increases. In concrete, the primary function of the chloride-ion is to destroy the passivity of the steel. Once this occurs, the actual corrosion rate of the steel is controlled by polarization and other effects as well as the continuance of the concrete to be an electrolyte. An increase in salt content is not necessary to keep corrosion active."

The results do not indicate serious or widespread corrosion of the longitudinal reinforcement in CRCP. They do suggest however, that corrosion could be a matter of concern in the future. The readings obtained on the I-80 project in Dallas County do indicate the possibility of serious corrosion, which is in line with the previous history of this project. It is more difficult to explain the few readings over 0.35 v that were obtained on the two projects on I-35 in Cerro Gordo County.

We have not attempted a national survey of the problem of corrosion of steel in CRCP, but we do know that Minnesota has discontinued the use of CRCP, supposedly because of the corrosion problem. In 1973 the state of Illinois issued a report describing a project in which they examined 151 cores indicating that corrosion of the steel reinforcement was relatively minor and that corrosion of the steel did not appear to be a potential problem. At the January 1975 Transportation Research Board meeting, the research engineer from Wisconsin associated with the Materials Department stated that they had also examined CRC pavement for corrosion and could find no evidence to indicate that it was a problem. We are sending you a copy of the Illinois report with this memorandum. I have asked for a copy of the report from Wisconsin and will forward it to you if and when I receive it.

SER:djh
Attachment
cc: R. L. Kassel
D. E. McLean

Table No. 1
Projects Investigated
Continuously Reinforced Concrete Pavement
Interstate Routes - 1974

Route: I-80 County: Pottawattamie
I-IG-80-1(58)4--04-78 Built: 1968 (open 1969)
1.656 miles; from Ia. 375 northerly approx. 1.9 miles.
Bars - Spec. #587

Station	Fine Aggregate	Coarse Aggregate	Mix
L: 86+50 - 1078+10	Cullom Pit	Hopper, W.W. Qr.	C-3
R: 15+08 - 1040+05	Springfield Pit	Hopper, W.W. Qr.	C-3
- 1053+79	Springfield Pit	Hopper, W.W. Qr.	C-3
1056+28 - 1065+10	Cullom & S'field	Hopper, W.W. Qr.	C-3

Route: I-80 County: Pottawattamie
I-80-1(69)19--01-78 Built: 1969
8.784 miles; from Underwood northeast to I-80N Interchange.
Bars - Spec. #646

Station	Fine Aggregate	Coarse Aggregate	Mix
	Corley & Avoca Pits	Woodbine & Sacton Pits	C-3

Route: I-80 County: Pottawattamie
I-80-1(36)34 Built: 1966
5.433 miles; from west line 4-77-40 east to point in E½ 5-77-39.
Bars - Spec. #587

Station	Fine Aggregate	Coarse Aggregate	Mix
	Corley Pit	Logan Qr.	C-4

Route: I-80 County: Dallas
I-80-3(14)109 Built: 1966
4.301 miles; from west line SW¼ Sec. 27-78-28 northeast 4.34 miles.
Mesh - 4" x 12"

Station	Fine Aggregate	Coarse Aggregate	Mix
EB: 470+10 - 595+99	Kenyon & B'ville	Booneville	C-4
- 699+33	Booneville	Booneville	C-4
WB: 470+10 - 699+33	Booneville	Booneville	C-4

Route: I-35 County: Decatur
I-35-1(21)5--01-27 Built: 1970
7.1 miles; from point near W¼ Cor. Sec. 5-67-26 northerly.
Bars - Spec. #646

Station	Fine Aggregate	Coarse Aggregate	Mix
	M.M. - W.D.M. Pit	M.M. - W.D.M. Pit	

Route: I-35 County: Story
I-IG-35-5(13)113--04-85 Built: 1966-1967 (open 1967)
5.165 miles; from U.S. 30 interchange north 5.2 miles.
Bars - Spec. #587

Station	Fine Aggregate	Coarse Aggregate	Mix
	Hallett Ames Pit	Hallett Ames Pit	C-3

Route: I-35 County: Hamilton
I-35-5(16)134--01-40 Built: 1967
6.030 miles; from north line Sec. 30-87-23 north 6 mi. to N¼ Cor. 30-88-23
Bars - Spec. #587

Station	Fine Aggregate	Coarse Aggregate	Mix
	Hallett Ames Pit	Alden Qr.	C-3

Route: I-35 County: Cerro Gordo
I-IG-35-7(11)193--04-17 Built: 1971
4.296 miles; from ½ mile south of Ia. 106 north to point near Cen. Sec. 29-97-21
Bars - Spec. #646

Station	Fine Aggregate	Coarse Aggregate	Mix
	Hallett - Clear Lake Pit	Wepking & Stricker Qr.	

