EMF shielding by building materials

Attenuation of microwave band electromagnetic fields by common building materials

The U.S. National Institute of Standards and Technology (NIST) conducted in 1997 extensive tests of how various common building materials can shield (dampen) electromagnetic fields. A wide range of materials and thicknesses were tested, such as bricks, concrete, lumber, drywall, plywood, glass and rebar.

The tests were conducted for frequencies from 500 megahertz to 8 gigahertz. This range covers emissions from cell phone towers, 3G, 4G, LTE, Wi-Fi, DECT, cordless phones, digital television, GPS, wireless smart meters, baby monitors and many other devices.

The frequency bands used by broadcast radio (AM, FM, shortwave, etc.) were not covered. Since they are lower frequencies, it is reasonable to expect less shielding of these types of signals than demonstrated in these tests.

The reason NIST did these extensive tests was to prepare for future generations of wireless control systems at construction sites, as well as for tools to measure the thickness of walls. It was not related to protecting the public health against EMF.

In general, these tests show that standard building materials provide poor shielding. To get a shielding effect worth considering (i.e. 99% or better) one would need a wall made of:

- 8 inches of solid concrete; or
- 18 inches of solid lumber; or
- 24 inches of hollow-core concrete blocks

Brick walls have to be unrealistically thick to be useful.

Other materials, such as windows and drywall, are essentially fully transparent to radio waves.

Reinforcing a concrete wall with steel rebar did not really improve the shielding, at least at the standard grid sizes.

Metals are far superior as shielding materials. Unfortunately, NIST did not test any steel or aluminum siding, or low-E glass, which all have shielding effects.

Whereas metallic shielding mostly reflects EMF, non-metallic materials mostly absorb EMF. As some sensitive people do not do well inside metallic shields, the non-metallic materials do have their place.

When considering a shielded room or house, the weakest link in the chain determines the overall shielding. Even the best shielded wall has little effect if the radio waves can travel through the window, door, roof, etc.

Peter Pauli and Dietrich Moldan from Universitaet Der Bundeswehr, Germany, have later tested several additional building materials.

The results of the testing

The NIST report provides very extensive and detailed information. The following is a condensed and simplified extract of the NIST data.

The tables show the attenuation of high frequency electromagnetic radiation in decibels, relative to unrestricted passage.

The decibels are calculated as:

$$dB = 10 * LOG\ (\text{reduction factor})$$

If the signal strength is reduced by a factor of 10 (i.e. 90% reduction), then the decibel number is 10.

factor	reduction	decibel
10	90%	10
100	99%	20
1000	99.9%	30
10,000	99.99%	40

For shielding of humans against EMF, these are the magnitudes that are relevant. On this scale, only thick concrete and very thick lumber (logs) are of any practical interest.

The shielding values do vary with the frequency, with the materials mostly performing better at higher frequencies. However, that is not always the case.

Concrete

Eight concrete mixes were tested, which gave some variation in the attenuation as shown. These are for concrete that has no rebar reinforcement.

Concrete	500 MHz	1 GHz	2 GHz	5 GHz	8 GHz
102 mm (4")	7 – 11	11 – 14	13 – 18	17 – 25	22 – 23
203 mm (8")	17 – 25	22 – 28	29 – 35	48 – 56	58 – 73
305 mm (12")	31 – 45	33 – 45	36 – 43	74 – 85	87 – 96

All tables show the shielding effect in decibels. 20 dB = 99%, 40 dB = 99.99%.

Reinforced concrete

Concrete reinforced with a mesh of steel rebar is not really better than plain concrete. The report tested two standard mesh sizes (70 mm and 140 mm between rebars) and compared with a concrete wall without rebar. 19 mm (3/4") thick rebar was used on a 203 mm (4") thick concrete wall.

Concrete 203 mm (4")	500 MHz	1 GHz	2 GHz	5 GHz	8 GHz
without rebar	23	27	35	55	73
with rebar 140mm OC	23	27	31	53	68
with rebar 70 mm OC	26	30	37	56	71

Concrete blocks

Concrete blocks with hollow cavities inside were tested for walls one, two and three blocks thick. The study did not test the shielding value of the blocks if filled with concrete. It would probably be less than a solid concrete wall of the same thickness.

Masonry block (concrete block)	500 MHz	1 GHz	2 GHz	5 GHz	8 GHz
203 mm (8”)	8	12	11	15	18
406 mm (16”)	13	17	18	27	30
609 mm (24”)	26	28	30	39	39

Lumber

Regular lumber in thickness up to six inches was tested. The wood was either spruce, pine or fir, which are the typical sorts used in North America. Heavier types of wood, such as oak, may have a better shielding effect.

A log house built of massive and dense logs may provide useful shielding.

Dry lumber	500 MHz	1 GHz	2 GHz	5 GHz	8 GHz
38 mm (1.5”)	2	3	3.3	4	4
76 mm (3”)	1.5	3	4.7	8	9
152 mm (6”)	4.5	6	8.5	20	25

Bricks

Brick walls consisting of one, two or three bricks were tested. Even three courses of bricks do not provide much useful shielding, except at the highest frequencies.

Brick	500 MHz	1 GHz	2 GHz	5 GHz	8 GHz
89 mm (1 brick)	0	3.5	5.5	15	16
178 mm (2 bricks)	3.5	5.5	7.5	32	14
267 mm (3 bricks)	4	7	10.5	32	27

Glass panels

Glass window panels with regular clear glass were tested. Low-E windows have a very thin metallic film on the glass, which should provide some shielding, but this type of window was not tested in this study.

Glass panels	500 MHz	1 GHz	2 GHz	5 GHz	8 GHz
6 mm (1/4”)	0	0.8	1.4	1	1.5
13 mm (1/2”)	1.2	2.2	3.4	0	1.6

Drywall

Drywall consists of 85-95% gypsum. The rest is mainly paper and various chemical additives. Drywall has no shielding effect.

Drywall	500 MHz	1 GHz	2 GHz	5 GHz	8 GHz
6 mm (1/4”)	0.1	0.3	0.6	0	0.4
13 mm (1/2”)	0.1	0.3	0.6	0	0.4

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