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Authors: Mir Ali, University of Illinois at Urbana-Champaign
Paul Armstrong, University of Illinois at Urbana-Champaign

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From Cityscape to Skyscape: The Changing Character of Cities

Mir M. Ali
Paul J. Armstrong

School of Architecture
University of Illinois at Urbana-Champaign

Abstract

Urban centers throughout the world are influencing the design of the supertall building as a "city within a city" and a "city in the sky." The future of cities world-wide points to exponential growth in developing countries and diminished global resources such as land, water, non-renewable forms of energy, among others. The trend is for cities in proximity to grow together and become megacities with large, dense populations. Today's megacities are overcrowded, environmentally stressed, their land prices are skyrocketing, and their infrastructures deteriorating. Skyscrapers shape the identity of cities and the urban landscape, extend the scale of the cities, and transform the panoramic view of the urban skyline. The supertall building is so designed that activities of the street and the city's infrastructure are extended vertically into its structure. Architects and urban designers recognize that the diffusion of activities between the skyscraper and the urban fabric is a constant reality. A comprehensive design process for supertall buildings involving collaboration among architects, engineers, planners, and other professionals involved in their planning, design, and construction is needed to identify all essential principles that unify them into a coherent design based on the contextual strategies of urbanism and principles of sustainable design. With increasing population density land-starved megacities of the future that are economically prosperous will have no choice but to build multi-use megastructures that will act as vertical cities.

Introduction

Megacities with a population of 10 million or more are a relatively recent phenomenon. The world is rapidly urbanizing as people from rural areas continue to move to the cities. This is happening more in the cities of the developing world. The challenge in designing the new cities of today and the future is accommodation of large populations while creating a higher quality of urban life. Planning for the increase in population is an intricate task, considering that problems such as pollution, urban sprawl, and exploitation of natural resources are non-reversible outcomes of poor planning.

With the advent of the globalized economy, the role of the advanced industrial metropolis is changing as former manufacturing centers become knowledge centers. This transition from production to knowledge will continue because as technology is advanced and as instantaneous worldwide communications become more widespread, more industrial and cultural activities will be rationalized and restructured on an international basis (Knight, 1986).

Energy consumption can be reduced overall through sustainable urban design. Dense cities are more energy-efficient than cities with lower densities and more urban sprawl. There is more energy exerted and money spent to sustain a city that is larger in size. By making a city smaller and denser the power grid becomes smaller, making the transfer of electrical energy more efficient. The need for automobile transportation, which is a large contributor to the problems of energy consumption and pollution, thereby declines.

Cities will continue to grow given population increases. The question is whether cities can be planned to accommodate the changes incurred by their expansion. Of course, some cities in the West are not growing because of their declining population. Growth is not something that can be stopped, but can only be controlled and influenced. Despite the global and local effects, cities will always thrive and continue to exist. The cities that will thrive will be the ones best prepared to deal with growth. Tall buildings and megastructures, through their attribute of agglomeration, are the likely solutions to the problem of population density that major cities will face.

Urban Design, Urban Growth, and Tall Buildings

Urban design is the study of how cities have achieved their physical form and the processes that go into renewing them (Cuthbert, 2006). It concerns the arrangement, appearance and functionality of towns and cities, and in particular the shaping and uses of urban public space. It has traditionally been regarded as a disciplinary subset of urban planning, landscape architecture, or architecture. However, with its increasing prominence in the activities of these disciplines, it is better conceptualized as a design practice that operates at the intersection of all three, and requires a good understanding of a range of others, such as urban economics, political economy, and social theory. Urban design is not merely the art of designing cities, but the knowledge of how cities grow and change. As such, it constitutes the study of how civilizations have chosen to represent themselves in spatial form, and the processes through which specific forms come about. Ultimately, urban design is about the transmission of urban meaning in specific urban forms. It examines how the spaces we inhabit are replete with symbolic values, collective memory, association, celebration, and conflict. The design of cities has been going on as long as civilized life has been in existence. Many ancient civilizations, such as that of the Greeks, had component parts that were used in organizing social space including the *agora*, the *polis*, the theater, and the stadium. The Greeks, as well as other cultures, used the gridiron to organize the city into streets, public squares, and urban blocks. Urban form had to pay some respect to nature, both in the organization of social space and in domestic architecture; therefore, cities evolved in accordance with certain natural laws in regard to location, climate, defense, and other considerations. Beyond that point, functional, economic, political, and religious factors generated enormous complexity in the way cities developed and worked.

Real knowledge of the social organizations of cities did not occur until the development of modern social science in the nineteenth and early twentieth centuries. While the physical attributes of the city were understood, the analytical theories of social thinkers such as Karl Marx (*Das Capital*, 1894), George Simmel (The *Philosophy of Money*, 1900), Sigmund Freud (*Civilization and its Discontents*, 1930), and Max Weber (*Economy and Society*, 1968) demonstrated that urban life in its full complexity could be explained only through “the invisible web of economic and social processes” (Cuthbert, 2006). This also led to a new concept of the public realm linked directly with emergent concepts of the modern world. The inception of urban design as a social process was viewed independently from architecture, but also something different from town planning, which had not become institutionalized until the establishment of the Royal Town Planning Institute in London in 1914. Architects continued to see cities as an extension of building design well into the twentieth century, with little or no recognition of the added complexities involved in urban structure.

The tall building is the quintessential modern building type. Consequentially, it is associated directly with the modern city, which often has made it the target for criticism of modern urban planning and design.[1] To some degree, architects have been complicit in their desires to put incompatible functions, such as low income housing, into tall buildings, or designing tall buildings with little regard to the real forces that shape culture, climate, and context. Today, many tall buildings are being designed with performance-based criteria rather than form or style as their primary *modus operendi*. After nearly a century of thinking of the city in formal terms as a collection of building components that could be manipulated and arranged aesthetically, architects are finally coming to terms with the reality of the complexity of the city and that their education, while comprehensive, is insufficient to address its exigencies fully. Consequently, architects, urban planners, social scientists, and others have allied to address the intertwined issues of planning, design, economics, social effects, and the like through careful analysis in order to yield a more balanced and comprehensive approach to urban design.[2] Furthermore, the role of tall buildings has taken on new dimensions as they become more integrated into their urban fabrics. Their capacities to affect the environments inside and outside the buildings themselves, as well as their enormous scales, have led to new sustainable paradigms in designing skyscrapers and cities interdependently (Beedle, Ali, and Armstrong, 2007).

