Shielding Design Challenge

Lead Shield

Scientists working on the MAJORANA DEMONSTRATOR (MJD) have determined that a minimum of 18 inches of lead brick will be necessary to sufficiently shield the detectors from outside sources of radiation.

The challenge in designing the enclosure will be to ensure that the bricks are stacked in such a way that no lines are created that could allow radiation from any source to reach the detectors.

Design and Build

Your task is to design an enclosure that limits repetition of brick edges, by staggering bricks both horizontally and vertically. Brick edges should not line up in adjacent layers.

The dimensions of a typical lead brick are the same as those of a typical clay brick (2in x 4in x 8in).

Your design must fit on the installed over floor base that will support the MAJORANA DEMONSTRATOR and its heavy lead shielding. Its dimensions are 144"x 144". The copper box at its center measures 28"tall x 40"wide x 24" deep.

Do the Math

While the average clay brick weighs 6 pounds, a lead brick the same size tops the scales at a whopping 26.25 pounds!

If there are 4,120 lead bricks in the completed enclosure, what is their weight in tons?

Deep Science

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The MAJORANA DEMONSTRATOR (MJD), which is being housed 4,850 feet underground in the Sanford Underground Research Facility (SURF), is looking for one of the rarest forms of radioactive decay-neutrinoless double-beta decay. Its detection could help explain why matter—in other words, us and everything else in the universe—exists.

To work properly, MJD requires a radiation free environment. Researchers are building the detector underground to eliminate the interference from cosmic rays. However, there is also radiation in the surrounding rock, equipment, specks of dust, and people. To completely shield the detector it will be placed within a copper box and surrounded by a lead enclosure.

SANFORD UNDERGROUND RESEARCH FACILITY

Shielding Design Challenge

Engineering Design Process

Identify/Imagine/Design

Find some sort of rectangular blocks to use for building practice. (Legos, wooden blocks, or dominoes might work well) Explore stacking patterns. What problems would there be if you were to build a traditional brick pattern wall for each layer? List other obstacles you may encounter. Explore patterns that incorporate bricks in various orientations. Brainstorm possible solutions for this structure. Choose your best design option and sketch a diagram of your idea.

Create

Begin constructing your prototype according to your plan. Considering your scale model, how many layers would it take to produce an equivalent of at least 18 inches of shielding? How many bricks would be necessary to complete the structure? NOTE: you will not have the time, or access to the required amount of material to build a complete prototype. Focus on a few layers.

Test/Improve

When you have completed a representative portion of your model, scrutinize your structure. Do any of the edges line up allowing radiation to reach the interior? If something isn't working, go back and improve.

Go High Tech

Build your dream model with Lego Builder Online or MECABRICKS.

Google SketchUp also gives you the ability to easily create your own 3D models.

Share

Which of your designs performed the best? What challenges did you have? How did you resolve them? Now that you have some experience, what might you change to optimize shielding?

Now that you have shared your findings with each other, it might be possible to select certain aspects from multiple designs and combine them to create a super structure! What could that look like?