Hot Dip Galvanizing Data Sheet GA

5.1 Galvanized Reinforcement for Concrete

1. General

Reinforced concrete is an important material in today's construction industry. Motorway bridges, office buildings and tunnels are all designed to take advantage of the properties of reinforced concrete.

In most circumstances, the steel used to strengthen concrete does not need any additional measures to protect it from corrosion. The highly alkaline condition of concrete ensures that a thin layer of oxide forms on the steel surface and seals or 'passivates' it so that it does not rust.

However, there are certain conditions under which the passivation does not occur, or it is not adequate. For example:

- Defects in the concrete (fissures, cracks, pockets of gravel, too little or inadequate concrete cover).
- Carbonation of the concrete (e.g. neutralisation by other acidic substances).
- The effects of chlorides (e.g. road salt or marine atmosphere).

Damage to reinforced concrete structures has increased because of past high levels of air pollution and the use of rocksalt for de-icing roads. This has led to the expression "concrete cancer", used by both laymen and experts. Damage to bridges, especially over motorways and other sensitive structures (fig. 2), is more widespread than was previously believed.

Once corrosion of the steel reinforcement has set in it is both technically difficult and expensive to repair. The need to protect the reinforcement from corrosion is becoming more and more apparent for some applications.

2. Coatings for reinforcing bar

One of the most effective methods of protecting rebar from corrosion is by applying a surface coating to the bar. Coatings fall into two main categories – metallic and non-metallic.

Non-metallic systems such as fusion bonded epoxy coating have the following disadvantages:

- The protective coating can be damaged relatively easily during transport, bending and fixing of the steel, in storage on site or while pouring concrete. The underlying steel is then exposed and not protected.
- Inconsistent bond between coating and concrete.

Of the metallic coatings available, hot dip galvanizing has been shown to be the most commercially viable and technically efficient.

The hot dip galvanizing of steel used in reinforced concrete has been successfully employed in the United Kingdom and elsewhere for many years (fig. 3). Even under difficult conditions (with very delicate steel structures and with high levels of corrosion) hot dip galvanizing of steel for reinforced concrete has proved itself to be reliable.

Detailed studies in Australia and other countries have led to its increasing adoption and popularity as a means of protecting reinforcing bar and mesh. The following advantages are particularly significant:

- It provides sacrificial protection to exposed steel, thus avoiding localized corrosion when the coating is broken by cropping of ends, by welding or by mechanical damage.
- The coating on the steel within the concrete remains passive under longterm conditions of storage and transport.
- The bond between reinforcement and concrete is maintained.
- Concrete spalling is less likely to occur with the same depth of cover compared to unprotected rebar.
- The risk of brown staining from unprotected rebar is virtually eliminated.
- Reinforced concrete can be used more reliably in aggressive environments.
- Unreliable workmanship giving variable concrete quality, e.g. poorly compacted or with too high a water/cement ratio, can be better tolerated.

Experience shows variations of up to 50% in the depth of concrete cover actually achieved due either to inaccurate placing of the form work or its subsequent dislodgement during pouring. Reduced cover is much less important with galvanized steel than with black steel. Unexpected problems in building design or in service conditions, which cause continuous contact between concrete and trapped water, can be better tolerated. The tolerance of galvanized steel to attack by chloride ions is greater than that of black steel.

3. Specification and installation of galvanized rebar.

Reinforcing steel should be galvanized in accordance with ISO1461 or BS729: 1971 (1986) "Hot dip galvanized coatings on iron or steel articles". These are the standard specifications for hot dip galvanizing. A European specification for hot dip galvanizing of iron and steel (pr EN1029) is under development.

