

Double Wall Framing Technique – An Example of High Performance, Sustainable Building Envelope Technology

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ABSTRACT:

Double wall technologies utilizing wood framing have been well-known and used in North American buildings for decades. Most of double wall designs use only natural materials such as wood products, gypsum, and cellulose fiber insulation, being one of few building envelope technologies achieving high thermal performance without use of plastic foams or fiberglass. Today, after several material and structural design modifications, these technologies are considered as highly thermally efficient, sustainable option for new constructions and sometimes, for retrofit projects. Following earlier analysis performed for U.S. Department of Energy by Fraunhofer CSE, this paper discusses different ways to build double walls and to optimize their thermal performance to minimize the space conditioning energy consumption. Description of structural configuration alternatives and thermal performance analysis are presented as well. Laboratory tests to evaluate thermal properties of used insulation and whole wall system thermal performance are also discussed in this paper. Finally, the thermal loads generated in field conditions by double walls are discussed utilizing results from a joined project performed by Zero Energy Building Research Alliance and Oak Ridge National Laboratory (ORNL), which made possible evaluation of the market viability of low-energy homes built in the Tennessee Valley. Experimental data recorded in two of the test houses built during this field study is presented in this work.

1. INTRODUCTION

A significant number of super insulated wall technologies has been developed, built, and investigated in North America and Europe since the energy crisis in the early 70's, listing double walls among the best performing constructions suitable for these regions. At the same time, wood based technologies are widely considered as primarily building materials for low-environmental-impact buildings [4, 30, 38, 48]. For example, current research performed by the Mid Sweden University demonstrated that both the primary energy consumption as well as the CO₂ emission generated during production of materials used in building construction are significantly lower in case of wood-framed constructions than for concrete buildings [14].

In the U.S.A., a detailed experimental and numerical analysis of over 150 wall technologies including advanced wood-framed walls was performed by ORNL. This information is available as the Whole Wall R-value Database [19, 20, 21, 22]. Some of these walls have

effective R-values exceeding $R_{SI} > 4.4 \text{ m}^2 \text{ }^\circ\text{K/W}$, including several double wall material configurations. In another study conducted for the U.S. DOE Building America Program by Straube and Smegal [42] thermal performance characteristics of high R-value walls have been investigated for North American residential applications. One of the conclusions was that moisture tolerant thermal insulation may be primarily choices for these applications due to potential exterior sheathing durability problems in high-R-value assemblies. Finally, several high performance insulation options including vacuum insulations and aerogels have been recently analyzed and tested by Fraunhofer Center for Sustainable Energy Systems (CSE), U.S.A. in wall retrofit applications [26, 40].

In Canada, thermal performance of buildings has become a dominant focus of changes to construction practices with special requirements for prescriptively built housing and small buildings being approved in 2012 (Part 9 of the National Building Code), and a more generalized National Energy Code of Canada for Buildings,¹ 2011. National Research Council of Canada (NRC) has conducted several projects developing high thermal performance wall assemblies that can be applied in extreme northern climates [35]. Based on this study, NRC has recommended using double stud wall, standoff truss wall, structural insulated panel, or structural insulated concrete wall system in wall housing assemblies to reach R-value larger than $R_{SI} > 5.3 \text{ m}^2 \text{ }^\circ\text{K/W}$. Some of these walls have been tested in the NRC laboratory for further performance verification.

In principle, thermal performance of wall frame assemblies can be increased by either: applying thicker and wider insulation space in wall cavity; installing insulating sheathing; improving thermal resistance of used insulation; mitigating of thermal bridging; and finally applying air/moisture-tight construction techniques. It is good to notice that double walls represent in very practical way a combination of the above measures in order to reach high R-value and sometime to improve other performance aspects such as durability, constructability, and costs. The main objective of this paper is to discuss a short history of development, structural variations, and thermal performance of double wall assemblies applicable in North American residential and small commercial buildings that have or could have R-values larger than $R_{SI} > 3.5$.

2. PROSPECT REDUCTIONS OF WHOLE BUILDING ENERGY CONSUMPTION AS A FUNCTION OF IMPROVEMENTS IN WALL R-VALUE

Double wall assemblies make possible reaching relatively high R-values only with use of low cost traditional fiber insulation and without a need for expensive exterior foam sheathing insulation. An improvement of the wall R-value is achieved in this case thanks to increased thickness of the wall and by an overall system design, making possible effective mitigation of thermal bridges. In order to illustrate an impact of wall thermal performance on the whole building energy consumption, a series of parametric simulations has been performed on a single-family residence. A small single-story house selected for this purpose has been the subject of previous energy efficiency modeling studies (Huang et al. 1987) serving in development of the ASHRAE 90.2 standard. The heating and cooling loads generated from this numerical analysis have been used to estimate the relation between wall R-value and whole building energy consumption in conventional wood-framed house. As depicted in Figure 1, about 60% wall R-value raise between most-commonly used in the U.S. $R_{SI} = 2.2 \text{ m}^2 \text{ }^\circ\text{K/W}$ residential walls and

¹ <http://www.nationalcodes.nrc.gc.ca/eng/necb/index.html>

expected in the close future $R_{SI} - 3.6$ structures, may generate between 5% and 8% changes in the building-envelope-generated whole building energy consumption for space conditioning. Considering that in most of North American residential buildings, walls may generate in average up to 25% of total loads associated to building envelopes (U.S. DOE Building Energy Data Book²), it is a substantial upgrade of the whole building performance generated by changes in only a single building enclosure component (wall). In that light, wall framing improvements can be considered as an important source of future energy savings in residential buildings.

