OAK RIDGE National Laboratory

Transformative Building Envelope Retrofit Using Insulation-Inflatable Walls

Final report

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ORNL is managed by UT-Battelle, LLC for the US Department of Energy

U.S. DEPARTMENT OF ENERGY

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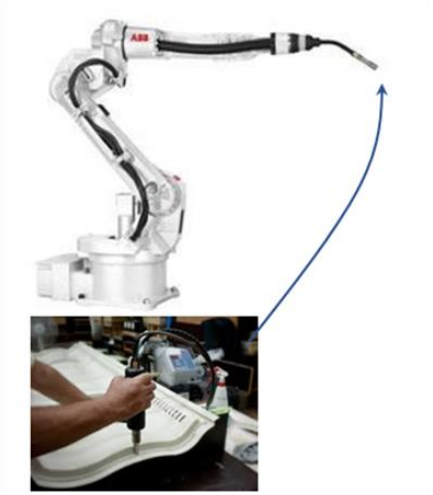
Retrofit improvement process using inflatable-insulation wall system

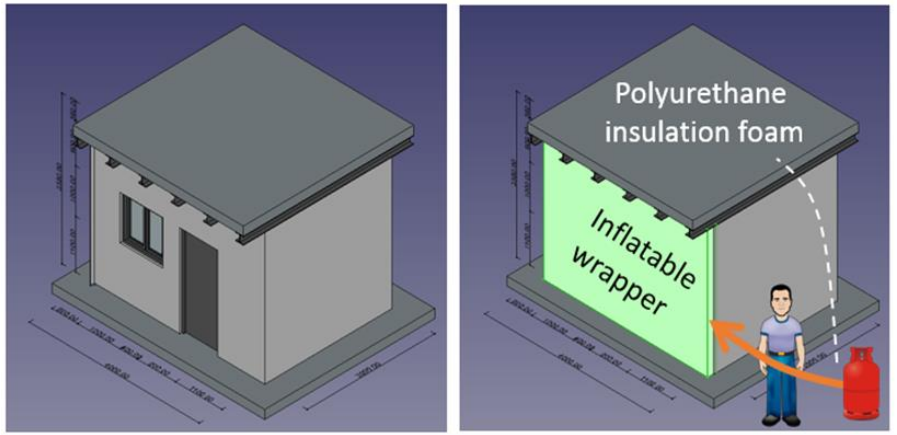
Before

After

Step 1
(Measurements)



Step 2
(Fabrication)



Step 3
(Installation)

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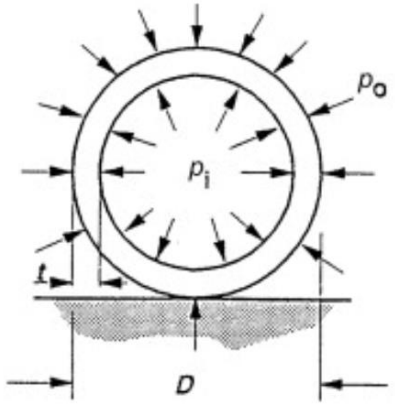
5566·2265
POLICÍA