Cities generally develop at a site with favorable agricultural conditions and dependable water supply and at a transportation interface. This interface in early times was a natural crossroads for trade routes, a protective bay, a mouth of a river, or similar location. Frequently the agglomerations developed for defense purposes and then grew due to the mechanization of agriculture. The location of some vital resource and its distribution also was a determinant for the location of people and their activities. The availability of transportation and, in later times, communication facilities, is an important determinant. The function of cities includes social, economic, political, and technical activities. Their elements incorporate religious, residential, employment, administrative (government), educational, entertainment, and commercial activities. Cities also provide other urban services such as communication, transportation, sanitation, security, fire protection, health, and welfare.

The ability of a city or community to support and sustain its current population and anticipated growth is directly related to its infrastructure of transportation (streets, roads, and public transport systems), utilities (water, gas, electric, sewage), and services (garbage, waste removal, maintenance). If the infrastructure is too small it cannot sustain added burden as the city grows in area and population. On the other hand, if it is too large then it is too costly to maintain relative to the populace or geographic area that it serves. Good planning involves predicting and coordinating urban growth with its infrastructure system so that they can grow incrementally together over time. The two most important issues governing where we live are housing and employment. The availability and affordability of housing determine the area of the city in which we live based on housing types and its costs. For many people, home ownership is not possible so they must rent. Consequently, cities must encourage development of affordable rental units of varying scales to accommodate the diverse needs of individuals and families.

Many new urban dwellers find their way to the city to work and to the suburbs to sleep. The move from farm to town by many was simply because of the attraction of the urban center and suburbia. Few aging suburbs have the mechanism within them to establish sub-cities. They will always be dependent upon the adjacent urban center. But as they grow and particularly as energy considerations require concentrations, high-rise buildings can develop in suburban centers at such central areas either to relieve congestion in large metropolitan areas or, as in the case of a less developed country, to direct growth of an existing urban area to another one thereby transforming its character in a preplanned manner. Various types of new settlements can arise. These have been identified in four categories as follows (Beedle, Ali, and Armstrong, 2007):

1. Type A. Dependent on a mother city
2. Type B. Independent, at least with a respect to employment
3. Type C. Expanded towns originating from a small urban development
4. Type D. Special function such as a new government center (Cities such as Brasilia, Putrajaya, and Islamabad are examples.)

Satellite Cities: This “Type A” new settlement is dependent to a greater or lesser extent on the mother city. A suburb expanded into a town is an example where transport and communication links are particularly strong. Examples abound in areas surrounding major metropolitan cities in the U.S. They are part of a larger agglomeration known as a conurbation, which comprises number of cities, towns, and villages that have physically merged to from one continuous built-up area. It is thus a polycentric form of agglomeration.

The successful new towns of the future in this category will not be designed according to the older “bedroom community” idea but more for totality of urban living—such as those in Singapore and Hong Kong. For such a program to be successful, three things seem to be essential. First, good communication with the old urban areas is necessary to provide continuity with the existing urban context. Second, the housing in the new towns must be accompanied by a full ration of what is essential to modern life. Third, there must be work; and appropriate sites for private, commercial, and residential development are necessary. These satellite towns, in fact, must be self-contained.

Junction Cities or Perimeter Centers: A special category of the satellite city is the usually unnamed settlement that arises at major arterial highway interchanges. They are prevalent in the U.S. and are characterized by the development, first, of service station facilities then followed by motels, then by high-rise hotels, and eventually office developments. They have a focus and an origin that is identical with that of the earliest cities: an intersection of “trade routes.”

Independent New Towns: These “Type B” settlements were initially conceived in the classic tradition of the garden city movement. Although they are influenced by a large urban area, transport and communication links with this older settlement are deliberately kept weak. They should be a mechanism of particular interest to urban and regional planners in developing countries to relieve the extreme load on the major urban settlements. It is not at all clear what the role of tall buildings will be in such new communities. But the strong likelihood is that the planning of such communities should consider the tall building as an alternative and anticipate the possibility of their later imposition when considering the design of the urban services.

Expanded Towns: “Type C” expanded towns originate from some nucleus of existing urban development. Some are truly independent and others are dependent on a large metropolitan area nearby. In the U.S. during the early 1980s one of the most significant urbanization trends was the increase and growth of these existing urban settlements rather than the move from farm to city. Many of the new inhabitants came from major cities, or suburbs, so that they are already accustomed to urban life. It is suspected that in most cases these small urban settlements will go through a very intense form of crowding followed by the necessary remodeling. Regrettably, most such jurisdictions are not at all equipped to handle the necessary planning function.

Special Function Communities: A government may decide from a purely national development standpoint to locate a “Type D” city at a particular location. Brasilia is a case in point in which a decision was made to locate the capital as closely as possible near the geographic center of Brazil. The record of success in such communities is not at all clear. Obviously the design of Brasilia itself featured prominent high-rise development, although done on such a massive scale with particularly large, open areas that the community was completely dependent on the automobile for transport. Thus, it can hardly be described as a typical community. The role of the tall building is yet unclear, but should certainly be taken into account in any such future development plans. Putrajaya was established near Kuala Lumpur as a seat of the central government. Likewise, Islamabad in the vicinity of Rawalpindi was established as the capital city of Pakistan. Eventually these two cities have merged with each other.

Slums and Squatter Cities: Another category that can be added to the list is the so-called "squatter city"**.** As cities grow they become mega-cities and attract large numbers of people seeking opportunity. Many cities, particularly those in developing nations, are growing at extraordinary rates that outpace urban and infrastructure planning. Many of their new residents reside in "squatter cities," that is, cities-within-cities that are unregulated and do not enjoy the support services provided to other residents of the city. The result is the development of slum-like living conditions exacerbated by unemployment, overcrowding, a lack of sanitation, and substandard housing.[3]

This was the case during the nineteenth century, when large numbers of people were attracted to cities for employment in factories. There were virtually no regulations governing the environmental effects of industry or the health of the city's inhabitants. Working class people who were crowded together in slum-like conditions provoked an outcry among reformers regarding the substandard living conditions. Eventually, laws were enacted that separated industrial zones from residential neighborhoods, regulated sanitation and public health, and upgraded the urban infrastructure including sewage treatment, potable water, and transportation services.

The Skyscraper Phenomenon

Skyscrapers began in an elementary form in Chicago with the Home Insurance Building designed by William Le Baron Jenny in 1885, 14 years after the Great Fire. They subsequently developed in New York City where the limitations of buildable space and soaring real estate prices mandated construction of elevator buildings of exceptional height. The Bessemer process ushered in light-weight steel-frame construction, which could be clad in fireproof materials on which the exterior sheath could be hung like a curtain. Clients and architects, including John Wellborn Root, grasped in their mass and proportion "an idea of the great, stable conserving forces of modern civilization" (Kostof, 1991).