Typically, the amount of structural members incorporated into the total wall area is called a framing factor. It used to be expressed as a percent of the total wall area (Syed, Kosny, 2006). It is good to remember that in conventional wood framed walls, each framing member represents thermal short worsening overall thermal performance. For conventional wood-framed walls, the wall area represented by framing members (framing factor) has been considered to be between 10% and 14%. However, according to the report prepared by Enermodal Engineering for the American Society of Heating Refrigeration and Air-Conditioning Engineers (ASHRAE), an average 25% framing factor is representative for all US residential buildings (ASHRAE, 2001). To illustrate a scale of thermal bridge effects generated by framing in conventional wood- and steel-framed assemblies, R-values of five structural configurations were numerically analyzed - (Kosny et al. 2014). The simulation results are shown in Table 1. It can be observed that an increase in framing effect coefficient in wood frame wall is almost consistent with increase in percentage of framing, whereas in light-gage steel walls this effect is more prominent.

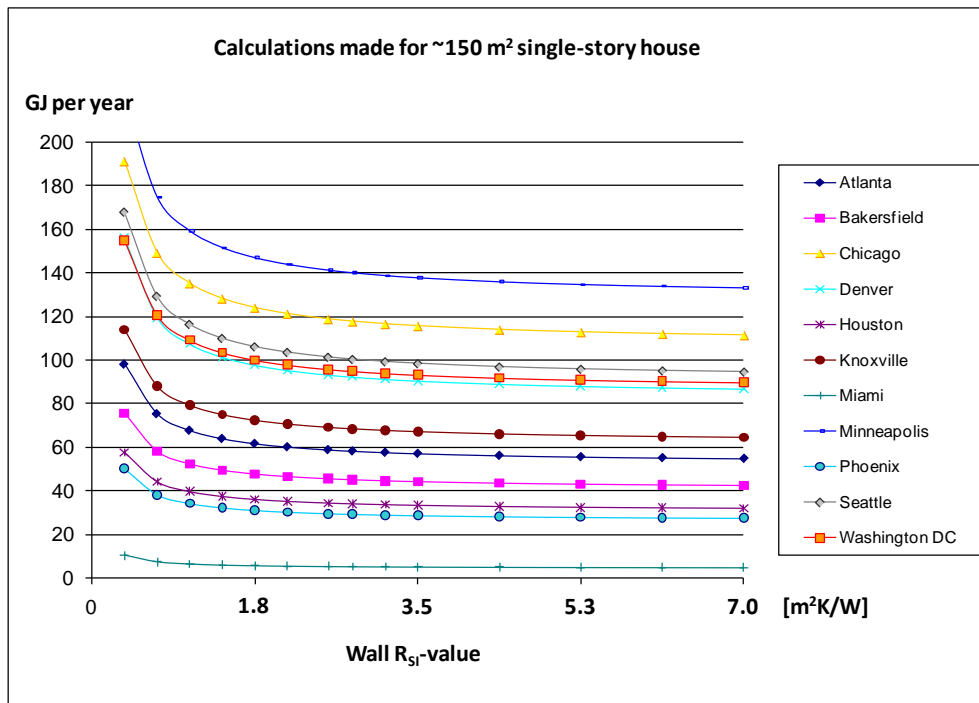


Figure 1: Total whole building energy consumption for twelve lightweight wood-frame walls calculated using whole building energy simulations for one story rancher.

² <http://buildingsdatabook.eren.doe.gov/>

Table 1. R-values and Framing Effect Coefficients for different percentage of framing in wood and steel framed walls

Percentage of Framing	R-Value $\text{m}^2 \cdot \text{K}/\text{W}$		Framing Effect Coefficient, f (%)	
	Wood	Steel	Wood	Steel
5 % Framing	2.13	1.64	7.13	28.79
8 % Framing (~ 610 mm. o.c)	2.05	1.34	10.75	41.49
11 % Framing (~ 400 mm. o.c)	1.97	1.21	14.27	47.40
11 % Framing (~610 mm. o.c with track)	1.97	1.19	14.07	48.21
14 % Framing (~ 400 mm. o.c with track)	1.90	1.09	17.16	52.70

As mentioned earlier, one obvious solution to increase wall R-value is to use a thicker insulated cavity. In addition to many available structural options using oversized framing members, it can be also achieved through a usage of two sets of wall framing, either via two 2x4 studs, a set of 2x4 and 2x3 studs, or a set of 2x6 and 2x4 studs. In practice, this type of wall is called double wall or double stud walls. Sometimes it is called party wall because it can be used as interior bearing walls that can reduce sound transmission in multi-family buildings through small gaps provided between the interior and exterior wall frames. Because of these wide wall cavities (empty or filled), double wall system can provide more fire resistance relative to the traditional wall frame assemblies. Figure 2 presents an example of double wall systems being assembled for constructing zero net energy housing in Canada (Riverdale Net Zero Project, 2007).



