Research
University of Colorado School of Architecture and Planning
Fiber Glass vs Cellulose Installed Performance
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ABSTRACT

The intent of the project was to determine if there is a significant difference in performance between wet spray cellulose and fiber glass batt insulation under actual application conditions. The research involved the design and construction of two identical test buildings at a site on the University of Colorado campus. Different types of insulation were installed in each of the buildings. After installing insulation, the buildings were monitored for performance of the fiber glass and cellulose. Air infiltration testing took place at multiple stages of construction. Weather data were collected on site and compared with the closest National Weather Service Station. The test results were analyzed weekly and the major analysis was performed after 67 days of data collection.

SITE SELECTION AND CONSTRUCTION

A site was selected in a parking area on University property. The test buildings were constructed on the south side, 12 feet away from a dark brown two-story building. This shielded the test buildings from high wind on one side. On the other three sides there were no obstructions for a mininum of 100 yards due to parking areas. The site landscaping consisted of asphalt pavement to the east, west and south of the test buildings.

Selection of a contractor to build the structures was done under state regulations for competitive bidding and by standard construction practices. Two identical test buildings were constructed with 8 foot x 8 foot x 8 foot exteriors. They were placed 25 feet apart one on the east and the other on the west side. The walls were 2 x 6 construction, 16 inches on center with Celotex asphalt board on the outside covered by Masonite T111 type siding. Except for the type of insulation used, both buildings were identical. Each had a 2 x 4 interior wall and identical wiring and plumbing placed in them. The floors were anchored to a wood frame on the asphalt pavement at the site. Two sheets of 4' x 8' x 1 1/2 " extruded polystyrene were installed on top of the frame and then 2 x 6 floor joists were placed 16" on center 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. The roof had plumbing extended through it along with 16 square inches of ventilation on the gable. A 6 square foot double pane aluminum window was placed on the south side. The buildings also had a 2' x 6'8" exterior pre-hung weatherstripped door on the north side.

TESTING METHODOLOGY

Temperature measurement of the walls was accomplished by placing temperature sensors in four locations: on the inside surface of the outside of the wall, in the middle of insulation, on the inside surface under the dry-wall, and on the outside surface of the dry-wall on the south, east, and west sides. Temperature measurements of the ceiling were taken by sensors placed in the attic on the top, middle, and underside of the insulation. Additional measurements were taken by a sensor placed inside the heated space. This sensor was placed 4 feet from the floor and 3' 6" feet from each wall, directly in the middle of each building. Other sensors measured relative humidity, power consumption using a transducer, a LI-Cor Pyranometer sensor to measure radiation and an outside shaded temperature sensor. All of these sensors were programmed to monitor at 15 minute intervals.

The buildings were monitored using two 8 channel data loggers by Nivan and one 16 channel data logger, a Campbell scientific model 21XL. The thermostats in each building and the heating sources were exchanged with each other approximately every week to insure that not only were the data loggers working correctly but so were the heaters and thermostats. The 1300 watt electric Alvin heaters were connected to a contact switch and a 24 volt transformer and thermostat to control the electric current accurately.

A miniature weather station was placed on Building B to record maximum wind speed which was read periodically throughout the study. Each building was equipped with its own electric meter to monitor electrical usage.

After construction the buildings were blower door tested with an Infiltec blower door that had been calibrated 2 months prior to testing. Each building was tested in both pressurization and depressurization modes before insulation and dry-wall. Both buildings were heated to 65 degrees from December 12, 1989, to January 2, 1990, without any insulation. The test building with the higher initial air leakage received spray cellulose. The other test building received fiber glass batts. Dry-wall was installed on the ceilings. R-19 as per manufacturer's specification was applied in the walls of the test buildings in this study. Building A received 5 1/2 " (R-19) of sprayed wet cellulose in the walls. This was determined by the number of bags required by the manufacturer. Building B received R-19 unfaced batts in the walls. The performance R-value of the side wall insulation differs as per manufacturer's specification. The cellulose had an installed R-value of 20.8 as per Suburban Insulations. Owens Corning when labeling a R-19 batt claims that in a 2x6 wall it performs to a R-18. This difference was considered when analyzing the overall performance of the two types of insulation. (See Figure 11 and Figure 12.) The unfaced batts were covered with 4 mil polyethelyne. The cellulose was not covered with an interior vapor retarder.

Insulation was also installed in the attics of the two test buildings. Building A received R-30 loose fill cellulose in the ceiling as per manufacturer's bag recommendation and Building B received R-30 kraft-faced batts in the ceiling.

The buildings were visually inspected for quality of insulation installation. Both had some minor flaws but were still visually better than that typically representative of field installation. Both buildings were then scanned using an I.S.I infrared camera to examine major deficiencies. The visual effectiveness of the insulating value on both buildings was found to be very uniform. The air leakage appeared slightly greater in the fiber glass building than the cellulose building. However, a quantitative test can not be determined using an infrared scan alone.

The buildings were tested again with the blower door. Dry wall was then installed on the inside walls and all joints were taped and spackled. Air sealing was conducted around the doors and windows only. A smoke test was used to insure a complete seal on each opening. With all dry-wall installed and the designated air sealing complete, the buildings were blower door tested for the last time.

