Breaking Ground:

Opening the Construction Market to New Building Technologies

Alison V. Tramba

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Professor Edmund Russell

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On my honor as a student, I have neither given nor received
unauthorized aid on this assignment.

Modern technology and innovative building materials have the potential to improve standards of living by addressing home safety problems and reducing energy usage while cutting down on living expenses. Outdated building regulations limit contractors to common materials and place constraints on construction technology, impacting their ability to develop optimal housing. Looking at these challenges to current construction, a team compiled by the Federation of American Scientists (FAS) began an investigation of the types of engineering and technology that affect such issues as safety, energy efficiency, and cost in building homes. In their search, a number of innovative solutions surfaced, including structural insulated panels (SIPs) made by HSN, Inc.; this company serves as a case study in successful development of technology and compliance with building codes. Although deemed the most promising material for the FAS initiative to use in building affordable, energy-efficient, and safe homes, the SIPs have yet to receive the widespread recognition as ideal construction materials that they deserve. The actual problem in updating housing technology and materials, then, does not come from a shortage of appropriate means of meeting the housing industry's safety- and energy-related needs. Rather, it lies in a lack of motivation towards development and promotion of emerging technology. According to FAS President Henry Kelly,

> "The lack of progress is not due to limits on what technology can achieve, but defects in the market for innovation and product improvement in building-shell technologies. There are many causes: the absence (or near absence) of any engineering or research divisions in even the most sophisticated home construction firm and the difficulty of establishing a clear brand advantage in a field filled with many small firms. The absence of a coherent set of regulations and a clear way to test and label different building-shell systems makes

it difficult for a superior technology to prevail in markets" (Kelly, personal communication, 2005).

Much of the problem derives directly from the difficulty of receiving construction certification. Current building codes do not actively reach out to new methods and materials for construction. Further, disinterest in research and inconsistent enforcement of codes allow traditional and even sub-par building methods to continue, thereby slowing the process of improving the quality of construction through inventive technology.

Even if slowly, products like HSN's panels are beginning to grab the attention of builders looking for strength and environmental friendliness. Establishing a comprehensive program to aid further development will encourage acceptance of new methods of construction. Components should include streamlined policy and building codes, organized research, and incentives for the use of favorable construction methods by consumers. With such provisions, the building industry can make use of the best methods of construction rather than traditional, outdated practices. The results will bring greater confidence in residential safety and energy consumption, meanwhile providing the greatest possible number of people with adequate housing.

A Need for Housing Technology

In a society seeking constant improvement, a logical use of modern technology lies in improving the quality of basics like housing. Creating a market that provides safe, affordable housing to residents and promotes energy efficiency poses a challenge. Current trends may not

indicate it, but environmental and societal expectations on construction methods demand constant improvements.

Safety

Most importantly, safety concerns require that the building industry support the best possible means of home construction. Although their frequency has declined by 54 percent over the past quarter century, home fires still claimed 2670 lives in 2002, comprising 80 percent of the total fire deaths in the country that year (National Fire Protection Agency, 2003). Large-scale natural disasters also arrive unannounced and devastate communities. For example, an anticipated five hurricanes will reach the shores of the United States alone by the end of 2005 (AccuWeather, 2005). Financially, hurricanes have ravished the U.S. in the past century, causing over a billion dollars in damage on each of 23 occasions (National Oceanic and Atmospheric Association , 2003). Floods create $2 billion in damage annually (National Flood Insurance Program, 2005). In other parts of the country, earthquakes cause structural damage to buildings and infrastructure. As of July 31, the United States Geological Survey (USGS) recorded 1814 earthquakes of varying strengths in the United States for 2005 (United States Geological Survey, 2005). While the majority of these were of low magnitudes, the stress and strain of any tectonic movement may compromise stability of buildings, particularly in regions inclined to frequent seismic activity. Taken together, these sources of financial destruction and human injury necessitate improvements in construction. Finding materials to minimize flood and fire damage eliminates expensive and time-consuming repairs. Stronger structures that combat extreme winds and earthquakes reduce safety concerns in high-risk zones. These basic concerns of the building industry demand ongoing investigation into improved methods of

construction. Application of modern technology to building is the responsibility of those related to the industry.

