

EIGHT-PENNY NEWS

VOLUME 11 • NUMBER 2

NOVEMBER 1992

Sorting Through Andrew's Mess Storm Reveals Strong Codes But Weak Compliance

If ever the skies dealt the construction industry a mixed blessing, Hurricane Andrew was it. Replacing and repairing the buildings destroyed by this most expensive of U.S. natural disasters is expected to revitalize Florida's anemic construction economy. Critics, however, say the storm has graphically exposed the building industry's shortcomings.

Poor, substandard construction was responsible for most of the \$20 billion in damages caused by Hurricane Andrew, according to engineers and inspectors from the Wind Engineering Research Council (WERC), who inspected both failed and sound buildings in the hurricane's aftermath. Both WERC and other engineers concluded that homes built to code generally withstood the hurricane's 120 mph winds. One engineer reportedly said that the code-complying houses probably could have resisted winds of up to 200 mph.

This conclusion focused scrutiny not only on the building industry, for not complying with the code, but also on south Florida's code enforcement bodies, which clearly failed in their mission

to ensure code compliance.

The homes that came apart, the experts said, did so because builders didn't properly incorporate the wind-resistant construction details called for by the South Florida Building Code, which is among the nation's most stringent. Key code violations were:

- inadequate nailing of roofing sheathing
- improper installation or failure to use hurricane strapping (the metal straps used to tie roof framing to wall framing)
- inadequate wall bracing

Engineers also said homes were weakened by the use of staples instead of nails to secure roof sheathing and by the use of pressed-board roof sheathing materials.

In response to these findings, the Miami Board of Rules and Appeals voted in September to prohibit the use of any roof sheathing other than plywood (the rule forbids the use of waferboard, particle board, composite, and oriented strand board), to prohibit the use of roofing staples, and to require the use of 30-pound roofing felt instead of the lighter 15-pound variety.

Rebuilding the mistakes.



Poorly secured trusses and roof sheathing were the most common failures in the homes destroyed by Hurricane Andrew. Initial investigations suggest that shoddy construction, rather than inadequate codes, caused most of the building failures.

Not even the Board, however, pretended they would be able to enforce these and other code provisions. There are far more buildings going up than south Florida's code officers can possibly inspect. In some cases, code officials reportedly told homeowners to go ahead and build, and worry about getting a permit later.

This raises fears that repaired and rebuilt houses will be no stronger than the ones they're replacing, so that another hurricane may cause similar havoc. Inspectors have already found many repaired houses with roofs sheathed with pressed-board sheathing secured with staples.

Officials and some contractors were quick to blame "shady" contractors. But at least one roofer accused of subcode roofing (he was using staples instead of nails to secure the sheathing) pointed out that these roofs met the old code,

and complained that he had not been made aware of the code changes.

Work for everybody. On the good side, the aftermath of Hurricane Andrew promises to reemploy many thousands of builders and construction workers who have been scraping by in the current recession. Previous to the storm, the recession, overbuilding, and a drop in the Florida immigration rate had cut building activity in the state to a third of its peak, 1989 level. But with 65,000 homes totally destroyed, 115,000 heavily damaged, and many thousands of commercial establishments needing to be rebuilt, the area should provide plenty of construction jobs for the next few years. Roofers will be among the busiest, since over 200,000 roofs need to be rebuilt. One local economist called the storm "a godsend"

continued

STATE BY STATE

New Hampshire:

Carpenters, though now in low demand, are expected to be one of the 20 fastest-growing occupations in New Hampshire in the next 13 years, according to the New Hampshire Department of Employment Security. Demand for carpenters is expected to rise 51% between now and 2005.

Rhode Island:

This year Rhode Island established a state workers compensation insurance fund, which has been writing policies since January 1. The fund offers coverage to employers who qualify by adopting safety programs and meeting other criteria. For information, call the state Workers Compensation Division at 401/272-0700.

