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Bridging the Gap: Proposed Evacuation Links at Height in the World Trade Center Design Entries

This presentation is based on a paper by the presenter and Antony Wood of the University of Nottingham.

The World Trade Center towers' collapse has created the largest single retrospective analysis of tall building design in the past 40 years. In no field is this more relevant than in the field of evacuation, where significant advances have been made. The case for an "alternative" design solution for tall building evacuation — allowing horizontal evacuation at height through skybridge linkages — has already been made. However, despite the real advantages exemplified in built examples like Petronas Towers, the skybridge seems a purely fantastical proposition to many, with no relevance beyond isolated, one-off scenarios.

It is interesting then that, of the seven official proposals for the World Trade Center redesign competition, five of the designs proposed some form of linkage at height between towers. The solutions for these linkages ranged from the abstract bridge forms spanning the open latticed towers of the THINK team (Rafael Viñoly, et al), to the clear, orthogonal skybridges of the Richard Meier team.

These proposals show that the idea of the skybridge is not purely a fictional notion, but is a very real solution for improved evacuation efficiency and is at the cutting edge of new tall building design. This presentation will analyze the skybridge links of the WTC replacement designs — impact on evacuation, structure, façade, tower operation, etc. — to establish the advantages of such linkages and how they could be incorporated into future tall building design.

Bridging the gap: An analysis of proposed evacuation links at height in the World Trade Centre design competition entries

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ABSTRACT
The World Trade Centre towers' collapse has created the largest single retrospective analysis of tall building design in the past 40 years. In no field is this more relevant than in the field of evacuation. The case for an 'alternative' design solution for tall building evacuation – allowing horizontal evacuation at height through skybridge linkages – has already been made (Wood, 2003). To many, however – and despite the real advantages as exemplified in built examples such as Petronas Towers – the skybridge seems a purely fantastical proposition, with no relevance beyond isolated, one-off scenarios.

It is interesting then that, of the seven official proposals for the World Trade Centre re-design competition, five of the designs proposed include some form of linkage at height between towers. The solutions for these linkages ranged from the abstract bridge forms spanning the open latticed towers of the THINK team (Rafael Vinoly, et al), to the clear, orthogonal skybridges of the Richard Meier team.

What these proposals show is that, far from the idea of the skybridge being purely a fictional notion, it is actually a very real solution for improved evacuation efficiency, which is at the cutting edge of new tall building design. This paper proposes to analyse in detail the skybridge links of the WTC replacement designs – impact on evacuation, structure, façade, tower operation etc – with the aim of establishing the advantages of such linkages, and how these could be incorporated into tall building design in the future.

Key Words: *Tall Buildings, Design, Evacuation, Skybridges*

1.0 INTRODUCTION

The terrorist attacks on September 11th 2001, resulting in the collapse of the World Trade Centre towers has, arguably, created the largest single retrospective analysis of the design of tall buildings in the past 40 years. All aspects of tall building design – safety systems, structural systems, façade materials, siting and layout – have been called into question, and significant research has – and continues to be – undertaken in the quest to validate and improve the viability of the high rise.

In no field is this more relevant than in the field of tall building evacuation. Significant advances have been made in investigating the opportunities for the improvement of existing systems (e.g. stairs), and also the viability of 'new' systems, e.g. the use of elevators in the event of fire (CTBUH, 2004). Another of these 'alternative' systems is the use of horizontal evacuation at height through 'skybridge' linkages between towers. The case for the skybridge, including the historical precedent and study of tall buildings currently employing skybridges, has already been made (Wood, 2003). However, to many – and despite the very real advantages as exemplified in built examples such as the Petronas Towers – the skybridge seems a proposition from the realms of fantasy, with no relevance beyond isolated, one-off scenarios.

It is interesting then that, of the seven official proposals for the World Trade Centre re-design competition as sponsored by the Lower Manhattan Development Corporation and the Port Authority of New York and New Jersey (Stephens, 2004), five of the designs proposed some form of linkage at height between towers. The solutions for these linkages ranged from the abstract bridge forms spanning the open latticed towers of the THINK team (Rafael Viñoly, Frederic Schwartz, Shigeru Ban, Ken Smith et al), to the clear, orthogonal skybridges of the Richard Meier / Peter Eisenman / Gwathmey Siegel / Stephen Holl team. In addition, many of the 'unofficial' proposals proposed some form of linkage at height between towers.

What all these proposals – and especially the five of the seven 'official' submissions – show is that, far from the idea of the skybridge being purely a fictional notion, it is actually a very real solution for improved evacuation efficiency, which is at the cutting edge of new tall building design. This paper analyses the skybridge connections in each of the proposals, before drawing conclusions on the role of physical connections at height in tall building design.

2.0 BACKGROUND TO THE WTC DESIGN REPLACEMENT PROPOSALS

The many varied proposals for the replacement of the World Trade Centre towers in New York mark an important watershed in the evolution of tall building design. In the same way that the Chicago Tribune Tower competition of 1922 (Tigerman, 1981) is established as a seminal snapshot of tall building design thinking internationally at the time, so will the year or so of frenzied design activity following September 11th 2001 be viewed as a 'stock take' of early 21st Century design thought in the field of the high-rise.

For the purpose of this study, it is necessary to categorise the many thousands of design proposals for the WTC replacement submitted, to place the case studies examined in this paper in context. The design proposals can be categorised into three areas:

(i) the 'Official' entries, as managed by the Lower Manhattan Development Corporation and the Port Authority of New York and New Jersey (7 No. team entries, first submitted in December 2002 – see Stephens, 2004).
(ii) the 'Unofficial' entries, as organised by organisations such as New York Magazine (September 2002), New York Times Magazine (September 2002) and the Max Protech exhibition (January 2002): "A New World Trade Centre: design Proposals" (see Protech, 2002).
(iii) 'Independent' proposals created by individuals / organisations but outside any 'set' competition or organising structure.

