

Top of the world

CW speaks exclusively to the senior project structural engineer on the Burj Khalifa, Ahmad K. Abdelrazaq, now executive VP and head of the high-rise and complex building division at Samsung C&T in Seoul, South Korea. **By Gerhard Hope**

A particularly striking photograph in the office of Abdelrazaq in the Samsung C&T headquarters in Seoul shows him in a hard hat calmly bestriding the highest point of the tallest building in the world. This is not the 124th floor observation deck, at 452m, that most tourists get to experience, but at the very top of the pinnacle of the 829.84m-high super-tall tower. Abdelrazaq was installing accelerometers for yet another world-first: one of the biggest mega-research projects in terms of super-tall building monitoring systems, in which Samsung C&T invested a considerable amount out of its own pocket.

“This is 828m above the ground,” Abdelrazaq explains about the photograph. “I climbed up about 200m to reach the top of the pinnacle. We installed accelerometers to measure the building acceleration, and sonimeters to measure wind speed and direction and atmospheric conditions. This has allowed us to check the actual building movements continuously every tenth of a second.”

Abdelrazaq keeps his pulse on the structural health of the world’s tallest building from his office in Seoul. “I can look and see what the building is doing: displacement, acceleration, weather conditions along the height of the tower, including temperature, humidity, wind speed and direction, any kind of dynamic excitations that the building may experience due to windstorms or seismic events that may take place in seismically-active areas, especially in Iran, just across the Gulf.” While the information gathered remains confiden-

tial, it is likely to influence the design and engineering of the next generation of super-tall towers.

What does it feel like being at the top of the world? “It is really a different feeling. You go up there and look around, and everything seems just on a completely different scale, like climbing a mountain, but at least with a mountain you can see the distance, whereas this is more like being in an airplane, but attached to the earth at a central point.” Abdelrazaq mentions that, at the time the photograph was taken, a sudden windstorm forced him to climb back down rapidly. “It was cloudy, it started to rain, the wind picked up and I could feel the movement a little bit.” He hastens to add that the tower has a robust lightning-protection system.

Still, Abdelrazaq says Burj Khalifa “is one of the most ‘quiet’ buildings I have ever seen in my entire career in designing, constructing, and monitoring super-tall buildings. The tower just does not move; this no doubt demonstrates that the wind engineering strategies, which are fully integrated with the architectural design, protect the tower against dynamic wind excitation in a passive way and tame the wind effects on the tower.

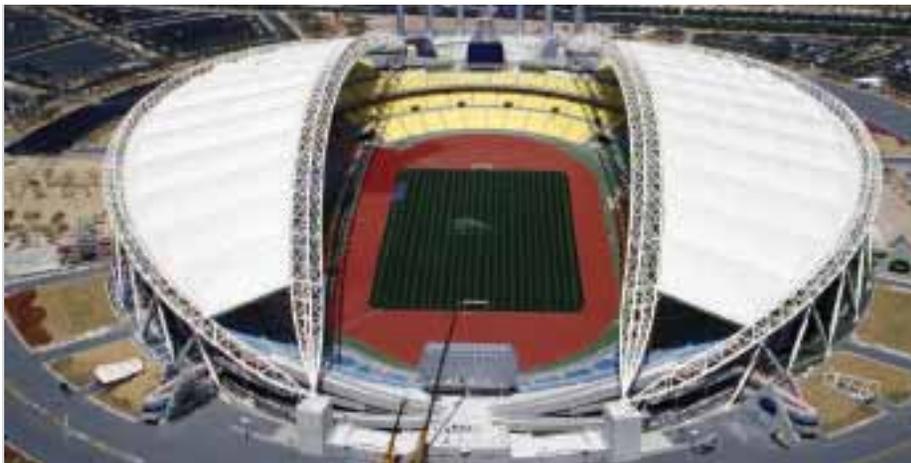
“Our biggest challenge during construction was how to control the building verticality and movement. The tower was subject to both vertical and lateral movement during construction; these movements tend to increase due to shrinkage and creep as a function of time. Our main aim was to maintain the tower verticality since it has a direct impact on the vertical transportation system and the building ser-

FACE TO FACE





The Samsung Cancer Centre in Seoul is a world-famous medical facility.



