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Experimental investigation of γ-ray attenuation coefficients for marble, ceiling and gypsum board in Thailand

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Abstract

In this research, the same building materials in Thailand were investigated as a gamma shield. Gamma photons emitted from gamma source of ^{137}Cs and the measurement has been performed using a gamma spectrometer which contain 2" × 2" NaI(Tl) detector connected to 1024 channel Multi-Channel-Analyzer (MCA). The results are in good agreement with the theoretical calculation of XCOM code.

Keywords: Gamma ray shielding, Mass attenuation, Building materials

1. Introduction

Due to increasing use of radioactive isotopes in several fields of applications, such as industries, energy production, medical uses and so on, there is also an increase in the interest estimating, as precisely as possible, the dose to which a population would be exposed to if an accident occurs. Even though all possible cautions are taken, one must be always alert and able to make decisions under high pressure. In the event of a large nuclear accident, the most important decision at the first moment is to define the necessity of the evacuation of the local population or to decide if simply providing shelter would be sufficient. Realistic dose calculations, which should evaluate the hazard due to airborne activity, ingesting of fallout-contaminated food and external irradiation, are a useful tool to estimate the dose to which the population would be exposed and also for decision-making [1-2].

Such useful information during accident situations is the effective shielding that the house' wall and ceiling could provide, making it possible to evaluate the contribution of an eventual plume and deposition of radioactive materials to the dose and estimate how much protection one can get just by being at home. For this purpose, the attenuation coefficient and density of building materials are important parameters to perform the necessary

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calculations. Up to now there are a little published experimental data for the attenuation coefficients for some building materials from Thailand. Therefore in this research is presents the mass attenuation coefficients for the specified sample of some building materials collected in and around Nakhon Pathom province, Thailand was undertaken with the aim of establishing a database for further studies.

2. Materials and Method

The building materials were investigated are marble, ceiling and gypsum board were collected from the local market in Nakhon Pathom province, Thailand. The chemical composition of some building materials was analyzed with an energy dispersive x-ray fluorescence (EDXRF) instrument of type Panalytical, Minipal 4 spectrometer (PW 4030/45B) with an rhodium (Rh) X-ray tube operate as shown in Table 1.

Table 1. Chemical compositions by weight of the investigated building materials

Compound (Wt.%)	Marble	Ceiling	Gypsum Board
Al_2O_3	13.1	6.79	0.77
SiO_2	77.1	20.0	2.31
SO_3	-	8.82	52.3
K_2O	2.93	3.81	
CaO	3.34	55.45	44.37
TiO_2	0.508	1.82	0.060
Cr_2O_3	0.006	-	-
MnO	0.109	0.093	-
Fe_2O_3	2.72	2.59	0.10
NiO	-	0.003	-
CuO	0.030	0.21	0.028
ZnO	0.021	0.047	-
SrO	0.0923	0.396	0.0896
ZrO_2	-	-	0.008
BaO	0.099	-	-
Bi_2O_3	0.013	-	-

Fig. 1. Some building materials in Nakhon Pathom province, Thailand (a) marble (b) ceiling (c) gypsum board

The thicknesses of samples were measured by vernier calliper, which can measure down to 0.05 mm. The density of each sample was measured by Archimedes' principle using distilled water as the immersion fluid from applying the relation:

$$\rho=(W_a /W_a -W_b)\times\rho_{distil\ water} \quad (1)$$

where W_a and W_b are the weight of samples in air and the immersion fluid, respectively. The density of distilled water is 1.00 g/cm^3. The experiment was repeated three times for density and thickness measurement. The average density and thickness of marble ceiling and gypsum board are enlisted in Table 2.

Table 2. Average density and thickness of some building materials available in Thailand

Material	No. sample	Thickness (cm)	Density (g.cm^{-3})
Marble	1	1.92	2.66±0.001
Ceiling	1	0.72	1.85±0.085
Gypsum Board	1	0.98	0.75±0.015