Other tests conducted included an overnight heat loss test and moisture readings. The overnight heat loss test was done by heating the buildings to 71 degrees and turning off all power. The moisture readings were taken in both buildings after insulation was installed. This occurred after one week, two weeks, 4 weeks, and again after 5 weeks.

MODELING

The buildings' heat loss was calculated using standard ASHRAE methodology and modeled against the airport weather data. The parameters were degree day, wind and solar radiation. Multiple regression technique was then used to predict the daily electric consumption compared to weather data. The regression had a standard error of 2.76 and is shown in Figure 6 and Figure 7.

TEST RESULTS

Over the course of the sixty-seven days of data collection, Building A (cellulose) maintained an average temperature of 72.32 degrees F while Building B (fiber glass) maintained an average temperature of 71.98 degrees F. This difference in the average temperature is considered to be insignificant.

The solar radiation and heating degree days were measured on site. There was good correlation between the National Weather Service degree days at Stapleton International Airport and the on-site readings. The weather data showed the site to vary between 5%-29% or an average of 4.7 degrees F warmer due to climatic factors. This may be a result of wind shielding and thermal exchange with the nearby building and the site components. (See Figure 2.)

FIGURE 1. SIXTY-SEVEN DAYS OF DATA COLLECTION ON SITE

1	2	3	4	5	6	7	8	9	10	11	12
Day #	Date	DD	Wind	Radiation	Pred A	Pred B	P A	P B	A A	A B	S W
1	23-Jan	34.50	15.4	1419.02	6.9	9.11					
2	24-Jan	14.10	10.4	1435.56	3.64	4.79					
3	25-Jan	16.13	14.1	1584.37	2.26	2.84					
4	26-Jan	35.52	9.1	1782.80	6.43	8.43					
5	27-Jan	33.48	14.2	1716.66	5.89	7.74	15.3	18	18	24	48
6	28-Jan	25.32	14.3	1733.19	3.43	4.54					
7	29-Jan	25.32	16	1600.91	4.68	6.01					
8	30-Jan	22.26	9.2	1551.30	4.08	5.2					
9	31-Jan	28.38	8.1	1485.16	5.88	7.55	18.9	24.1	18	23	48
10	1-Feb	34.50	7.3	311.14	8.44	10.97					
11	2-Feb	32.46	5.3	1782.80	6.67	8.59					
12	3-Feb	22.26	8.1	1617.45	4.23	5.37					
13	4-Feb	30.42	7.0	1204.06	6.75	8.69					
14	5-Feb	23.28	6.2	1733.19	4.68	5.91	25.9	33.3	31	40	34
15	6-Feb	17.15	5.7	1700.12	2.62	3.27					
16	7-Feb	25.32	8.3	1749.73	4.67	5.98					
17	8-Feb	22.26	8.8	1733.19	3.67	4.70	16.2	17.8	11	14	23
18	9-Feb	12.05	9.9	1600.91	0	0					
19	10-Feb	10.01	16.2	1749.73	0.57	0.60					
20	11-Feb	11.03	9.0	1270.20	1.03	1.25					
21	12-Feb	36.54	9.3	129.25	8.03	10.6					
22	13-Feb	50.83	11.3	129.25	11.88	15.65					
23	14-Feb	55.93	11.0	542.64	14.2	18.5	35.9	43.6	36	47	67
24	15-Feb	43.69	4.2	1683.59	9.78	12.68					
25	16-Feb	32.46	7.6	1600.91	5.95	7.78					
26	17-Feb	31.44	12.8	1633.98	6.51	8.39					
27	18-Feb	30.42	7.9	1319.81	6.72	8.65	32.5	37.1	29	38	33
28	19-Feb	27.36	6	1187.52	6.38	8.14					
29	20-Feb	23.28	3.7	1303.27	4.65	5.94					
30	21-Feb	23.28	7.1	1303.27	4.82	6.15					
31	22-Feb	17.15	6.1	1667.05	2.70	3.37					
32	23-Feb	19.19	7.9	1154.45	3.79	4.81					
33	24-Feb	18.17	6.2	1452.09	3.04	3.85					
34	25-Feb	17.15	8.1	129.25	3.76	4.84					
35	26-Feb	26.34	6.3	493.03	5.26	6.91	34.9	44.4	34	44	52
36	27-Feb	29.40	10.6	129.25	7.34	9.50					
37	28-Feb	19.19	4.4	1286.74	3.87	4.88					
38	1-Mar	21.24	5.4	1782.80	4.10	5.16	15.8	19.4	15	20	20
39	2-Mar	14.09	5.7	1286.74	2.39	2.95					
40	3-Mar	12.05	6.1	1204.06	1.75	2.14					
41	4-Mar	17.15	6.9	906.42	3.24	4.12					