For reasons of quality / depth of subject, the emphasis of this paper is on category (i) above, with some reference to schemes in categories (ii) and (iii).

3.0 OFFICIAL PROPOSALS

3.1 Team Richard Meier, Peter Eisenman, Stephen Holl et al.

Perhaps the most obvious skybridges in any of the official competition entries were those proposed by the 'New York' team led by Richard Meier et al. The design created two grid-like structures perpendicular to each other, the first grid composed of three vertical towers and four levels of horizontal connecting elements running north-south along the site, the second grid of two vertical towers orientated east-west, with the same four levels of horizontal connecting elements (see *Figure 1a*). The design is described by the architects as a 'grid of voids and solids' (Sudjic, 2003), the geometric form reflecting the abstract concept of presence (solid) and absence (void).

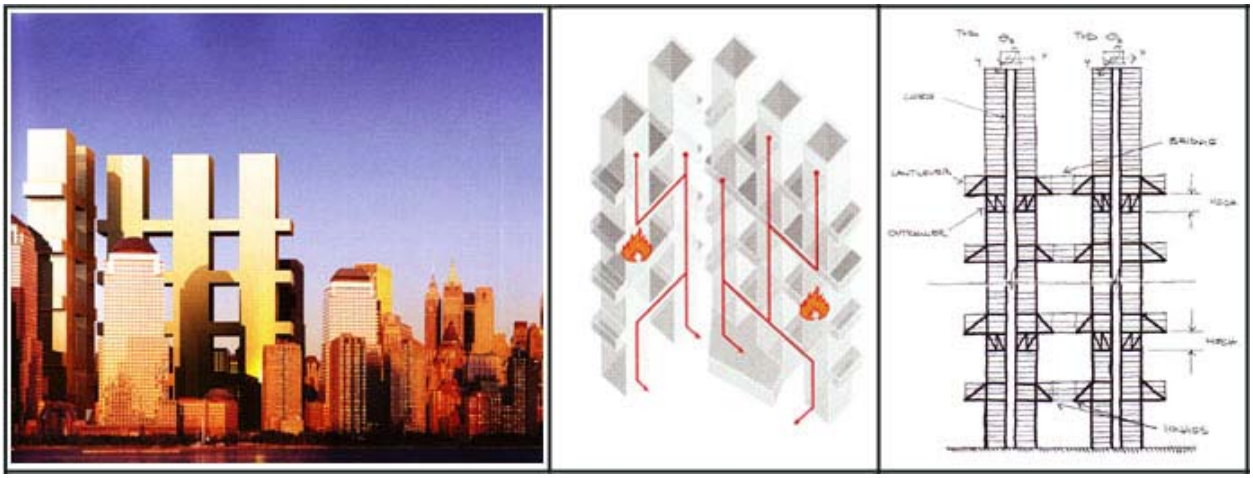

Figure 1: *Design Proposal, Richard Meier Team*. From left, (a) View across the Hudson River, (b) Evacuation diagram, (c) Structural Diagram (Source: Nordenson and Riley, 2003)

The five towers' footprints only occupy about a quarter of the World Trade Centre site, allowing the large area remaining to be developed as external public space. However, this small urban footprint has not restricted the inclusion of large open floor areas at higher levels, as the horizontal 'skybridge' elements of the scheme are designed to be *superfloors*. These large linear floorplates, spanning between the vertical towers, offer space suitable for trading floors, conferences and skylobbies. Below them monumental gateways are created, directing pedestrian flow into the site, whilst above them – on top of the skybridges – terraced skygardens offer recreation and views out to the city.

The rectilinear skybridge connections are reminiscent of some of the early theoretical work of the Japanese Metabolists (e.g. Arata Isozaki's *City in the Air, Shinjuku project,* 1960-61 – see Ross, 1978), whilst the idea of the superfloor has been employed in the Shanghai Stock Exchange Building (1997, WZMH Architects). The proposal by Meier et al progresses this idea beyond any built example and in doing so offers a more varied range of tenant occupancy programmes than available in typical towers, where one is usually restricted to occupying a series of floors in vertical sections.

> *"A tenant could occupy a typical horizontal floor plate or lease spaces that are arranged vertically, or staggered, or even looped around one of the voids."* Nordenson and Riley, 2003

Structurally, this scheme requires major interventions in the mega-structure to create its clearly defined skybridge superfloors that span large distances. Each vertical tower is supported by a concrete core with perimeter columns, cross-braced in the short direction with the superfloors spanning between sets of 4 diagonally braced cantilevers which are also used to support the superfloor ends (See *Figure 1c*). A hinged outrigger system allows for movement between tower and bridge caused by lateral wind loads. In terms of impact on evacuation, this arrangement of vertical towers and horizontal skybridges offers a multitude of evacuation routes, thus improving evacuation efficiency significantly. Multiple routes of evacuation in both the vertical and horizontal plane are offered, as the superfloors link together the individual cores containing vertical escape systems (see *Figure 1b*).

Peter Eisenman has acknowledged how important this benefit is to the public post September 11th, as exemplified by discussions with school children, who seemed only to be interested in how one would escape in the event of an emergency:

> *"Safety, psychologically, is the most important thing for these kids. One kid said, "suppose five planes hit at once, then what would you do?" We couldn't answer the question. But that was clearly in their minds, and was clearly in our minds as a pragmatic solution."*
>
> Peter Eisenman (From the Architectural League, 2003)

Naturally, along with improved evacuation comes improved circulation in normal mode. The designers have designated the top and second from bottom superfloors as *skylobbies*, where horizontal non-emergency circulation between towers is possible. Double-decker lifts would transport occupants from the ground floor to these large open skylobbies from which local elevators, which serve every floor within a distinct vertical zone, would ferry them up or down to their individual floor of choice, creating a clear and efficient vertical transportation system.

