Rethinking the Skyscraper in the Ecological Age: Design Principles for a New High-Rise Vernacular

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Abstract

This paper investigates tall buildings from an aesthetic and social, as well as commercial and environmental, viewpoint; as contributing elements in the fabric of a city. Though we have seen major advances in the technologies, efficiencies and performance of tall buildings over the past couple of decades, arguably the urban expression of the typical skyscraper has not changed much from the predominant glass-and-steel aesthetic championed by Modernism in the 1950s. Against a backdrop of the large-scale homogenization of cities architecturally around the world, the paper suggests ten design principles which, if adopted in skyscraper design, could result in tall buildings which are more appropriate to the place in which they are located – physically, environmentally, culturally, socially and economically. In doing this, it promotes the need for a new vernacular for the skyscraper in each region of the world, and suggests this would have significant ecological, as well as social, benefits.

Keywords: Ecological, Social, Aesthetic, Design Principles, Vernacular

Are we there yet?

Though we have seen major advances in the technologies, efficiencies and performance of tall buildings over the past couple of decades (Parker & Wood, 2013), arguably the urban expression of the typical skyscraper has not changed much from the predominant glass-and-steel aesthetic championed by Modernism in the 1950s. The architectural details have become much more refined since then, and certainly both materials and systems perform much better than a half century ago, but the rectilinear, air-conditioned, glass-skinned box is still the main template for the majority of tall buildings being developed around the world. Many of these boxes vary with how they meet both ground and sky, but they are part of a globalized expression.

There is, of course, a smaller group of ever-more adventurous sculptural forms[1] that have come to the forefront alongside the more commercially-inclined boxes over the past decade or two (defined by the focus of the CTBUH 2006 Conference as "Tapered, Tilted, Twisted", with a tongue-in-cheek "Tortured" added posthumously – see Wood, 2007). But, in both the "box" and the "sculptural" approach, the relationship between the building and its location is predominantly either a commercial one or a visual one. Thus these buildings are largely divorced from the specifics of the place they inhabit – physically, culturally, environmentally and, often, socially too. For hundreds, and in some cases thousands, of years the vernacular architecture in many of today's tall building cities had to be intrinsically tied into its location – for its materials, its ventilation, its ability to function within a given climate and culture – but this was largely rejected in the Modernist belief in a "universal architecture", which transcended mere "context" and worked on a higher philosophical plane.

The consequence of this was, and still is, the aesthetic homogenization (and, arguably, cultural homogenization) of cities around the world – a force that has gathered pace exponentially over the past two decades, with the easier flow of capital, labor, goods – and architectural models – that now ensues. Now a "progressive" city is largely defined by its set of skyscraper icons (see Figure 1), but the association is largely "synonymous" rather than "indigenous" – the same set of icons would largely become just as synonymous with other cities around the world if they were placed there. The models are thus readily transportable.

Of course it is difficult to talk about "indigenousness" in a building type which has only 130 years of history, and which has now spread from its North American roots to encompass almost the entire world. Both the words indigenous and vernacular imply a long-standing connection with a culture, so how can a relative typological newcomer be even considered in such terms? The answer, of course, is that we need to consider the future, and how the tall buildings being built today will reflect their culture and setting in 100 or 200 years from now (after all, many of them will still be around for that time by default; the industry has yet to constructively dismantle/demolish a building over 200 meters in height, let alone the 1,000-meter heights we are starting to see today). Thus the buildings we are realizing today will become the vernacular of a place tomorrow – a huge responsibility.

There is an argument, of course, that these commercial or sculptural forms are indeed a pure reflection of the finance-oriented and image-obsessed global culture of today, but I believe passionately that we need to find an alternative to this homogenization of cities and culture; the homogenization of expression; the homogenization of the urban experience. It is the differences between places that make them interesting, not the things that are identical, and there is most definitely a path to be charted between commercial return, iconicity and an indigenous approach to the skyscraper that varies physically, aesthetically and programmatically throughout the world. It is only when a building maximizes the potential of its connection with local climate and culture that it can be truly classed as "sustainable" in all facets of that word, including the ecological aspects. Tall buildings are a vital part of the future for creating more sustainable patterns of life – largely through their concentration of people, space, land use, infrastructure and resources – but in many ways they are only several small steps along the huge path they need to traverse to become truly sustainable, and to become positive contributors to the cities they inhabit. There are still far too many question marks hanging over the typology – on ecological, social and cultural grounds (Wood, 2008).