The Daegu World Cup Stadium in Korea used steel trusses, precast and reinforced concrete.



Incheon International has been acknowledged as the world's best airport for seven consecutive years.

VICES. We monitored the tower movement and load distribution from its foundation to the top of the pinnacle. We ran a detailed construction sequence of the tower and predicted the building movement with time, then we compared these movements to the measured ones, then we made the necessary corrections to keep the tower alignments.

“Our predicted movement was in line to the measured; this constantly gave a high level of confidence in our predictions. We measured load transfer into the pile, measured the building settlement and column/wall shortening, the lateral movement of the tower during construction and after its construction, and these have come close to our predictions. We undertook this extensive monitoring as part of the risk-management programmes we put in place during the design and construction planning. It essentially gave us a real-time feedback on the design assumptions, feedback on the building behaviour, and it allowed us to communicate with the designers, consultants and the owner should we have noticed unusual behaviour. And we were able to manage almost a total verticality of the tower, to within 25mm of tolerance during construction, which is a great achievement by itself, since it outperformed the standard practice.”

Thus Abdelrazaq declares: “Burj Khalifa has been a huge success technically, and in many aspects it has actually changed the face of Dubai. Definitely it has had a major

impact in terms of what we do as architects and engineers, extending the limit of technologies to a new level.” Being involved on the project from the early design concept, while at SOM on the one hand, and participating in the development of construction planning, logistics, and in resolving all the technical challenges on another, while working with Samsung and, finally, building the tower and monitoring its behaviour, gave a complete perspective on the challenges that one may face in building a super-tall and in making it a success by integrating with all the stakeholders. Completing the construction of Burj Khalifa has also meant that Samsung C&T has evolved into a holistic contractor and integrator in the design and construction planning for tall and complex buildings, says Abdelrazaq.

“Most people think of us as being a contractor, but our new business model has changed completely. We are doing everything related to super-tall and complex/large development buildings, from feasibility studies to final construction cycle. We are now able to tailor our contract type to reflect the client needs. We are able to take a project as turnkey, design-and-build or a negotiated type of contract that would usually start with preconstruction service, or as simply a contractor. If we feel it is appropriate, we may also consider investing in some projects. We have now virtually changed the way of delivering high-rise and complex building projects domestically and internationally.

“I mean, we are actually about building cities. If you look at our division and the type of projects we do, if you give us a city, we will build it. We are not only looking at it as a contractor, but we feel a sense of responsibility to communities, not only here in Seoul, but around the world,” says Abdelrazaq. His division comprises a core team of experts that deal with design, construction planning/logistics, business development and construction management (when needed), “all in the same room, dealing with high-rise and complex building projects.”

At present the division is using BIM technology to simplify and integrate its works in a holistic way, by engaging all core team experts into the project from an early stage, regardless of the way the project is being procured. “We believe that our investment in this technology will result in more gains



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and help avoid potential risks that the project may face, especially complex projects. We provide constructability and due diligence review on all building systems, and to potentially identify means of adding value to the project and the client, while improving the overall project qualities and delivering the project objectives.”

Abdelrazaq says Samsung C&T has “a global core team of experts, not only Korean staff,

but from everywhere. We are able to move and mobilise on any project anywhere, whether it is in Russia, the Middle East, South East Asia or even the Americas. We are really flexible, and that comes down to having the right expertise in-house, knowing the industry very well, and being able to mobilise our resources quickly, no matter where the client is and wherever we are needed.”

In order for tall-building projects to be viable, “you need to look at the entire development in a holistic way to avoid cost and time overruns.” This means an integrated approach in terms of engineering, construction, planning, design and implementation. “Our early involvement in projects will no doubt result in significant benefits to the client by offering time and cost-savings that may not be realised should the client approach the project in a more traditional way, especially for large and complex projects.