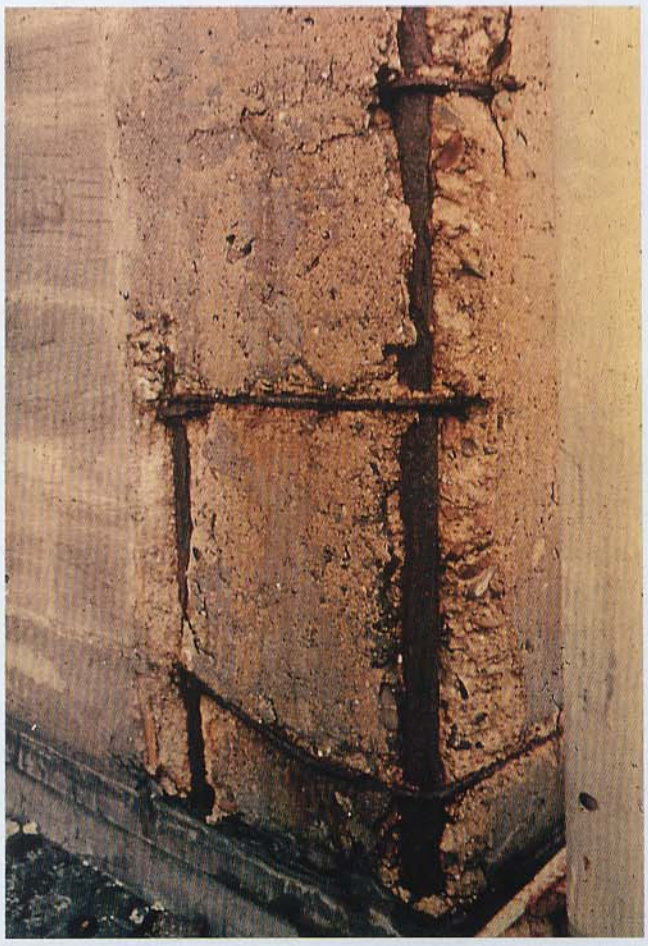

Fig. 1: Corrosion of rebar caused by inadequate concrete cover.

5.1 Galvanized Reinforcement for Concrete

Fig. 2: Renovation of a reinforced support wall.

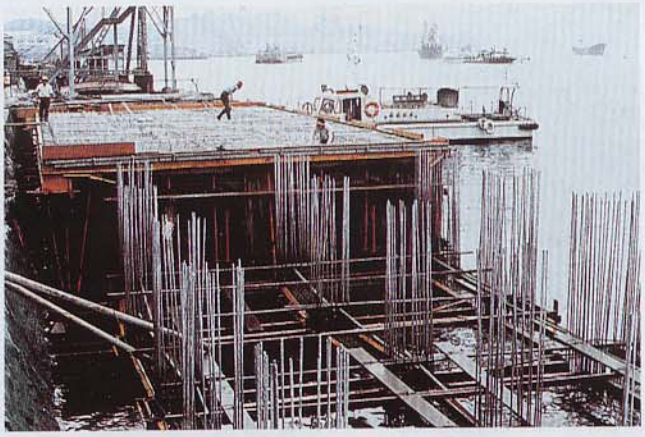

Fig. 3: Galvanized steel rebar used in a dock in Japan.

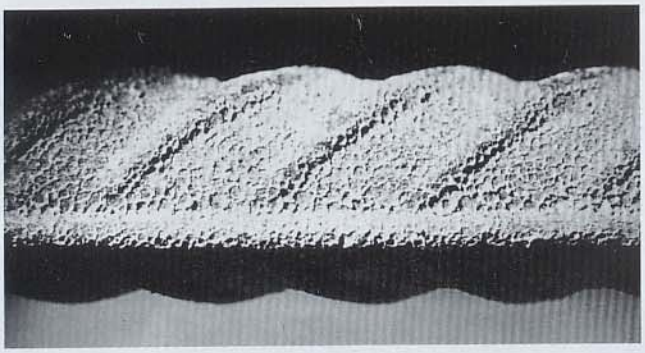

Fig. 4: The surface of galvanized rebar showing the familiar spangled effect.

Most reinforcing bars comply with Euronorm 80 (BS4449). In some cases, the steel is heat-treated to give improved ductility and weldability immediately following hot rolling.
There are few or no changes in the mechanical properties of the galvanized rebar after bending in accordance with the procedures outlined in BS4449: 1988.
Galvanized steel is commonly welded without difficulty and Galvanizers Association can provide information and advice on the various types of welding arrangement and process (see Data Sheet 2.10).
The specification could also state that "the concrete shall be of a normal type containing at least 0.002% chromate". This inhibits hydrogen formation and evolution, ensuring development of full bond strength of bars to concrete and preventing concrete sticking to formwork.

4. The economics of galvanized rebar.

When the costs and consequences of corrosion damage to a vulnerable reinforced concrete building are analysed, the extra cost of galvanizing the rebar is small. It can be regarded as an 'insurance premium', but a premium which is low and need be paid once only.
While the cost of galvanized rebar may be up to 50% more than that of black rebar, the cost of galvanized reinforcement as a percentage of total building cost is much lower than generally realised. It can be less than 0.5%, depending on the nature of the structure.
Galvanized rebar is a reliable basis for good concrete technology. It minimises the chances of steel corrosion and consequent concrete deterioration. It makes a strong and cost-effective contribution to long term concrete durability.
The capacity of galvanizing to protect reinforcement from corrosion is confirmed by experience in many countries. When the costs and consequences of corrosion damage to reinforced concrete applications are analysed, the cost of galvanized rebar may be fully justified.

Published by:
Galvanizers Association
Wren's Court, 56 Victoria Road,
Sutton Coldfield,
West Midlands,
B 72 1 SY, U.K.