CORROSION TESTING OF BRIDGE DECKS

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When the corrosive half-cell potentials on a bridge deck exceed about 10 percent or when corrosion-caused delamination exceeds about 1 percent of the deck area, a chloride analysis generally would not be required because the chloride content is already too great. For the average depth of reinforcing steel, the quantity of chloride apparently needed to cause corrosion was statistically related to the maximum amount at the 95 percent confidence limits of 1.0 lb/yd^3 (0.59 kg/m^3). The accuracy of chloride determinations was about equal whether the concrete was drilled or cored. Although the half-cell potential of -0.35 volts CSE is indicative of active corrosion, an equipotential contour map is the most reliable means for evaluating the corrosion activity of steel in concrete. After repair of concrete delaminations, the percentage of corrosive potentials decreased by about 50 percent. Repairing concrete delaminations does not prevent or necessarily control corrosion at other locations.

•SEVERAL reports of investigations relate the causes of or factors that influence the corrosion of steel in concrete bridges (1-12). Some also contain laboratory types of investigations of field structures (1, 3, 10, 13-15). For the most part, however, the published reports are not oriented to screening large numbers of structures for an operational type of evaluation of the corrosion condition.

As reported by Kliethermes (4), Hall (5), and others (6, 7), the corrosion of steel in concrete bridge decks is related to the use of deicing salts, and the problem was found in 46 states. In NCHRP Synthesis 4 (6), concern was expressed for 200,000 bridge decks in the United States. Because of the large number of structures that have been exposed to deicing salts, it is obvious that research techniques must be streamlined to determine operationally the methods of repair and/or preservation of the decks (2-6, 8, 10, 15). Except for special cases, there are simply too many bridges and too few people and dollars to spend a long period of time thoroughly evaluating each structure. Therefore, the intent of this investigation was to find a reasonable means to obtain the necessary technical information with a minimum of effort and resources.

In general, it has been demonstrated that the corrosion activity of steel in concrete can be nondestructively determined by half-cell potential measurements (7, 10); by evaluation of physical concrete distress through visual observation, sounding (10), or chaining (11); by ascertaining the chloride content associated with the corrosion of steel in concrete (1, 3, 7-10, 13); and by determining the concrete cover over the corroding steel (2, 6-10, 12, 13, 16).

With a few exceptions, concrete quality in California is good enough that corrosion is not of special significance. This is not to imply that concrete quality does not affect the time to corrosion of the steel. It is only pointed out that, once the bridge is built, it cannot be changed, and concrete that is structurally and physically sound has no real function in correcting, controlling, or preventing corrosion of steel in existing bridge decks. Therefore, this corrosion investigation was specifically oriented toward evaluating corrosion investigation techniques and did not include a systematic evaluation of concrete strength, absorption, air entrainment, etc., although these factors do have a significant effect on performance if seriously deficient.

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As a result, chloride analyses were made of the bridge deck concrete to evaluate quantity, effects of sampling method and number of samples, and relationship to concrete distress and to the 2 techniques employed for obtaining half-cell potentials of the steel. In addition, an evaluation was made on 5 structures to determine the effect of repairs on the change in the half-cell potentials of the steel.

BRIDGES INSPECTED

Twenty-two bridges were inspected in 1972 and 1973 to determine the operational feasibility of using various inspection techniques to evaluate the corrosion behavior of the steel in the decks. The overall results are given in Table 1.

As Table 1 shows, the data accumulation for the various bridges consisted of a chloride analysis (8, 15), the measurement of half-cell potentials (7), measurements of concrete delaminations (11), and the concrete cover. Where the cover is shown to the closest 0.01 in., it was measured by a pachometer; when the value is shown to be plus or minus, the indicated concrete cover was not measured but was that specified.

As will be recognized, when dealing with a random investigation of individual field structures, the data obtained do not always result in information that is suitable for an overall analysis. For example, the investigation was directed at evaluating inspection techniques for structures that had been exposed to deicing salts; however, one older bridge was found to have been constructed with calcium chloride added to the concrete. In addition, another bridge deck, selected as being in "good condition", was found to have an average of 5 lb of chloride per cubic yard at the level of steel (2.97 kg/m^3), and corrosion was not active and there was no evidence of past distress. The reason for the passive condition of this bridge deck was not investigated, although previous work (10) has shown that corrosion may be dormant for a period of time in salt-contaminated concrete under conditions of low moisture content.

