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EVALUATION OF X-RAY RADIATION SHIELDING OF CONCRETE WITH TWO POLYMERIC ADDITIVES

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Abstract: The safety factor is the most important point to consider when using medical radiology, as the walls of X-ray rooms must be immune to the radiation at a safe level. The insulations that are currently used in large rooms in the radiation is a lead substance and because of this substance of toxic effects on the human was only touch or inhalation of its evaporation.So Our research is aimed at reducing the amount of lead used by increasing the susceptibility of the concrete wall to insulate the radiation by addition of two types of polymers Rheobuild 833 and Rheomac uw450 to the standard M15Mix IS-10262 concrete mixture for the construction of insulating walls using molds metals with dimensions (20,20,10) cm, and in quantities of (100, 200, 300) mg and evaluated to determine their susceptibility to radiation capture. The best isolating was found at the addition of 200 mg, with an improvement rate of 29% for the Rheobuild 833 polymer and 23% for the Rheomac uw450 polymer.

Keywords: *X-Ray, Shielding, Concrete, Polymeric Additions*.

تقييم قابلية عزل الاشعة السينية للسمنت مع اضافة نوعين من البولمرات

الخلاصة: إن عامل الأمان هو اهم النقاط الواجب اخذها بنظر الاعتبار عند استخدام الاجهزة الطبية الاشعاعية، حيث ان جدران غرف الاشعة السينية لابد وان تكون عازلة للاشعة بدرجة امنة. ان العوازل المستخدمة حاليا بشكل كبير في غرف الاشعة هو مادة الرصاص ولما لهذه المادة من اثار سمية على الانسان سوى كانت باللمس او استنشاق ابخرتها.لذلك يهدف بحثنا هذا الى تقليل كمية الرصاص المستخدمة وذلك من خلال زيادة قابلية الجدار الكونكريتي لحجز الاشعة باضافة نوعين من البوليمرات وهي ,Rheobuild 833 Rheomac uw450 الى خلطة الكونكريت القياسية M15Mix IS-10262 المخصصة لبناء الجدران العازلة باستخدام قوالب معدنية بقياس (20، 20، 10) سم وبكميات 100، 200 ، 300 ، ملغم وتم تقييمها لتحديد قابليتها على حجز الاشعة، وقد وجد ان افضل عزل كان عند اضافة 200 ملغم حيث حققت نسبة تحسين 29% للبوليمر Rheobuild 833 ونسبة 23% للبوليمر Rheomac uw450

1. Introduction

Radiation shielding is one of the most important requirements that needed for wall building x-ray diagnostic rooms in different radio inspection fields. Where the x-ray radiation shielding needed often with the building materials. This kind of protection needed after shielding with a Pb layer. [1]

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Many researches have been done by many research groups increase the physical and mechanical properties of concrete walls where a polymeric material have been adding with a percent of 2%. It was found that if the percent of addition oxides this percent it will affect negatively on different properties of the concrete walls. [2-4]. The addition of such materials like Pb slag to concrete mixture will give the concrete good shielding. where it was indicated that by increasing the lead slag ratio in the concrete up to 30%; increases the attenuation of γ-radiation which in turn increases the linear attenuation coefficient (μ) and decrease the half value thickness ($X_{1/2}$) of the concrete. [5]

The addition of boron oxide has investigated after addition to concrete Portland cement. Modified Active Belite (BAB) shown a good effect by increasing the gamma radiation attitude with about 30% when added with a percent of 0.14%[6]. Further additions have investigated. Where, (5-30) % of iron slag and ball bearing balls have been substantial add to concrete and this addition lead to enhancement the bulk density and improvement in attenuation performance of the concrete walls by Substantial improvement of 20%–25%. [7].

More oxides have been adding to the mixture with 10% of SiO_2 fume mixed magnitude, goethite with 20% of fly ash and 30% of cores and find granules of furnace slag. It was indicated that the physio-mechanical properties were increased win the fine granules have been add [8]. The enhancement the shielding efficiency against g-rays for ^{137}Cs at photon energy of 0.662 MeVand for ^{60}Co at two photon energies of 1.173 and 1.333 MeV. Which indicated a slightly improvement between 3-7%. [8,9]

Furthermore, addition of barite will increase the attenuation coefficient of concrete [9]. From that it could be concluded that the addition of oxides and iron slag increased the physical properties in addition to radiation shielding. Mien while the addition of polymers increased the water absorption properties and some mechanical properties. the enhancement of radiation shielding for concrete will be studied after addition of two different polymeric materials which used in concrete construction.