This paper thus outlines 10 design principles which the author believes would result in tall buildings much more related to their locations; a local-specific approach to skyscrapers, as opposed to the adoption of a global template. It uses built examples to illustrate the points made and, in some cases, some of the work developed by the author as an architectural professor at various institutes, working together with students. The 10 design principles are not intended to be approached in isolation. Perhaps the very best buildings would embrace all 10 principles, though some might not be possible in certain locales. Ultimately the intention is to inspire a regionalist[2] approach to tall building design, where skyscrapers in Shanghai function every bit as well as those in Seattle or Sydney in commercial and energy terms, but that feel part of a local vernacular, a local response.

Figure 1. Cities of the world are becoming culturally and aesthetically homogenized, with skylines that become synonymous with the place, but are not necessarily related to the culture or climate. Skylines from top: Warsaw, Miami, Melbourne. (images copyright Filip Bramorski, UpstateNYer, Cazz)

It should be stated at the outset that the path to this is not, in the author's view, through using historical vernacular forms in a literal sense (e.g., pagoda as tall building – see Wood, 2005). But neither is it in an abstract way either (e.g., local philosophy inspires form or geometry of plan) – though both of these approaches are a positive step away from a standard globalized architecture. The way forward is in the direct and very practical response to a set of local conditions, which is the very basis on which vernacular architecture has evolved for thousands of years.

Design Principle 1

Tall Buildings should relate to the physical characteristics of place

Virtually all cities have an existing physical legacy, an "evident built infrastructure" – streets, spaces, urban axes, buildings, monuments, other objects. The tall building

1: The question of what has inspired this recent diversification of approaches to building form, and whether they can be justified in energy/carbon terms, is a valid one that needs to become a more essential part of the industry's dialogue. The sustainability discussion in recent years has been focused almost exclusively on operating energy which, while vitally important, has resulted in the neglect of a sufficient discussion of embodied energy in building construction. Even the very definition of "net-zero energy" seems to omit the materials and construction process entirely. Numerous exemplar tall buildings have recently made great strides in the reduction of operating energy. However, the energy expended to create building forms in the first place is by no means constant across buildings, with iconic-sculptural forms clearly requiring more material gymnastics (and hence more carbon) to deliver the same quantity of floor area as a more regular form. But there is another side also to this equation: that of a building's greater contribution to society beyond delivering maximum floor area with the minimum energy/carbon expenditure. What do iconic-sculptural forms bring to our cities in terms of beauty or impact on urbanity and the human senses? Do we want to live in a world full of ultra-energy-and cost-efficient but rather dull boxes? What about the impact on social sustainability and urban diversity and a whole range of other, less-quantifiable aspects of "sustainability"? Like with all things, there will be an optimal balance point in this equation, but the debate thus far, for obvious reasons, has been focused on quantifiable metrics rather than subjective questions.

2: The term Regionalism, in the context of this paper, is best described by Robert Powell: *"Regionalism is not simply the nostalgic privileging of the vernacular form, but a synthesis of the vernacular with modernism. It is a way of thinking about architecture which is culturally regenerative – not a style, but a search for a cultural continuity… It implies the embracing of modernism whilst simultaneously maintaining links with traditional forms and practices"* (Powell, 1993)