North Carolina: Some contractors will have to develop safety programs to comply with new workplace safety laws passed in the wake of last year's fire at a chicken processing plant that killed 25 people. (Most of the deaths were attributed to major safety violations, such as fire exits being nailed shut to prevent theft.) The legislation requires high-risk employers (as determined by workers compensation modifiers and/or the company's claim experience) to establish an employer-employee safety committee responsible for conducting periodic inspections. The legislation also roughly doubles the number of OSHA inspection officers.

Georgia: Contractors here are among the first in the South to be required to use water-conserving 1.6-gallon/flush toilets. Legislation requires that such toilets be the only ones installed in any homes started after April 1 of this year. **New Jersey, Maryland, and North Carolina** also recently adopted regulations requiring low-flow plumbing fixtures. Similar bills are pending in **Arizona, Pennsylvania, and the District of Columbia.** □

Foundation Walls: How Thick is Thick Enough?

The average 8-inch-thick foundation wall has sufficient compressive strength to support several houses instead of just one. But when it comes to lateral strength, some engineers and builders argue that you need a full 8 inches, especially in dense, heavy soils.

A recent study in Alberta, Canada, sponsored by the Alberta Municipal Affairs Innovative Housing Grants Program, found that a 6-inch foundation wall not only supplies adequate lateral strength, it also cuts construction costs by an average of \$600 (about \$700 U.S.).

But don't expect Canadian (or American) builders to make the switch to 6-inch walls anytime soon, says Terence Toth, acting manager of research and development for Alberta Municipal Affairs. "The main obstacle is homeowners who don't like the idea of having thinner walls than their neighbors," he says.

Builders are also reluctant to break tradition and go with 6-inch walls. While the Canadian code allows 6-inch walls, some builders have raised concerns:

- Thin walls would suffer more from poor quality control because they offer

less margin for error. For instance, construction tolerances on walls sometimes vary by up to 1 inch. A 6-inch wall is acceptable, but a 5-inch wall might fail.

- Thin walls would have to cure longer before being backfilled. This is to ensure that the wall reaches sufficient strength to withstand the resulting stress.
- Because cast-in-place beam pockets and nailing ladders, which remain after the forms are stripped, make the opening at the top of the wall smaller, there may not be enough room for pouring

the concrete through. Anchor bolts are recommended for thin walls.

- There is some concern that thinner walls would not provide adequate strength for brick-veneer houses. Although the testing conducted in Alberta found the thinner walls were strong enough to prevent the veneer from cracking, the test results have been disputed by some engineers.
- Finally, testing was done only in Alberta with the types of soils found in that province. Denser soils might stress the 6-inch foundation walls. □

Lucas Case Goes Developer's Way

In what is seen as a major victory for developers, the U.S. Supreme Court ruled in June that the State of South Carolina had to compensate developer David Lucas for "taking" his land through environmental regulations that stopped him from developing it. The long-anticipated decision means cities, states, and the federal government may have to compensate landowners when regulations prevent those landowners from developing or otherwise getting economic use of their land.

Lucas bought the two building lots along the South Carolina coast, about 300 feet from the beach, in 1986 for \$985,000. He planned to build single-family homes on the two lots — a use allowed at that time. (The lots on either side of the ones he bought, in fact, already had houses built on them.) Then in 1988, the South Carolina Legislature enacted the Beachfront Management Act, which established a "baseline" of flood- and storm-prone areas all along the coast. Anything between this baseline and the water was off-limits to building. Lucas's lots fell within this zone. Suddenly his half-million dollar lots were useless as building lots.

He sued the state, arguing that the Beachfront Management Act was in effect a "taking" of his property. Government "taking" of private property without compensation is prohibited by the Constitution's Fifth Amendment. Lucas argued that because the regulation denied him of virtually all economic use of his land, the state essentially took it from him.

Lucas won the case in the first court in which it was tried; that court ruled that his land had been rendered "valueless" and ordered the state to pay Lucas \$1.2 million. That decision was soon reversed by the South Carolina Supreme Court. Lucas appealed that decision, and eventually ended up in the U.S. Supreme Court.

