

Influence of γ Irradiation on Concrete Strength

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Aging of concrete due to gamma irradiation. Strength of concrete are in a good correspondence with already known results.

Keywords: concrete, gamma irradiation, strength.

1 Introduction

Mechanical properties of concrete are changing in the course of its ageing. Ageing of concrete is accelerated by climatic conditions, mechanical stress, aggressive liquid, etc. This article deals with a question of irradiation influence, which arises, for example, as a consequence of uranium ^{238}U and ^{235}U fission reaction in the nuclear reactor. It concerns neutrons and gamma irradiation acting on concrete constructions and accelerating their surface and internal changes. The concrete in these facilities plays not only the structural role, but also the role of shielding material that has to absorb the aforementioned types of irradiation and prevents their penetration. Of the irradiation spectrum we will observe only influence of gamma irradiation. The gamma irradiation is being absorbed at the passage through concrete, what can induce water radiolysis [1] in the material and consequently chemical reactions leading to changes of the concrete phase composition [2] and thus the hydration degree decrease. We can expect that this hydration degree decrease becomes evident by the decrease of the concrete strength. This hypothesis is being proved in this article.

2 Concrete composition

Samples determined for testing were made according to the formulation, which is stated in Table 1 [3]. This formulation was used at construction of the containment of the nuclear power plant Temelín. Composition of cement CEM I 42,5 R Mokra is listed in [3]. Concrete beams, on which consequently the experiment took place, were made of this mixture. Volume mass of concrete 28 days old was $2358 \text{ kg} \times \text{m}^{-3}$.

Table 1: Composition of 1 m^3 of concrete

Component	Mass
Cement	499 kg [42,5R]
Water	215 kg
Plasticizer (Ligoplast SF)	2.8 kg
Aggregates:	
0–4 mm	705 kg
8–16 mm	450 kg
16–32 mm	527 kg

3 Method of irradiation

Irradiation was carried out in the company Bioster a.s. Veverska Bityska, where ^{60}Co is used as a gamma irradiation source. The activity of source ^{60}Co at the beginning of experiment was $A = 462 \text{ kCi}$ ($1.73 \times 10^{16} \text{ Bq}$) and at the end of experiment was 449 kCi ($1.68 \times 10^{16} \text{ Bq}$). These values were necessary for calculating of total radiation dose rate which was $0.935 \text{ kGy} \times \text{h}^{-1}$. Concrete beams at dimensions $0.4 \times 0.1 \times 0.1 \text{ m}$ after 90 days from concreting were used for the experiment. Each beam had gamma irradiation dosimeters fixed on it. Beams were irradiated for 90 days with a dosing input of approx. $0.25 \text{ kGy} \times \text{h}^{-1}$, i.e. the maximum dose was 0.5 MGy for the whole period of irradiation. The difference between radiation dose rates is caused due to items,

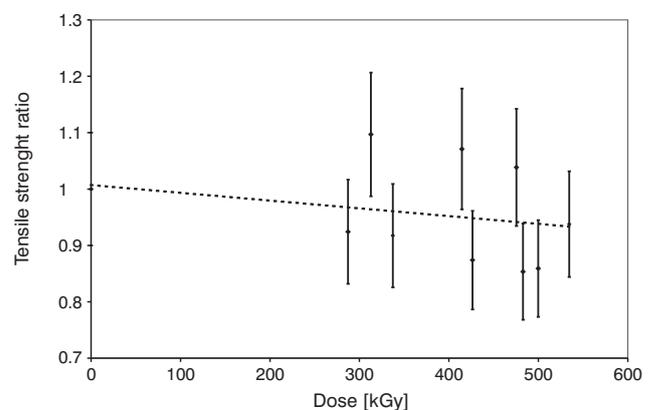


Fig. 1: Dependence of tensile strength ratio on dose

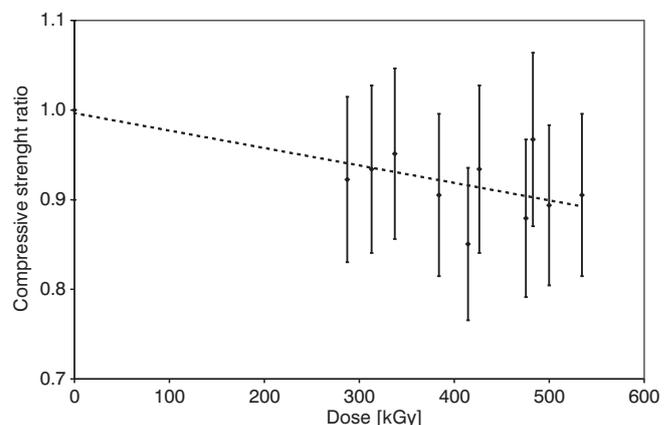


Fig. 2: Dependence of compressive tensile strength ratio on dose

which were placed between source of radiation and irradiated samples. Classical rectifying diodes calibrated by means of standard dosimeters were used as dosimeters [4], which error is about twenty per cent. Standard dosimeters are limited for higher doses of the gamma irradiation, therefore, the dosimeters, which we used, were calibrated for lower doses and consequently extrapolated for high irradiation doses.

4 Method of strength measurement

At first, the flexural strength test (three – point supporting) was applied to concrete samples. After this destructive test the compressive strength test was used on the first fragment (in accordance with ČSN 73 13 18) and the tensile strength test on the second fragment of splitting (in accordance with ČSN 73 13 17).

Conclusion

Measured values of concrete strength (Fig. 1, 2) are according to current measurements obtained by various experimentators viz [5].

Acknowledgments

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