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# Closing the Gap between Fantasy and Reality: Pushing Current Technologies Into the Future

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She travels widely to present at international conferences and document buildings. Her photographs form the basis for her lectures, teaching and research – many appearing in the CTBUH Skyscraper Database.

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The tall building is a discrete architectural type. The causal aspects of its evolution can assist in determining which aspects will be of the most benefit in pushing the idea forward. If tower-type buildings are symbols of the ideals and aspirations of the civilizations of any period in history, then what should our current response be based upon our technical achievements?

The age of the iconic skyscraper has come to be dominated by a combination of the preference for the stylistically unique in conjunction with the quest to build tall. The uniformity and rectilinear nature of International Style architecture that dominated tall building design through the better part of the 20th century has given way to unrestrained expression that is reliant on pushing the limits of technology, including the structural capabilities of materials and systems, as well as the methods used to calculate and fabricate those systems. This encompasses many evolving areas of digital design.

Tall buildings present one of the most challenging design problems that we face. What is being constructed today will impact our environment for many decades to come. Skyscrapers are not readily demolished. They are massive buildings with extremely significant structural systems that must create livable spaces for thousands of people (inside and outside) as they engage the city, and which need to remain viable for a significant duration.

There is such a significant gap between the physical realities – and sheer mass – of skyscraper design and the fantastical images of skyscraper "dreams" that we see in visionary proposals and competition entries. We seldom see the same abandon in the design of museum types, for instance. Although conceptual explorations for smaller building types might push the limits on form and materials, often as a direct result of digitally driven liberation, they are usually grounded in some sort of material concern.

The *Evolo Skyscraper Ideas Competition* has been running since 2006 to inspire an interest in the design of tall buildings. The winning entries have become increasingly fantastic, as illustrated in Figure 1. This is not to suggest that "ideas competitions" are invalid approaches for eliciting innovation; rather, the lack of basic material and structural concerns makes such competition results more suited to a digital industry such as film, and limits their applicability to the practice of architectural design.

"The Evolo Skyscraper Ideas Competition winning entries have become increasingly fantastic… the lack of basic material and structural concerns makes such competition results more suited to a digital industry such as film, and limits their applicability to the practice of architectural design."

Figure 1. *Light Park Floating Skyscraper,* Evolo 2013: 3rd place. © Ting Xu/Yiming Chen. Source: http://www.evolo.us/category/2013/

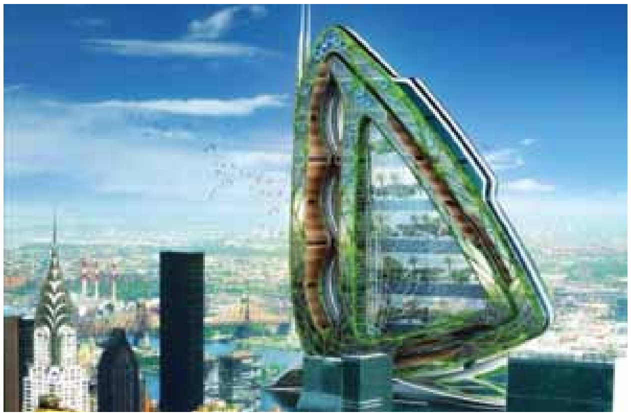

Figure 2. The *Dragonfly* urban vertical farm concept in New York. © Vince Callebaut Architects. Source: http://inhabitat.com

Figure 3. The *Asian Cairns* farmscraper concept in Shenzhen. © Vince Callebaut Architects. Source: http://hyperallergic.com

The technology of building tall has advanced significantly in the past 15 years – with major progress in megacolumns, outriggers, diagrids, composite construction, concrete pumping technologies, high-performance envelopes, and vertical transportation. But it has not necessarily kept up with the fantasy visions of towers that we see in renderings and competition entries, many of which ignore present-day material and construction realities – and gravity. Many of these proposals may include genuinely inspirational ideas, but they presently belie construction. However, it is the nature of "ideas competitions" to bring forward compelling visions of the future of architecture (see Figures 2 and 3). What should be the focus of future skyscraper developments?

