

Investigation of Shielding Material in Radioactive Waste Management – 13009

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ABSTRACT

In this study, various waste packages have been prepared by using different materials. Experimental work has been performed on radiation shielding for gamma and neutron radiation. Various materials were evaluated (e.g. concrete, boron, etc.) related to different application areas in radioactive waste management. Effects of addition boric compound mixtures on shielding properties of concrete have been investigated for neutron radiation. The effect of the mixture addition on the shielding properties of concrete was investigated. The results show that negative effects of boric compounds on the strength of concrete decreasing by increasing boric amounts. Shielding efficiency of prepared mixture added concrete up to 80% better than ordinary concretes for neutron radiation. The attenuation was determined theoretically by calculation and practically by using neutron dose rate measurements. In addition of dose rate measurements, strength tests were applied on test shielding materials.

INTRODUCTION

In radiation protection point of view high ionizing radiation levels should be shielded according to radiation limits. Radiation shielding is required for safety handling of radioactive waste packages. Shielding materials are selected according to radiation types. Generally boron admixtures are used in cementation process for shielding of neutron radiation. For neutron shielding boron and boron compounds are used because of their high neutron absorption cross-section [1].

MATERIALS AND METHODS

Borax, also known as sodium borate, sodium tetraborate, or disodium tetraborate, is an important boron compound, a mineral, and a salt of boric acid. Borax has a wide variety of uses. neutron-capture shields for radioactive sources is one of the uses of boron compounds. Natural boron isotopes (Borax) were used for tests. These are B10 (19.8 %) and B11 (80.2 %). B10 boron isotope has 3870 barns absorption cross-section. For this reason B10 is generally used in nuclear industry to control nuclear reactions. Hydrated boron minerals have extra advantages because of the hydrogen content. Because hydrogen can slow-down the fast neutrons. The type and thickness of shielding material depend on the type of radiation, the activity of radiation source and the dose rate which is permissible for outside of the shielding material. Water cement ratio was taken as 55/100 by weight for concrete samples. Natural borax raw material was used as additives. Borax admixture amount for total weight was determined between range from 0 to 10

percentage of total weight of concrete. Mixture groups were defined in Table I. Five concrete slabs were prepared in 10x10x3 cm idimensions of each mixture groups. These samples were prepared and conserved at 24 °C during 21 days for curing. Two collimators were placed between the source and the detector to maintain stable measurements. Experimental setup is presented in Figure 1.

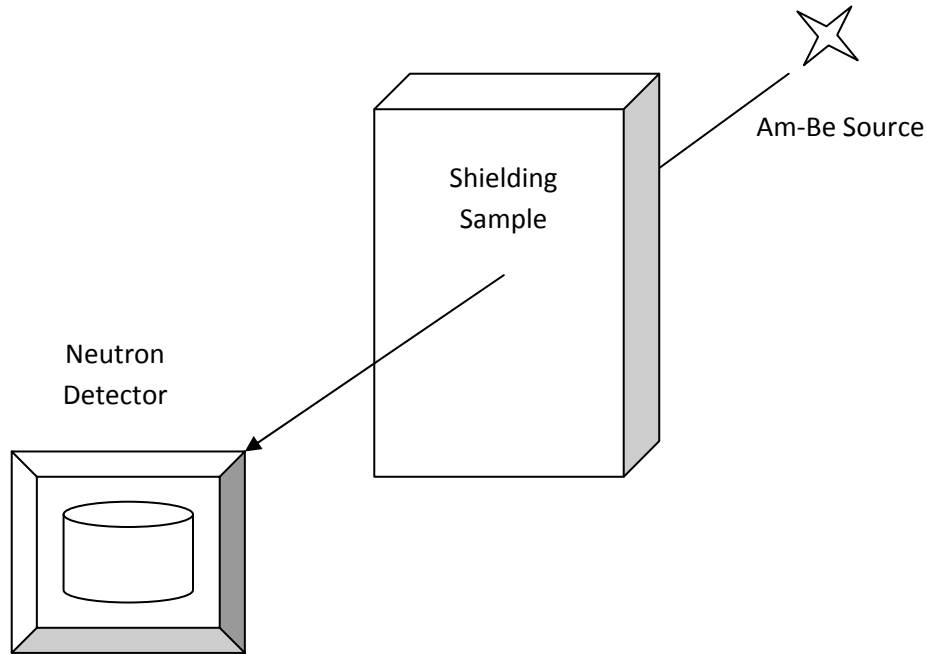


Fig. 1. Experimental setup for tests.

For neutrons, an Am–Be source irradiated the samples to obtain the fast removal cross section (ΣR). The neutrons were measured by a BF₃ detector and the Hp–Ge type detector was used for photons. After the readings were taken, the Beer–Lambert law was used for calculation.

$$I=I_0e^{-ax} \quad (\text{Eq. 1})$$

where x is the thickness of the slab in cm was used to calculate a in units of cm^{-1} where it represents the neutron removal cross section (ΣR) for neutrons and the linear attenuation coefficient (μ) for photons. The half value layer (HVL) and linear attenuation coefficients were calculated by using the following equation. $\text{HVL} = \ln 2 / \mu$ where μ is the linear attenuation coefficient. Am-Be neutron source was used for providing neutron radiation.