Figure 2. Double wall construction (Riverdale Net Zero Project, 2007)

3. CONSTRUCTION OF DOUBLE WALL

The double wall represents a relatively low-tech method of building energy-efficient walls with use low-cost materials and well-known wood framing technique. It was introduced in 1970-ies during the time of energy crisis. In addition to the new building applications, double wall construction technique can be used to retrofit an existing building, and this can be done via adding interior or exterior non load bearing walls to the existing load bearing assembly. As

mentioned before, this construction method virtually eliminates thermal bridging within the wall assembly, although there still can be thermal bridges present at sills, top plates, and window and door openings. Additional advantage of double walls is their excellent acoustic performance. Double walls are usually built from two parallel layers of framing. Next, both stud walls and the space between them are filled with continuous insulation. Depending on the insulation thickness provided, a whole-wall R-value larger than $R_{SI}-5.3 \text{ m}^2 \text{ }^\circ\text{K/W}$ can be reached. It should be noticed that whole-wall R-value is used here (rather than clear-wall R-value) to indicate the effects of framing elements and interfaces or junctions within wall assembly. For example, double (2x4) wall with 240 mm $R_{SI}-6.0 \text{ m}^2 \text{ }^\circ\text{K/W}$ insulation has whole-wall R-value of $R_{SI}-5.3 \text{ m}^2 \text{ }^\circ\text{K/W}$ (Straube and Smegal, 2009). Any type of insulation materials can be used to fill out the wall cavity, but blown cellulose insulation is preferred for better durability performance due to capability of storing and redistributing small amounts of moisture in addition to the fact that it is an environmentally friendly material made from recyclable paper and cartoon products.

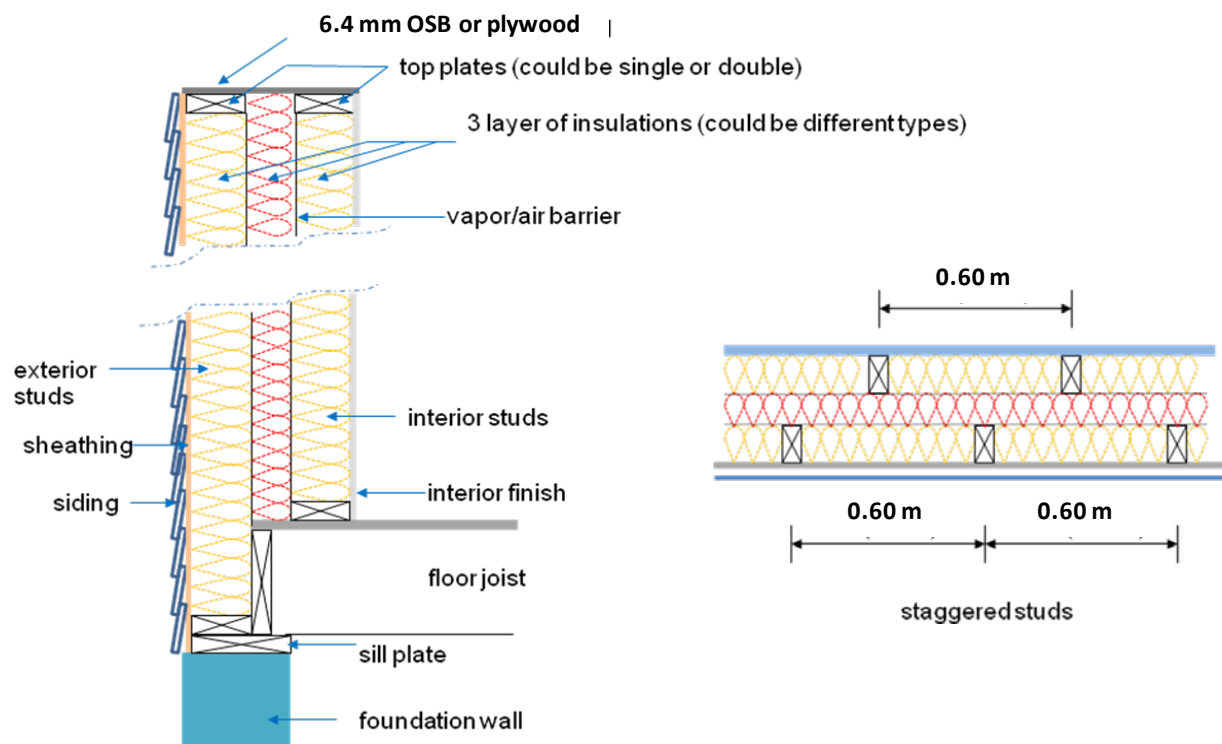


Figure 3. Cross section of double wall framing system.

