Oryginalny artykuł naukowy

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Quantitative approaches to concrete repair compatibility

Indeks kompatybilności – nowe ilościowe podejście kompatybilności napraw betonu

DOI: 10.15199/33.2017.06.21

Abstract. The compatibility concept, which started developing in the early nineties, is now widely considered as a fundamental basis of the concrete repair design process. The main challenges to be faced in view of fully implementing the approach in engineering practice lies in evaluating quantitatively the various compatibility requirements. In this paper, analytical and modeling tools are considered for the evaluation of dimensional compatibility. The ability of these tools to take into account the combination of variables such as the exposure conditions is shown through a few examples.
Keywords: compatibility, compatibility index, concrete, cracking, dimensional compatibility, durability, ring test.

Streszczenie. Koncepcja kompatybilności została sformułowana w latach 90. i jest powszechnie uważana za podstawową zasadę napraw betonu. Jednym z największych wyzwań dotyczących pełnego wdrożenia tego podejścia do praktyki inżynierskiej jest możliwość ilościowej oceny różnych typów kompatybilności. W artykule zaprezentowano dwa podejścia do ilościowego charakteryzowania kompatybilności napraw. Na kilku przykładach przedstawiono możliwość ich wykorzystania w analizie wpływu kombinacji różnych warunków podczas stosowania wyrobów i użytkowania obiektu na kompatybilność.
Słowa kluczowe: kompatybilność, indeks kompatybilności, beton, zarysowanie, kompatybilność wymiarowa, trwałość, ring test.

The aim of concrete repairs is to extend the useful service life of an existing structure, to restore its load-carrying capacity and stiffness, and/or to strengthen its members [3]. The requirement for compatibility between the existing concrete and the repair material has been addressed conceptually by various authors since the early nineties [1 ÷ 6]. Guidance on the approach can now be found in reference documents such as EN 1504, ACI 562, and report MERL-2014-87 issued by USBR [8]. The level of compatibility will generally determine whether a repair project is a success or a failure, and whether a repaired structure is durable.

One of the main challenges to be faced now lies in evaluating quantitatively compatibility and determining what it requires under given circumstances (characteristics of the structure to be repaired and the environment). For the compatibility approach to be fully implemented in repair engineering design, adequatee characterization tests and design tools for concrete repair are needed. In the present paper, two approaches for quantitative evaluation of dimensional compatibility of repairs are presented.

Compatibility index evaluation based on the restrained--shrinkage ring test

Restrained-shrinkage ring test. This paper presents the results of the large project on the quantitative relationship between the individual dimensional compatibility-related properties (notably elastic properties, creep, drying shrinkage) and the corresponding stress and strain values recorded in an annular restrained shrinkage test, commonly referred to as the ring test (Figure 1).

While the actual deformation and stress gradients across the thickness of the specimens are considered in the calculations, the analysis of the results is based on the average stresses. The evolution of the average shrinkage-induced stress ($\sigma_{c\,avg.}$) over time can be calculated with equation 1, where ε_{fs} is the concrete free shrinkage, E_c and E_s are the elastic moduli of concrete and steel, ϕ_c is the creep coefficient of concrete, v_c and v_s are the Poisson's ratios of concrete and steel, and a, b, and c, are the internal, interfacial and external radii of the composite steel-concrete ring specimen:

$$\sigma_{c\,avg.}(t) = \frac{b(b+c)}{c^2-b^2} \frac{\varepsilon_{fs}(t)}{\left[\frac{1}{E_s}\left(\frac{b^2+a^2}{b^2-a^2}+v_s\right)+\frac{1+\phi_c(t)}{E_c(t)}\left(\frac{b^2+c^2}{c^2-b^2}-v_c\right)\right]} \quad (1)$$

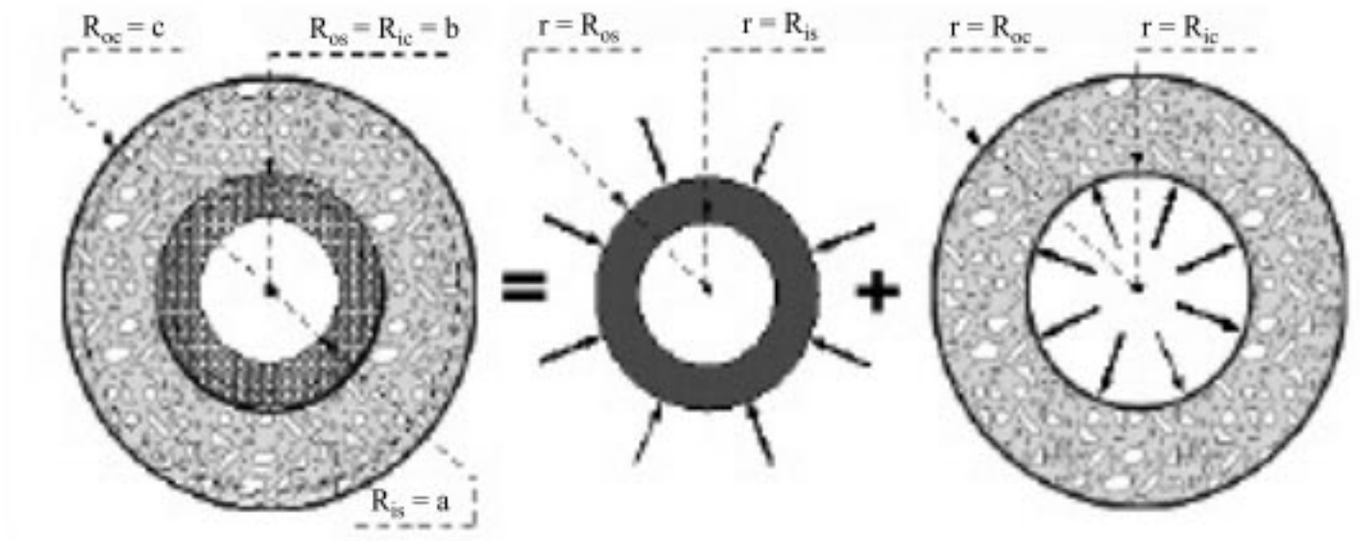

Fig. 1. Basic analysis of the restrained shrinkage test specimen (mechanical equilibrium) and geometrical parameters
Rys. 1. Podstawy analizy skurczu mieszanki (równowaga mechaniczna) w teście pierścieniowym i parametrów geometrycznych próbki

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