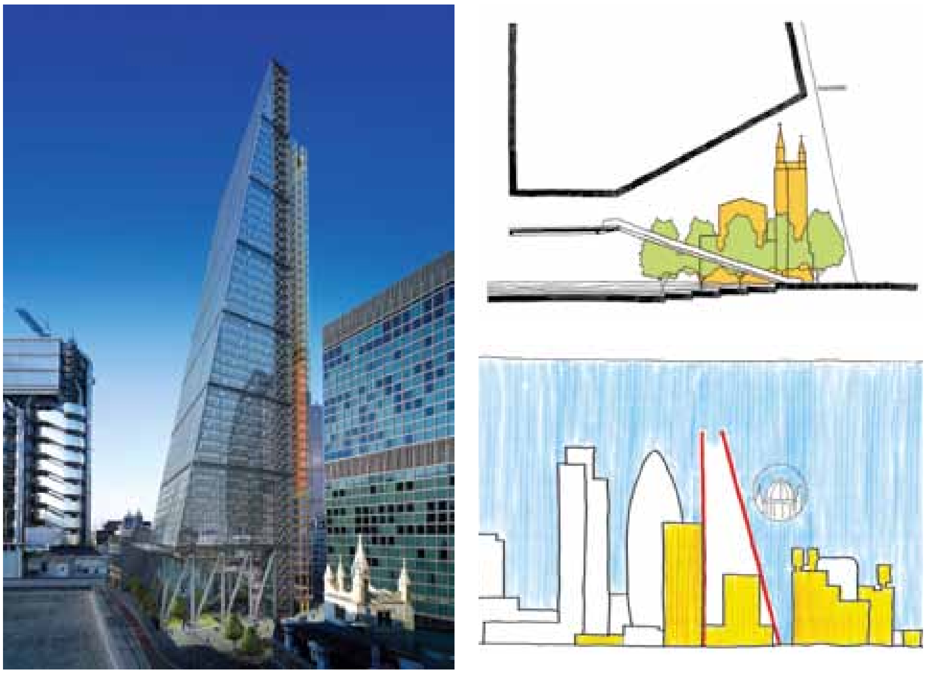

Figure 2. Tall Buildings should respect the existing built legacy, and relate to it where possible. The sloping form of the 122 Leadenhall Building London (2014) came about as a response to not blocking views to/from both St Paul's Cathedral and the St Andrew Undershaft church to the east of the site. Copyright: Rogers Stirk Harbour + Partners

– though potentially dwarfing many of these existing elements in scale – should respect and physically embrace this existing "urban grain" by extending circulation routes into and through the site, allowing important nearby monuments to impact the form or expression of the building , massing the form to respect important viewing corridors, etc. An example of this is the sloping form of the 122 Leadenhall Building London (see Figure 2), which came about so as to not block the views to both St. Paul's Cathedral and the existing Grade 1-listed St. Andrew Undershaft church to the east of the site. In some cases, built legacy in the low-rise realm might influence the form of the high-rise, for example with the skyscraper forming a backdrop or frame to an important monument.

Design Principle 2

Tall Buildings should relate to the environmental characteristics of place

This is considered perhaps the most important aspect of creating "sustainable" tall buildings, and the aspect which the Modernist "universal" architecture most displaced.[3] For any building to truly be environmental, it needs to not only respect all aspects of local climate, but should maximize the potential for using each aspect of climate within the building. Thus not only should sun, light, wind, air, and rain be considered so as to have as minimal negative effect on the building as possible; most if not all of these elements can be embraced into the building to positive effect (see Figure 3).

Wind and air buoyancy should be used for natural ventilation so that ALL tall buildings, irrespective of building function, should be naturally ventilated for at least part of the year (and ideally all of the year[4]).

Sun has long been embraced in the use of solar panels, but there are perhaps greater returns from incorporating technologies such as solar-thermal systems into the skin of a skyscraper (especially in intense solar environments like the deserts of the Middle East), or using solar energy capture for phase-change materials, etc.

Wind harvesting is an interesting phenomenon in tall buildings. Much of the tall building world thought this was the technology with the greatest potential for generating energy in skyscrapers a decade or so ago,[5] and yet to date we see only three tall buildings with significant wind turbines realized (2008 Bahrain World Trade Center, 2010 Strata Building, London, and 2012 Pearl River Tower, Guangzhou), and at least two of these with considerable problems reported. Thus, though the jury is still out on whether wind energy capture and tall buildings are a good mix, there must be ways of overcoming the problems and improving the economies of scale. Large-scale "wind farms" on the tops of some tall buildings are surely worthy of further investigation.