The treatment of the ends of the skybridges are interesting – cantilvered out to form viewing platforms and extending the 'grid' expression. The cantilevered ends at the north-west corner of the site are offset, representing fingers entwined together in a protective manner. These cantilevered 'fingers' at the superfloor ends seem to be potential skybridges of the future, waiting to be connected to other buildings as they rise around the site after this design was built. This would offer circulation links to future neighbours and further alternative escape routes which could be extended out into the city.

> *"The dream of 'cities in the sky' in which the horizontal dimension is treated as importantly as the vertical dimension is now fast becoming reality."* Abel, 2003

3.2 Team THINK – Rafael Viñoly, Frederi Schwartz, Shigeru Ban et al.

The THINK team (Rafael Viñoly Architects, Frederic Schwartz Architects, Shigeru Ban Architect, Ken Smith Landscape Architect et al) proposed three schemes: *The Great Room, Sky Park* and *The World Cultural Centre.* The latter of these three made it to the final round of the LMDC competition where it would eventually finish runner-up to the scheme by Daniel Libeskind Studio (Stephens, 2004). The World Cultural Centre design consisted of two open-latticework towers, circular in plan, built around the footprints of the original twin towers. These structures create a 'site' for cultural buildings to be inserted, including memorials, a museum, conference centre, performing arts centre and viewing platforms, all designed by different architects (see *Figure. 2a*).

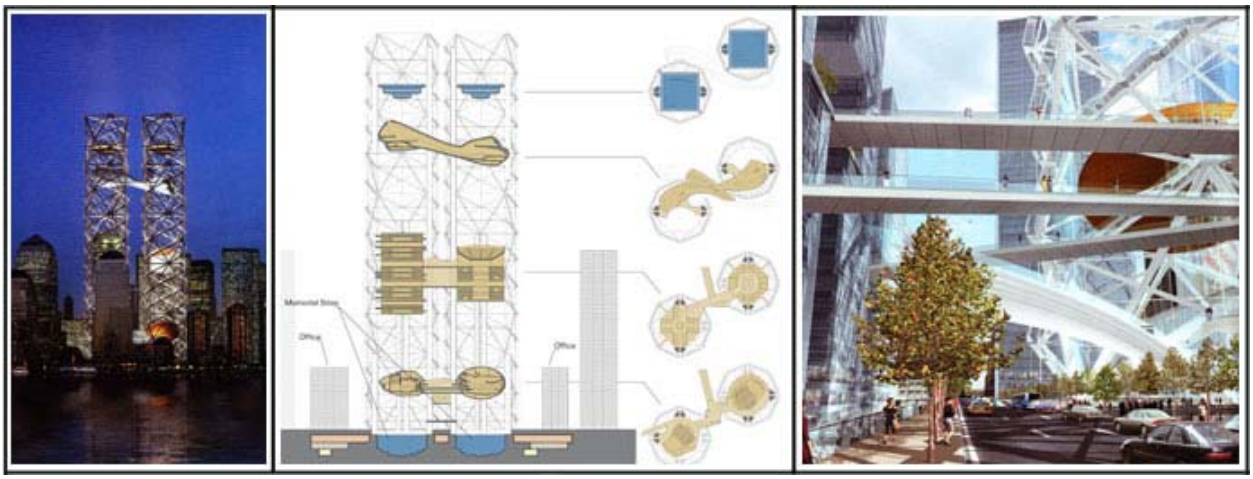

Figure 2: *Design Proposal, THINK Team.* From left, (a) View across Hudson River, (b) Skybridge plans and Section, (c) Elevated pedestrian walkways. (Sources: (a) & (c) Stephens, 2004. (b) Rafael Viñoly Architects, 2002)

These cultural buildings are connected between the two latticework towers by a series of abstracted skybridges, whose purpose is largely to create additional cultural space and to tie the towers together symbolically (see *Figure 2b*). The uppermost skybridge, a twisted, distorting form, connects the two wings of the museum at the approximate places the two planes hit the original World Trade Centre towers. However, this symbolic marker proved too gruesome for many New Yorkers and was removed for the final round of the design competition (Stephens, 2004). Each of the cultural programmes within the towers is serviced by its own set of double-decker elevators, positioned on the tower's perimeter. Unfortunately while this makes for efficient vertical circulation, it restricts the potential of the skybridges in respect to multiple routes of evacuation offered, as one cannot use a skybridge to cross over to the adjacent tower in an emergency, unless one is within that programme's distinct circulation core.

Since the 2 towers are largely empty, containing only cultural spaces, a variety of commercial towers to the north, east and south of the World Trade Centre site are proposed to meet the required commercial floor-areas stipulated in the competition brief. Linking these perimeter buildings to the main towers are a network of elevated pedestrian walkways (see *Figure 2c*), allowing one to move around the site without having to touch the ground or cross busy roads, in a manner reminiscent of the pedestrian walkways in the Central District of Hong Kong.

3.3 Team Foster & Partners

> *"We propose to celebrate New York's positive spirit with a unique twinned tower – the most secure, greenest and tallest in the world. This is a huge responsibility: human safety must be paramount."* Foster and Partners (from Sudjic, 2003)

Following the terrorist attacks of September 11th 2001, resulting in the collapse of the World Trade Centre towers, Foster and Partners commissioned a comprehensive study into safety in tall buildings. The findings of this study informed their official design proposal which consists of a crystalline, geometric twinned tower, subtly converging in 3 places along its height at what the architect calls the *kissing* points (see *Figure 3a*). These links would offer alternative escape routes between the towers, if any emergency effectively cut off vertical evacuation routes in one of the towers' central cores. Furthermore, the skybridge created at one of the kissing points is an open-air terrace, offering the radical possibility of evacuation by air succour.

