

Title: **"Pavements in the Sky": Use of the Skybridge in Tall Buildings**

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Improved safety in tall buildings has become a major issue. The high level 'skybridge' – an old idea – is one solution which could be applied to both new and existing buildings and enrich our cities.

## Pavements in the sky: the skybridge in tall buildings

Antony Wood

Since the World Trade Center Towers collapsed in full view of the watching world (FEMA, 2002), the improved safety of tall buildings has become of prime importance globally (Pearson, 2001). International groups such as the UK-based 'Safety in Tall Buildings Working Group' (Roberts, 2002), and Arups High Rise (Wainwright, 2002) which are considering these safety implications have made recommendations for improvement in three general areas:

- structural systems, especially with respect to progressive collapse
- fire proofing, to structure and fabric

- evacuation systems, concentrating specifically on vertical evacuation systems such as elevators and stairs.

While this work is vital towards making tall buildings safer, it is perhaps not enough. The risk to our cities is increasing – through terrorism, war or accident as urban densities increase – and we need to tackle the problem at a more fundamental *design* level, not as an *alternative*, but in *addition* to the improved safety mechanisms suggested above.

One possible way of improving the safety of tall buildings is by introducing horizontal evacuation at height through use of a *skybridge* linking towers. The concept of being able to evacuate occupants at a level other than ground, should the building be at risk, seems sensible, especially if any emergency in a tall building effectively cuts off vertical evacuation routes and thus the connection to the ground plane.

Creating this 'pavement in the sky' between towers, however, is not without considerable challenge; structurally, operationally and psychologically, as well as in design and occupant terms. This article considers the implications of incorporating skybridges in tower design on an urban scale but, first, it is necessary to sketch the use of the skybridge historically; in both the built and unbuilt realm.

### The skybridge in theory

*The houses of concrete, glass and iron ... must rise on the edge of a tumultuous abyss: the street, which will no longer stretch like a foot-mat level with the porter's lodge ... will be linked by metal walkways and immensely fast escalators ... Let us throw away sidewalks, arcades, steps ... let us raise the level of the city'*

Sant Elia, *Futurist Manifesto*, 1914 (Caramel and Longatti 1988)

<sup>1</sup> Early images of the urban future envisaged vehicles crossing on bridges high above the banality of everyday life at street level. From Harry Petit's *The Cosmopolis of the Future*, 1906



### The birth of the skybridge: New York

The idea of the skybridge is not new. Within 30 years of the appearance of the first skyscraper as a building form in Chicago in the latter part of the nineteenth century,<sup>1</sup> cities of the future were envisaged as forests of skyscrapers within vast networks of roadways. Many of these early images of the urban future envisaged high-level circulation (for both people and vehicles) between towers; elevated from the ground plane, distanced from the banality of everyday life at street level [1].

Amid skyscrapers, motorcars and bi-planes, the skybridge became a key feature of these futuristic visions, pioneered by the likes of Harvey Wiley Corbett, Hugh Ferriss, Harry Petit et al (Willis, 1986). Moses King's *King's Views of New York*, published in 1906 (Leeuwen, 1988), and Hugh Ferriss's *Metropolis of Tomorrow*, published in 1929 (Ferriss, 1929), became the primary sources of a glimpse at the urban tomorrow. In these pioneering visions of the future city conjured in the heady days of Art Deco New York, the notion of the skybridge was born.