Route: I-35 County: Cerro Gordo
I-35-7(12)198--01-17 Built: 1971
4.400 miles; from point near Cen. Sec. 29-97-21 north to Worth Co. line.
Bars - Spec. #646

Station	Fine Aggregate	Coarse Aggregate	Mix
	Fertile Pit	Wepking & Stricker Qr.	

Route: I-29 County: Fremont
I-29-1(13)10--01-36 Built: 1972
10.076 miles; from approx. 1 mile south of Ia. 2 northerly 10.1 miles.
Bars - Spec. #646

Station	Fine Aggregate	Coarse Aggregate	Mix
NB: 442+00 - 602+50	Fyfe @ Payne Jct.	Hopper, W.W. Qr.	C-6
604+38 - 997+00	Fyfe @ Percival	Hopper, W.W. Qr.	C-6
SB: 442+00 - 602+20	Fyfe @ Payne Jct.	Hopper, W.W. Qr.	C-6
604+08 - 997+00	Fyfe @ Percival	Hopper, W.W. Qr.	C-6

Route: I-29 County: Fremont
EACI-29-1(12)20--08-36 Built: 1971
6.305 miles; from point in NE¼ Sec. 5-69-43 northerly to Mills Co. line.
Bars - Spec. #646

Station	Fine Aggregate	Coarse Aggregate	Mix
	Fife Pit "B"	Hopper & Kerford, Weeping Water	C-6

Route: I-29 County: Mills
E-ACI-29-1(11)27--08-65 Built: 1970 (open 1971)
6.400 miles; from Fremont Co. line north 6.400 miles.
Bars - Spec. #646

Station	Fine Aggregate	Coarse Aggregate	Mix
	Lyman-Richey & Western S&G	Hopper, W.W. Qr.	Cl.V

Route: I-29 County: Harrison
E-ACI-29-5(18)85--19-43 Built: 1967
6.378 miles; from just north of Modale northerly thru the Mondamin intersection.
Bars - Spec. #587

Station	Fine Aggregate	Coarse Aggregate	Mix
SB:1741+18 - 1828+50	Sacton Pit	Sacton Pit	C-3
SB:1484+11 - 1741+18	Woodbine & Pisgah Pits	Logan Qr.	C-4
NB:1484+11 - 1828+50	Woodbine & Pisgah Pits	Logan Qr.	C-4

Route: I-29 County: Harrison-Monona
I-IG-29-5(15)103--04-67 Built: 1967
5.290 miles; from point in NE¼ Sec. 5-81-45 north to S¼ Cor. SE¼ 5-82-45.
Bars - Spec. #5 7

Station	Fine Aggregate	Coarse Aggregate	Mix
	Hallett, Wall Lake Pit	Hallett, Wall Lake Pit	C-3

Table No. 2-1

Corrosion Readings and Chloride Content

Continuously Reinforced Concrete Pavement

I-29, Harrison-Monona, I-IG-29-5(15)103--04-67

Station No.	2602	2590	2548	2494	2440	Total
On Cracks						
No. readings	40	40	40	40	40	200
Av. reading (v)	0.22	0.23	0.27	0.15	0.15	0.20
Standard Dev. (v)	0.01	0.03	0.02	0.02	0.02	0.05
Chloride Content (lbs. per cu. yd.) 10 locations Depth: 3-4 in.						1.93
Between Cracks						
No. readings	30	31	34	31	33	159
Av. reading (v)	0.21	0.21	0.26	0.14	0.14	0.19
Standard Dev. (v)	0.01	0.02	0.03	0.01	0.01	0.05
Chloride Content (lbs. per cu. yd.) 10 locations Depth: 3-4 in.						0.92
Av. distance between cracks (ft.)	1.73	2.22	2.39	1.92	2.26	2.10

