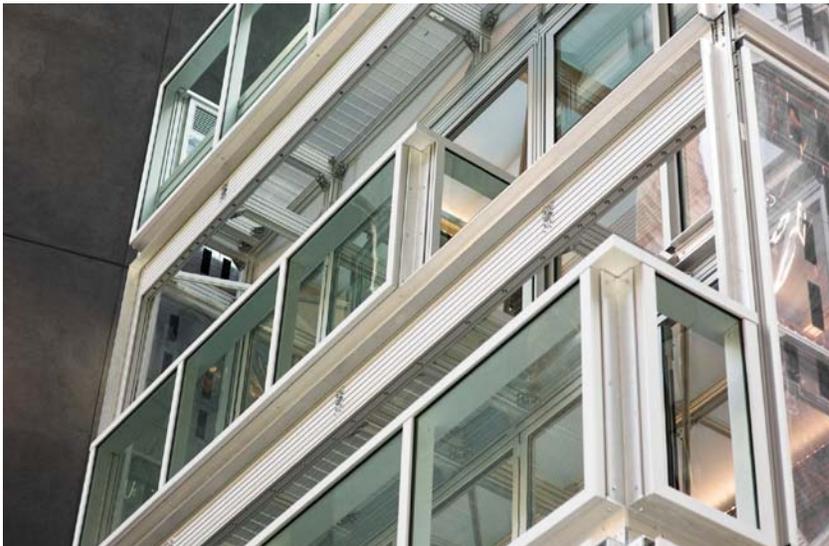


# Drive & Control profile

## From the Factory to the Home: Rexroth Helps Make Cellophane House Homebuilding Concept a Reality



KieranTimberlake's "Cellophane House" demonstrated how aluminum framing can be used in architectural construction to create sustainable housing that can be completely dismantled without adding an ounce of material to a landfill or an incinerator.

Rexroth aluminum framing, successful in factory applications, entered a new arena when KieranTimberlake made this product a key element in a unique, sustainable version of the family home.

Rexroth structural aluminum framing is at work in numerous factories around the world in countless assembly and production applications. But in the summer of 2008, Philadelphia-based architectural

innovators KieranTimberlake ([www.kierantimberlake.com](http://www.kierantimberlake.com)) were invited by curators at The Museum of Modern Art to participate in the exhibition *Home Delivery: Fabricating the Modern Dwelling*, which offered an

### Challenge

Provide aluminum structural framing for the construction of a five-story off-site fabricated dwelling

### Bosch Rexroth Solution

- Customized aluminum structural framing, with specially designed connectors
- Support, materials coordination and machining provided by Rexroth distributor

### Benefits

- Aluminum is lightweight, durable, and recyclable
- Framing can be configured in countless ways to meet a broad variety of design and construction needs
- Through digital modeling, an exact list of framing components can be specified
- Contributed to sustainable housing that can be completely dismantled and re-assembled without any waste created
- Reduction of time, labor and waste



Cellophane House used lean manufacturing concepts and architectural ingenuity to create a new vision for mass customizable housing. The outer walls of the house consist of a thin film skin laminated with photovoltaic cells.

examination of both the historic and contemporary significance of factory-produced architecture from 1833 to today.

KieranTimberlake’s “Cellophane House,” which was designed specifically for the exhibition, used Rexroth’s aluminum structural framing, a number of lean manufacturing concepts and lots of architectural ingenuity, to create a new vision for mass customizable housing. The five-story prefabricated dwelling, erected in a lot adjacent to MoMA in Manhattan, offered a striking solution to contemporary issues in housing. One of five

prefabricated structures built as part of the Home Delivery exhibit at MoMA, Cellophane House offered a bold new look at how aluminum framing can be used in architectural construction—and at how its capabilities can help create sustainable housing that can be completely dismantled without adding an ounce of material to a landfill or an incinerator.

“We aimed to create a mass customizable system of building, not just a one-off,” said Timberlake, “Cellophane House continues the investigation of off-site fabrication and integrated component assemblies explored at Loblolly House in 2006.