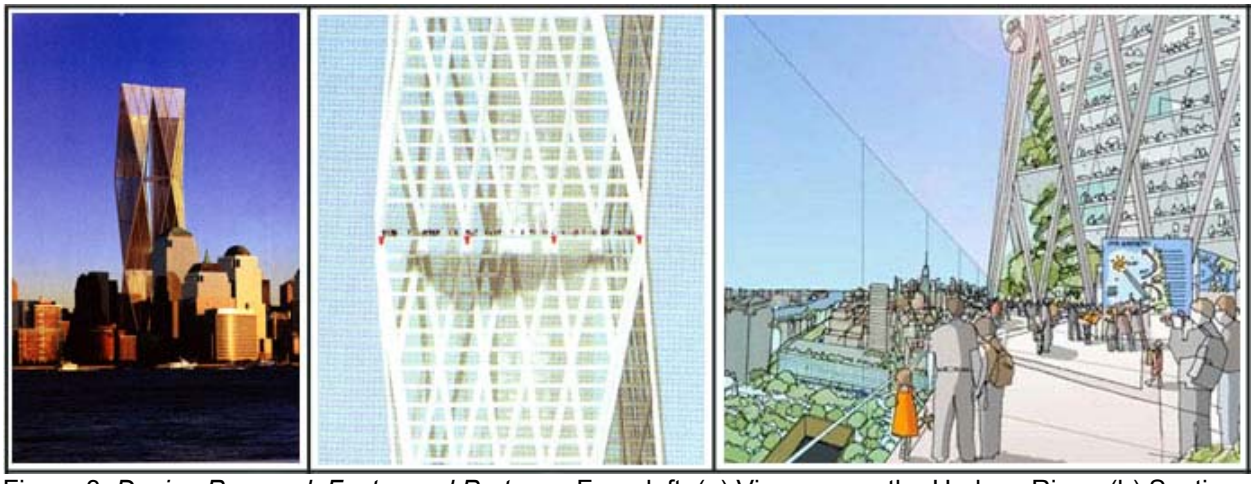

Figure 3: *Design Proposal, Foster and Partners.* From left, (a) View across the Hudson River, (b) Section through skybridge terrace, (c) View from skybridge terrace. (Sources: (a) & (b) Stephens, 2004. (c) Lower Manhattan Development Corporation, 2002)

The ‘kissing point’ skybridges do not just impact positively upon safety in the towers, they also contribute significant public space to the proposal. This public space which in tall buildings is usually restricted to the ground floor interface, is now hundreds of meters in the sky, containing observation platforms, terraces, shops, cafes and parks. The open air terrace, whilst allowing evacuation by helicopter, also offers external recreational space to the office worker (see *Figure 3c*), a rarity in typically air-conditioned high-rise buildings. The public kissing points also break down the tower’s scale, both aesthetically and operationally, separating the office space into ‘villages’, each with their own amenities.

Structurally the proposal is similar in concept to Foster’s recently completed, award-winning Swiss Re Tower in London (2004), with a concrete central core and perimeter structural diagrid. However, by conjoining the towers, they are able to resist wind loads collectively, allowing for a more slender structure (see *Figure 3b*). Also, by creating a tower that “kisses and touches and becomes one” (Czarnecki, 2003), Foster has created a beautiful and elegant design that symbolises unity and togetherness post September 11th. So whilst Foster talks of ‘human safety being paramount’, the creation of evacuation links at height in this design doesn’t just impact positively on safety and evacuation, but also on public realm, environment, structure, aesthetics and normal circulation etc.

3.4 Team Skidmore, Owings & Merrill (SOM), with SANAA et al

This design team (SOM with SANAA, Michael Maltzan Architecture, Tom Leader Studio et al) proposed nine crooked towers scattered across the whole World Trade Centre site, connected at various levels by orthogonal skybridges, creating what the architects describe as a *vertical city* (see *Figure 4a).*

> *“The “vertical city” is experienced at many levels, a dense choreography of communities, New Yorkers, and memorial visitors.”*
>
> SOM et al (From Lower Manhattan Development Corporation, 2002)

