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Fairbanks Wall System Study

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FAIRBANKS WALL SYSTEM STUDY

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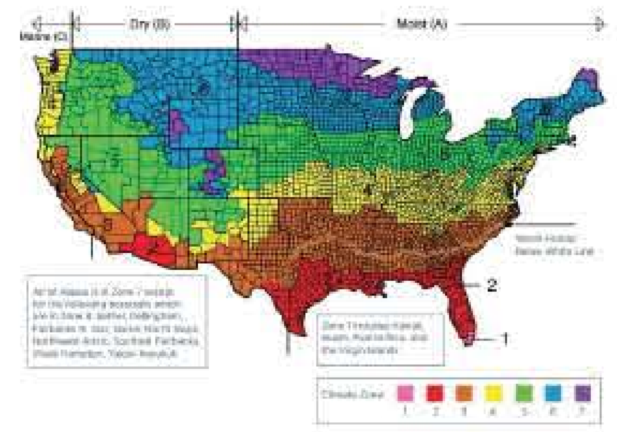
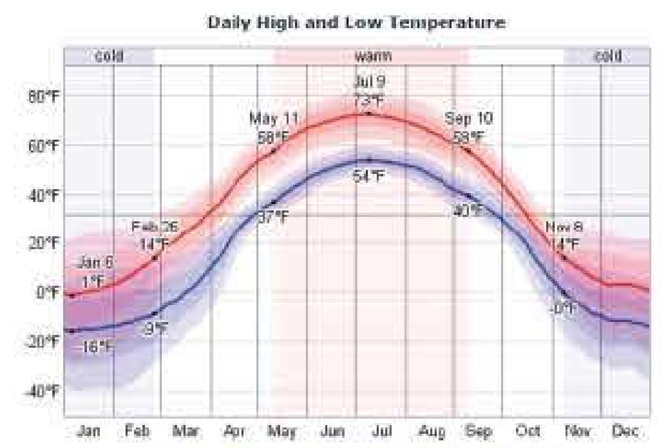
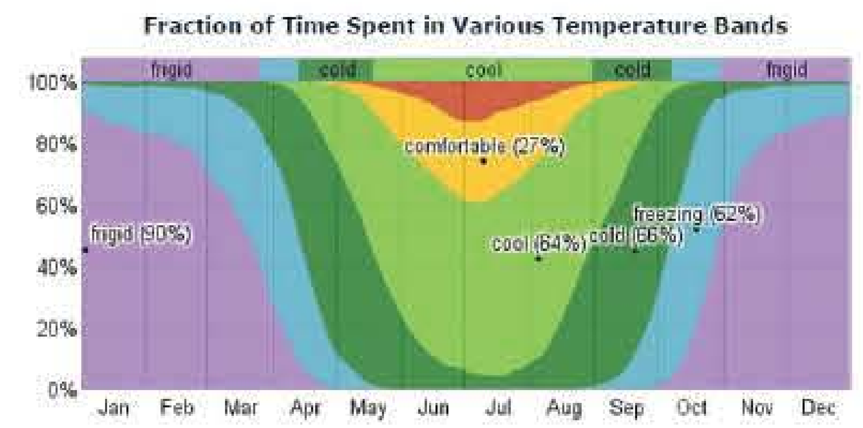
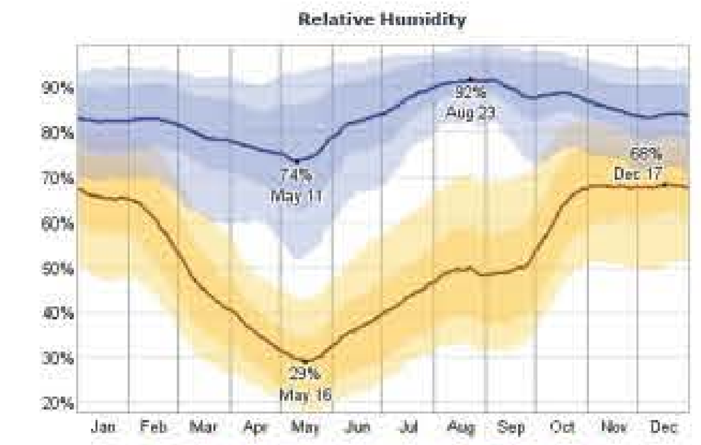
Portland State UNIVERSITY
ZGF
ZIMMER GUNSUL FRASCA ARCHITECTS LLP