FlyingAir


OUTDOORSMAN

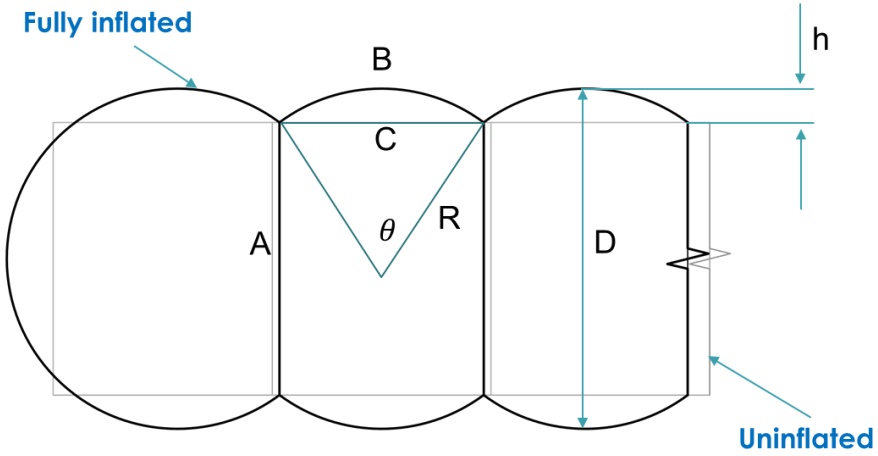
Hoop stress

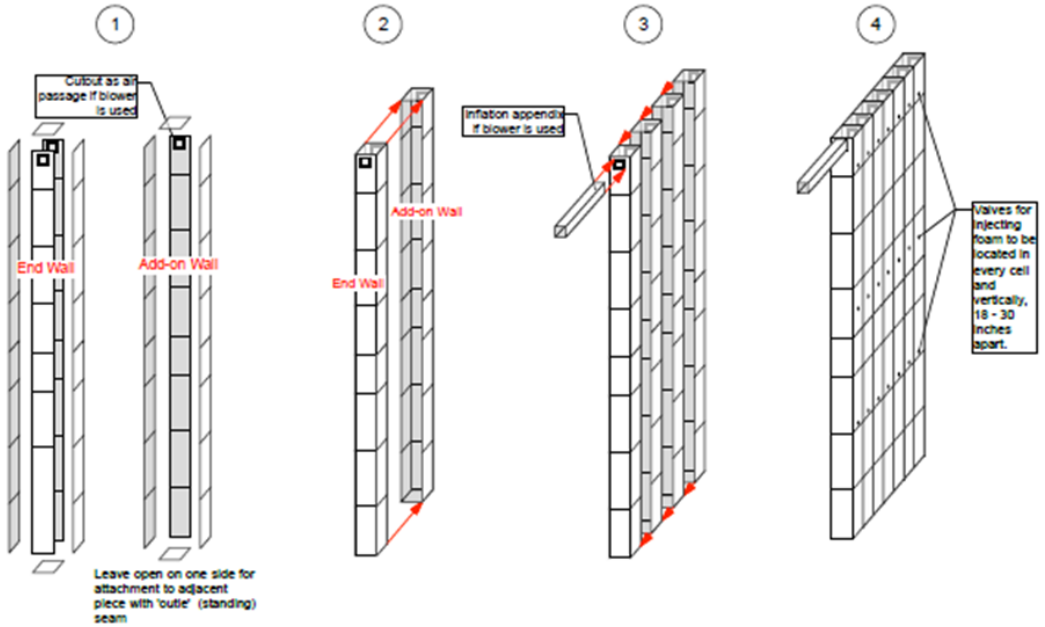
$$\sigma_h = \frac{(\rho_i - \rho_o)D}{2t}$$



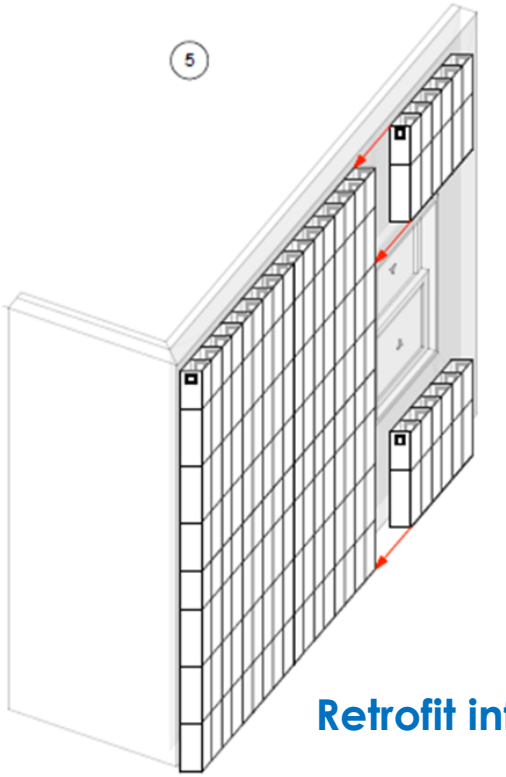
Central angle

$$\theta = \frac{B}{2} cos^{-1}\left(\frac{A\theta}{2B}\right)$$





Unit cell



Retrofit inflatable structure

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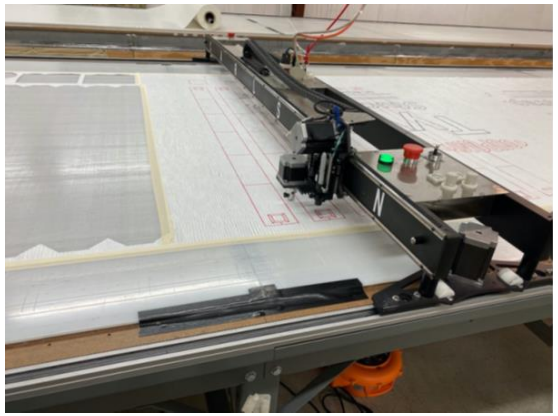
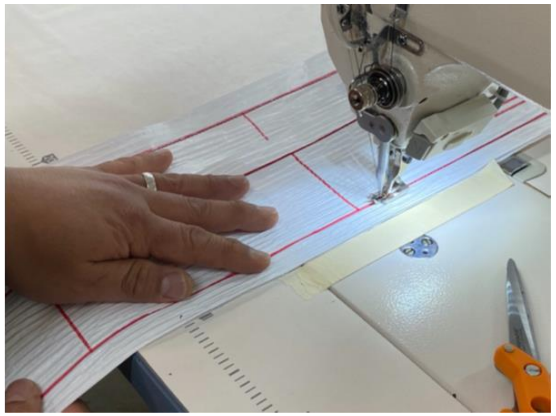
Fabrication