Unlike ancient or historical cities, which typically had few distinctive vertical landmarks, the modern city is a collage of vertical spires, monuments, and forms that compete with one another for dominance on the urban skyline. Likewise, the field of vision of skyscrapers spreads out for miles and can be viewed from distant vantage points well beyond the city.

The intensification of the American Central Business District (CBD), which began in the nineteenth century, has created a "forced density" of skyscrapers in a fairly restricted area (Kostof, 1991). This densification has also comprised the individual integrity of the tall building and its iconic status. As a practical matter, the high-rise building had to function within the fine-grained checkerboard pattern of the American city. Although it was originally conceived as a free-standing tower that could be viewed from all sides, the skyscraper became embedded in its urban block and forced to function as space-defining, rather than mid-space, masses.

Until recently, skyscrapers had been an American phenomenon. Today, skyscrapers can be found in every major city throughout the world. While modern architects such as Le Corbusier and Mies van der Rohe embraced tall buildings, European cities resisted building skyscrapers in the early and mid-twentieth century. Europeans took great pride in preserving the historical character of their cities and the skyscraper in particular was viewed as an interloper. Eventually skyscrapers were built in European cities beginning with Germany and London. Typically, they were permitted only on the periphery or in areas that had been devastated by bombing during World War II. Today tall buildings are more widely accepted and restrictive zoning laws and building codes have been enacted to regulate height, natural light and ventilation, as well as their environmental impact and energy consumption. In the U.K., for example, tall buildings are undergoing a revival that would have been unthinkable a decade ago. In addition to London, cities like Birmingham, Liverpool, and Manchester have new high-rises and other cities like Leeds, Sheffield, Brighton, etc. are considering viable options in this regard. Similarly the city of Dublin in Ireland is considering the construction of tall buildings as a result of its increased population and economic prosperity.

By contrast, Japan, Hong Kong, Singapore, Malaysia, China, and parts of the Middle East have fully embraced tall buildings. Japan, Hong Kong, Singapore, and China have large numbers of people living in dense cities where building towards the sky is the only option. In the Middle East, countries such as United Arab Emirates and Qatar are building entire cities in the desert comprised of tall and supertall buildings. Amman is considering a number of high-rise proposals at this writing. Tall buildings have always had a prestige factor and represent nations and economies that are vibrant, progressive, and modern.

Urbanism and Demographic Issues

In 1975 when the United Nations Population Division created the term "megacity" there were only five megacities in the entire world. With the emergence of 17 megacities in the past three decades it is very apparent that these large cities are to be the homes of a large percentage of the population in the future. The megacities are present in both the developed and the developing countries: Tokyo, Mexico City, Seoul, New York, Sao Paolo, Mumbai, Delhi, Calcutta, Dhaka, Los Angeles, Jakarta, Cairo, London, etc.

Pollution, city planning, crime, infrastructure, and energy consumption are universal problems in cities whether they are of 10 million or 100,000 inhabitants. These issues only become multiplied in megacities. According to the United Nations Population Division, by the year 2030, five billion people will live in urban areas throughout the world (United Nations, 2002). By 2050 Asia will account for 61% of the world's population. Cities such as Tokyo, the largest city in the world, and Hong Kong, Shanghai, Mumbai, Jakarta, Seoul, Dhaka, etc. are major contributors to that statistic. Most of Asia, aside from Japan, is still developing compared to the industrialized world. There is a trend in population growth in developing countries that is severely affecting the world population. Due to social, cultural and economic factors growth in developing countries is much more rapid than in industrialized countries. The Population Division of the United Nations has also predicted that the urban population will grow by 75% by the year 2050. This means that not only is the world population growing but also that the percentage of people living in the city is increasing even faster. Population issues are not characteristic of only developing countries—they are also present in developed countries. Some developed countries experience population issues because of geographical constraints encouraging inflow of migrants.

The statistics show that the population will increase and continue to do so. As the population increases dramatically it is clear that planning needs to be implemented as soon as possible to account for the rapid growth. The statistics also show that most of this increase will be absorbed by the cities of the world, many of which already have overwhelming problems. City planning and government action will help ensure that these cities will better be able to accommodate the population growth. Infrastructure, mass transportation, energy consumption, and pollution control head the list of problems facing cities today and in the future these problems will only multiply.

It is the government that plays the largest role in planning for future development and controls form of cities through zoning laws.[4] Utopian examples have shown great importance on the city planning and zoning of cities. Most of their premise is based on a specific master plan. However, these utopian cities have been designed contradictory to the way most cities have developed over the years. Though it is financially improbable that any of the current megacities of the world be completely overhauled to conform to one of these plans, zoning can be enforced on new development and it should be done in coordination with restrictions on sprawl.

There are limits to the rate at which the human population can draw from planetary sources and limits to the rate at which planetary sinks can absorb the wastes and pollution created by people. Unlike the growth of industrial metropolises, which was based on natural advantages of resources and location and was accidental in nature, development of the advanced industrial city depends on human-made advantages and must, therefore, be of a deliberate nature (Knight, 1986). Sustainability involves staying within these limits on a local, regional, and global scale. Megacities, as cities of the future, should be planned consciously accounting for environmental concerns to preserve the natural resources and provide for smart, sustainable growth.

Environmentally Responsive Approach

According to Lynn Beedle (1975), if the tall buildings are "good" (i.e., suited to the urban habitat for which they are designed) the urban environment is improved. If they are "bad," hardly anything can be done to improve the city. So when we say "good" and "bad," in connection with skyscrapers, we do not mean the structure alone, or the architecture alone. Most important, it is about "planning and design" of buildings in a large context.

