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Engineering a Better Future

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Aine Brazil is a leading structural engineer who has been instrumental in shaping the skylines of cities across the globe. In her 40-plus year career, she has been responsible for the design and construction of some of the most significant high-rise buildings in the United States and internationally. Brazil's prominent work and significant contributions to the built environment have earned her numerous accolades and titles. She has always been, and continues to be, passionate about encouraging women to join the engineering profession. Brazil established a discussion and mentorship program at her firm to help female employees grow their careers, and founded a scholarship program at her alma mater to provide financial support for young women pursuing an engineering degree.

Aine Brazil, Vice Chairman, Thornton Tomasetti, is the recipient of the 2018 CTBUH Fazlur R. Khan Medal. Through a 40-plus-year career, she has been responsible for the design and construction of some of the most significant high-rise buildings in the United States, and globally. She also started a mentorship program at her firm to help women grow their careers, and founded a scholarship program at her alma mater, the National University of Ireland, to provide financial support to young women pursuing engineering degrees. CTBUH Editor Daniel Safarik interviewed Brazil on the occasion of receiving her award at the ***2018 CTBUH Tall + Urban Innovation Conference.***

Have you always been interested in tall buildings? When you started your education, did you imagine that you'd be designing them?

When I started pursuing a civil engineering degree, I knew that buildings were my main interest, but being from the west of Ireland, I didn't see a lot of tall buildings around me. When I was in college, the tallest building in Ireland was 17 stories. So, it wasn't something I saw all the time.

But my first job in London was designing towers in Kowloon Bay, Hong Kong, and I was kind of smitten immediately. From the structural analysis and detailing standpoints, I enjoyed the challenges, which always seemed to me a little bit more extreme, because there are so many design issues to be considered, beyond that of a typical shorter building.

The first project I worked on in the United States, in Chicago, was then called the Northwestern Atrium Center [now Citigroup Center] – which was over a railway station [Ogilvie Transportation Center]. It is interesting that so early in my career I was working on tall buildings over railway tracks, and now at this stage I am doing so much work over the tracks at Hudson Yards in New York. It's sort of bookended, you know?

It must be interesting to approach the problem of building over railways from a civil engineer's perspective. Are you drawn to the interdisciplinary nature of this field?

Yes, certainly. Understanding the interface between structure and the functionality of the building has always been my passion. I don't want to design "the best structure." I want to design "the solution that results in the best building." Obviously for tall and supertall buildings, the structure has to be excellent for the building to work properly. More than for other types of buildings, with tall buildings, the "best structure" and "best building" often go hand-in-hand.

Some buildings are famous for their structures because they are expressed on the outside. It must be particularly gratifying for a structural engineer to work on those types of buildings.

That's true. It can be exciting to see the structure exposed. But there are far more where the decision has been made to hide the structure. If it really serves the purpose, I can justify exposing the structure. But it really has to serve the purpose.

Looking back, what has been the most challenging project you have worked on, and why?

In many ways, the most challenging has been the most recent project I have been

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working on, 30 Hudson Yards, and not for its height - it's around 390 meters - and certainly not for its slenderness (see Figure 1). But it is challenging because of its base and its interface with tracks and infrastructure. There are a lot of things happening within it that have rendered it "softer" and less efficient, that cause torsion, etc. There are lot of things that a structural engineer would not do if given the choice! You have to thread everything down between the Long Island Rail Road tracks, which are not in a straight run – they are coming together in a mesh to get into the throat of Penn Station. So there is this narrow 24-meter wide range, and more than 20 tracks to bridge over. And of course it had to achieve high levels of resilience and redundancy, so it was challenging to take all of that work and still develop a building that made sense from a functional standpoint. It doesn't look like the kind of building that might need a tuned mass damper (TMD), but because of all that softness, it ended up having a considerable need for one. There are buildings that are challenging structurally, and those that can be challenging in other ways, and this one combined a little bit of everything.

Is there a region in which you have not yet worked, but you would like to?

I have enjoyed working in the Northeast of the United States, and where my clients have taken me, including Istanbul, Miami, and Milan. The challenges are different with every project. I've never felt I was missing out by not doing the world's tallest building or some of the crazy things my partners are doing in the Far East. The goal has been to learn from what we're all doing in the office, and bring the best innovations from all the projects to the table. I have enjoyed learning from all of them. But I don't feel like there is a need to be in a specific region. Definitely, supertall buildings are a different challenge. I think we, as a structural community and at Thornton Tomasetti, have been learning consistently. Every day, there is another thing we can learn from, about how to better design tall buildings and improve their performance.