In the case of rain, many sustainability rating systems such as LEED now award points for rainwater capture and recycling but, in the case of most tall buildings, the area of capture is usually only a part of the tower roof or podium roof. In the context of skyscraper

Figure 3: Climatic elements are not only something to be mitigated in tall building design, but can become embraced for positive effect in both the form and operation of tall buildings; natural energy capture, natural ventilation, rainwater capture etc. The strategies and systems to enable this can influence the design and expression of the building. Pearl River Tower, Guangzhou (2013) demonstrates several of these ideas. Copyright: SOM

3: See Oldfield, Trabucco & Wood, 2009, for an interesting discussion on how policies and architectural trends have directly influenced the energy characteristics of tall buildings over the past 130 years.

4: It is only in the move away from "hybrid" ventilation systems (i.e. natural ventilation when conditions allow and mechanical ventilation when they don't) towards full natural ventilation that the mechanical systems – with their space, embodied energy and operating energy implications – can be removed entirely. Of course this means that occupants will need to tolerate greater variations in internal environment fluctuation than the narrow band of temperature and humidity conditions to which they have become accustomed through air conditioning, but this will need to happen with increasing climate change anyway (i.e. when energy consumption becomes a matter of survival rather than choice). Mankind will likely need to accept periods of "less than perfect" internal environmental conditions in both residential and office buildings, and adjust clothing – and possibly even working patterns – to suit. For more on natural ventilation in tall buildings, including a dozen or more modern skyscraper case studies that employ such techniques, see Wood & Salib, 2012.

5: This was largely because the science of wind energy capture was sound: power out of a wind turbine is the cube of the wind speed in. Thus doubling the speed increases power by a factor of 8, and wind speed increases with elevation above the plane of the earth generally, especially in cities when clearing the potential wind blocking by surrounding low rise buildings. However the other issues caused by wind turbines on tall buildings, amongst them vibration, noise, maintenance etc., has thrown a question mark over their use. Ultimately the energy out from such small-scale turbines takes years to justify the embodied energy in making the turbines in the first place, and many believe that the large turbines and reliable wind conditions of off-shore wind farms are a more productive way forward. The counter to this, of course, is that much of the energy is then lost in conveyance between point of origin and point of need (i.e. the city) and that it is not a case of either/or, but both – we need energy generation both "localized" in the city and through larger-scale installations outside the urban realm.

forms, however, the roof is a negligible area in comparison to the façade, especially when one considers that rain at height does not fall vertically but is typically driven in a horizontal plane by wind. Thus perhaps the true potential of rainwater capture is in the façade and not the roof, and this could become a strong influence on the form and aesthetics of some tall buildings.

Design Principle 3
Tall Buildings should relate to the cultural characteristics of place

Whereas the physical and environmental aspects of place are more easy to define, the cultural aspects of place are less tangible. Culture is more connected with the patterns of life in a city, and how this manifests itself in the customs, activities and expressions of the people. Culture can thus be embraced in a literal way in the building, as demonstrated by the 1984 Dayabumi Complex in Kuala Lumpur (see Figure 4), with its Islamic outer façade skin an interpretation of the vernacular Jali screen (though this also has the significant added benefit of shielding the curtain wall behind from direct solar gain). Or it can happen by embracing an aspect of the culture directly into the building program. In 2010, for example, a student scheme we developed in Mumbai (Wood, 2010) was placed on the site of an existing dhobi ghat; the huge outdoor washing areas in Mumbai that account for

Figure 4: Tall Buildings can reflect the local culture in a literal way – as demonstrated here with the 1984 Dayabumi Complex in Kuala Lumpur with its façade a modern interpretation of the Islamic *jali* screen – or in a more direct way, by incorporating specific activities and ways of life into the program of the building. Copyright: Antony Wood

80% of the city's laundry. Rather than sweep this cottage industry aside in the knowledge that everyone would have a washing machine in the brave new world of Mumbai's future, the social housing tower that occupied the site brought this horizontal activity into the vertical world. Each permeable residential apartment was orientated around a terrace containing large washing vats, so that the residents could continue to take in the city's laundry. Further, the façade became the interface for drying the clothes – thus creating solar shade at far less embodied energy expense that the fixed shading systems of many modern towers. And the resulting aesthetic was very much an expression of local culture with, quite literally, a façade of cloth (anyone familiar with Asian residential towers knows that many of them often look that way already!).