2. Experimental work

2.1 Materials

The materials have been grouped into two groups according to the addition material and each group contain three samples each one with different addition amount. The main material is the concrete that composed from the standard concrete mixture according to M 15 Mix Designs as per IS-10262-2009 [10]. Where the Ratios of Concrete mix design (Portland Cement, Sand, Stone) is (1:3:6) with 300 liters of water. The stone that used in this mixture was fine granules with 20 mm size. The total quantities of mixture component were presented in Table (1)

Table (1) The Concrete mixture quantities

Material	Weight
Portland Cement	600 g
Smooth 20 mm stone	3600 g
Sand	1800 g
Water	300 g
The total weight	6300 gm

2.2 Additives

Two polymeric addition have been used. These materials were supplied by BASF Company. These materials are:

1- ***MasterMatrix UW 450*:** This material admixture meets the requirements of the U.S. Army Corps of Engineers CRD-C 661-06, Specification for Anti-Washout Admixtures for Concrete. *MasterMatrix* UW 450 admixture has little to no effect on concrete setting time at commonly used dosages of 260-780 ml /100 kg of cement. [10]
2- ***MasterRheobuild 833*:** this is a chloride free material. The material meets the standard ASTM C-494 Type B, D and G. The addition of this materials should not exceed the dosage limit in normal concrete, a dosage of between 800-200 ml/100 kg of cement. [11]

2.3 Samples Grouping

Both additions add with 100,200 and 300 mg to the concrete mixture and compared with two samples without additions. All sample were prepared the dimensions (20 x 20 x 10) cm. and then plated with 10 mm of Pb. The process of casting with the addition has been done manually, the samples used are small and have been used metal molds with a smooth surface, which gave a product with a smooth surface and we need only a simple cleaning process.

The installation of lead plates on concrete samples was done using adhesives, which are used extensively in laboratories, while the installation of such pieces in practice is done by bolts because the pieces are large and heavy compared to laboratory samples. All these experiments were done in the laboratories of Medical Engineering department, Mechanical and Electrical Engineering college, University of Damascus and cooperation from Assad University Hospital.

Figure (1) Samples testing

2.4 Methodology

The use of basic radiation to a mobile device and the test reagent Radiology behind the sample as shown in Figure (1) where the radiology meter that used is in these experiments. Where the x-ray source was a basic x-ray imaging device.

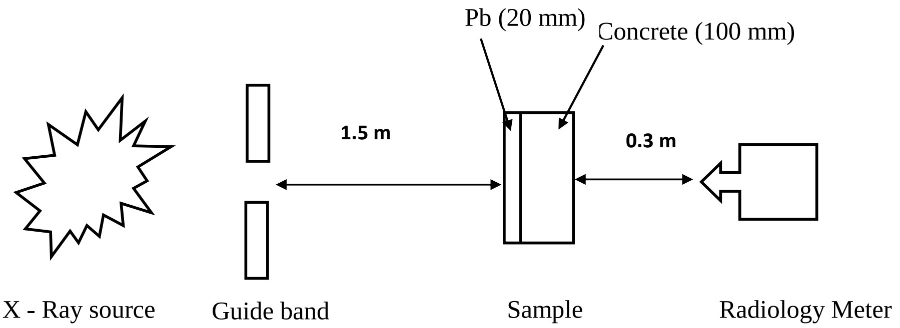

Figure (2) Test Diagram.

The radiation survey has been carried out to measure the radiation dose rate penetrated concrete samples for the range from 50KeV to 100KeV. The meter device was (OD-01) that designed by Step – Sensortechnik und Elektronik Pockau GmbH, Germany Shown in Figure (2).

Figure (3) STEP OD-01, OD-02 Survey Meters

3. Results and Discussion

Through the experiences we had got the multiple values showing the relationship between the value of the dose and the voltage behind the sample.
The tests result for testing the main mixture without addition and the three cases of addition of both types of polymers with 100, 200 and 300 mg of polymeric additions. The best insulation was obtained when adding 200 mg to Rheobuild 833 polymer

Table (2) Shielding Percent comparison between the two types of additions with the optimum shielding (200 mg added).

Voltage (Kv)	Without Addition	(Rheobuild 833) Addition		(Rheomac uw 450) Addition	
	Dose (μSv/h)	Dose (μSv/h)	Shielding %	Dose (μSv/h)	Shielding %
50	2.23	2.34	28%	3.11	25%
60	5.41	5.77	32%	7.93	27%
70	27.21	31.66	29%	38.42	18%
80	34.73	39.18	34%	52.83	26%
90	42.81	46.91	29%	60.54	23%
100	67.55	73.23	24%	88.71	17%
		Average	29%	Average	23%

Figures (4&5) illustrated the relationship between the voltage and dose for without and add of (100, 200, 300) mg polymers