Temperature Varies from -16-73 degrees Fahrenheit





Relative Humidity ranges from 29% (dry) to 92% (very humid)

Abstract

The purpose of this study was to understand and develop the best wall system possible for ZGF Architects to potentially implement into future projects in the city of Fairbanks, Alaska that requires a wall system to reach at least R-30. ZGF has been working on an 80,000 square foot surgical addition to the Fairbanks Memorial Hospital and ask for our research to inform future insulation system selections. The extreme climate of Fairbanks, Alaska is what makes this project unique and challenging and then you add to that a medical program that requires different interior temperatures for each program. The hospital currently uses an EFIS wall system and ZGF would like to skin the addition with a rainscreen system. They expect that this system will out perform the current system and be more sustainable. Throughout the process we have been working alongside Liz Rhodes and Rich Shiga, they have helped us orient our research and kept us on the path to understanding insulation in Fairbanks, Alaska. Our goal throughout this process has been to understand insulation types better, their application in a wall system and tried to achieve that through research and testing using digital media. Following several weeks of researching different insulation types we began to select the most viable one's for Fairbanks alongside our representatives from ZGF Architects. After selecting eight insulation types from our research we began to eliminate them in order to begin testing the best assemblies. We have three assemblies to show today that we selected based on extensive research and from that we discovered the most effective system based on the REMOTE wall system strategy. Of the three we discovered that the most effective combination was Closed-cell Polyurethane Spray Foam with Mineral Wool closer to the exterior facade. The REMOTE wall system has two-thirds of the insulation on the outside of the framed in wall and one-third is within the stud frame. In order to test each system we used a combination of WUFI and the Dew Point Calculator. These tools allowed us to measure dew point and relative humidity for each wall assembly, WUFI is able to calculate the system in layers, however one weakness it has is it can't account for thermal bridging through attachment points such as the hardware used in the system. After using both systems to run test, it would make sense to use a different digital media that looks at relative humidity and dew point from three dimensions.

Research

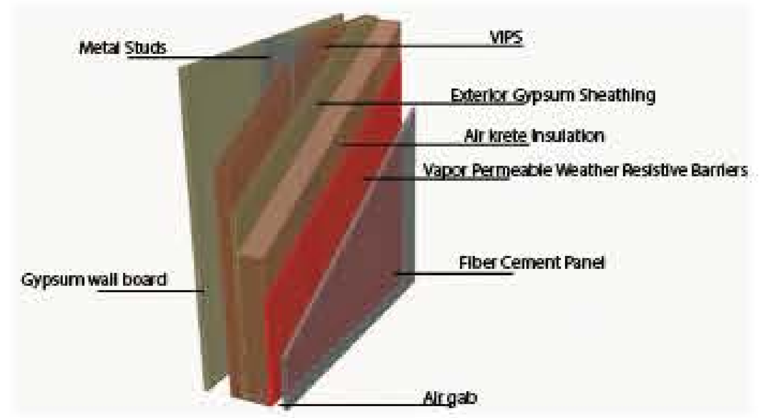
The city of Fairbanks has one of the shortest construction windows in the country because of the extreme change in temperature that can happen at any time. Construction usually happens between June and September when the weather is relatively fair that means in that short window a building has to be weather sealed and the work completed much faster then the lower 48 in order to continue work inside a heated envelope during the winter months. Temperatures range from -16 in the winter to 73 degrees Fahrenheit in the summer, it can also be very humid ranging from only 29% humidity that is dry to 92% that is quite humid. It is because of the moisture penetration from the outside elements that makes a double wall system so important for the city of Fairbanks, Alaska. Finding ways to control the dew point and the moisture penetration is why ZGF Architects decided on a rainscreen wall system in the first place. A rainscreen system is the "first line of defense that minimizes rainwater passage into the wall by minimizing the number and size of holes and managing the driving forces acting on the wall." As quoted by the AIA in regard to G.K. Garden's paper, the rain screen principle requires wind, gravity, surface tension, capillary action and differences in pressure.