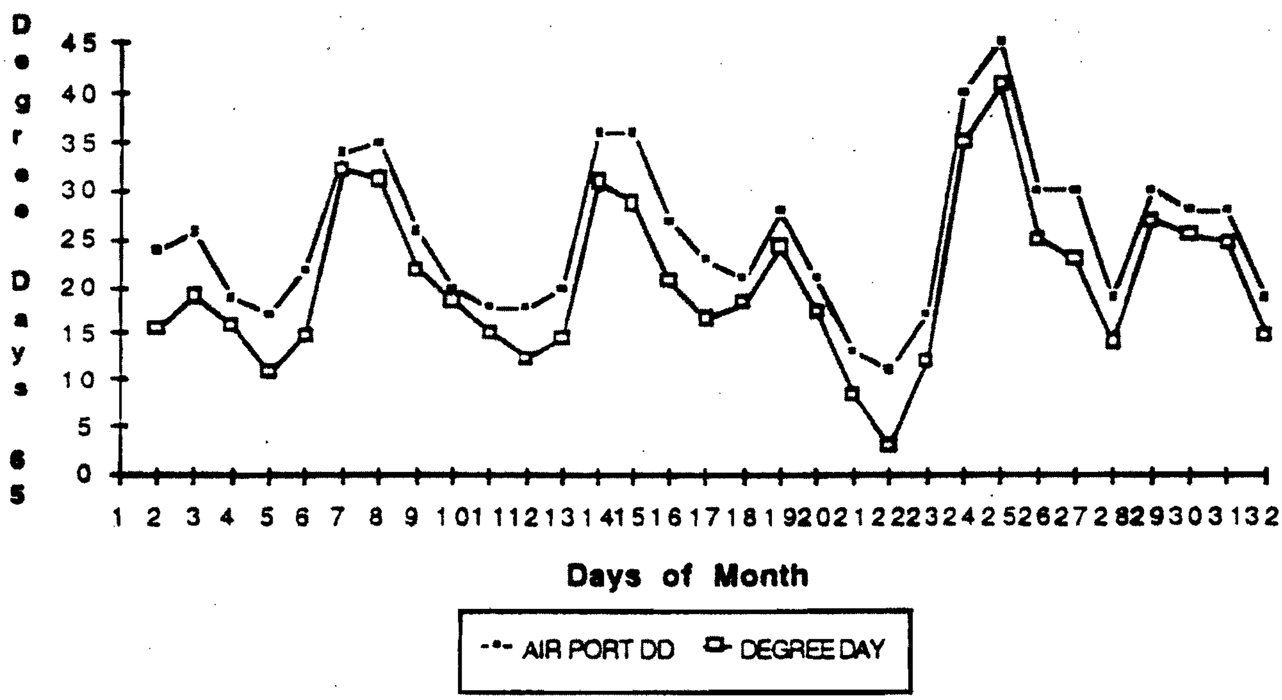
1	2	3	4	5	6	7	8	9	10	11	12
Day #	Date	DD	Wind	Radiation	Pred A	Pred B	P A	P B	A A	A B	S W
42	5-Mar	29.4	7.0	129.25	4.35	6.03					
43	6-Mar	30.42	21.6	939.49	6.95	8.97					
44	7-Mar	21.24	5.8	741.07	4.49	5.77	23.5	30.1	23	29	53
45	8-Mar	15.11	6.5	360.75	3.11	3.98					
46	9-Mar	13.07	6.2	1600.91	1.85	2.22					
47	10-Mar	13.07	6.8	1584.37	2.19	2.64					
48	11-Mar	15.11	4.8	823.74	2.35	3.03					
49	12-Mar	31.44	9.2	129.25	6.99	9.19					
50	13-Mar	31.44	9.5	1650.52	6.60	8.49					
51	14-Mar	22.26	7.3	1385.95	3.88	5.00	28.5	34.7	27	35	50
52	15-Mar	18.17	9.7	1534.77	3.13	3.93					
53	16-Mar	16.13	7.4	757.60	2.98	3.80					
54	17-Mar	23.28	7.4	344.22	5.27	6.82					
55	18-Mar	16.13	6.3	1518.23	2.73	3.39	15.1	17.8	14	18	31
56	19-Mar	7.97	6.6	873.35	0.93	1.06					
57	20-Mar	5.93	6.4	1005.63	0	0					
58	21-Mar	12.05	8.7	1369.41	1.23	1.51					
59	22-Mar	35.52	9.4	211.93	7.61	10.06					
60	23-Mar	40.62	11.9	162.33	9.94	12.97					
61	24-Mar	25.32	6.5	1071.78	5.34	6.87					
62	25-Mar	25.32	6.9	1154.45	5.80	7.39					
63	26-Mar	14.09	4.0	658.39	2.31	2.96					
64	27-Mar	25.32	8.4	129.25	5.64	7.37	39.8	50.4	40	50	69
65	28-Mar	23.28	7.9	129.25	5.66	7.31					
66	29-Mar	23.28	4.7	162.33	5.75	7.40					
67	30-Mar	14.09	4.1	1352.88	2.22	2.74	13.6	17.1	14	17	17

Legend For Figure 1.

