PATH
PARTNERSHIP FOR ADVANCING TECHNOLOGY IN HOUSING

U.S. DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT

Energy Efficient Panelized Homes

Birchwood Farms Community in Dallas, Georgia

TECHNOLOGY HIGHLIGHTS:

BUILDING ENVELOPE

- Engineered Panel System
- Optimum Value Engineering
- Open Web Floor Trusses
- Foam Skim Insulation in Wall Panels
- Spray Applied Cellulose Insulation
- Low-e windows

HVAC

- Compact HVAC Distribution
- Foamed Over Ducts
- Insulation Buried Ducts
- Supply Ventilation

Outlook Construction is raising the energy bar on its Birchwood Farms development, a 120-unit community located 45 minutes north of Atlanta. The homes feature progressive building practices that have resulted in excellent energy performance. The 3-bedroom houses, which range from 1450 sq.ft. to 2100 sq. ft., use as little as $1 worth of energy per day. The builder's confidence in the thermal comfort and energy efficiency of these homes prompted him to guarantee each homeowner's heating and cooling costs for two years.

As a smaller-volume regional production builder, Outlook is able to quickly integrate new products and techniques into its custom and production homes. Many advanced building technologies have become standard practice for the company. Panelized wall systems, advanced 24" on-center framing, open web floor trusses, stud cavities skim-coated with polyurethane foam, low-e windows, downsized HVAC, compact HVAC distribution, and pressurized ventilation are among the practices that have been adopted.

Steven Winter Associates, Inc. (SWA), a building systems consultant, worked with Outlook Construction to design a prototype home using multiple advanced building technologies. In one energy efficiency measure, attic ducts were sprayed with polyurethane foam before being buried under blown insulation. SWA also recommended refinements to the HVAC system including duct layout, jump ducts, outside air supply, and right-sized mechanical equipment.

As an energy-conscious builder, Outlook has been actively investigating cost effective performance improvements to its line of affordable homes. The homes at Birchwood Farms feature high energy performance with a HERS rating of 89.9 (50% better performance over Energy Star) on a tested model. Multiple tests were performed to quantify the building tightness, duct leakage, and balance of the distribution system.

"Training is critical because with panels, your labor force is key. You can plan for it all on paper but if you can't make it happen in the real world, things get tough."

– David Munisteri, Outlook Construction

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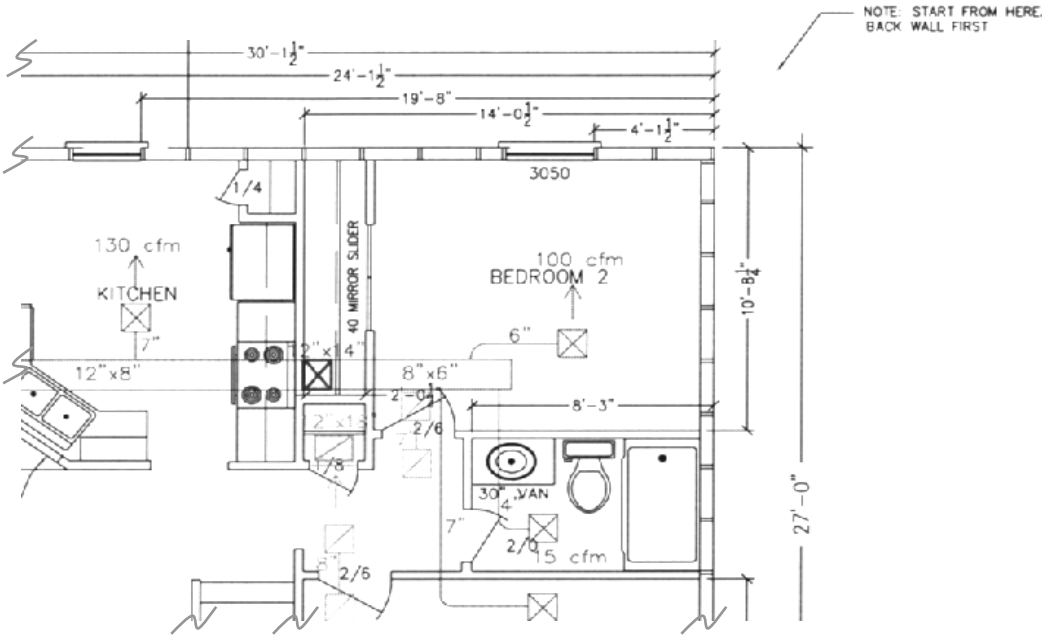
Advanced Technologies

It is the goal of the U.S. Department of Housing and Urban Development's Partnership for Advanced Technology in Housing (PATH) program to accelerate the development and use of technologies that radically improve the quality, durability, energy efficiency, environmental performance, and affordability of America's housing market. The Birchwood Farms Model Home features several of these technologies, carefully planned and implemented to yield performance and cost benefits to both the builder and the homeowner. Highlighted below are the PATH technologies used in this project.