Environmental and Energy Factors

The building industry also holds accountability to the environment. Presently, homes account for about 21 percent of the nation's energy consumption, drawing significantly from limited resources such as natural gas. This usage produces 17 percent of the greenhouse gases emitted by the United States (US Department of Housing and Urban Development, US Department of Energy, & US Environmental Protection Agency, 2005). Greater insulation in wall materials combined with innovative appliances reduces energy costs and harmful wastes. Homes also require a large number of materials for construction; 25 percent of the world's wood harvest goes to the construction industry (Wood Consumption Alliance). Traditional construction also wastefully expends steel, cement, glass, and other materials. As reported by the National Association of Home Builders (NAHB), 24 percent of municipal solid waste comes from construction sites, sometimes containing hazardous materials (National Association of Home Builders, 2005). Introducing more sustainable, efficient materials reduces this problem of large volumes of waste. Better engineering of materials and technology in the industry can decrease the impact of construction on the environment and concurrently save money.

Affordability

Quality of home construction directly correlates with the price of a home, leaving many low-income families to compromise safety and comfort for an affordable cost. Home prices are on the rise, forcing many families with limited financial resources to rent rather than own their residences (Athavaley , 2005). As developmental considerations widen to include cost-reducing technology, more families can afford homes that assure safety and comfort and that lower energy

bills. The need for such housing places a directive on the construction industry to encourage more efficient and suitable means of building.

Engineering Solutions

The solution to these challenges in the home construction industry lies in implementation of new engineering techniques, both in materials and building technology. Initiatives intended to increase safety in homes and public buildings, particularly in areas at risk of large-scale damage, benefit from strengthened materials and structural enhancements that do not add bulk to buildings. Current plans to reduce waste and energy usage bank on technological improvements in construction materials and appliances (US Department of Housing and Urban Development, US Department of Energy, & US Environmental Protection Agency, 2005). Research in this arena has introduced a number of products that utilize modern technology, particularly in materials science. Improved forms of concrete, lightweight insulation materials, and high-strength adhesives all have places in the manufacture of strong, space-efficient structures (Moeller, 2005). Use of these materials cuts down on the demand for wood and creates a far more sustainable structure Sandwich panels made of Fiber-cement and foam proof efficiency in passing all required building tests and meet demanding codes attracted the FAS, giving even more reason for the company's panels to act as a case study in building-shell technology. The SIPs provide a prime example of the benefits to engineering a revolutionary design.

Fiber-cement Structural Insulated Panels (SIPs)

Originally struck by the impressive insulation properties of the Styrofoam used in cups, several laboratories test have concluded that the same material in greater thicknesses could insulate homes well. He designed the first "sandwich panels" with expanded polystyrene (EPS) as the core and a layer of plywood as each facing.

The expectations with regard to insulation are demonstrated, Several other characteristics desirable to builders in the region: The afact they withstood 200 mph winds, did not cost much, and reduced the time necessary for raising a home from weeks to hours. Thousands of SIP's original buildings still stand firm; Many passed the last 5 Florida Hurrican without damange.

Working from the design that entered production in 1984, Sip manufacturers continuously improves their panels. The facings are now composed of fiber cement board, a stronger and more moisture-resistant material than the original oriented strand board (OSB) or plywood. Confident with his product, Haddock set up shop in Florence, Alabama, where he expanded the line of products; he varies EPS and fiber cement board thicknesses to adapt to climates and environments in which he builds.