“For example, if you look at some of the most successful largescale developments, these are the ones that are approached more holistically rather than divided up into smaller packages. Some of the largescale projects in the Middle East could have been more successful had they been approached this way. In fact, some of these projects have been delayed and may already have cost and time overruns. If these had been approached more holistically, the client could have saved huge sums, and the projects could have been executed in a much more coherent and coordinated manner, with greater consistency in terms of quality, delivery, infrastructure optimisation ... the list goes on.”

In terms of the Middle East, Abdelrazaq has specific views on this region and the role that Samsung C&T can play here. “There is a huge amount of work going on, especially in the GCC. No doubt many exciting projects will come up soon once things stabilise in both Iraq and Egypt. As you know, this was going to be a huge market. Right now people are trying to get their bearings, and once that all settles down, I think there will be a huge surge of business. Even now it is a little bit slow, but I think there is a huge potential out there. And we are not waiting for the opportunities to come to us, we are just going there, pursuing projects in all sectors and areas, from high-rise to healthcare, aviation, sports, hospitality, civil works and power plants.



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Ahmad Abdelrazaq is an executive VP and head of the high-rise and complex building division at Samsung C&T in South Korea. Since joining Samsung in 2004, he has been involved in the design and construction planning, including structural design, of a range of projects. Presently he is also serving as the project director on several high-rise and complex projects domestically in Korea and around the world, including the Worli mixed-use development in Mumbai, the UIC project in Singapore, the Rasuan Tower in Indonesia and the Yongsan Land Mark Tower in Seoul.

Prior to joining Samsung, Abdelrazaq was associate partner and senior project structural engineer at Skidmore Owings & Merrill (SOM) in Chicago in the US, where his reference projects spanned the Jin Mao Tower, Tower Palace III, the LG Kangnam Tower, the LG Art Centre, Chicago Place, Hotel De Artes in Barcelona, Millennium Park in Chicago and the Hong Kong Convention Centre. And, most importantly, the Burj Khalifa project, where he was involved in developing the structural and foundation systems for the tower.

Abdelrazaq is also a lecturer at Seoul National University, where he teaches a high-rise building and spatial structural design courses for graduate students. He also recently presented a similar mini-course at the American University of Dubai. He has served as an adjunct professor at the Illinois Institute of Technology's School of Architecture, researching concrete, steel and composite structural systems and the shaping of super-talls to control their dynamic response to wind excitation. He was also involved in developing a mega-scale research project for a full-scale health-monitoring programme for super-tall buildings that was fully funded by a National Science Foundation grant to monitor the response of high-rise buildings to wind effects. This resulted in an award-winning paper.

At present, Abdelrazaq chairs the Tall Buildings Committee of the American Society of Civil Engineers.



Incheon Grand Bridge is the longest bridge in South Korea, and one of the longest cable-stayed bridges in the world.



Samsung C&T's power-plant capability includes such projects as the Wooljin nuclear power plant.

“The Middle East is in dire need of infrastructure. Here is a place with a huge quantity of resources, but in terms of the amount being spent on infrastructure to improve living conditions, this is still on the rise and has not been realised. There is an inconsistency. Hopefully after all the political uprisings in the region, things will settle down, and a lot of these resources can be invested back into the countries, just to improve the living conditions of the people at all levels,” says Abdelrazaq. “We have secured several projects in Qatar related to all kinds of business sectors. We are definitely keeping a close watch on projects related to the World Cup.”

What are the key determinants for the viability of a high-rise or super-tall project, and what should be taken into account in the initial stages? “Definitely for every tall-building project, some are realistic, some of them are not. Some of the key issues that decide the viability of these projects are, first of all, they have to be financially viable and able to generate a profit, sustainable,

contextual and iconic, fast to build, rational and logical, cost-effective by utilising local materials and resources (including local skilled labour) and, most importantly, a good design that can change its use and function without fundamentally changing the design concept. These projects should be built in the shortest possible time to avoid financial burdens that they can present to the owner and loss of revenue. Simply put, clients cannot afford projects that take a long time to build.