There are other factors that also must be considered as cities grow. Great urban spaces designed for pedestrians should be preserved. The "memory" of the city should be maintained through its monuments and the urban environment in which they reside. The zoning of cities into segments, each containing the necessities of day-to-day life, should always be encouraged. Le Corbusier's Unite d'Habitation of 1952 in Marsailles, for example, has a deck of shops, a supermarket and a hotel halfway up, a school, a gymnasium, and other facilities on the roof. However, its 337 apartments are not really at a scale to sustain a supermarket or even a great variety of shops (Broadbent, 1990). On the other hand, there are many problems that must also be addressed, particularly with regard to housing and the economic disparity between the rich and the poor, especially in the developing world. Self-built housing and communities occur spontaneously at the peripheries of highly urbanized areas. In cities like Brasilia and Chandrigarh (in India) such developments often have a far greater vitality than anything that has been formally planned. In many cases, having built a basic dwelling the "owner-occupier" then begins to build around it concrete block walls, asbestos cement roofs, and so on. This "hardening" process seems to be occurring everywhere in the emerging world as the shanty-dwellers build up their resources (Broadbent, 1990). The solution, however, is not to warehouse people in substandard government-supported housing, but to find acceptable and humane solutions appropriate to each city. Multi-use megastructures may once again need to be considered as an acceptable approach to meeting the needs of population increases and urban density worldwide.

There are the internal environment and the external environment for a tall building. Is it planned and designed to account only for "tallness"? Beside the normal concerns that apply to all buildings, this can cover such things as (a) vistas and views from windows and balconies and associated orientation with regard to adjacent buildings, (b) internal courtyards and access to individual units, (c) creation of a "sense of place" both for the internal regions and for individual units, (d) tallness criteria as regards occupancy category, and (e) a consideration of life style of those who are perhaps not yet accustomed to city living.

The tall building is part of the urban system, a system whose quality it creates. This comprises the external environment. Thus, the planning and design must necessarily include not only structure and architecture, and the adjacent buildings and street space, but also the interface with people's interest at the street level (first floor shops and amenities), with the transportation system (whether by foot or by aircraft), with business and residential activity, with the cultural life of the city at its center, with the basic urban services of power, sanitation, water supply, and even with the "impact" of the skyscraper on the cityscape from outside the city walls (Beedle, 1975).

The characteristics of a bioclimatic, humanist approach in tall building design offers some guidelines for the design of "people centered architecture." Bioclimatic design addresses the relationship between climate and life (particularly the health and activity of human beings), architectural form, and its environmental performance with respect to climate and minimizes dependency on non-renewable resources (Yeang, 1996). The aims and rationale include the lowering of financial and energy costs over the life cycle of building, beneficial effects on occupants (such as access to natural light and ventilation), and a regionalist approach to design.

Many architects, engineers, and planners believe that large and densely-packed tall buildings that are apparently "un-ecological" and large consumers of energy, if properly designed and constructed, can represent an essentially sustainable or green form of development. Skyscrapers are not only utilitarian building forms but they can also be made "more environmentally sustainable" than smaller buildings.[5] That is, they can actually minimize negative impacts on the environment while protecting the health of their occupants. To achieve these goals, building professionals are increasingly resurrecting strategies that were routinely employed in smaller structures in the past, such as natural ventilation and shading devices to reduce heat gain, and adapting them to larger and more complex buildings. Meanwhile, they are exploiting new technologies, from solar power cells to sophisticated wind turbines, to create a new breed of large-scale buildings that are both comfortable and environmentally benign.

The World Commission on Environment and Development (WCED, 1987) otherwise known as *The Brundtland Report* defined sustainable development as that which "meets the needs of the present without compromising the ability of future generations to meet theirs." Some view sustainable development as primarily an economic problem, with solutions relying heavily on the market mechanism and increased productivity. Others are more critical and point out that market forces alone are insufficient to address the disparities between industrialized and developing nations (Cuthbert, 2006). The point here is that the design of buildings and cities is only part of the equation when we consider the broader issues involved in developing sustainable societies and resource management.

Megacity-regions can become more sustainable by adhering to policy recommendations offered by "smart growth" advocates. These recommendations include (1) concentrating developments in selected areas at very high densities; (2) preserving open space, farmland, natural beauty, and critical environment areas; (3) setting up polynucleated or multinodal human settlements in a regional context; (4) providing a variety of transport options; and (5) involving citizens, civil society groups, the private business sector, and government agencies in the formulation, adoption, and implementation of smart growth policies and strategies (Smart Growth Network, 2003).

Megacities

There is common agreement among development theorists that the governance of mega-urban regions is the key to making them more livable. Governance may be defined as "the mechanisms, processes, and institutions, through which citizens and groups articulate their interest, exercise their legal rights, meet their obligations, and mediate their differences" (Ruble, Tulchin, and Garland., 1996).

In December 1998, *Asiaweek* published a special report on the "quality of life" in forty Asian cities. It ranked the "livability" of these cities according to various criteria, such as economic opportunity, environment and sanitation, health care, transportation, personal security, housing costs, and leisure. Among the cities of Asia, they ranked Tokyo as number one in livability, despite its problems with affordable housing, garbage disposal, and environmental pollution. Ranked second and third were two other Japanese cities, Fukuoka and Osaka (Choong, 1998).

Average per capita income was the main factor correlated with a city's ranking. Tokyo's per capita annual income of $51,374, Osaka's of $39,271, and Fukuoka's of $24,548 clearly outranked the incomes of all other Asian cities. The lowest ranked city according to the income criterion was Yangon (formerly Rangoon) in Myanmar (formerly Burma), with a per capita income of $66. On the other hand, the sizes of cities affected livability and governance in an inverse manner. Among the top ten cities, only Tokyo and Beijing were megacities with populations in excess of 10 million, whereas the seven top-ranked cities were quite small (Laquian, 2005).The survey also identified the key elements of good governance (Choong, 1998):

1. *the rule of law*, or legal frameworks that are fair, predictable, and equitably enforced;
2. *transparency*, or the free flow of information that enables members of the society to understand and monitor the institutional processes affecting their lives;
3. *effectiveness and efficiency* in meeting needs through the best use of resources;
4. *accountability*, wherein decision makers (in government, the private sector, and citizens groups) answer for their actions to the citizenry.
5. *responsiveness*, the ability and willingness of leaders and administrators to serve the interests of stakeholders;
6. *consensus*, which takes the form of mediating different aspirations through conflict resolution, bargaining, and compromise to reach agreement on what is in the best interests of the community;
7. *equity*, which involves opportunity for all men and women to improve their well-being; and
8. *strategic vision*, a long-term perspective on what is needed for the society to grow and flourish in a sustainable way.