### The translation into film

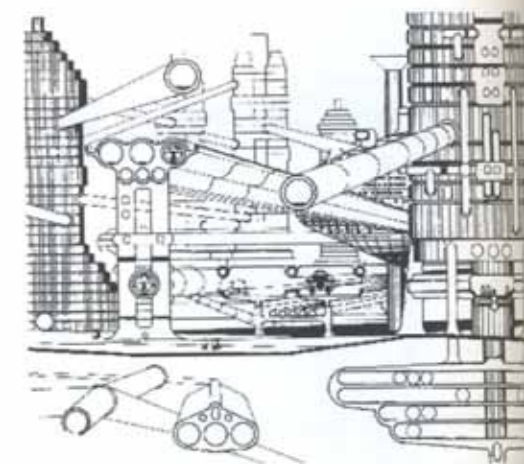
Much of this early imagery of the skybridge found its expression in film. Acknowledging a debt to the images and skyscrapers of New York, the German director Fritz Lang, in 1927, together with the set designers Otto Hunte, Erich Kettlehut and Karl Vollbrecht, created the film *Metropolis*, which envisaged huge bridges spanning between towers at height [2]. Inspiring almost every 'city of tomorrow' futuristic film since – from H. G. Wells' *Things to Come* (1936) through Ridley Scott's *Bladerunner* (1982) to more recent films such as George Lucas' *Star Wars: Attack of the Clones* (2001) – the skybridges of Ferriss's and Lang's *Metropolises* have become a constant element in science fiction cinematography (Neumann, 1999).

### The Modern Movement: Europe

America was not the only country to develop the idea of the skybridge. The Italian Futurist movement, and Sant'Elia through his 1914 designs for *Citta Nuova* specifically (Caramel, 1988), created images of towers linked by bridges, modelled on an industrial aesthetic. This work of the Futurists, in parallel with the New York pioneers, inspired a generation of European architects and urban designers of the Modern Movement, from Auguste Perret in France [3] to Iakov Chernikhov and El Lissitzky in Russia, who created proposals for towers linked at height (Cohen, 1995).

### Archigram

Owing to the Depression in 1930s America, and two world wars in Europe, none of these early theoretical projects was ever realized. It was left to a group of young UK architects working on the theoretical fringes of architectural possibility to use the idea of the skybridge. During the 1960s, Archigram, comprising Peter Cook, Warren Chalk, Dennis Crompton, Ron Herron, David Greene and Mike Webb, came up with a number of fantastical proposals incorporating high-level bridges between



2 One of the most powerful images of the 'city of tomorrow', Fritz Lang's film *Metropolis* of 1927 depicted huge high-level bridges

3 Sant'Elia's *Citta Nuova* inspired a generation of Europeans. Cities, Auguste Perret, 1922

4 Post-war proposal for skybridges in a city. Interchange project, Ron Herron & Warren Chalk, 1961

5 The building in skybridge, City in the Air, Shinjuku, Arata Isozaki, 1960-61



buildings. These included Cook's Metal Cabin Housing scheme of 1962, Herron/Chalk's Interchange project of 1963 [4], Cook's Plug-in City of 1964 and Herron's Walking City of 1964 (Cook, 1999).

#### The Japanese Metabolists

It was the Japanese Metabolists, however, who worked most comprehensively with the idea of the skybridge during the 1960s. Freely acknowledging the influence of Archigram, architects such as Kenzo Tange, Kisho Kurokawa and Arata Isozaki proposed vast urban schemes in the sky (Ross, 1978). Isozaki's City in the Air scheme, with stretched floors of housing and office space as the bridges between vertical cores is typical of this [5].

#### The skybridge in practice

*'Rather than concentrating on the vertical aspect, which creates a spatial dead-end, the 3-D city depends on sky passages that connect buildings together at certain levels. In the early twentieth century, each building had its own underground level; now these are connected and became part of the city. The same thing could happen in the air.'*

Hiroshi Hara, 1999 (Toy 1995)

Though its origins were in the fantastical notions of theorists, architectural illustrators and science fiction cinematography, the concept of the skybridge has not remained a purely abstract proposition. Antonio Contino first explored the use of connecting two buildings with an enclosed bridge at the end of the sixteenth century with his Bridge of Sighs joining Venice's Palazzo Ducale to the adjacent prison, and there are now a dozen or more tower and skybridge arrangements in existence.

