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Basis for selection of PC and PCC for concrete repair

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Synopsis A classification of concrete polymer composites is presented, which takes into account the influence of the solid phases, as well as the composite interaction with a fluid phase, which in the limit will be the ambient environment. The classification is based on a structural model, enabling the qualification and quantification of material properties.

A brief overview of damage and causes of damage to concrete and concrete structures is given. A study of damage and damage causes reveals the requirements, which the repair materials have to comply. The comparison of both requirements and structural material properties enable the proper choice of the repair material, or indicate the way to proceed in developing repair materials for specific repair jobs.

Keywords Concrete polymer composites, resin concretes, polymer modified concretes, repairs, rheological models, concrete damage, material classification, maintenance, mechanical properties.

INTRODUCTION

The repair and maintenance of concrete and reinforced concrete has been approached by civil engineers until now in a phenomenological way. Starting from the repair requirements and the given repair product, they looked for the best design and execution procedure to achieve the highest performance of the repaired concrete composite material. In doing so, the engineer could limit his considerations to well understood mechanical and physical actions and behaviour. However, experience gained in one application was not transferable to other areas. Therefore the authors propose a general framework, in which every aspect of scientific research and practical experience would be put in as a positive feedback for product development and evolution. The basic idea is that every application requires material properties, which can be derived from the material structure. The modelling of material structure can explain material mechanical and physical behaviour, and can show the way for exploiting the synergetic capacities of composite materials.

A general classification of composite materials is presented, based on a model, developed earlier [1, 2]. It is built up with four components, i.e. matrix, dispersed solid phase, dispersed fluid phase and externally introduced phase. Polymer concrete and polymer cement concrete are placed in the classification. The advantage of the classification is its ability to indicate material properties. This will be explained with respect to concrete repair materials.

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CLASSIFICATION OF CONCRETE POLYMER COMPOSITES (CPC)

The most decisive criteria for the behaviour of materials are the 'structurality' of the system ('superstructurality') and the 'inner specific surface'.

'Superstructurality' describes whether the dispersed phase is segregated in the dispersing phase without mutual force contact, or whether it is aggregated and capable of transferring a force flow directly from one particle to another, even across an intermediate layer of the matrix. It also describes the quantity and type of the fluid phase (gas, liquid) and its degree of continuity with the ambient environment.

The second important criterion is the existence of discernible boundaries of phases or the inner specific surface. It determines the magnitude and the quality of the interface between phases. Both superstructurality and inner surface may interact to improve material properties. For example, in a continuous porous polymer concrete, a second system can be introduced in the pore system by impregnation. In the PIPC material so obtained, two interspersed bearing structures are active, creating a deformation and failure system which is capable of absorbing a great supplementary quantity of energy in the additional material interfaces.

Both 'superstructurality' and internal specific surface are described by the classification of Figure 1.

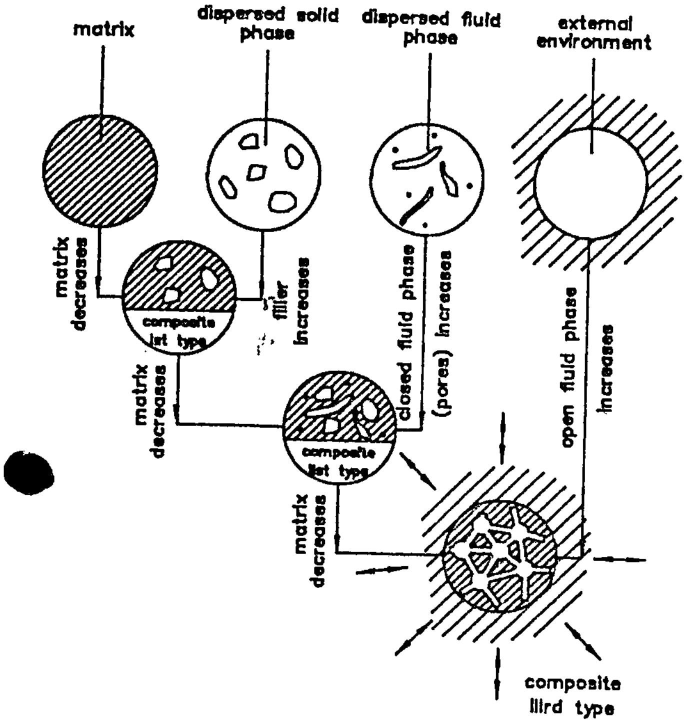

Figure 1 Basic classification of structural composites

A more detailed classification, derived from Figure 1, is given in Figure 2.

In Type I composites the solids fill the whole volume. They range from pure matrix systems as a first boundary system, to aggregated systems as a second boundary system.

In Type II composites the dispersed phase remains aggregated, but the matrix is partly replaced by closed pores. Theoretically, type II composites end if the pore system becomes continuous, connecting the system with ambient environment (third boundary system).

Type III composites are characterised by the continuous pore system, enabling composite interaction with ambient environment. The limit system is reached when the matrix looses its continuity (fourth boundary system).

In Type IV composites the material becomes loose, without any matrix binder (fifth boundary system).

CONCRETE DAMAGE

Concrete damage can be classified into four main types, according to its appearance.

Type I – damage to concrete skin or concrete cover. The damage can be a continuous corrosion by water, acids or frost action. The concrete skin can be cracked or desintegrated by bad placing or faulty design.