The Supreme Court agreed with him, ruling that because the Beachfront Management Act had robbed him of all

economic use, it was a taking that had to be compensated. It then sent the case back to a lower court to determine the amount of compensation due to Lucas. Most observers believe that will be less than the \$1.2 million originally awarded.

Not all or nothing. Lucas's victory was not the all-encompassing victory that many developers had hoped for. At issue was not whether all environmental and zoning regulations were takings, but whether the Beachfront Management Act's regulations in particular had left the land with "no economically viable use" — a test the Court has been using in these cases for several years. Lucas did not take issue with the Beachfront Management Act itself, and

"Government agencies will be less likely to set aside large parcels of land to protect wildlife now, because they cannot afford to compensate the landowners..."

the Court did not challenge the state's right to impose such a law.

In addition, the Court noted that compensation was due primarily because Lucas had originally bought the land with no such restriction on it. Had he bought the land after the Beachfront Management Act was passed, he would not have owned title, as it were, to development rights, and therefore could not suffer from having them taken from him; had that been the case, most observers feel he would have lost.

In short, the Court did not create any new rules or standards by which takings cases should be judged, though it did deemphasize the question of whether the taking was for the public good (historically a crucial issue in these cases), making that consideration secondary to the question of whether the taking was total. (The court

upheld the principle, however, that governments can prohibit, without compensation, uses that clearly cause the public harm.)

So what is different? If the Lucas ruling didn't rewrite takings law, it will probably alter, at least subtly, the way land is regulated, say observers. "Government agencies will be less likely to set aside large parcels of land to protect wildlife now, because they cannot afford to compensate the landowners," says attorney Kenneth Bley, of Malibu, Calif. "Governments now face some tough choices trying to balance economics with their concern for protecting the environment."

The Lucas decision will almost certainly give pause to city, state, or federal government bodies writing environmental or zoning regulations that might take from landowners all existing economic use of their lands. Because of the Lucas case, such regulations will more likely leave current landowners with some economic use of their land — by reducing densities, for instance — or establish (as South Carolina did after Lucas sued) some sort of special permitting process for those already owning land affected when a bill is passed.

Meanwhile, the government's power to regulate land and property use continues to be attacked in lower courts. The U.S. Court of Claims, which is the court that usually hears federal takings cases, heard 52 takings cases last year — the most in a decade. Among its decisions was one ordering the U.S. to pay a Minnesota developer \$761,818 after wetlands regulations prevented him from building on 13 acres he owned. And the Pennsylvania Supreme Court last year found that a historic designation of a theater amounted to a taking because it kept the owner from expanding to draw bigger crowds. If these trends continue, Lucas may be the first in a series of decisions that make it tougher to heavily regulate land and property use. □

From What We Gather

Foundations contribute between 25% and 40% of a house's total moisture load, according to the U.S. Department of Energy's *Moisture Control Handbook*.

Remodeling spending fell below \$100 billion for the first time in three years in 1991 when it declined 8.3%, from \$106.7 billion in 1990 to \$97.8 billion, according to the U.S. Census Bureau. Most of the drop, however, was in rental property expenditures, which fell 18%. Spending on owner-occupied home remodeling fell only 1.4%, dropping from \$63.2 billion to \$62.3 billion.

Western lumber production fell to its lowest rate since 1985 last year, when sawmills in the 12 western states

produced just over 19 billion board feet. This represented 41% of the lumber used in the U.S. in 1991; southern mills supplied 29%, while imports (mostly from Canada) supplied 28%.

Sales of manufactured homes (mobile homes) are rising, according to the National Conference of States on Building Codes and Standards. In the first five months of this year, production and shipments increased by more than 10,000 units over last year's figures. The reason? Perceived value. An increasing number of people feel manufactured homes, which are more spacious and sturdier than ever, make a sensible, affordable alternative to stick-built homes. □

Saving Aging Decks

Unless they are well cared for, most decks don't age gracefully. Deck boards more than 10 to 15 years old tend to crack and check. Some break. But an old deck's infrastructure is normally sound, so pulling the whole thing apart wastes time, materials, and effort.

