8.3 Case Study in Sustainability: Crystal Beach SCIP House

This Crystal Beach house on Bolivar Peninsula, TX, survived the impacts of Hurricane Ike with little overall damage, despite the destroyed homes surrounding it (Figure 8.3-1). Before the storm, this house was situated five rows inland from the beach and is now situated three rows from the beach, but with an unobstructed view of the ocean because the four rows of houses in front were destroyed. In the first two rows of houses, closest to the Gulf, foundations and pilings were mostly obliterated and the ground was heavily scoured in many cases lowering the elevation by 3 to 4 feet[1]. The road and power lines closest to the Gulf are gone and the vegetation line has moved back. Whether the regulatory officials will allow anyone to build back in this heavily scoured zone is unknown.

Figure 8.3-1 - Aerial Photograph of the Crystal Beach House Before and After Hurricane Ike

Image courtesy of Google maps

Image courtesy of the National Oceanic and Atmospheric Administration satellite photo taken: 9.14.2008

Of all of the residences the MAT Team visited, this Crystal Beach residence was one of the most sustainable, if not the most sustainable, in large part due to its structural concrete insulated panel (SCIP) construction. The following sections describe the construction of the house, including sustainable features (Section 8.3.2), its performance during Hurricane Ike (Section 8.3.3), and details regarding SCIP construction for those who may be interested in using this type of construction during rebuilding efforts (Section 8.3.4).

Overview of Structural Concrete Insulated Panel (SCIP) Construction Technique

The SCIP technique was developed in the late 1960's by Victor Weismann and was originally called Thin Shell Sandwich Panel construction. SCIP systems are widely used internationally and are beginning to see wider use in the United States. The SCIP system is considered a "green" construction method and is relatively inexpensive, strong, and hazard-resistant.

SCIPs are prefabricated foam panels that have an insulated core of rigid expanded polystyrene (EPS) sandwiched between two engineered sheets of welded wire fabric mesh (Figure 8.3-2). Typically, the panels start at 4 feet wide by 8 feet long, but can be prefabricated up to 40 feet in length. The panels are connected during construction of the house and coated on both sides with concrete[2], adding strength.

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[1] Per Ron Bell

[2] The coating is accurately called a "Structural Cement Plaster" and is considered concrete if it includes aggregate that is greater than ¼ inch. For the purposes of this study, it is called concrete.

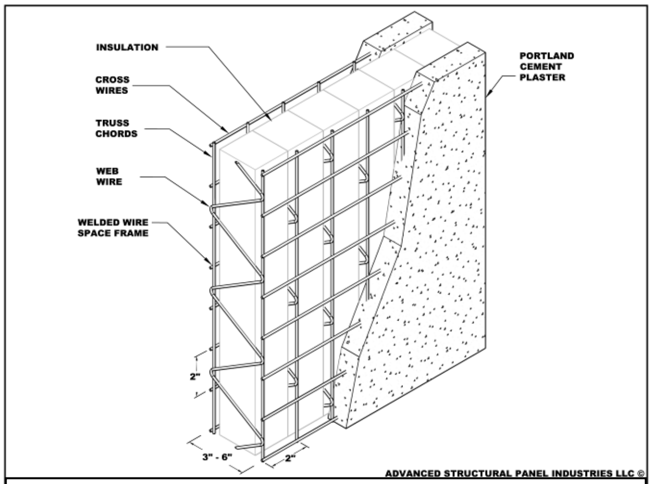

Figure 8.3-2. Cross-section of SCIP. Graphic used with permission from Advanced Structural Panel IND,LLC

Panels used for load bearing walls are generally 5 inches thick.. The panels can withstand 200 mile-per-hour (mph) winds and seismic forces up to 8 on the Richter scale, have a 2 to 4-hour fire resistance rating[3], and are vermin- and termite-resistant. The panels are also energy efficient, with insulation values starting at greater than R-9. This value does not include the air tightness of the system nor the thermal mass advantages which increase the R-value. (see example under 8.1.3.2) A comparable 2" x 4" stud wall might have an insulation of R-8 or R-9. [(VanderWerf et al, 1995]). The panels are made with recycled and sustainable materials and the protective concrete structural coating will last a long time (over 100 years). All of the materials and can be reclaimed and recycled when the life cycle is complete. Additional information on SCIP construction is provided in Section 8.3.4.

8.3.1 Construction of Crystal Beach SCIP House

The Crystal Beach house is a two-story residence constructed in 2004–2005 using SCIP construction. The house was built in accordance with the UBC code and is elevated one story above grade on round steel tubes. The underside of the first floor structural beams is at an elevation of 19 feet-2 inches MSL (the house sits in Flood Zone V-19 with an elevation of 17 feet NGVD). The first floor deck is on four longitudinal and four transverse 6-inch steel H beams. Much of the house is constructed using prefabricated SCIP:

- SCIPs comprise the load-bearing exterior walls, floors f, and roof
- SCIPs span between the floor beams and the roof .
- SCIPs are used for all interior walls

Only a minor amount of wood products are used in the house—accounting for approximately 3 percent of the cost of the house—and include door casings, window casings, and cabinets in the kitchen and bathroom.

The builder added Portland cement plaster mix (concrete mix) on site to complete the SCIP system. The roof, floors, and exterior and interior walls are all made of approximately 5-inch-thick SCIP. The floors are thicker, with 1½ inches of concrete on the bottom of each SCIP and 3 inches on the top side (including the concrete and slate on the floor).

