Manufactured Residential Utility Wall System (ResCore), Overview

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INTRODUCTION

This paper provides an overview of the design and development of a manufactured residential utility wall system referred to as ResCore. ResCore is a self-contained, manufactured, residential utility wall that provides complete rough-in of utilities (power, gas, water, and phone) and other functions (exhaust, combustion make-up air, refrigerant lines, etc.) to serve the residential kitchen, bath, utility, and laundry rooms. Auburn University, Department of Industrial Design faculty and students, supported by a team of graduate student researchers and the project's advisory team, developed the ResCore. The project was accomplished through a research subcontract from the U.S. Department of Energy administered by the Oak Ridge National Laboratory.

The ResCore wall system features a "layered" manufacturing technique that allows each major component group - structural, cold water, hot water, drain, gas, electric, etc. - to be built as a separate subassembly and easily brought together for final assembly. The two structural layers are reinforced with bridging that adds strength and also permits firm attachment of plumbing pipes and other systems to the wall frame.

BACKGROUND

This project was begun in 1996 with the conceptual development phase accomplished as part of a senior level design studio. A mockup of the ResCore wall was developed during the Spring Quarter by seniors and graduate students. The Industrial Design staff and graduate students fabricated the first prototype. Installation occurred in a local Habitat for Humanity home in September 1996. The initial ResCore was a single wall serving adjacent kitchen, bath, laundry, and utility rooms.

A follow-on phase during the summer of 1997 refined the initial design and developed two additional prototypes. These prototypes were installed in Habitat for Humanity homes built in Plains, Georgia in October 1997. The second and third prototypes differed from the initial prototype in that the utilities were provided in a series of adjacent and connected walls.

CONCEPT DEVELOPMENT

During the initial concept development, the students focused on ideas supporting the development of an all-encompassing residential utility module or core that was similar to past examples by others. The largest number of concepts presented at the initial concept review meeting with the project advisory team reflected this direction. Through critical analysis of the concept designs, the problems associated with a fully constructed utility module housing kitchen, bath, laundry, and utility room functions became apparent. The problems included transportation (weight, size, in-transit protection, etc.), placement on the building site (crane, large vehicle access, etc.), and the interface with traditional construction details (recessed subfloor, etc.).

The most significant issues working against the use of a fully constructed and outfitted utility core
were its weight (estimated to be in the thousands of pounds) and size. The cost associated with oversized-load shipment and the use of heavy equipment (cranes, etc.) to place the utility module would most likely offset the cost advantages of prefabrication. The advantages of prefabrication would have to be pursued through the reduction of the weight and the resolution of site placement problems.

One of the early concepts focused special attention on developing the area within the complete module where the utility functions were concentrated. This was the "utility wall" that most fixtures abut. In terms of utilities provided, this wall contained the highest concentration and had the highest level of complexity. Consequently, it was the focus of significant labor and material costs and therefore could benefit significantly from prefabrication. It was determined that by developing the utility wall the advantages of prefabrication could be optimized while maintaining a unit weight that could be managed effectively by manual labor at the building site.

The utility wall was also where the largest concentration of plumbing and electrical crafts labor would occur. Significant time and cost efficiencies from fabrication of the core wall off site in a manufacturing facility could be accomplished, provided that the wall’s shipping size and weight were kept within reason.

The utility wall concept became the "agreed approach" between the design and project advisory teams as the most appropriate way of bringing manufacturing efficiency to the provision of utilities in conventional residential building construction.

ENERGY-EFFICIENCY CONCEPTS INVESTIGATED

A major project goal was energy efficiency. Various approaches were investigated to determine potential energy-efficiency gains including:

- Waste energy recovery
- Reduced distribution losses
- Combined equipment
- Use of non-conditioned air
- Reallocation of costs

The project team determined that waste energy recovery was not cost effective, given the small amounts of energy involved and the intermittent nature of most of the waste energy sources. Reduced distribution losses were achieved through shortened distribution runs. The team also determined that pipe insulation was not cost effective because of the short runs. In addition, insulation would make visual inspection of the piping by the building inspector difficult. Combined equipment was determined to be beyond the scope of this project. However, the close proximity of appliances and equipment to each other would facilitate the use of combined equipment if others developed them. The use of non-conditioned air for combustion equipment (furnaces and water heaters) was considered cost effective and a "wise" option to prevent possible back drafting. The prototype ResCore walls were installed in all electric houses and therefore did not include this feature. Other uses of non-conditioned air were considered not cost effective.

The primary means to improve the home's energy efficiency came from the potential to reallocate the construction cost savings from using the ResCore wall. Funds "freed" by the use of the ResCore wall could be reallocated to purchase more energy-efficient equipment than the low-income, or entry-level, home buyer would otherwise be qualified to finance through their
mortgage.

INITIAL PROTOTYPE DEVELOPMENT AND INSTALLATION

A great deal of knowledge was acquired through formal discussion with the industry members of the project advisory team during the initial prototype development phase of the utility wall concept. The design was also significantly enhanced through the process of fabrication of the initial prototype and its installation in a house, Figure 1. The size of this prototype wall was 8 inches wide by 8 feet tall by 15 feet long. The weight of this prototype was maintained at less than 200 pounds which allowed the available on site labor to accomplish its placement in the house and connection to the below floor utility services.