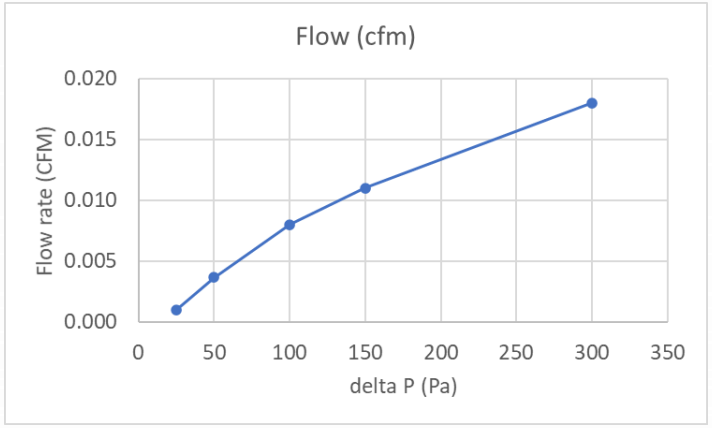


Finished structures

Preliminary performance evaluation

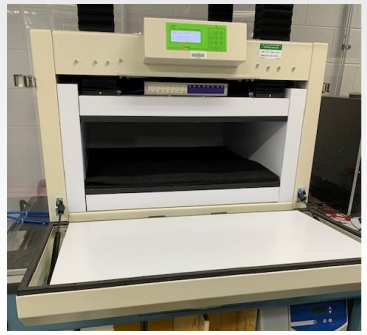
Air permeance

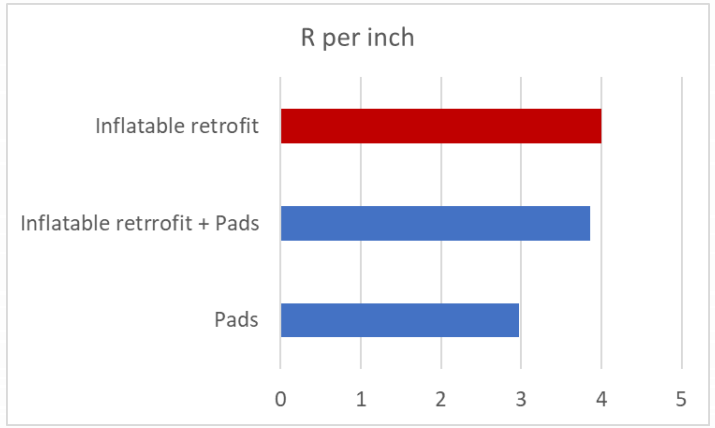
- ASTM E2178, Standard Test Method for Air Permeance of Building Materials



Thermal performance

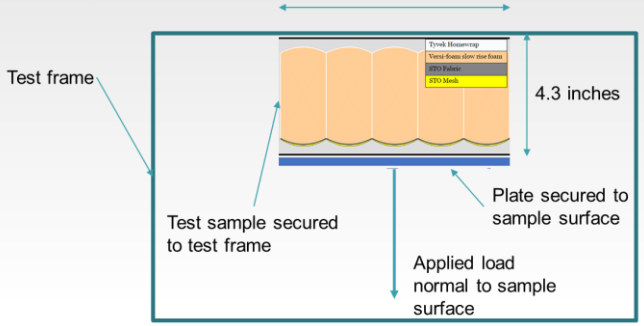
- ASTM C518, Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus

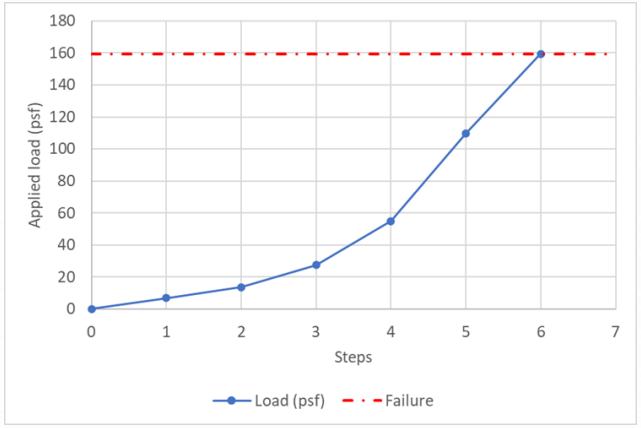




Structural testing

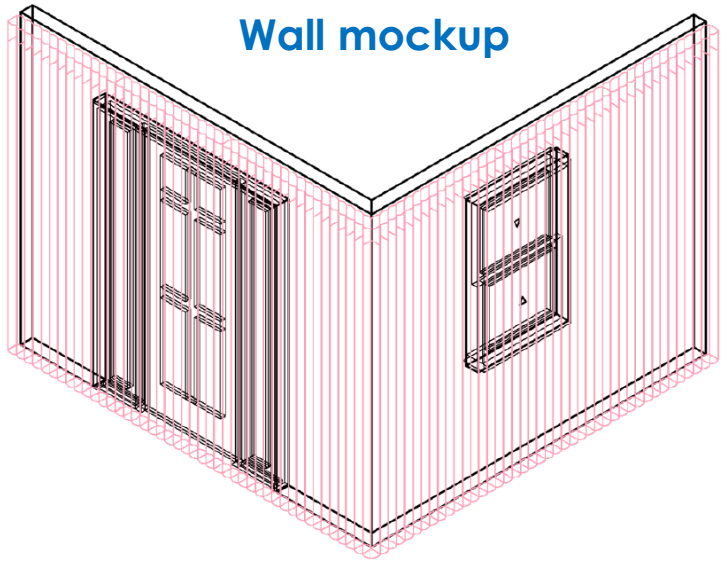
- Tensile testing of inflatable retrofit systems installed on oriented strand board exterior sheathing



