Research
University of Colorado School of Architecture and Planning
Fiberglass Vs Cellulose Installed Performance By Soontorn Boonyartikarn, Arch D. and Scott R. Spiezle

The University of Colorado at Denver, School of Architecture and Planning, has undertaken a research project under the direction of Soontorn Boonyartikarn, Arch D. and Scott R. Spiezle as the principle investigators. The project was to design and build two identical test buildings in order to evaluate the performance of fiberglass batts verses wet spray cellulose. The buildings were constructed on University property and built under state regulations for competitive bidding and by standard construction practices. The walls were 2 x 6 construction, 16 inch on center with celetex asphalt board on the outside covered by masonite T111 type siding. Each building had identical wiring and plumbing placed in them with a 2 x 4 interior wall. The floors were anchored to a wood frame on the asphalt pavement at the site. On top of the frame was placed two sheets of 4' x 8' 1 1/2 " extruded polystyrene and then 2 x 6 floor joists 16" o.c. placed on top of the insulation. The joists were covered with 5/8 " O.S.B. board as a flooring. The roof construction was of 2 x 12 rafters with a 4/12 pitch with O.S.B. board covering the rafters and asphalt rolled roofing placed on top for weather protection. Each roof had plumbing extended through the roof along with 16 square inches of ventilations on each gable. On each building a 6 square foot double pane aluminum window was placed on the south side. Each building also had a 3 x 6' 8" exterior pre-hung weatherstiped door on the north side.

Temperature sensors were placed on the outside surface, middle of insulation and inside surface under the dry-wall, and on the outside surface of the dry-wall on the south, east, and west sides. Temperature sensors were also placed in the attic on the top, middle, and underside of the insulation. Other sensors include the measurement of power consumption (using a transducer), relative humidity and a LI-Cor Pyranometer sensor to measure radiation. All of these sensors were programed to monitored all readings at 15 minute intervals. A mini weather station was placed on building B to record overnight high and low temperatures and maximum wind speed each day at the site. Along with this each building was equiped with its own Kwh meter to monitor any and all current going into each building.

After construction the buildings were blower door tested with an Infiltec blower door that had been calibrated 2 months prior to testing. The building was tested in both pressurization and depressuization modes before insulation and dry-wall. Building A had a average 50_{pa} air exchange of 90.8 while building B had 80.9 air exchanges at 50_{pa}. The E.L.A @ 10_{pa} were 87.5 and 81.52 and their leakage ratios were 23.47 and 20.9 respectively.

Both buildings were heated to 65 degrees from December 12,1989 to January 2, 1990 without any insulation. Building A used 469 Kwh and Building B used 473 Kwh or a difference of less than 1%. The consumption usage during that period was nearly the same while building B was approximately 12% tighter than building A.

A coin was flipped to determine which building would get cellulose and fiberglass. Building A received 5 1/2 " R 19 of sprayed wet cellulose in the walls and R -30 loose fill cellulose in the ceiling. Building B received R-19 unfaced batts in the walls and R-30 kraft faced batts in the ceiling.

The buildings were again blower door tested on the 16th of January. At that time there was only insulation in the walls and dry-wall on the ceiling (with the ceiling insulation above the dry-wall). Building A now had an air change at 50_{pa} of 29.45 or a 66.34% reduction and an E.L.A. of 24.00 sq" or a 73.6% reduction and a leakage ratio of 6.21 sq. inches per 100 sq feet of building skin or again 73.6% tighter.

Building B the tighter building originally had an air change rate of 47.9 @ 50_{pa} or a reduction of 41.2% and an E.L.A. of 42.85 sq inches and a leakage ratio of 11.08 for a reduction in air tightness of 47%. In other words the cellulose tightened the building 36% - 38% more than the fiberglass. See chart 3-A for full results.

Chart 3-A

BLOWER DOOR TEST

BEFORE INSULATION OR DRYWALL ON THE 12TH OF DECEMBER

	BUILDING A			BUILDING B		
	PRESSURE	DEPRESSURE	AVERAGE	PRESSURE	DEPRESSURE	AVERAGE
50 PA ACH	91.97	83.02	87.495	84.96	78.08	81.52
E.L.A.	94.4	87.2	90.8	79.2	82.6	80.9
LR.	24.4	22.54	23.47	20.47	21.34	20.905
C VALUE	2070.901	1872.835	1971.87	2106.119	1749.664	1927.892
n VALUE	0.551	0.552	0.5515	0.611	0.548	0.5795

AFTER INSULATION, AND DRYWALL PLACED ON THE CEILING JANUARY 16TH

	BUILDING A			BUILDING B		
	PRESSURE	DEPRESSURE	AVERAGE	PRESSURE	DEPRESSURE	AVERAGE
50 PA ACH	30.19	28.7	29.445	48.71	47.09	47.9
E.L.A.	23.4	24.6	24	44.5	41.2	42.85
LR.	6.05	6.36	6.205	11.51	10.65	11.08
C VALUE	886.988	777.966	832.477	1213.706	1250.016	1231.861
n VALUE	0.716	0.666	0.691	0.614	0.653	0.6335