Oscar Niemeyer's 1958-60 National Congress Complex in Brasilia [6a] was the first modern building to have a bridge between two towers at height. Other Western examples include Roche & Dinkeloo's 1969-83 United Nations Plaza in New York [6b], Massimiliano Fuksas' 2001 Twin Towers in Vienna and Mihajlo Mitrovic's Genex Tower in Belgrade, Yugoslavia (Mitrovic, 2001).

Given the strength and range of proposals of the Japanese Metabolists, it is perhaps not surprising

that the most significant use of the skybridge today is in Asia. In 1968-71 Shin'ichi Okada drew directly on the ideas developed a decade earlier by Kenzo Tange and the Metabolists, with the three skybridges of his Kajima Corporation Headquarters building in Tokyo [6c]. It is in Hiroshi Hara's 1993 Umeda Sky Building in Osaka [6d], and Cesar Pelli's 1997 Petronas Towers in Kuala Lumpur, however [6e], that the dramatic potential of the skybridge as an element in high-rise design is best portrayed. The gateway formed between Pelli's towers and bridge stands as the built equivalent of Perret's tower visions [3], while the vision for a 'mid-air city' of interconnected skyscrapers of which Hara's Sky Building is a part is the closest we have yet come to the realization of the urban impressions of Ferriss, Cook and Isozaki.

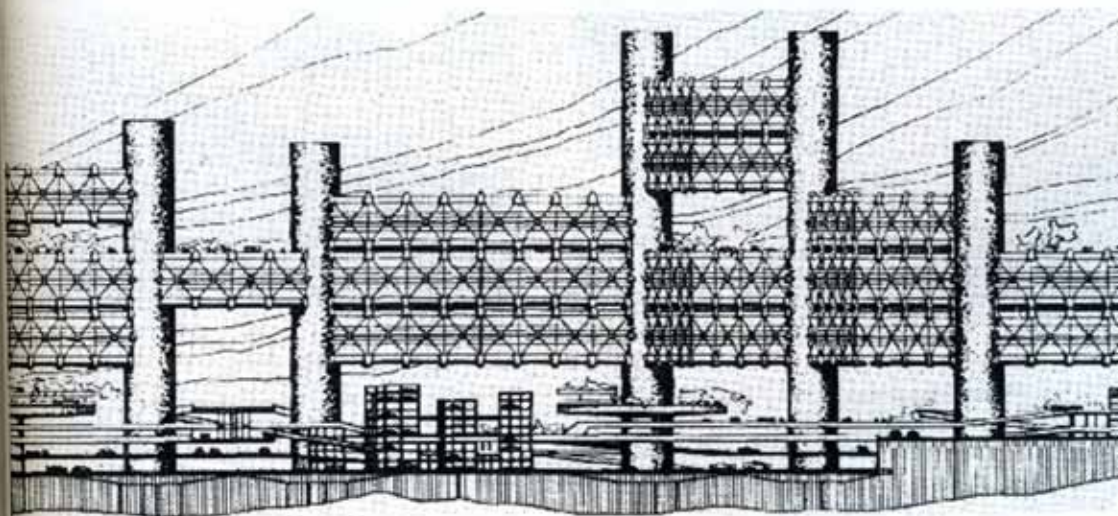
#### Implementation implications

*'... houses touching the skies, towers if you like, well-spaced blocks linked by footbridges, such that inhabitants of the sixtieth floor can visit their neighbours without going up or down too far...'*

Auguste Perret, 1921 (Cohen 1995)