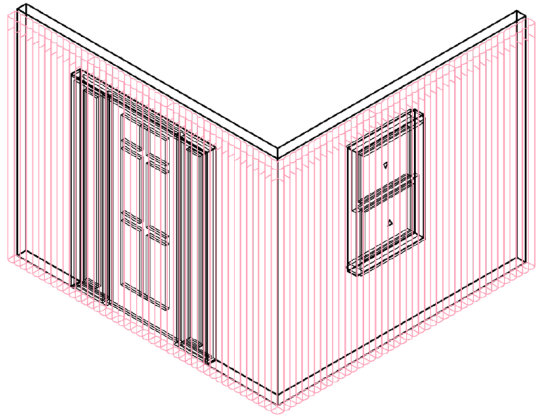


Test enclosure

Wall mockup



Installation



Installation

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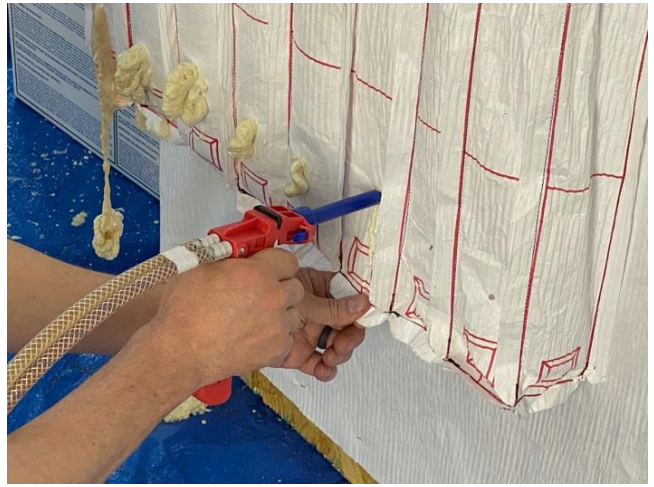
Application of spray foam insulation

(1)



(2)

(3)

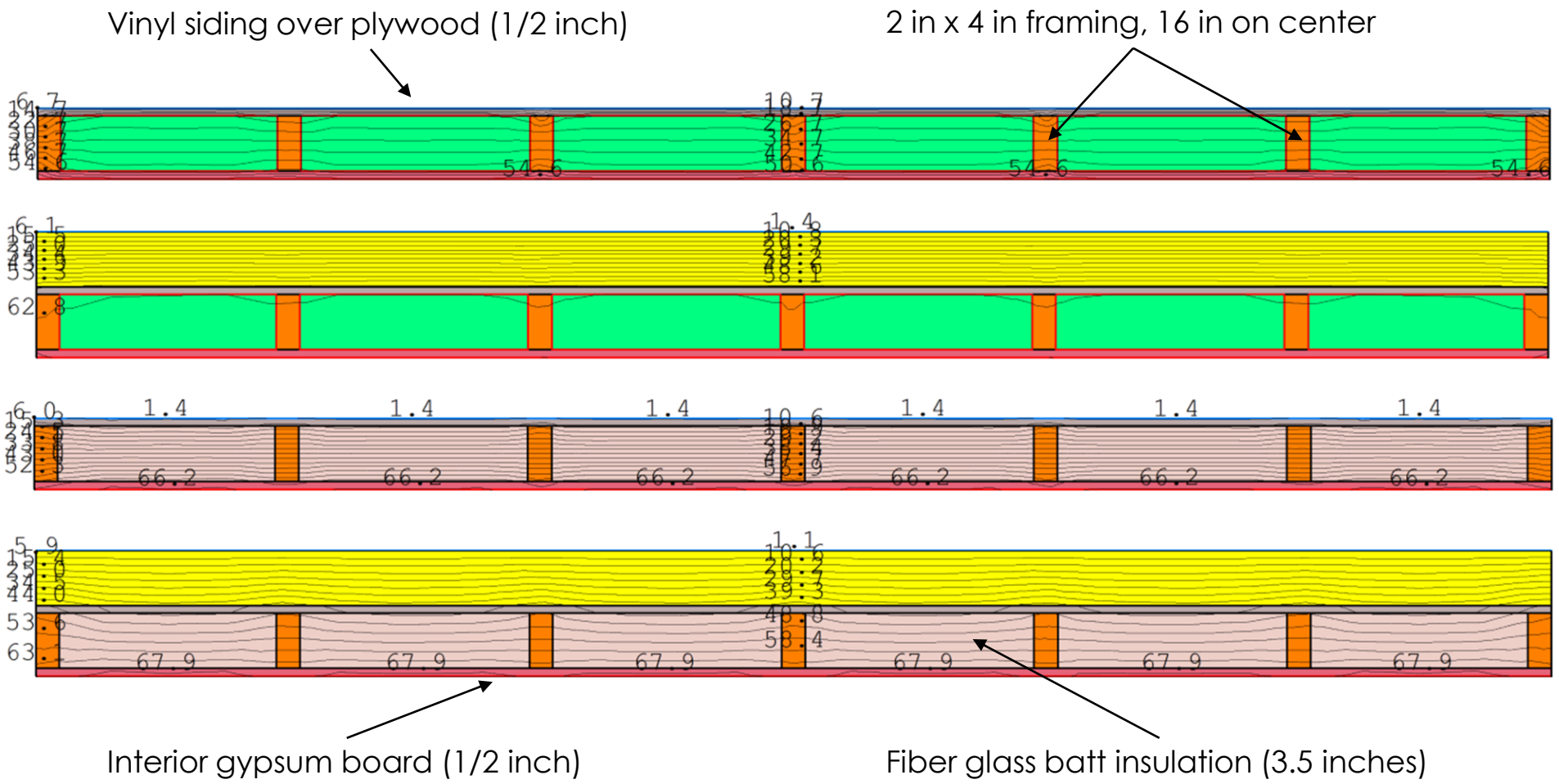
(4)