PERCENT IMPROVEMENT BEFORE AND AFTER TEST

	BLDG A	BLDG B
50 PA ACH	66.3	41.2
E.L.A.	73.6	47
LR.	73.6	47

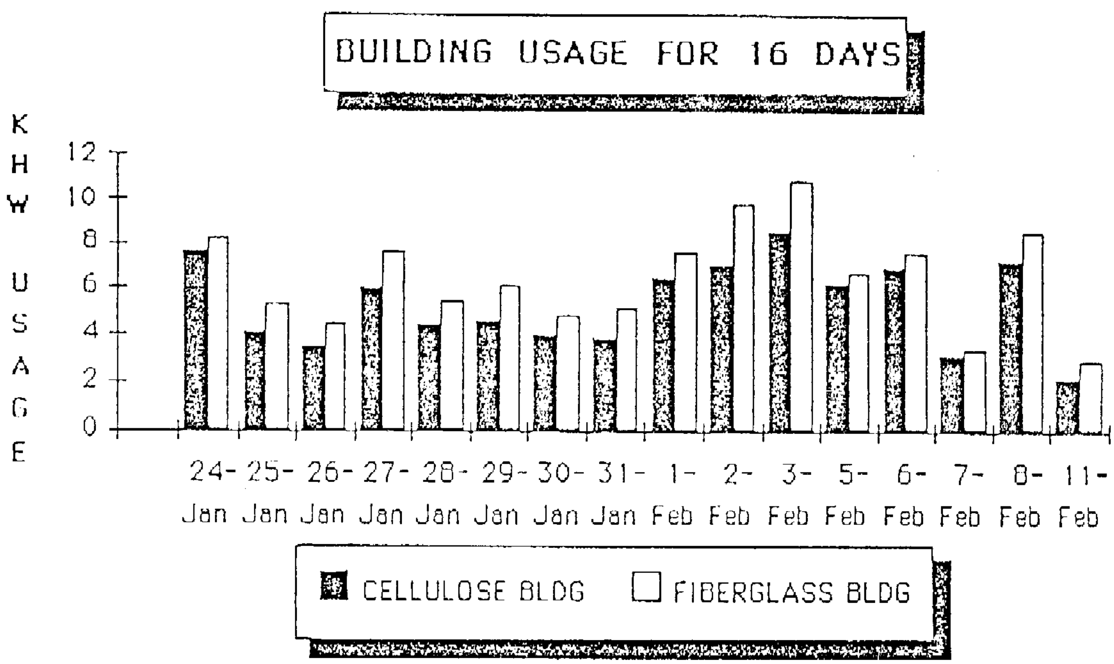
Visual inspection was performed on both insulation jobs and both had some flaws, but were within manufacturers recommendations. Infrared scanning was also performed on both buildings using an I.S.I infrared camera to see if there were major deficiencies in either building. Again the installation was within manufacturers guidelines. The air leakage was a little greater in the fiberglass building than the cellulose, but nothing dramatic.

After dry-walling was completed, air sealing was done on both buildings around the windows and doors only.

From the 16th of January to the 24th of January the equipment was tested using two 8 channel data loggers by Nivan and one 16 channel data logger, a Kimbell scientific 21x. The thermostats in each building and the heating sources were exchanged with each other to insure that not only were the data loggers working correctly, but so were the heaters and thermostats. The heaters were connected to a contact switch and a 24 volt transformer to the thermistor and a 1300 watt electric Alvin heater to control the current accurately.

After the first three weeks of monitoring Building A used 82 kwh less than building B or 26.4% less heat. See Chart 3-B