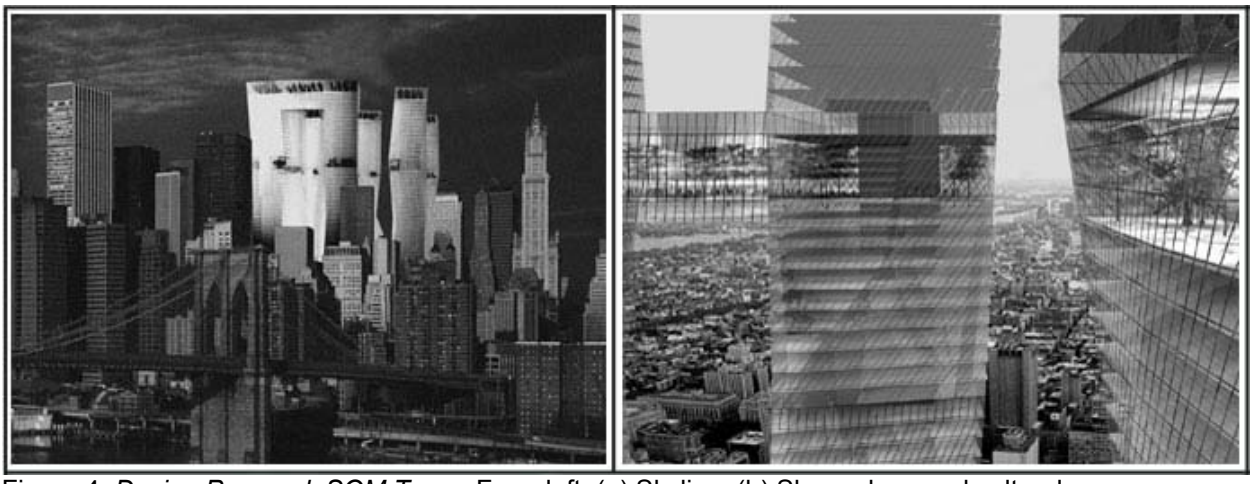

Figure 4: *Design Proposal, SOM Team.* From left, (a) Skyline, (b) Skygardens and cultural spaces connected by skybridges. (Source: Lower Manhattan Development Corporation, 2002)

Inspiration for this concept came from early 20th century visions of cities of the future such as Moses King’s ‘King’s Views of New York’, published in 1906 (King, 1906), which reveals visions of a futuristic New York city having skybridges spanning between towers as bi-planes fly overhead. The SOM team didn’t want to restrict public interaction to just the base of the towers, instead opting to return the 16 acres of public space lost to the tower’s footprints with 16 acres of public sky gardens, and a further 16 acres of cultural spaces located in horizontal ‘strata’ across the scheme (see *Figure 4b).*

> *“Connected by aerial platforms, the towers host elevated gardens and cultural facilities that expand and displace the site’s public realm to upper floors and to an archipelago of landscaped rooftops.”* Giovannini, 2003

The nine towers are designed to be built in a series of phases, with new towers appearing as the market demands. As they emerge, they will be joined together by orthogonal skybridges at varying levels offering alternative means of escape between the towers. However, the primary objective of these skybridges is to connect and extend the public realm between the towers, so that the bridges themselves become cultural spaces, sky gardens, public terraces and even museums or libraries, floating between the towers. In doing so, an exciting cultural network in the sky is created.

3.5 United Architects – Foreign Office Architects, Greg Lynn FORM, UN Studio et al.
The United Architects team (Foreign Office Architects, Greg Lynn FORM, Kevin Kennon Architects, Reiser + Umemoto RUR Architecture, Imaginary Forces NYC, UN Studio et al) proposed arguably the most radical design of the competition: a series of five crystalline towers, leaning into one another and fusing together at around 800 feet high, creating what seems to be a single cathedral-like building (see *Figure 5a*). Located around the east side of the World Trade Centre site, the building acts as a curtain of protective, united towers, framing the memorial of the original World Trade Centre footprints and providing over 10.5 million square feet of floor area (United Architects, 2002).

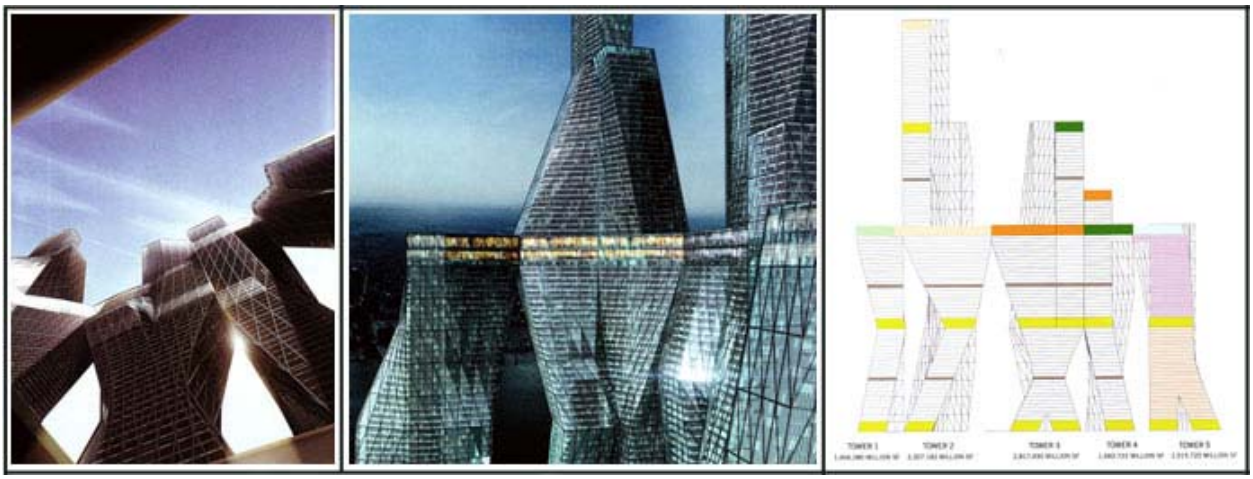

Figure 5: *Design Proposal, United Architects Team.* From left, (a) View up from sunken memorial, (b) Skyway, (c) Section. (Sources: (a) Stephens, 2004. (b) & (c) Nordenson and Riley, 2003)

Where the towers collide they create what the architects describe as a *skyway (see Figure 5b)*; five continuous floors of public amenities linking all five towers, with gardens, retail areas, a sports centre, conference centre, broadcast centre and a 'sky memorial' where people can look down from their elevated position upon the sunken footprints of the original World Trade Centre towers. This idea can be seen as a combination of the 'superfloors' in the design by Richard Meier et al and the public areas at the 'kissing points' in the design by Foster and Partners. In conceiving this skyway, United Architects have transferred some of the public activity that normally occurs at the ground floor interface and lifted it 800 feet into the air to the heart of the building, drawing people in to visit this immense public space and in doing so creating a 'city in the sky'.