The wood studs in double wall can be placed either in-lined or staggered order (the studs in the first wall are offset from the studs in the second) with studs spacing 600 mm on each side – see Figure 3. By placing studs in staggered way, thermal bridging is reduced further due to wider distances between structural members. Either interior or exterior stud-frame wall can be designed as load bearing (structural) wall, depending on the architectural need (e.g. interior space dimension). In general, structural design procedure for the load bearing wall is similar to that of the standard wall system. Gravity and lateral loads (wind or earthquake) should be transferred fully to the structural wall by designing adequate nailing between the sheathing to stud frames.

Single or double top-plate can be used for the structural wall depending on adequacy of the wall chord (i.e. top plate) in carrying and transmitting in-plane lateral load to the wall and foundation (Figure 4). For the exterior non load bearing wall, structural adequacy with respect to out-of-plane wind load should be checked including the cladding and components attached to it. Normally the wall cladding and component system will be the determining factors instead of the wall frame. On top of the top-plate, gusset plate made of plywood or OSB (~9.5 mm thick) can be used to connect the interior and exterior wall frame. As for framing members, single or double top plate would have less impact on the whole R-value because significant thermal breaks can be provided between the exterior and interior frames. One of the concerns of this wall with respect to durability is that the sheathing is kept very cold, and has little drying potential if the sheathing is wetted by air leakage or rain water penetration.

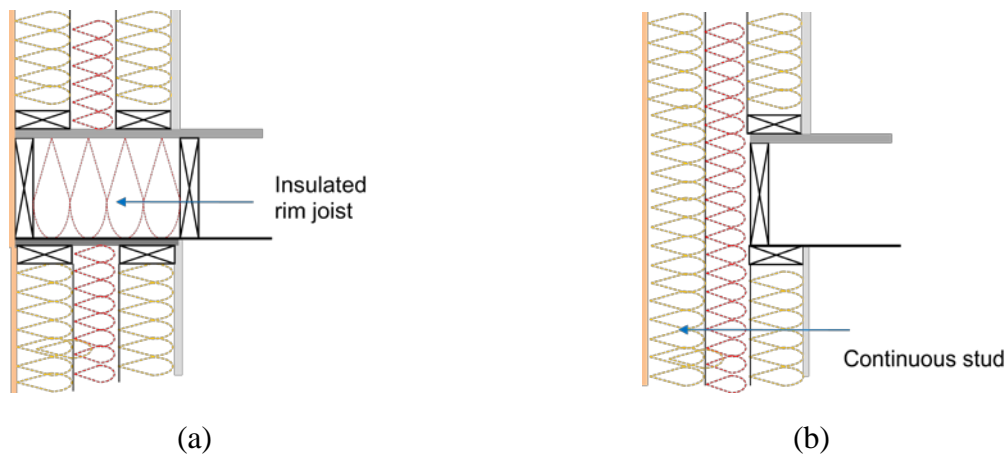


Figure 4. Inter-storey junction in double wall system (platform v.s. balloon framing)

For two-story or higher constructions, platform system can be used with insulation material inserted inside the rim joist to minimize thermal bridging (Figure 4a). As one can see, in the platform system thermal bridge is reduced into a very small area, i.e. gusset plate. Balloon frame system also can be constructed for the exterior non load bearing system to eliminate the work of insulating the rim joist as in the platform system (Figure 4b). Stronger and stable engineered wood composite such as Laminated Veneer Lumber (LVL) or Laminated Strand Lumber (LSL) can be used for constructing long and slender studs in balloon framing. Using balloon framing can increase R-value of the double wall system due to elimination of thermal bridging suffered in un-insulated rim joists of the platform framing. The main constraint about reaching higher R-value is interior space demand, and if this is not an issue for architect or home owner, R-value larger than $R_{SI}-8.8 \text{ m}^2 \text{ }^\circ\text{K/W}$ can be reached simply by increasing the space between the two stud lines and filling it out with insulation. As shown in Figure 5, two layers of framing can be separated with fiber fabric to enable an application of two different types of thermal insulation.

Regarding the fire safety regulations which apply to the double walls, the International Residential Code (IRC section R302.11) requires draft-stopping in double-stud assemblies every 3.m (10ft.) (minimum) along the length of the wall, from bottom plate to top plate and covering the full depth of the double cavity, using 1-cm (1/2-in.) gypsum drywall or 1.6-cm (3/4-in.) plywood. The code also requires fire blocking to keep the top of the wall assembly separate from the floor framing or attic spaces above. If full-depth top plates that span across both stud walls

are not used, it is recommended that 1-cm (1/2-in.) drywall or 1.6-cm (3/4-in.) plywood between the top plates, and fire-caulk the joints are installed.



(a)

(b)

Figure 5: Construction details of double wall framing system designed by Jan Kosny for Oak Ridge, TN U.S.A. field experiment (Miller et al. 2010); (a) Internal layer of framing, (b) Two layers of framing separated with fiber fabric.