In Table 1 the chloride content at the level of the steel is given in terms of the average, the maximum content analyzed in any sample, and the maximum content that would be indicated by calculating a statistical distribution and deriving the maximum quantity at the 95 percent confidence limits of the data. The 95 percent confidence limit was used to define a repeatable maximum limit of chloride content rather than to depend on a randomly obtained maximum value. In Table 1 there is fair agreement between the actual maximum chloride content found in a bridge deck and the maximum calculated from the 95 percent confidence limit of the data.

Table 1. Bridge condition variables.

Bridge	Chloride Content (lb/yd^3)*			Corrosive Potentials (percent)	Delamination (percent)	Years of Service	Average Concrete Cover (in.)
	Average	Maximum in Sample	Maximum at 95 Percent Limit				
Weimar, Right	0.2	0.4	0.6	3	0.1	14	1.5±
Weimar, Left	0.2	2.0	0.8	5	0	14	2.43
New England Mills, Left	0.2	1.6	1.6	7	0	14	2.50
New England Mills, Right	0.5	1.6	1.6	4	0	14	2.71
Grapevine, Left	0.9	1.4	1.1	—	5	23	1.5±
Grapevine, Right	0.9	1.2	1.2	—	22	23	1.5±
Cressy	1.0	2.4	3.1	—	18	22	1.5±
Lebec Road	1.3	3.4	2.9	—	28	9	1.5±
Gray Creek	1.0	1.6	1.9	17	6.7	6	1.90
Canyon Creek	1.3	1.9	2.3	4	5.5	7	1.66
Ft. Tejon	2.0	3.6	3.2	—	40	23	1.5±
Pony Bar	1.9	3.1	3.4	35	30	6	1.70
Milagra Drive	3.0	6.4	6.4	6	11	7	1.30
101/116 Separation	2.7	4.9	5.6	2	7.6	17	1.43
Sawmill	2.2	3.5	3.7	10	0.4	8	1.78
Mt. Shasta, North	2.6	4.1	4.2	21	1.3	8	1.58
Sly Park	3.5	6.0	6.0	37	12	8	1.68
Lake Street	4.0	5.8	5.7	47	10	8	1.56
Long Valley	5.0	8.0	8.6	0	0	14	1.5±
Lebec	5.0	8.8	10.0	—	28	9	1.5±
Mt. Shasta, South	6.1	9.9	8.2	73	6.7	8	1.58

*At the depth of steel; 1 lb/yd^3 = 0.59 kg/m^3.

To obtain the chloride content at the level of the steel, the original data were plotted on semilog paper. The chloride content was plotted on the log scale ordinate against its associated depth below the surface of the deck on the linear abscissa. For the approximate 4-in. (10.2-cm) depth of the cores, the best fit of the points was made by a straight line, then the chloride content at the level of the steel was obtained for the determined average depth of cover.

In Table 1 the column "Corrosive Potentials (percent)" represents the percentage of potential measurements of the steel in the bridge deck relative to the saturated copper-copper sulfate half-cell (CSE) that are more negative than -0.35 volts (13, 14). Also, the column "Delamination (percent)" represents the percentage of the bridge deck having the concrete delaminated as determined by the chain drag (11). The "delamination" designation also included any surface area of the deck from which concrete had already spalled as a result of corrosion.

Chlorides Versus Potentials and Deck Delaminations

Data were grouped according to ranges of chloride content and then the averages for potentials and delaminations for the bridge decks were plotted against the associated chloride content, as shown in Figures 1, 2, and 3.

As shown by Figure 1, when the average chloride content was 0 to 1.0 lb/yd^3 (0.59 kg/m^3) or less, the average percentage of corrosive potentials was 4.8 percent of the total measurements, and the average percent of concrete delamination was 4.5 percent of the total deck area.

In Figure 2, where the maximum chloride content in any sample at the level of the steel was used as a criterion, it will be observed that, for chloride contents of less than 1.0 lb/yd^3 (0.59 kg/m^3), the percentage of corrosive potentials was found to average 4 percent, and the average area of delamination was 0.05 percent.