Figure 1. 30 Hudson Yards, New York (the tallest building under construction at the rear), with its neighbors in Hudson Yards. The project is being built partly over an active rail yard, presenting a structural engineering challenge.
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What technology has you excited right now?

We have been involved in developing the Hummingbird harmonic damper, which I think will revolutionize the field. I'm not the lead developer of that project, but I am proud to be involved. I rely on the super-smart people all around me to make me smarter, and thankfully, I have a good few of those. Hummingbird, to me, is probably something that will change the way we all do damping systems in buildings. In the near furture, you'll see them everywhere, because they will reduce the cost of damping to a third or a quarter of what it is now. It is such a simple mechanism that eliminates a lot of the complexities inherent to the big mass and sloshing dampers. This is something that is so easy to bring to site. It has tremendous potential to take dampers out of the realm of being really difficult and costly, and something to be avoided if you can!

How does this compare to distributed dampers that go in-line with structure?

Hummingbird goes into horizontal planes as opposed to vertical planes. So it can be hung in ceilings, sit on a roof, and be located around all the ancillary items that go in a roof or underfloor system. You don't need to assign a giant room at the top of your building to accommodate something like this. Because it comes in pieces it is very easy to install, and to replace parts if necessary. And in general, it would be lighter.

Dampers traditionally cost anywhere from US$3 million to US$5 million. If you figure out how much more you could spend on structure – some owners will conclude, "I can do the 'dumb' structure thing and increase the thickness of the members." That's sometimes cheaper than a damper system. But if you can achieve a damper system that is cheaper and just as effective, then you can reduce the amount of material going into the building, reduce cost, and give back floor space. If you're an owner, and you are given the choice of spending US$2 million for massive structure and US$4 million for a TMD, most will go for the structure if they have the space. That's a lot of material going into the building, which if it could be reduced, could really help the sustainability of the project. I can think of a lot of buildings I have done where Hummingbird would have been applicable, and hopefully this is one of the things that we'll see more of soon.

Is there something the industry does that you look at today and say, "I can't believe we're still doing this"?

To be honest, that to me is more a question of process than materials or technology. In the 40 years I have been designing buildings, I cannot believe that we are still using drawings. It is only in the past few years that we have begun to accept that we can design as well as construct in 3D. You don't have to take a 3D concept and "dumb it down" to get it on a 2D piece of paper and get it through the building department, and then have people use that 2D drawing and try to recreate what you thought the 3D should have been!

Figure 2. One Vanderbilt Place, New York.

There is no question 3D [digital] models are being used, but it is not being done as standard, and not to the extent that it could be. One of the things about 30 Hudson Yards of which I am very proud is that it was one of the first supertall buildings where the 3D model was used to deliver the steel to the site. Essentially, we developed the design, model and connections, and handed it to five fabricators from four countries: Canada, United States, Italy and Mexico. They could all use the model to fabricate the steel and coordinate the fabrication across all those places to make something that works.

We just recently collaborated with another engineer of record, Severud Associates, to do the same thing under contract, where we ended up 3D-designing the steel for the One Vanderbilt project going up in Midtown Manhattan (see Figure 2). We collaborated with Severud from the early stages so they would be able to deliver the steel for that project, and it has gone like a dream.

These are the things I think we need to do, and I feel very strongly about it. We need to evaluate our process as much as our materials. Unless we get together to work more collaboratively, we're not going to achieve the improvements we would like to see.

We can enhance the product a lot better by reducing glitches. Construction is a tough business, and the ***Harvard Business Review*** has listed it practically at the bottom of innovative industries. We can make sure we take construction out of that bottom position!

Do you think the tall timber trend is over-hyped, or is it here to stay?

I think it is very exciting. I think that there will be tall buildings built in timber. I am not sure it will because timber is the most efficient solution. Timber has a tremendous advantage, in that it is a material that is beautiful when it is exposed. But a number of things still need to be worked out. If you are doing a tall building and you have low mass density, as timber does, then you have to resolve that – maybe you can use Hummingbird! Beyond that, you have to develop a more consistent approach to the design of connections and a more uniform distribution of load. I'm not sure how well understood the creep issues are yet. And obviously, there are fire engineering issues, whether that means you have to encase the structure or something else.

It is going to take some time in US cities, because of the more conservative approach to fire engineering that we see here. I don't think we'll see the tallest timber buildings in the United States. There's a lot of material that goes into those structures, because the elements have to be bigger and their capacity enhanced.

I would love to see more tall buildings in timber – I could definitely see them being built in the 30- or 40-story range. But I don't see them stretching way beyond that.

There seems to be a debate in structural engineering right now about the objectives of "collapse prevention" vs. "functional recovery" from an earthquake. Do you think there is an acceptable and achievable time frame for functional recovery that can be designed into tall buildings in seismic zones?

