FERROCEMENT STRUCTURES: CONSTITUTIVE RELATIONS, NON-LINEAR FINITE ELEMENT ANALYSIS, AND ANALOGY WITH REINFORCED CONCRETE

Ganga Kasi Viswanadha Prakhya

Abstract

This dissertation studies some aspects of the behaviour of structures made of ferrocement mortar in thin panels reinforced with many layers of galvanised steel mesh, as widely used in many parts of the world in recent years. Techniques and concepts from the theory of the more familiar reinforced concrete structures are transferred to ferrocement where possible.

The stiffening effect of material between cracks has long been recognised to influence the behaviour of reinforced concrete elements, but is still in the early stages of investigation for ferrocement. There has been great interest in recent years on different models of tension stiffening in reinforced concrete, ranging from development of simple empirical formulae to incorporation in powerful numerical techniques such as finite element analysis. This dissertation extends such work to ferrocement.

A critical reanalysis of past experimental results on direct tension and flexure of reinforced concrete has been carried out to derive a non-dimensional parameter β_t that defines the shape of the non-linear descending branch of the effective stress-strain curve of the concrete component in tension. The value of β_t depends on tension zone parameters only. Incorporating this curve, firstly, a *two-zone* model presented that provides analysts with a simple and effective tool to predict the moment-curvature relations and the mean steel level strains of reinforced concrete elements. Secondly, it is shown that the β_t-curve is effective, versatile and easy to implement in the finite element code.

Experiments carried out on ferrocement elements with bundled arrangement of reinforcement in uniaxial bending are described in detail. The primary variable is the angle of all the reinforcing mesh layers with the principal bending direction. This systematic study is apparently the first if its kind. Based on the test results, a simple equation is derived to evaluate the mean steel level strains in flexural members, which can be used in estimating crack widths in the serviceability range of loads. Emphasis is placed on various constitutive relationships. The applicability of the β_t-curve has been experimentally verified for these ferrocement elements.

Further progress is made to make use of the β_t-curve in the non-linear finite element analysis of both reinforced concrete and ferrocement elements. However, in the view of the rapid development and increasing numerical problems encountered in this field, it is decided to restrict to a relatively uncomplicated plane stress layering technique with a load control method. The main additional features of the program include material and geometric non-linearity, smeared cracking and use of fixed crack model. A degenerated eight nodded element with frontal storage scheme is implemented.

Examples of analysis both from the *two-zone* model and the finite element program are presented. Comparison of the test results with those reported from other sources shows satisfactory agreement. In addition to beams and slabs, the capability of the computer program is also verified against some past experimental results on reinforced shells of *micro-concrete* effectively another form of ferrocement.