In Figure 3, which uses the maximum chloride content at the average level of the steel calculated to the 95 percent confidence limit, the average percentage of corrosive potentials was 4 percent, and the average area of delamination was 0.05 percent.

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It is obvious from Figures 1 through 3 that a maximum chloride content at the average level of the steel is related to the incidence of active corrosion potentials, and the resulting concrete delamination confirms the amount previously associated with corrosion of the reinforcing steel (10).

Figures 2 and 3 may give a misleading impression that increasing chloride contents result in an increase in corrosive potentials and delaminations. Because the structures are those that have received deicing salts over a period of time, increasing salt content only reflects a gain of salt in the concrete with time. The continuing corrosion of the steel in concrete is time-dependent and not necessarily related to increasing salt content above some threshold level. For example, it is not required that the bridges in Table 1 have more than 3 lb of chloride per cubic yard (1.8 kg/m^3) in order to contain 26 percent corrosive potentials and 13 percent of the area delaminated. 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 as an electrolyte. An increase in salt content is not necessary to keep corrosion active.

For example, in Table 1, one bridge is listed with 8 years of service that contains a maximum of 9.9 lb of chloride per cubic yard (5.8 kg/m^3), and the relative area of corrosion-caused concrete delamination on the deck is 6.7 percent. Conversely, another bridge with 6 years of service has a maximum chloride content of 1.6 lb of chloride per cubic yard (0.94 kg/m^3) and also has 6.7 percent of its deck delaminated by corroding steel. From these and other data shown, it is obvious that, once the concrete becomes chloride-contaminated, the corrosion-caused distress is not controlled

Figure 1. Average chloride versus corrosive potentials and deck delaminations.

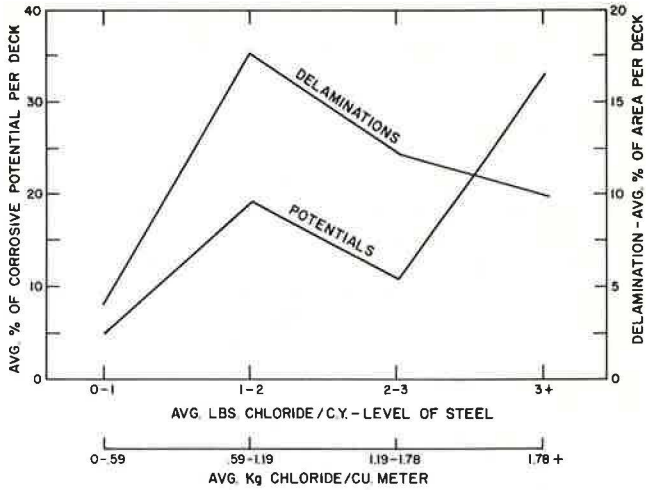


Figure 2. Maximum chloride versus corrosive potentials and deck delaminations.

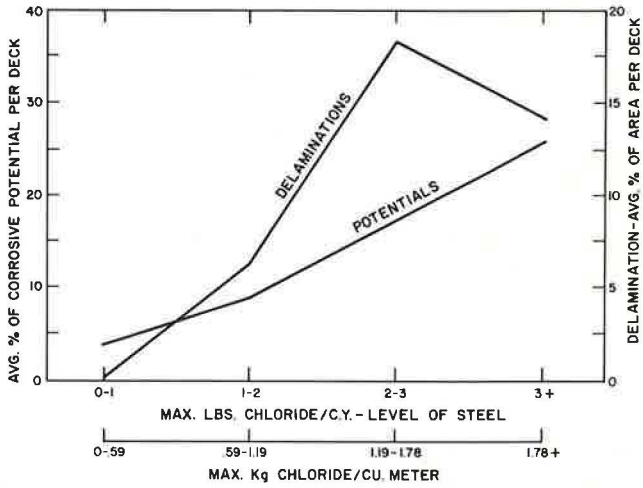
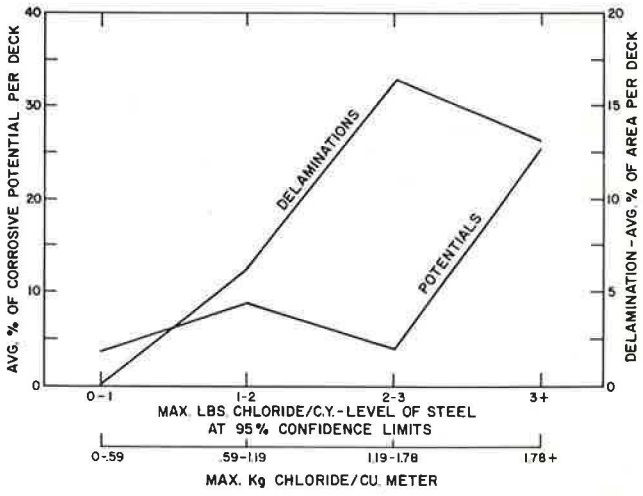


