HAVER ET AL. ON CORROSION OF STEEL AND WALL TIES 191

DISCUSSION

Questions (Ian Chin; Wiss, Janney, Elstner Associates)

- The paper includes under "carbonation" the neutralization of hydrated cement by SO2. Won't this extension of the definition lead to confusion?

- The conclusion that steel in the very negative half-cell readings for the steel in the sea wall (Figure 7) gave a false indication of corrosion are of concern to me. Such a "low" half cell reading usually indicates chloride-caused corrosion of steel, or the presence of galvanized steel. Examination of a core (Figure 7) will not often reveal either. Neither will the EDX pattern (Figure 15) that apparently ends before the zinc peak. Would the authors please comment?

- The conclusion that "currently accepted potential values are inaccurate for predicting corrosion of reinforcement" appears unwise in the light of the thousands of examples to the contrary, the minimal study of the steel in the sea wall, and the fact that there has never been an understanding that very negative half-cells <u>absolutely</u> <u>indicate</u> corrosion. ASTM C 876 simply indicates a probability. Further, half-cell potentials are primarily dictated by chemistry, and not corrosion, and accordingly any half-cell reading should suggest a study of the chemistry of the steel:cementitious material surface. Would the authors comment?

- The paragraph suggesting that wet-dry cycling leads to carbonation and neutralization is of doubtful accuracy. Carbonation occurs most rapidly at about 50% R. H., and scarcely at all at 0 or 100 percent. Sea water is not acid and has little effect on concrete pH except near the surface where soluble hydroxides are leached away. Indeed such reactions as

can increase the pH of the concrete. Would the authors comment?

- The statements that small amounts of chloride -- 0.06 percent by weight of mortar -- are probably added by the mix water and do not cause corrosion are both generally erroneous. Most mortars contain about 15 percent cement, making the chloride level about 0.4 percent by weight of cement, or twice the corrosion threshold. Most tap waters contain at most 100 ppm chloride, contributing only 0.005 percent chloride by weight of cement. On the other hand, some sands do contain chloride that is bound within the particle matrix and will not contribute to corrosion. Would the authors comment?

AUTHORS' REPLY (R. Heidersbach)

- The point about carbonation is valid and we agree--in the location in question the relative importance of atmospheric gases versus suphur compounds in sea water (or sea spray) cannot be determined. We have used the common practice of stating that cementitious materials that have lost their alkalinity have "carbonated" although it is obvious that other reasons for a loss of alkalinity may have been present.

- We disagree. Our experience is that one cannot determine the presence or absence of corrosion without visual and microscopic examination of the metal surface. The X-ray spectrum referred to by Mr. Chin does not end before the zinc peak. The complete spectrum was recorded and only that portion with peak information was printed. A zinc peak is clearly evident in Figure 17 and would have been shown in Figure 15 if zinc had been detected.

- Mr. Chin questions our phrase "currently accepted potential values are inaccurate for predicting corrosion." We disagree. We have no knowledge of the "thousands" of samples that Mr. Chin refers to, but our experience on concrete structures indicates the same problems we have discussed here for masonry. We chose this extreme example of masonry exposed to sea water to illustrate the point we have observed on numerous occasions on masonry Unless an independent confirmation of corrosion activity buildings. can be made, we can see no justification for using ASTM C876. Mr. Chin correctly suggests that a study of the metal:cementious material That is why we have reported the visual interface is necessary. observations and the SEM and X-ray results discussed above.

We agree that ASTM C876 only states a probability. We disagree with the probability stated in the standard. It should also be noted that ASTM C876 specifically refers to concrete, not masonry. Unfortunately, many forensic consultants use ASTM C876 for masonry. - We agree that carbonation occurs at intermediate humidities. Since coastal structures dry out between tide and storm cycles, we assume this is when the loss of alkalinity, presumably due to carbonation (see Mr. Chin's first comment) occurs. Whatever the cause, there can be not doubt that the mortar we examined in this study was no longer alkaline, yet the mortar residue protected the underlying metal from corrosion.

- Mr. Chin is correct that aggregates can be a source of chlorides in mortar. He is incorrect in his assumption that there is a corrosion threshold. Our work clearly shows that corrosion can occur at chloride levels well below the supposed threshold. We have also documented that corrosion need not occur even when the chloride level is several times the supposed threshold.