> *"… I think it's a mistake to think solely two-dimensionally, as though the ground plane were the only repository for public space. It belongs in many places, including the sky."*
> Kevin Kennon (From the Architectural League, 2003)

Although one may view the scheme as a singular colossal structure, the 5 towers that combine to create it are, in fact, structurally independent and designed to be constructed individually in phases from 2006 to 2012, with each tower supported by its own concrete core and an external, diagonally braced structural skin. However, by connecting the 5 towers, as they are built, their collective structural strength becomes far greater than their structural strength individually, allowing the overall building to resist massive forces (see *Figure 5c*).

Along with increased strength comes increased safety. By creating the skyway, a horizontal evacuation link spanning all 5 towers is formed, conjoining together all their individual cores and escape routes. This permits evacuation paths from any individual stairwell in any tower to any other stairwell in an adjacent tower in a manner similar to that found in the scheme by Richard Meier et al.

> *"The conjoined towers, unlike the traditional vertical tower with its unitary vertical systems, offer multiple routes of escape and fire-fighting access following vertical and, if necessary, horizontal routes"* Nordenson and Riley, 2003

Although this horizontal evacuation link only occurs in one place (unlike some of the other designs), it still unites 29 distinct stairwells and 43 areas of refuge in what the architects describe as the safest building in the world (Sudjic, 2003). Services too could be linked through the skyway, allowing improved safety features such as sprinkler systems supported by multiple sources of water pressure.

The concept of the skyway not only impacts on the scheme's public realm, safety and structure but also on its aesthetic, emotive and spatial qualities. The towers seem to lean upon one another, as if for support, creating a powerful symbol of unity in the wake of September 11th, whilst below the skyway, vast arches are formed that help define public space and direct people into the site.

> *"The connections between the towers create a remarkable silhouette across the skyline, a symbol of collectivity; their gaps also create monumental urban spaces, that frame views and channel circulation ."* Nordenson and Riley, 2003

Overall it is perhaps this scheme by United Architects that makes the most out of the potential offered by high rise links, not only reassuring with enhanced structural performance and improved evacuation efficiency, but by creating a unique public realm in the sky and a design that symbolises unity, all owing to the creation of the skyway.

4.0 UNOFFICIAL PROPOSALS

4.1 Richard Dattner

One of the most revealing of the 'unofficial' schemes from a skybridge perspective is this proposal by Richard Dattner, generated by 17th September 2001 and later submitted to Larry Silverstein. The scheme sees a version of the original World Trade Centre towers, linked by 3 skybridges at differing levels (see *Figure 6a*). It is obvious that this response came about as a pure reaction to the evacuation issues raised through the World Trade Centre towers' collapse. As Dattner stated, one of the main design influences is the ability to 'allow access and egress between towers' (Dattner Architects, 2001).

4.2 Hariri & Hariri

This design proposal, named 'The Weeping Towers', consists of 11 slim square towers, serving as vertical circulation and service cores to a variety of organic public and private spaces bridging between them at height (see *Figure 6b*).

> *"Reaching between the towers and floating in the sky, these structures will be visible to the entire city, signifying the heart and strength of our freedom and the world's financial capital."* Hariri & Hariri (from Protetch, 2002)

4.3 Coop Himmelb(l)au

This design proposal proposes three mixed-use towers, arranged in plan to form a triangle over Ground Zero and surrounding a cone-shaped apartment tower. The towers are linked by ad-hoc skybridges that incline in section, thus linking towers at differing levels (see *Figure 6c*).

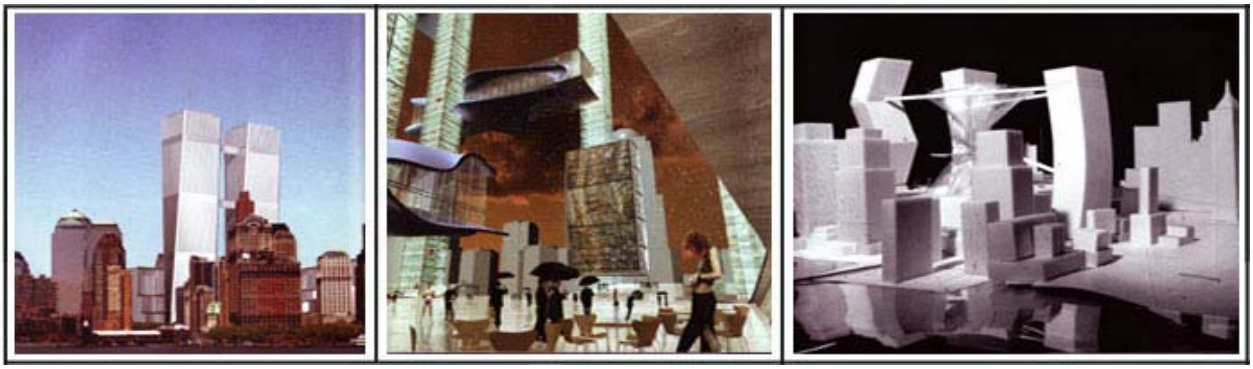

Figure 6: *Unofficial Proposals*. From left: (a) Richard Dattner, (b) Hariri & Hariri, (c) Coop Himmelb(l)au. (Source: Stephens, 2004)

4.4 'Touching Tower' Approaches – Foreign Office, Zaha Hadid, NOX

Similarities of approach can be seen with the official proposal by United Architects, in a number of towers that taper or bend in to touch each other, thus creating direct linkages between towers rather than separate skybridge links. These include proposals by Foreign Office Architects, Zaha Hadid and NOX which all propose some direct contact between a number of towers.