Engineered Panel System (1)

The 2x6 panelized open wall system used for the exterior structure helps to contribute to overall quality and tightness of the home. The panels are assembled off-site in a controlled environment with finer tolerances and higher quality than are typically possible with field construction. Fabrication is based on detailed shop drawings generated from the home design. After factory fabrication, panels are shipped to the site for just-in-time delivery.

During design, the location of window and door openings is coordinated with Outlook's standard panel length of 12' to minimize the number of studs. While panels are available in longer lengths, the builder finds benefits to working with a standard unit size. Most importantly, the 12' panels used by Outlook can easily be erected by framing crews and do not require a crane for installation.



There are several factors that entice builders to use open wall panels. Local panel suppliers often initiate the use of panels, but builders also seek out such systems when they have tight job schedules, when jobsite lumber theft is a problem, when labor rates are high, or simply when they are searching for cost savings and quality improvement. If used wisely, panels help builders increase jobsite productivity, reduce project cycle time, reduce jobsite waste, and enhance construction quality, including the quality of interior and exterior trim and finishes.

Outlook and other builders across the country report that trained, experienced erection crews are key for successful use of panels. Repeating home designs are also important for

achieving maximum benefits. Repetition allows framing crews and subcontractor trades to become extremely familiar with the process and therefore increase productivity. In addition, the panel supplier can perfect the panel system for a particular home design and produce multiple home packages more efficiently and with fewer errors, resulting in reduced cost to the builder. Communication between builder, crews, and suppliers must be maintained throughout the process. Pre-planning, drawing review, and careful scheduling are all critical aspects of building with panels.

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The panels for the Birchwood development are engineered using advanced framing principles referred to as Optimum Value Engineering (OVE). The OVE framing technique reduces the amount of lumber used to build a home while maintaining the structural integrity of the building. Using OVE results in lower material and labor costs and can also improve energy performance. While the system can be applied as a whole package, many of its components can be used independently, depending upon the specific needs of the project. OVE innovations used at Birchwood Farms include the following:

24" On-center Framing (2) **-** 2x6 wall studs spaced 24" on-center align with roof framing (roof truss spacing is already typically 24") and floor joists. This creates a direct load path while substantially reducing lumber and labor costs.

Open Web Floor Trusses (3,4) - The builder used open-web floor trusses spaced 24" on-center. Standard construction practices call for 9-1/4 inch I-joists at 16" on-center. I-joists are often cut (and therefore structurally compromised) by trades installing ductwork or other utilities. The open webs used in the prototype allow for easier coordination and installation of ducts that remain in conditioned space so that distribution losses are drastically reduced. The unique open-web floor truss product has trimmable ends that can be cut to fit on site, reducing installation time.

Ladders at "T" Intersections - Flat horizontal blocking is placed between studs to secure partition framing. With wall framing spaced 24" on-center, three 22-1/2" scrap pieces are set horizontally at 24" on-center to replace two studs at a "T" intersection. The joint is stiffened by the horizontal blocking but much less lumber is used. Most importantly, exterior wall insulation can continue uninterrupted around the building envelope with no uninsulated hidden cavities.

Open Corner Framing - Only two studs are needed at an outside building corner, one at the end of each intersecting wall. A third stud is traditionally added to support gypsum board at the corner, but the same goal can be accomplished with either a flat stud (to leave an open-ended cavity at the corner) or with drywall clips. One stud can be eliminated and the open corner cavity can be insulated along with the wall, eliminating the need for the framer to insulate a closed cavity prior to installing sheathing.

Right Sized Headers (5) **-** Rather than size all headers in bearing walls to accommodate the worst case load and span conditions, each header is individually sized for its particular load and span. Smaller headers save materials and reduce cost.