1.	Day #	The day of the experiment
2.	Date	Date of the readings, all in 1990
3.	DD	Airport Degree Days 65 F
4.	Wind	Airport Wind Daily Average
5.	Radiation	30 day Site Radiation/Regression using % of Sunshine From Airport
6.	Pred A	Predicted Regression of Electric Use A
7.	Pred B	Predicted Regression of Electric Use B
8.	P A	Period of Actual Readings 4 To 7 Days Totaled For Building A
9.	P B	Period of Actual Readings 4 To 7 Days Totaled For Building B
10.	A A	Period of Predicted Readings 4 To 7 Days Totaled For Building A
11.	A B	Period of Predicted Readings 4 To 7 Days Totaled For Building B
12.	S W	Period of Actual Readings 4 To 7 Days Totaled Average Daily Wind

Figure 2

Measurement of Site Degree Days Versus Airport Degree Days



Performance Before Insulation

Initial testing of the two buildings prior to insulation revealed that Building A had an average air change per hour of 90.8 at 50 $_{pa}$ while Building B had 80.9 air changes at 50 $_{pa}$. The Equivalent Leakage Area (E.L.A.) at 10 $_{pa}$ were 87.5 and 81.52 and their leakage ratios were 23.47 and 20.9 respectively. Therefore, Building B was approximately 12% tighter than Building A. During this same period, Building A used 469 Kwh and Building B used 473 Kwh for a difference of less than 1%. In both buildings there was a large amount of heat loss due to infiltration and low U values of the buildings. Therefore, despite the difference in initial air infiltration, the energy consumption of the two buildings was not significantly different prior to the application of insulation.

After Insulation

Air infiltration testing after insulation in the walls and ceiling and dry-wall on the ceiling only, showed that Building A had an air change at 50_{pa} of 29.45 or a 66.34% reduction in air infiltration. Building A also had an E.L.A. of 24.00 sq. inches 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 comparison, the cellulose insulation tightened the building by roughly 38% more than the fiber glass batt insulation.

After Installation of Interior Dry-Wall

After all dry-wall was installed and taped, and air sealing was completed around the doors and windows, the buildings were tested again with the blower door. Building A had an air change at 50_{pa} of 9.9 or a 66.38% reduction and an E.L.A. of 7.55 sq inches or a 68.5% reduction and a leakage ratio of 1.95 sq. inches per 100 sq. feet of building skin or again 68.5% tighter.

Building B had an air change rate of 15.9 at 50 $_{pa}$ or a reduction of 66.6% and an E.L.A. of 12.8 sq. inches and a leakage ratio of 3.32 for a reduction in air tightness of 70.1%. In other words, the dry-wall made each building between 66.6% and 70% tighter.

FIGURE 3. A COMPARISON OF AIR LEAKAGE BEFORE INSULATION AND DRY -WALL *

Building A (Cellulose)

50 PA	PRESSURE	DE-PRESSURE	AVERAGE
ACH	94.4	87.2	90.8
E.L.A	91.2	83.1	87.5
L.R.	24.4	22.5	23.5
C	2070.9	1872.8	1971.8
n	0.551	0.552	0.551

Building B (Fiber Glass)

50 PA	PRESSURE	DE-PRESSURE	AVERAGE
ACH	79.2	82.6	80.9
E.L.A	84.9	78.1	81.5
L.R.	20.5	21.3	20.9
C	2106.1	1749.6	1927.8
n	0.611	0.548	0.579

*Measurements taken December 12, 1989.

FIGURE 4. A COMPARISON AFTER INSULATION AND WITH DRY-WALL PLACED ON THE CEILING

Building A (Cellulose)

50 PA	PRESSURE	DE-PRESSURE	AVERAGE
ACH	30.2	28.7	29.4
E.L.A	23.4	24.6	24.0
I.R.	6.1	6.4	6.2
C	886.8	777.9	832.5
n	0.716	0.666	0.691

Building B (Fiber Glass)

50 PA	PRESSURE	DE-PRESSURE	AVERAGE
ACH	48.7	47.1	47.9
E.L.A	44.5	41.2	42.8
I.R.	11.5	10.6	11.1
C	1213.7	1250.0	1231.8
n	0.614	0.653	0.633

FIGURE 5. COMPARISON AFTER All DRY-WALL INSTALLED AND AIR SEALING AROUND DOOR AND WINDOW

Building A (Cellulose)

50 PA	PRESSURE	DE-PRESSURE	AVERAGE
ACH	9.9	9.9	9.9
E.L.A	6.9	8.2	7.5
I.R.	1.8	2.1	1.9
C	322.3	299.1	310.7
n	0.778	0.736	0.757

Building B (Fiber Glass)

50 PA	PRESSURE	DE-PRESSURE	AVERAGE
ACH	15.3	16.5	15.9
E.L.A	12.0	13.6	12.8
I.R.	3.1	3.5	3.3
C	439.2	454.2	446.7
n	0.702	0.676	0.689

FIGURE 6. SUMMARY OF INCREASED TIGHTNESS AT EACH STAGE OF CONSTRUCTION

	Building A (Cellulose)				Building B (Fiber Glass)		
	Before Insulation	After Insulation	After Dry-Wall		Before Insulation	After Insulation	After Dry-Wall
50 PA ACH	87.5	29.4	9.9		81.5	47.9	15.9
E.L.A.	90.8	24.0	7.5		80.9	42.8	12.8
I.R.	23.5	6.2	1.9		20.9	11.1	3.3

Conclusion of Test Results

The total electric usage over the sixty-seven day test period showed that Building A used 315.75 Kwh's while Building B used 387.6 Kwhs, a difference of 71.85 Kwh. Building B used about 22% more Kwhs. Figure 7 and Figure 8 indicate the difference between the modeled performance and actual performance of the two buildings.