Zaha Hadid's proposed towers touch and merge at various places, connecting floors and people and encouraging social interaction by allowing cross-over circulation between office and residential towers (see *Figure 7b*). These cross-over links could also offer an opportunity for transfer of excess heat produced in offices to be transferred to heat residential spaces.

"Hadid …. reinvents the skyscraper as a building type, operating on the principle of connecting rather than isolating floors and people, and varying spaces rather than repeating them identically."

Giovannini, 2002

Foreign Office Architects designed what they call a *bundled tower:* eight 110 storey bending tubular towers, arranged in a circle, touching one-another at points along their height (see *Figure 7a*).

> *"Our proposal is to form the complex as a bundle of interconnected towers that buttress each other structurally, increasing the structure's moment of inertia without necessarily increasing the floor depth or total area."* Foreign Office Architects (from Protetch, 2002)

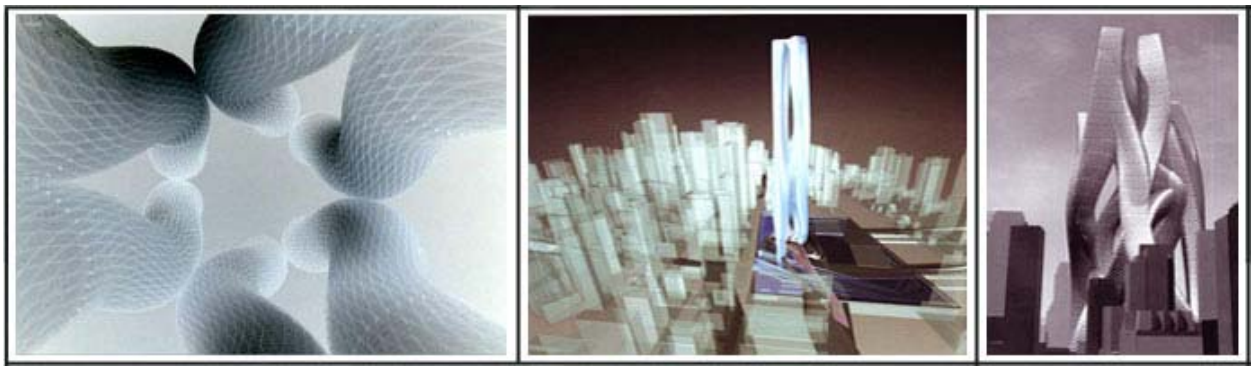

Figure 7: *Unofficial 'Touching Tower' Proposals*. From left: (a) Foreign Office Architects, (b) Zaha Hadid (c) Nox. (Sources: (a) Foreign Office Architects, 2002. (b) & (c) Stephens, 2004)

Each tower's footprint consists of a 36m diameter circle which alone would be too slender to achieve the 500m plus heights proposed by the architects. But by creating links at height between the towers, they act together structurally, creating a much larger effective footprint and offering a structurally viable depth to height ratio. This allows the creation of a building that would be the tallest in the world, whilst maintaining the many advantages of a slender tower.

A further advantage of these structural links at height is that they allow the creation of skylobbies, 16 in all, each bridging two adjacent towers every 36 stories. Since each individual tower has its own core containing vertical escape systems and building services, the skylobbies offer horizontal evacuation between the towers at differing levels across the building, whilst also providing additional paths for services such as electricity cables and fire-suppression systems that can be used should there be a problem (perhaps in an emergency) with their original vertical path. This design approach obviously later influenced the official proposal by United Architects, of whom Foreign Office Architects were members.

4.5 Kohn Pederson Fox

KPF's proposal, published in New York Magazine, consists of a *sky promenade*: a ramped walkway stretching from out in the Hudson River to about one fifth of the way up a new 2001-foot-high tapering tower (see *Figure 8a*). This timber walkway allows pedestrians to journey around the World Trade Centre site at height, looking over the city and down on the original twin tower footprints which are transformed into reflective pools.

> *"Pedersen…compares the sky promenade to the exhilarating experience of walking on the pedestrian decks of New York's suspension bridges."* Giovannini, 2002

Although this sky promenade joins together new office buildings and residential blocks below and offers an alternative evacuation route from the new tower, its main achievements are symbolic and experiential: linking the World Trade Centre site with the Hudson River, and offering a vibrant pedestrian walk above the noisy street level.

Figure 8: *Unofficial Proposals*. From left: (a) Kohn Pederson Fox, (b) Allied Works Architecture (c) Lot-EK. (Sources: (a) Giovannini, 2002. (b) & (c) Protetch, 2002)

4.6 Allied Works Architecture

This abstract proposal for the Max Protetch Gallery consists of a labyrinth of spaces and rooms, dedicated to remembrance, reflection and celebration, positioned at various heights across the site and connected together by 'streets' on the third, tenth and roof stories (see *Figure 8b*). These streets in the sky, bridge between volumes, providing the opportunity for people to look down across the site and into the various voids and rooms (some uninhabitable) proposed, or to look out across the city whilst circumnavigating the site.

4.7 Lot-EK
This design, submitted to the Max Protetch Invitation Exhibition, is made up of 8 towers linearly arranged along the eastern edge of an excavated void. Pedestrian bridges span this void allowing people to look at, but not walk upon the 'archaeological' site of the original World Trade Centre. The tower's western façades are alive with activity from vertical elevators and horizontal translucent volumes, spanning between the towers and acting like 'city streets' in the façade (Protetch, 2002). These volumes intersect with the elevators providing horizontal circulation and evacuation between buildings and enlivening the tower's flat façade (see *Figure 8c*).