Figure 3. Maximum chloride versus corrosive potentials and deck delaminations at 95 percent confidence limits.



by chloride content beyond that needed to depassivate the steel but is controlled by other variables that specifically relate to the corrosion process and its effect.

Chloride Sampling

On 6 bridges, the chloride content of cores that were sliced and then pulverized in the laboratory was compared to that obtained by drilling the concrete and analyzing samples that were pulverized in situ. Results are given in Table 2.

At each bridge, cores 3 in. (7.6 cm) in diameter were obtained and sliced into 1-in.-thick discs that were then pulverized and analyzed. At each core location and approximately 1 in. (2.5 cm) from the edge of the core hole, 4 drill samples were made at 90-deg intervals about the circumference of the core hole. The drillings of the 2 different diameters of drills were first made to a 1-in. (2.5-cm) depth below the surface, then the pulverized concrete was removed with a small spoon. The hole was then air-blown to clean out the residue, and the process was repeated for the depth between 1 in. (2.5 cm) and 2 in. (5.1 cm) below the deck surface.

As shown in Table 2, the mean values for the chloride contents obtained either by drilling or coring do not appear to be consistently different statistically, as evidenced by the standard deviation and coefficients of variation.

In some cases, as shown in Table 2, the coefficients of variation for the results of the drilled samples are both greater and less than those for core samples. For an equal number of observations, the greater the coefficient of variation, the less the accuracy of the mean. Therefore, it seems that the major variable is an inconsistent distribution of chlorides through the structure rather than the diameter of the sampling apparatus, per se. This is further emphasized by the fact that the average of the coefficients of variation for the chloride analysis of the drill samples was about 33 percent whereas the average of the coefficients of variation for the cores was 36 percent. In a previous study (7) the coefficient of variation for cores was about 30 percent. From this, it is obvious that a sufficient number of samples (say, at least 6) should be obtained in order to evaluate the chloride content with a much higher level of confidence than can be obtained with a smaller number of samples.

POTENTIALS AND CONCRETE CONDITION

Half-cell potentials were measured and tabulated (Table 3) for 8 bridges having concrete delamination. In large delaminated areas, where 2 or more measurements were made, the potentials were tabulated for a maximum and minimum value. In small areas of delaminations, where only 1 potential measurement was made, it was listed as an "isolated" potential.

In general, where the length in area of delamination was about 3 ft (1.0 m) or more, at least 2 potential measurements were made. The average of the maximum potentials was -0.453 volts CSE, and the average of the minimum potential within the same delaminations was -0.334 volts CSE. At concrete delaminations that had a diameter (roughly) of about 1 ft (0.3 m) or less, the average of the single potential readings made in these locations was -0.385 volts CSE.

As shown in Table 3, in locations where the concrete was not delaminated, the average of all potential measurements was -0.180 volts CSE.

On a field structure, as compared to laboratory specimens, there is a greater possibility of error in defining corrosive and noncorrosive potentials. This is because of the polarizing effects between the anodes and cathodes on the large masses of steel in a field structure. This effect will reduce the actual open-circuit potentials of the anodes and simultaneously increase the potentials of the cathodes.