Figure 7

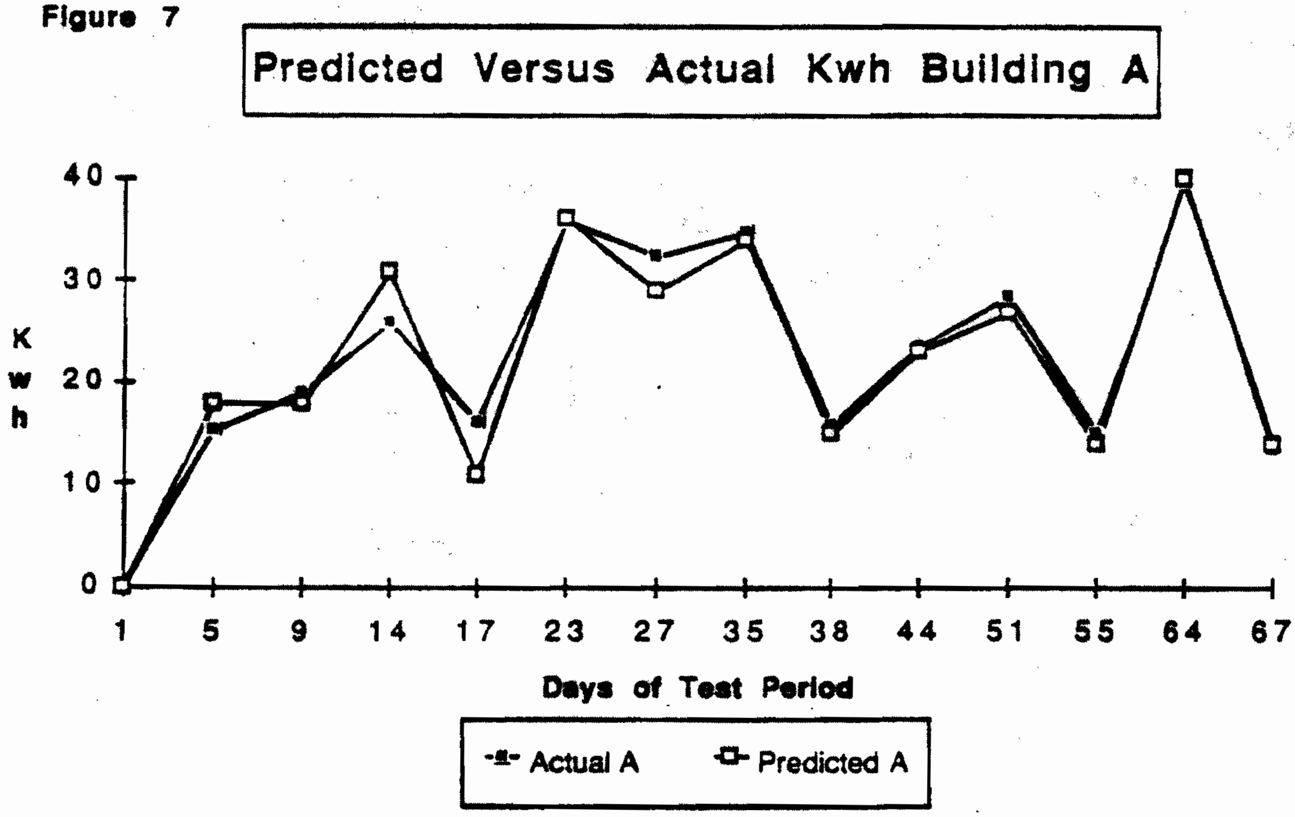
