Analysis and Repair of Damages in Precast Reinforced Concrete Panels

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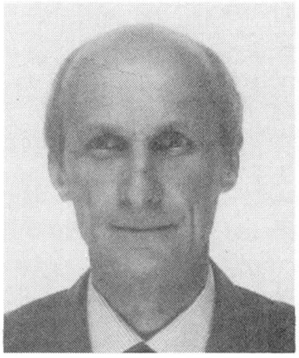

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Summary

The long-term viscoelastic analysis of exterior precast concrete panels subjected to shrinkage and temperature induced strains is discussed. The exterior stratum of the panels is assumed viscoelastically restrained and a general approach for sectional and structural analysis is developed. The obtained results point out that cracking limit state can be attained with great probability so that repairing works often become necessary. The basic aspects of the service behaviour of these particular structures, discussed in a worked example, allow to feasibly define the prerequisites of the rehabilitation works.

Keywords: Shrinkage, temperature, creep, panels, thermal strain, tensile strength.

1. Introduction

A great number of precast buildings with structural arrangements consisting of R.C. bearing panels has been erected in Eastern Europe in the years 1960-1980. These buildings have been subjected to various degrading phenomena, especially regarding the exterior walls for which panels consisting of an internal bearing stratum and of an external thin one have been employed. The restraint degree between these two parts varies in a quite general way, so we can observe panels with the two parts free to exhibit relative displacements or panels for which relative movements are partially or rigidly prevented. Three typical connections illustrating these concepts are shown in Fig. 1. As a consequence of the restraining degree a marked statical interaction between the two strata can arise when imposed deformations are present. This can produce cracking phenomena to which a reduction of the structural life-time is related.
The rehabilitation of precast exterior walls requires to repair cracks and to reduce the intensity of the imposed deformations, in particular the ones due to temperature variation. In fact, owing to the significant age of the panels shrinkage has nearly reached its asymptotical value so no further increments of this imposed deformation have to be expected in the repaired structures. An efficient and economical rehabilitation technique consists in injecting the cracks by means of epoxy resin and in applying on the exterior surface an insulation stratum in order to reduce the temperature effects. The design of these repairing devices requires a reliable analysis of the state of stress produced in the external stratum of the wall by time variable imposed deformations, taking into account their interaction with concrete creep. This in order to correctly evaluate the final tensile stresses in concrete and to reliably proceed in assessing structural safety for cracking limit state.

2. Long-term stress analysis of precast exterior walls

Referring to Fig. 2, the external stratum of a precast exterior wall can be represented by a beam element viscoelastically restrained at its end and subjected to the imposed deformations due to shrinkage and temperature. According to Fig. 3, we assume that the shrinkage deformation $\bar{\varepsilon}_1$ is uniformly distributed along the depth of the stratum while temperature can be considered to be distributed according to a parabola with extreme values $\bar{\varepsilon}_2$, $\bar{\varepsilon}_3$.
The time variation of shrinkage is monotonically increasing while for temperature we can assume a time sinusoidal distribution with period θ=1 year. In this way we can subdivide the imposed deformations into three partial deformations, namely : a constant deformation $\bar{\varepsilon}_1$ monotonically increasing in time produced by shrinkage ; a constant deformation $\bar{\varepsilon}_2$ and a parabolic deformation $\bar{\varepsilon}_3 - \bar{\varepsilon}_2$ due to temperature with a time sinusoidal distribution. The deformations $\bar{\varepsilon}_1$, $\bar{\varepsilon}_2$ do not produce sectional stresses as they are distributed according to the Bernoulli-Navier hypothesis. The stresses connected to them are only the ones produced by the end restraints. On the contrary the deformation $\bar{\varepsilon}_3 - \bar{\varepsilon}_2$ generates sectional stresses which have to be added to the ones produced by external restraints. In Fig.4 the developing in time of the total stress at the superior edge of the section, calculated according to a viscoelastic analysis is reported. Creep reduces the stresses which lie at the interior of the two extreme lines 1-2 respectively depending on the surrounding temperature existing when the wall was erected. In particular to a high surrounding temperature only a wall shortening in time can be consequent so that temperature effects will have the same sign of the ones due to shrinkage, represented by line 3, and the total tensile stresses reach their maximum value (line 1 of Fig. 4). On the contrary a low surrounding temperature forces the wall only to increase its length consequently the total stress is minimized (line 2 of Fig. 4). For an intermediate temperature of erection the total stress varies according to line 4. After injecting the cracks only temperature effects produce tensile stresses in concrete as shrinkage deformations can be assumed totally exhausted. In this way indicating by f_{ctm} the mean strength of concrete and by $\sigma_{ct}(\bar{\varepsilon}_2, \bar{\varepsilon}_3)$ the tensile stress produced by temperature, the cracking limit state can be assessed imposing that $f_{ctm} \geq \sigma_{ct}$. As σ_{ct} depends linearly on $\bar{\varepsilon}_2$, $\bar{\varepsilon}_3$ the preceding inequality enables us to define the maximum temperature strain compatible with an uncracked state of the panel and the prerequisites of the insulating stratum which has to be placed on the external surface of the panel.

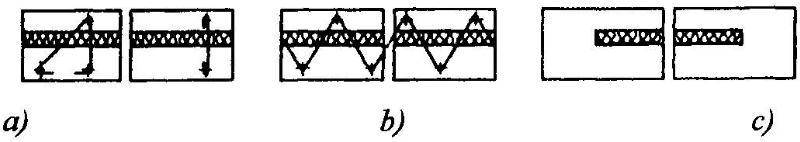

Fig. 1 Types of restraint : a) free b) partial c) rigid

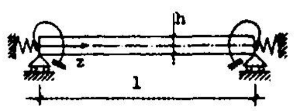

Fig. 2 Structural scheme of the external stratum

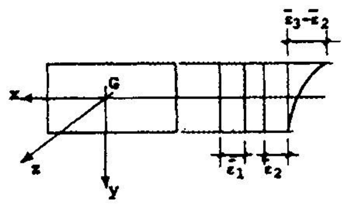

Fig. 3 Strain distribution

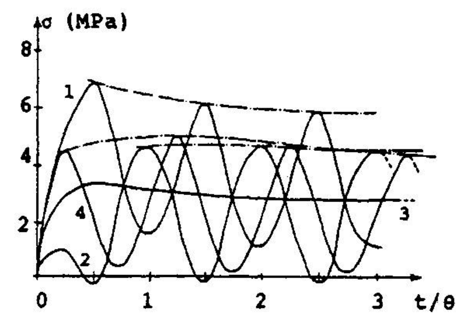

Fig.4 Total stress diagram