4. TRUSS WALLS – AN ALTERATION OF DOUBLE WALL DESIGN

Another North American wall assembly that is similar to the double wall is called the truss walls or standoff truss wall system. Sometime it is also referred to the Larsen truss wall system because it was developed first by John Larsen in Canada in the early 80's (Christian and Kosny, 1996). Figure 6 illustrates an example of Larsen truss wall construction. In principle, Larsen truss wall is a double wall assembly plus vertically 1.9 cm gusset plates (OSB or plywood) spaced at 60-90 cm o.c. that tie the exterior and interior studs frame (Figure 6). This creates stiffer out-of-plane wall frame system. Unlike in some of the double wall systems, the interior wall frame of Larsen truss wall is designed as a load-bearing wall, which does not compromise interior space demand. Figure 8 shows typical cross sections of the Larsen truss wall assembly. The truss wall cavity is normally filled with environmentally friendly dense blown cellulose insulation. The exterior frame can be extended below the rim joist in the wall-to-foundation junction to provide insulation space that eliminates thermal bridge which is commonly occurred in this junction. Due to reduced impacts of thermal bridges associated with structural intersections and wall opening details, Larson truss walls, demonstrate lower differences

between clear wall and whole wall R-values comparing to other conventional wood-based technologies (Kosny and Desjarlais, 1994).

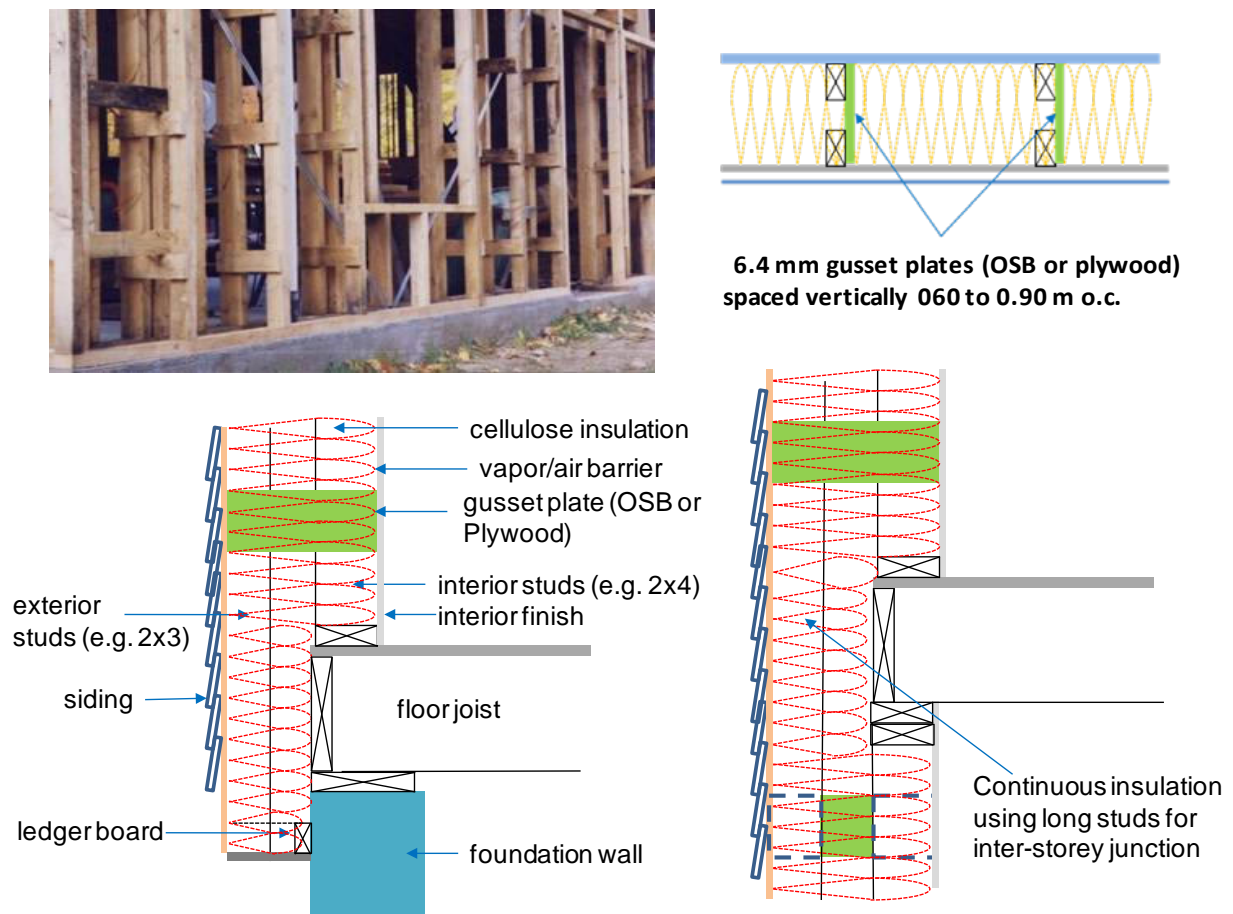


Figure 6: Larsen truss wall construction

Depending on the insulation thickness provided, whole-R-value higher from $R_{SI} - 6.2 \text{ m}^2 \text{ } ^\circ\text{K/W}$ can be reached. For example, truss wall with 0.30 m $R_{SI} - 7.6 \text{ m}^2 \text{ } ^\circ\text{K/W}$ cellulose insulation has whole-wall R-value of $R_{SI} - 6.4 \text{ m}^2 \text{ } ^\circ\text{K/W}$ (Straube and Smegal, 2009). The three layers of low permeable materials (drywall, dense pack cellulose, house-wrap) make the walls virtually impermeable to infiltration. As in the double wall, a significant cavity thickness plus cellulose insulation in the truss wall provide a good fire resistance and sound insulation.