Information for the construction of this house was provided by the builder, Ron Bell.

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[3] http://www.studiorma.com/HOME-BLDG-SCIP.htm

8.3.1.1 Foundation and Load Bearing Walls

The house is built on a 3-foot-deep by 3-foot-wide concrete strip footing with a 6-inch slab on top. A center 3-foot-deep by 3-foot-wide concrete beam crosses in each direction (Figure 8.3-3). All the concrete for the foundation was poured at one time.

The steel tube columns are spaced at 16 feet, 0 inches on center. The columns are attached to 1-1/18-inch bolts that extend 24 inches deep into the foundation (Figure 8.3-4 and 8.3-5). Rebar extends from the foundation slab into the hallway (stair) panels.

The roof is supported by the exterior walls, interior hallway walls, and SCIP beams. Two SCIP beams, each 18 inches deep with rebar—added for additional strength—follow the slope of the roof and run from the outside wall up to the ridge line of the house (Figure 8.3-6). The roof spans between the SCIP beams are also comprised of SCIPs (Figure 8.3-6); the spans are reinforced with rebar every 16 inches on center on the underside. According to the builder, rebar was added to strengthen the walls and increase the floor loadings to meet the high wind (165 mph) requirements for construction in this hurricane-prone area.

Sustainable Features of Foundation

- *Recycled content:* The steel round tubing; steel H beams; and stair tread pans, stringers, and railings are 100% recycled. All of the steel tubing and steel H beams were purchased from a salvage steel business.

Figure 8.3-3. Construction photograph shows foundation with nine sets of bolts for the columns. There is a perimeter-grade beam and a center-grade beam. The men on the right are standing on sand at the height of the 6-inch slab. Photo courtesy o f Ron Bell

Figure 8.3-4. Construction photograph shows 24-inch deep bolts extending into the cement foundation (red arrow). The slab extends over the outside concrete foundation. Photo courtesy of Ron Bell.

Figure 8.3-5. Construction photograph shows columns bolted in place. The nuts under the flange are used to level the 6-foot by 6-foot H beam. The rebar that will extend into the first floor vertical walls will be welded to the first floor (elevated) beam shown in the photograph. Photo courtesy of Ron Bell.

Figure 8.3-6. The roof SCIP beams are shown above the fans, following the roof slope. The 18-inch deep beams are tied into the 30-inch deep columns that are vertical members in this photograph. The Crystal Beach House used No. 14 gauge wire frame.

8.3.1.2 Envelope

Roof System: The SCIP panels on the roof have a recycled rubber roof system comprised of a waterproofing coating, a reinforcing fabric, and an elastomeric membrane (Figure 8.3-7). The first coat is a liquid acrylic emulsion used as the waterproofing base coat. This layer is followed with a mesh polyester reinforcing fabric. The fabric is then covered with two coats of recycled rubber roofing made of a liquid acrylic emulsion formulated with ground-up rubber recycled tires. This liquid acrylic emulsion can be sprayed or rolled on. The final cured top coats are light gray monolithic elastic membranes. According to the manufacturer, this system product stays elastomeric and does not soften in the summer heat. According to the builder, the roof has a UL Impact Rating of Class 4, the highest rating. According to the builder, with proper upkeep, this type of roof will last 50 years or more, but should be inspected every 2 years and touched up as needed.

Sustainable Features of Roof

- *Recycled content:* The elastomeric monolithic roof contains recycled rubber tires.
- *Longevity:* The monolithic roof system construction means that individual pieces, such as shingles will not blow off. The builder stated that some of the roofs installed near Boone, Iowa have been in place for 32 years and are doing well.