The maximum measured potential in any corrosion cell should be used as a criterion for analysis. In this regard, since concrete delamination on the 8 bridges surveyed was observed, when the average of the maximum values was -0.453 and the average of the isolated values was -0.385 volts CSE, it is obvious that these values signify active corrosion of the steel. Even though these values indicate the potential of corroding

steel, it must be recognized that they represent an advanced stage of corrosion and are of a numerically greater potential than when corrosion was initiated.

The determination of noncorroding potentials of steel is not defined by the criterion that the concrete is not delaminated. This is because the corrosion of the steel may not as yet have progressed to the stage where it causes the concrete to fracture. This is illustrated in Table 3, where the average potential of the steel in nondelaminated concrete for one bridge (South Mt. Shasta) was -0.382 volts CSE whereas the average for all structures was -0.180. Although nondelaminated concrete cannot be used to establish clearly either an active or passive potential of the steel, it is obvious that the bridge deck concrete was observed to be sound when the average potential was -0.180 volts CSE.

For a high level of assurance that corrosion is active, a potential numerically greater than -0.350 volts CSE seems to be a reliable criterion. In certain cases, because of the probable effects of polarization, etc., measurement of potentials of steel will be in the range of -0.25 to -0.35 volts CSE and concrete distress may be evident.

POTENTIAL SURVEY METHODS AND DECK REPAIR

Half-cell potentials can serve 2 or more purposes, which can encompass (a) determination of the locations where steel is corroding; (b) classification of corrosion activity of steel according to the percentage of corrosive potentials; and (c) determining the effectiveness of a repair method.

To develop an economical method to classify the condition of bridges, potentials were made on a grid pattern of either 4 ft (1.2 m) or 2 ft (0.6 m) and on a random basis. The random selection method of obtaining potentials was based on obtaining the measurements in the curb area of lowest elevation at spacings of approximately 4 ft (1.2 m) longitudinally, and a minimum of 30 values was required.

A complete potential survey was made of 5 bridges before and after concrete repairs (Table 4). The repairs were made only at locations of delaminated concrete.

There appeared to be no significant difference in the percentage of corrosive potentials when a potential measurement spacing was either 4 ft (1.2 m) or 2 ft (0.6 m). However, when smaller intervals were used and results were plotted on equipotential contour maps, there was better definition of corroding areas.

With regard to evaluating the corrosion activity of the decks as determined by the percentage of corrosive potentials (percent of values numerically greater than -0.35 volts CSE), the overall average of corrosive potentials computed either by the complete or random survey for all structures was 19 percent. However, as will be noted in Table 4, the random survey did not detect any corrosive potentials on 2 structures (Canyon Creek and Sawmill) whereas the complete survey did detect corrosion activity. In one case (Sawmill), the amount of concrete delamination of the deck was 0.4 percent; in the other case, the bridge had 6.7 percent delaminated area. It is obvious that the random survey, although a rapid system for evaluating corrosion activity as compared to the time involved in obtaining a complete potential record, will not be perfect. Discrepancies can be minimized in the random type of survey by obtaining potential values in areas of delamination.

As previously mentioned, the percentage of corrosive potentials were determined for 5 bridge decks before and after repairs. From these data it is shown that, after repairs were made, there was a reduction in the percentage of corrosive potentials by an average of about 50 percent. Therefore, this type of repair is basically a mechanical repair that can initially reduce but not prevent or control additional corrosion of the steel.

DISCUSSION

The corrosion of steel in concrete is a dynamic process. There are continual replenishment of oxygen; conversion of iron to its final form of rust; polarization effects;

Table 2. Concrete sampling variations.