A *metropolis* is meant to be the chief city (but nor necessarily the capital) of a country, state, or region, but is often loosely used to refer to any large city. The term *city* is essentially a political designation, referring to a place governed by some administrative body or organization. As cities have grown larger, they tend to coalesce, or merge together, in the more congested parts of the word where many cities are located. Patrick Geddes (1915) observed more than seventy years ago that groups of cities were forming what he called “conurbations.” “Megalopolis” was the name urban geographer Jean Gottmann (1961) gave to a continuous urbanized strip linked by a transportation corridor. *Conurbation* and *megalopolis* both mean essentially the same thing: they both represent expansion, that is, the spatial merging (but not necessarily the political merging) of two or more cities along major transportation corridors, the former term referring to urban growth, for example, around London and the later defining the merging of cities such as along the eastern U.S. from Boston to New York. A *superconurbation* is simply a giant conurbation or megalopolis with a population of around 12 million. Eventually, conurbations will likely join megalopolises to from a *world ecumenopolis*, in which many city clusters in different regions will join with other agglomerations in a sort of vast interconnected continental-wide megalopolis (Brunn and Williams, 1983).

Between 1970 and 1990 the number of cities worldwide with a population of over five million grew from 8 to 31, of which 21 are located in Asia. New approaches to building cities on a giant scale are constantly emerging. The days of singular solutions setting patterns are over. A positive exchange of ideas will occur resulting in their blending. These experiments of creating “cities in the sky” have occurred both in the East and West and will continue. There are well established cities where the population is less than this but is rapidly approaching megacity scale of 10 million.

The first large city in the modern era was Beijing, which surpassed one million population around 1800, followed soon after by New York and London. But at that time city life was the exception; only three percent of the world’s population lived in urban areas in 1800. The advent of industrialization spurred relocation to urban centers from the nineteenth through the early twentieth century. The cities had employment opportunities, and new arrivals from rural areas provided the factories with cheap, abundant supply of labor. But the cities also became unhealthy places to live because of crowded conditions, poor sanitation, and the rapid spread of infectious diseases.

The cities of the western nations underwent the fastest urban growth. New York, London, and other western capitals were magnets for immigration and job prospects. In 1950, New York, London, Tokyo and Paris boasted of having the world’s largest metropolitan populations followed by Moscow, Chicago, and Essen, Germany. By then, New York had already become the first megacity, with more than 10 million people. However, soon after this many American cities began to level off or shrink while population around the world was growing dramatically. Growth of megacities shifted from the industrialized western countries to the developing countries.

The rise of megacities poses formidable challenges in health care and the environment, in both the developed and developing world. The urban poor in developing countries live in slums with deplorable living and sanitation conditions. The megacities of the future pose huge problems for waste management, water use, and climate change as well as socio-economic problems. Megacities are likely to be a drain on the Earth’s decreasing resources, while contributing to environmental degradation.

It is worth reviewing some of the megacities, because daily life there is likely to be typical for a majority of the world’s cities. Such a review has been presented in Beedle, Ali and Armstrong (2007). Most megacities are already facing severe environmental challenges that will only get worse by rapid population growth. There are about 24 megacities as of this writing–-a number poised to increase in the near future—with Tokyo having the largest population of 34 million and Lagos and Beijing tied with a population of 11 million at the other end of the spectrum.[6]

Megastructures and Futuristic Proposals

Megastructures can be viewed in simple terms as extremely large buildings. These visionary structures have been proposed by both architects and engineers since the nineteenth century. Although the megastructure concept has not fared well in recent years, it is difficult to imagine that the megacity of the future will not exist without megastructures of some type. Megastructures are generally characterized by two high-density urban conditions: a massive, even monumental supporting frame; or alternately, various arrangements of habitable containers that are added without virtually any constraining limits (Banham, 1976).

The early history of megastructures starts with the industrial revolution, when the technological and scientific developments in materials, structures, and construction methods proved that such buildings can exist. The term "megastructure" evolved during the 1960s with metabolist movements, but the concept of a tall building becoming a city in the sky is a product of the industrial age. Many megastructuralists saw their task as being the proposal of "urban structures of the future" in which a modern, high-technology society could construct its own equivalent of spontaneous group form by natural accretion and reconstruction (Banham, 1976). The resulting megaforms were the dominant visionary concept of urbanism and architecture in the 1960s (Schueller, 1990).

From the mid-1950s, and for almost twenty years, the idea of an urban area as a large, interconnected building dominated much architectural thinking about cities. Its modern genesis is Le Corbusier's Fort l'Empereur project from his Algiers plan of 1931. His drawing shows a curving, massive sub-structure of an elevated super-highway, surmounted by two-story houses (Banham, 1976). Visions of the city as a gigantic structure were almost always tied to a future in which the imperfections of modern cities would be swept away by the force of new technology. Two of the first technologies that were to suggest development ideas on the scale of the city were greenhouse structures made entirely of metal and glass, and the streetcar, which was easier to incorporate into city design than the steam-powered railroad train (Barnett, 1986).

Joseph Paxton's metal and glass Crystal Palace, constructed in London's Hyde Park for the Great Exposition of 1851, for example, was a greatly enlarged version of the greenhouses, train sheds, and shopping arcades designed by Paxton and other architects during the nineteenth century. The scale of the Crystal Palace and the speed with which its modular construction was carried out became harbingers of modern construction practices based on prefabrication and kit-of-parts components. At a scale of 1,848 ft. (495m) long by 408 ft. (136m) wide, with a central transept 72 ft. (24m) wide and 108 ft. (36m) high, it was essentially an enclosed city nearly a third of a mile long with buildings on both sides.[7]

The Unite d'Habitation represented Le Corbusier's portrayal of whole urban neighborhoods as gigantic buildings. It had tremendous influence on other architects, particularly in Great Britain. Alison and Peter Smithson's 1952 competition for housing at Golden Lane in London, for example, took Le Corbusier's upper-level street of shops inside the Unite and elaborated it into a concept of streets in the air, interconnecting linear buildings to form a sub-district of a city.

Moshe Safdie's Habitat, designed for Expo 1967, the world's fair held in Montreal, was the first occasion for a large public audience to see megastructural city-design ideas in built form. Habitat consisted of prefabricated concrete apartment capsules that were hoisted into position on a reinforced-concrete armature. The capsules were neither standardized nor removable; as they helped support one another. Resembling the picturesque qualities of a Mediterranean hilltop village, the high cost and idiosyncratic character of Habitat made it prohibitive as a prototype for residential construction.

Paolo Soleri is regarded as the most persistent and persuasive voice among megastructuralists. He represented most forcefully in words and designs the desire to stop the persistent tendency of the human race to spread. The characteristic hollow-shaped towers of Soleri's mid-1960s Arcology style are often accompanied by more conventional megastructures (Banham, 1976).