Concrete slabs were prepared at different amounts of boron admixtures. These are shown in Table I.

TABLE I. Concrete slab samples with boron admixture percentages.

Slab samples	A	B	C	D	E
Boron %	2	4	6	8	10

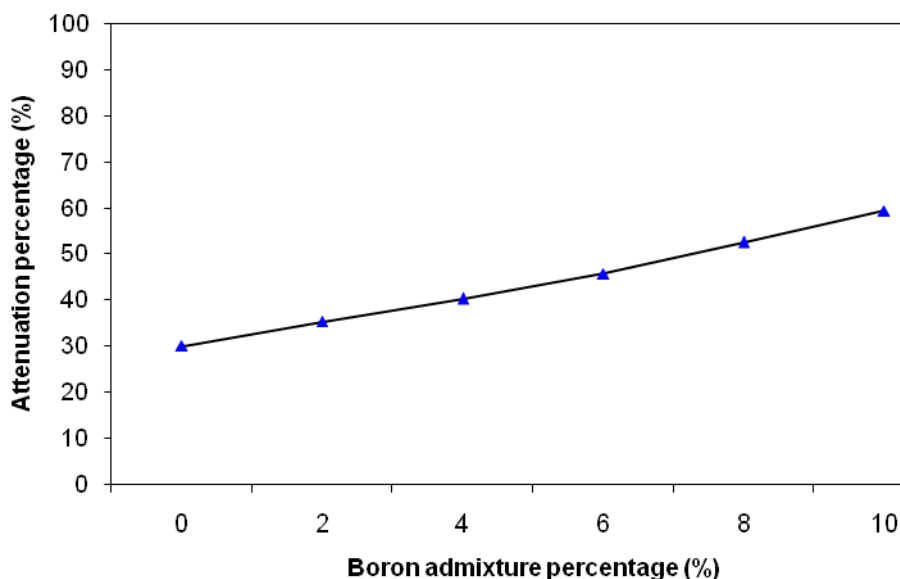


Fig. 2. Attenuation of neutron versus boron admixture in concrete.

The quality of concrete can be improved by using suitable materials and appropriate mix proportions. Parameters that affect the quality of concrete include: water to cementitious materials ratio, cementitious materials content, and size and grading of aggregates. Incorporating supplementary cementing materials, such as fly ash, blast furnace slag or boron as used in this study, can further decrease the strength of the concrete. As expected, the compressive strength of all concrete specimens increased with the period of curing and decreased as the boron ratio increased. As the percentage of boron in the mixture increased, the compressive strength decreased, an observation valid for white and grey portland cement. The results agree with those reported by other researchers [2, 3]. The results indicate that strength of shielding materials depend on the ratio of adding mixture. Strength of the shielding material decrease by increasing the ratio of adding mixture as shown in Figure 3.

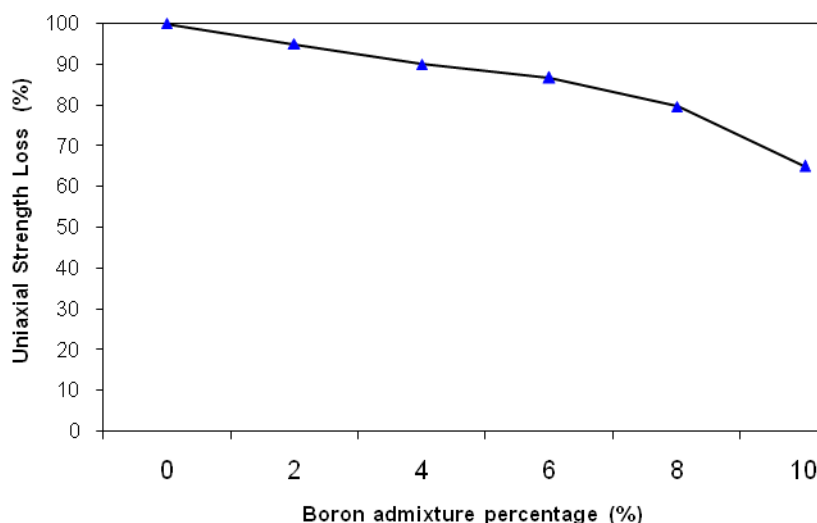


Fig. 3. Uniaxial strength loss of samples.

CONCLUSIONS

The experimental program was designed to evaluate the performance of five concrete slabs (at different amount of boron admixtures) in relation to neutron shielding properties. The following conclusions could be drawn based on the data developed in this study: By using the results of this study, up to 10 percentage of boron admixture provides better neutron shielding in concrete. But after 6% of admixture cause decrease in uniaxial strength of concrete. It means that concrete stability is going worse by adding more than 6 percentage of boron admixture. Optimum shielding material mixture is determined as 6% by weight boron adding of concrete weight. By this method shielding efficiency can be increased. In addition of the efficiency tests, there are other parameters for choice of shielding material such as their cost and weight should be taken into account.

REFERENCES

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