Design Principle 4
Variation with Height in Form, Texture and Program

Tall buildings should not be monolithic vertical extrusions of an efficient floor plan, but should vary in form, program and expression with height. This variance in form should be inspired by the city, both physically and environmentally. The main difference between a tall building and a small building is that the latter will only have a direct visual relationship with its immediate site content, whereas a tall building potentially has a visual relationship with many places far and wide in the city, at differing horizons within its form. This visual dialogue with these distinct places (and other buildings) can help inform a variance in form to further connect the building to its locale. Further, the industry is now realizing that climate varies significantly with height, and thus some of the great heights being achieved with tall buildings today effectively means that we are designing single tall buildings that cut across multiple climate zones (see Figure 5). The external air temperature at the Burj Khalifa in Dubai, for example, is reported to be approximately 6–8 degrees Centigrade cooler at the top of the building than at the bottom, so this could be reflected in the form, façade, systems and even program of the building.

A tall building should thus be considered as a number of stacked communities according to the opportunities of each specific "horizon," both climatically and physically in its relation to the city, rather than extruded as a single monolithic form from the ground floor. This could manifest itself in the manipulation of building mass as well as program, and there should also be variance in skin and texture

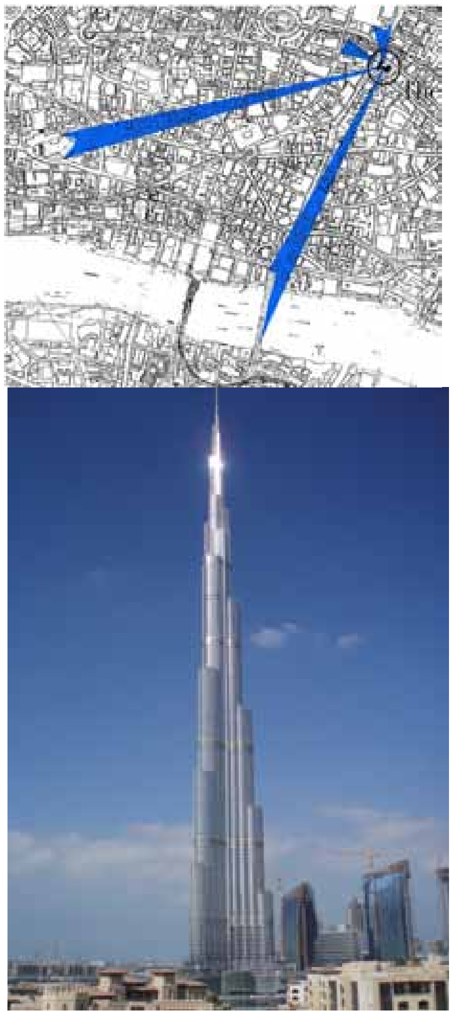

Figure 5: Both climate and the visual relationships in a city vary massively with height (top). The great heights being achieved with some tall buildings today effectively mean a single building is being designed across numerous climate zones. For example the Burj Khalifa (bottom) is approximately 6–8 degrees Centigrade cooler at the top of the building than the bottom. This should be used to influence the form, skin and program of the building. Tall Buildings should be designed in height "horizons," taking advantage of the unique opportunities of each horizon. Photo Copyright: Peter Weismantle

throughout the building, depending on the responsibilities of each different horizon within the form. The MEP and other systems would also vary (at the very least air intake should occur at the top of the tower, to take advantage of several degrees of free cooling). The concept of scale should thus be introduced throughout the building – a tall building could be thought of (and designed accordingly) as a number of small buildings placed on top of each other within an over-arching framework of structure, systems, aesthetics, etc., rather than one extruded, monolithic form inspired by a single plan.

