DECAY OF IRON AND STEEL IN ENGINEERING WORKS.*

By W. H. Maxwell, Assoc.M.Inst.C.E.

DURING recent years, the writer has been called upon to give close attention to the question of the relative durability of various metals subjected to corrosive influences, as met with in structural engineering, more particularly in connection with deep-well work for public water supply purposes, in steel bridge work, and in boilers and steam engineering generally.

The remarks which follow are in no sense intended to be a complete survey of the subject of corrosion of iron and steel, but simply to outline a few of the more practical points as met with in practice.

At the outset, it may be observed that, however simple the usual text-book theory may appear in regard to the common phenomenon of the corrosion of metals, such as the rusting of common iron or steel, those who are responsible for the prevention of corrosion in important engineering structures will soon realize that the problem is one of much greater complexity than a case of simple oxidation, as commonly supposed. The underlying causes and remedies for such deterioration are still somewhat imperfectly understood, and, even in the simplest cases, there remains room for fuller investigation.

Complications Affecting Corrosion.—In most cases met with in practice, it is not a question of investigating the action of water and air upon *pure* iron, but the deterioration to be arrested is invariably found to be the product of these substances mixed with numerous impurities, thus giving rise to an almost endless variety of conditions and results. The impurities of water and air vary with the locality, and the precise composition of metal is often a varying and elusive contingency of manufacture, somewhat difficult to trace and control.

Commercial Iron and Steel.—In view of the fact that commercial iron and steel are not uniform in composition, and that water and air are invariably contaminated in numerous ways, it is not surprising that the growth of knowledge on the subject has been slow, and that many of the opinions formed have since proved erroneous.

Want of Uniformity in Composition of Metals.—In the case of ordinary commercial irons and steels, the more soluble constituents dissolve out first, according to the nature of the liquids or other deteriorating influences with which the metals are brought into contact. Different batches of steel cannot be depended upon for uniformity of composition and equal durability under like circumstances.

Great care should be taken to prevent irregularity of composition in iron if corrosion is to be retarded. The greater uniformity of wrought iron, as compared with steel, also renders the former metal more resistant to galvanic activity.

Segregation in Metals.—Steels usually show great tendency to segregate, owing to the different temperatures of solidification of their constituents, and the smaller the proportion of iron present the greater is the want of uniformity due to segregation. Under these conditions, differences of potential exist, galvanic activity is set up, and the steel becomes highly corrodible.

Uniformity of Coatings Necessary.—Provided the metal can be completely covered with an efficient protective coating in order to insulate it from other metals or from the electrolyte in which it may be immersed, resistance to corrosion will be increased, but it is essential such coatings should be entirely continuous, otherwise, galvanic currents may be concentrated at points or pinholes, and thus cause greater damage than if uniformly distributed over the entire surface of the metal.

Local Conditions Affect Rate of Corrosion.—The behavior of metal is very largely dependent upon the precise local conditions to which it is subjected; for example, a strong industrial atmosphere may give rise, in the presence of moisture, to a powerful corrosive action. The writer has often experienced the highly damaging effect of fumes from passing locomotives upon mild steel bridge work exposed to such fumes in the presence of moisture.

Practical Observations.—Also, he has found that steam boilers and condenser tubes sometimes become pitted and grooved in a very unaccountable manner. Two or more boilers installed at the same date, made of similar material, fed with the same class of feed water, and worked under like conditions have oftentimes been observed to give widely divergent results—one being in good condition after 15 years' use, whilst another may become seriously pitted within one-fifth of that time. The repair of an old boiler with new boiler plate sometimes hastens the destruction of one or other of the metals, but it is impossible to foretell which metal will be the first to fail. The best classes of iron, such as Low Moor, are invariably more reliable than modern mild steel, which is a composite material involving many uncertain complications.

Metals Immersed in Corrosive Waters.—The writer has closely observed, for many years past, the varying degrees of corrosion occurring in the case of wrought iron, mild steel, and cast iron immersed in corrosive waters in structural works, particularly when these metals are used in juxta-position with gunmetal and other alloys. In the latter case a very marked and rapid deterioration of iron and steel has been observed to take place in certain natural waters, and under conditions such as these, the author has been engaged upon investigations into the question of the most suitable method of lining bore-wells 336 ft. deep by 3 ft. 6 in. diameter, for water supply purposes.

Deep-well Linings.—The usual mild steel linings were found to be inadmissible, owing to their very limited life under the conditions to be dealt with, and cast iron tubes with specially machined points were finally decided upon—a double lining being used through the first 165 feet of impermeable clay with the annular space between the inner and outer tubes grouted up with Portland cement grout. Great care was taken that no machined parts of the metal were exposed to the action of the water—these being protected by bituminous composition, and by closely fitted metal sleeves.

Foundry Skin.—Except where fully protected in this way, the foundry skin of the metal was not allowed to be broken, as this skin was found to have a strongly resistant action to the corrosive tendencies of the water. Should any machined face of the metal be exposed, deterioration will proceed rapidly at that part.

Uniformity and Insulation of Metals.—In all such works where metal must be fixed in contact with corrosive waters, the metals used should be as uniform in composition as possible, and if the employment of different

*Extract of paper presented in the Journal of the Institution of Municipal and County Engineers (Great Britain).