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Final "Best in Class" Report,
Energy Efficient Exterior Wall Design

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Introduction

The design and implementation of a highly energy efficient exterior wall that is durable and cost effective is a critical component of a high performing home and can pose a challenge to production builders. As energy efficiency requirements increase for building codes and voluntary programs such as ENERGY STAR and green building programs, the production builder must evaluate numerous designs and products in order to optimize framing, insulation, fenestration, and air sealing. An example of a successful energy efficient wall design is the implementation feature of this report.

The high performance wall design was implemented into K. Hovnanian's Monmouth High Performance test home. This Building America test house, built in 2009, is a single story, slab-on-grade design located in the mixed humid climate (climate zone four). While a primary goal of the project was to meet or exceed the Building America (BA) 40% Whole House Energy Savings target over the 2008 BA Benchmark, a secondary goal was to develop a wall system that would conform to future energy code requirements for the mixed humid and/or cold climates. The implementation of new products and practices to improve energy efficiency has the potential to create unintended moisture and durability issues and have increased cost implications. For this project, a number of wall frame/insulation/air sealing combinations were considered and modeled in order to meet the project goals. The features considered included site built versus panelizing, 2x4 versus 2x6 framing, OSB sheathing with and without exterior rigid foam, structural insulated sheathing (SIS), air sealing products and methods, and various wall cavity insulation types and densities of fiberglass batts, blown loose fill fiberglass, cellulose, and spray foam.

Figure 1 – K. Hovnanian's Monmouth High Performance Test Home

Description of Implementation Feature

The high performance exterior wall design was selected for the Monmouth new construction test home based on energy efficiency, durability, cost effectiveness, and with confidence that the wall would be practical to build for this and subsequent houses. This high performance wall system was configured with a standard 2" x 4" wood frame, 16" on center, with structural insulating sheathing (DOW's SIS sheathing) panels. The framing was optimized to reduce thermal bridging and increase insulation volume, including 3-stud corners, strategic window placement, minimized use of cripples, engineered headers, and continuous drywall at partition walls. The continuous drywall approach was achieved through a 1" offset of the intersecting interior walls from the exterior wall plane. The 1" thick, R-5.5 SIS panels integrated the structural shear bracing, weather resistant barrier, and exterior air barrier as well as added wall insulation and a thermal break for the framing. Wall cavities were insulated with R-13 Kraft-faced, fiberglass batts (the batts could have been un-faced in this climate zone). The exterior cladding was vinyl siding. In addition, the builder decided to panelize the wall system to enhance the consistency of the final product.

The wall panels were built in a factory (panelized) in 12' and 16' lengths and shipped to the site. The 16" o.c. stud spacing was used for 2" x 4" nominal dimension wall framing to allow for multiple stories in similar 2-story house designs and to provide sufficient attachment area for the insulating sheathing and siding. As part of the factory fabrication process, synthetic (EPDM) rubber gaskets were installed along the face of the top and bottom plates prior to the placing of the SIS panels.

Figure 2 – Optimized Framing: Engineered Headers

Figure 3 – Factory Installed Gaskets

Figure 4 – Factory Installed SIS Panel Sheathing

The SIS panels were sized to full height (vertically) to eliminate horizontal seams, and then vertical seams were taped where possible in the factory prior to shipment. This fabrication process was developed to provide as much of the air sealing details in the factory to minimize the field work necessary to ensure a consistently tight building envelope. On site, the wall panels were installed over a sill gasket and the floor-panel seam caulked. All sheathing seams not taped in the factory were subsequently taped in the field, and panel-to-panel connections were air-sealed.

