Creep behaviour of reinforced concrete beams strengthened with composite plates

Mickaël MULLER, Evelyne TOUSSAINT, Jean-François DESTREBECQ and Michel GREDIAC

Laboratoire d'Etudes et de Recherches en Mécanique des structures
Université Blaise Pascal Clermont II 24, avenue des Landais BP 206
63174 Aubière Cedex, France
mickael_muller@hotmail.com

Civil concrete structures are generally designed to sustain service life ranging between 50 and 100 years. The longevity depends on constitution of structures and type of loading. Several parameters may reduce this life span like new service conditions, creep, environmental or fatigue effects. Some economical reasons do not always allow the destruction and the construction of a new structure to replace a damaged one. In order to fulfil new service conditions and/or to reduce time effects, a solution consists in adding an externally bonded composite material. This additional material relieves stresses in the concrete member. This solution has been used for some years in North America and Japan but its development is rather recent in Europe.

Stresses and strains analysis of viscoelastic phenomena can be taken into account in the design of modern structures. Actual materials (such as concrete, glue, …) exhibit indeed behaviours which evolve during time : creep/relaxation, retreat, ageing. These differed properties generate stress and displacement evolution as well as strain redistribution. These effects can be cause of structural disorders [1].

The objective of this study is to assess the effect of time on reinforced concrete structures strengthened with composite plates. An analytical model is developped to predict the behaviour of reinforced concrete structures strengthened with composites. Constitutive equations of the different materials are modelled with an incremental analysis of the theory of linear viscoelasticity [2]. Only concrete is considered as viscoelastic in the present approach. Indeed, the stiffness on the glue is much lower than the stiffness of the concrete and it has been checked that its influence on the viscoelatic response on the beam is negligible. The incremental analysis is based on the decomposition of Dirichlet series of the relaxation function. Thus it is not necessary to store the stress history in the computer. Moreover, the problem can be modelled with global variables within the theory of beams. Another advantage of this approach is that it is well suited to phasing.

Different specimens have been tested under three point bending to validate the model : reinforced concrete specimen, strengthened reinforced concrete specimen, pre-cracked and strengthened reinforced concrete specimen, reinforced concrete specimen

strengthened three months after the first test of relaxation. Such tests lead to similar loading conditions as those of actual structures of civil engineering. The displacement at the center is imposed by a jack to obtain an initial loading leading to compressive stresses equal to 40% of the compressive strength of the concrete. A sensor records the load which can therefore be plotted vs. time. The experimental setup is shown in Figure 1.

The first relaxation test on reinforced concrete specimen allows the determination of parameters used for the incremental analysis. Results obtained on heterogeneous beams are compared with those provided by the model. As an example, Figure 2 compares experimental results obtained on the pre-cracked and strengthened reinforced concrete specimen with results provided by the model. Several load cycles have been applied to the specimen in order to take into account a possible phasing. As a conclusion of this example, incremental formulation gives a rather good estimation of the evolution of the load vs. time.

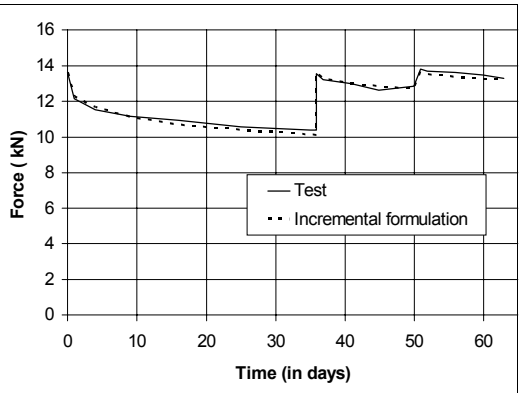

Figure 1. Layout of the test

Figure 2 : Comparison between theory and experiment

The paper will present the incremental analysis used for modelling the problem. Results obtained with the different tests will be discussed and compared with numerical results provided by the numerical model.

[1] Plevris N. And Triantafillou T.C. : Time-dependent behavior of rc members strengthened with frp laminates. *Journal of structural engineering*, vol. 120, n° 3, p. 1016-1043, 1994

[2] Jurkiewiez B., Destrebecq J.F., Vergne A. : Incremental analysis of time-depend effects in composite structures. *Computers and Structure*, vol 73., n° 1, p. 425-435, 1999.