ABSTRACT

The present research investigation is mainly concerned with corrosion of reinforcing steel in concrete beams in saline environment, under different design load conditions. In addition, some fundamental aspects regarding corrosion of reinforcing steel, like the influence of concrete mix, concrete cover and reinforcing bar diameter on the rate of corrosion and the loss of bond, are also investigated.

The primary objectives of this study are:

1. to determine the loss of strength of reinforced concrete beams due to corrosion.
   a. with different percentage of shear reinforcement less than the design requirement, adequate and in excess of the design requirement.
   b. under different states of stress - under no load, less than crack load and greater than crack load conditions and
   c. cast with and without cover block.

2. to quantify the influence of
   a. the mix proportions of concrete
   b. the bar diameter and
   c. the cover on the corrosion of reinforcement in concrete and the loss of bond.
For studying the influence of cover, bar diameter and grades of concrete on rate of corrosion, cube specimens of size 150 x 150 x 150 mm of two different mix proportions (M10 and M20), with two different sizes of bars embedded in concrete 8TOR and 12TOR, with two different depths of cover (15mm and 25mm) were cast. Similar specimens were prepared for pull out tests also.

All these cube specimens were immersed partially in 3% NaCl solution for varying periods. Some of these specimens were subjected to galvanostatic current for accelerating the corrosion process while some were subjected to alternate wetting and drying at intervals of 12 hours.

All these specimens were immersed partially, in 3% NaCl solution for periods of 20, 40, 70 and 100 days. The corrosion was accelerated by impressing a direct current on the reinforcement. The specimens were divided into three groups for test purposes. The specimens in one group were tested under no load condition. To the specimens in the other group a load, less than the cracking load, was applied before the specimens were placed in the salt solution. The third group of specimens were loaded up to the first crack appearance.

Cu/CuSO4 half-cell measurements were made on the specimens at the top and bottom surfaces, with both single and double electrode, at different test periods.
Corrosion extent was assessed based on the following methods over the study period

(i) NDT method single half cell potential measurements using Cu/CuSO₄ electrode

(ii) Displacement method - Weight loss in steel

(iii) Titration method - Chloride ion concentration in concrete

Voltage measurements were made using the electrodes fabricated as a part of this study.

The weight loss of steel was estimated after removing the steel and measuring the volume by a special displacement pycnometer (developed and manufactured as a part of this thesis).

Based on the above, the following major conclusions were arrived at,

1. The study reveals the importance of considering corrosion of reinforced concrete beams during design of structures.

2. It should be emphasised that the beams exposed to corrosion environment should be provided with at least 20% excess shear capacity so that the unfavourable shear failure mode could be suppressed.

3. The premature shear failure which occurs due to preferential corrosion of stirrups in aggressive environment can be avoided by careful design of beams considering corrosion using sacrificial steel.
4. An attempt has been made to correlate laboratory accelerated corrosion with that occurring in field under mild, moderate and severe exposure conditions.

5. The TOR steel corrodes 1.7 times faster than that of mild steel.

6. Use of M_{15} is to be avoided in coastal area.

7. Use of vibrated cover blocks in imperative in coastal areas.