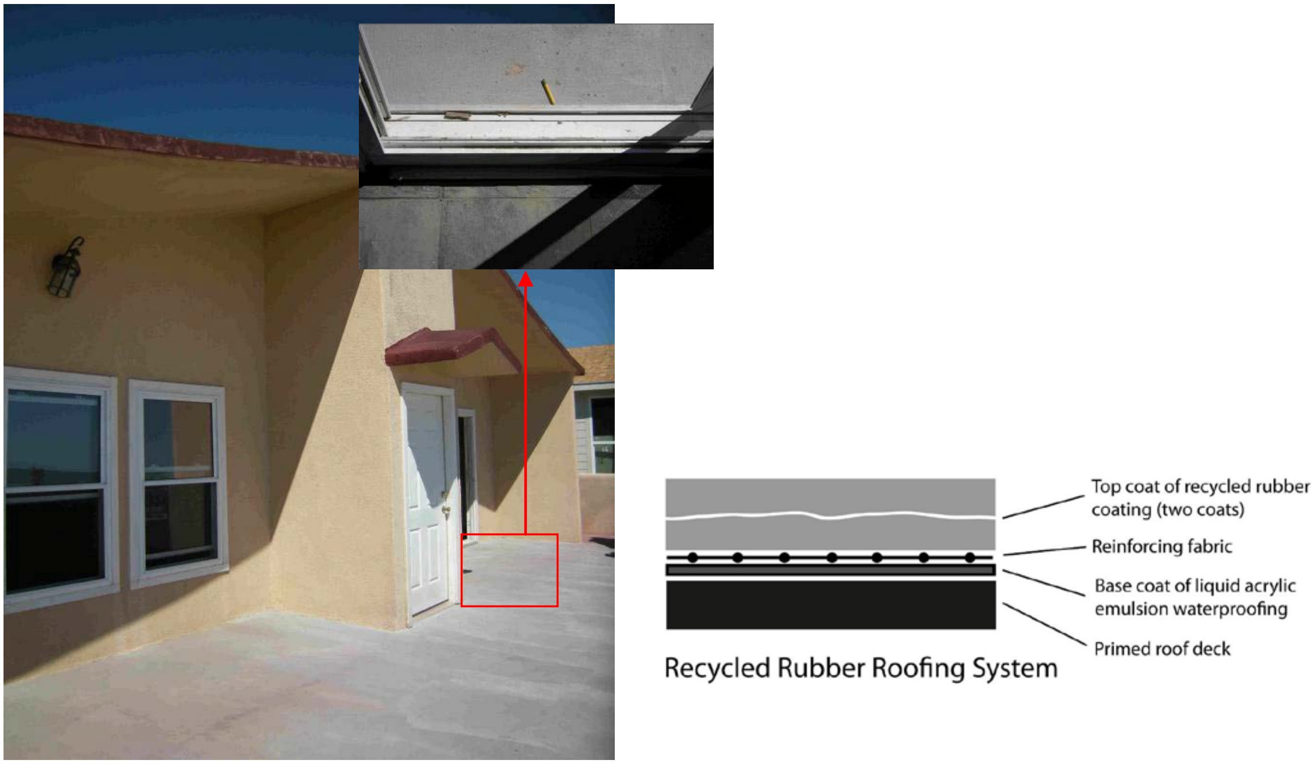

Figure 8.3-7. Recycled rubber tire elastomeric membrane on second floor walk-about deck, door pediment, and main roof. Inset shows close up of roof. 10/18/09 on (101808d, 3741)

Load Bearing Walls and Wall Coverings: The load bearing walls are constructed of SCIPs. All wall coverings in the house are SCIPs coated with Portland cement plaster. Minor amounts of wood are also used.

Sustainable Features of Walls

- *Insulating characteristics*- while the steady state thermal value is R- 9.0, when the thermal mass is taken into consideration and the dynamic thermal value, the R-value is higher (see Section 8.3.5).
- *Stairs* – constructed of recycled steel along with all of the "walk about" metal railings on all floors
- *Exterior walls* - The exterior cement plaster wall has 40 percent fly-ash added; the fly ash is a recycled product. In addition, a minor amount of fiber made from recycled plastic was added to the mix.

According to the Dave Stevenson , of Advanced Structural Panel Industries (ASPI), an expert on SCIP construction,[4] the Crystal Beach house has a finished-in-place weight of approximately 31.5 lbs per square foot and a density greater than 120 lb/ft^3.

Mass walls are defined as follows:

- Masonry or concrete walls having a mass greater than or equal to 30 lbs per square foot and solid wood walls having a mass greater than or equal to 20 lbs per square foot are defined by the IRC 2000 as massive walls. This type of wall has heat capacities equal to or exceeding 6 Btu per square foot. By comparison most wood-frame walls have about ½ Btu/square foot/degree (VanderWerf et al, 1995).
- According to the 2006 IECC commercial building envelope prescriptive requirements, mass walls are defined as having a mass of at least 35 lbs per square foot of wall surface area or, if the material density is 120 lb/ft^3, a mass of 25 lbs per square foot.

Based on its material density and mass, the Crystal Beach SCIP is considered a mass wall under both the 2006 IECC Commercial Building Code and the IRC 2000. 2006 ? (Janice does not have a IRC more recent. Can someone check a more recent IRC?)

Doors and Windows: The doors of the house are constructed of solid core fiberglass impact-resistant doors. The windows are American Architectural Manufacturers Association (AAMA)-certified Hurricane Resistant (specifically, AAMA 506-2000, Missile Level D, Rating: +50 /-50 for wind zone 3).

Soffit and Roof Ventilation: The house has no soffit or roof ventilation. Make-up air for ventilation is provided through an exterior vent.

Exterior Mounted Equipment: Two 2-ton air conditioner condenser units are on the North (back) side of the house, one each on the first floor and second floor deck.

Utilities: The electrical and plumbing were installed in accessible conduit and can be repaired without ripping out the wall.

According to the builder, SCIP homes in Texas can have the air conditioner turned off during peak demand times: "This house will hold a two-degree (temperature) range from 3:00PM to 9:00PM." The builder stated that he ran this test on the Crystal Beach SCIP house after it was built.

Energy Efficient Features of the Crystal Beach House Construction: Structures in southeast Texas have historically been

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[4] VanderWerf, Peter and Munsell, W. Keith, 1995, *The Portland Cement Association's Guide to Concrete Homebuilding Systems*, Published by McGraw Hill Companies, Inc. (see Acknowledgements)

constructed of adobe, stone, and brick. Adobe buildings were typically built with thick walls of heavy material and no insulation. The hot sun can bring the day time temperatures into the upper 90s (^{o}F), but the adobe buildings remain relatively cool. The thick walls absorb the heat without the interior temperature rising much. At night, when temperatures cool, the heat radiates out.

- Infiltration and exfiltration – The lack of air infiltration and exfiltration contributes to the energy efficiency of the residence.
- Insulated Roof – The roof, where most heat loss/gain occurs, is energy efficient because it is insulated, is air tight, has thermal mass (unlike most stick-built homes), and is a light color. .
- R-Value – The steady state R-value, a measure of how heat moves through the walls, is calculated to be approximately R-9.0 for the exterior wall of the Crystal Beach SCIP house (Table 8.3-1).