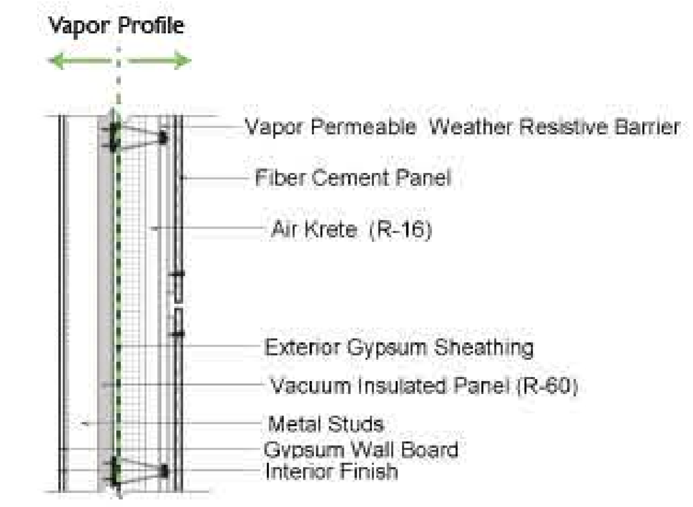
The rainscreen system seems like a fine strategy for a climate like Portland or Seattle where rain is a problem and its removal away from the wall assembly is key. However, what happens when excess water collects at the base of the wall does it find its way into the foundation or does it evaporate through the gravel and dirt at the base of the wall. Through this process we gathered information about several wall systems such as mineral wool, cellulose, cotton, fiberglass batts, VIPs, Air Krete and both open and closed-cell polyurethane spray foam. From that research we found mineral wool, closed-cell polyurethane spray foam, Air Krete and VIPs to have the best potential in Fairbanks. When Air Krete is combined with VIP panels in a REMOTE wall system it creates the worst wall system for Fairbanks, Alaska despite the VIP panels high R-Value. In that system the VIP has to be placed in between the studs rather than the outside envelope where it is much more effective. The Vacuum Insulated Panel is a relatively new product for building envelopes, having served primarily as insulation for refrigerated trucks and other transit applications.

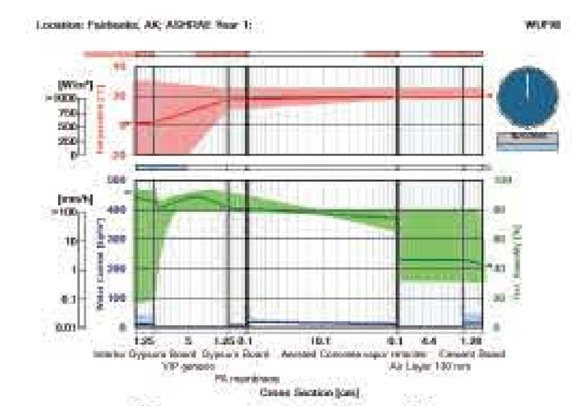
Using WUFI, each assembly has shown more or less the best way to combine the different materials into an effective wall system. However, as in the case VIP and Air Krete combination that doesn't necessarily mean that they would work for the climate of Fairbanks, Alaska. The VIP panel has the potential to change cold climate wall systems as a singular element, but as a part of system it doesn't work so well and is expensive. Mineral Wool was the system that ZGF first began to push and we have found through our research that it not only works well as a singular combination but it also works well with other materials such Air Krete and closed-cell polyurethane spray foam. The purpose of this research has been to find the ideal combination of insulation within a rainscreen wall system and we have done so by combining different materials into a wall system. But, that might not be the right answer, because as our research has shown part of it has been to combine sprayed materials with panels and sheets as in the case of the VIP and Air Krete combination. This combination may seem viable, but what happens to the Air Krete during installation, does it require an additional stud frame on the exterior that would then drastically increase the size of the wall and affect thermal bridging.