The winning entries from the 2014 Evolo Competition clearly acknowledge the need for towers that integrate high-speed vertical transport systems, capture carbon, improve the air quality of cities, incorporate new materials, use 3D-printing technologies, and generally push a sustainable agenda. These are "fantasies" deserving of realistic exploration.

The situation may require that we step back and reconsider the tall building typology going forward, to better direct our energies towards understanding how we can effectively build upon current technologies to create a more socially and environmentally responsive framework. There is a need to reconcile current digital fantasies with the technical realities of what we *can* do in light of what we *should* do. The typology of the 21st-century tower has evolved from a commercially driven optimization problem to a dynamic, compelling and often controversial area of design. As the planet urbanizes, the tall building is being claimed as the solution. However, the questions "how tall?" and "how dense?" have not been properly addressed.

## The Design Potential of Controversy

Recent stylistic and structural changes in tower typology have potentially made the tall building a more engaging building type, as well as perhaps a more contentious one. This provides an interesting opportunity for debate, particularly with reference to project proposals as they are introduced in the media.

Many of these blur the lines between digital design, technical aspirations and present realities. A great number of the most speculative skyscrapers have a "green" agenda. Sustainable themes include the incorporation of wind turbines and vertical farms that push the limits well beyond what has been accomplished to date in projects such as the Pearl River Tower in Guangzhou by SOM or the Wuhan Greenland Center by Adrian Smith + Gordon Gill Architecture (see Figures 4 and 5).

Figure 4. Pearl River Tower, Guangzhou uses its sculpted form to direct wind toward turbines situated at the recesses in the façade. © Tansri Muliani

Figure 5. Wuhan Greenland Center's distinctive floor slots help to reduce the vortex shedding. © AS + GG Architects

> “Contemporary towers can exploit the growing digital capabilities and the interoperability of software systems that allow geometries to be translated from the design office to the engineer, and ultimately to the fabrication equipment. Within this, it becomes important to reconcile structural and material realities with digital dreams.”

Figure 6. Sky City, Changsha. © China Broad Group

The idea of the sustainable skyscraper was the focus of the CTBUH 2012 World Congress Shanghai – *Asia Ascending: Age of the Sustainable Skyscraper City*. The conference program made clear that the notion of the sustainable skyscraper remains an oxymoron and fairly elusive, requiring significantly more research and exploration, as evidenced by the CTBUH 2014 conference theme; *Future Cities: Towards Sustainable Vertical Urbanism.*

Perhaps one of the most-discussed projects internationally has been Sky City by China Broad Group. The proposed 838-meter, 220-story tower in Changsha, China, is a visionary and ambitious project (see Figure 6).

Sky City relies heavily on prefabrication, a methodology already tested on other China Broad Group projects, such as their well-publicized 30-story hotel built in 15 days. This is to enable an aggressive construction time frame of months rather than years, which contrasts significantly from actual tall building construction in China at the present time. Sky City also claims to be highly sustainable based on the use of systems previously tested by other Broad Group buildings. The building, in terms of construction methods, speed and scale, seems to present the most imminent realization of a highly visionary skyscraper design.

## Structure as an Expressed Aesthetic

The towers constructed to date represent the limitations of the technology of our time, as the height of the tower is directly connected to the tensile capabilities of materials, in conjunction with the understood best arrangement of the gravity and lateral-load systems. However, the structural typologies of towers might provide a starting point for re-engaging in their design. Many visionary schemes depend on unrealistically light structural systems, eccentric loading and challenging cantilevers. This lightness makes many schemes difficult to take seriously, when we know the extreme challenges that need to be overcome in order to execute heavily cantilevered projects like the CCTV Building in Beijing by OMA. Fortunately, our current crop of “visionary” projects being executed in reality do provide an inspiring, if not easily replicable, way forward.