The structural design procedure for the load-bearing wall subjected to gravity and lateral loads is similar to that of the standard wall system. Because of laterally stiffer relative to the double wall system, the exterior non-load bearing wall can carry heavier out-of-plane wind load. Depending on the structural load demand, single or double top plate can be used for the interior bearing wall with horizontal plywood or OSB plate closure tied to the exterior wall frame for each storey. The exterior wall also can be balloon-framed to minimize thermal bridging between the floors (Figure 6). The studs' frames can be spaced 0.40 m or 0.60 m o.c. depending on the load requirement, since the whole-wall R-value is not influenced by this spacing requirement due

to significant thermal break provided between the interior and exterior wall frames. Window framing on the interior load bearing wall can be designed as in the standard wall construction, i.e. using double header, since again this will not notably affect the wall R-value due to thermal break applied between the walls. To make it airtight in opening areas, plywood is applied to tie typically deep window box frames. To anchor each truss at the top of the walls of the house, the upper most gusset plate is extended 38 mm and nailed to adjacent roof trusses or rafters. The ceiling joists are cantilevered outward to form the soffit and meet the rafter tails (ceiling joists and rafters are lapped to opposite sides of each stud) with a 50 mm block in between to create a thrust-resisting triangle.

As in other double wall systems that have very thick insulation layers, in winter conditions, a relatively cold area can easily develop on the interior side of the exterior sheathing. This fact may lead to moisture deposition issue if drying system ability is not sufficiently facilitated. However, OSB exterior sheathing can be eliminated and replaced with t-bracing and 19 mm drop siding over the house wrap. Let-in metal t-bracing in exterior and interior load-bearing walls and wooden under-rafter diagonal bracing sufficiently stiffens the structure, particularly once the sealed drywall is installed. Due to the amount of framing involved and time needed for assembly, the Larsen truss can be prefabricated off-site. For retrofitted wall envelopes, a vapor barrier could be applied over the wall sheathing before installation of trusses without fear of condensation as long as 2/3 of the R-value of the envelope is outside of the barrier.

Other variation of Larsen truss wall is to use ‘an actual’ standoff truss system (Hefner, 2007). Instead of using gusset plate to tie the interior and exterior wall frames, 2x2 diagonal braces are applied to the cords (exterior and interior studs) with metal gang-nail plate connectors at certain spacing and angles. It is claimed by Hefner (2007) that this truss wall could reach $R_{SI}=8.8 \text{ m}^2 \text{ }^\circ\text{K/W}$ or more with 0.30 m insulation cavity.

5. LABORATORY AND FIELD TESTS OF HIGH-R-VALUE DOUBLE WALL ASSEMBLY

A unique configuration of the double wall, making possible an application of two different types of blown cavity insulation, was developed by Oak Ridge National Laboratory (ORNL), U.S.A. (Kosny et al. 2014). As depicted in Figure 7, this wall was constructed with two lines of staggered composite wood studs, separated from each other with about 5mm. distance. In this space between two lines of studs a separation liner fabric was installed. In this wall design, the internal wall cavities were filled with cellulose fiber insulation mixed with microencapsulated PCM. The exterior side cavities were filled with conventional blown cellulose. Table 2 shows thermal properties of conventional cellulose insulation and two different PCM-cellulose blends which can be used for internal side insulation of the double wall - as shown in Figure 7. Thermal conductivity for PCM-cellulose blend was investigated earlier by Kosny et al. (2007) as a function of amount of added Micronal PCM from BASF. Dynamic thermal performance characteristics of the 25% PCM-cellulose blend are presented in Shukla et al. (2013).

Table 2. Steady state thermal properties of PCM-enhanced cellulose, as tested by Fraunhofer CSE with use of the heat flow meter apparatus.

Material configuration	Used PCM type	Material density	Medium test temperature	Thermal conductivity
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25% weight percent blend of cellulose with PCM	Shape stabilized PCM product, from Syntroleum	42.0 kg/m ³	12.5 °C	0.03774 W/mK
		42.0 kg/m ³	40.0 °C	0.04141 W/mK
Compressed 22% weight percent cellulose-PCM blend	Microencapsulated PCM from Microtek	94.7 kg/m ³	15.0 °C	0.04216 W/mK
		94.7 kg/m ³	25.0 °C	0.04333 W/mK
		94.7 kg/m ³	35.0 °C	0.04426 W/mK
		94.7 kg/m ³	50.0 °C	0.04591 W/mK