Federation of American Scientists' Housing Technology Project

Determined to find a better approach to construction than the traditional stick-built methods, the Federation of American Scientists (FAS) began investigation of a number of SIP technologies. The FAS sought low-cost, energy-efficient materials that would maintain stability through natural wear and tear, as well as in regions at high risk of considerable damage, After much comparison of products, the FAS decided that Fiber-cement panels most completely suited their needs and filled the requirements of their project. The FAS collaborated in completing extensive testing on the panels: earthquake simulations on a shake table proved that a structure of the SIPs could survive quakes of greater magnitudes than have ever been recorded (Trentec, 2005). Moisture-resistance analysis recorded impressively low levels of permeance (Southwest Research Institute, 2005), and fire-resistance testing qualified the panels for International Code Council (ICC) certification (Southwest Research Institute, 2004, ICC

Evaluation Service, 2004). In the interest of the environment, the FAS requested comprehensive energy-use comparison between a traditional stick-built home and an identically designed home made of SIPs. The outcome showed a usage difference of 7,663 kW per year, saving $922 annually (Florida Solar Energy Commission, 2005). The FAS team of engineers and building specialists used this information in the design of a model home in Houston, Texas, hoping to bring public awareness to the panel technology.

Despite their remarkable performance, very few builders utilize Fiber-cement panels or similar products in various levels of construction. The FAS became curious about the factors hindering promotion of building technologies.

Obstructing Progress in Building Technology

An investigation into the policies surrounding the construction industry reveals the source of stagnation in building. Current building codes provide beneficial guidelines but also immobilize innovative technologies through their fragmentation and contradiction across markets. Regional policies and markets differ such that a code that could conceivably provide a unified structure in one region contains confusing inconsistencies in another. Beyond the work that individual companies do, little research has gone into alternative technologies, and few efforts have been made to inform the public of any progress that would benefit them economically or in terms of comfort and safety.

International Code Council (ICC) Regulations

Formally defined building requirements dictate the performance levels of construction materials and methods. These policies constantly undergo revisions, demonstrated by drastic changes to agency organization in the last decade. Whereas three main code councils formerly dominated the industry in the United States, a single entity now holds jurisdiction over builders

internationally. The Building Officials and Code Administrators International (BOCA), the International Conference of Building Officials (ICBO), and the Southern Building Code Congress International (SBCCI) convened in 1994 to form the International Code Council (ICC). This single body seeks:

- "Consistency with and inclusion of current codes,
- A comprehensive code, and
- Consideration of safety, health, reasonable costs, the ability to expand the construction market and avoidance of favoritism within the industry" (Tramba, 2005).

Since its inception, the ICC has published an annual International Building Code (IBC) that regulates the construction industry. According to the IBC, any jurisdiction in the world may acceptably adopt such policy as the official building code for the region (International Code Council, 2003). To make this a reasonable allowance, the code must comprehensively address all possible aspects of construction regardless of regional variation of needs. Its documentation outlines specific means of constructing individual elements of homes and indicates tests that materials must pass in order to meet performance benchmarks. The ICC Evaluation Service (ICC-ES) certifies materials that comply with their specifications. ICC certification publicly acknowledges the materials' quality and grants permission for their use in certificate-specified building jobs (ICC Evaluation Service, 2004). ICC also issue the 2004 Florida Building Code.

Application of the ICC fails to solve all complications in construction regulation. The ICC-EC evaluation applies only in places that accept the IBC as the governing specifications, which means that ICC certification alone does not guarantee permission to build in some places In addition, the ICC privately publishes its codes,

selling them for a profit and making them difficult for interested individuals to reasonably obtain. Even gaining access to the codes does not ease their interpretation. The specifications described in the code require detailed knowledge of building or civil engineering in order to understand them.

