

## SKYSCRAPER FUTURE VISIONS

Mohamad Kashef

### Abstract

*This paper addresses two skyscraper visions: Tokyo's Sky City and the Shimizu Mega-City Pyramid. Prompted by the dearth of land and growing urban problems in Tokyo, these skyscraper visions offer alternative built forms with revolutionary technologies in building materials, construction methods, energy generation, and transportation systems. They are designed to be self-sufficient with homes, offices, outdoor green spaces, commercial establishments, restaurants, hospitals, trains, cars, and conceivably everything that hundreds of thousands of people need during the course of their lifetimes. The promise is that creating such vertical cities would relieve Tokyo from overcrowding and replace the urban concrete "jungle" on the ground with super towers straddling expansive green spaces or the water of Tokyo Bay.*

### Keywords:

Skyscraper; mega-city; Tokyo.

### Introduction

Like other utopian ideas (Fishman 1977), The Mega City Pyramid and Sky City aim to create total environments, making it possible for residents to live from cradle to grave without a need to set foot outside the city limits. Though reminiscent of Le Corbusier's Contemporary City (Boesiger, 2006), Arcosanti (Soleri 1984) and other radical Mega City concepts of the mid-twentieth century, the Sky and Pyramid cities present somewhat plausible urban living scenarios. They incorporate analyses of innovative building components, construction techniques, and movement systems that make them appear not such a distant reality. Ropungi Hills (Fig. 1) could be seen as a smaller-scale dry run for the Sky City concept. It is a self-contained urban complex that replaced a crowded housing district in the middle of Tokyo. Residents were relocated during construction and came back to a skyscraper complex that caters to all their needs, including homes, offices, shops, and public spaces (Jerde Partnership). The Shimizu Mega-City Pyramid and Tokyo's Sky City concepts have been popularized by the "Extreme Engineering" video series of the Discovery Communications ([www.discovery.com](http://www.discovery.com)).



Figure 1: Images from Roppongi Hills Development in the Center of Tokyo (Jerde Partnership; [www.jerde.com](http://www.jerde.com)).

## Tokyo Sky City

Tokyo Sky City is a super tower concept proposed by Takenaka Corporation engineers that, if ever built, would reach two thirds of a mile high, twice the height of current tallest skyscraper, and accommodate 136,000 people (Takenaka, [www.takenaka.co.jp](http://www.takenaka.co.jp)). It would have a 30-acre footprint and require the demolition of 120 Tokyo city blocks. Tokyo's soil mainly consists of loose sandy sediment with bedrock more than a mile-and-a-half deep, which makes it the worst choice for an approximately 600-million-ton super structure. Takenaka proposed a foundation system that

would entail digging thousands of shallow friction piles (concrete-filled) and topping them with a massive, reinforced concrete slab. This would create a unified, immovable footing anchor with a bearing capacity equal to or exceeding bedrock. The weight of the super structure above would be supported by six mega columns along the hexagonal perimeter of the tapered tower profile (Fig. 2). The closest existing example of such mega columns would be those used in Taipei 101, which is almost half the size of Sky City. Each mega column in Taipei 101 was made of three-inch-thick steel plates and filled solid with steel reinforcement and concrete. The Sky City