Now, researchers at Virginia Polytechnic Institute (VPI) in Blacksburg are working on methods for covering old,

over the top of the old deck. The panels can be arranged in a straight or parquet pattern, with deck screws used at either end of each 31/2x51/2-inch board to fasten the panels to the existing deck.

"We're still in the experimental stages with this," Loferski says. "We're not certain that consumers will accept these as a good alternative to a new deck. But



You've rolled roofs; you may soon be able to roll decking as well, if researchers at Virginia Polytechnic Institute can work the kinks out of this "deck refurbishing product." The thin deck boards come linked into 42x42-inch panels rolled up like sections of snow fencing. To install, you roll the product out over an old, weathered deck and fasten it.

unsightly decking with new materials. Their "deck refurbishing product" will consist of a series of thin, 31/2x51/2-inch pressure-treated deck boards assembled into 42x42-inch panels and held together (and in line) by strips of plastic or paper (see photo). These panels will be rolled and shrink-wrapped so they "resemble sections of snow fencing," says Joseph Loferski, an associate professor of wood engineering at VPI.

Once the product is on the market, a homeowner or remodeler will be able to walk into a lumberyard, pick up as many panels as needed to cover a deck, and unroll the panels

they will be a lot less expensive."

There are some other issues the researchers must resolve. For instance, if the treated boards are more than 3/4 inch thick, they will not be compatible with most existing entry doors. But if they are much thinner, the boards may not be strong enough to prevent cracking. Also, some cutting will have to be done to fit the panels around existing deck edges, posts, steps, and other features.

Once the prototype is completed within the next few months, it will probably be another year before the panels are brought on the market. □

Low-Flow Products Directory

The International Association of Plumbing and Mechanical Officials (IAPMO), which publishes the Uniform Plumbing Code, is offering a free directory of water-saving products. The *Directory of Water-Conserving Plumbing Products* should simplify the specification of ultra low-flush toilets, showerhead flow restrictors, and other products, many of which are now required by law in some states. For a copy, contact IAPMO at 20001 Walnut Dr. South, Walnut, CA 91789; 800/854-2766. □

Back-to-Basics Management Tips

At a seminar given at the Kitchen and Bath Industry Show, Marilyn Hermance, of Custom Accessories, Houston, and Morton Block, of Morton Block and Associates, Philadelphia, stressed the following management must-dos:

- **You cannot operate without company rules.** These should include printed policies regarding sick days, drug use, vacation time, and so on.
- **Review your insurance policies carefully.** You may not be covered on some important items. For instance, if an employee is embezzling from you, your insurance might reimburse you for the embezzled amount but not for the legal costs you incur.
- **Be sure you are charging sales tax** and any other required taxes on materials, labor, freight, and services. Otherwise, if you get audited, you could wind up paying a substantial fee as well as a penalty.
- **Spend your time doing what you do and like best,** and

hire people to do the other stuff.

- **Don't use attorneys or accountants** who don't have malpractice insurance.
- **Know what forms the law requires** your company to fill out, and confirm that all of them are being filled out and sent to the right places by your attorney or accountant. Don't just take someone's word for it.
- **List the due dates for your annual corporate taxes** somewhere and be sure you get a proof of payment.
- **If you're starting a business, have at least six months of working capital** on hand before you open your doors. Do a complete forecast of projected sales and expenses.
- **Get a financial statement** from each of your suppliers.
- **Don't bleed your company** by going overboard with travel and entertainment spending. Don't pay yourself more than you can afford. □

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Green Newsletter Debuts

The *Environmental Building News*, billing itself as "a bimonthly newsletter on environmentally sustainable design and construction," published its first issue this July, becoming the latest, and perhaps the most scholarly, of several resources dedicated to the practice of "green" building and design (see "Green Builders Sprouting All Over," *Eight-Penny News* 5/92).