If the IBC is accepted as the standard across the board and it becomes more accessible, it still does not ease the use of alternative materials and building technologies. As it stands, the IBC provides a fractured set of criteria that expects the use of limited materials and technology. The ICC-ES produce supplementary documents, such as ICC-ES Acceptance Criteria 04: Acceptance Criteria for Sandwich Panels, to set the standards for non-traditional forms of construction (International Code Council, 2004). As much as the ICC attempted to consolidate national building codes in the mid-1990s, its efforts have only gone halfway. As of January, 2004, UBC testing criteria from 1997 were still accepted for the fire tests that the FAS and manufacturers completed (Southwest Research Institute, 2004). Other required tests for load-bearing strength can be modified.

The moisture and seismic resistance testing that the FAS sample of Fiber-cement panel came from the American Society of Testing and Materials (ASTM), the official publisher of all IBC-directed tests, but do not actually have IBC benchmarks to meet. Their results, while important, cast no bearing on whether or not a material or technology can be used in the field (Chappman, G. & M. Mehrafza, personal correspondence, 2005). This complicates comparison of the EPS panels with other materials tested by the IBC methods. Documenting requirements for new materials and technologies in several places makes meeting all expectations difficult and reveals the ICC's continued fragmentation. Due to both high costs of completing mandatory ASTM tests and the small bearing that certification holds in places where codes go ignored,

developers are discouraged from attempting to bring panels into the mainstream.
Now Miami-Dade County Product approval (NOA's) can be a good guide line for National Aceeptance.

Regional Codes and Markets

Within the United States, a broad range of building codes and policies exist. Along the West Coast, significant planning for earthquakes encourages the adoption of strict building codes. This work prompted changes to the 1991 UBC (Celebi, Page, & Seekins, 1996). Similarly, parts of Florida that see frequent hurricanes have wind requirements above the load testing demanded by the IBC. Outside of city limits, however, the Florida code frequently gets ignored. As a result, builders find that sticking to typical local designs turns a profit and they have little motivation to adopt new materials and building technology. Completing extensive testing as the FAS did to promote SIP technology is costly and not worthwhile if local buyers are satisfied with current trends. Without knowledge of new and innovative materials and technology, residents settle for homes that meet minimal codes.

Publicity and Research

The construction industry does very little to move new building technology towards the mainstream. Frequently, citizens constructing homes are left completely unaware of the benefits of building with new technology or materials. When hearing about the simplicity of products such as Fiber-cement panels, most are skeptical of their performance. They inaccurately assume weakness because of the foam's lightness and do not understand the significance of the results from ICC-regulated testing without it being translated into generally accepted terms (Jagoda, personal correspondence, 2005). Limited research and testing of new building materials and

technologies prevents major breakthroughs and keeps the public from viewing SIPs and other advancements as preferable means of construction.

Solutions

FAS_Fiber-cement panels serve as a case study that modern technology and materials can better the housing market with regard to safety, energy efficiency, and cost. Haddock and the FAS met all ICC criteria, spending significant amounts of money and time in the process. The combined effort conducting ongoing research and development should be an industry-wide model of how to follow through with the introduction of new technologies. Considering the challenges that FAS has faced, however, a number of improvements to the industry would positively update the necessary procedure for certification and acceptance of new building technologies and materials. These changes fall under the responsibility of multiple parties, including policy makers, policy enforcers, engineers and scientists conducting research, and federal and local programs encouraging a consumer shift towards energy-efficient housing. While the actual construction requirements should not become relaxed, general understanding of them and how to use them to the benefit of the builder should improve.

Building Code Updates

The ICC must follow through in its halfway effort of streamlining national building codes before it can effectively manage all types of construction projects. Periodic updates to the code should include more than just minor changes; as technologies and materials enter the market, they should have a place in the code rather than in supplemental publications. If the IBC really does “recognize the need for a modern, up-to-date building code addressing the design and installation of building systems through requirements emphasizing performance,” it should open its regulations to the most advanced technology. The code should drive the market to promote

greater development rather than research forcing the ICC to update the code (International Code Council, 2004).