#### The client's brief

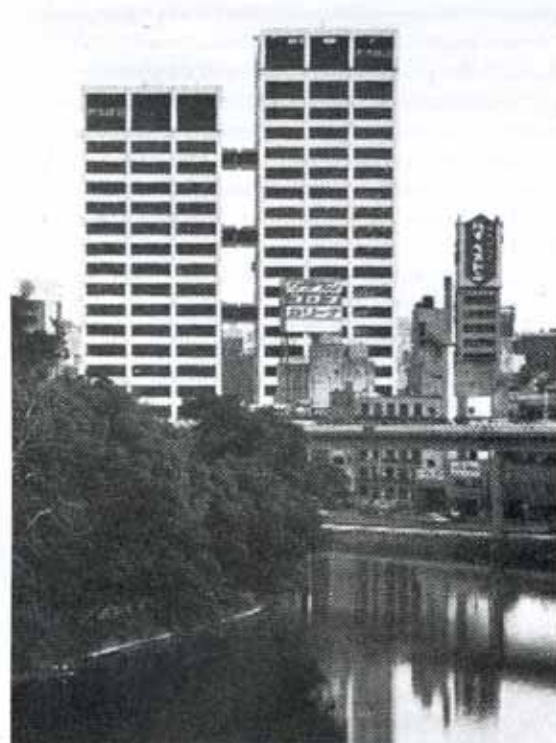
If skybridges are to become an accepted element in high-rise design, not only between two towers but perhaps as an extensive network within a city, the first, and perhaps the biggest, challenge is the effect that this would have on project briefs. The clients/building owners need to agree to the idea of physical connection to a neighbour at height, and accept the necessary implications. In the case of most, if not all, buildings currently employing skybridges around the world, the two buildings are in common ownership and, even if the building is occupied on a multi-let basis, the landlord is effectively the same. Crucially also, this would have been the case when the buildings were conceived, designed and constructed; the skybridge would have been an integral part of the vision for the building; psychologically, constructionally and operationally. In the vast majority of our tall buildings today, connection occurs only at ground floor: the



5



6a



6c



6 The skybridge in practice  
a National Congress Complex, Brasilia, Oscar Niemeyer, 1958–60  
b United Nations Plaza, New York, Roche & Dinkeloo, 1969–83

c Kajima Corp HQ, Tokyo, Shin'ichi Okada, 1968–71  
d Umeda Sky Building, Osaka, Hiroshi Hara, 1993  
e Petronas Towers, Kuala Lumpur, Cesar Pelli, 1997





'pavement' matrix within which the towers sit is usually owned by a separate, city authority body. Who would own the 'pavement in the sky', and thus be responsible for its construction, maintenance and security?

#### Internal planning: the skylobby

Incorporating skybridges would have a huge impact on the internal planning of the tower, primarily on the floor(s) where the skybridges connect, but possibly on surrounding floors too. These connection floors would essentially become skylobbies where many of the activities that occur at the ground floor will be required here too. In the main, this space would be for circulation purposes with stair and lift lobbies etc, but there will also be a need for reception and security facilities. The issue of security is of prime importance since, with the skybridge and horizontal circulation from neighbouring buildings, entry into the building would no longer be restricted to the ground floor.

There is, however, also the opportunity for other functions at this skylobby level since, in theory, a large number of people from both the object tower and other towers could be passing through the skylobby zone. Could some of the retail, arts and leisure facilities that normally occur at ground level within the city be lifted up into the sky to occupy a new 'public zone' at height? Could this horizontal influx of people at height become the catalyst for the provision of functions that would occupy prime zones beneath and above the skylobbies such as fitness centres, art galleries, retail malls?

