R-Value of Straw Bales Lower Than Previously Reported

Much of the published information on the energy performance of straw-bale buildings is based on measurements done in 1993 by Joseph McCabe at the University of Arizona as part of his master’s thesis. McCabe used a “guarded hot-plate” apparatus (procedure ASTM C 177-85) to measure heat flow through a single bale that was 23” (580 mm) wide by 161/2” (420 mm) tall. He reported R-values of 48.8 (RSI-8.6) for bale on edge and R-54.8 (RSI-9.7) for the bale laid flat. Thus he concluded that the insulating value is R-2.68 per inch (0.056 W/m°C) when heat flow is perpendicular to the orientation of the straws (bales stacked on edge) and R-2.38 per inch (0.061 W/m°C) when the heat flow is parallel to the straw orientation. These values were reported in EBN’s feature article on straw as a building material (EBN Vol. 4, No. 3) and in many other publications. Follow-up studies conducted since 1993 have given widely differing results. In 1994 a thermal probe was used by R. U. Acton at Sandia National Laboratory to deduce the R-value of a 161/2”-wide (420 mm) bale as R-44 (RSI-7.7), which seemed to support McCabe’s findings, but this is considered a fairly primitive testing procedure. In 1996, Oak Ridge National Laboratory (ORNL) constructed a bale wall that was stuccoed on the cold side and covered with gypsum drywall on the warm side. This test found the R-value to be only R-17 (RSI-3.0). On a per-thickness basis, this is just R-0.94 per inch (0.15 W/m°C). The explanation for this very low R-value, suggested researchers, was that an air gap resulted from the way the drywall was attached to the bale wall; this could have created convection currents in the walls, depressing the R-value.

In 1997, the California Energy Commission (CEC) sponsored their own tests, working with Architectural Testing Inc. of Fresno, California. Two straw-bale walls were built and plastered on both sides: one had bales laid flat, producing a 23”-thick (580 mm) wall, and the other had the bales laid on edge, producing a 16”-thick (400 mm) wall. The walls were then tested in the company’s new state-of-the-art guarded-hot-box (ASTM C 236-style) apparatus. With the bales laid flat, the total R-value was R-26 (RSI-4.6) and, with the bales on edge, the R-value was R-33 (RSI-5.8). On a per-thickness basis, this is just R-1.13 to R-2.06 per inch (0.13 to 0.07 W/m°C). An explanation for these low R-values was provided by researchers Tav Commins and Nehemiah Stone in a paper presented at the ACEEE Summer Study (see page 14 for review of proceedings). On disassembly of the walls following the measurements, the walls were found to be quite wet. Water had been sprayed on the stucco to prevent cracking, and the walls were tested after less than a week of drying. This water was found to have wicked as much as 6” (150 mm) into the wall along the edges of some of the bales. Also, during construction the walls were compressed with polypropylene strapping, which left a 3” (80 mm) gap at the top; this gap was filled with loose straw. Upon disassembly, it was found that there were voids at the top of the wall and very loose packing in places.

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