Table 8.3-1. Calculated steady state R-value of Crystal Beach house

Item	Steady state R-value	Crystal Beach House	Calculated R-value
Portland Cement Plaster	0.2 per inch	1 to 1½ inches deep inner and outer layer	0.4 to 0.6
Expanded Polystyrene	4.0 per inch[5]	2¼-inch thick	9.0
			Total = 9.0

The dynamic R-value is a measure related to the amount of time the walls of a house take to respond to external temperature changes. Studies have shown that the dynamic R-value is greatest when insulation is located on the outside of the concrete mass (wall) and second greatest when the insulation is located in the middle of the concrete mass, as in the Crystal Beach SCIP house configuration (refer also to Section 8.3.5). The Crystal Beach house also has the added benefits of 7-inch concrete floors and a 5-inch concrete roof, both of which add to its thermal mass and result in an even higher R-value.

The manufacturer is intending to request that the California Energy Commission provide an analysis, insulation value ratings, and thermal mass for their SCIP system, considering the location of the structure or the heating and cooling degree days.

Figure 8.3-8. View looking south towards Ocean, from second floor porch after Hurricane Ike. Four rows of houses were destroyed in front of house 10/18/09 (101809 3720)_

Although the dynamic R-value has not been tested by the manufacturer of the SCIP system used in the Crystal Beach house, plans for such

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5- where is footnote? It should read page 36, if pages are identified.

a test are currently being pursued (refer to text box). Based on studies performed by the Oak Ridge National Laboratory, the dynamic R-value for the Crystal Beach SCIP house is estimated to be greater than R-12, as this is according to the chart on 8.3.5. But this R-value for Crystal Beach House would actually be higher as this chart does not take into account A) Crystal Beach house has concrete floors and roof, B) Crystal Beach house is air tight, C) Crystal Beach house is in Texas. Note, that according to this chart, the thicker the R-value the Dynamic value increases exponentially(correct term) (not a relationship of 1) *[(]* (refer to Section 8.3.5 for additional discussion of the thermal characteristics of SCIP construction).

8.3.2 Crystal Beach House Performance in Hurricane Ike

The Crystal Beach house performed well during Hurricane Ike. The house was originally located five rows of houses back from the Gulf of Mexico— the house now sits approximately three rows inland from the Gulf of Mexico (Figure 8.3-8).

According to an eye witness, this house sustained a significant impact from another house on the Gulf side to the east. Debris found by the owner after the storm also suggests this as the source of some damage. Reportedly, the other house, which had detached from its foundation, floated into this one during the storm surge. After impact, the detached house began to break apart and much of it floated underneath the Crystal Beach house, which sustained minor damage from the impact, with three small cuts in its top surface.

Figure 8.3-9. Remaining debris on north deck. A small amount of water entered into the Crystal Beach SCIP house because there was so much debris on the decks, the drains plugged up, and water entered below the door.

8.3.2.1 Foundation and Load Bearing Walls

The foundation did not sustain any damage during Hurricane Ike (Figure 8.3-10 and 8.3-11). The 16-foot first floor column spacing of the Crystal Beach SCIP house allowed large debris, including that from the house in front of it, to pass below the house with no damage to the foundation.

The 3-foot depth of the [*grade beam yes?]* helped to prevent scour under the foundation.

All bolts connecting the columns of the house to the foundation are protected and were not damaged by Ike. In accordance with its design, the connections allowed the house to act as a monolithic structure and withstand high winds and flood.

8.3.2.2 Envelope

Roof System: The rubber roof coating was not penetrated and remained intact during Hurricane Ike.

Sustainable Siting

This house, located 5 rows back from Gulf of Mexico, survived Hurricane Ike, while the first 4 rows of houses in front of this residence were heavily damaged and no longer exist.

Walls and Concrete (skins)Cover: Two impact holes and one hole as a result of railing bending were observed on the south side. This is the only elevation that sustained damage. One impact hole in the second floor, west side of the house was also observed (Figure 8.3-12). According to the builder, the appearance of the hole was reminiscent of impact holes found during testing of the panels at TTU when the walls were shot with an air cannon. The hole could have been caused by windborne debris or floodborne impact. All the holes were exterior skin impacts to the plaster that did not penetrate the wall. They were subsequently repaired with concrete (Portland cement plaster).

The impact of the neighboring southwest house could have caused the two impact holes and the bending of the railing. The second impact hole resulted in a hole on the underside of the second floor deck. The final hole on the first floor deck resulted from cracking of the concrete when the railing bent (Figure 8.3-13).

Stairs: Minor damage to the exterior stairs was observed, including cracks in the cement face on the first floor handrail supports where the adjacent house floated into it, and some damage to the cement stair treads.

Doors and Windows: The fiberglass doors did not sustain any damage during Hurricane Ike. The hurricane-rated windows also did not sustain any damage.

Exterior Mounted Equipment: Neither of the two 2-ton air conditioner condenser units located on the first and second floor decks sustained any damage—their location on the North (back) side of the house likely protected them.

Utilities: The plumbing was damaged when flood-borne debris moved under the house (Figure 8.3-14); replacement cost was expected to be approximately $1,800. Additionally, minor damage occurred to the power coming into the house, including a broken conduit and a #4 wire that needed to be replaced. The plumbing was exposed and was torn off at its connection to the house. The builder removed the broken fitting and replaced it and the exposed plumbing.

Figure 8.3-10. View looking north at the Crystal Beach SCIP house. Figures 8.3-11 to 8.3-14 show close ups of the house.