#### Optimum vertical placing of the skybridge

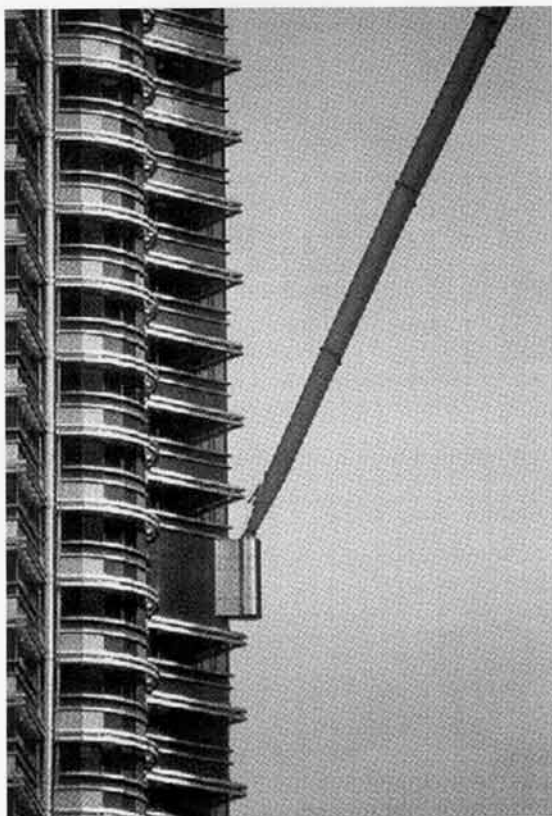
The placing of the skylobbies vertically (and consequently the skybridges) should occur at a level of lift zoning changeover (for example, between low and high zone lift banks) and, furthermore, be placed so as to ensure maximum efficiency of evacuation circulation in the event of an emergency. Having the horizontal linkage too close to the ground plane, or too close to the top of the tower, would impede this efficiency since the vast majority of the occupants would need to travel significant distances vertically before they could discharge horizontally to the next tower. Studies need to be done to understand the effects on circulation flow of differing configurations but common sense would tell one that the zone of primary efficiency would be somewhere around the middle of the tower. Or, more precisely, somewhere around the middle of the building mass/number of occupants. Since Petronas Towers steps in mass towards the top of the towers, the skybridge (in this case double-storey) placing at level 41 and 42 is roughly the centre of gravity of the total building occupants of the 88 floors [6c].

#### Strategic planning for incorporation

No two high-rise towers owned by differing parties are the same design. And, crucially, very few adjacent towers are built at the same time, with a clear dialogue between the differing operations. Strategic planning in the design and construction of a single tower needs to be adopted to create provision for linkage to later towers, if skybridges are to become a reality.

The first aspect of this strategic planning is an agreed height for the placing of the skybridges vertically which, being common to all towers, will have an effect on the efficiency of the internal vertical circulation and evacuation flow. For example, since not all towers are the same height, placing a skybridge at level 30 of a 60-storey building may be efficient for that building's circulation, but not for its neighbour if it is only 30 storeys tall. Of course there is no reason why the skybridge zone cannot step up or down in height from one tower to the next – and this may be the best solution – but this will have an impact on the vertical circulation systems in the tower, and the 'usable' floor area, since two skylobbies – taking up two floors – will be required.

The optimum common placing vertically of the skybridge, with respect to the vast majority of towers they serve, is thus vitally important. It may be that since buildings of 30 storeys or less are considered fairly efficient for vertical evacuation of the occupants anyway, skybridge linkage at that tower would be considered unnecessary (though its existence could be justified in making the building a 'stepping stone' to the next tower?). An accepted common height linkage at level 30 would work well since the vast majority of high-rise buildings in a city such as New York, Chicago or Hong Kong have a number of floors significantly above that. The world's tallest 100 buildings in terms of number of floors ranges from the 42-storey Palace of Culture



and Science in Warsaw to the 110-storey Sears Tower in Chicago. Of course the function of the floor plate has a big influence here since residential accommodation generally needs less floor-to-floor height than office accommodation, ie the residential function contains more floors per height.<sup>7</sup>