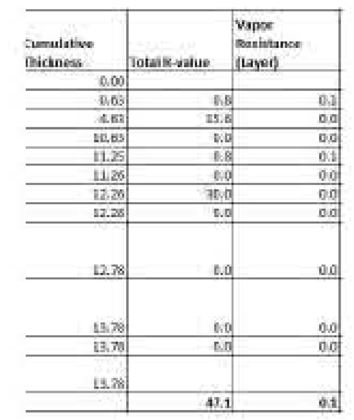
Testing

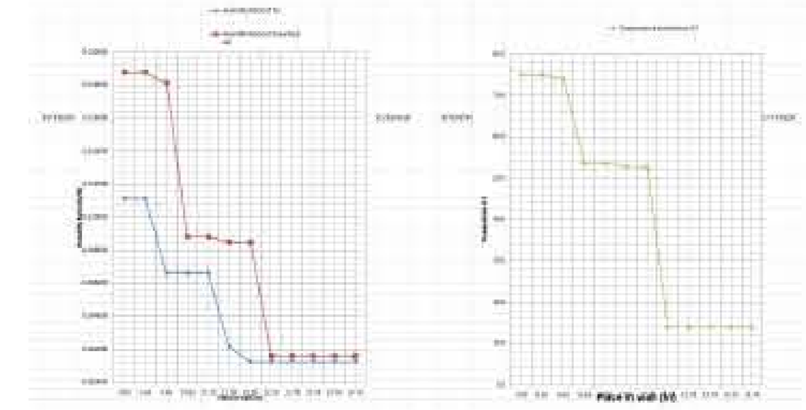
The REMOTE Wall System is a strategy designed especially for extremely cold climates like Fairbanks, Alaska. Unlike the conventional wall system, this system attaches the vapor barrier to the outside of the sheathing rather then inside the stud frame. Two-thirds of the insulative value is moved to the outside on top of the vapor barrier and the remaining one-third is placed inside the wall cavity. The purpose is to install as much insulation as you can inside the heated envelope while keeping the dew point on the exterior of the vapor barrier. Having learned that we moved into the next step, testing our top three wall systems based on the research that we did with the Dew Point Calculator and WUFI. WUFI takes the layers and runs a two year simulation and the results allow you to see how the wall responded to water penetration within the system. The idea is that it should have an unobstructed path through the system as shown in the graphs. Relative humidity is represented in green and the least amount of water trapped inside of the system appears larger because it worked to expel excess water rather then stop it all together. Compare that to the VIP and Air Krete combination were as soon as it hits the insulation it begins to have errors pop up because it is having trouble expelling the water within the system. VIPs are advertised as moisture resistant and as it shows in the graph they are. What WUFI examines is the systems ability to expel water, but as you can see there is still almost 2 kg of water per meter squared in the assembly. That is why this system may not be the best, because what we wanted to do is control condensation from getting through the envelope and this program seems to show that the best systems allow water to get through freely so that they don't remain in the system and create problems with mold and mildew.