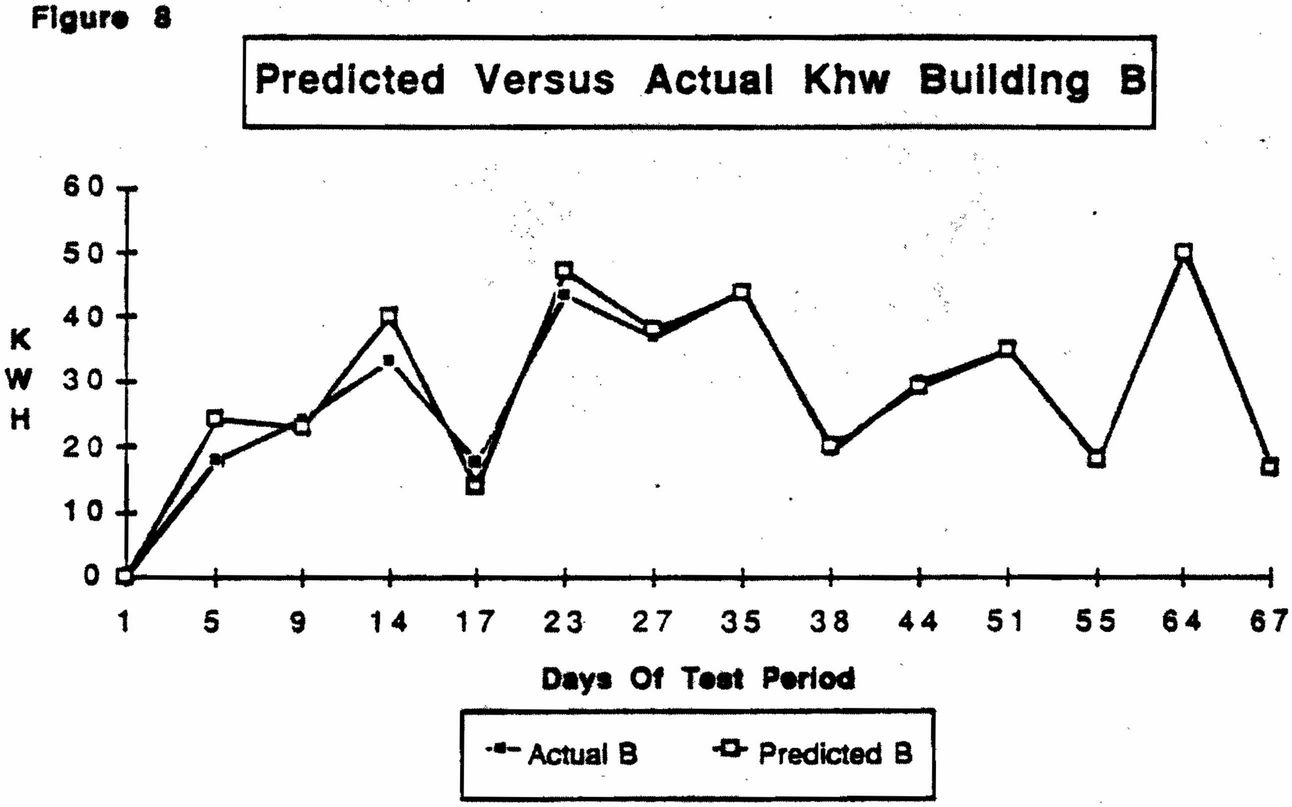
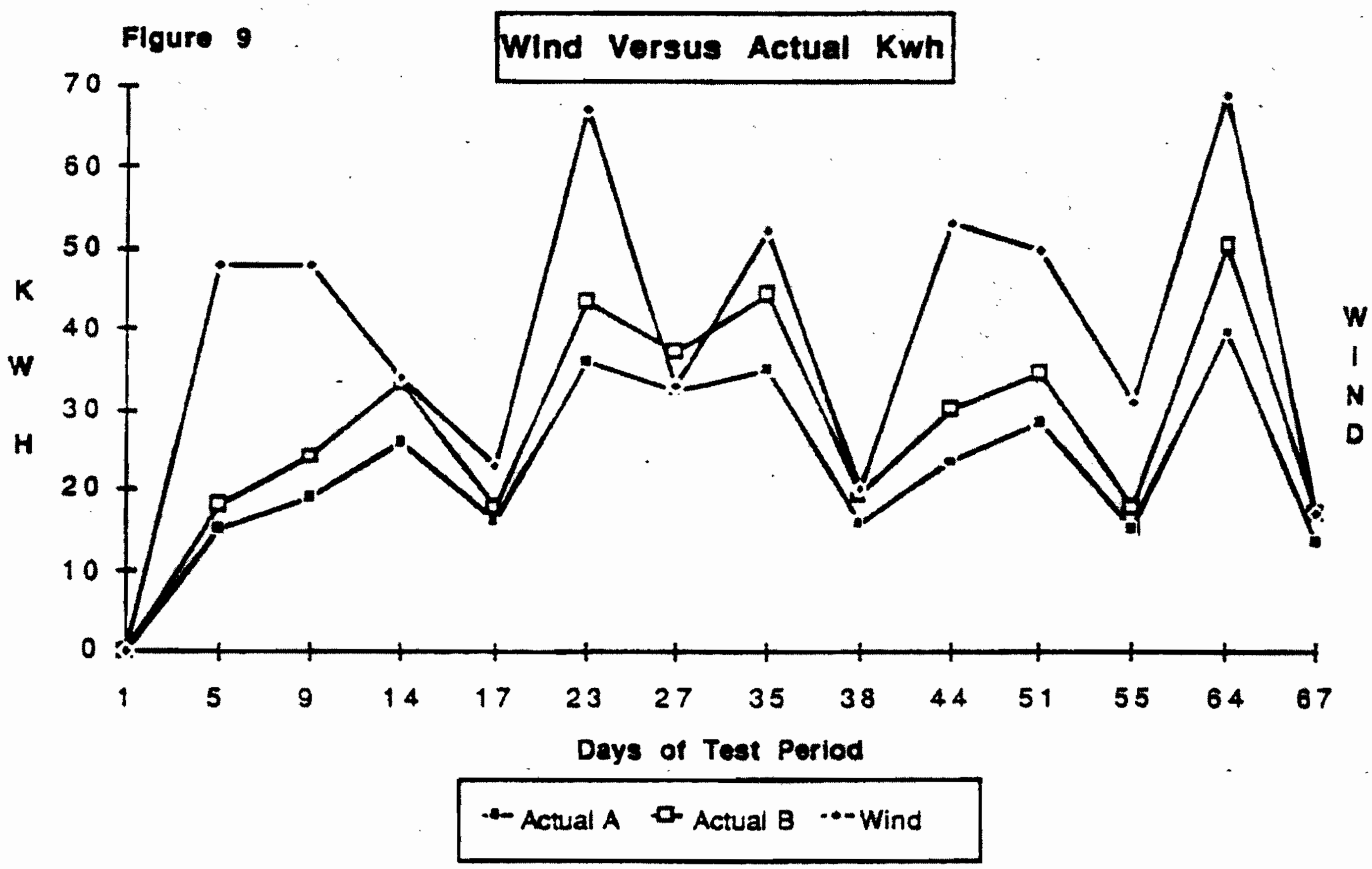