Figure 7. The megacolumns of the Chow Tai Fook Centre, Guangzhou. Megacolumns have become the critical part of a tall building structure, and are also factors in their architectural expression.

Figure 8. The double-façade system of the Shanghai Tower. The system encloses multi story atrium spaces that sit outside of the primary structural system, which is composed of megacolumns combined with outrigger floors.

Many innovative and exciting projects are being realized that either directly express their structural system (see Figures 7 and 8) – as in diagrid towers – or combine the heavier megacolumn and outrigger systems necessary to achieve extreme heights with lighter, more geometrically versatile structural systems – such as seen in the new Shanghai Tower. There is a rich history of expressive structure already established in Asia that has served to successfully transform banal corporate towers into icons of the future (see Figures 9 and 10).

Diagrid structures are chosen by designers for a reason: they can support challenging geometries, as they have ultimate flexibility. What is common to most applications is the ability of the diagrid to provide structural support to buildings that are non-rectilinear, adapting well to highly angular and curved forms (see Figure 11). The perimeter diagrid in its purest form is capable of resisting all of the gravity and lateral loads on the structure without assistance of a traditional core, enabling some pronounced deviations from typical structural types that are entirely dependent on a core for stability. The tallest constructed diagrid tower is Guangzhou IFC, by Wilkinson Eyre Architects, which stands at 439 meters (see Figure 12).

## Advanced Computer Modeling's Impact

The development of BIM (Building Information Modeling) has been critical to ensuring the successful design and fabrication of highly complex buildings. Geometric complexity requires a very high level of accuracy, and makes the assessment of loading on members and connections far more challenging than rectilinear structures that can be reduced to simple, determinate transfers of load. The use of such software is essential to the collaboration required within complex buildings, and to the coordination and fabrication of their cladding systems.

Where 20th-century towers tended towards repetitive planning that aligned with the technical limitations of drawing and structural design of the time, contemporary towers can exploit the growing digital capabilities and the interoperability of software systems that allow geometries to be translated from the design office to the engineer, and ultimately to the fabrication equipment. Within this, it becomes important to reconcile structural and material realities with digital dreams. The exciting opportunities of the diagrid and other steel structures lie in understanding the fabrication and erection of the systems as part of the architectural design problem (see Figure13).

## Façades Much More than Skin Deep

Building to extreme heights has literally put a lot of pressure on façade design. Sustainable,

Figure 9. In 1985 the Hong Kong and Shanghai Bank by Foster + Partners launched the use of highly expressive structure and prefabricated components into the realm of tall building design.

Figure 10. The use of the diagonal as a form-giving device transforms the Bank of China into an iconic tower that is visually distinct from the surrounding, more traditional skyscrapers in Hong Kong.

Figure 11. The Poly International Plaza, Beijing, employs a diagrid system using concrete-filled tubes that vary in diameter and thickness from ∅1.3 m, 50 mm thickness at the base to ∅0.7 m, 20 mm thickness at the top. Alternate floors are connected to the diagrid to create tensile connections between the nodes. Intermediate floors are hung from the floor above.

Figure 12. The tubular steel diagrid sits elegantly behind the sleek glazed exterior of Guangzhou IFC. The toroidal geometry of the gently curved tower was made possible only through the use of advanced computer systems. © Tansri Muliani

high-performance envelopes are being studied, tested and incorporated into tall buildings. The varied geometries that have become common in new, iconic skyscrapers have resulted in the development of new enclosure systems, which, through digital design and fabrication, have pushed beyond the limits of traditional curtain-wall systems (see Figure 14). Highly efficient, climate-responsive façade systems are increasingly being used in contemporary construction, although some tall buildings are still confined to using less complex, shallower systems, due to their lower cost. Floor plate sizes are actually being reduced in order to permit access to views and daylight, with some towers beginning to reintroduce natural ventilation. More advanced, sustainably-motivated towers are incorporating double-façade techniques, although these instances are still somewhat rare.

Figure 13. Workers install the glazing that will form the double façade system on the Poly International Plaza. The coordination of such complex geometries is possible only through the advancements of BIM systems.