The primary purpose of the megastructure was to create a vast increase in density within the confines of the existing city. However, greater mobility and economic prosperity in industrialized countries have promoted the development of suburbs facilitated by highways and the automobile. Practical problems have also prevented realization in the past of the megastructure as a prototype for the future city. Real estate forces alone make it impractical to build structures for hundreds of thousands of people in just a few years. The unique structural framework of the megastructure, a new element not required by conventional buildings, is required at the onset to hold up the equivalent of many conventional buildings in a single structural form. Many megastructure concepts were based on moving entire building elements from one location to another, rather than simply moving people. However, the megastructure as a concept can serve as an orderly and efficient means of city growth. But taking a building it up to the scale of a city can actually create enormous inefficiencies. The following urban structures that were proposed in the past point to the difficulties associated with them for implementation.

Cite de Refuge (Le Corbusier): Based on the charitable and reformist principles of the Salvation Army, the program for the Cite de Refuge of 1931 combined overnight accommodation for men and women, a children's crèche for single or married but working mothers, a canteen for inmates or casual visitors, and ateliers for technical training. Since it had no architectural precedent, Le Corbusier set out to create "a new mechanism for generating light, space, greenery, human well-being, and moral uplift" (Curtis, 1986). The Cite de Refuge combined the concept of a universal modern architectural style with the modernist theory of planning, which imposed a new kind of uniformity on city design, with orientation and sunlight, rather than streets and courtyards, determining architectural form (Barnett, 1986). Consequently, the slab-like building with its south-facing curtain wall and factory aesthetic assumed the appearance of "a Panopticon for improvement." Yet despite its flaws, it was also innovative employing a double-glazed facade for heating and ventilation.

Unite d'Habitation (Le Corbusier): Le Corbusier's Unite at Marsailles, completed in 1953, was a chance to demonstrate his theory of a "vertical garden city" for an society (Curtis, 1986). It provided concentrated, high-density living, liberation of the ground for nature, and light, space, and greenery for the inhabitants. Its mixed-use program includes residences, shopping, entertainment, and a kindergarten on the roof. The rectangular, slab-form of the building is angled to the street so that its longitudinal axis runs exactly north-south. Each apartment has double exposure and so it could enjoy morning sun and view of the landscape to the east, with evening sun and views of the sea to the west. *Brise-soleil's* (sun screens) are used on the facades and the depths calibrated according to the sun angles and seasons. Le Corbusier compared its structural concept to a bottle rack in which standardized double-height living units could be inserted. The Unite is raised above the ground on massive *pilotis*. Le Corbusier used reinforced concrete, rather than steel, to express a more archaic character and also to accommodate differences in craftsmanship during construction. Roughness, therefore, became an aesthetic virtue.

Archigram: Archigram, started by Peter Cook in London in 1961, came as a revolutionary group of architects who set to undermine the established notions of architecture, particularly of city planning (Cook, 1999). *Archigram I* chose to bypass the decaying Bauhaus image, which was considered an insult to Functionalism. Much more important to the group was the dissemination of information, a way of telling students and young architects about all the extraordinary and the unthought-of in the academic and professional worlds. Their rhetoric seemed to send a generation in search of machine/city analogies, both functional and visual. Some of these analogies were powerfully direct, such as Hans Hollein's proposals for buildings designed like giant Rolls Royce radiators and turbines in Lower Manhattan (Banham, 1976). Some of the group's projects are as follows.

City Interchange (Warren Chalk and Ron Herron): Chalk and Herron proposed a "communication interchange" complex which utilized node points at strategic locations for "static and motivated" communication. Their "public transit interchange" system called for a combination of local light rail trains and "linear induction motor-propelled trains" for long distance and inter-regional rapid transportation. Some noteworthy features of the proposal included:

- Inter-city electric underground ring;
- Sub-underground inter-center links and outer metropolis commuter services;
- North/south and east/west communication crossover and interchange networks for feeder roads off express trunk routes skirting the metropolis;
- Mass transit express bus turnabouts;
- Long- and short-term underground parking for cars and buses;
- Heliport and hovercar station connecting to a supersonic air travelport on the perimeter of the outer metropolis;
- Services provided by a line control station for inert-regional distribution;
- High-speed vertical lift interchange links for pedestrians located within an interchange station amenity arena;
- Horizontal low-speed travelator and escalator arteries radiating outward to the periphery;
- A static communications control center;
- Towers containing services suspended from central masts; and
- Tower groups containing electronic data transmission, traffic control and administration, radio-telephone tower, communication and news service relay station, inter-commercial closed circuit television hook-ups, public television, and telstar "re-diffusion" center.

Plug-in City (Peter Cook): Plug-In City was meant to be a method of permitting structures to be tailored to the needs of individuals, with endless permutations creating cities of infinite variety. The Plug-in City program of 1964 pulled together a series of seemingly disconnected notions and small projects, reinforcing and qualifying the theme of flexibility, and eventually suggesting a total project in which the entire environment could be programmed and structured for change. Plug-in City was the combination of a series of theoretical ideas drawn from modernist sources that had been developed between 1926 and 1964. It was an agglomeration of cylindrical towers, inverted pyramids of plug-in, modular housing, and linear stepped-back terraces of housing, all served by giant diagrid frames of inclined service/communication tubes, among which were hung removable roads and railways as well as public spaces covered, in bad weather, by inflatable roofs. Capsules identifiable as shops, homes, and offices could be lifted, stacked, and plugged into place by mobile cranes (Banham, 1976; Barnett, 1986).

Walking City (Ron Herron): Ron Herron's Walking City was based on the notion of a moving or transportable city that would be capable of "walking" from one location to another as resources to sustain the city were depleted. The illustrations describing the city, with their Orwellian overtones of alien forms, suggest futuristic imagery borrowed from science fiction and popular culture. It is unlikely that the engineers who designed the various movable structures at Cape Kennedy had ever heard of the Archigram Group. Yet in 1964 these engineers had designed and constructed several structures, some the height of 40-story office buildings that moved serenely across the flat landscape. Yet in visionary architecture such concepts as prefabricated apartments hoisted into position on a skeletal frame, to be plugged into prepared utilities, are still considered impractical by most designers and builders. There are also important urban problems, such as intra- and interurban transportation, which could be attacked immediately, effectively, and speedily if there were a similar degree of courage and commitment–especially financial.

Plug-In University Node (Peter Cook): The University Node was an exercise in 1965 to discover what might happen to the various notions of a gradual infill, replacement, and regeneration of parts within a Plug-in City megastructure, but with a specific kind of activity. The main enclosures were simply tensioned skins slung on trays which collectively created the "node." Each student would have a standard metal box and could choose to have it located anywhere on the decking. In a sense, this anticipated the nomadic nature of subsequent projects. The nature of Plug-in City, involving the replacement of one function by another (though occupying the same location), could be demonstrated and a more intense glimpse of the likely detail of rooms, lift-tubes, skins, and even hand-rails could be disclosed (Cook, 1999).