		Depth							
		0-1 in.				1-2 in.			
Bridge	Sample Type	n	$\overline{X}$	Std. Dev.	Coef. Var. (percent)	n	$\overline{X}$	Std. Dev.	Coef. Var. (percent)
Lebec	3-in. cores	6	9.74	3.11	31.9	6	4.54	2.50	55.1
	All drillings	24	8.00	1.98	24.8	24	5.42	1.74	32.1
	¾-in. drillings	4	10.2	3.53	34.6	4	6.00	1.18	19.7
	1-in. drillings	20	7.56	1.24	16.4	20	5.30	1.83	34.5
Cressy	3-in. cores	3	1.60	0.80	50.0	3	0.93	0.61	65.6
	¾-in. drillings	12	1.83	1.20	65.6	12	1.12	0.72	64.3
Lebec Road	3-in. cores	6	2.60	0.92	35.4	6	1.20	0.62	51.7
	¾-in. drillings	24	2.73	0.87	31.9	24	1.40	0.80	57.1
Ft. Tejon	3-in. cores	6	3.93	0.99	25.2	6	1.67	0.39	23.4
	¾-in. drillings	24	3.77	1.31	34.7	24	2.19	0.77	35.2
Grapevine, Right	3-in. cores	6	1.37	0.23	16.8	6	0.73	0.16	21.9
	¾-in. drillings	24	1.44	0.21	14.6	24	1.04	0.08	7.7
Grapevine, Left	3-in. cores	6	1.13	0.48	42.5	6	0.70	0.11	15.7
	All drillings	24	1.27	0.21	16.5	24	1.03	0.11	10.7
	¾-in. drillings	16	1.20	0.21	17.5	16	1.01	0.09	8.9
	1-in. drillings	8	1.40	0.15	10.7	8	1.07	0.15	14.0

Note: Chloride content in pounds per cubic yard; 1 lb/yd³ = 0.59 kg/m³.

Table 3. Potentials and delaminations.

	Delaminated Concrete									Nondelaminated Concrete			
	Maximum Potential (volts)			Minimum Potential (volts)			Isolated Potentials[a] (volts)			All Potentials (volts)			
Bridge	n	Mean	Std. Dev.	n	Mean	Std. Dev.	n	Mean	Std. Dev.	n	Mean	Std. Dev.	Percent Delaminated Concrete
Canyon Creek	6	0.390	0.049	6	0.247	0.106	4	0.278	0.064	1742	0.096	0.094	5.5
Gray Creek	26	0.462	0.059	26	0.343	0.068	80	0.356	0.100	376	0.180	0.010	6.7
South Mt. Shasta	10	0.523	0.076	10	0.429	0.091	97	0.466	0.066	391	0.382	0.084	6.7
Lake Street	25	0.496	0.036	25	0.383	0.044	107	0.388	0.070	377	0.227	0.093	10.0
Pony Bar	22	0.381	0.074	22	0.247	0.090	86	0.314	0.074	198	0.024	0.104	30.0
North Mt. Shasta	2	0.50	0.20	2	0.41	0.15	48	0.420	0.095	609	0.263	0.095	1.3
Sawmill	2	0.43	0.08	2	0.36	0.06	42	0.383	0.044	592	0.231	0.100	0.4
Weimar	1	0.34	—	1	0.23	—	10	0.29	0.062	392	0.181	0.071	0.1
Weighted average	94	0.453	0.060	94	0.334	0.072	474	0.385	0.075	4677	0.180	0.086	

[a]Isolated potentials signify that only one measurement was made in localized area.

Table 4. Potential measurements.

	Before Repair					After Repair		
	Full Survey			Random Survey		Full Survey		
Bridge	Spacing[a] (ft)	n[b]	Percent Corrosive[c]	n	Percent Corrosive	Spacing (ft)	n	Percent Corrosive
Gray Creek	4	454	26	56	14	4	453	16
South Mt. Shasta	4	459	73	99	82	4	460	37
North Mt. Shasta	4	630	21	148	32	4	630	6
Lake Street	4	477	47	49	45	4	477	22
Canyon Creek	4	478	4	—	—	4	482	2
Canyon Creek	2	1802	3	99	0	—	—	—
Sawmill	4	607	10	30	0	—	—	—
Milagra	2	1041	7	180	5	—	—	—
Pony Bar	4	342	35	49	41	—	—	—
Long Valley	4	142	0	30	0	—	—	—
Weimar, Right	4	380	3	90	9	—	—	—
Weimar, Right	2	1424	4	—	—	—	—	—
Weimar, Left	4	389	5	90	9	—	—	—
New England Mills, Right	4	466	4	90	3	—	—	—
New England Mills, Left	4	465	7	90	12	—	—	—

[a]Minimum center-to-center spacing; 4 ft = 1.2 m, 2 ft = 0.6 m.
[b]Number of observations.
[c]Percent of potentials numerically greater than -0.35 volts.

variations in the half-cell potential due to oxygen, chloride, and hydrogen ion concentrations; and variations in the moisture content of the concrete that affect its resistivity and ability to act as an electrolyte.