Design Principle 5
Maximize Layers of Program and Usage on all Systems and Materials

Traditional programs for tall buildings need to be challenged to increase the usefulness

Figure 6: Every expenditure of carbon through the embodied energy in materials and systems needs to be justified by overlaying more usage on those systems. In the 2011 NBK Osaki Building in Tokyo, the "Bioskin" solar shading shields internal spaces from solar gain and, through the system containing recycled rainwater, simultaneously reduces the external urban heat island effect through evaporation. Copyright: Nikken Sekkei

of the typology in sustainable cities of the future. This challenging of program should occur on two levels: (i) the type of functions that are traditionally accommodated within tall buildings, and (ii) the number of functions that are accommodated in a single tall building. Tall buildings have the versatility to accommodate uses other than the standard office, residential and hotel functions that currently predominate, and cross-programming/mixed-use gives opportunities for more duality, for aspects such as waste heat generated through one function being used in another, for car parking / car sharing, for sharing supporting functions and servicing, etc. In addition, the layers of usage that can be overlaid on all materials and systems should be creatively considered in all aspects of life, as a response to sustainability, including tall buildings. Every expenditure of carbon through embodied energy should be accompanied with the question: "How many layers of usage can we get from this element?"

The BioSkin system on the 2011 NBF Osaki Building in Tokyo (see Figure 6) operates a sun-shading system that not only shields the interior spaces from solar gain, but contains recycled rainwater that evaporates through the ceramic skin when heated by the sun, simultaneously lowering the urban heat island effect.[6] Similarly, double-skin façades have been used in some buildings as return air ducts for ventilation for a number of years now, as have stair voids for internal ventilating atria stacks. But can we get more radical than this? Can we see vegetation taking the place of solar shades within double-skin façades, forming "façade farms" that simultaneously soak up solar gain, create agricultural produce, and improve the psychological environment for building occupants? Could we see the use of façade shading systems as rock climbing walls, or liquid dampers/water storage tanks as swimming pools?

Design Principle 6

Tall Buildings Should Provide Significant, Communal, Open Recreational Space

More open, communal, recreational spaces (internal or external, hard or landscaped, large and/or small) need to be introduced into tall buildings. This means breaking away from the contemporary insistence on maximum financial return on every square meter of floor space. Such spaces have been proven to improve the quality of the internal environment, which has a direct impact on saleable/rental return, satisfaction of occupants, productivity of workers, and so on. In addition, the inclusion of these spaces will make tall buildings more suitable for socio-economic groups often marginalized from tall buildings through the lack of such vital spaces where a sense of community can develop—families, the young, the old, etc. Social sustainability on an urban scale is a major challenge for our future cities. The 1997 Commerzbank, Frankfurt, despite being almost two decades old, is still perhaps the most significant tall building for skygardens in existence[7] (see Figure 7); every occupant has direct physical access to one of the 10 four-story skygardens spiraling up the building (which are also part of its natural ventilation strategy). This commercial building could also serve as an excellent model for an idealized residential building, with narrow, cross-ventilated floors of residential apartments grouped around a "garden in the sky" where a sense of community can develop. This is difficult to achieve when the elevator and corridor are the only infrastructure for chance meetings.

Design Principle 7

Introduce More Façade Envelope Opacity

Tall buildings should be designed with more envelope opacity, not as all-glass transparent boxes requiring significant external shading devices to control the excessive light, heat and glare created by making it all-glass in the first place. Although the impacts on both internal daylighting and views out need to be balanced, all-glass towers do not make sense, especially in intensely hot solar environments. In addition, greater façade opacity gives an opportunity for greater thermal mass to allow the envelope to be more insulated from external temperature and climate variations. Greater façade opacity also gives the opportunity for wider façade variance and expression, as evidenced by projects such as O14 in Dubai (see Figure 8).

6: The NBK Osaka "BioSkin" system was winner of the CTBUH 2014 Innovation in Tall Buildings Awards. See CTBUH, 2014

7: The Shanghai Tower, currently nearing completion in Shanghai, will likely challenge this, with its continual perimeter zone of skygardens stretching 600+ meters into the sky.