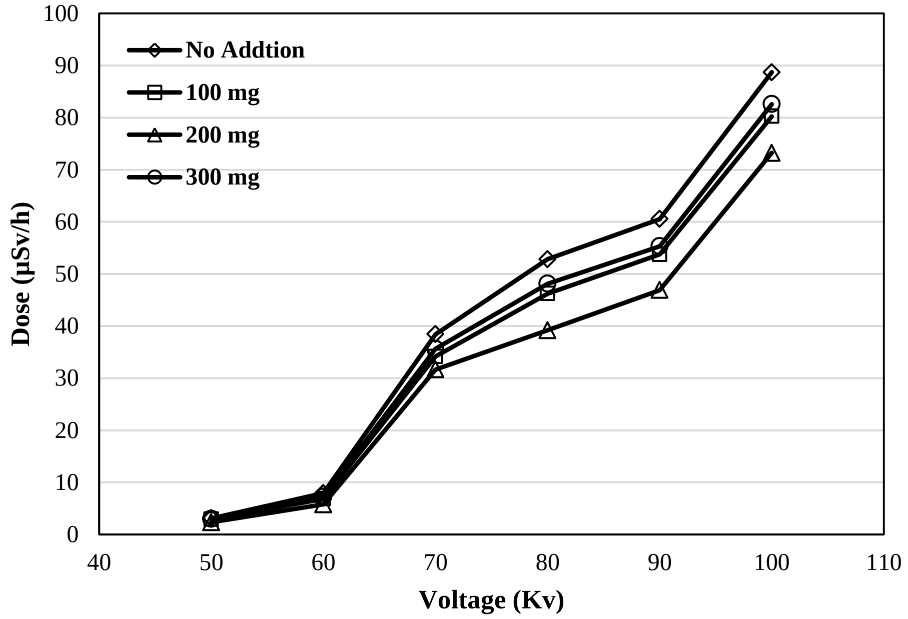

Figure (4) The relationship between the voltage and dose for (100-300) mg of Rheobuild 833

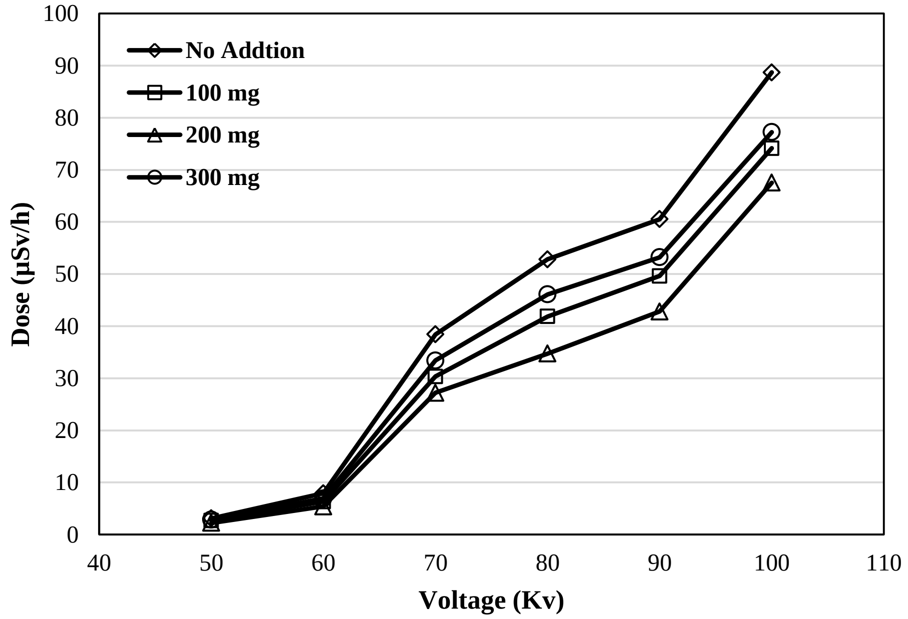

Figure (5) The relationship between the voltage and dose with (100-300) mg of Rheomac uw 450.

The best absorption was with samples contains 200 mg of addition for both materials. And when compare the 200 of both additions the best was indicated with Rheobuild 833. This because the second material give the best performance toward water absorption. As mention in the data sheets. [10,11] as presented in Figures (6 and 7).