#### Structure and fabric; the skyportal

Of course, it is not only in an agreed common height that strategic planning between a number of towers needs to occur. Floor plates between towers will not align in level and thus the skybridge needs to be able to take up this vertical tolerance within its length, making completely horizontal skybridges a rarity. Furthermore, since one tower could be built several years before its neighbours, provision in the tower's floor plate, structure and fabric needs to be made for future linkage. This requires not only the provision of skylobbies, but also of *skyportals* within the building envelope, ready for future skybridge linkage. *Structural skynodes* would be needed [7], ready to support the structure from the skybridge, and *envelope skyportals* would be needed to give flexibility in the cladding systems to allow a part of a facade to become an entrance later. In time, a single tower may be linked up to several neighbours (possibly at different heights), and flexibility of both the tower structure and envelope through 360 degrees needs to be designed to accommodate this. A study of sites surrounding the object tower may assist with this omni-directional linkage; both the orientation (ie what direction could future skybridges be coming from?) and the distance from the existing tower to give an indication of structural span.

7 Structural sky node ready to support the skybridge, Petronas Towers, Kuala Lumpur

8 Precedents for an enclosed skybridge a Corporation Street

Footbridge, Manchester, Stephen Hodder Associates, 2001 b Floral Street

Footbridge, London, Wilkinson Eyre Architects, 2003

#### Design of the skybridge

Horizontal bridges spanning between towers at height will have a significant impact on the architecture of the towers and how they are perceived. The skybridges must be embraced as a positive element of the building and constructed in an appropriate architectural language, but this could be difficult when spanning between two towers designed to completely different rationales and expressions, possibly several decades apart? This is one of the main challenges facing us as designers. The skybridge must become an element in the conceptual framework for the building(s). In Petronas Towers [6e], the power of the message, in the spirit of the Chinese philosopher Lao Tse, is as much about what is not there, as what is: a spatial 'gateway to the infinite' defined between the two towers and the skybridge (Pelli, 2001).

The skybridge itself could take many different forms. In Hara's Umeda Sky Building there are three levels of skybridge, each with a differing response. At level 22 of the 40-storey office building, a 6m wide steel-framed bridge links horizontally between the two towers, between levels 34 and 38, 'flying' escalators form a diagonal bridge and, at levels 38 to 40, the floor plate itself forms the physical link [6d]. In the UK, there are some recent precedents for high-quality 'enclosed bridge' design at low level, eg Stephen Hodder's Corporation Street Footbridge, Manchester [8a] and Wilkinson Eyre's Floral Street Royal Ballet School Bridge, London [8b]. Perhaps the design approaches here could serve as inspiration for higher level skybridges?

Of course, the solution to the structural and environmental problems will have a major impact on the final outcome of the skybridge design. Structural spans, and the need to take the loads back to the primary tower structure, will most probably result in the structural solution becoming expressed in the design. The impact of wind, sun and rain at height will influence the choice of cladding materials and arrangement of the skybridge envelope itself. The effects of the physical skybridge connection on movement of each tower relative to another through wind or earthquake needs also to be a considered part of the design.

#### Conclusions

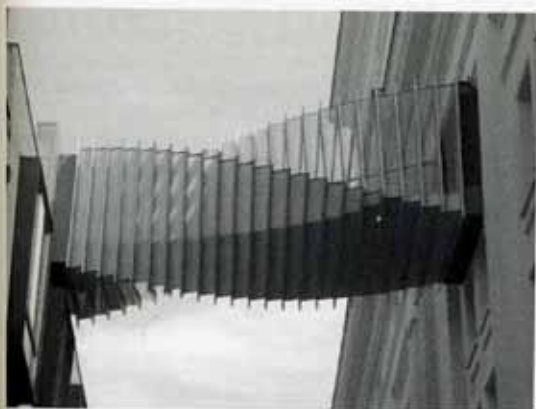
*'It is only logical to conceive of multi-level cities. The organisation of, say, New York, which tolerates multi-level components, connected by only two horizontal levels (street and subway) and both of those at the base, is archaic.'*

Archigram, 1964





8a



8b

There is still much to study if there is to be any chance of skybridges becoming a reality in high-rise design. There are, however, many clear benefits to their incorporation, not least the improvement to emergency evacuation strategies. Many international groups recognize the benefits of using elevators in the evacuation of tall buildings (Klote, 2003), but until the safety problems of their usage in the event of fire have been overcome, they are not yet a viable possibility in a single tower. The possibilities offered by the skybridge change all that. In Petronas Towers, for example, the emergency evacuation strategy incorporates movement of occupants from one tower to the next where they can be evacuated safely (and more swiftly) by elevators in the safe tower (Ariff, 2003).