“In the last ten years, Dubai, China and other countries have really been a haven for architects to be free to do whatever they wanted from an architectural standpoint, mainly because, especially in Dubai, clients are really interested in doing something different. We are at a new age of technology, especially computers, where engineers and architects can produce whatever they can dream, while using new technologies and materials. This no doubt has presented new challenges to the design and construction teams above

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and beyond of what was conceived in the 1990s. After all, tall and complex buildings have always been about new technologies. Now we are getting to a stage where we have so many technologies, whether it is material or design or the way we are doing the work in the computer and so on. That has changed the way we design and build projects. Some may have not resulted in positive outcomes,” adds Abdelrazaq.

“For me, everything starts with good, responsible and realistic design. Buildings and towers do not have to be complex to be a good design. Even if they are complex, they must remain simple at many levels. Sustainability is important: how you design a building to make it sustainable and to be flexible for future use is extremely important. And these buildings have to be contextual and fit well within the environment that they are intended to be in. You cannot simply take a building out of one locality and hope it is going to work in another, or take one good design and extrapolate it into another. There is a huge paradigm shift for the designer to consider. The designer needs to reflect on whether the right systems have been selected for the right environmental conditions. What works in New York will not work effectively in Dubai, China or Korea. We are constantly finding that some of the global design companies are not necessarily fully aware of the local conditions and cultural needs for particular cities.

“In addition to all of that, we are contributing back to the profession in terms of how we use these technologies successfully, to bring it into new designs. Our work is not limited to being only a contractor or a designer, but also to adopt know-how and expertise in the long-term, in the development of a new generation of building systems.”

Abdelrazaq points to Incheon Tower in Seoul as “another step beyond what we did at Burj Khalifa.” At this particular project, Samsung C&T has introduced “a dampening system that has never been used before on a mega project. This new system adds significant reliability into the design under extreme events without added cost.” Then there is Samsung C&T’s involvement with



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the Yongsan International Business District in Seoul, where it will construct the Yongsan Land Mark Tower (111 storeys, 620m), designed by Renzo Piano out of his Paris office. The \$30bn development comprises many buildings designed by 19 renowned architects from around the globe using different design, technologies. “This landmark development, when completed, may become a museum for high-rise and complex building designs,” says Abdelrazaq. The entire development is expected to be constructed and completed simultaneously by 2016. The

sheer scale of this development will dwarf the Burj Khalifa development in comparison.

“Samsung C&T has been selected as the contractor for the Land Mark Tower and the overall environmental clean-up of the site. We are presently providing preconstruction services by working closely with the design team in terms of conducting design review for all building systems, constructability reviews, cost estimation, scheduling and developing the construction methods for the project. BIM is being used in the design and construction planning of the project. Thus we are more

FACE TO FACE

or less acting as a CM/PM on the project. This is a new trend. We are really extending the limit of what we can do, and what can be achieved,” says Abdelrazaq.

Given the Middle East’s fascination with tall buildings, is there a future for such projects, in terms of the global financial turmoil and the downturn in the construction industry? “Densification of cities is extremely important, especially in the Middle East. The approach that has been taken in the Middle East so far is to keep expanding horizontally, and for me that is not necessarily sustainable due to the need for infrastructure. Having consolidation is extremely important. We do not have to look too far: if you look at Seoul, it is a city that works, just in terms of the number of people using public transport, for example.” Abdelrazaq points to the Samsung headquarters in Seoul, where he was involved with the design in 2004. The headquarters is home to 20,000 office workers, of which 90% use the metro system, as it is located in close proximity to a metro station. In addition, all the buildings are interlinked by an underground podium level to reduce congestion at street level.

“It is a nice way of looking at how we develop cities and integrate them with mass transit, utilising the latest technologies in infrastructure to reduce the manual labour to keep the city clean, energy-efficient, green with large open plazas, flexible and adoptable to change as new technologies are introduced. Look at Hong Kong, Singapore, New York, Chicago and Tokyo – these are the kinds of cities that really operate on that level. In the Middle East, as new cities develop or are replanned, they need to look at this global best practice for a better future. Having introduced a rail system that connects all Middle East countries is a good start and the best way to connect the dots in the region. If they do it well, by using bullet or high-speed trains, you must wonder whether we need to use airplanes?”