Design Principle 8

Embrace Organic Vegetation as an Essential Part of the Material Palette

In those climates that allow, vegetation should become an essential part of the material palette for tall buildings, both internally and externally. The benefits of vegetation on both the building and urban scale are now well proven (see Wood, Bahrami and Safarik, 2014) and include: increased shading and thermal insulation of the building envelope, improved air quality (both internally and externally), reduction of urban heat island effect, carbon sequestering, oxygen generation, sound absorption, possible agricultural produce, providing natural habitat for insects and small animals, as well as the psychological benefits for both building and urban dwellers. Great things are now being achieved with greenery in tall buildings, particularly in Singapore but also in other cities globally, as evidenced by the 2014 One Central Park building in Sydney (see Figure 9). In the context of this paper, the adoption of local vegetation (which is already hardy to the environment) would also contribute to the localized aesthetic of the building too, since even if every tall building the world over were cloaked in greenery, they would all reflect their local indigenous plant species, in the same way that the fields and forests of every region around the world are different. The embrace of vegetation into our buildings would also create an aesthetic more in keeping with the main challenges of the age (climate change and environmental challenges) than the 70-year old glass curtain wall aesthetic that still predominates.

Design Principle 9

Introduce Physical, Circulatory and Programmatic Connections Between Tall Buildings: Skybridges

It seems completely nonsensical that cities are making a push for ever-denser, ever-taller urban form, but allowing only the ground plane to be the sole physical means of connection between towers. Skybridges and Skyplanes (wider skybridge connections that contain functional space beyond just circulation) have the potential to enrich both tall buildings and cities, allow the sharing of resources between towers (spatial as well as service infrastructure), improve evacuation options, and reduce energy consumption through allowing horizontal as well as vertical movement between towers. There has hardly been a science-fiction city of the future created in the past 100 years that hasn't embraced the idea of the multi-level city, because it seems implausible to people creating those future cities that we would reach to hundreds of stories and yet require every inhabitant to descend to the ground plane to move sideways, breathe fresh air, or get lunch. In Hong Kong and many other cities in China, we often see numerous identical residential towers side by side in long rows – five, six, seven towers – often separated by just a few meters, but with vacant fire refuge floors all lined up at the same level. What leap of imagination would it take to physically connect these vacant refuge floors with skybridges, simultaneously giving more fire evacuation routes but, perhaps more importantly, creating the potential for communal zones in the sky[8]? Fortunately, many building designers and owners are now recognizing this,[9] with projects such as

Figure 7: The 1997 Commerzbank in Frankfurt is still one of the best examples of significant, communal skygardens in a tall building anywhere in the world. This office building is also potentially an excellent model for an idealized residential building, with thin, cross-ventilated floors of apartments all grouped around one of ten "gardens in the sky," where a sense of residential community can develop. Copyright: Nigel Young – Foster + Partners

Figure 8: It is nonsensical that we are building towers with all-glass façades, especially in intense solar environments such as the Middle Eastern deserts, then expending more energy installing solar shading to cover up the glass. Tall buildings should concentrate glazing where it is best placed, and introduce more opacity back into the façade, which would also give a greater opportunity for more varied expression, as seen in the 2009 O14 Building in Dubai. Copyright: Reiser and Umemoto

8: The proposition of the skybridge is outlined in more detail in Wood, 2003. The potential of skybridges for evacuation, as well as the great potential of Hong Kong for connections at height, is explored in Wood, 2011.

9: It is interesting that, in the competition to replace the World Trade Center New York towers in the mid 2000s, of the final seven competition proposals, five of these proposals included links between towers in some form. See Wood & Oldfield, 2007.

Figure 9: The benefits of introducing more greenery into our cities are well documented, plus green walls made up of local plant species would help create both a localized vernacular for tall buildings, and an aesthetic more akin to the environmental challenges of the age. The 2014 One Central Park in Sydney shows what is now becoming possible with greenery in the skin of high-rise buildings. Copyright: John Gollings

Figure 10: It is nonsensical that we are going ever more vertical in our cities, without introducing the horizontal. Skybridges and Skyplanes give the opportunity for not only linking functions, circulation, services and fire evacuation routes across tall buildings, they can create significant urban habitat in the sky, as evidenced by Singapore's 2009 Pinnacle @ Duxton housing project. Copyright: ARC Studios

Singapore's 2009 Pinnacle @ Duxton housing scheme connecting seven residential towers with not only skybridges, but skyparks at two horizons in height, containing gardens, jogging tracks and significant urban habitat at height (see Figure 10).