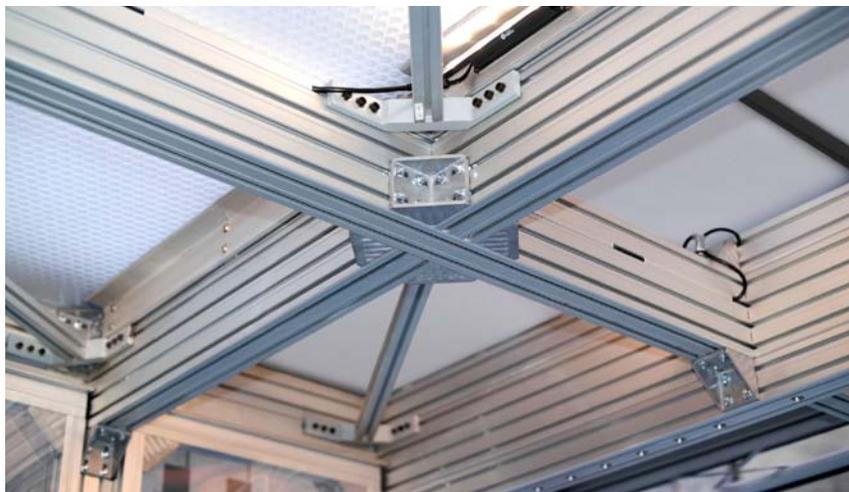
Using this type of building reduces the time, labor and waste associated with stick-built construction. We wanted to show how a lean manufacturing approach could bring optimal benefits to home building.”

KieranTimberlake selected Rexroth’s aluminum framing

system to provide the structural support for both Loblolly House and Cellophane House. “Aluminum is lightweight, durable, and recyclable, with broad re-streaming possibilities. Rexroth framing offers a pre-existing, readily available system already in production—one we could enhance with custom connectors. We adapted this system to meet the requirements of a two-story free-standing structure for Loblolly House, and extended the range of the system while taking advantage of its inherent intelligence to five stories for Cellophane House,” explained Timberlake.

#### **Inherent Sustainability**

In putting together the concept for Cellophane House, KieranTimberlake envisioned a structure that emphasized a sustainable and customizable building system. Cellophane House is clad primarily in polyethylene terephthalate (PET), a fully recyclable plastic typically used for water bottles. The outer



KieranTimberlake developed composite beams for long spans and designed and fabricated custom connectors for column-beam and diagonal brace connections.

walls of the house consist of NextGen SmartWrap™, a thin film skin laminated with photovoltaic cells. The multi-layered, high performance wall controls the interior climate of the house, and also offers the potential for the house to exist off-grid by harnessing solar energy.

### Laying the groundwork

To help make its sustainable vision a reality, KieranTimberlake collaborated with Airline Hydraulics (Bensalem, PA; www.airlinehyd.com), a Philadelphia-area distributor who provided Rexroth aluminum framing for Loblolly House, and supported the project with a vast knowledge of framing products used for industrial applications, and CVM Structural Engineers (Wayne, PA; www.cvmengineers.com) to provide aluminum structural framing components that were sized and specified to meet the unique challenges of this project.

"What's exciting to me about this project is that nobody had ever used aluminum so extensively for structural support in a multi-level building," said John Sellman, Sales Engineer for Airline Hydraulics. "The frame of a multi-story structure experiences enormous forces in the form of shear stresses. KieranTimberlake's hardware designs stood up to these forces which allowed them to change their entire approach to construction with Rexroth aluminum extrusions."

KieranTimberlake worked with CVM Structural Engineers to

develop a sturdy matrix made of aluminum framing to support floors, ceilings, bathrooms, and more. "Off-site fabricated elements can be attached and detached with ease to the aluminum frame," Timberlake explained. The matrix allows any of the walls, floors, structure, or envelope to be replaced without invasive modifications or specialized tools."