Application of Stucco finish

(a)

(b)

Wall constructions used for R value calculations & hygrothermal simulations



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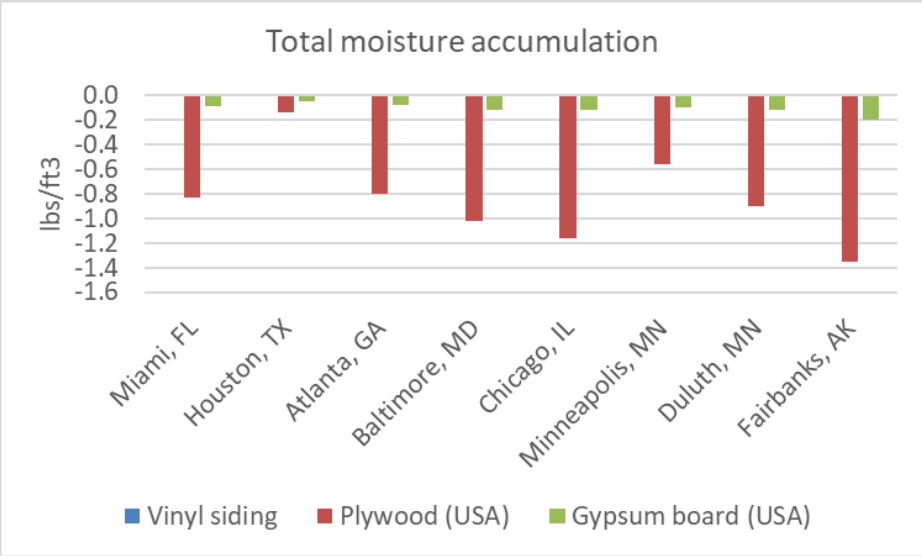
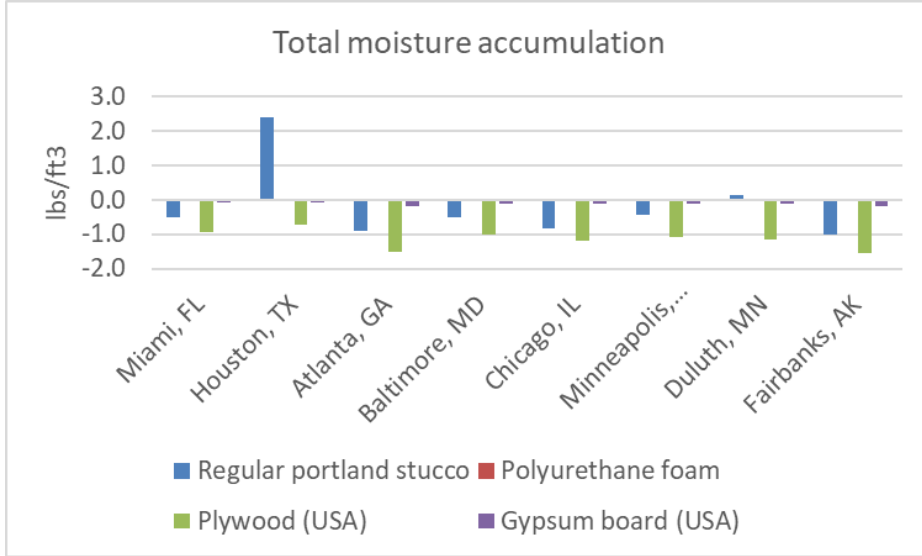
Hygrothermal simulations