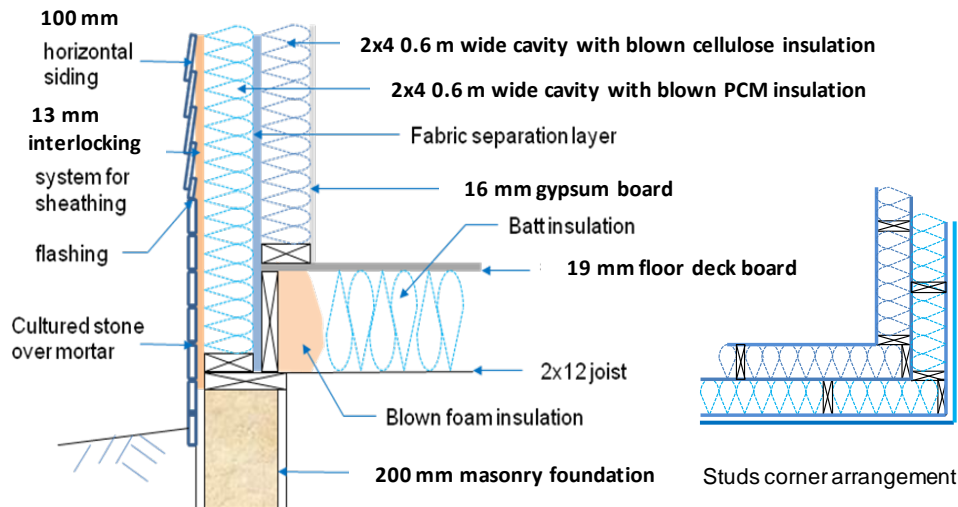


Figure 2: Schematic of the double wall containing two types of cellulose fiber insulation, designed by Jan Kosny for the ORNL field experiment (Kosny et al. 2014).

In order to measure steady state R-value of the described above double wall, the hot box testing procedure (ASTM C1363) was utilized. For the purpose of the hot-box testing, which was performed by ORNL, a 2.4 m by 2.4 m. wall specimen was constructed. During the series of hot-box tests an average density of the conventional cellulose insulation was about 56 kg/m³, while for the 22% -by weight cellulose-PCM blend, it was about 75 kg/m³. Steady-state hot box tests were performed with three different sets of temperature conditions yielding in average the wall R-value of R- 3.8 m²K/W (21.2 h-ft²-F/Btu). A summary of hot-box test results is presented in Table 3 below.

Thermal performance of discussed above configuration of the double wall was also investigated in full whole building scale. Four high thermal performance wall technologies constructed in four identical homes have been monitored and analyzed in Oak Ridge, Tennessee,

U.S.A. (Miller et al 2010). This project was a partnership between ORNL and building materials and construction companies. It was sponsored by Tennessee Valley Authority and the U.S. Dept of Energy to demonstrate and develop new energy efficient technologies for homes. Detailed energy performances comparisons for all four tested houses are discussed in Shrestha et al. (2012). Tested opaque envelopes included structural insulated panel (SIP), optimum value engineering (OVE), double wall with phase change material (PCM) insulation in house, and exterior insulation and finish system (EIFS) in house (Kosny et al. 2014).

Table 3. Steady state thermal resistance of double wall as tested by ORNL.

Test	Temperatures °C (°F)			Measured heat flux W/m ² (Btu/h-ft ²)	Measured R-value m ² K/W (h-ft ² -F/Btu)
	Meter side	Climate side	Temperature difference		
1	22.5 (72.5)	-0.2 (31.7)	22.7 (40.8)	5.84 (1.85)	3.89 (22.1)
2	24.7 (76.4)	15.9 (60.7)	40.6 (15.7)	2.27 (0.72)	3.83 (21.8)
3	37.1 (98.7)	16.4 (61.6)	53.5 (37.1)	5.52 (1.75)	3.73 (21.2)

Figure 8 shows the test house constructed with double walls, which were filled with blown cellulose (external layer) and PCM-enhanced cellulose insulation (internal layer). The house is two-story with total floor area of 253 m². The wall studs are made of 2x4 Laminated Strand Lumber (LSL) and are spaced 0.60 m o.c. (Figure 5). In the tested double wall, two layers of studs are staggered by 0.30 m. The interior framing is supported on top of the bottom plate that is fastened through floor sheathing and floor truss, while the exterior framing is supported on the sill plate and is fastened to the floor truss. A top plate was used to tie the two walls together for lateral strength. It is anticipated that this double wall system function as composite system (Figures 5 and 7). The interior frame acts as the structural wall component responsible for transmitting gravity and lateral force to the foundation. However, since the two double top plates are mechanically connected and wall sheathing is provided in the exterior wall, a portion of lateral load is carried by the exterior walls as well.



Figure 8: Oak Ridge field experiment – installation of the cellulose insulation inside the exterior wall cavities and front view of the test house with double walls (Miller et al. 2010).