5.0 CONCLUSION
As we can see from the breadth and range of these proposals from some of the top architectural practices across the globe, the concept of connecting towers at height through skybridges is no longer a fictional notion belonging to the realms of fantasy. On the contrary, it has been incorporated in many of these schemes as a very real proposal for increased circulation generally, and increased evacuation efficiency specifically. Perhaps not surprisingly, in the immediate aftermath of the World Trade Centre towers' collapse, one gets the impression that the desire to create physical links between towers at height became one of the key design criteria in many of the replacement design approaches.

Despite the obvious improvement in evacuation efficiency, the skybridges are far-removed from the banal, utilitarian corridors they could have been. In almost all cases the skybridge has been elevated from its role as a circulation device, to become a key element in both the architectural language of the scheme and the intended experience of the building user.

The actual variance in physical manifestations of the skybridge in the WTC replacement proposals is interesting. Proposals range from sinuous bridges (THINK) to whole floor plates spanning the void (Richard Meier et al), from skywalks at one level (UNITED) to skybridges at multitude levels (Foster). Far from impacting only evacuation efficiency, the provision of skybridges has revealed itself to have positive influence on many other aspects of tall building design; structural robustness, possible letting configurations and redundancy of service supplies to name but three.

It is disappointing that the winning WTC scheme by Daniel Libeskind – and the variant that has developed since then – rejects the benefits of these physical links at height, but all the approaches outlined in this paper have one thing in common; a desire to make the new World Trade Centre a vehicle in extending current thinking in tall building design. In doing this, each scheme moves away from the high rise approach typified over most of the past century - the Tall Building as a piece of isolationist high-rise sculpture. These new schemes, through connection, project the Tall Building as a complimentary piece in the urban jigsaw. For the first time since the fantastical 'city in the sky' proposals of the likes of King, Ferris and Lang (see Wood, 2003), we are finally seeing real 'urban' solutions for the Tall Building – high rise that are concerned with the impact on the city, the quality of urban space created, and the experience of the building user. The skybridge is an essential part of that step forward.

6.0 REFERENCES

Abel, C. (2003).SKY HIGH. Royal Academy Publications, London.

CTBUH (2004). *"Emergency Evacuation: Elevators Systems Guidance".* Council on Tall Buildings and Urban Habitat Publications.

Czarnecki, J. (2003). ARCHITECTS AT THE FOREFRONT AS THEY SHOW GROUND ZERO ASPIRATIONS, *Architectural Record,* Vol. 191, No.2, 2003, February, pp. 31-50.

Dattner Architects (2001). NEW WORLD TRADE CENTRE PROPOSAL, NEW YORK, Internet WWW page at: http://www.dattner.com/html/framegather5.html

Foreign Office Architects (2002). WORLD TRADE CENTRE, Internet WWW page at: http://www.f-o-a.net

Foster and Partners (2002). WORLD TRADE CENTRE, NEW YORK, USA 2002 -, Internet WWW page at: http://www.fosterandpartners.com

Giovannini, J. (2002). RISING TO GREATNESS, *New York Magazine*, September 15th 2002.

Giovannini, J. (2003). VISION QUESTS, *New York Magazine*, January 13th 2003.

Hariri & Hariri (2002).THE WEEPING TOWERS – A NEW WORLD TRADE CENTRE (2002), Internet WWW page at: http://www.haririandhariri.com/

Kevin Kennon Architect (2002). WORLD TRADE CENTRE COMPETITION, NEW YORK, Internet WWW page at: http://www.kkarchitect.com/

King, M. (1906), *King's Views of New York 1896-1915 & Brooklyn 1905: an extraordinary photographic survey.* Boston.

Lower Manhattan Development Corporation (2002). INNOVATIVE DESIGN STUDY, Internet WWW page at: http://www.renewnyc.com/plan_des_dev/wtc_site/new_design_plans/default.asp

Richard Meier (2002). MEMORIAL SQUARE DESIGN PROPOSAL FOR WORLD TRADE CENTRE SITE, NEW YORK, Internet WWW page at: http://www.richardmeier.com

Nordenson, G., and Riley, T. (2003).TALL BUILDINGS*,* The Department of Publications (The Museum of Modern Art), New York, pp. 126-131 & pp.156 – 169.

Protetch, M. (2002). A NEW WORLD TRADE CENTRE, HarperCollins Publishers Inc., New York.

Ross, M. F. (1978). BEYOND METABOLISM: THE NEW JAPANESE ARCHITECTURE, Architectural Record Books. New York.

Stephens, S. (2004). IMAGINING GROUND ZERO: OFFICIAL AND UNOFFICIAL PROPOSALS FOR THE WORLD TRADE CENTRE COMPETITION, Thames & Hudson, London.

Sudjic, D. (2003). SEVEN PROPOSITIONS FOR NEW YORK, *Domus*, no. 856, February, pp.33 – 49.

The Architectural League (2003). Q & A: ARCHITECTS DISCUSS THEIR WTC PROPOSALS, TRANSCRIPT OF ENTIRE PROGRAMME*,* Internet WWW page at: http://www.archleague.org/nyc/qanda.html

Tigerman, S. (1981). CHICAGO TRIBUNE TOWER COMPETITION & LATE ENTRIES, Rizzoli, New York.

United Architects (2002). UNITED ARCHITECTS WORLD TRADE CENTRE, Internet WWW page at: http://www.unitedarch.com

Rafael Viñoly Architects (2002). WORLD TRADE CENTRE COMPETITON – WORLD CULTURAL CENTRE, Internet WWW page at: http://www.rvapc.com

Wood, A. (2003). PAVEMENTS IN THE SKY: USE OF THE SKYBRIDGE IN TALL BUILDINGS. Architectural Research Quarterly. Cambridge University Press, UK. vol. 7. Nos. 3 & 4. 2003. pp. 325 -333.