Figure 8.3-11. (101808d- 3688) View looking north under the house. Foundation of the Crystal Beach SCIP house did not sustain damage from Hurricane Ike.

Figure 8.3-12. Impact hole on second floor south elevation, west side.

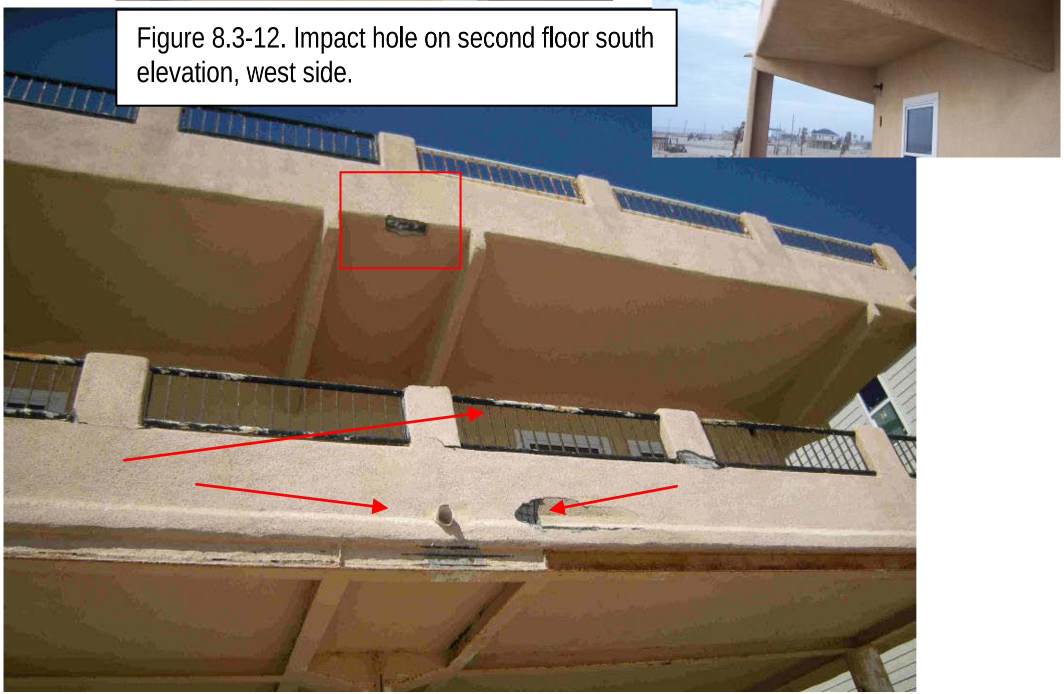

Figure 8.3-13. Photograph 3687. South elevation of house – Impact hole on underside of second floor deck, shown also in inset. The bottom hole was due to the concrete cracking when the railing was bent. (remove lower left arrow- drain)

Figure 8.3-14. (10/18/08, (101808d, 3684). View looking north under the house. Foundation of the Crystal Beach SCIP house did not sustain damage from Hurricane Ike. However, minor damage to the underside of the first floor was sustained from floodborne debris

8.3.3 Sustainability Aspects of SCIP Construction

There are several unique aspects to SCIP construction that relate to sustainability. The first is the efficiency of the structural system. It combines concrete and steel into a highly efficient hybrid system. In addition, it adds insulation to the core area and this configuration is considered to be one of the best insulating configurations according to the studies done by the Oak Ridge National Laboratory (Section 8.3.5). Secondly, the system uses recycled material during construction and, potentially, can be recycled following destruction of the house at the end of its life cycle. Lastly, the SCIP system provides a very durable hazard-resistant house with an expected long life cycle. Each aspect is described below.

Efficiency of System and Energy Efficiency

- *Efficient use of materials during construction*

  The house is constructed with structurally efficient use of concrete. Concrete is used where it is needed most in compression, and steel is used where it is needed most for tensile strength. The minimal use of materials in strategic locations produces a structurally efficient composite panel.

- *The building is air tight, which gives it strong thermal properties*

  The SCIP system's monolithic construction without penetrations, exposed joints, or minimally interrupted insulation results in reduced air infiltration and exfiltration that increases the thermal performance of the structure. This lack of breaks in the exterior wall envelope makes a very tight structure and the conditioned space, or naturally cooled space, remains cool without transfer of cool air to the hot outside air.

- The thermal mass and the dynamic properties. See Section 8.3.5 for more specific detail.

Use of recycled materials in construction materials

- *Use of fly ash, the waste product of burning coal*

  There are two thin shells of concrete used during construction. The normal mixture for Portland cement of 1 part cement to 4 parts sand can be reduced by using other cementious products, such as fly ash. The Portland cement content requirement can be reduced by 30 to 50 percent. The addition of fly ash has excellent performance characteristics including improved hydration, reduction of shrinkage cracks, and workability on the wall.

- *Steel wire truss (interior of panel)*

  Typical recycled content of ASTM A-82 wire ranges from 30 percent to 80 percent. The actual content can be verified by the wire mill certifications when required.

- *Expanded polystyrene (EPS)*

  EPS in the Crystal Beach house is 35 percent recycled material from manufacturing processes. It is made from post-production waste such as excess trim left over during the manufacturing process of other items. The waste materials are reground into this product and included in the EPS; in some cases, EPS can be composed of 100 percent recycled material.

- *Wood used during construction for form work*
  The wood is reused in the construction of other projects.