Design Principle 10

We Need to Bring ALL Aspects of the City Up into the Sky

If cities embrace the principle that the dense vertical city is more sustainable than the dispersed horizontal city, then we need to recognize that the ground level is an essential support layer to the people who live in cities now. It is the ground level where the essential elements of life in the city are largely contained; circulation, recreation, education, shopping, health and, most crucially, where a sense of community forms. Thus if we are looking to concentrate perhaps 10 or 100 times more people on the same quantity of land through building tall – a proposition not out of scale with urbanization patterns that are happening in countries such as China,[10] India, Indonesia and others – then we need to replicate these facilities that exist at the ground plane up in the sky, including the parks and the sidewalks, the schools and doctor's surgeries, the shops and sports facilities, and many other public and civic functions. The ground plane thus needs to be considered as an essential, duplicable layer of the city that needs to be replicated—at least in part—at strategic horizons within and between buildings in the sky; not in place of the ground plane but in support of it. This does not mean the re-creation of the ground plane in a literal way, blocking out light and view to/from the spaces below and encouraging a physical stratification of society akin to the "Blade Runner" dystopian visions. Nor does it mean replicating the failed Le-Corbusian second-floor concrete "streets in the air" which, at the very least, sucked life away from the street because there was insufficient population density to support them where they were implemented.[11] The skybridges and skyplanes would largely create public realm at strategic horizons by connecting and unlocking the spaces that exist inside the towers at those heights, thus re-creating the horizontal, public dynamic that exists at the ground level. Far-fetched?

10: The urbanization of China, and how this is impacting tall buildings, is explored extensively in the Introduction to the CTBUH 2012 Shanghai Conference proceedings: *Asia Ascending: Age of the Sustainable Skyscraper City,* see Wood, Johnson and Li, 2012.

11: Consider Hong Kong as the antithesis of this. In the Central district of Hong Kong (as well as numerous other areas in the city) three entire levels of walkway are required to handle the sheer number of circulating people; street level, below-street level through the connection of MTR subway stations and entrances, and above street level through the world's largest network of skybridges, snaking between and through largely private buildings. One can walk for, quite literally, miles without touching the ground in Hong Kong. See the Robinson & Wood, 2014 paper in this proceedings.

Perhaps, but one only needs look to cities such as Singapore and Hong Kong to see it already happening, albeit on a smaller scale than suggested here.

So What's Needed to Deliver All This?

The principles outlined above are obviously tinged with a utopian ideal, and contain considerable challenges to make happen – technically, operationally and financially. For sure, they cannot happen by the developer or architect working in isolation. To make this happen, we need a completely different way of thinking about our cities – a new regulatory, political, financial and social framework for urban development. Currently, in most cities of the world, the responsibility for urban infrastructure – sidewalks, roads, parks, power, lighting, waste, sewage etc – lies with the local government, but their involvement in the actual building stops at the front door to those buildings. The building itself becomes the responsibility of the developer alone, especially financially, with the local government playing only an oversight role. Yet much of what is suggested through the design principles above involves the creation of urban, public infrastructure inside the buildings, and thus we need to rethink how our buildings are financed and realized. Each building needs to become a public-private partnership, with the spatial and public infrastructure in the building being financed by the local government, the same as it would be in the low-rise horizontal realm. And to deliver this, an overall three-dimensional, long-term, stratified-in-height plan needs to be created, to replace the limited two-dimensional zoning-plan-plus-maximum-building-heights-specified visions that predominate now. Each tall building would thus become considered as a vital element in an overall, three-dimensional urban framework, rather than as a stand-alone icon superimposed on a two-dimensional urban plan. This would also help to break down the individual ego informing many tall buildings, once they need to fit into an overall framework and be, quite literally, connected to neighboring buildings.

Which brings us back to the main topic of this paper, and one of the main challenges for the typology into the future: to create tall buildings that are relevant to the specifics of place—physically, environmentally and culturally. To do this, we need tall buildings that maximize their connection to the city, climate and people. The future of our cities, and perhaps our continued survival on this planet, relies on it.

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