Additional insight was acquired through conversation with the various building trades associated with the completion of the prototype house’s interior spaces. The drywall, paint, and cabinetry trades made suggestions. Response from tradesmen involved with the Habitat project has been positive. These insights have lead to improvements that were incorporated into the design and fabrication of the two subsequent prototype walls.

The initial prototype wall was unloaded and positioned by four “average” laborers since its total weight was less than 200 pounds. Laborers connected the wall to the below floor rough-in plumbing when the wall was installed, as well as to the dwelling's water, gas, and electrical services. The wooden triangular frames steadied the wall in a vertical position during shipment and initial installation. These frames are removed when the wall is tied into the remainder of the structure. The wall is then ready for sheathing with gypsum board. The total time required to off-load, position, install, and connect services is about two hours.

SUBSEQUENT PROTOTYPE DEVELOPMENT AND INSTALLATION

The follow-on phase further refined and demonstrated the concept in two additional Habitat for Humanity houses. The floor plans of these three- and four-bedroom, one-and-one-half bath houses were more challenging than the initial prototype. In one house there were two interconnected utility walls. The other floor plan required three interconnected utility walls (Figure 2.). The photo sequence (Figures 3. & 4.) illustrate a typical on-site delivery and installation. Delivery can be made from either a trailer or flatbed truck.

These prototypes presented new design challenges such as whether to "hinge" the walls together and provide "flexible" interconnections of the utility services, or provide separate wall segments with "quick connects" for the utility services, or a combination of the two. The prototypes had hinged wall segments (Figure 5.) and used a combination of flexible interconnects for the electrical services and carefully coordinated, easy to assemble, joints in the rigid piping services.

The three wall hinged system weighed over 500 lbs. and required six persons to move into final position. This installation manpower requirement, while no problem for the Habitat project, was still well above the desired level of four persons maximum. Modifications to future walls to increase stud spacing from 16 to 24 inches, will markedly reduce overall weight while maintaining adequate strength during shipment and handling.

The second and third prototype utility walls were installed in Habitat for Humanity homes built in Plains, Georgia, in late October 1997.
EXPECTED IMPACT OF RESCORE

Assuming that the ResCore concept is adopted and widespread manufacturing begun, we believe that the following impact will occur:

- Higher quality - The wall will be manufactured in a controlled environment to tight tolerances and rigid quality control standards. Each of the system interfaces (electric, gas, water, sewer, heating ventilating air conditioning, etc.) will be accomplished by design and careful fabrication, rather than as the result of field adaptations that occur with traditional construction. The result will be more capability, operating correctly, within less space. Since only one entity is responsible for production, high quality standards can be readily maintained.

- Lower cost - Savings estimates range from a low of $500 to a high of $2000 for the initial prototype wall, depending on the on-site crafts labor rates of the job. Manufacturing crafts will benefit from an indoor work environment, ample materials inventory, mechanized support, systems subassemblies, and quantity purchasing to lower costs dramatically. On-site installation can be accomplished quickly with semi-skilled personnel. On-site crafts will benefit from the elimination of costly craft coordination “down time” and the ability to focus their efforts on the high-value-added portions of the construction process.

- Faster construction - Based on the prototype, a typical installation of the completed wall is estimated to take between one and two hours. This compares favorably to the days or weeks commonly needed for traditional construction due to weather and craft coordination delays.

- Better overall housing value - The savings accrued from the installation of this wall can either lower the total cost of the house or be reinvested in improvements without increasing the cost to the home buyer. Reinvestment in higher-efficiency, cost-effective heating and cooling equipment, domestic water heater, and/or major appliances can provide a significant return on investment. This is especially important to families at the lower end of the economic spectrum.

FUTURE POTENTIAL OF RESCORE

The use of existing computer-aided design and manufacture (CAD/CAM) technologies to produce the wall will result in the potential for “mass customization” permitting manufacture of the wall for virtually all residences. Other buildings with repetitive utility walls are also candidates for this technology. These include motels, hospitals, nursing homes, prisons, and similar structures.

Future quality and material improvements that cannot be afforded on a one-of-a-kind, site-built, basis will be assimilated into this high-volume manufacturing process. The manufacture of these building components will both reduce waste and facilitate the economical recycle of remaining unused materials.

PRODUCTION DEVELOPMENTS

Concept development, design, construction, installation, testing, and evaluation of prototypes have been completed. Several markets have been identified and initial contacts with potential users
established. Initial contacts with several potential manufacturers have also been made. Additional expressions of interest in either the manufacture or use of the ResCore are solicited by the authors.
Captions:

Figure 1. The first prototype of the ResCore wall (black line) was installed in a Habitat for Humanity house in Opelika, Alabama. A bath, laundry, utility, and kitchen are served from the single utility wall.

Figure 2. The subsequent prototype installation of the ResCore utility wall involved three (shaded) interconnected walls. This installation was located in a Habitat for Humanity house in Plains, Georgia.

Figure 3. A prototype ResCore wall was delivered to the construction site on a small, flat bed trailer.

Figure 4. The three wall prototype of the ResCore utility wall system weighed about 500 lbs. and required six persons to carry to final position.

Figure 5. The ResCore wall is tipped into final position and lowered over the plumbing stub-ups which penetrated the floor slab.