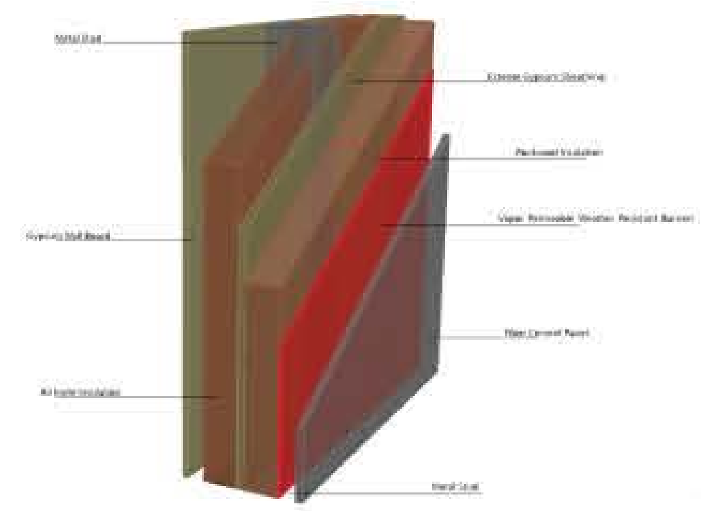


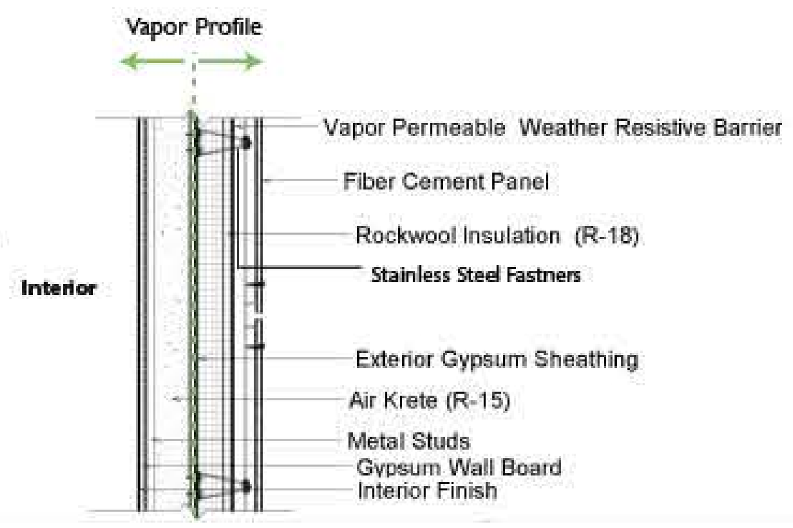


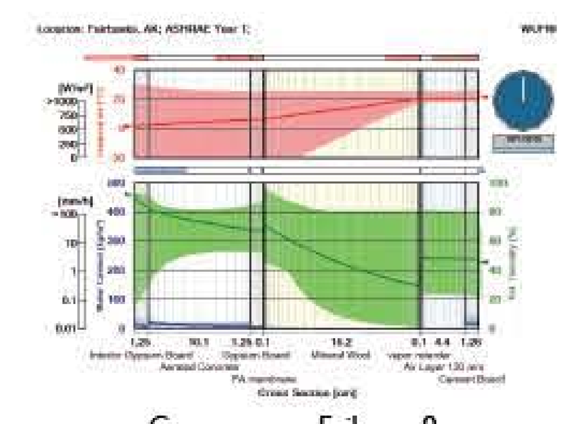


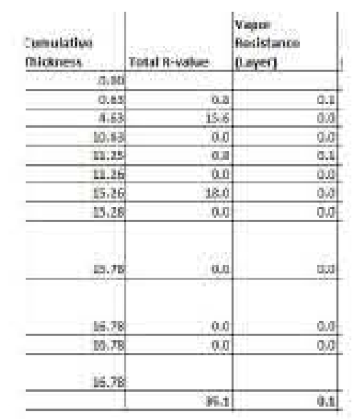


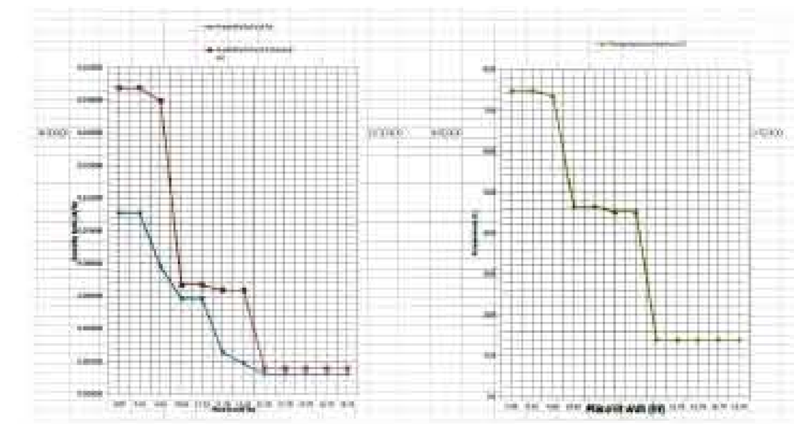
Convergence Failures: 15
Water Content: 1.98 kg/m^2