High Performance Insulation Strategy

As a builder of ENERGY STAR® Homes, Outlook actively pursues new technologies for creating a highly efficient building envelope. The project team explored various insulation techniques in different housing assemblies to determine optimum methods for insulating the panelized walls. Energy-saving insulating strategies are described here in detail.

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Foam Insulation Skim-coat on Wall Panels - Outlook Construction joined with KES Insulation to develop a unique and highly effective two-step insulation process. In the first step a half-inch layer of polyurethane is sprayed into a wall's stud cavity, creating a sealed space and air barrier. The layer of 2 lb. closed-cell foam doubles as a vapor retarder placed to the exterior of the insulation, an ideal location for homes built in hot and humid climates. Spraying polyurethane at the band joists is another insulation method KES uses for additional sealing.

Spray-Applied Cellulose Insulation (6) **-** In the second step of the wall insulation process, cellulose insulation is damp-sprayed into the remaining 5" stud space. Cellulose is made of recycled products (such as newspaper) and provides an excellent thermal barrier. When the damp mix is sprayed on, interlocking fibers in the cellulose form a continuous coating that seals cracks or openings and provides an excellent barrier against air and noise infiltration. The combination of foam and cellulose yields R-23 wall insulation values—far superior to the R-13 fiberglass batt insulation typically used in the Atlanta region.

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Energy Efficient HVAC

SWA engineers performed energy modeling to pinpoint opportunities for energy efficiency improvements. To complement the highly insulated building envelope, the builder implemented a number of strategies for optimizing efficiency of the HVAC equipment and distribution system.

Air Handler in Conditioned Space (7) - Designers created a small mechanical closet on the first floor of the prototype to house the air handler for the heat pump within conditioned space. This represents significant improvement over the traditional practice of placing equipment in unconditioned garages, attics or crawlspaces. Locating the mechanical equipment within conditioned space greatly improves operating efficiency and protects indoor air from contaminants that may be present in unconditioned areas.

Compact Duct Layout - In a compact duct layout design, registers are located on interior corners of rooms closer to the air handler. Eliminating long runs of ductwork has two benefits: energy efficiency increases and initial construction cost decreases. A centralized return (7) directly below the air handler saves material cost and energy without compromising performance. HVAC engineering improves thermal comfort, eliminating hot and cold spots throughout the house.

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Mastic-sealed Ducts (8) - Air leakage from duct joints and connections causes significant energy losses and affects pressurization, air distribution, and indoor air quality. Duct tape traditionally used to seal ductwork eventually loses its powers of adhesion and falls off. Mastic is a putty-like sealant used to fill cracks and crevices that does not harden and crack but rather remains flexible over time, resulting in a much better air seal and improved energy performance.

Pressurized Ventilation—A fresh air duct brings air directly to the handler at a controlled rate for fresh air ventilation. A 6" duct carries fresh air from the soffit in the back porch to the return of the air handler. A butterfly damper is adjusted to allow 60 CFM of fresh air into the air handler.

Foamed-over Ducts (9,11) - Leaky and poorly insulated ducts can add 20-40% to a homeowner's heating and cooling costs. SWA recommended a two-part approach to achieve optimal energy performance from ducts located in the attic of the prototype house. First a 1" layer of 2 lb. closed-cell polyurethane foam was applied to the ductwork to boost R-values, control condensation, and provide additional air sealing. The foam adds R-7 to flex duct's existing R-6, resulting in a total insulation value of R-13.

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One important advantage of the foam is that it controls condensation that typically occurs when hot attic air comes in contact with ductwork containing cooler conditioned air. In addition, the closed-cell foam creates a vapor barrier so that moisture from hot humid ambient air doesn't permeate the insulation layer. The dewpoint, which is located at a point inside the insulation, is protected by the vapor barrier.