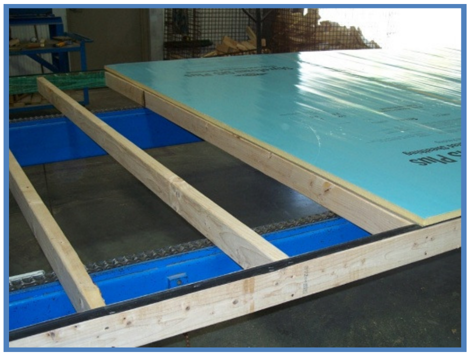

Figure 5 – SIS Panel Installed over Gasket

Figure 6 – Factory Installed Seam Tape

The continuous drywall method allows for continuous insulation and drywall air barrier where a partition wall meets the exterior wall. This method requires panel layouts to hold the interior wall 1” from the exterior wall to allow the drywall on the exterior wall to be slid into place behind the interior wall intersection. A standard structural metal strap was used to connect the top plates of the interior and exterior walls. To complete the wall air sealing methodology, closed cell polyurethane foam was sprayed from the attic side over all top plates (and other ceiling penetrations) in order to air seal this critical area.

Figure 7 – 1” Interior Wall Offset for Continuous Drywall Method

Figure 8 – Attic Top Plates Sealed with Spray Foam

Figure 9 – Attic Knee Wall with Sealed Air Barrier

Windows and doors that use wood trim required jamb extensions to accommodate the thicker exterior sheathing dimension. Windows were installed and flashed per OEM specifications and then air sealed around the rough opening from the interior using low expansion foam. All other wall penetrations were flashed and air sealed. Rigid air barriers at the fireplace, bathroom tub, and framed cavities and bulkheads were installed, sealed, and insulated in the field as required. Garage-side drywall was sealed at top and bottom plates and around the door and electrical boxes. The fiberglass batt wall cavity insulation was installed per RESNET Grade I guidelines.

Figure 10 – Taped SIS & Exterior Window Installation

Figure 11 – Interior Window Installation

Figure 12 – Window Installation including Flashing and Air Sealing

Figure 13 – Rigid Air Barrier Sealed

Figure 14 – Fiberglass Batt Wall Cavity Insulation

How it was Incorporated into Common Business Practice

Overall project goals including energy savings targets, cost effective solutions, and ease of construction were established during an initial project meeting. Next, design stage conference calls were conducted on a regular schedule; attendees included the project manager, architect, structural engineer, purchasing agent, and development manager. The wall system design evolved during these meetings based on results of energy modeling and an ongoing cost analysis of various system components. Subsequent design stage calls also included the site supervisor, trade partners, and vendors. The agenda for the regular design meetings involved input from those involved in the material selection, construction details, installation requirements, and planning for the construction sequence in order to finalize the wall system design and ensure that all team members were coordinated and understood the importance of their roles.

Given the new materials, wall configuration, and air sealing details, the standard construction schedule required incorporating changes to keep an even workflow and the proper sequence for the trades. A list of changes (any details that were not already included in the standard

Figure 15 – K. Hovnanian's Monmouth High Performance Test Home

specifications) was developed and these changes were listed in their proper construction sequence to avoid costly delays. These "monitoring points", additionally identified as either requiring a trade review (training), documentation (inspection), or testing, were then incorporated into the actual construction schedule in order to manage the changes. The development of the monitoring points (15 total: 5 reviews, 3 tests, & 7 documentation points) and integrating them into the construction schedule ensured that steps were not skipped or missed, specific trade reviews were scheduled before the work started, changes were inspected and documented before being covered up, and testing was performed at the right time.

Testing with a blower door confirmed a very tight house (2.4 ACH50) with an improvement of approximately 60% when compared to the same model home built using standard construction. The successful implementation of this wall design was accomplished by integrating building science with quality management including extensive attention to the construction details. Just as important as the details, however, was the coordination with the trades contractors and fabricators to implement the large number of changes. After the house was complete, valuable "lessons learned" feedback was provided by team members. As a result, this production builder is developing strategies to incorporate this energy efficient and cost effective wall design as standard practice in other communities.

Trades, and Vendors Involved

The implementation of the energy efficient wall design required the coordination of many trade partners and vendors. Implementation reviews, specific by trade, or trades as required, were conducted on-site just before the work was done to ensure the project manager, site superintendent, and affected trades clearly understood their goals and expectations.