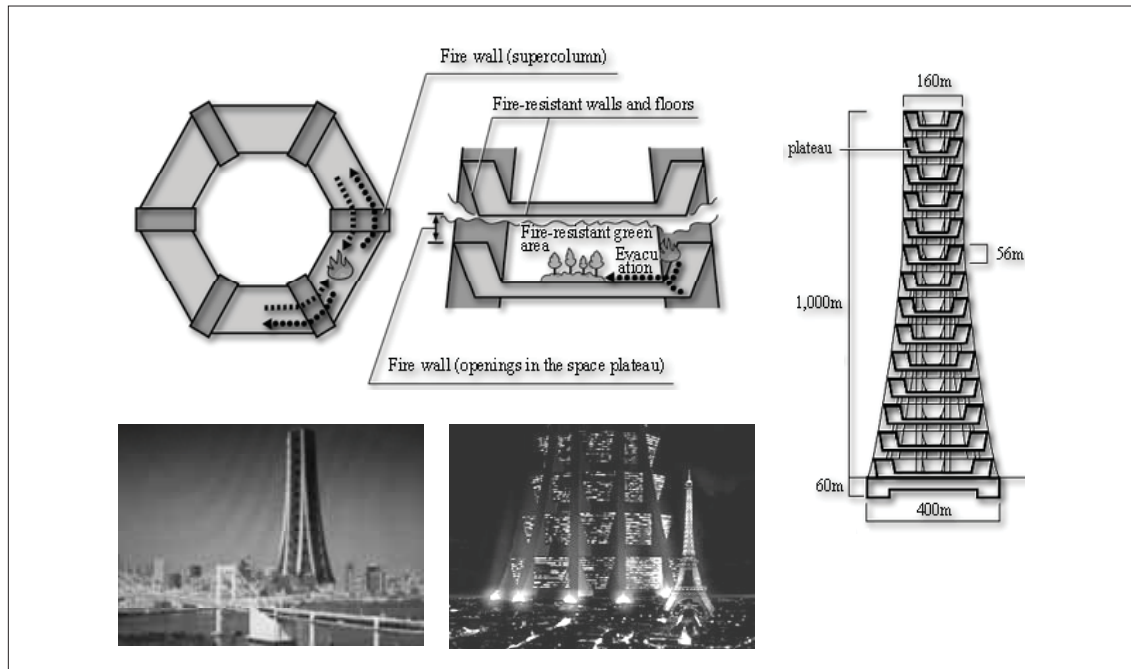


Figure 2: Sky City Concept Images and Diagrams (Discovery Communications, [www.discovery.com](http://www.discovery.com); Takenaka, [www.takenaka.co.jp](http://www.takenaka.co.jp)).

mega columns would be massively larger and require almost three billion pounds of steel. It would probably require a global network of steel mills operating at full capacity for months to produce enough steel for Sky City. Transporting column sections and other structural members from steel mills to the Sky City construction site would be impossible or at best extremely difficult to accomplish (Discovery Communications).

Factories would have to set up shop on site and use automated construction technology to fabricate, build, and assemble mega column sections from the ground up a much smaller space and work on demand to regulate the building sway induced by wind (Discovery Communications). An all-weather automated construction system called "Big Canopy" (Fig. 3) was developed by Obayashi engineers and is already in use in Japan; this would facilitate the on-site assembly of column and roof sections. This system incorporates four major elements: 1) a self-rising, all-weather, temporary roof canopy supported on four hydraulic jacks; 2) a computer-operated hoist system with various cranes mounted against the roof; 3) a battery of high-speed construction lifts; 4) an automated management system that directs the flow of materials (Thai Obayashi; Wakisaka et al. 2000; Gassel 2005).

Most innovative about the Sky City concept is the open plateau system (Fig. 4); the mass is articulated vertically into 14 building clusters or rings, each of which is 180-feet high and surrounds an open, outdoor space larger than a football stadium; the vertical rings are separated by a 60-foot open air gap, making the building hollow. Massive space trusses would be used between plateaus to support the weight of the

levels above. The air gap between plateaus would allow noxious smoke to dissipate, quickly reducing dangers associated with fire. As soon as each plateau is finished, it would be habitable and people could move in while higher plateaus are under construction. The completion of each plateau would create an entire community with homes, offices, shops, cinemas, recreational facilities, etc. (Discovery Communications). Wind tests for Taipei 101 have shown that the buck-shaped skyscraper could create extreme wind conditions that would put the building at risk. Engineers had to reconfigure the building corners to a cutout "W" shape to deflect wind. The Sky City could generate much stronger winds, especially at high altitudes. The circular cross section and tapered profile, as well as the 60-foot, open-air gap between Sky City plateaus would allow wind to slip right past and through the building mass. Another innovative solution is the use of computer-operated, hydraulic piston dampers as a counterweight to reduce building oscillation with the wind. Ordinarily, it might need a fifty-million-pound counterweight. The automated power counterweight would occupy a much smaller space and work on demand regulating the building sway induced by wind. Rope free multi-decker elevators and high speed monorails traveling at 30 miles/hour would move thousands of Sky City residents horizontally and vertically throughout Sky City.



Figure 3: Big Canopy – Automated Construction System for High-Rise Buildings (Thai Obayashi, [www.thaiobayashi.co.th](http://www.thaiobayashi.co.th)).



Figure 4: Sky City Open air Plateau (Discovery Communications, [www.discovery.com](http://www.discovery.com)).