Figure 8


Predicted Versus Actual Khw Building B
60
50
40
30
20
10
0
KWH
1
5
9
14
17
23
27
35
38
44
51
55
64
67
Days Of Test Period
Actual B
Predicted B

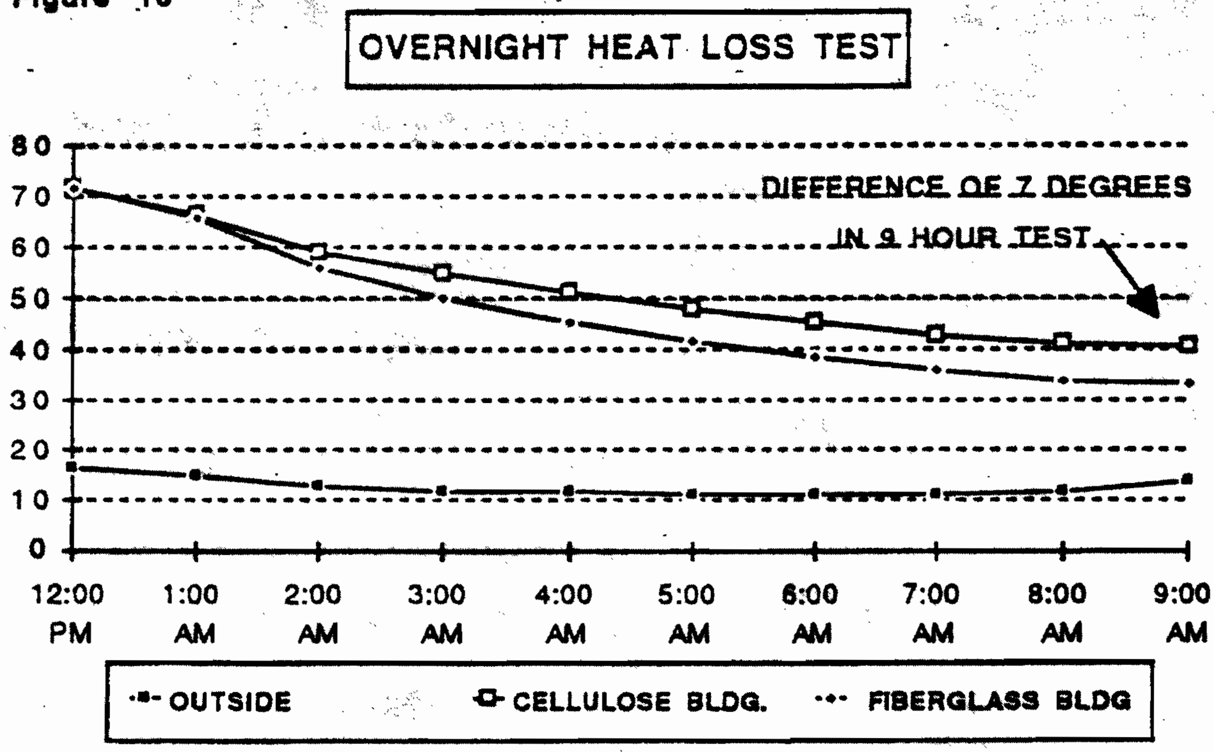
The wind component and electrical usage show significant relationship as seen by Figure 9. This plot is for between 4 and 8 day periods of time when the meters were physically read (summation of electric use for those days) versus the summation of the average wind over that same period.

Figure 9



The overnight heat loss test showed that the cellulose building maintained 7 degrees F more heat over a 9 hour period. This indicates that Building A had a better overall U value. Since the pre-insulation test of the buildings reflected nearly identical performance, it may be concluded that the superior overall U value was due to the insulation installed.

Figure 10



The moisture readings taken in the insulated buildings after one week, two weeks, and again after 5 weeks revealed that the wood studs in Building B remained constant (around 9%) while the wood studs in Building A rose as high as 17% moisture content. The cellulose insulation was installed with approximately 70% moisture which is more than the 55% that is recommended. This application is not atypical. The relative humidity in Building A remained higher than in Building B for a period of 6 weeks indicating that the cellulose and wood studs were still releasing moisture. At no time did any of the studs tested go over 22%. This is due in part to the lack of an interior vapor retarder thus allowing diffusion of the water used to install the cellulose.

ANALYSIS OF RESULTS

This study utilized the following analysis to determine if the difference in heat loss between the two test buildings was a result of the difference in air infiltration quality of the two types of insulation and/or their insulating performance. The conclusion was that this difference is due mainly to air infiltration. This was determined by examining the equation

$$Q = L\,(A\ \Delta t + B v^2)^{1/2}$$

Q = airflow in cfm
L = effective leakage area in square inches
A = stack coefficient $(cfm)^2\ in^{-4}\ (f)^{-1}$
Δt = average indoor-outdoor temperature difference for the time interval of calculation ° F
B = wind coefficient $(cfm)^2\ in^{-4}\ (mph)^{-2}$
v = average wind speed measured at a local weather station for the time interval of interest, mph
I = Estimated air change per hour (cfm x 60 min/hr) / volume

For Building A
$Q = 7.55((0.0156)26) + (0.0039 \times 7.5^2)^{1/2}$
$Q = 5.96$ cfm = 358 ft^3/ h

$I = (358\ ft^3/h) / 387\ ft^3$
I = .925 A.C.H.