Chart 3-B1



USAGE IN KWH

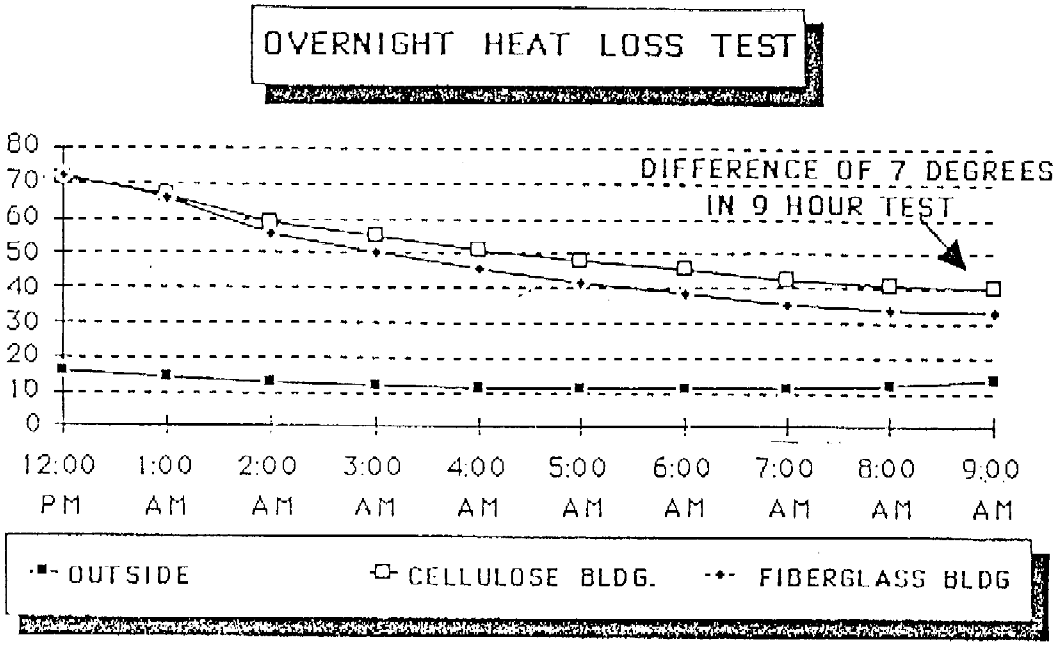
DATE	TIME	CELLULOSE BUILDINGS	FIBERGLASS BUILDINGS	CELL Δ	FIBER Δ	MAX WIND	DAILY MAX TEMP	MIN TEMP
24-Jan	12:23	614.75	606.5			12	62	0
25-Jan	10:35	622.4	614.7	7.65	8.2	18	65	20
26-Jan	14:01	626.5	620	4.1	5.3	1	48	20
27-Jan	12:08	630	624.5	3.5	4.5	19	54	26
28-Jan	17:08	636	632.2	6	7.7	4	63	24
29-Jan	17:20	640.4	637.6	4.4	5.4	8	57	28
30-Jan	18:42	645	643.7	4.6	6.1	4	63	27
31-Jan	11:52	649	648.5	4	4.8	1	36	27
1-Feb	17:00	652.8	653.6	3.8	5.1			
2-Feb	14:20	659.2	661.2	6.4	7.6	1	63	21
3-Feb	19:40	666.3	671	7.1	9.8	0	51	24
5-Feb	11:10	674.9	681.8	8.6	10.8	13	65	29
6-Feb	10:40	681.1	688.5	6.2	6.7	15	68	29
7-Feb	1:00	684.9	696.2	6.9	7.7	18	68	37
8-Feb	10:30	688	699.6	3.1	3.4	3	71	43
11-Feb	11:47	695.3	708.2	7.3	8.6			
12-Feb	10:50	697.5	711.1	2.2	2.9			

Moisture readings were also taken in both building after insulation after one week, two weeks, and after 5 weeks after insulation. The wood in Building B remained constant (around 9%) while the wood in building A rose as high as 17% The insulation was installed with approximately 80% moisture which is more than recommended. The relative Humidity in building A is still higher than in building B indicating the wood is still releasing moisture. This is due in part to there being no interior vapor retarder.

The weather data from the site verses that of the National Weather Service at the Denver airport shows our site to be any where from 17%-49% milder. This is due to protection from the wind along with radiation off the building that is 12 feet to the north of the test cells.

An overnight heat loss test was done by heating the buildings to 71 degrees and turning off all power. In chart 3-C one can see that the cellulose building maintained the heat of 7 degrees more over a 9 hour period. This shows the building to have a better UA value which we determine is due to the insulation since in our pre insulation test the buildings performed nearly identically.

Chart 3-C



In conclusion although there was an initial difference in the amount of air infiltration between the two buildings there was virtually no difference in their energy usage. In these buildings, air infiltration seems to be offset by their shielding and have little effect on energy consumption. The cellulose appears to tighten the building about 38% more than fiberglass insulation. With typical installation without occupancy the cellulose building appears to be performing 23-24% better. It should be noted that the site is shielded from high wind by a building only 12 feet from it. The site also has a large thermal mass due to the asphalt pavement and the large building directly to the north radiating heat. These factors would effect the climate of the site. Therefore these relative percentages of heat loss from the cellulose to the fiberglass may be on the low side. In a less urban setting, especially where wind and air infiltration would be greater factors, these differences may be larger.

Conclusion

In the investigation into wet spray cellulose it is clear that proper installation procedure is important not only as far as performance but also to avoid potential moisture problems resulting from ill-adapted installation and design.

The research at the University of Colorado at Denver, School of Architecture and Planning, suggests that the performance of cellulose verses fiberglass is as much as 38% better. Cellulose achieves a tighter building cavity allowing less heat loss due to air infiltration and its overall performance appears to be about 26% better in tempered climates. It may be concluded that this benefit would become more significant in more severe climates.

In light of the findings one might have to ask whether the existing standard for measuring thermal performance in a laboratory is an accurate reflection of performance or is there a need to test products as they are installed in the field?