### The Shimizu Mega-City Pyramid

The Shimizu Mega-City Pyramid is a conceptual scheme for the construction of a massive, pyramidal open-air truss over Tokyo Bay in Japan (Fig. 5). The gigantic truss would be able to support the weight of two dozen eighty-story skyscrapers hung from critical truss joints. The structure would be over 3,000 feet high and would house 750,000 people. Its footprint would cover the area of 275 Tokyo city blocks (Discovery Communications). If materialized, it would be the first offshore city ever built and the largest man-made structure on earth. The Shimizu Mega City Pyramid is proportionately identical

to the ancient Egyptian pyramids (Eternal Egypt, [www.eternalegypt.org](http://www.eternalegypt.org)). However, it is 55 times larger than its ancient inspiration and “hollow,” lacking the unyielding appearance of the solid stone Egyptian pyramids. It bears more resemblance to the Luxor Hotel in Las Vegas, Nevada built in the mid 1990s with the exact match dimensions of the ancient pyramids. The Luxor Hotel (Fig. 6) has the largest glass-enclosed atrium in the world and serves as a dry run for the Mega City Pyramid. Wind tunnel tests for the Luxor Hotel showed that a dangerous vortex of wind usually occurs on the leeward side of the pyramid, causing a drastic drop in air pressure that could pull the heavy glass curtain



off the building. Engineers had to redesign the glass curtain attachments to withstand wind turbulences on the Pyramid surfaces (Discovery Communications).

Wind test results of the Luxur Hotel guided the exposed truss design of the Mega City Pyramid, which would be totally open to the elements, allowing wind to blow throughout the structure. This would drastically reduce wind impact on the Pyramid and improve the structure's ability to withstand powerful typhoons in the Pacific. Only habitable spaces within skyscrapers and circulation channels would be enclosed. Despite such an open truss design, the weight of the steel trusses of a 3,000-foot-high pyramid, 24 skyscrapers, and all other facilities that service 750,000 people would exceed trillions of pounds. According to the design scheme, the pyramid weight would be supported on 36 massive columns sunk in Tokyo Bay. Each column must be able to handle 50 million tons, which is more than 50 times the weight of the Golden Gate Bridge (Discovery Communications). The weight of the proposed structure is so large that it cannot be built with currently available materials. The Mega City Pyramid design relies on the future availability of super-strong, lightweight materials based on carbon nanotubes. These are nanoscale cylinders of carbon with a lattice of carbon atoms, each of which is covalently bonded to three other atoms. The structure of a nanotube can be imagined as a sheet of graphite rolled into a tube akin to a sheet of chickenwire. It buckles, but does not break and can be straightened back without any damage.

When perfected, carbon nanotubes are expected to be vastly lighter, stronger, and



Figure 5: The Shimizu Mega-City Pyramid Proposal in the Tokyo Bay; (Discovery Communications, [www.discovery.com](http://www.discovery.com)).



Figure 6: Luxur Hotel in Las Vegas, Nevada, the Largest Glass-Enclosed Open Atrium in the World (Source: Author).

longer lasting than steel. Mixing nanotubes with plastic and metal can give them extraordinary strength, creating a new generation of super-strong and super-lightweight composites that would make steel obsolete (Gasman 2006;

Poole et al. 2003). Construction logistics for such a giant building is beyond the capacity of even the most accomplished construction companies in existence. No cranes or hoisting mechanisms in operation today can jack these massive structural members into place. The design scheme calls for spider-shaped, robotic plants that would spin a web of massive trusses, transforming carbon and other materials into miles of support right on site.

Dante Bini proposed an air-induced hoisting system to lift millions of pounds of trusses into position. Bini spent a good deal of his career designing and building large, reinforced concrete domes, replacing cumbersome scaffolding with an air-lifting mechanism. In 1967, he laid out a large, inflatable membrane on the ground and topped it with a web of reinforced steel held in position by a network of high-tension steel springs. Almost 300 tons of wet concrete followed, which was covered by a second membrane to hold

