Engineers...The Unsung Heroes Turning Ideas Into Facts

Art works with technology by combining glass, wood, and steel to create functional buildings from visions and imagination

By **Judith Love Cohen,** *California Delta '57,* and **David Katz**

BEAUTIFUL ARTISTIC BUILDINGS all need one: a structural engineer to carry out these exquisite visions. In this article, we will look at two examples of this artistic process and collaboration: one from the viewpoint of an engineering firm and the other from the viewpoint of the architects. It is our thesis that while the overall public may never hear of these unsung heroes, engineers are essential for a collaboration that fulfills the artistic vision. It enhances and adds to the building structure in an exceptionally unique and imaginative way. The art of a building is like a mathematical equation—both sides (the engineering and the architectural aspect of a building) contribute to the finished structure.

A night view of the Polish pavilion built for the 2010 Shanghai Expo.

We start with the international engineering firm, Thornton Tomasetti, which was responsible for the engineering portion of creating the structure of the Brookfield Place Entry Pavilion project in lower Manhattan—at the building formerly called the World Financial Center. The design architect was Pelli Clarke Pelli. We spoke with Michael Bauer from Thornton Tomasetti, the lead project engineer for the structure. The primary focus of the interview was the story-high basket-shaped columns, a quite brilliantly shaped structure holding up the entire roof and glass facade.

Let's begin to explore the engineering process. Thornton Tomasetti's involvement begins much before a computerized three-dimensional model of the project. It often starts with a simple sketch. The structural engineer collaborates with the architect to determine concepts that work structurally while achieving the architectural vision. In this case, there were many complicated problems that needed solving. At the heart of the matter are the 53-foot-high steel column baskets, holding up the 7,000-square-foot roof and 18,000-square-foot facade of glass.

There were several important decisions to be made between the engineering firm and the architectural firm. The question Thornton Tomasetti came up with was: "What are the challenges in creating a seamless, sculptural form that is also the main structural support?" The engineer and architect worked together to identify critical aspects of the project related to the steel. These included tight steel tolerances, surface quality requirements, and intumescent paint for fire protection. The engineer was also responsible for determining the number of pipes needed for the column. How thick should the pipes be? How many circular ties are needed to put the pipes together? All this needed to be balanced with what the architect desired. It must have an aesthetic feel as well as be structurally sound.

Begin with an arc

An architectural project such as this also draws heavily upon advanced computational modeling, often called parametric modeling. Michael Bauer explains an example of parametric modeling, using a computer. In the basket shape example, he explains that you begin with an arc. This arc is half of the profile of the basket. The next step is to put that profile around in a circle, in this case 32 times, creating a funnel shape. A designer using parametric modeling would then twist the lines to create an interwoven shape, kind of a

Inside the Brookfield Place Pavilion, below, At right is an artist impression of the completed complex (Graphic: Pelli Clarke Pelli Architects/courtesy of Pelli Clarke Pelli Architects).

twisted funnel. The designer then creates the various input parameters such as the angle of the twist and the number of profiles, and the radius of curvature of the funnel. "Once you have set up a kind of logic, you can then change that and see in real time how that affects the visual."

Another impressive feature is the elegant glass facade of the Brookfield Place Entry Pavilion. The two steel columns support the entire facade—a great engineering feat. The glass facade is attached to glass fins which are hung from a series of points around the perimeter, engineered in such a way that the glass can move several inches allowing for it to withstand a windstorm or earthquake. The glass facade engineer and manufacturer was Permasteelisa Group. Thornton Tomasetti's role in the glass facade design was to work with the steel fabricator, glass facade manufacturer, and architect to determine how the glass would be installed and supported.

"What's reasonable and what can be changed?" is an important question to ask during the process, working and collaborating with the architect. The quality of the glass and the nature of the fitting are very important factors for the architect and glass manufacturer. Thornton Tomasetti was also involved in the process from the beginning to help determine how the glass would interface with the supporting structure. In fact, since the actual glass manufacturing site is in Germany, the architect and owner made several trips there. They viewed the various light qualities of the glass throughout the day to ensure unremitting aesthetics at all times. In terms of assembly, these beautiful columns were too large to assemble in the steel fabrication space or ship to the site in one piece. The columns were divided into multiple pieces and transported to the actual site to be bolted and welded together. With great precision, they used large cranes to position the columns and then to hang the glass facade that enclosed them. Voilà! A masterpiece of engineering and architecture was born.