Table No. 2-2

Corrosion Readings and Chloride Content

Continuously Reinforced Concrete Pavement

I-29, Harrison, E-ACI-29-5(18)85-19-43

Station No.	1805	1725	1661	1605	1549	Total
<u>On Cracks</u>						
No. readings	40	40	40	40	38	198
Av. reading (v)	0.11	0.10	0.18	0.11	0.12	0.12
Standard Dev. (v)	0.02	0.02	0.02	0.01	0.02	0.03
Chloride Content (lbs. per cu. yd.) 10 locations Depth: 3-4 in.						0.52
<u>Between Cracks</u>						
No. readings	36	34	36	33	34	173
Av. reading (v)	0.11	0.08	0.18	0.11	0.10	0.12
Standard Dev. (v)	0.03	0.03	0.03	0.01	0.01	0.04
Chloride Content (lbs. per cu. yd.) 10 locations Depth: 3-4 in.						0.30
Av. distance between cracks (ft.)	4.44	3.12	2.37	3.07	4.82	3.55

Table No. 2-3

Corrosion Readings and Chloride Content

Continuously Reinforced Concrete Pavement

I-29, Mills, E-ACI-29-1(11)27-08-65

Station No.	268	159	112	60	9	Total
On Cracks						
No. readings	40	40	40	40	40	200
Av. reading (v)	0.15	0.19	0.21	0.20	0.20	0.19
Standard Dev. (v)	0.02	0.02	0.03	0.03	0.02	0.03
Chloride Content (lbs. per cu. yd.) 10 locations Depth: 3-4 in.						0.73
Between Cracks						
No. readings	24	25	29	25	34	137
Av. reading (v)	0.16	0.20	0.19	0.19	0.19	0.19
Standard Dev. (v)	0.04	0.05	0.04	0.04	0.04	0.04
Chloride Content (lbs. per cu. yd.) 10 locations Depth: 3-4 in.						0.29
Av. distance between cracks (ft.)	2.56	2.34	2.85	2.51	3.70	2.79

Table No. 2-4

Corrosion Readings and Chloride Content

Continuously Reinforced Concrete Pavement

I-29, Fremont, E-ACI-29-1(12)20-08-36

Station No.	1324	1232	1179	1126	1078	Total
<u>On Cracks</u>						
No. readings	40	40	40	40	40	200
Av. reading (v)	0.23	0.21	0.21	0.21	0.27	0.23
Standard Dev. (v)	0.02	0.03	0.03	0.03	0.03	0.04
Chloride Content (lbs. per cu. yd.) 10 locations Depth: 3-4 in.						1.19
<u>Between Cracks</u>						
No. readings	35	35	29	37	35	171
Av. reading (v)	0.17	0.18	0.19	0.18	0.24	0.19
Standard Dev. (v)	0.04	0.02	0.02	0.02	0.03	0.04
Chloride Content (lbs. per cu. yd.) 10 locations Depth: 3-4 in.						0.24
Av. distance between cracks (ft.)	3.85	4.24	3.41	4.42	4.59	4.10

Table No. 2-5

Corrosion Readings and Chloride Content

Continuously Reinforced Concrete Pavement

I-29, Fremont, I-29-1(13)10-01-36

Station No.	931	772	693	596	540	Total
On Cracks						
No. readings	36	40	40	40	40	196
Av. reading (v)	0.26	0.20	0.23	0.24	0.26	0.24
Standard Dev. (v)	0.03	0.03	0.02	0.03	0.02	0.04
Chloride Content (lbs. per cu. yd.) 10 locations Depth: 3-4 in.						0.99
Between Cracks						
No. readings	29	34	33	36	36	168
Av. reading (v)	0.21	0.21	0.24	0.26	0.28	0.24
Standard Dev. (v)	0.02	0.01	0.02	0.02	0.01	0.03
Chloride Content (lbs. per cu. yd.) 10 locations Depth: 3-4 in.						0.22
Av. distance between cracks (ft.)	6.64	4.34	4.95	4.84	3.85	4.89

Table No. 2-6

Corrosion Readings and Chloride Content

Continuously Reinforced Concrete Pavement

I-80, Pottawattamie, I-IG-80-1(58)4-04-78

Station No.	136	129	125	120	103	Total
On Cracks						
No. readings	28	30	33	33	37	161
Av. reading (v)	0.26	0.19	0.19	0.22	0.26	0.23
Standard Dev. (v)	0.02	0.01	0.02	0.01	0.02	0.04
Chloride Content (lbs. per cu. yd.) 10 locations Depth: 3-4 in.						2.09
Between Cracks						
No. readings	24	27	27	28	28	134
Av. readings (v)	0.25	0.19	0.17	0.21	0.27	0.22
Standard Dev. (v)	0.02	0.02	0.01	0.02	0.03	0.04
Chloride Content (lbs. per cu. yd.) 10 locations Depth: 3-4 in.						0.41
Av. distance between cracks (ft.)	6.83	6.45	6.07	5.99	4.78	5.96