As shown in Figure 7, thermal bridging at the corners is minimized by applying double stud corner practice with insulation surrounding it. The exterior wall OSB sheathing has a built-in protective weather resistive barrier (WRB) overlaid at the factory to eliminate the need for house wrap. All joints were taped to make the sheathing air tight. A high-density polyethylene sheet having about a 6.4 mm high dimpled profile was also installed on the exterior of the sheathing to ventilate the exterior part of the wall. It provides drainage of transient moisture migrating through the wall and creates two independent air flow streams to dry out both the cladding and the concealed wall cavities. The product eliminates the impact of solar driven moisture problems, and reduces the impact of interior moisture loading at the same time.

In order to illustrate thermal performance advantage of the double wall over the conventional wood framing assembly, Figure 9 presents measured wall heat fluxes in the double wall house and the identical house with 2x6 wood stud walls. In conventional wall 14-cm (5.5-in) wood studs are spaced 60-cm. (24-in.) from each other and wall cavity is insulated with R-3.3 m²K/W (R-19 h-ft²-F/Btu) fiberglass batts. Presented below recorded heat flux data shows walls’ performance comparisons during three winter days – see Figure 9. It can be observed that the double wall generates significantly lower heat losses comparing to the conventional 2x6 wall. In addition, significant dynamic effects can be observed in all wall orientations. During the winter time, they are mainly caused by thermal loads generated by fenestration and by the thermal mass response of the double walls. More detail analysis will be presented in following publication.

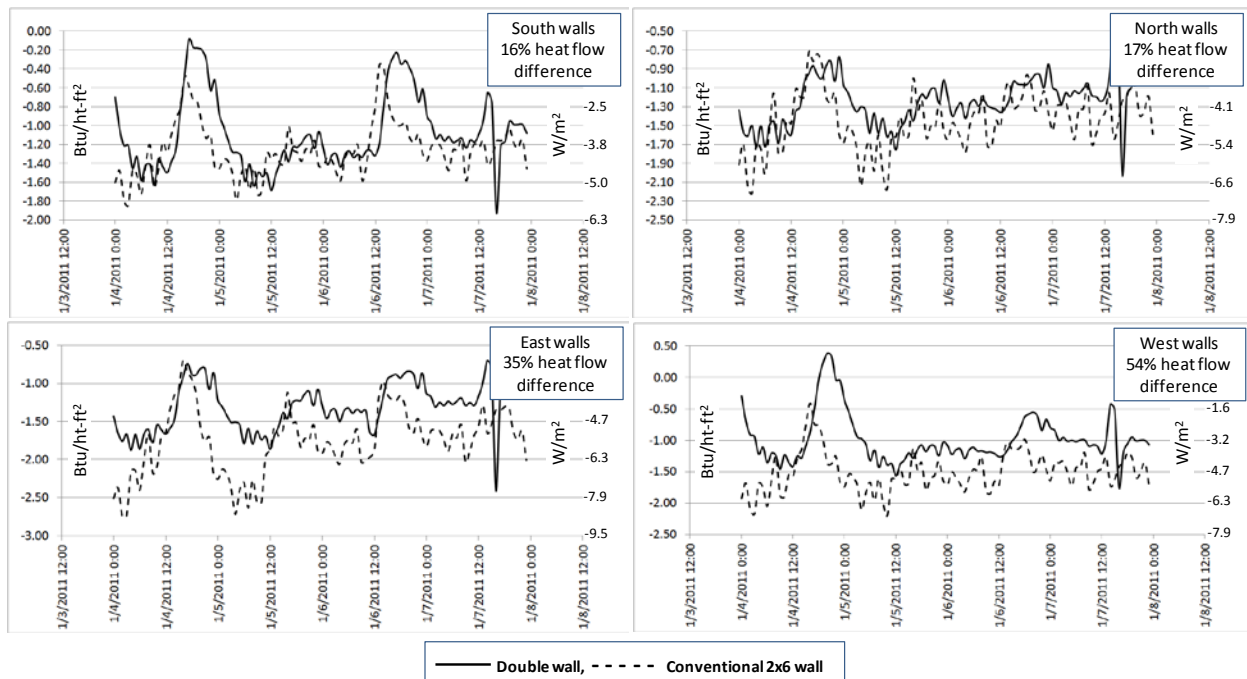


Figure 9: Oak Ridge field experiment –heat flux data recorded for all four wall orientations during three days in January 2011.

6. CONCLUSIONS

It can be observed that many different high R-value double wall assemblies have been developed and successfully tried out using many different insulation materials with different wall thicknesses and framing members. Traditionally several configurations of double walls and truss walls have been considered as energy efficient solution for low-energy buildings. A review of existing practices of residential double wall construction techniques was conducted to identify wall assemblies, structural members, and insulation materials of high thermal performance. Current research demonstrated that R-values of these walls can easily exceed $R_{SI} > 5.3 \text{ m}^2 \text{ }^\circ\text{K/W}$. Results of analytical and experimental research work performed at ORNL and Fraunhofer CSE were presented. In addition, test data recorded during the four test houses experiment in Oak Ridge, Tennessee, U.S.A. were utilized to compare field performance of double walls and conventional 2x6 wood framing. Measured wall heat fluxes in the double wall house were compared to the test data from identical house with 2x6 wood stud walls. It was observed that during the winter days of consideration the double wall generated significantly lower heat losses comparing to the conventional 2x6 wall.

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