In addition to pacing regulation with technological developments, policy should expand to include elements of environmental concern. A recent initiative between Housing and Urban Development, Environmental Protection Agency, and Department of Energy called "Partnerships for Home Energy Efficiency" has pledged to reduce energy usage in homes by 10 percent in the next decade (S. Bodman, A. Jackson, & S. Johnson, 2005). Without specific requirements, however, this goal will likely not come to pass. Products such asFiber-cement EPS panels certainly meet such standards, so adding them to official code would promote the use of technology and materials that have taken environmental factors into account. Making the code more comprehensive moves the construction industry towards overall greater efficiency.

Parties required to meet IBC regulations must have greater accessibility to them, both physically and conceptually. In theory, lower prices for the volumes will raise the number sold, thus returning comparable profits for the ICC. Greater presence of the code would make individuals more aware of its significance. To ease understanding, a companion volume already accompanies some editions of the IBC to explain its dense technicalities. Continued efforts on the part of the ICC to bring the code—at a comprehensible level—to contractors and local officials will promote more consistent enforcement of regulations.

Uniform Policy Enforcement

Simple adoption of the IBC as standard minimum code solves the problem of regional inconsistencies in building regulations. Additional policies may be advised in places particularly prone to earthquake or hurricane damage, but if the IBC's updates contain policies to address seismic activity and heavy wind loads, addendums will add very little. Uniform requirements

leave local officials with the responsibility to monitor those in the construction industry. Stricter watch than that in Florida, for example, where low-cost homes rise without any monitoring, will assure quality construction in all regions.

Research and Development

Demands for high-quality building certainly inspire research into the best possible building materials and technologies. Driven to compete in a market that must meet high standards, construction firms will invest in research, development, and promotion of building components that bring them to the forefront in the industry and improve the quality of home production. Programs affiliated with universities can provide academic resources to conduct tests and experiment with some of the most innovative materials and technologies available. Funding from industry introduces a connection between the academic and commercial sectors to benefit students and business alike, meanwhile working towards ideal home construction methods that keep families safe, energy bills low, and natural resources in sufficient supply.

Consumer Incentives

Satisfaction with current home-construction trends leaves consumers with little reason to support innovation in the market. Improvements in safety features, as fiber-cement panels provide, influence residents who have experienced damage from storms and earthquakes. For the general population, however, cost savings provide a more likely reason to support new building materials and technologies. The energy savings in a home built with SIP panels exceeds $900 per year, as proven by the energy analysis conducted with the help of the FAS. The HUD/DOE/EPA program designed to cut costs and energy use must find a means of luring homeowners and potential builders to adopt new technologies. Fortunately, the Energy Bill that passed in Congress on Friday, July 29, 2005, includes provisions for tax breaks to citizens who make use

of modern energy-saving technology (Herbert, 2005). Continued nationwide initiatives along these lines would certainly provide the push that citizens need to shift their perceptions of safe and environmentally-responsible housing. Consumer demand combined with industrial research and development will bring emerging technologies to the core of the construction industry.

Conclusions

Emerging technologies both in materials and building practices give the construction industry the potential to improve safety and energy factors. At this junction, the responsibility for putting such technologies in mainstream industry falls on policy makers and enforcement officials who have the authority to direct the industry. The ICC has taken steps towards consolidating their codes and standards, but the process of completely streamlining a formerly fragmented procedure of certification remains difficult. Fiber-cement panels proved that gaining accreditation for innovative SIPs is a possible, albeit timely and costly, procedure. To emphasize the importance for all materials and technologies to meet codes, regional officials must insist on constant compliance by builders and contractors. Consistent standards across the industry will generate greater competition among developers trying to sell their homes, as everyone required to meet the same expectations tries to differentiate themselves. Encouraging more research and development of building materials and technologies only serves the public well, as the outcome provides improved safety, comfort, and energy efficiency. As such advancements reach the mainstream market, lower costs bring optimal housing to citizens at all levels of income. While this process of improving the construction industry takes time, its importance to the safety and comfort of residents makes the FAS' attention to it worthwhile.

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