Another critical aspect to consider is operation and management. This is “a nightmare, especially with super-talls, if not done well,” says Abdelrazaq. “If you have a problem with a shorter building with a unique shape, for example, you can somehow develop an alternate way of managing it. However, in today’s market, if you take that problem and multiply by a 100 or 150 times, all of a sudden





The Samsung HQ in Seoul accommodates 20,000 workers a day.

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this small problem extrapolates itself into something that becomes a very big burden on the management of some of these projects.”

Pointing to the Samsung headquarters as an example, Abdelrazaq says: “We constantly make modifications to lower the operational cost. Since we built it, we have lowered the energy use by more than 27%, and that will continue to improve. When you design a building, you have to be flexible enough to be able to adopt new technologies and systems to constantly upgrade the building without fundamentally disturbing the users, and then at the same time achieve better efficiency, minimise the operational costs and management fees. So implementing an excellent BMS is a critical component of building management.”

The adoption of BIM in the design stage also has a major impact on maintenance issues. “BIM technology is the way forward for high-rise building projects, whether the client accepts it or not. We are really striving to use that as a tool for our future business; it is a small investment but with a potential for big returns. Firstly, BIM use depends on the client’s ultimate goals and objectives. In

a residential tower that is being sold, the client has no incentive to create a BIM model, as they may have no obligation to operate or maintain the building.

“Secondly, if it is a complex facility such as hospital projects and other complex facilities (such as the Cleveland Clinic in Abu Dhabi, or hi-tech facilities, data centres or complex high-rise building projects), where the operation and management are extremely important to the overall hospital operation and management and/or undisturbed operation of the manufacturing of the facility, then the overall management, maintainance and any potential modifications must be streamlined, and the time and cost needed to make the modifications should be minimised, and with almost no disturbances to the building use. One must essentially do all that is needed from your computer on your desk, including design, procurement, prefabrication of the components and finally the installation. Abdelrazaq says some of the latest advances in BIM technology “allow us nowadays to monitor a building in real-time. This means you can actually run an energy-analysis model to predict the building’s energy needs for

the MEP system, perform the calculations and evaluate the system after its construction with real-time input/output data, and potentially make adjustments to the MEP system to optimise the energy needs during the testing and commissioning period and throughout the building’s life. This kind of system can be streamlined entirely, and presents an opportunity that could have a major implication on best MEP practice and facility management.”

Given the complex issues surrounding tall buildings, from technology to lifecycle costing, what does the future hold? “I think constructing tall buildings will never stop, and it will continue to grow, regardless of what is being said,” asserts Abdelrazaq. The global population is expanding exponentially, and placing increasing strain on land resources for other purposes. “Tall buildings tend to play a major role in terms of densification and minimising the amount of natural resources we really need. Obviously some planners think tall building may not be sustainable. In the long run, I believe that tall buildings are sustainable, as we can work, live and enjoy life, art, music and culture over a small area of land with very little need for transportation (which uses 35% of the world’s energy consumption), in comparison to widespread cities that some countries have.”

Abdelrazaq adds that, in terms of an ultimate ceiling for super-talls, “there is really no limitation on height. What drives it is vertical transportation and financial viability. It has to have some logic and phasing that could generate some cash flow during its construction, if possible. There is a dire need to build these projects quickly, which can only happen by introducing new construction methods and materials. We need to change traditional construction methods and look for new technologies. Standardisation becomes very important, and mechanisation of the entire construction process is critical. These are the kinds of things that must always be on one’s mind – to me, it is always about how you can practically implement it, in a sustainable way that can stand the test of time; all the stakeholders should be able to embrace, feel comfortable and confident in using these new technologies. We should always strike a balance proven technologies and the use of the new ones, and the way to integrate all of that,” says Abdelrazaq. 