The number of kilowatts of electricity is calculated by the following formula:

Kwh/day =(FPM *1.08*ELA* Δt *24)/(Btu's per Kwh)

ELA=Equivalent Leakage Area in square feet

Kwh/day = (FPM * 1.08 * ELA * Δt * 24)/ (3412 Btu)

Using the National Weather Service data for daily average wind speed and degree days from Stapleton International Airport, the following results are obtained.

cfm= 4 Mph * 88 = 352 FPM
BTU/hr= 352 * 1.08 * (7.55 / 144) .052 * 26 *24 / 3412
Kwh/day =3.61 khw potentially due to air infiltration

These calculations do not take into consideration the shielding effect that was present at the test site from the surrounding buildings. With the shielding factor included, the results would be lower.

For Building B

$Q = 12.8((0.0156)26) + (0.0039 \times 7.5^2)^{1/2}$
$Q = 10.11$ cfm = 607 ft^3/h

$I = (607\ ft^3/h) / 387\ ft^3$
I = 1.57 A.C.H.

Kwh/day = (FPM * 1.08 * ELA sq Ft * Δt * 24)/ (3412 Btu)

Again, using the data from National Weather Service which did not account for the shielding effect of the surrounding buildings at the test site, the following results are calculated.

cfm= 4 Mph * 88 = 352 FPM
BTU/h= 352 * 1.08 * (12.8 / 144) .089 * 26 *24 / 3412 Btu's
Kwh/day = 6.19 khw potentially due to air infiltration

The buildings were well shielded and may have only experienced 4 mph winds on an average compared to the airport which had an average of 7.9 mph for the month of February and 7.9 mph for the month of March. This difference in wind velocity could account for much of the difference in the calculated heat loss versus the actual heat loss.

In the first set of equations using the ASHRAE formulation developed at Lawrence Berkley Laboratories the difference between the (I) estimated air exchange of the buildings is 59%. These calculations take into account the height and shielding of the buildings. The weighted value of estimated air exchanges in relationship to the percent of the total heat loss of each building shows the cellulose building would use 46% fewer btu's per day.

The second set of infiltration calculations show a 58% difference in estimated Khw/day assuming an average wind speed of 4 mph.

FIGURE 11. Heat Loss for Building A

	U-value	Area in sq. ft	Δ t	Btu/h	% of Heat Loss
Roof	0.0288	49.00	26°	36.69	3.3%
Walls	0.0413	169.75	26°	182.15	16.4%
Glass	0.59	6.00	26°	92.04	8.3%
Door	0.39	20.25	26°	205.33	18.5%
Floors	0.0617	49.00	26°	78.60	7.1%
Air Infiltration @ 352 FPM*	1.08	0.052	26°	553.50	46.4%

FIGURE 12. Heat Loss for Building B

	U-value	Area in sq. ft	Δ t	Btu/h	% of Heat Loss
Roof	0.0288	49.00	26°	36.69	2.5%
Walls	0.0467	169.75	26°	205.95	13.8%
Glass	0.59	6.00	26°	92.04	6.1%
Door	0.39	20.25	26°	205.33	13.7%
Floors	0.0617	49.00	26°	78.6	5.2%
Air Infiltration @ 352 FPM*	1.08	0.089	26°	879.7	58.7%

CONCLUSION

The uninsulated buildings had readings that showed a small difference in air infiltration and virtually no difference in their energy usage. However, after insulation was installed a significant difference was found. The cellulose building used a total of 315.75 Kwh between January 25, 1990 and March 31, 1990, while the fiber glass building used 387.6 Kwh during the same period. This represents more than a 22% difference in energy usage. The analysis of findings suggests that part of this difference is due to the unequal rate in air infiltration between the two buildings. The cellulose insulation alone tightened Building A approximately 38% more than fiber glass insulation tightened Building B. This was the case both before and after dry-wall installation. The dry-wall had a relatively equal effect on both buildings and was therefore not a significant factor when comparing the tightness between the two buildings. It is clear that the degree in tightness is due to the type of insulation used.

The reduction in air infiltration resulting from the cellulose insulation improved the energy consumption. Under more normal conditions where there is less shielding, the difference in performance could be even greater. Based on ASHRAE calculations procedure, air infiltration accounts for 20-60% of the heat loss of a building, depending on other thermal related components. Calculations indicate that air infiltration accounts for 46% of the heat loss in Building A and 59% in Building B. The installed R-Value as per the manufacturer of the cellulose was 15.6 % greater than the installed R-Value as per the manufacturer of the fiber glass wall insulation. This however would account for 14% in conductive loss through the sidewalls and only a small percentage (1%) of the overall difference in performance.

The shielding of the site from high wind by a 20 foot building only 12 feet from it reduced the amount of air infiltration in the test buildings from what could have normally occurred. The site also had a large thermal mass due to the asphalt pavement and the large dark building directly to the north radiating heat. This could partially explain the difference in site degree days versus the National Weather Service degree days from the airport. These factors greatly affect the micro climate of each building site. Therefore these relative percentages of heat loss when cellulose is used compared to the use of fiber glass may be on the low side. It is anticipated that the performance would depend on the site and shielding of the building.

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