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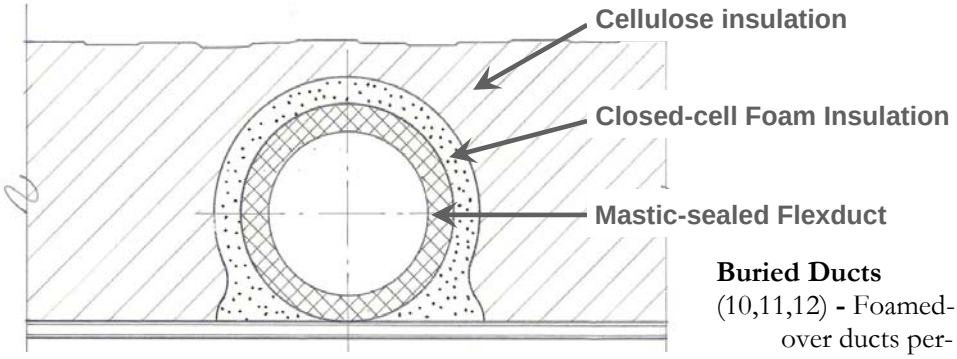
The application of foam insulation adds yet another benefit. It acts as a backup to the mastic sealant, providing additional air sealing. Foam has the advantage of being easier to apply in hard-to-reach places. The air sealing properties are especially beneficial around registers that penetrate the ceiling (an area that is typically prone to leakage). The detail below shows the flex duct with foam insulation and cellulose fill.



11 *Detail of foamed-over buried ducts*

Buried Ducts (10,11,12) **-** Foamed-over ducts perform optimally in conjunction with a second energy-saving technique: ductwork buried under attic insulation. Burying the ducts under blown-in cellulose insulation minimizes losses from distribution of conditioned air. Ideally ductwork should be placed directly on the gypboard or the bottom chords of the roof trusses; however sections occasionally need to be lifted above the insulating layer in order to coordinate with the truss webs.

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While buried ducts work well to save heating and cooling energy in any climate, the blown insulation alone does not prevent condensation problems in hot humid climates. When heat and moisture are prevalent, buried ducts used together with sprayed-on foam yield the best result.

Benefit and Cost Information

Home Energy Performance

SWA performed a number of tests to evaluate energy performance at the Outlook Construction prototype home. The slab-on-grade single-story house with attached garage was tested for building tightness, duct leakage, and balance of the air distribution system. A blower door test for overall envelope tightness showed an average natural infiltration rate of 0.159 ACH (air changes per hour), a "tight" house with a HERS rating of 89.9.

Cost

Analyzing the net cost increase from a whole-building perspective shows an additional cost of less than $500 for the prototype. Integrated design, production efficiencies and cost tradeoffs all help offset the price of higher cost, higher efficiency technologies. The wall panels with 2x6 studs spaced 24" on-center use essentially the same board-feet of lumber as 2x4's at 16", and the time and material cost of wall panels was less than stick framing. Low-e windows and other important energy-saving measures had already been adopted by Outlook Construction (some are now required by Georgia's energy code). After SWA engineers tested and documented the effects of these upgrades, the builder was happy to learn that added cost of the new windows was offset by a substantial drop in cooling load and the resulting downsized HVAC system.

The foamed-over buried ducts similarly have a net-zero cost implication due to further HVAC down-sizing. For comparison's sake, the insulator estimated the cost to foam the ducts at approximately $350 when done on a production scale. Insulating the exterior wall with a foam skim-coat and 5" of damp-spray cellulose constituted the only substantial cost increases. The combination of changes to traditional insulation and HVAC practices yielded a 66% reduction in annual heating and cooling energy and an annual cost savings of $239. This represents a simple payback of approximately two years on the up-front cost increase, plus an immediate positive cash flow (assuming a 6% mortgage).

Builder's Experience

David Munisteri, Outlook Construction

On building with panels… David Munisteri reports that panel system selection depends largely on budget. Outlook has used Structural Insulated Panels (SIPs) for clients in the past, with good results. Most builders who choose SIPs do so for the unmatched energy performance and are able to accept higher material cost due to quality improvements and labor savings. Outlook's two-part wall insulation system achieves a competitive R-23 using open wall panels or even OVE stick framing. The combined technologies yield excellent energy performance at minimal added cost. Training the labor force to work with panels presented the biggest challenge. To offset a slowdown in jobsite productivity, Outlook used the manufacturer's own group of installers to set panels in place.

On building for the future… every home Outlook builds meets the requirements for ENERGY STAR® Homes. By using advanced framing and high R-value insulation systems on every project, the builder guarantees the heating and cooling portion of a homeowner's energy bill for 2 years. The homes are also designed to meet the American Lung Association's "Healthy House" standards for indoor air quality. Outlook has developed its reputation as an "energy builder" and now caters to a niche market of homebuyers seeking healthier, more sustainable houses at competitive prices.