- *Recycled after its useful life*

  If this construction system were used on a large scale it could be recycled at the end of its life cycle by grinding up the structure and magnetically removing the wire. The remaining concrete could be ground into aggregate and reused. The expanded polystyrene could be recycled by floating it out of the mix.

Longevity of Building Materials and Hazard Resistance

- *Durable construction with a long life cycle*

  The cement encasing the panels is forecasted to have a100-year durability[6]

- *Mold, moisture, and insect resistant materials*
  - Moisture resistant materials clean easily after a storm and can be waterproofed if plaster admixtures are used during construction, or spray applied later
  - Mold resistant as materials do not support the growth of mold in the core. EPS has no nutritional value[7].
  - Termite/ Insect resistant

Hazard Resistant

- *Mud Slide*
  - A W-Panel SCIP home in the path of a large mud flow resulting from the Mt St. Helen’s eruption in May 18,1980 was inundated with mud. After removing the mud with a "Bobcat" loader, the house was pressure-washed, painted, and reoccupied.
- *Flood resistant*
  - A subdivision in Panama of about 500 SCIP (termed “Covintec”) homes, each about 450 square feet, was reportedly inundated with heavy rains in December 2004. None of the 400 + homes inundated by flood waters had structural damage[8].
- *Fire resistant*
  - The fire resistance rating depends on the thickness of various components of the SCIPs, but varies from 1 to 2 hours (ICBO Report #2440, Concrete Homebuilding Systems). [*Note: http://www.studiorma.com/HOME-BLDG-SCIP.htm says up to 4 hours and this is cited earlier] (Advanced Structural Panels plans to submit the SCIP system to ICC for testing which may result in a higher Fire Resistance value).*
  - According to manufacturers, the insulation can melt at very high temperatures but will not support combustion (VanderWerf et al, 1995).
- *Seismic resistant*
  - Four buildings in California successfully resisted the Landers earthquakes in 1992. These buildings were constructed of the 3-D SCIP system and were part of a research facility in the Mojave Desert. They had a lot of unsupported structure as they were mostly glass on one side and the tallest building was 24 feet. The Landers earthquakes were registered at 6.5 and 6.9 on the Richter scale, and were located approximately 50 to 75 miles from the site. An engineer who examined the buildings

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[6] Sustainable Building Solutions.com

[7] Falcon Foam, Expanded Polystyrene, http://www.falconfoam.com/eps_mold.asp

[8] According to August Simons, V.P. of Hopsa, a company that produces Covintec. In a technical evaluation with a local university, Covintec showed that the systems resisted 900 kgs/m^2 of outside water pressure.

afterwards stated, “There is no sign of crack or damage of any kind to superstructures and foundations”.[9]

  - Compared to a traditional block system following REP 94, (Structural Design Code for the Republic of Panama, Chapter 4 Seismic Loads, this version dates from 1994[10]) regulations, the Covintec system (SCIP) has been demonstrated to be 30 percent more resistant to seismic movement[11].

Resources for SCIP

- International Conference of Building Official’s Uniform Code…ICBO Report #2440. (expired), W-panel [http://www.awci.org/cd/pdfs/7906_e.pdf]
- ICC Evaluation Service Legacy Report ER-3509 “Structural ‘Thermi-Impac™ Panel,’ reissued 12/1/2003 [http://www.icc-es.org/reports/pdf_files/UBC/3509.pdf]
- ICC Evaluation Service Legacy Report ER-5618, “Tridipanels 3D/EVG”, reissued 3/1/2006 http://www.tridipanel.com/PDF/5618.pdf]

- *Hurricane resistant[12]:*
  - *Hurricane Andrew (08/24/1992)*: 14 houses in Liberty City, FL (Dade County), built by Habitat for Humanity using SCIP technology, survived with no structural damage. Another SCIP house, located in the hardest hit area (Homestead, FL) was one of the few to survive with no structural damage.
  - *Hurricane Hugo (09/22/1989)*: 200 houses built with SCIP technology experienced no structural damage from winds of 195 mph
  - *Typhoon Pamela* (1976): U.S. Military Housing located in Guam, Pacific Ocean, survived 178 mph winds. This storm was the hardest to hit Guam in 100 years. The wind-speed indicator broke at approximately 186 mph; most likely winds were higher. The U.S. Navy documented these houses.
  - *Hurricane Marylin* (09/15/1995): SCIP houses located on U.S. Virgin Islands did not suffer structural damage; resort structures located in Antigua remained habitable.
  - *Hurricane Ivan* (*09/16/2004*): Proven to have withstood high wind events, such as Hurricane Ivan.
- *Code-Compliant*
  The SCIP system was approved in 1979 by the International Building Code Officials (ICBO) and in 1997, under the Uniform Building Code. Advanced Structural Panel Industries will be submitting the SCIP system to the ICC, which will ultimately result in a current ICC-ES Report under IBC. Their goal is a 1- to 4-hour fire rating, Seismic Design Categories A-F, and Hurricane Force Wind specifications.

8.3.4 Details of SCIP Systems

The SCIP system is composed of a three-dimensional, No. 11 or 14 gauge wire frame utilizing a truss concept for strength and stiffness. Each surface of the welded wire space frame is a 2-inch square mesh pattern of longitudinal and transverse wires. The truss design is typically 3 to 6 inches deep and diagonal spreader wires separate each surface of the welded wire space frame. The actual truss design varies depending on the manufacturer.