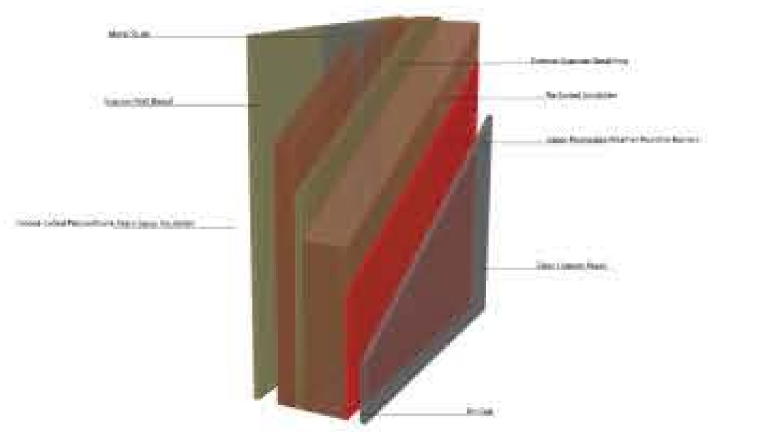


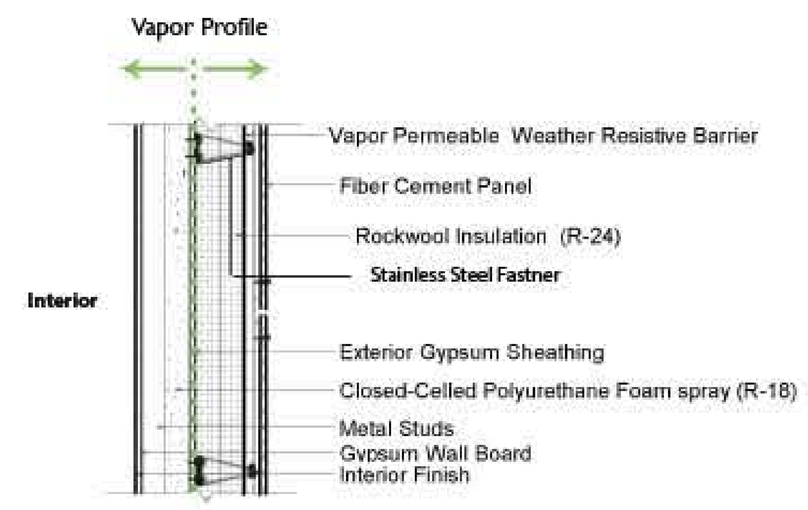


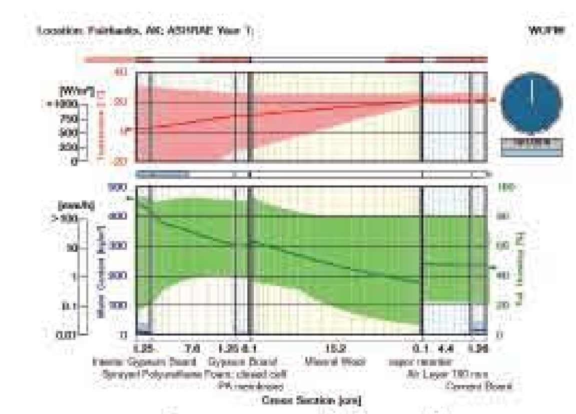


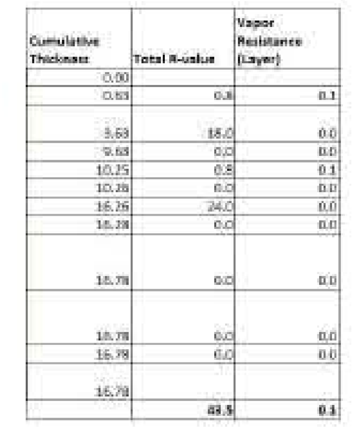


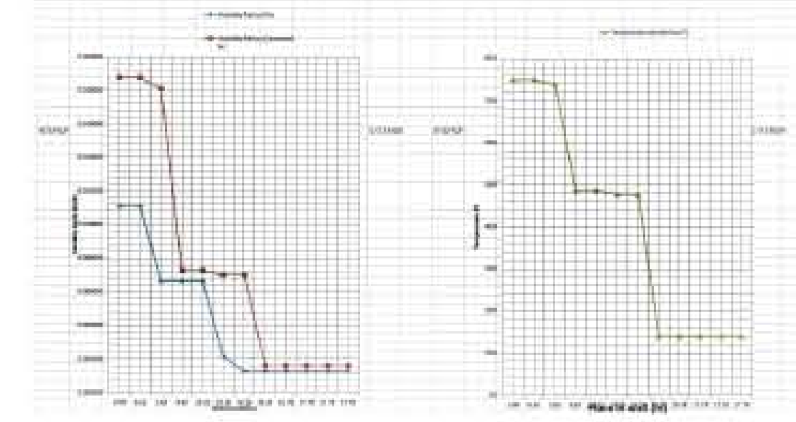
Convergence Failures: 9
Water Content: 1.74 kg/m^2











Convergence Failures: 5
Water Content: 0.54 kg/m^2

-R-Value of 30 per inch
-1/4-2" thick sheets
-3-5 dollars per panel
-Pros: Fire resistant, more efficient then other insulation types, moisture resistant and nearly 100% recyclable
-Cons: Fumed silica core is expensive to produce, cannot be punctured and requires specialist to cut

VACUUM INSULATED PANELS

-R-Value of 6-6.5 per inch
-Can be sprayed up to 8" thick
-1.75-3 dollars per square foot
-Pros: Reduces the risk of moisture penetration, adds structural integrity to the wall and is a good vapor retarder
-Cons: The Blowing agent has a high global warming potential, must be protected from fire and is relatively expensive

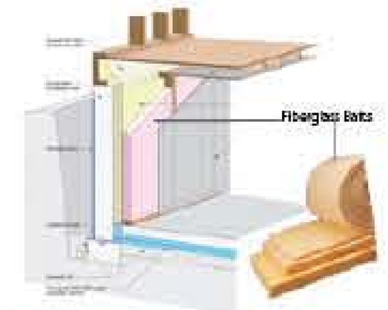
CLOSED- CELLED POLYURETHANE SPRAY FOAM

ROCKWOOL BATTS

-R-Value of 4-5 per inch
-Comes in a variety of thickness
-60 cents per square foot
-Pros: Fire resistant, lightweight, simple to install, produced from a renewable naturally occuring volcanic rock
-Cons: Contains crystalline silica that if inhaled over a long period could cause lung diseases including cancer

AIR KRETE

-R-Value of 3.9-6 per inch
-2.07 lbs per cubic foot is the density
-30-50 cents per board foot