Another major advantage offered by skybridges is the possibility of floor space savings. Most high-rise buildings around the world have been designed with a *phased evacuation strategy* in mind, ie evacuating a number of floors at a time. Given the high public profile of the events of the World Trade Center Towers' collapse, it is now doubtful that tall building occupants will feel comfortable to remain in a tall building in an emergency situation, as required in this phased evacuation approach (Barber, 2003). An alternative *simultaneous evacuation strategy* might need to be adopted, in which all occupants are evacuated at once. This will have an obvious impact on valuable floor space owing to an increase in the number and width of evacuation stairwells (or number of lifts). Alternative evacuation strategies employing skybridges, however, could allow for the simultaneous evacuation of towers without

increasing the number of stairs or lifts. This significant commercial floor space saving would be of huge benefit to building developers and owners.

Is a network of skybridges in our cities, however, even a remote possibility given the considerable challenges facing us in terms of operation, structure, security, building envelope, tower dynamics etc? Is the skybridge destined to remain in the realm of science fiction and one-off 'local' solutions between two buildings with the same owner? Further, even if skybridges can be accommodated in future high-rise design, what about the thousands of tall buildings that already exist in our cities? Is there a way that skybridges can be accommodated retrospectively in existing buildings?

It may seem to many that the challenges are too considerable and that the contents of this article are nothing but a fantastical dream. But it is perhaps not as far from reality as those people might think. Differing cultural, social-economic, political and climatic environments result in different solutions to architecture and urban design around the world. For many years now, in the Central district of Hong Kong, one has been able to ascend from the pavement level and circulate on a pedestrian network without touching the ground for a square mile or more: a network of bridges spans between first floor tower lobbies, arching over roads and diverting public routes through traditionally non-public buildings. And, along this vibrant route in the air, facilities have flourished: shops, restaurants, galleries.

In a city with a hot, humid climate such as Hong Kong, this continual air-conditioned skybridge link between buildings has climatic benefits to city occupants. Similarly, the extreme cold winter environments of Minneapolis in the US and Calgary in Canada have resulted in a series of skybridge connections between buildings in the downtown areas at first floor level, providing a warm, protected circulation route. In these cities, the ground floor plane has become the domain of the motor vehicle: pedestrians have made a claim for the sky.

Is it too far-fetched to believe that, albeit requiring a colossal amount of initiative, drive and planning, what has started at 10m elevation in cities such as Hong Kong, Minneapolis or Calgary could not occur at 100m, or 200m, in those cities and others? Many of the conditions and problems to be overcome are the same once the ground plane is departed.

There are many sensible reasons why skybridges could become a key element in our future cities, not least the alternative routes of evacuation they would offer in the event of emergency. But the skybridge is not just about an alternative circulation route. As in the early dreams of Ferriss, Lang, King and the memories of millions of people who have gazed wistfully up into a cluster of skyscrapers, or climbed to the highest observation deck for a view down on a city, or sat enthralled at the latest science fiction urban imagery, these pavements in the sky could enrich our cities in a myriad of ways.



## Notes

1. For a discussion of the early development of the skyscraper as a building type, see Condit (1952).
2. For a general discussion of the world's tallest buildings, see Zaknic (1998).

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## Biography

Antony Wood is a Lecturer in Architecture at the University of Nottingham, where he currently leads the Year 3 Design Studio and Construction courses. His architectural practice background includes tall building/large project experience in Hong Kong, Bangkok, Jakarta and Kuala Lumpur, as well as the UK.

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