Type II – corrosion of reinforcements by carbonation, chloride attack, insufficient cover.

Type III – insufficient quality of concrete cross section, by local loss of material strength or stiffness.

Type IV – excessive deflections of concrete structural members.

After detection, the importance of concrete damage must be evaluated, in order to determine the necessary actions to be taken: replacing, repair, strengthening, or protection. In the evaluation the damages are put in one of the following categories:

Category I – loss of safety against collapse
Category II – loss of durability
Category III – damage to exterior appearance
Category IV – effect of damage of small importance.

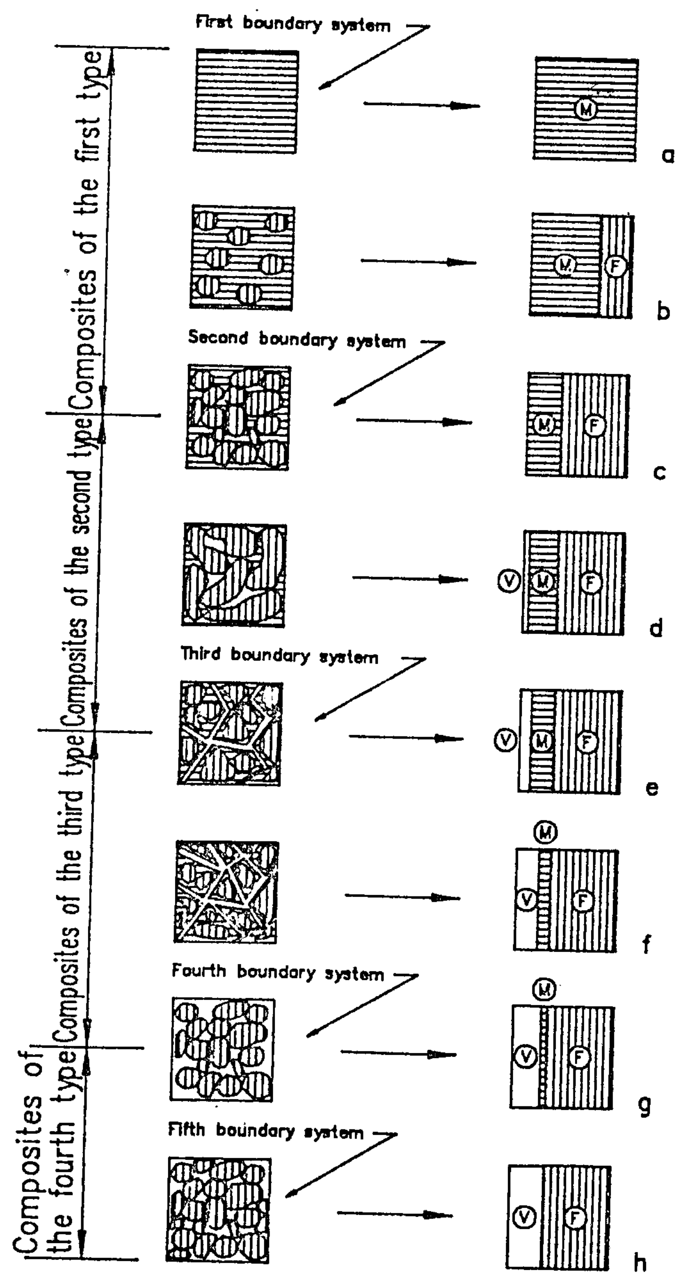

Figure 2 Detailed classification of structural composites

A majority of concrete damages will be classified in the categories I to III, and will call for action. Except for replacing, polymer concrete and polymer cement concrete materials are widely used for repair, strengthening and protection. The requirements of the repair material depend on the constructional purpose: must the repair material contribute to the strength and stiffness of the repaired element or not?

If the repair material does not contribute to strength and stiffness, the following requirements must be fulfilled:

- the repair material must resist the chemical action of the concrete and the influence of humidity in the concrete
- the repair material and the concrete must have similar thermal and diffusion properties, to avoid thermal stresses and vapour pressures
- the adhesion between repair material and concrete must be sufficient.

Comparing these requirements with the scheme of Figure 2, the following are needed:

- matrix material for bonding strength
- continuous pores if vapour pressures can arise
- closed pores or semi-permeable pores if corrosion protection is needed
- filler to adapt thermal properties.

These requirements can be fulfilled if the material structure is of type c to f in Figure 2. The proper choice is further determined by specific requirements and cost considerations.

If the repair material has to contribute to strength and stiffness of the concrete element, it is further needed that:

- the strength and deformability of the repair material are of the same magnitude as those of concrete
- a high modulus of elasticity is needed
- creep must be limited
- bond strength must reach at least cohesion strength of concrete.

The structure of the repair material will have to be of types c to e. The proper type of matrix and filler will be determined by specific magnitudes of requirements.

CONCLUSIONS

Based on an adequate model of structural behaviour a classification of materials can be set up. The concrete repair materials PC and PCC are introduced in the classification. The classification acts as an interpreter between producers of materials, who are well aware of internal structure of phases (infrastructure), and users of materials, who are engineers, well aware of the mechanical and physical behaviour of materials, determined by the superstructure.

If both producers and users agree about this common classification of materials, it will help both parties involved in concrete repair to take advantage of mutual experiences, and it will give a new dimension to the world of cement polymer composites.

The RILEM Committee TC No 105 CPC is working on a materials coding system, from which the above mentioned characteristics can be derived directly.

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