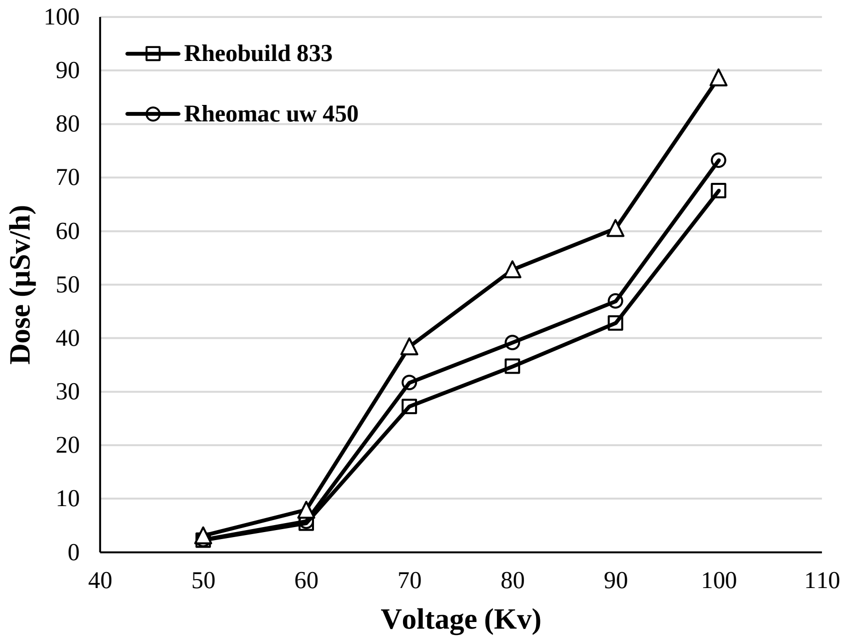

Figure (6) The relationship between the voltage and dose with addition 200 mg of both Rheobuild 833 and Rheomac uw450

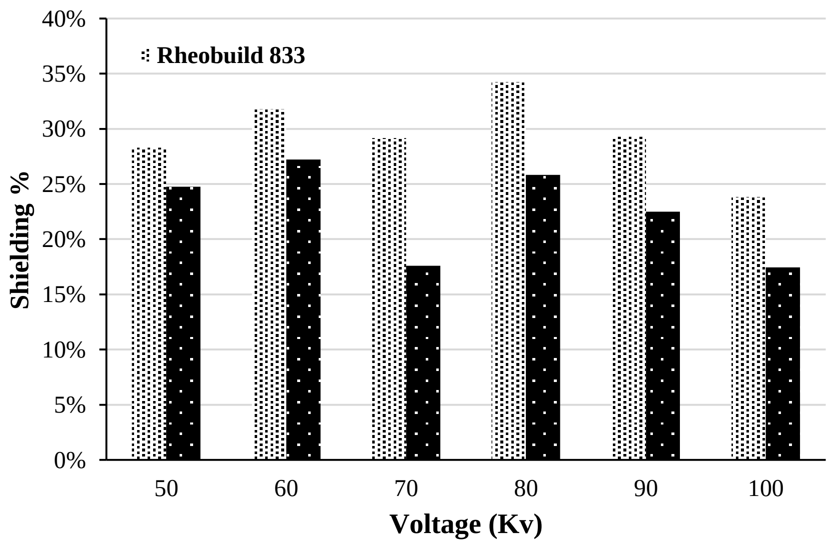

Figure (7) The relationship between the voltage and dose for the 200 mg additions samples

The addition of polymeric materials (Rheobuild833, Rheomac uw450) led to a decline in the percentage pass rays behind the sample tested, and at increasing the proportion. The isolation efficiency of both materials showed that Rheobuild 833 showed a higher percent of shielding with 29% when compared with 23% for the samples with Rheomac uw 450 addition. As shown in Table (2)

The explanations of these results need to put the behavior of x-ray when passed though materials. Where, some are absorbed, some pass through without interaction, and some are scattered as lower energy photons. The attenuation of a gamma beam by an absorber material is usually characterized as occurring under ‘‘good geometry’’ conditions where every photon that interacts is either absorbed or scattered out of the primary beam such that those that reach the receptor have kept all their original energy [12].

According to that the addition of these materials with 100 g and 200 g increase the densification of concrete wall and the porosity will be perfectly filled with the polymeric material. This will make the radiation absorbed by the dens geometry. But when this ratio increases to 300 g increased the percentage passing rays behind the sample This is due to the increase of polymer will led to reduce the density and the geometry of the bulk will be weaker and some cracks could make the pass wavelength easily passed through the matrix of concrete. You can take advantage of reducing the proportion of passing rays resulting from the addition of polymeric materials, reducing the thickness of the wall of bullets used by a calculated equivalent drop rays behind the sample.

4. Conclusions

This work gave main conclusions:

1- The best shielding percent came by adding 200 mg of both sample with addition of (Rheobuild 833) and Rheomac uw 450.
2- The better shielding was by adding of (Rheobuild 833) with shielding percent of 29% in comparison with (Rheomac uw 450) Addition which gave 23%.
3- It was found that the best voltage used were 80 volts, which gave shielding percent 34% when adding polymer (Rheobuild 833), and 26% when adding polymer (Rheomac uw 450) at optimum condition.
4-Reducing the thickness of the wall of bullets means a basic two advantages, the first low rate of toxicity in laboratory space as lead is toxic, and the second economic by reducing the cost of construction of the wall. When comparing the cost of lead used and the cost of polymers added.

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