Multi-century tradition

Now, let us take a look at another example of collaborative structural engineering, this time from an architectural perspective. Marcin Mostafa of WWAA was the power behind a brilliant piece of architecture that was built for the Shanghai Expo in 2010 as part of the Polish Pavilion. The idea for this incredible work was based on Polish folk art paper patterns, which is a multi-century tradition.

Marcin, along with Natalia Paszkowska, created a modern version of the Polish folk art motif which was implemented as an external graphic skin on the building. This gives the building a beauty and grandeur of great dimension and originality.

A remarkable aspect of the building is that it has no perpendicular walls, rather they are all slanted. Its appear-

TELL US THE TALE...WIN A T-SHIRT

SEND US YOUR clever caption(s) for this photo from *The Bent* archives, and if it is judged one of the best, you will win a ΤΒΠ t-shirt.

The picture above was taken on the occasion of the installation of the Texas Theta Chapter at the University of Texas, El Paso, in March of 1969. Wearing "typical" garb of both nationalities of El Paso's border culture are, from the left, Secretary-Treasurer R.H. Nagel, Texas Theta Vice President Albert Menchaca, Assistant Secretary-Treasurer F.F. Lyle Jr., Texas Theta President Scott W. Binegar, and Tau Beta Pi Vice President John L. Jones. The sombreros and serapes were gifts to the visitors from Texas Theta.

Email entries to *tbp@tbp.org*, or mail them to HQ by February 2, 2015.

The photo for the Fall Caption Contest, below, showed the staff and Secretary-Treasurer R.H. Nagel as he arrives for another day at ΤΒΠ Headquarters in 1957.

Authors of the following three captions will receive a t-shirt:

"Oh yes sir, we are all very happy working here, but just one question...When do we move out of this janitor's closet into a real office like you promised us last year?"—*Mark F. Pyfer, M.D., PA Z '85.*

"Robert, this petition for a larger office already has five names on it."—*David W. Kortebein, IL A '85.*

"Don't look at me like that; I put the seat back down."—*Stephanie J. Buttrey, MI Γ '77.*

We thought that the three tied for honorable mention should get just that:

Nagel's Angels: "Once upon a time, there were five little girls who went to the engineering academy. And they were each assigned very hazardous duties but I took them all away from all that and now they work for me. My name is Nagel."—*Yi-Hsien Doo, P.E., MI Z '81.*

"Well it's about time?!?! We've been waiting for you to make the coffee!"—*Gregory M. Gatlin, MD B '83.*

"I hope this new guy works out. Engineers in glasses are sexy."—*Ronald S. Kane, Ph.D., P.E., NY H '65.*

Thanks for all of the entertaining responses, and congratulations to the winners!

Engineers...The Unsung Heroes (Continued)

ance is modern and cutting edge, yet relates very much to the Polish culture.

Interestingly enough, Marcin was very young, 27 years old, when he entered into the architectural competition to design the building, and he won. Because of his youth, Marcin freely admits that he and Natalia needed significant help in building this structure. He chose Buro Happold, an award-winning, internationally recognized firm that provides structural engineering among other services. In our opinion, this engineering firm is extremely innovative and one of the best in the world.

More sustainable

Marcin admits that there was substantial collaboration between Buro Happold and WWAA. For instance, the original concept was for a wood facade. However, Buro Happold came up with the idea of using a steel structure for the main foundation with a wooden skin, because "it was more sustainable", and had the possibility of being able to be taken apart and reused in the future. The external layer of wood was designed together with Buro Happold. The creation of this structure was a complicated process, using many models, both from WWAA and from Buro Happold.

Marcin talks about the computer numerically controlled (CNC) process which takes the designs as input, and through a router uses this data to cut the patterns into any material. Here, the CNC machine cuts the patterns into the plywood skin to be first made into a small model. Then with a complex modeling design, in-house, a larger scale version was created. And, of course, the final large panels were cut elsewhere. Again, there was collaboration on the external layers between WWAA and Buro Happold.

The lighting inside of this folk art building is really breathtaking. Together, Marcin and Natalia and Buro Happold have created an incredible work of art.

Judith Love Cohen, *California Delta '57,* worked as a USC undergraduate on NASA projects such as the abort guidance system for the lunar excursion module and the science operations ground system for the Hubble Space Telescope. She went on to serve on the USC astronautical engineering advisory board. Cohen recently received an award from IEEE for literary work on children's books on STEM at her children's publishing company, Cascade Pass. *www.cascadepass.com*

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