Site superintendent

Using the monitoring points included in the construction schedule, the site superintendent had the overall responsibility to make sure that all design details were successfully implemented. The site superintendent participated in many design review calls and all on-site, trade specific training reviews.

<u>Wall panel vendor</u>

The wall panel vendor's (panelizer's) involvement was important during the early design stage to provide feedback, identify plant and shipping limitations, and evaluate costs. A wall construction and installation review was conducted by conference call to confirm details because elements of the wall design, including materials and fabrication methods, were new to the panelizer as well. The wall panel construction for this house was observed and documented during a factory site visit.

<u>Window and door vendor</u>

Energy efficiency ratings, extension jamb details, attachment methods, and costs were evaluated with the window and door vendor during the design stage.

<u>Framing trade partner</u>

The framing trade partner's involvement was critical throughout the process, from early design stage discussions through on-site implementation reviews. The framer's input was very valuable during the wall panel review (particularly the top plate discussion), window and door flashing review (the framer typically installs windows and doors for this builder), and the air sealing review. The air sealing review was important because these changes represented the greatest deviation from standard builder practice and required the most coordination between trades, particularly the sequence of the installation, air sealing, and insulation of the various air barriers. The resulting installation sequence consisted of the framer installing the air barriers and the insulation trade partner air sealing and insulating the air barriers.

<u>Insulation trade partner</u>

The insulation trade partner performed the bulk of the air sealing and installed insulation in coordination with the other trade partners. Due to the changes in the typical wall details and the enhanced performance goals, it was imperative that the insulation trade partner participate in the design stage calls to provide material and cost information and input on the construction sequence. They also participated in the air sealing and insulation reviews in order to coordinate with the framing trade partner and ensure all thermal bypass areas were covered and a Grade I installation for the insulation products.

<u>Siding trade partner</u>

The siding trade partner participated in the wall panel review to ensure appropriate siding attachment methods. In addition, due to the use of a non-nail base sheathing, the siding contractor provided valuable feedback on the framing details necessary to ensure proper siding installation according to manufacturer's specifications.

<u>Electrical trade partner</u>

The electrical trade partner participated in the wall panel installation and air sealing reviews to ensure that wires were not run in the 1" space at partition walls and that electrical boxes, especially those mounted to the exterior of the thermal envelope, were sealed.

Risks Avoided

The successful design and implementation of this high performance wall design demonstrates multiple advantages for the builder and their customers including the following:

Energy savings

Increased insulation levels directly contribute to energy savings for space conditioning. The wall system successfully integrated increased levels of insulation, minimized framing losses, exceptional air sealing, and enhanced durability into a complete high performance wall system. The wall system, including the air-sealing details, has achieved performance levels that will meet current and future energy codes.

Moisture management

The design of the wall system incorporates features that help significantly to minimize moisture problems including an integral drainage plane, layered flashing surfaces around windows and doors and at wall-roof interfaces, and around penetrations. The wall air sealing details also reduce any bulk air movement into the wall cavity that can add excessive moisture load to the sheathing.

Air Infiltration reduction

Use of sheathing gaskets to limit air movement into the wall system, along with detailed sealing of the top plates and sheetrock edges contribute to a very tight wall cavity construction. This reduction in wall cavity air leakage maintains the thermal performance of the fiberglass insulation especially during large temperature differences between inside and the exterior in winter.

Installation quality

The thorough planning and design review process among team members resulted in the development of a quality management process that can be successfully implemented. The establishment of review/training, documentation, and testing monitoring points contributed to an improved construction process that could adapt to even significant changes in typical practices and material use. Adaptation of the construction schedule helped to ensure that team members were coordinated and understood their goals and expectations. This quality management process resulted in the successful design and implementation of this energy efficient, durable, cost effective wall system.

Applicable Guideline Documents

- 2009 International Residential Code
- 2009 International Energy Efficiency code
- DOW product data & installation instructions
- ICC 700 National Green Building Standard

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