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[10] http://74.125.47.132/search?q=cache:H4jen0aDd0kJ:www.acs-aec.org/Documents/Disasters/Projects/ACS_ND_001/PANAMsce.pdf+Panama+REP+94+seismic+building+codes&cd=1&hl=en&ct=clnk&gl=us

[11] http://www.covintec.info/faqs.htm

[12] Nancy Ross, “*In the Eye of the Storm: In Homestead and Hugo’s Wake, Two Dwellings use Technology To Withstand a Hurricane*,” Washington Post September 10, 1992. http://rabsltd.com/doc/EyeOfTheStorm.pdf

During fabrication, 2 ¼-inch EPS is placed in the core of the truss. The EPS is held back from each face of the wire truss about 3/8 inches to allow for the wire to be embedded in the applied 1¼-inch thick Portland cement plaster finish in the field. The finished overall wall thickness is approximately 4¾ to 5 inches for a 3 inch panel core. Panel cores are available from 3 to 6 inches. The 6-inch panel cores have a finished thickness of 7 ¾ to 8 inches. Individual diagonal welded wires extend through the foam core connecting each concrete face and forming a structural truss, thereby yielding a very strong panel.

Structurally, SCIPs are very efficient systems. The construction uses minimal material and only where needed. Each of these components are utilized to maximum efficiency, concrete for compression forces, steel for tensile forces, and foam as insulation (pers. com., Dave Stevenson, ASPI). The foam core is placed at the center for maximum efficiency regarding acoustic and thermal properties.

The lightweight face wire grid and insulation panels, weighing 1 pound per square foot, are erected on site and wire-tied to form the desired structure. All panel joints and connections are lapped with joint mesh in compliance with the American Concrete Institute Code governing Reinforcing Mesh Design (pers. com., Dave Stevenson, ASPI). Additional reinforcing can be added as required by design.

After the panels are erected and prior to installation of the cement plaster covering, an inspection is required to verify all connections are made correctly and comply with the approved plans and details. Following this, the required concrete plaster thickness is applied. This is normally a 1- to 1½-inch thickness of 2000 psi structural Portland cement plaster. The plaster may be applied by hand or machine. The resulting structure is a monolithic reinforced concrete building that is resistant to many hazards.

- The finished in-place weight is approximately 31.5 pounds per square foot.
- The finished wall thickness is about 5 inches.
- SCIP panels are structurally rated and can be used as roofing material or walls without any additional structural support (ICBO Report #2440, ICC ER-3509, ICC ER-5618).
- The panel can be designed to achieve a 1-hour and a 2-hour fire resistive design (ICBO Report #2440).

The combination of reinforcing steel, concrete, and foam allows the panel to perform as a structural composite: the concrete resists compressive forces, the steel resists tensile forces, and the foam core provides insulation and acoustic properties. This system reacts to applied forces with a 2-inch by 2-inch reinforcing matrix (face wire grid) as opposed to normal reinforcing schedules of 12-inch or greater.

This versatile system's advantages include architectural design flexibility. The panel forms the primary structural element of many buildings and additional framing is not required. In this case, steel beams are the primary structure for the first floor as they are required because of the elevated deck. It is also possible to fabricate structural columns and beams with the panels. Beams and columns can be formed utilizing the panel as a stay-in-place form, instead of using wood as a form. Advanced concrete design has been used to fabricate commercial structures with 60-foot clear span folded plate roofs (pers.com., Dave Stevenson, ASPI).

According to Dave Stevenson (ASPI), an SCIP will carry 250 pounds per linear foot when un-plastered; when plastered, the allowable load is 3,000 to 5,000 pounds per liner foot of wall, depending on height. By comparison, a 2-inch by 4-inch stud wall at an 8-foot height will have an allowable load of 1,000 pounds or less.

8.3.5 Details on Thermal Characteristics of Exterior Envelope in SCIP Systems

The R-value is a measurement used to indicate a material's resistance to heat flow. The "steady state" R-value is determined by measuring a products heat loss resistance under test conditions. In the test, each side of the material is maintained at a constant or "static" temperature. Heat is primarily lost by conduction, but can also be lost by convection and radiation. The "dynamic" R-value is related to the amount of time a thermal mass (walls of a house) takes to respond to external temperature changes. This is known as thermal lag, or the dynamic effect of thermal mass.

The more slowly heat passes through a material, the higher the R-value. If one square foot of material lets one Btu pass each hour from a hot side, at 71 degrees, to a cold side, at 70 degrees, it has an R-value of 1. In the real world, the temperature on both sides of a material is constantly changing. In these conditions, the thermal mass effect reduces the total heat passed through the walls of a house. The thermal mass of a wall reflects how much heat it will store. Each material has a thermal mass just as it has a thermal resistance value (VanderWerf et al, 1995).

Masonry and concrete construction, mass envelope construction, are helpful in lowering heating and cooling loads. In certain climates, buildings containing mass, even thin shell mass, can be more energy efficient than similar conventional wood-framed houses. Numerous historic and current field studies have demonstrated that in some U.S. locations, heating and cooling energy demands in buildings containing mass walls of high R-value could be lower than those in similar buildings constructed using lightweight wall technologies, such as wood-framed walls. In addition, mass building envelope components are slower to heat up or cool down in reaction to exterior temperature changes.