The *News* will cover such issues as selection of low-impact building materials, site planning to protect open space, energy-efficient construction, alternatives to old-growth timber, and indoor air quality.

The newsletter costs \$60 a year, for six issues. For information, contact Environmental Building News, RRI, Box 161, Brattleboro, VT 05301; 802/257-7300. □

Remodeling Group Targets the Little Guys

A new trade group, the Remodeling Contractors' Association of America (RCAA), was recently formed to fill the needs of all remodelers, including the small, one-person operations. According to a spokesman for the group, other associations were meeting the needs of bigger remodeling firms while

ignoring "the little guys."

Based in McLean, Va., RCAA started operations earlier this summer. Within two months, the group had attracted about 200 members. The association's goal is to keep dues low (\$30 per year) while providing members with such business services as group health insurance, a retirement

plan, discounts on business forms and travel, and Visa and MasterCard discount services. The group is also planning a trade show to be held in Baltimore in the spring of 1993.

For more information, contact the group at 8180 Greensboro Dr., Suite 1175, McLean, VA 22102; 703/671-7222. □

Dozing the High End on the Gold Coast

If you don't like it, tear it down, seems to be the word on Seattle's east side. According to Mike Burbridge, of the Bellevue Public Works Department, up to 90 Seattle homes are razed each year to make way for new, bigger homes. For the most

part, the homes being removed are small, plain ranches built in the '40s and '50s. But that isn't always the case. When a 4,000 square-foot home assessed at \$1.1 million was torn down (see photo), it made headlines.

The house had gold

bathroom fixtures, a library, three fireplaces, and had been lived in for about a year before it changed hands and the new owner decided he'd like something different. Although a neighbor offered to move it so he could replace his own older, smaller house, the owner decided to go ahead and destroy it, lest the moving take too long and delay construction on his new place. The problem with the old one? The new owner wanted to replace it with a stucco design.

Burbridge says that "people with megabucks want to get into the area because it's close to downtown Seattle and on the water." Teardowns are frequent, he says, because few lots are empty. "If they want in, they have to buy land with a home already on it." The buildings are usually just torn down, according to Burbridge, and very few are salvaged.

Burbridge remembers "only a half-dozen cases where the homes have been remodeled, mostly because of their historic value." He expects the tear-down trend to continue for at least ten years, as more and more affluent people move to Seattle.

— Kathleen O'Brien



This \$1.1 million Seattle home was torn down after one year of occupancy — not because it was condemned, but because the new owner wanted a different house.

Hurricane Andrew, continued

for the state's construction economy.

This prospect wasn't lost on carpenters and contractors from around the country, many of who rushed to south Florida. This caused grumbling among some local building groups. It also raised some concern that out-of-state builders might build homes that aren't up to code. To prevent this, Miami passed a law requiring out-of-state contractors to take a licensing test to make sure they know the code.

However, with plenty of work for everyone, at least for now, no one is complaining too loudly. Contractors looking for help are reportedly beating the bushes (and the orchards, where they are hiring agricultural workers as laborers), and wages for everyone rose quickly from their depressed levels.

Price gouging charged. Rising even faster were the prices of the things hurricane victims needed most.

While the state received over 1,000 complaints concerning the cost of everything from ice (which was suddenly going for \$4 a bag) to mobile homes, the most significant complaints concerned building materials. Plywood and roofing materials rose particularly fast; plywood reportedly went from around \$10 a sheet to around \$25 in just a few days.

This led to charges of price gouging against suppliers and manufacturers, several of whose financial records were subpoenaed by Florida attorney general Bob Butterworth. Initial investigations show that the increases did not come from local suppliers, but from suppliers at the national level, according to Butterworth. This was confirmed by reported price increases at distributors in other parts of the country.

