

FOREST PRODUCTS LAB  
MADISON, WISCONSIN  
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# ENGINEERING REPORT OF LIGHT CLAY SPECIMENS

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THERMAL CONDUCTIVITIES FOR DESIGN  
COALITIONS STRAW/CLAY FORMULATIONS  
EXTEND VOLHARD'S K-VALUE VS. DENSITY  
CURVE IN LOW CONDUCTIVITY END

TEST RESULTS FOR THERMAL CONDUCTIVITY MEASUREMENTS, TEST  
CONDITIONS, AND FORMULATIONS OF SPECIMENS PROVIDED BY  
DESIGN COALITION

Four formulations of light weight straw loam provided by Design Coalition were tested for thermal conductivities with the results as shown in table 1 below. The specimens were first removed from their lay up forms and band sawed to 4 or 6 inch nominal uniform thickness. The specimens were then equilibrated to 75 deg. F and 50% relative humidity in the room in which they were thermally tested in a Lasercomp Fox 600 series thermal tester.

Table 1

Specimen	Density (#/ ft <sup>3</sup> )	Density (kg/m <sup>3</sup> )	Conductivity (W/m*K)	delta temp. (deg. C)	temp_median (deg. C)	R/inch (hr*F*ft <sup>2</sup> /BTU/inch)
Low Dens. I	10.2	164	0.08	4.54	23.21	1.80
Low Dens. II	13.0	209	0.09	approx 4.5	approx 23	1.69
So. Dakota I	15.8	254	0.09	4.51	23.40	1.55
So. Dakota II	13.3	213	0.09	4.54	23.39	1.67
Reg I	13.3	213	0.08	4.55	21.30	1.72
Reg II	13.7	220	0.09	4.54	23.59	1.66
NM I	38.1	612	0.13	4.58	23.21	1.11
NM II	43.9	705	0.16	4.19	23.40	0.90

After thermal testing the specimens were oven dried at 105 deg. Celsius and re-weighed to estimate their moisture content at the time of testing with results shown in table 2 below.

Table 2

Specimen	Test weight (grams)	Oven dry (grams)	Moisture content (% dry wt. bases)
Low Dens. I	6878	6426	7.0
Low Dens. II	8652	8121	6.5
So. Dakota I	10953	10383	5.5
So. Dakota II	9330	8839	5.5
Reg I	8867	8382	5.8
Reg II	9158	8644	5.9
NM I	17660	17059	3.5
NM II	20379	19774	3.1

The formulation as provided by Design Coalition is as follows:

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#### STRAW-CLAY INSULATION TEST SAMPLE PREPARATION

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Three components were mixed to make the straw-clay insulation infill for the thermal tests. These were Wisconsin wheat straw, brown clay from surface excavation near Madison Wisconsin (here after called Madison clay) and tap water. The straw was in 25 pound bales that tested 13% moisture with a range of 11-15%. Test depths were 4 and 8 inches using a wood moisture reading from a Delmhorst BD10 moisture meter. The locally mined clay when analyzed was 41% clay, 40.6% silt and 18.3% sand & 0.1% gravel. Straw, clay and water were combined in 1:1:7 weight ratios respectively. Clay slip was made first by combining the clay and water. This was done by mixing the clay into the water with a Silverson Hydromax™ high shear mixer or by soaking the clay overnight in the water then mixing with a paint stirrer on a drill. Straw was then put on a plastic tarp and the clay slip used to coat the straw by pouring it onto the straw while tossing the straw with forks. When homogeneous, the mixture was stuffed in a five sided frame made from 2x6's with OSB sides measuring exactly 2 feet by 2 feet on the interior and the width of the 2x6's. Stuffing was done by lightly stomping on the mixture as it was added. When full, the top 2x6 was added and the OSB sides removed after the sample had set 2 hours. Narrow wooden diagonal corner pieces were added after the OSB was removed to maintain frame geometry. The samples were allowed to dry in ambient conditions protected from any direct weather exposure as rain or snow.