-Pros: Fire resistant, moisture resistant, fully recyclable and doesn't shrink, settle or expand over time
-Cons: Cured foam is extremely fragile and vibration can cause the foam to disintegrate



FIBERGLASS BATTS

-R-Value of 3.5-3.6 per inch
-3.5-14" thick
-30 cents per square foot
-Pros: Widely available, fire resistant, won't settle over time and no expert needed to install
-Cons: Small punctures or holes can cause huge losses in R-Value and requires 10 times as much energy as cellulose insulation

OPEN-CE LLED POLYURETHANE SPRAY FOAM

-R-Value of 3.5 per inch
-Can be sprayed up to 12" thick
-1-1.20 per square foot
-Pros: Reduces moisture penetration, outdoor allergens and pollutants, provides thermal insulation and reduces air infiltration
-Cons: Must be protected from fire, allows water vapor to pass through and chemicals and VOCs release during application that can cause asthma and other health effects

"Airkrete." Airkrete. N.p., n.d. Web. 10 Dec. 2014. "Product Data Sheet." EcoTouch Pink Fiberglass. Owens Corning, n.d. Web. 10 Dec. 2014. "ROXUL CAVITYROCK® MD & DD." ROXUL CAVITYROCK® Performance Rainscreen Insulation System. N.p., n.d. Web. 10 Dec. 2014.
"Spray Foam Insulation - Insulation - CertainTeed." Spray Foam Insulation - Insulation - CertainTeed. N.p., n.d. Web. 10 Dec. 2014. "What Are Vacuum Insulation Panels? | Thermocor VIPs." What Are Vacuum Insulation Panels? | Thermocor VIPs. N.p., n.d. Web. 10 Dec. 2014.