If you have a 9.0-magnitude earthquake, what happens to all the other infrastructure around you? Do you have electricity, water supply, or water pressure? A skyscraper without any of these things is totally useless. We need to take a step back. When we look at the question of resilience in tall buildings, it really has to be tied to the resilience of the entire neighborhood. If we can determine what the utility recovery time frame is, then we can make some assumptions about the time frame that would be acceptable for repairing a building. We have been having these kinds of conversations for a long time with respect to man-made disasters, such as a blast. We say, "how long will it be before we get up and running?"

If you really get the "big one," any building that is not base-isolated will have extensive damage, at the very least to nonstructural elements like partitions and ceilings, which alone could make it unsafe to occupy. In my mind, we have to look at the overall resilience of the entire city.

From the point of view of structure, everybody is talking about things like fuses, and having something that can be replaced. To my mind that is logical, but I think we forget where we sit – in an urban environment. Tall buildings are really a part of the infrastructure. If the rest of the infrastructure is not functioning, it becomes almost a pointless discussion. Of course, if I am a client who wants to build tomorrow in the heart of San Francisco, I don't want to hear that. I want to be told my building will be the one left standing. But from a logical perspective, what you do and how much you spend to make that happen will depend on the environment that surrounds you.

One of the many reasons you are receiving the Fazlur Khan Medal is for your efforts to mentor and bring more women into the industry. What do you think the tall building industry can or should do to increase the meaningful participation of women?

I think the participation of women in high-rise engineering and architecture will increase once we entice more women into the base industry. That's where we need to start. The pipeline is first, and then the ability of the industry to retain people is the next piece. I think there is a wonderful pipeline right now of young, talented women who have studied structural engineering, and are interested in tall buildings. We have many of them at Thornton Tomasetti. As they see their designs incorporated into projects like Hudson Yards, they will experience the rush that comes from solving those challenges. But it is through the programs like ACE Mentor in high schools and the Salvadori Center, starting in middle schools, where it will really matter for the next generation – we need to get them excited now.

In a Salvadori Center class, I saw a little girl, who was probably about age 10, in a frilly pink dress, jumping up and down with her hand in the air, trying to answer a question about structural engineering! Where do we lose them after that? The key is that there be a continuing focus on STEM [science, technology, engineering, and mathematics] and it continues to be something fun.

We hold an annual Day of Discovery at Thornton Tomasetti on Columbus Day, and we bring about 60 young girls aged 12 to 17 into our office. We find a current project and pair them with an all-woman team. Last year we worked on the Culture Shed at Hudson Yards, and there were women steel fabricators, architects, MEPs, and structural engineers – the entire team had key woman members. When you see the excitement of these kids knowing what is possible, you realize you can make a difference… Now, that's a small group of kids, but we need to keep doing this, and try to make sure that anyone who is in the profession who is excited finds a way to let people know about it. If we do that, I think we will improve the numbers. It is going to take a long time to move the dial as much as we want to.

And then there is the question of retention, and this being a global industry working across a lot of different cultures.

And it's a quite fine thing talking to kids, but we also need to make sure the women in our industry stay with us. We just had a meeting the other day about our new flex-time and family leave policy. The whole question of making sure both parents had the opportunity to take that leave came up. The fact is, we are in an industry that is and always has been a pressure cooker. We're not going to be able to change the fact that, once money is available, the client will always want to build as fast as possible. It is not going to make it easy for people to have flexible working hours. But I think it can be done. It's a mindset – I want Thornton Tomasetti to be the company that is the best career choice for women. If we are open to the fact that people sometimes go through periods where they need a little more flexibility, then those really dedicated and talented people will come back from leave willing to work full-time, and probably more than full-time. That applies to men and women. If we want to be successful, we need the best of 100% of the people, not 50%. Innovation is fed by diversity.

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That's where I am really pushing myself now. If you really want to know what more I want to do in this industry, it is to make it more inclusive and innovative. I've had the most amazing fun doing tall buildings. It's been the most amazing career. Why wouldn't I want to see the girl jumping up and down in her frilly dress have the same or better opportunity, and not be ground down before she gets there? I can still hardly believe how fortunate I have been to have been welcomed and accepted by the engineering community and to have those people in my life, starting with Charlie Thornton, all the way up to the younger partners who push me to do better all the time. It's been a wild ride, but it's been great.

See Aine Brazil's profile, the Hummingbird technology, and all the other innovative projects in in the latest CTBUH publication ***Tall Buildings + Urban Habitat, Volume 1,*** now available at the CTBUH Web Shop: store.ctbuh.org/26-tall-buildings-urban-habitat. ■