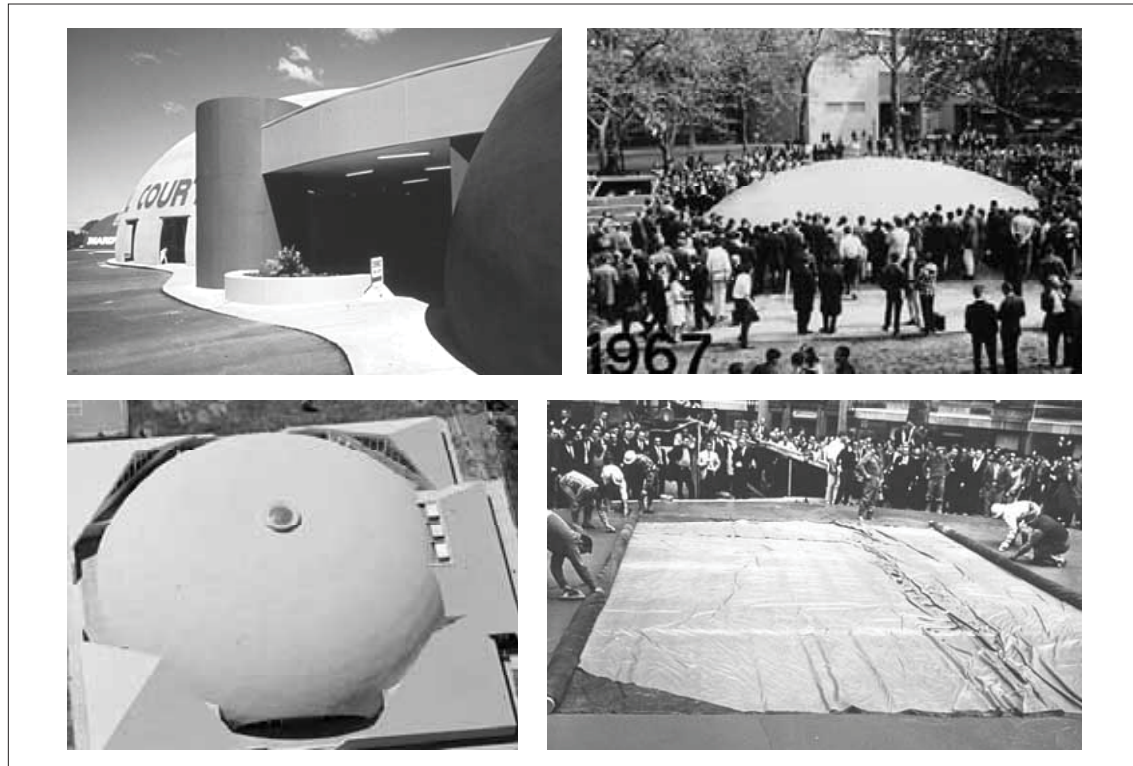


Figure 7: Binishell Domes during and after Construction in the United States and Australia (Dante Bini, [www.binissystems.com](http://www.binissystems.com)).

it in place. Defying structural logic at the time, Bini pumped air under the first membrane, and a large dome shell was shaped into place in less than an hour (Fig. 7). Following several successful attempts in the United States and Australia, Bini has built hundreds of such domes around the world. He proposed to use a similar system to lift the massive truss members of the Mega City Pyramid into position (Fig. 8). The idea is to build a square truss base on location and then connect the corners diagonally with telescopic expandable truss shafts that will be jacked into place by an inflated balloon placed underneath (Dante Bini, [www.binisystems.com](http://www.binisystems.com); Discovery Communications).

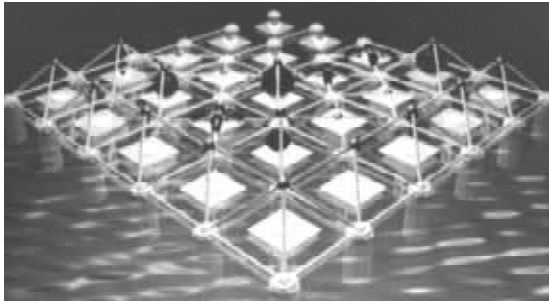


Figure 8: Using Bini's Inflatable Dome Method to Lift Trusses of the Mega City Pyramid into Place (Discovery Communications, [www.discovery.com](http://www.discovery.com)).

The most innovative aspect of the Mega City Pyramid design concept is its three-dimensional transportation system. The truss members forming the pyramid are hollow, with an internal space large enough to allow trains and cars to move freely between different parts of the city; structural members double as the city highways or subway tunnels. Trusses connect at hollowed

spheroid nodes, which would provide structural support and serve as transfer points for travelers (Fig. 9). Residents and visitors could also connect to an outside transportation system that carries them to the heart of the city of Tokyo (Discovery Communications). Transit options would include accelerating walkways, inclined elevators, and a personal rapid transit system where individual, driverless pods called "ULtra" would travel within the trusses. Heathrow Airport in London recently adopted the ULtra (Fig. 10) Personal Rapid Transit (PRT) to provide better access to its terminals. Each pod can fit four passengers and travels along guideway networks. Powered by an electromagnetic grid imbedded underneath guideways, ULtra is an on-demand, driverless car summoned to the rider location and not vice versa. It is an environmentally friendly form of transportation that saves more than half the fuel used by current private and public transportation systems (ATS, [www.atsltd.co.uk](http://www.atsltd.co.uk)).



Figure 9: Skyscrapers Hung from Critical Truss Joints which also Function as Transportation Hubs in the Mega City Pyramid (Dante Bini, [www.binisystems.com](http://www.binisystems.com)).