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#### Conclusions:

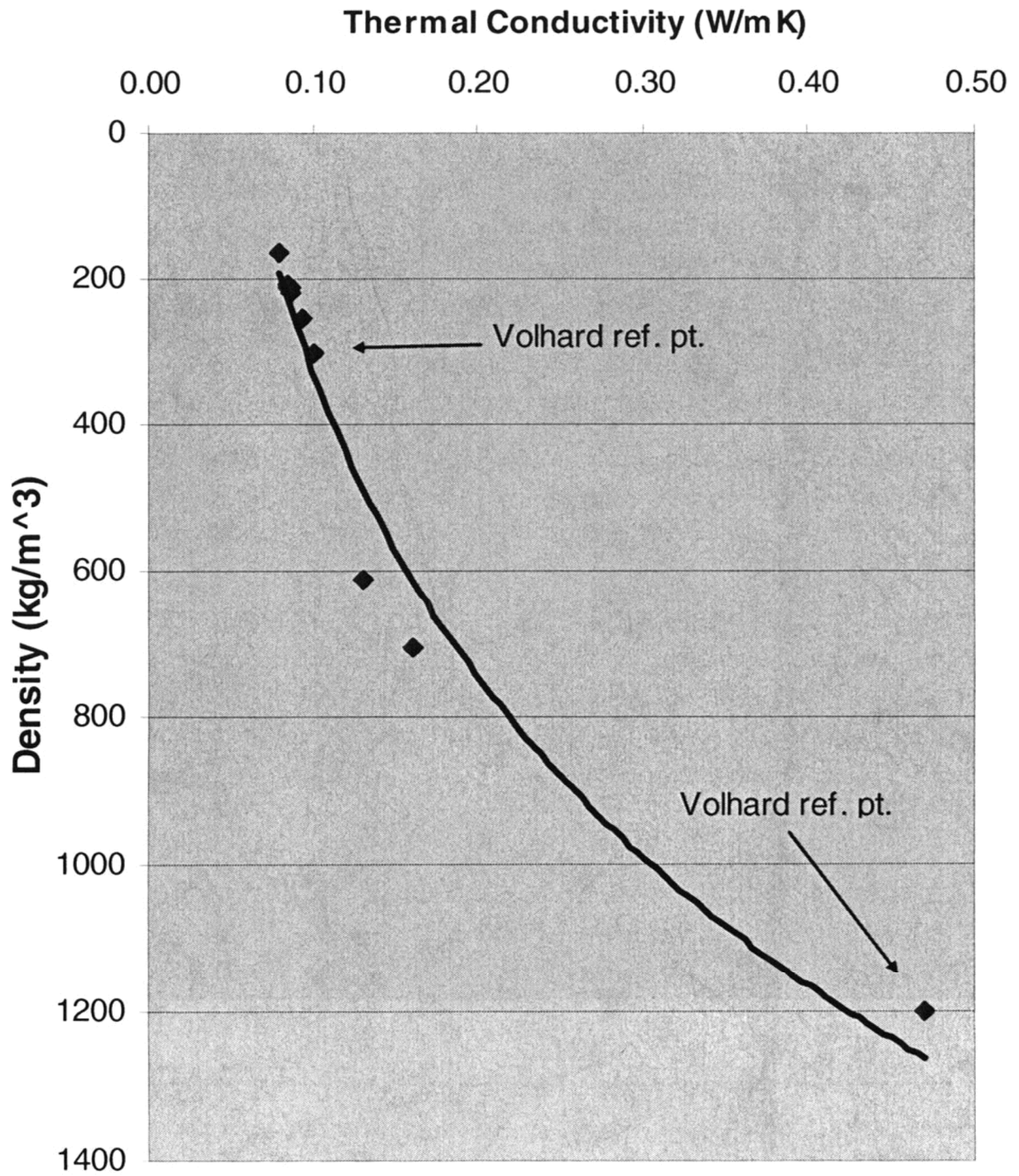
The light weight specimens provided by Design Coalition appear to extend the measured properties of denser formulations of Straw and clay/loam materials sited in the building design literature (Minke, 2000: Earth Construction Handbook, pp35). The curve fit to thermal conductivity of the Volhard data (Volhard, 1983) places materials with densities of 300 kg/m<sup>3</sup> at 0.1 W/mK. As the plot below shows the FPL measurements fall on the trend line of Volhard data.

Thermal performance at mean temperatures other than the room temperature averages chosen for our tests were not measured and may be presumed to change.

Thermal performance at moisture levels other than those shown in table 2 were not measured and may be presumed to change.

The weights before and after thermal testing were taken with only nominal losses of around 10 grams measured- near the accuracy of accounting for straw fiber being chaffed off the specimen. Moisture movement at higher temperature differentials than we used may be significant.

# Density (descending) vs. Thermal Conductivity



# Density (descending) vs. Thermal Conductivity

