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Modular High-Rise: The Next Chapter

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Full Stack Modular's CEO and founder, Roger Krulak, was formerly Senior Vice President of Modular Construction at Forest City Ratner Companies (FCRC), where he was a leading member of the team that built the modular business supporting foundation of FCRC's flagship project, 461 Dean Street, the tallest volumetric modular building in the world. An internationally recognized expert in modular construction and innovation, Roger Krulak was the recipient of the 2014 Popular Mechanics "Breakthrough Award" for his work on the creation of the high-rise modular process, has been appointed to the Building Innovation Panel for Singapore, and regularly speaks all over the world.

In 2016, 461 Dean Street, the world's tallest volumetric modular building, was completed in New York City (see Figure 1). As few such projects had ever been attempted, let alone in a construction market with New York's constraints, the project's developer, Forest City, and contractor, Skanska, formed a joint modular manufacturing venture to assure the predictable delivery of the 930 modular units that make up the building. Full Stack Modular is a new company that has taken the assets and lessons from that project and plans to scale it up into a global business. Full Stack's CEO, Roger Krulak, outlined his plans in an interview with CTBUH Editor Daniel Safarik.

What has held the industry back from fully embracing modular?

There are two major answers. One is a technology answer. There are two problems with construction technology. One is that we're at the bottom of the barrel of 50 industries, spending like 2–3% of gross revenue on IT. It's a ridiculous number. What that means is, technology advances in relation to construction have been really slow. That is a major driver, because, in order to be a manufacturer of a reliable product, you need to have a process by which you build that product. And then you need to have something that drives that process.

If you are making pencils, that's not a hard thing to do. But if you are making buildings with 12 trades, it's a whole different ball game. The convergence of that process is complicated.

The technology has almost caught up. Using an integrated model from a manufacturing perspective, or AutoCAD and its respective plug-ins and pieces and CATiA from the building design world, you can create a federated process that allows you to manufacture things in one place and install them in another place.

The other reason is that the way that our industry is organized currently is broken. There are basically three siloes in any construction project. There is development and financing in one silo. There is architecture, engineering, and design in another silo. And then there is construction management in the third silo.

Thanks to the insurance companies, they have made it so that no one wants to bridge the information gaps from one silo to the other, because no one wants to be responsible. I mean, look at the sinking [Millennium] tower in San Francisco – who wants liability for that? It's a huge problem.

The way the industry has tried to address it is through processes like Integrated Project Delivery (IPD), which is really fascinating theoretically. But at the end of the day, somebody has to own the model. One entity has to put all the pieces together, in the drawings, before you build it in the factory or on-site.

Historically, the means and methods of the processes are decided by the trades that get the contracts. Apart from the structure, literally, the trades usually end up doing whatever they want so long as it meets the performance specifications of the designer. Then, they take the end product back to whoever owns the model, and then they fight about all the clashes that resulted because everyone was still designing in their own bubble.

The reason modular has not happened is not because it is illogical, but because the requirement to get it done is to change the way you do business. The way we do business is to flip everything on its head. We're the design-builders of the building. We can work with an architect or we can provide our own architecture. We are really agnostic about that. We can work with contractors big or small. What we offer to the developer, our customer, is one turnkey solution. You give

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us the program, the requirements, and we'll fit it into land that you have. We will do it in a way that you think is appropriately marketed to the customer, and we take it from there. In our factory we do labor and materials, electrical, mechanical, and structural. We assemble it, bolt it up together, and connect all the systems, and we're done.

To me, the innovation of volumetric modular construction is that we are changing the process by which you create buildings.

We research and report on new methodologies all the time, and it's pretty rare that someone can make a claim that their methodology is that innovative. The fundamental process of construction remains the same.

Here's my favorite story. Josef Shafran, my great-grandfather, was a carpenter. He was born in Russia, he moved to Detroit, and had a very successful career in carpentry. My grandfather was a carpenter, ran a lumber yard, became an executive. If you took my great-grandfather Josef and put him on a construction site today, he would be ridiculously comfortable. Nothing would surprise him. He would not know how to use a cell phone, computer, car, or ride on an airplane. But on a construction site, he would be completely comfortable. That is sad.

The conditions you have described certainly apply in the United States, and the genesis of your solution and your company had a lot to do with the peculiarities of the New York labor market. There are other prefabrication-oriented builders out there with similar goals of efficiency and predictability, such as the Broad Group of China. Do you think Full Stack is a US-centric model, and/or can this be exported?

Full Stack is finishing, to the largest extent possible, as much of the work as we can in the factory, so that the work on-site is *de minimus* – 15–20%, closer to 20% when you include the foundation.

So that is very different from what Broad Group does. Even though the chairman [Zhang Yue] is a charming man – and I think he is a real innovator, a disruptor, who is trying to think out of the box – they use a ridiculous amount of labor on-site. That works in China. And to some extent, it would be hard for us to do what we do if Broad Group had not put forth their idea first.

