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Tentative Characterization of Old Structural Concrete through Mechanical Fracture Parameters

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Abstract

Structural concrete of the building of Vítkovice railway station from 1970s is characterized via mechanical fracture parameters. In this paper, six core-drilled cylindrical specimens with diameter of 75 mm were provided by a Chevron type notch of depth of 12 mm. Three-point bending fracture tests were conducted on these specimens supported as beams with the span of 170 mm. Load vs. deflection and load vs. crack mouth opening displacement diagrams were recorded from which modulus of elasticity (E), fracture toughness (K_{Ic}) and fracture energy (G_F) were determined using linear elastic fracture mechanics approach and work-of-fracture method. Mean values of these parameters (with their coefficient of variability) were obtained as follows: E = 39.4 GPa (29.1 %), K_{Ic} = 0.90 MPa·m$^{1/2}$ (18.5 %), G_F = 174.0 J/m^2 (26.0 %). These parameters can serve as first guess or indicative values for structural assessment and life-time predictions.

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Keywords: Structural concrete; core-drilled samples; cylindrical specimen; Chevron notch; fracture test; mechanical fracture parameter.

1. Introduction

Among the most frequently used building materials one can primarily name silicate-based, particularly cement-based composites [1]. Thanks to their character and to the production technology, these materials are very adaptable and utilizable for a wide range of applications. Thus, from the perspective of the modern construction concepts of the last almost two centuries, concrete can be definitely regarded as a traditional material. Many reinforced concrete buildings are, therefore, already designated as cultural monuments, several ones also in the Czech Republic. Within

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the project “Analysis and presentation of the values of modern architecture of the 1960s and 1970s as part of the national and cultural identity of the Czech Republic” a particular attention is paid to diagnostics of selected reinforced concrete structures and heritage procedures for restoration of building cores. In this paper, structural concrete of the building of Vítkovice railway station from 1970s is characterized using standard fracture test and described via parameters of selected relevant fracture-mechanical models. These parameters are important indicators of the material behaviour, although common contemporary engineering practise is usually limited to elastic and strength characteristics only which can be derived from ‘simple’ compressive tests. However, the material brittleness vs. ductility can’t be expressed by these classical parameters and thus characteristics describing the resistance of the material against the crack propagation are becoming important for many types of analyses and assessments of the structures nowadays.

2. Specimens

Six cylindrical specimens were obtained as cores drilled out from the above mentioned building. These samples were geometrically adjusted to create regular beam-shaped specimens with circular cross-section and then provided by the Chevron type notch (see Fig. 1). Tab. 1 introduces specimen dimensions (according to the sketch in Fig. 2) used in further calculations. Note, this shape of specimen and notch type is typically used for determination of mechanical fracture properties of rocks [2–4].

Fig. 1. Specimens before (left) and after fracture test.

Table 1. Dimensions of tested specimens.

			Specimen ID					
	Symbol	Unit	V7	V9	V13	V15	V17	V18
Diameter	D	mm	74.09	74.16	74.97	75.05	74.99	74.68
Length	L	mm	215	237	211	224	196	194
Notch tip depth	a_0	mm	11.28	11.46	11.98	11.77	11.94	12.55
Notch depth	h_0	mm	18.54	18.59	19.00	19.30	18.90	19.12
Area of initially uncracked ligament	A_{lig}	mm^2	2742.99	2749.21	2791.35	2751.28	2806.55	2762.72

3. Fracture tests

The mechanical fracture parameters of concrete [5, 6] were determined from experiments on specimens in three-point bending test configurations. The scheme of the testing setup and pictures from the test are shown in Figs. 2 and 3, respectively. Specimens were loaded under displacement control; therefore, it was possible to record the load vs. displacement and also the load vs. crack mouth opening displacement curves (*F–d* and *F–CMOD* diagrams) during