Price controls. With both labor and materials rising, the cost of

building rose too, and some consumers cried foul. To help prevent construction price-gouging and set standards for insurance reimbursement, the state passed a set of guidelines establishing "reasonable and fair" construction prices.

These guidelines, which the state took pains to point out are not mandatory, were based on the cost of repairing or replacing an "average" \$80,000 home. The idea, said state insurance commissioner Tom Gallagher, was to give consumers and insurance companies a way to evaluate estimates and bills to make sure they aren't getting ripped off.

Contractors, however, objected strenuously. The guidelines, they argued, set unrealistically low expectations of what repairs in the inflated post-storm economy will cost. The result, the Florida Roofing, Sheet Metal and Air Conditioning Contractors Association argued, will

be that legitimate contractors will be underbid by "fly-by-night" operators who may not build to code. The Association, objecting that the state was looking after insurance carriers at the expense of contractors, filed suit in Orange County Circuit Court to have the guidelines overturned.

Some of the more immediate crises — the price gouging, the disputes over price guidelines, the turf battles between in-state and out-of-state contractors — were on their way to being cleared up as this article went to press in late September. Less promising, however, is the debate over how to regulate construction so that repaired and new buildings meet code. It appears that, in the confusion and push of the rebuilding effort, the lessons about hurricane-resistant construction taught so violently by Hurricane Andrew might be overlooked. □

Foam Meets Steel, Wins

Recent investigations by Manville Roofing Systems and other former phenolic foam manufacturers confirm that, under certain conditions, phenolic foam insulation corrodes steel-deck roofs. Researchers don't yet know how widespread the problem is. Phenolic foam was most widely used in commercial steel-deck roof systems built during the mid-1980s. Some of those decks may be structurally unsound, presenting safety and estimating problems to anyone who works on them.

Roofers and engineers investigating roof failures first suspected the problem several years ago. They've since found that any water that enters the roofing system via leaks or condensation dissolves the sulfonic acid normally found in phenolic foam. The acid then corrodes the steel deck and fasteners,

"eating some good-sized holes in the roof," says Don Berg, deputy director of technology and research for the National Roofing Contractors Association. The acids do more damage when there's plenty of oxygen available and temperatures are high. Given the right conditions, they even eat through galvanized decks.

When a roof deck is seriously corroded, fasteners can pull through, and the roofing material is more likely to uplift in wind. Insulation may sag or buckle. And since corroded decks don't support loads well, they could collapse under anyone who walks on them. Builders working on commercial properties with steel-deck roofs should not only walk carefully on the roof, but should also cover their contractual backsides with good hidden-condition clauses. □

TAX TALK

Happy Stops Along the Traveling Trail

Nearly everyone knows you cannot deduct the cost of commuting to and from your regular workplace. However, this rule has a little-known loophole that was opened by a 1990 IRS ruling. Many business owners are spinning their wheels under the old rules and failing to get full mileage out of this (rare) delightful revenue ruling.

The ruling centers on the deductibility of *daily transportation expenses* when going to a *temporary* job site. Let's begin at your house. If you get into the car and drive to your regular place of business, you can't deduct the mileage. However, if you stop on the way to do *any sort of business* — meet with a client

or pick some things up from a supplier — you can deduct (at 27.5 cents/per mile) the mileage of the trip from your house, to the intermediate stop, and on to the office. You can also deduct the mileage if you drive to any other "temporary" workplace, such as to a construction site or a client's home or office.

— contributed by Irving Blackman, Blackman Kallick Bartelstein, 300 S. Riverside Plaza, Chicago, Illinois 60606

The other recent revenue ruling concerns the cost of Saturday night overlays you take to receive discount excursion airline fares. Many airlines have special fares that require a Saturday night

layover. So many employers have their employees stay the night (or go a couple days early) to get the lower fare. One of these employers recently asked the IRS if it could deduct the extra cost incurred by that Saturday night stay. (Extra days at the beginning or end of a business trip usually aren't deductible.) The IRS said yes, the cost of the extra night and meals is deductible, as long as the extra cost doesn't exceed the extra cost you would have incurred by paying the higher airline fare.