Instant City (Archigram): Traditional cultures even in industrialized countries remain slow-moving and sometimes resentful of the more westernized metropolitan regions. The Instant City project is a reaction to this with the idea of a traveling metropolis, a package that comes to a community, giving it a taste of the metropolitan dynamic–which is temporarily grafted on to the local center–and whilst the community is still recovering from the shock, uses this catalyst as a first stage of a national hook-up. The Instant City is both corrective and coercive, by definition there is no perfect set of components.

Metabolist Cities: As stated before, the Metabolists originated in Japan during 1960s as a disparate group of individual architects named after the biological models of growth and change that inspired their work. They created complex urban structures, though with a clear preference for reinforced concrete over the lightweight steel structures favored by Archigram. Their large-scale projects were a reaction to the pressures of overcrowding in Japanese cities, which started in the late 1950s. The Metabolists proposed the development of constantly growing and adapting "plug-in" megastructures where the living cells, as in Noriaki Kurokawa's Nagakin Capsule Tower of 1971 in Tokyo, would be reduced to prefabricated pods that would be attached to repetitive helical skyscrapers (Frampton, 1992).

The vast Tokyo Bay project of 1960, by Kenzo Tange, and the twisting towers of the Helix City project of 1961 for the Ginza district of Tokyo, by Kisho Kurokawa, are two of the movement's iconic works. The Tokyo Bay project is considered by some to be one of the most heroic—although simplistic—visions of town planning to appear in the twentieth century (Banham, 1976). It features a central monumental axis of governmental and other public buildings along a pair of parallel highways with separate blocks linked together in irregular chains. Within these links Tange proposed office and other building types generally conceived as megastructures of habitable bridge trusses spanning between skyscraper service towers arranged on a regular square planning grid.

The Helicoids Project is the most well known and recognizable of all Japanese Metabolist projects. This was originally intended as a proposal for the rebuilding of the Ginza district of Tokyo, but was subsequently developed as an independent project and became the ultimate symbol of Metabolism. The main features of the Helicoids Project were the vast cylindrical towers which form “trees” on which the individual dwellings could “come and go like seasonal leaves, each according to the natural time-scale of its own proper metabolism.” Each structure was to be situated on a floating concrete island in order to relieve the pressure on Japan’s limited supply of urban land.

Pompidou Center (Renzo Piano and Richard Rogers): The megastructure trend reached an apotheosis with the construction of the Pompidou Center of 1977 in Paris. It takes all the elements of modernism—technique, circulation, repetition, mechanical services—to an extreme. It consists of thirteen bays made from large trusses constructed by Krupp in Germany with clear spans of 156 ft. (52m) and spaced 42 ft. (14m) apart. The entire megastructure is stabilized around its perimeter by cross-bracing and cantilevered arms, or *gerberettes*, forming a structural exoskeleton providing spaces for circulation on one side and mechanical equipment on the other. On the plaza facade, the main circulation up to each floor is by a tube of cantilevered escalators while a “wall of services”—brightly colored pipes and ducts—defines the facade that faces the street.

The Pompidou Center represents one approach to Late-Modern architecture that Arthur Drexler has termed “Cages” or constructional buildings, which often employ extravagant elements that are intentionally over-scaled to create a sculptural effect. Banham (1976) likened it to Archigram’s Plug-In City with its visibly open frames, with communications, circulation, and services threaded through them, and in its “graphic detailing.” In retrospect the Pompidou Center, as a “supermarket of culture,” is regarded by some critics as a Late-Modern failure (Jencks, 1988). It centralizes and monopolizes too many artistic activities and, despite its popularity and iconic status, has had a negative effect on other cultural institutions.

Extreme Architecture: Skyward Megastructures

To overcome the problems of megacities, there is a need for economic growth and prosperity, redistribution of wealth, and education at the grassroots level. People will continue to migrate to more prosperous regions from the impoverished ones. However, to achieve sustainability horizontal expansion of megacities will be counterproductive. There is a need for building upward and it is likely that more multifunctional megastructures like Taipei 101 and the Burj Dubai Tower (under construction at this writing) will be built. This will not be the only solution to the expansion of cities but it can play a major part.

The reasons behind the concept of megastructure can be summarized as follows:

1. *Rise of population and emergence of megacities:* The development of megastructures closely follows the growth of the city. Migration of population from rural areas to urban areas resulted in higher density of urban areas which in turn caused the rise of megacities.
2. *Technical and structural innovations in building industry:* Technological advancement in lightweight steel structures (and new concrete structures), transport system, elevators, and the energy supply system favored the high density vertical city.
3. *Contemporary phenomenon of cross-cultural imitation:* In the past, building forms were often culturally unique. Today, they have crossed the cultural, regional and environmental barrier. Three main factors behind this change are:
    a. Universal availability of materials;
    b. Universal communication of ideas and development; and
    c. Adaptation of high-rise towers as symbols of developed society.

4. Pressures of urbanization and demand for space: Tall buildings vis-à-vis megastructures provide more habitable space in considerably smaller footprint of a plan, successfully overcoming the threat of sprawl.
5. Intensification of buildings: Due to rising costs of construction and increasing competition of urban land, there is a tendency to gain maximum on the given investment.
6. Economics: Economics of land--both plot and surrounding areas--are likely to increase in value due to development affecting the global market.
7. Symbolism and prestige: These structures are a reason for pride and prestige for the nation, for the individual owner, and for users of the building.
8. Aesthetics of urban form: Supertall towers as landmarks and points of reference create symbols of growth and development of urban areas, and represent the visual character of a city.
9. Interior flexibility: Megastructures offer more flexibility to the interior space.

All of these factors will guide the development of future megastructures—whether utopian or real. Population increase, limited natural resources, sustainable growth, and advanced technologies are the driving forces for building supertall buildings. The skyscraper is the most intensive building type—by virtue of its enormous size and mass—it is a major consumer of energy and materials. However, skyscrapers are also efficient in terms of their density, and in order to accommodate increasing populations they will continue to be built. Technology to build to the sky is no major problem. The stumbling blocks are financing, the real estate market, environmental concerns, and whether people would like to live and work in the clouds far above the ground below. Both steel and concrete are viable materials for such projects.