No retrofit

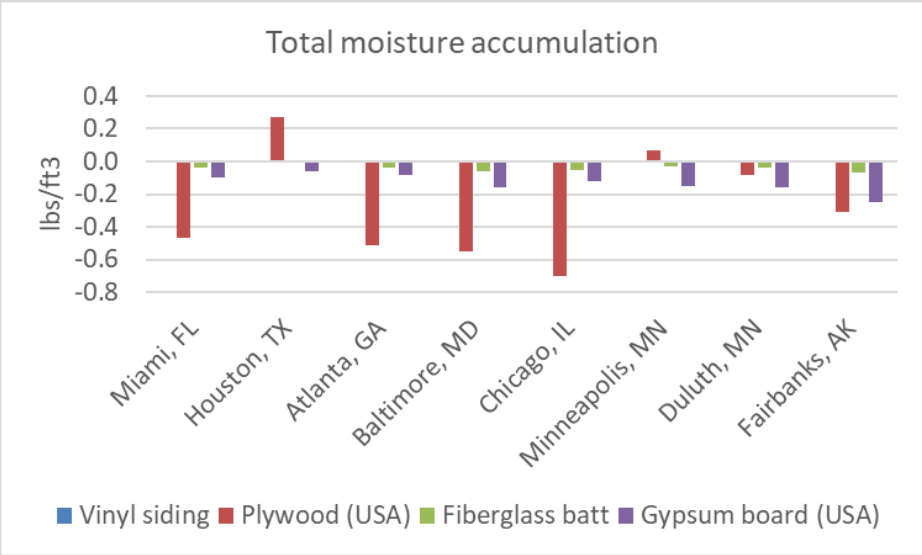
Retrofit

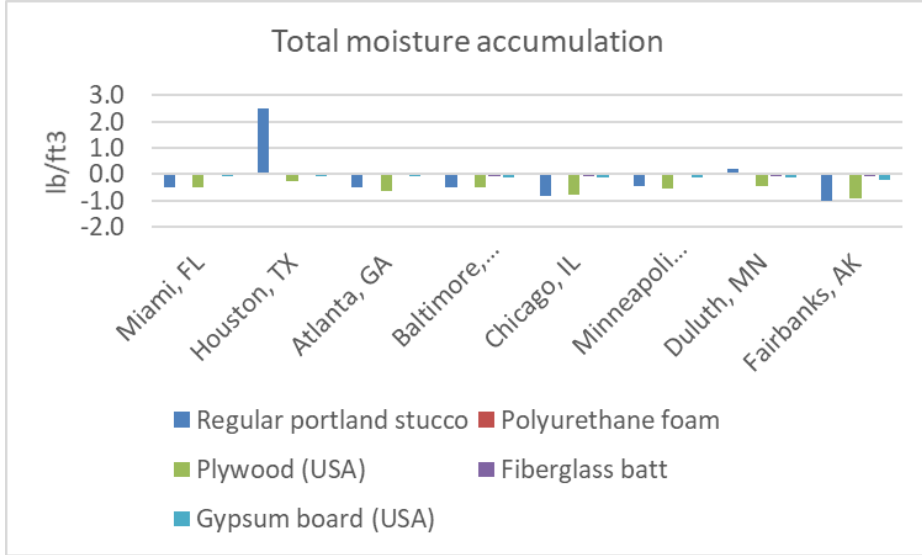
Uninsulated wall cavity





Insulated wall cavity





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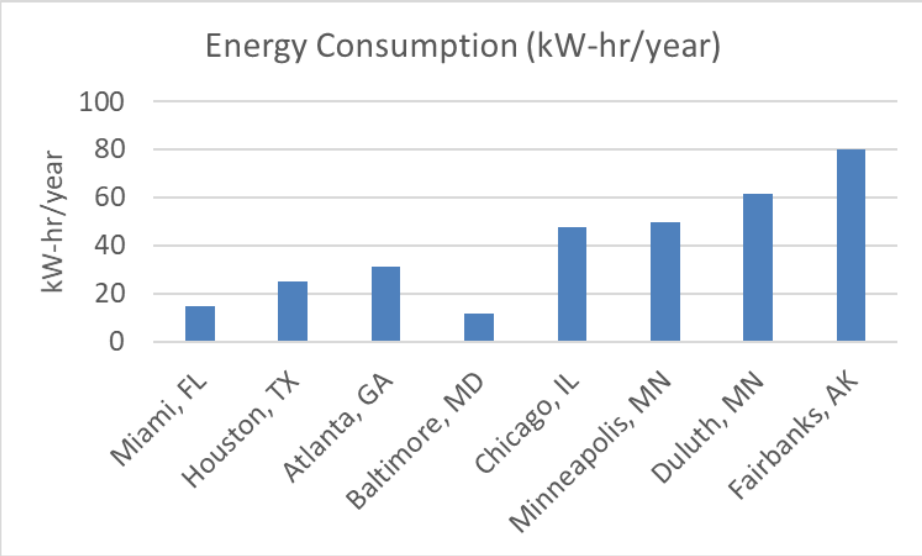
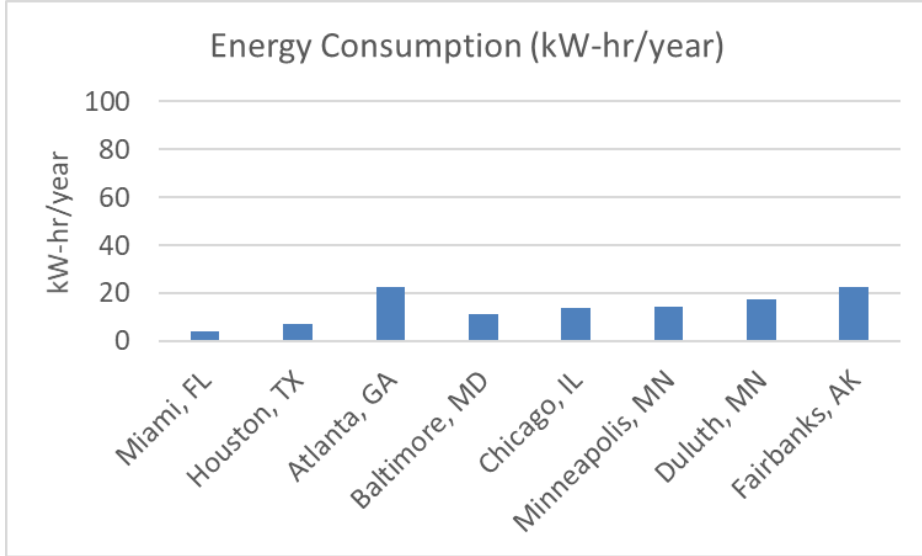
Energy consumption