When I started this thing eight years ago, and we did our first R&D project, we produced a 600-page book, in which we talked about what we thought about the potential of volumetric modular, the systems of analysis we used, etc. I gave this to Bruce Ratner at Forest City, and he put it on his desk with the 500 other things that were on his desk. I heard nothing about it.

And then, I was on vacation and I got an e-mail at 3:00 a.m. It was from Bruce. He said, "Look at this video! How did they do a hotel in 15 days?" It was of course the famous Broad Group video of T-30. I said, "If you're willing to get 15 cranes and 300 laborers, we can build in 15 days too, as long as you are willing to also spend about a year and a half manufacturing." But that video is really what kicked off the whole initiative of building 461 Dean Street.

Figure 1. 461 Dean Street, New York. © SHoP Architects

For dense urban areas in most of the world, it is quite complicated to do large-volume projects in crowded areas. It doesn't matter if it's the Philippines, New York, or Singapore. By the way, Singapore is very focused on modular construction, and they are having some success. The Crowne Plaza Hotel extension in the airport is done that way (see Figure 2). There are four projects going on at the Singapore University of Technology and Design, and there is a building under planning that is supposed to be 40 stories.

Figure 2. Crowne Plaza Hotel Changi extension, Singapore. Source: Dragages

This model has been successful for some time. Forest City, in the 1970s, was one of the four participants in a US Housing and Urban Development (HUD) program called Operation Breakthrough. It was a project to build affordable housing for the elderly, as an offshoot of Section VIII. They built 35,000 modular concrete units. The buildings are still around today. But there were two major flaws. One was that they did not handle the end-to-end process. To be fair on that point, there was no technology at the time that would have made that easy. The other problem was, they had one customer. They were completely exposed to the economy. And when it got killed in 1972, they didn't have anyone else to sell to.

When I was working at Forest City, the philosophy began to evolve to be, "you don't want just one customer or one typology." You want to have hotels, dormitories, factories, residential buildings. All of these have different economic cycles.

Do you think global economic cycles today support widespread use of modular high-rise technology?

There is no question that there will be demand for this type of technology in the near future. In the next five years, China needs to build 44 million apartments for the elderly. That's manufacturing nirvana! They're doing it in Australia, albeit with different methodologies. We're looking at a hotel project in St. Thomas. In areas of labor or material scarcity, this is a godsend. I'm going to Austria, the United Kingdom, Thailand, and around the world this year. To me, it's a global phenomenon and a globally applicable model.

The process is designed for dense urban areas. The fact that there are more and more dense urban areas around the world, where you want to control waste, minimize interruptions, and do as much off-site work as possible, suggests a wide market. One reason, as in New York, could be that labor is expensive because of unionization. But in Singapore, the problem is that they have no skilled labor. They import marginally skilled labor to do the work there. But if you can get a factory going that has predictable production capacity, you don't need skilled tradesmen to build a quality product. You just have to have a good QA/QC system, and you have to bifurcate and decouple processes so you can have a quality product over and over again.

The 461 Dean Street project is notable for being the world's tallest volumetric modular building. Do you have plans to go taller,? Are there practical thresholds to how high you can go with your model?

There is a threshold. There is nothing about our system and process that flies in the face of conventional engineering. Meaning that, with a double-loaded-corridor building, 45 stories is about the limit, beyond which extraordinary structural enhancements would be required. Once you jump that line, you are doing serious work to resist moment connection issues, wind, seismic, and snow loads. That does not change with our model. Beyond 45 stories it is probably not very efficient.

In a tower configuration, if you have, say, a 22-meter-square plan, where the brace-framed structure would be as long as it is deep, you can easily go to 65 stories. But beyond 200 meters, the impact of the structure on the design, independent of anything else, is height squared times the per-floor cost of anything below that point.

Modular has been used for some time, mostly to build compartmentalized, residential, hotel, or medical buildings. How effective is the volumetric modular approach for open-floor-plate designs, such as office buildings?

The unitary value of a multifamily building makes a modular building of this type quite attractive. When you start to lose that advantage of things that can be easily transported or lifted by a crane, then the value of it goes down. In our process, the more work you shift to the site, the less value there is. That's not the case with everything – for instance the Broad Group has their sub-assemblies that create speed of assembly, and that's the value.

What's next for Full Stack?

I get emails from Africa every week, saying, "can you come open a factory here?" I'm not ready to do that yet. But I can see a time when we have developed a system in order to create buildings the way I talk about, where we can provide all of that design, software, and manufacturing support, so that you can build anywhere in the world. Manufacturing is not complicated – setting it up is. The reason we are called Full Stack is that we are ultimately going to be process-technology, lean-manufacturing, lean management-oriented, so that we can teach others how to do this. ■