Table No. 2-7

Corrosion Readings and Chloride Content

Continuously Reinforced Concrete Pavement

I-80, Pottawattamie, I-80-1(69)19-01-78

Station No.	1144	1081	935	872	853	Total
<u>On Crack</u>						
No. readings	40	40	40	40	40	200
Av. reading (v)	0.19	0.21	0.19	0.24	0.22	0.21
Standard Dev. (v)	0.02	0.01	0.02	0.02	0.02	0.03
Chloride Content (lbs. per cu. yd.) 10 locations Depth: 3-4 in.						1.04
<u>Between Cracks</u>						
No. readings	28	33	29	26	34	150
Av. reading (v)	0.20	0.21	0.17	0.24	0.23	0.21
Standard Dev. (v)	0.01	0.01	0.02	0.01	0.01	0.03
Chloride Content (lbs. per cu. yd.) 10 locations Depth: 3-4 in.						0.42
Av. distance between cracks (ft.)	1.36	2.32	2.39	1.52	2.48	2.01

Table No. 2-8

Corrosion Readings and Chloride Content

Continuously Reinforced Concrete Pavement

I-80, Pottawattamie, I-80-1(36)34

Station No.	1595	1562	1509	1470	1409	Total
<u>On Cracks</u>						
No. readings	37	35	40	37	40	189
Av. reading (v)	0.23	0.25	0.21	0.19	0.17	0.21
Standard Dev. (v)	0.03	0.02	0.03	0.02	0.03	0.04
Chloride Content (lbs. per cu. yd.) 10 locations Depth: 3-4 in.						0.85
<u>Between Cracks</u>						
No. readings	34	32	36	34	31	167
Av. reading (v)	0.26	0.26	0.22	0.20	0.17	0.22
Standard Dev. (v)	0.02	0.02	0.02	0.02	0.03	0.04
Chloride Content (lbs. per cu. yd.) 10 locations Depth: 3-4 in.						0.33
Av. distance between cracks (ft.)	5.38	5.81	4.84	4.90	3.73	4.90

Table No. 2-9

Corrosion Readings and Chloride Content

Continuously Reinforced Concrete Pavement

I-80, Dallas, I-80-3(14)109

Station No.	685	680	585	532	514	Total
<u>On Cracks</u>						
No. readings	38	36	40	39	35	188
Av. reading (v)	0.30	0.33	0.32	0.30	0.30	0.31
Standard Dev. (v)	0.03	0.02	0.03	0.03	0.03	0.03
Chloride Content (lbs. per cu. yd.) Depth: 3-4 in.				locations		--
<u>Between Cracks</u>						
No. readings	31	31	37	35	32	166
Av. reading (v)	0.33	0.35	0.35	0.34	0.33	0.34
Standard Dev. (v)	0.03	0.02	0.02	0.02	0.02	0.03
Chloride Content (lbs. per cu. yd.) Depth: 3-4 in.				locations		--
Av. distance between cracks (ft.)	5.10	5.55	4.38	4.69	6.01	5.12

Table No. 2-10

Corrosion Readings and Chloride Content

Continuously Reinforced Concrete Pavement

I-35, Decatur, I-35-1(21)5-01-27

Station No.	387	412	493	550	600	Total
On Cracks						
No. readings	40	40	40	40	40	200
Av. reading (v)	0.27	0.24	0.21	0.24	0.28	0.25
Standard Dev. (v)	0.03	0.06	0.02	0.02	0.03	0.04
Chloride Content (lbs. per cu. yd.) 10 locations Depth: 3-4 in.						2.28
Between Cracks						
No. readings	34	31	32	27	32	156
Av. reading (v)	0.21	0.18	0.20	0.22	0.27	0.22
Standard Dev. (v)	0.03	0.03	0.03	0.02	0.04	0.04
Chloride Content (lbs. per cu. yd.) 10 locations Depth: 3-4 in.						0.42
Av. distance between cracks (ft.)	1.85	3.08	2.61	2.21	2.34	2.42