Oak Ridge National Laboratories Study on Dynamic R-Values

Oak Ridge National Laboratories performed a study in ("Thermal Mass - Energy Savings Potential in Residential Buildings" by*J. Kosny, T. Petrie, D. Gawin, P. Childs, A Desjarlais, and J.Christian, Buildings Technology Center, ORNL* NO DATE, however, completed study was suppose to be made available in 2001.
See link:
http://www.ornl.gov/sci/roofs+walls/research/detailed_papers/thermal/index.html)

Comparing the insulating properties of lightweight construction, wood framing, and masonry or concrete construction. Over 1000 experiments were run. Oak Ridge National Laboratories used a dynamic R-value to represent the changing thermal mass. For each analyzed material configurations, four different sets of thicknesses were considered and were organized according to their R-value to achieve the following:

Foam	Concrete	R-value
4 inches	6 inches	17.2
3 inches	4 inches	13.0
2 inches	4 inches	9.0
1 inch	4 inches	5.0

Four different material configurations were considered for massive walls, with the following results:

Material placement		Term	Example	Highest Dynamic R-Value
Thermal Insulation	Concrete Mass			
Exterior – single side	Interior	"Intmass"	Masonry block wall insulated with rigid foam sheathing	#1
Interior	Exterior – single side	"Extmass"	Masonry block wall insulated with rigid foam in the core	#4
Exterior – two sides	Interior	ICI	Insulated concrete forms	#3
Interior	Exterior – two sides	CIC	2- or 3-inch concrete mass on each side	#2

As shown in Figure 8.3-15, the Intmass and CIC material configuration results in significantly higher dynamic R-values than the ICI and Extmass configurations. The thicker mass of a CIC wall is able to absorb more heat than traditionally built stick houses and the dynamic R-values increase significantly with this construction. For example a CIC Steady State R-value of 17 will Have a dynamic R-value of 27, according to the chart.

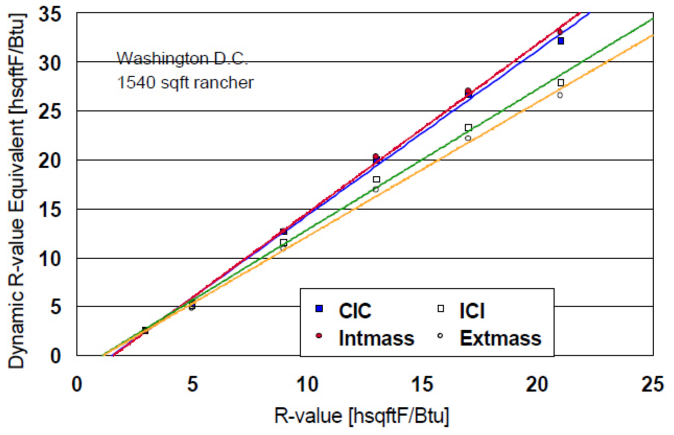

Fig.3. Dynamic R-value Equivaents for Washingtonn D.C. for 1540 ft$_2$ one-story rancher.

Figure 8.3-15: Add text and source Each wall configuration, CIC, INTMASS, ICI, EXTMASS, had different thicknesses of concrete and insulation layers for the same 1,540 sf ranch house. Each analyzed material configuration,had four different sets of thicknesses and were organized according to their R-value: R17.2, R-13.0, *R-9.0, R-5.0. Each point represents one of the Washingoton DC ranch houses.The chart shows that the best wall configuration are those with mass, (concrete) with good contact to the interior of the building. (Intmass and CIC). Wall configurations with the insulation was placed on the interior side of the wall were the worst performing. Note that the relationship between the dynamic R-value and the steady state R-value is not linear. The higher the steady-state R-value the dynamic R-value increases significantly (exponetially ?)The CIC and Extmass relationship is approximately 1.0.*

Energy Savings in Houses with High Dynamic R-Values

The ORNL study showed further that all mass wall systems outperform the conventional wood-frame technologies in terms of energy savings. In particular, the Intmass and the CIC perform the best. These systems can be expected to provide an energy savings of 12 percent for the same low R-value of 5 or an energy savings of 18 percent with the same R-value of 20. This represents a potential energy savings of 12 to 18 percent for houses constructed with massive walls.

Thermal mass makes the largest difference in moderate climates, when significant reversals of heat flow occur within a wall during the day. During the day, the mass absorbs the heat and then during the evening when the outside air temperature cools down, the mass radiates the heat to the outdoor air. The heat never enters the inside space. Studies indicate that some houses in southern Florida built of block with R-15 walls use only as much air conditioning as a frame house with R-23 insulation. Block houses need about two-thirds as much cooling over the course of a year as a comparably insulated frame house (VanderWerf et al, 1995). This same house in North Dakota would still save about 5 percent of its heating bill over a similar frame house.

Calculating Thermal Mass and Dynamic R-Values

To measure thermal mass, some building codes measure the thermal mass using the pounds per square foot of wall area. Other building codes use a measure of how much heat the wall holds in Btu/square feet/degree (VanderWerf et al, 1995).

The new 2007 International Energy Conservation Code will recognize the benefits of thermal mass. The Thermal Mass benefit of the SCIP system can be calculated with prescribed formulas under the ANSI / ASHRAE Standard 90.2-2007, *Energy-Efficient Design of Low-Rise Residential Buildings*, and the *International Energy Conservation Code*.

Resources for SCIP's:

A. Impac International has not produced foam core panels for 5 years.

B. Panel producers:

Therml Impac Afordable Homes Co., Trinidad

Exports Panels and Builds Internationally

www.tiahco.com

C. Advanced Structural Panel Industries

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