Figure 14. The Shanghai Tower's double façade system adds a lightness and complexity of geometry through its structural layering. © Tansri Muliani

## Creating a Vital Urban Future

Although many visionary skyscraper designs purportedly support a sustainable agenda, few choose to tackle the difficulty of the impact of tall towers on the increasingly dense urban environment. This increase in density is inevitable and desirable as a means to preserve agricultural land and limit urban sprawl. However, not all density is supportive of a rich urban life. Beyond issues of the relationship between the height of inhabitation and its relationship to the landscape, described as "Biophilia" (Wilson 1986), the height and spacing of buildings impacts the climatic condition at grade. There are extremely important lessons that need to inform the positioning of tower types in order to allow solar access in cold climates and provide shade in hot ones. Dense urban environments will also modify the wind regime, which can result in spaces that can be either too windy or stagnant. The nature and width of the roadways adjacent to towers will impact the viability of street life. Car-oriented cities and elevated roadways adjacent to towers can serve to negate their connection to pedestrian life. Visions of density often deny the realities of density.

One of the preoccupations of our impression of the skyscraper as an urban type is its reading as part of the skyline. While skylines might be important indicators of the character and identity of a city, they do detract from the more important detailing of the engagement of dense buildings with the streetscape. Concurrently, much design effort is expended on detailing the silhouette and the "vanity top" of the tower. The images of Shanghai (see Figures 15 and 16) highlight other issues associated with increased urban density, such as pollution and air quality, which become necessary to discuss when looking at the relationship between tall

Figure 15. A view of the skyline of Shanghai from The Bund. © Tansri Muliani

Figure 16. The perceived density presented by the skyline denies the significant impact of the car-oriented spaces that separate the buildings in Shanghai's Pudong District.

Figure 17. Hong Kong is perceived as the exemplar of a life-filled city. However, the streets of Hong Kong are not necessary all bustling.

buildings, urban density, sustainability and livable cities. Natural ventilation strategies are not "automatic;" they require some desire to open the windows.

When examining urban issues, there is nothing inherently wrong or right about "iconic-looking towers." In dense urban situations, the pedestrian precinct is mostly influenced by the bottom levels of towers, so if the cladding or form of the overall tower is innovative or banal, it does not necessarily influence the vitality of the urban space – if the grade condition supports urban activity. It is not the tower itself, but rather its position and condition at street level, that either supports or degrades the pedestrian realm (see Figures 17, 18, and 19). There are many highly vibrant cities that feature towers in dense configurations. Although there are some instances of extensive podium structures that cause the towers to be set back from the street edges, towers in the most vibrant cities tend to directly engage the streetscape. This creates a direct connection between the occupants of the tower and life on the street. These important issues of street level concerns also tend not to be addressed in fantasy proposals for tall buildings.

## Going Forward

The tall building typology has evolved dramatically as a result of innovation in construction techniques, a drive to increase urban density and digital explorations. Ongoing developments in Asia clearly show us that tower design is no longer limited to a directed corporate exercise in efficiency that advocates repeated floor plans and limited variations in cladding design. This new urban fabric needs to be re-engaged more broadly by the architectural profession, as we gain the means to close the gap between open-ended digital speculation and the realities and potential of actual construction. There are many topics and areas of discovery that deserve investigation, and that can be used to propel tall buildings into the future in very compelling ways. Current tall building technologies are poised to support explorations in typological studies, the technical aspects of construction, façade design, sustainable design as well as urban design. This power needs to be used to build sensitive tall buildings that build on the valuable lessons learned. Perhaps the gap between reality and fantasy need not be that large. ■

*Unless otherwise noted, all photography credits in this paper are to Terri Meyer Boake*

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Figure 18 The Causeway Bay area of Hong Kong has very few "iconic" tall buildings, but is kept alive with intense retail.

Figure 19. The new International Commerce Center in Hong Kong is not located in a retail district. Even the glazed nature of its base condition cannot create street life.