Table No. 2-11

Corrosion Readings and Chloride Content

Continuously Reinforced Concrete Pavement

I-35, Story, I-IG-35-5(13)113-04-85

Station No.	875	937	1049	1551	5481	Total
<u>On Cracks</u>						
No. readings	40	40	40	40	40	200
Av. reading (v)	0.22	0.18	0.16	0.13	0.18	0.17
Standard Dev. (v)	0.01	0.01	0.02	0.03	0.02	0.04
Chloride Content (lbs. per cu. yd.) 10 locations Depth: 3-4 in.						1.93
<u>Between Cracks</u>						
No. readings	38	35	32	32	38	175
Av. reading (v)	0.22	0.18	0.15	0.11	0.15	0.17
Standard Dev. (v)	0.01	0.01	0.02	0.03	0.01	0.04
Chloride Content (lbs. per cu. yd.) 10 locations Depth: 3-4 in.						0.84
Av. distance between cracks (ft.)	3.09	3.39	3.24	3.19	4.16	3.41

Table No. 2-12

Corrosion Readings and Chloride Content

Continuously Reinforced Concrete Pavement

I-35, Hamilton, I-35-5(16)134-01-40

Station No.	432	505	565	613	656	Total
<u>On Cracks</u>						
No. readings	40	40	38	40	40	198
Av. reading (v)	0.25	0.21	0.20	0.20	0.28	0.23
Standard Dev. (v)	0.03	0.02	0.03	0.02	0.05	0.05
Chloride Content (lbs. per cu. yd.) 10 locations Depth: 3-4 in.						1.05
<u>Between Cracks</u>						
No. readings	35	35	33	33	34	170
Av. reading (v)	0.23	0.19	0.18	0.20	0.27	0.21
Standard Dev. (v)	0.03	0.03	0.03	0.02	0.06	0.05
Chloride Content (lbs. per cu. yd.) 10 locations Depth: 3-4 in.						0.40
Av. distance between cracks (ft.)	4.36	4.72	4.80	3.18	2.56	3.91

Table No. 2-13

Corrosion Readings and Chloride Content

Continuously Reinforced Concrete Pavement

I-35, Cerro Gordo, I-IG-35-7(11)193-04-17

Station No.	901	921	925	977	983	Total
<u>On Cracks</u>						
No. readings	40	40	40	40	40	200
Av. reading (v)	0.29	0.22	0.20	0.31	0.27	0.26
Standard Dev. (v)	0.04	0.05	0.04	0.04	0.05	0.06
Chloride Content (lbs. per cu. yd.) 10 locations Depth: 3-4 in.						2.39
<u>Between Cracks</u>						
No. readings	29	35	34	35	30	163
Av. reading (v)	0.26	0.17	0.17	0.22	0.19	0.20
Standard Dev. (v)	0.03	0.03	0.03	0.05	0.04	0.05
Chloride Content (lbs. per cu. yd.) 10 locations Depth: 3-4 in.						0.83
Av. distance between cracks (ft.)	2.09	2.57	2.17	3.76	2.97	2.71

Table No. 2-14

Corrosion Readings and Chloride Content

Continuously Reinforced Concrete Pavement

I-35, Cerro Gordo, I-35-7(12)198-01-17

Station No.	1096	1120	1161	1197	1252	Total
On Cracks						
No. readings	40	40	40	40	40	200
Av. reading (v)	0.29	0.24	0.13	0.33	0.19	0.24
Standard Dev. (v)	0.04	0.04	0.02	0.04	0.02	0.08
Chloride Content (lbs. per cu. yd.) 10 locations Depth: 3-4 in.						2.65
Between Cracks						
No. readings	35	35	31	33	31	165
Av. reading (v)	0.21	0.21	0.13	0.26	0.17	0.20
Standard Dev. (v)	0.05	0.05	0.02	0.08	0.02	0.07
Chloride Content (lbs. per cu. yd.) 10 locations Depth: 3-4 in.						0.87
Av. distance between cracks (ft.)	2.88	3.36	2.17	2.92	1.69	2.60

Table No. 3

Coarse Aggregate Sources
Continuously Reinforced Concrete Pavement
Research Project HR-1004

Aggregate Sourse	Average Chlorides (lbs. per cu. yd.)	Number of Samples
Wepking & Stricker	2.01	40
Martin-Mar. W. Des Moines	1.65	20
Woodbine & Sacton Pits	1.28	20
Hopper	0.99	80
Hallett, Ames	2.25	20
Alden	1.63	20
Logan	1.12	40
Hallett, Wall Lake	1.93	20

Note: The average chloride content shown above for each coarse aggregate is the average of samples taken at both on-crack and between crack locations. The averages are for the full depth of the sample. This in contrast to the chloride figures shown in Tables 2-1 through 2-14, which are for the 3-4 inch depth only.