Checking the radioactivity of building materials

We are constantly exposed to natural nuclear radiation: from the ground, and from cosmic rays; even our bodies are weakly radioactive.

For the average person, the earth contributes most to the annual natural radiation dose. This radioactivity is mainly due to the presence of uranium and thorium, and the products of their decay. Small quantities of radioactive potassium are also sometimes present. When these atoms disintegrate, they emit penetrating *gamma* rays.

When we are inside a building we generally receive a higher dose of radioactivity than if we were outdoors. This is because materials surround us on all sides. In addition, some building materials can possess considerably greater radioactivity levels than the generally low levels found in soil (although in some localities, the ground can set Geiger counters clicking rapidly).

The OECD's Nuclear Energy Agency has suggested that the *gamma*-ray activity of building materials should be limited to a level such that any dwelling made from them should not give its occupants an additional annual radiation exposure of more than 1·5 millisieverts, corresponding to a radioactivity of 370 becquerels per kilogram. Broadly, this is equivalent to saying that any building should

Sources of natural radiation

	dose (millisieverts per year)
cosmic rays (at sea level)	0·3
ground and buildings	typically 0·5–1·0, but 'hot spots' exist
our body	0·3

Most of the natural background radiation comes from the ground. To this dose must be added that from artificial sources (for example, a chest X-ray metes out about 0·3 mSv).

How radioactive?

material (and use)	number of samples	radium equivalent (becquerels per kg)
wood	2	0
rock-wool insulation	1	10
lime	2	0–25
gypsum (plaster)	4	5–25
sand	3	65–75
concrete blocks and tiles	5	55–105
basalt aggregate	7	80–175
Portland cement	7	80–180
mud brick	4	160–185
clay brick	25	130–290
clay	12	155–**1020**
slag (aggregate)	3	270–**420**
fly ash (concrete)	15	140–**630**
phosphogypsum (plaster)	9	120–**1100**
red sand	1	**605**
rutile and ilmenite (paint)	2	**640–700**
clay brick with red mud	1	**830**
red mud	2	**1490–2390**
zircon sand and zircon flour (tile glaze, fire bricks)	3	**1730–3700**

Samples with a radioactivity above 370 becquerels per kilogram (bold) exceed the acceptable limit suggested by the OECD's Nuclear Energy Agency. However, those materials with the highest radioactivity are normally used in small proportions of the total building, so concern should not arise.

not be significantly more radioactive than if it were made from solid earth (of low radioactivity).

(One sievert equals one joule of ionizing energy transmitted to one kilogram of material. The old, more familiar, 'rem' unit equals 10 millisieverts. One becquerel is one atomic disintergration per second.)

Australia has no standards for the natural radioactivity levels of building materials. Indeed, very few measurements of this quantity have even been made here. Europe, where there is much more concern about this aspect of safety, has built up an extensive body of data. In Germany, tens of thousands of dwellings have been measured, and authorities need to be informed of all building materials with radioactivity levels above 370 Bq per kg. A licence is needed to sell materials with levels more than twice this figure.

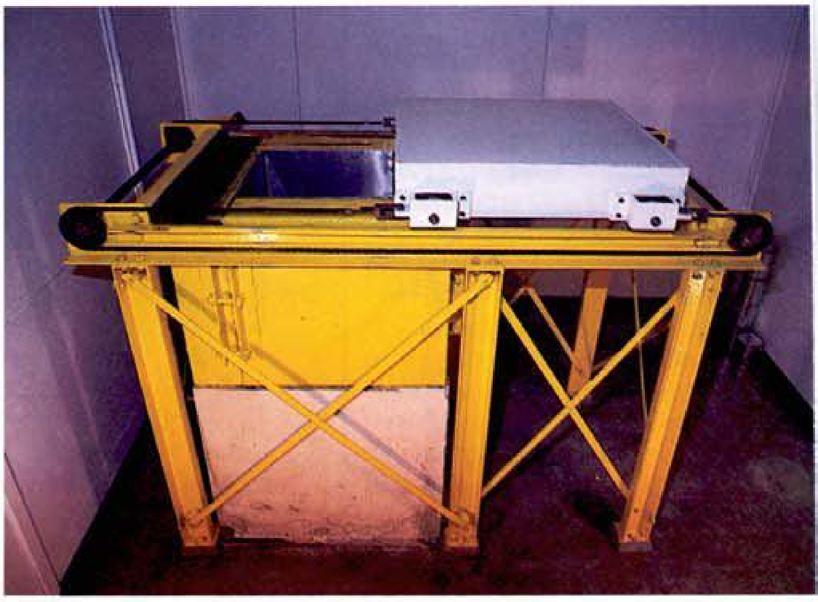
In West Germany, the use of red mud from alumina plants as a building material has been restricted because of its high radioactivity, and in Sweden production of aerated concrete based on alum shale was halted in 1975 because of its uranium content.

Mr Julius Beretka of the CSIRO Division of Building Research and Dr Billy Mathew of the Division of Mineral Physics undertook a study to determine the radiation levels of a range of Australian building materials. They examined more than 20 common materials; some are used directly in construction while others are industrial wastes and by-products sometimes incorporated in building materials or with a potential for use in them.

The measurements were made with a special *gamma*-ray counting chamber recently built at the Melbourne laboratory of the Division of Mineral Physics. The chamber is heavily lined with lead bricks, reducing the radioactive background inside it to a very low level.

The results are shown in the table, and they sum up all the detected radioactivity as a radium equivalent. As you can see, the radium equivalent varies considerably depending on the origin, geological history, and chemical processing of the sample. Many samples had low levels — notably sand, lime, and natural gypsum — and wood's radioactivity was so low it couldn't be detected.

The radium equivalent of some materials varied from below the suggested level of 370 Bq per kg to above it. For example, fly ash varied from 140 to 630, and clay from 155 to 1000. Phosphogypsum, generated as a by-product during the manufacture of phosphoric acid for fertilizer (it can be used for making plaster products), ranged from 120 to 1100. The researchers suggest it would be prudent to monitor the radioactivity levels of such materials before



The lead-lined counting chamber.

Phosphogypsum, a by-product that can show an elevated radioactivity.

using a new source for building.

Some materials gave readings consistently above the criterion level. However, these do not pose a radiation hazard because they never constitute more than a small fraction of the material used in a building.

It is worth noting that when Mr Robert Stanford, a consultant to Alcoa in Western Australia, measured the radiation exposure in two rooms made of bricks containing 25% red mud, he found it was not much higher than that of houses in Perth made of conventional materials (0·13 mSv per year compared with 0·09–0·12).

In some instances the radioactivity comes largely from the finer particles, the researchers found. Hence, the radioactivity of phosphogypsum, fly ash, and mineral tailings could be reduced by sieving and discarding the fines.

The CSIRO researchers believe there is value in setting standards or guidelines prescribing the acceptable levels of radioactivity of building materials, based on the specific activity of available building materials, radioactivity of the environment, and other considerations.

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