No retrofit

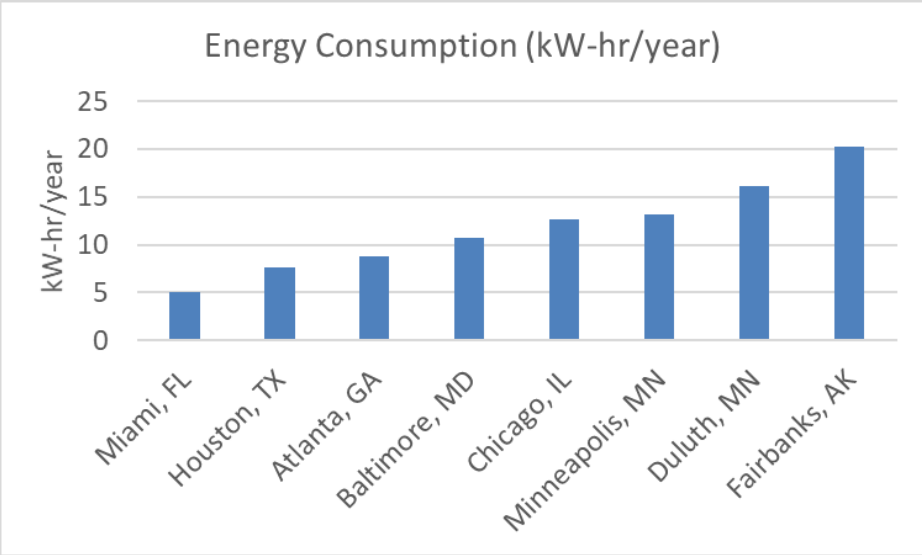
Retrofit

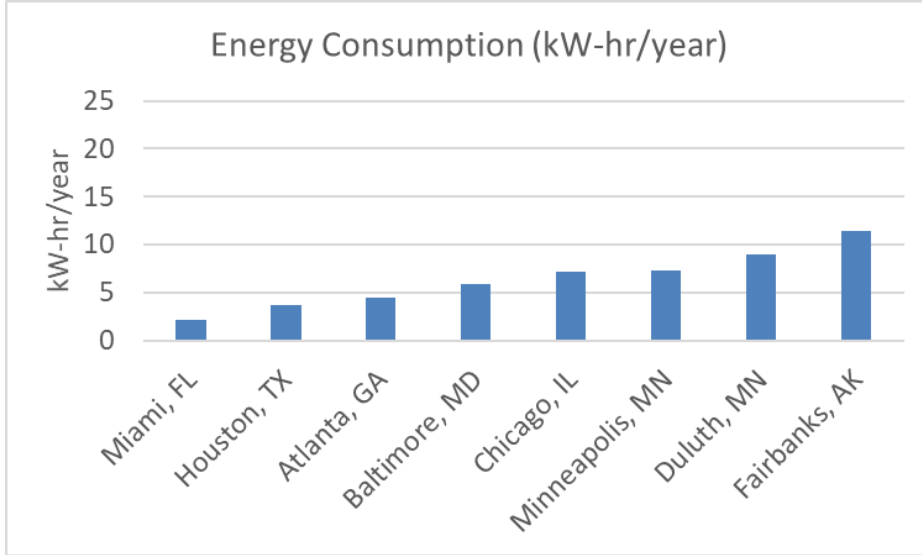
Uninsulated wall cavity





Insulated wall cavity





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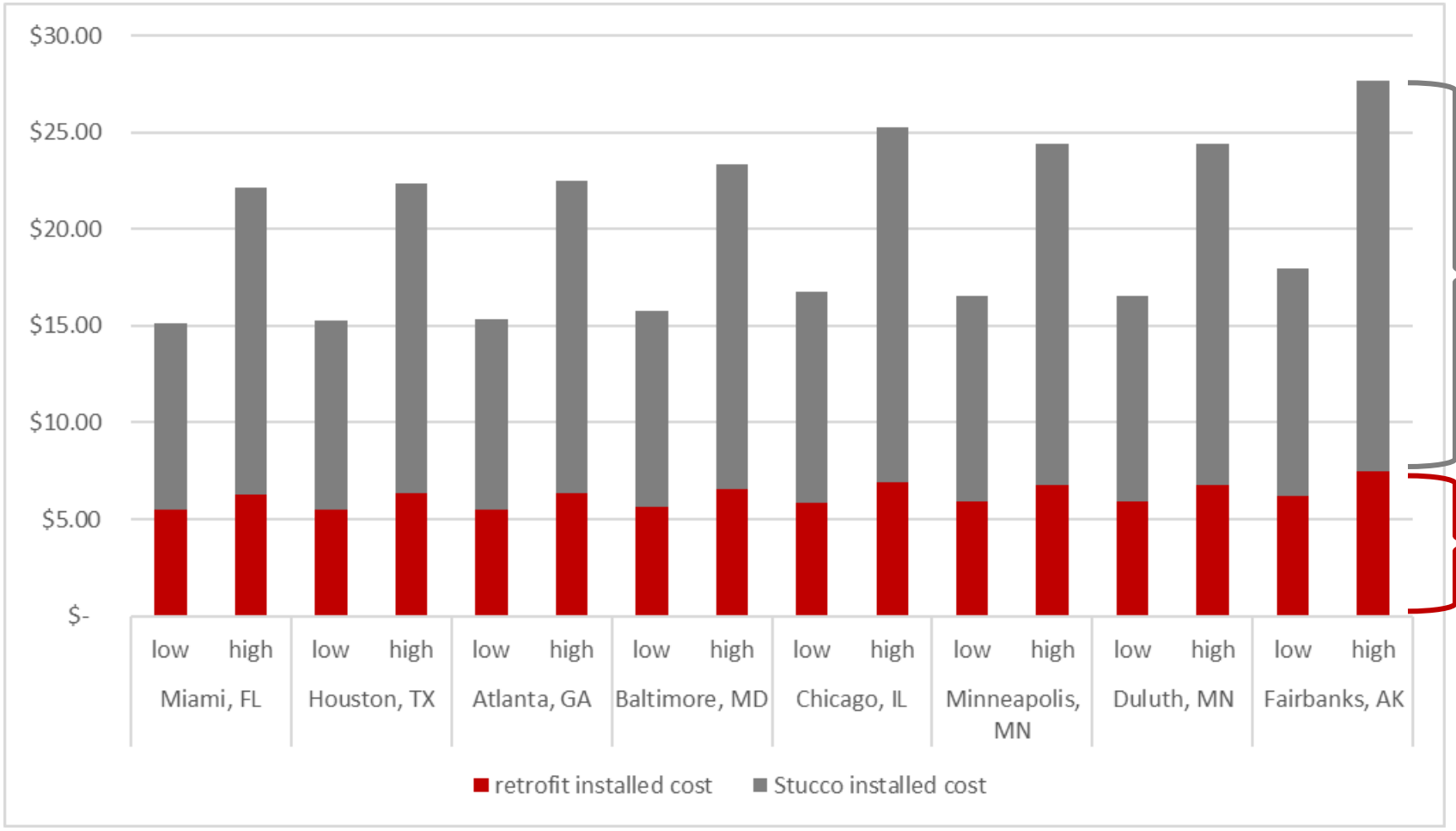
Cost analysis of inflatable retrofit system with stucco finish



Stucco installed cost

Retrofit installed cost

(assumption: labor cost is equal to the sum of labor cost for installing a weather resistive barrier and spray foam insulation)

Summary

- In aggregate, feasibility of an inflatable retrofit system filled with polymer foam insulation was demonstrated and the flexibility over conventional exterior insulation approaches was highlighted.
- At an insulation value of R 20, the installed cost is in the range of $11 to $28 per square foot depending on location and cladding material.
- Customization of the inflatable retrofit system to accommodate a variety of building typologies and deliver exterior insulation with minimal labor are certainly advantages.
- Next step, to develop the ancillary elements to integrate the system with doors, windows and service penetrations and to demonstrate installation on larger structures to better understand and quantify cost & performance benefits with respect to the on-site application of exterior insulation & the installation of prefabricated cladding systems.