"With our distributor's help, we were able to push the limits of the Rexroth system in several ways. We developed composite beams for long spans and designed and fabricated custom connectors for column-beam and diagonal brace connections," said Timberlake. Because Rexroth's T-slotted aluminum framing is designed to be bolted together with no special tools or specialized expertise, it helped KieranTimberlake apply an elemental manufacturing concept—modular fabrication—for Cellophane House's unique design. The T-slots in Rexroth framing also provided channels for concealing low-voltage wiring to energy-efficient LED light fixtures in the building.

### Off-site Fabrication: Lean Concepts Find a Home

KieranTimberlake used lean manufacturing techniques to ensure the sustainable design of Cellophane House. "The automotive industry has advanced by dividing a car into individual modules, composed of preassembled parts manufactured off the main assembly line. When a module is finished, it is delivered to the main plant and



Connections had to have tolerances of less than 1/32". The precise tolerances offered by Rexroth's aluminum framing system as well as Building Information Modeling helped meet these challenges.

attached," Timberlake explained. That, he suggested, is what helps provide lean manufacturing benefits—savings in time, cost, and raw materials. Cellophane House was assembled in the same way, with all housing components fabricated independently and simultaneously, for similar time, cost, and material advantages. No component was dependent on the assembly of the others. For example, the louvers on the Cellophane House roof and its adjoining wall were assembled at the same time—a feat not possible in traditional construction. A traditional stud wall can take weeks to build if constructed in succession, but partitions and panels for Cellophane House took only days to assemble. The use of Rexroth aluminum framing allowed lean concepts like this to be applied to many aspects of the house. "Rather than force the materials to conform to our design, we let the standard sizes of the

materials dictate the dimensions of the house, eliminating time and labor required to cut the material to size,” Timberlake said.

Of course, prefabricated design presents its own unique challenges, for example, a high level of precision is needed to ensure that building components such as stairs can be properly attached to the frame. Connections had to have tolerances of less than 1/32” — the thickness of a business card. Since the frame is left exposed in the design, there was no option to “hide” framing imperfections through the use of drywall, moldings or veneers. The precise tolerances offered by Rexroth’s aluminum framing system helped meet these challenges, as did Building Information Modeling, or BIM.

Using BIM, KieranTimberlake was able to create a virtual version of Cellophane House months before construction even began. The parametric digital model also allowed geometrical and dimensional certainty, allowing parts to be assembled in advance to exacting tolerances. “Unlike a CAD drawing, the BIM model includes all the information for a building such as its geometry,



The frame of a multi-story structure experiences enormous forces in the form of shear stresses. KieranTimberlake’s hardware designs stood up to these forces which allowed them to change their entire approach to construction with Rexroth aluminum extrusions.

spatial relationships, geographic information,” Timberlake explained. The Rexroth profiles for various framing components could be imported directly into the BIM model, which helped generate parts lists and track data like cost, weight, and quantity. Through the use of digital modeling, KieranTimberlake was able to create an exact list of materials needed to make shipping, rigging, and attachment easier — saving time, labor, money, and materials. Only six extra pieces of aluminum framing were left over after Cellophane House was built. The BIM system allowed

KieranTimberlake to see the house and framing matrix to employ leaner construction processes.

### **The Impact of Cellophane House**

Cellophane House, on display at MoMA between July and October of 2008, garnered much Internet exposure. For the first time, the design and architectural world saw how modern technologies and lean concepts could make a traditional process — building a house — more efficient, sustainable, and environmentally responsible.

Cellophane House, through its innovative design, components and construction, is like no other. It models the potential to use lean, sustainable design concepts to reframe traditional homebuilding ideas. Just as it was stacked on-site, Cellophane House was un-stacked, from the top down in 38 days after the exhibition ended. Throughout this process, the individual materials retained their integrity and remain ready to be reassembled at any time.

And thanks in large part to KieranTimberlake’s imaginative use of Rexroth structural aluminum framing, lean manufacturing concepts have now left the factory and are helping to create the family dwelling of the future.

**Rexroth**  
Bosch Group