METHODOLOGY.

Some of the methods used by Integrity testing in investigations of buildings and structures are summerised in this brief.

Further information on our testing services can be obtained from our web site Home A PDF file of this available at Papers

CONTENTS

Covermeter

It is important to determine the amount of concrete cover to the reinforcement. This is necessary for the assessment of the rate for chemical attack to reach the reinforcement and corrosion initiation. The concrete cover depth is determined by the use of a covermeter which determines the depth of reinforcement by measurement of effect of the steel bar on the induced magnetic field of the search probe. The covermeter probe is passed over the surface of the concrete and the depth of the of the cover to the reinforcement is determined by the strength of the reflection of the electrical, magnetic field induced. The instrument is quite accurate giving results to within ± 1mm.

Carbonation

Normal fresh Portland cement concrete has a pH of at least 12.5, principally caused by the large presence of hydroxyl ions (OH-) in the cement gel. This creates a passive and protective oxide layer on the surface of any embedded reinforcing steel. There exists capillaries and pores even in the most dense concrete. These in time allow the diffusion of carbon dioxide and water through the concrete mass. The carbon dioxide will react with the concrete hydroxyl ions $Ca(OH)_2$ chemically, reducing the hydroxyl ion concentration and accordingly the pH of the concrete.

In the reaction

$$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$$

The pH reduces

$$pH\ 12.5 \sim 13.5 \rightarrow pH < 10$$

While the carbonation process does not affect the concrete strength unduly, in fact it usually increases the strength. As the pH falls the reinforcing steel loses its protection against corrosion. In a pH environment of pH10 or less the steel, in the presence of oxygen and moisture will likely corrode.
To test for carbonation either cores are taken from the concrete or small drill holes are made testing the drill tailings as the drill penetrates the concrete. The concrete core or tailings are tested with a pH indicator phenophalein. The indicator is designed to turn pink in Ph values less than 10.

Chloride Concentration Testing

The passive oxide film, which is formed on the reinforcing steel due to the alkalinity of the concrete and which prevents the initiation of corrosion is destroyed in the presence of a sufficient concentration of free chloride ions. The mechanism is beyond the scope of this report, but empirical testing has shown that for a standard OPC concrete sample a 0.4% of total acid soluble chlorides by weight of cement, is the safe upper limit.

The following generalisations can be adopted for the probability of corrosion of the embedded reinforcement.

0.3 - 0.4 %	Corrosion improbable
0.4 - 1.0 %	Corrosion probable
1.0% and greater	significant corrosion likely

The causes of chloride contamination can include

i) Diffusion from salt spray as in marine conditions
ii) Use of chloride contaminated water or aggregate
iii) Admixtures such as calcium chloride, $CaCL_2$
iv) Use of chemicals containing chlorides

The presence of carbonation increases the amount of chloride ions available for the depassivation of the steel.

Half Cell Tests

This is quite a simple NDT test, where the negative voltage is measured from corroding reinforcement.
The Half cell potential testing technique was developed by the US Corps of Engineers and is an empirical test to measure the voltage produced when reinforcement is corroding. The test is carried out to ASTM C876-1980 specification and uses a calibrated reference half cell [copper/copper sulphate]. The test is based on the principle that corroding reinforcement produces a negative DC electrical current of approximately 0.5 volt. The US Corps of Engineers set empirical limits for the test as follows:-

- More negative result than 0.35 volts , 90% probability of reinforcement corrosion.
- Between negative 0.25 & 0.35 volts, potential for corrosion of the reinforcement in the presence of water and oxygen.
- More positive than 0.25 volts, no corrosion and potential for corrosion negligible.
- More importantly, the ASTM standard states “ that should there be a negative shift greater than 0.1 volt between two adjacent points, this indicates the formation of potential corrosion cells.

MOD-SHOCK™.

This is an exclusive system developed by Integrity Testing Pty. Ltd. used to determine the adequacy and load capacity of the foundations. The results will also be used to determine the structural adequacy of the piers and abutments, both for the integrity as well as the stiffness of the elements.
Piers and piles will be tested, using both horizontal and vertical tests where applicable. The tests not only giving the integrity of the elements but also used to determine the structural stiffness of the piers. The full details regarding the Mod-Shock™ test can be obtained from the website Papers

Cement Content and UPV tests.

The cement content of the concrete can be determined by Chemical analysis, using the test procedures from S & H COO2 procedures, related to tests from B.S.1881, 1988. The object of the tests to determine the amount of cement that was used in the concrete, this being important for durability factors and also for "E" values used in the calculation formulae for load capacities. In conjunction with these tests we also use Ultrasonic Pulse Velocity Tests [UPV] to determine the approximate strength of the concrete in terms of MPA. The test is relatively simple in that it measures the time an ultrasonic pulse takes to travel through the concrete and by empirical means this can be correlated to give an approximation of the strength of the concrete in terms of MPA.

DBTS™.

This is a development of Integrity Testing Pty. Ltd., whereby with the use of multi-transponders placed on the bridge deck, the behavior of the bridge under loading can be studied. This refined behavior linked to a number of measured properties of the bridge from the test enables a finely tuned model of the bridge to be produced. This model being sufficiently accurate to generally determine SAFE loading capacity to better than 10%, when correlated against traditional dead weight tests and actual failure tests in closely controlled trials. For the tests, the transducers can be placed in a number of configurations, to determine torsional mode shapes, should they exist. The bridge is then tested and the measured the responses are recorded, both in an unloaded situation as well as under dynamic loading from a known truck weight.
The full details regarding the DBTS™ can be obtained from the website Papers.

Application of Tests.

As previously described the tests are used to determine the following criteria: -

- Reasons for deterioration of the existing structure.
- Durability and life expectancy of materials.
- Integrity and load capacity of foundations and piers
- Load capacity and SAFE working loads of the bridge.
- To determine a remedial strategy for the bridge.