— contributed by tax consultant Milton Zall, Zall Enterprises, 606 Kenbrook Dr., Silver Spring, MD 20902

Cold-Climate Techniques Migrate South

Certain "tight" building techniques were developed for northern climates, which is primarily where they remain. But a recent Virginia study suggests that insulation measures normally used only in northern states may bring significant energy savings in milder climates as well.

The study, conducted by the Virginia Center for Coal and Energy Research (part of Virginia Polytechnic Institute), compared that state's existing energy-efficient building program with a more aggressive pilot program. It found that high-performance energy-saving systems such as high-density wall insulation and air sealing techniques targeted at basements and attics reduced energy use in single-family homes by 10% to 24%, compared to houses built under Virginia's existing energy-efficiency program.

The existing program, says Kathy Greely, a research assistant at the Center, relies on "pretty typical" weatherization techniques: attic insulation, primary window replacement, storm window installation, caulking, and weatherstripping."

The study found that some of these measures were not

cost effective in most houses, and that others, particularly higher wall R-values and greater attention to air sealing in attics and basements, should take precedence. As a result, the Center now recommends that caulking and weatherstripping around windows and doors and primary window replacement be given lower priority than other measures that focus on

sealing areas outside of the "neutral-pressure plane" (which is in the middle level of the house), such as the basement and the attic.

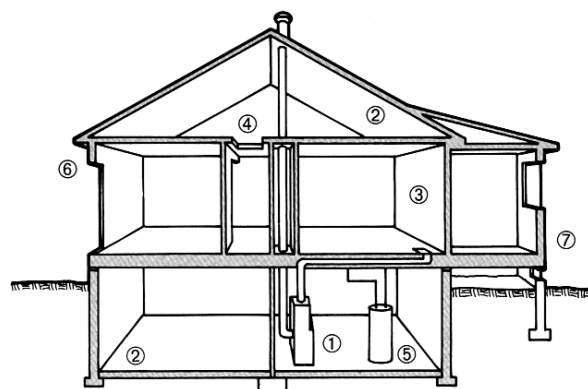
Basement and attic areas are the most affected by the "stack effect," in which convection currents pull air in through the bottom of the house and out through the top. For this reason they lose far more energy than the

"neutral-pressure plane" — generally the house's main living areas. Leaks in basements and attics, say the researchers, are routinely sealed in cold climates, but they are often ignored in moderate climates like Virginia's.

The new system tries to correct this oversight. Based on programs previously tested and used primarily in cold-

climate states, the new recommendations (see illustration), say the researchers, can result in significant energy savings in Virginia's relatively mild climate. The Center has recommended it to 27 Virginia Community Action Agencies. So far, seven of them have adopted it, and more are expected to follow.

— Kathleen O'Brien



A recent Virginia study found that attic and basement air-sealing techniques normally used only in extreme northern climates are also effective in Virginia's milder climate. Assuming certain moderate insulation levels, researchers say, the key is to discourage the "stack effect" by reducing infiltration in and out of the house's basement and attic.

Recommended Weatherization Steps for Single-Family Homes (in order of priority):

1. Heating system: inspect; perform simple repairs; seal leaks in ducts, plenum, and register boots.
2. Major attic and basement leaks: conduct blower test to find major leaks in attic, basement/crawlspace, and ducts; seal any large openings or other bypasses.
3. Sidelwalls: fill with blown high-density cellulose.
4. Attic insulation: upgrade R-19 to R-30; vent attic; insulate and weatherstrip attic hatch.
5. Water heater: lower thermostat to 110°F; insulate first 3 feet of water lines; install insulation jacket.
6. Neutral-pressure plane: caulk and weatherstrip only if needed for client comfort; make sure ventilation rate stays above 0.35 air changes per hour.
7. General building shell repairs: Replace doors and windows if inoperable; do other repairs necessary to protect weatherization work.