Figure 10: PRT (Personal Rapid Transit): ULTRA (ATS, [www.atstld.co.uk](http://www.atstld.co.uk)).

## Epilogue

Skyscraper building has been driven in part by the scarcity of land in congested urban areas, as in the cities of New York, Hong Kong and Tokyo. Higher land value renders a stacked-up office space a more efficient and economically viable solution; there is no where to go but up. However, the sheer size and spectacular height of skyscrapers engages people's imaginations, emotions, and memories. Once built, a skyscraper becomes a symbol for the place where it resides. The image of the Empire State building has come to represent New York City globally. The Sears Tower turned into a household name that epitomizes technological prowess and corporate power in Chicago. Considered the last great engineering achievement of the twentieth century and the tallest buildings in the world for several years, the Petronas oil company towers have become symbols for the economic success and arrival of modern Malaysia. They are a source of national pride and provide

Malaysians with a sense of accomplishment and reward for being the world's chief exporter of semi-conductors. Petronas Towers created a powerful image that forever will be associated with Kuala Lumpur.

The catastrophic collapse of New York World Trade Center Towers in September 2001 led some to predict the end of the Skyscraper Age. These predictions proved to be wrong; New York is rebuilding and when completed in 2010, the Freedom Tower will pierce the sky at 1,776 feet high, in a clear reference to the year of U.S. independence. Despite the recent Asian financial market crisis, the Shanghai World Financial Center is moving ahead and scheduled for completion in 2009. At 1,614 feet high, it is expected to be among the tallest in the world. Taipei 101, the tallest building in the world today (1,670 feet) is being challenged by Burj Dubai, which is expected to rise above the 2,000-foot mark. A spiraling, 115-story tower is on the drawing board and may be built along

Chicago's lakefront. This bold proposal comes on the heels of equally bold, but unsuccessful attempts, such as the famous "Skyneedle" of Cesar Pelli. The race is on!

The last hundred years have produced three different skyscraper styles. The golden age skyscrapers refer to those built before the World War II, such as the Woolworth, Empire State, and Chrysler buildings. These were unique structures with Art Deco ornamental references and iconic configurations. After World War II, the elegant, art deco skyscrapers gave way to the glass and steel box characteristics of modern architecture. The glass and steel box grew out of a strict interpretation of the modern dictum, "form follows function." The idea of exposing the steel and concrete members and removing any ornamental references or structural impurities was embraced as a requisite for good architecture. The Seagram building in New York epitomized this Skyscraper Age that was summed in Mies Van Der Roh's slogan "less is more."

The next generation of skyscrapers is referred to in different ways, such as postmodern, high-tech, ultramodern, etc. Advanced building materials and structural systems, as well as digital media, are fueling architects' imaginations and desire to test the limits and indulge in creating spectacular building configurations that can be described as steel and glass firework displays. Form and function have become somewhat dissociated. From helicoidal and spiral to sail-shaped, cantilevered configurations defying gravity, the tall structure is regaining its status as an icon and asserting itself as a symbol of culture and civilization. The Shimizu Mega-City Pyramid and Tokyo's Sky City visions revived

various twentieth-century colossal skyscraper ideas such as Antonio Sant Elia's Citta Nova and Frank Lloyd Wright's Mile High. They reenacted these ideas within an ultra modern framework that avails of technologies yet to be perfected. The scientific prowess that accompanies the Shimizu Mega-City Pyramid and Tokyo's Sky City visions coupled with the need for vertical space may eventually transform them into reality.

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## Mohamad Kashef

*Mohamad Kashef, Ph.D. He is assistant professor of planning and design, College of Arts and Sciences, East Carolina University, United States. He practiced architecture, urban planning, and project management with multinational consulting firms and construction companies in the United States, Canada, Egypt, and Saudi Arabia. Taught courses, seminars, and studios in urban design, history and theory of architecture and urbanism, and historic preservation. Assisted various cities and communities in the United States in the preparation of downtown development plans and urban design guidelines. Combined architectural and urban planning education and practice (BArch, MA, PhD). Registered Architect and Licensed General Contractor in Canada and the United States. Research is focused on introducing a balanced physical planning and design agenda that integrates both architectural and planning knowledge with an emphasis on sustainable practices. A special research interest in tall buildings and multi-use structures that integrate unique architectural configurations with innovative technologies and green solutions. Other design and research concerns include heritage and urban conservation within a global context. Participated in the revitalization and restoration efforts of the Historic Citadel District in Cairo, Egypt. He can be reached by email at [Kashefm@ecu.edu](mailto:Kashefm@ecu.edu).*