For radiation shielding properties, a narrow beam γ-ray transmission geometry was used for the attenuation measurements of the samples. The diagram of the geometry is show in Fig. 2. The source was enclosed in a lead container with one face aperture, 3 mm. in diameter. Samples were positioned on a specimen holder at 400 mm. from the source. The distance between source and detector is 550 mm. A 2”×2” NaI (Tl) crystal detector with the energy resolution 8 % at 662 keV and Multi-Channel Analyzer (MCA) plug-in-card were used with associated electronics to record the pulse-height spectra to a ^{137}Cs radioactive source. The radioactive sources were procured from Office of Atom for Peace (OAP), Bangkok, Thailand. The intensities of photon were measured without and with placing the sample between source and the detector. The intensities of incident and transmitted photon, I_0 and I, respectively, were measure for a fixed preset time by selecting a narrow symmetrical region with respect to the centroid of the photo peak. The net area under each peak gives the intensity of gamma-rays. The counting time for each measurement was chosen so that 10^5 counts were recorded under each peak given a statistical accuracy better than 0.3 %. The statistical error in this experiment was calculated from the relative error, ratio of standard deviation to mean values in three stages (i) ray-sum measurement, (ii) density measurement and (iii) thickness measurement. Finally, the total error has been determined from combining the errors for three stages in quadrature [3].

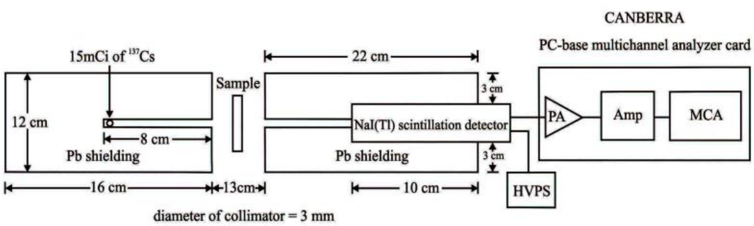

Fig. 2. Experimental setup of narrow beam transmission method

3. Results and discussions

Table 3. Theoretical and experimental mass attenuation coefficient ($\times 10^{-2}$ cm^2/g) of some building materials available in Thailand

Sample	$\mu_{m\ (th)}$ ($\times 10^{-2}$ cm^2/g)	$\mu_{m\ (ex)}$ ($\times 10^{-2}$ cm^2/g)	%RD
Marble	7.697	7.665 ± 0.025	0.42
Ceiling	7.721	7.534 ± 0.017	2.42
Gypsum board	7.748	7.553 ± 0.036	2.51

The mass attenuation coefficients (μ/ρ) for samples were measured at 662 keV photon energies. The resulting experimental values of the mass attenuation coefficient with their uncertainties are shown in Table 3 together with theoretical values, calculated by the XCOM program [4]. XCOM program was applied to calculate mass attenuation for the investigated samples in a wide range 50-2000 keV (Table 4).

Table 4. Calculated mass attenuation coefficients for building materials available in Thailand in the energy range 50-2000 keV

E (keV)	Marble	Ceiling	Gypsum Board
50	0.395	0.659	0.556
60	0.296	0.449	0.389
70	0.244	0.340	0.302
80	0.213	0.277	0.252
90	0.192	0.238	0.220
100	0.179	0.211	0.199
150	0.143	0.153	0.149
200	0.126	0.131	0.130
250	0.116	0.118	0.118
300	0.108	0.109	0.109
500	0.087	0.087	0.087
700	0.075	0.075	0.075
800	0.071	0.071	0.071
1000	0.063	0.063	0.064
1250	0.057	0.057	0.057
1500	0.052	0.052	0.052
1750	0.048	0.048	0.048
2000	0.045	0.045	0.045

4. Conclusions

This work presents experimental and theoretical determination of mass attenuation coefficients for some building materials. The materials studied here represent marble, ceiling and gypsum board representative of those used in Thailand. The results allow the comparison of shielding for different kinds of urban constructions and can be used in models for emergency preparedness and estimation of public exposure in contaminated urban areas.

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References

[1] Medhat ME. Gamma –ray attenuation coefficients of some building materials available in Egypt. *Annals of Nuclear Energy* 2009; 36:849-852.

[2] Salinas ICP, Conti CC, Lopes RT. Effective density and mass attenuation coefficients for building material in Brazil. Applied Radiation and Isotopes 2006; 64:13-18.

[3] Keawkhao J, Laopaiboon J, Chewpraditkul W. Determination of effective atomic number and effective electron densities for Cu/Zn alloy. *Journal of Quantitative Spectroscopy & Radiative transfer* 2008; 109:1260-1265.

[4] Gerward L, Guilbert L, Jensen KB, Leyring H, WinXCom-a program for calculating X-ray attenuation coefficients. Radiation Physics and Chemistry 2004; 7: 653-654.