If these facts are 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/yd^3 (0.59 kg/m^3), there is no reason to believe that there always 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. This is emphasized by previous work (9, 10) where it was demonstrated that corrosion activity was nil when the specific electrical resistance was greater than 60,000 ohm-cm in salt-contaminated concrete (10). However, it was also demonstrated that when nondistressed salt-contaminated concrete was painted, there were electrical potential (18) and visual (10) indications that corrosion was accelerated. In addition, evaluations of electrical potential measurements have indicated that there is corrosion activity of steel in concrete when corroding bridge decks are overlaid with concrete or waterproof membrane (4, 5).

When suitable data are available, the economics of bridge deck repair or corrosion prevention with procedures such as epoxy injection to bond the delamination (19, 20), concrete removal and replacement (4, 5, 6, 8, 11), cathodic protection (19), or the use of waterproof membranes (4, 5, 6, 10) can be determined.

SUMMARY AND CONCLUSIONS

Chloride, Potentials, and Delaminations

The quantity of chlorides in concrete associated with the incidence of active corrosion of the steel is about 1 lb/yd^3 (0.59 kg/m^3) of concrete.

It was observed that the maximum quantity of chloride at the 95 percent confidence limits found at the average level of the steel was the best indication of salt content in a structure that is causing corrosion of the steel.

Except for isolated cases, the data indicate that the chloride content need not be determined if more than about 1 percent of the surface area of the bridge deck concrete is delaminated or if more than about 10 percent of the total potential measurements are numerically greater than -0.35 volts to the saturated copper-copper sulfate half-cell (CSE).

The data also indicate that if the average chloride content at the level of the steel is greater than about 1.0 lb/yd^3 (0.59 kg/m^3), an analysis to determine the maximum statistical amount may have no practical significance because the chloride content is already too great.

Sampling for Chloride Determination

On 6 bridges it was observed that it did not seem to make any significant difference in the accuracy of the chloride determination whether the concrete sample was obtained by coring or by drilling. This would indicate that the major variable in concrete sampling is controlled by the variation in the salt content per se. In this respect, it may be that the variations in salt content are controlled by concrete properties, salting and snow-removal practices, drainage, etc., but the size of the sampling apparatus as used in this investigation demonstrates that this latter variable, per se, is not significant. Therefore, it is obvious that concrete samples for chloride analysis could be obtained by recovering drilling dust or by cutting and pulverizing concrete cores.

With a coefficient of variation of the chloride contents found to be in the average range of 33 to 36 percent, no less than 6 samples for chloride analysis should be obtained to make a valid survey.

Potentials and Concrete Condition

The average potential of the steel in nondelaminated concrete was found to be -0.180 volts saturated copper-copper sulfate half-cell (CSE). For delaminated concrete, the average potential in small isolated areas was -0.385 volts whereas the average of the minimum and maximum values found in large corroding areas was -0.334 and -0.453 volts CSE respectively. These values confirm that there is great assurance of active corrosion when the potential of the steel is numerically greater than -0.35 volts CSE.

The determination of active corrosion at half-cell potential values numerically less than -0.35 volts CSE will require interpretation and consideration of evidence, such as corrosion-caused concrete delaminations being present, or plotted equipotential contours that indicate an anodic or corrosion area at a lesser maximum potential.

Potentials, Random Survey

It was found that a random survey of the electrical half-cell potential could be a rapid and economical means for evaluating the corrosion activity of the steel in numerous bridges. This method has limitations, as has any other statistical sampling, but it appears to be economically worthwhile where a rapid evaluation of numerous structures is concerned.

Potentials, Before and After Repair

From potential measurements made on 5 bridge decks both before and after the repair of concrete delaminations, it was found that the percentage of corrosive potentials was reduced by about one-half. Therefore, repair of delaminations in chloride-contaminated concrete is a mechanical type of repair that can initially reduce some but not all locations of corrosion activity.

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