Numerous skyward megastructure projects have been considered in the past (Ali, 2001). Predictions of such structures where people can live, work, and play creating a 24-hour living and working environment have been made (Khan, 1972). Developers and architects have been continuing with such visions of building up to a mile (1.6 km) high originally proposed by Frank Lloyd Wright for the Illinois Tower in 1956 (Colaco, 1986) to even as high as 2 miles (3.2 km). Examples of such futuristic structures, both real and visionary, are presented below. Several visionary projects have been conceived for Tokyo in particular where the population has reached 34 million. These are in essence "vertical cities in the sky" and could have impacted the skyline in a significant way. Although some of these are not economically viable at present, they are nevertheless setting trends about what the future may hold for megacities.

The Bionic Tower: This proposed mega-tower was developed by Celaya, Pioz & Cervera Architects. Although at one time many considered 150 stories, roughly 1,640 ft. (500m), to be a practical limit on the height of skyscrapers (Ali, 2001), this limit is being exceeded today by supertall buildings. The "Bionic Tower Vertical City," a skycity in a tower for the city of Shanghai, China (Figure 1), is to be erected to a height of approximately 3,700 ft. (1,128m) housing 100,000 inhabitants as well as many other services. Another similar proposed megastructure, the Bionic Tower, projected to rise 4,089 ft. (1,221m) in Hong Kong remains a visionary project.

The architects have compared the space saving of the Bionic Tower to the space consumed by typical European cities. In a typical European city, for example, 100,000 people are housed within 1.5 sq. miles (4 sq. km) whereas the Bionic Tower can house the same number of people within a more compact footprint of 0.4 sq. mile (1 sq. km). New materials are currently being developed and advancements in computational hardware and software programs are allowing structural engineers to analyze the structural integrity of forms that previous methods of analysis were unable to tackle. Therefore, these complex structures can now be engineered and designed in a way to predict their deformation and reactions to a variety of natural forces.

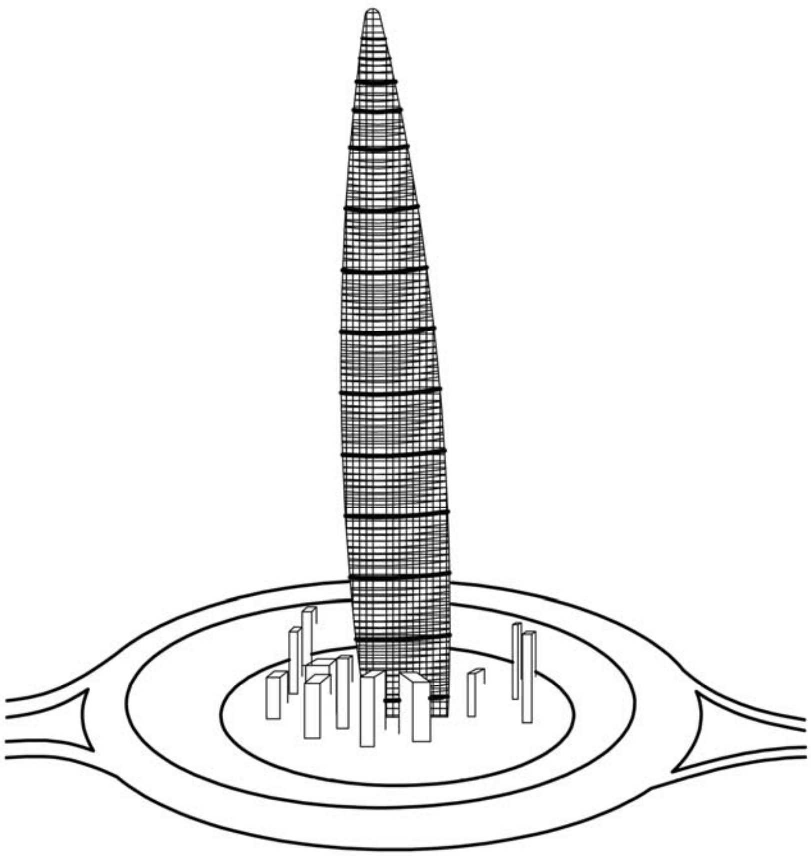

Fig 1: Bionic Tower

Sky City 1000: Japan's Takenaka Company has proposed two visionary projects for vertical cities. These two projects suggest a future of giant high-rises connected to form larger cities, allowing for ample open green space. One of these, The Sky City 1000 project, was co-developed by Takenaka with Shizuo Harada of ESCO Co. Ltd.

In the twenty-first century and beyond, high density functions will be increasingly concentrated in urban centers. There will also be a concurrent increase in demands for contact with nature. Sky City 1000 (Figure 2) is a proposal for a 3,280 ft. (1,000m) high vertical city that will house 36,000 residents and 100,000 workers. It is a megastructure that combines the functions of the city with the natural environment, where urban development will be augmented by ecology and nature. The functions of this medium-sized city will include housing, commerce, education, and recreation. Comprised of 14 concave dish-shaped, aerial bases called "Space Plateaus" stacked one upon the other, the vertical city will be a fusion of architecture, transportation, communications, and energy. Residences, offices, commercial facilities, schools, theaters, and other facilities will be organically related to the structure. Sky City 1000 will be a comprehensive urban environment constructed with a sustainable outlook that can help alleviate land problems and preserve the natural environment.

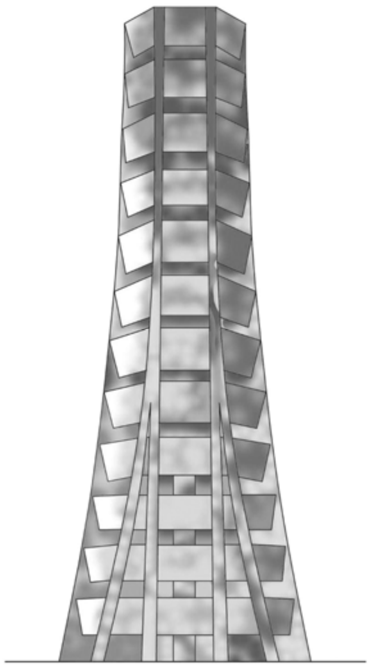

Fig. 2: Skycity 1000

Holonic Tower: The Holonic Tower (Figure 3), also by Takenaka Company, is a proposal for a 1,970 ft. (600m) high megastructure that is intended to function for 500 years. To be sustainable, buildings of the twenty-first century must effectively utilize construction materials beginning at the planning stage. This visionary tower shown in is a super, multi-facility building which will be designed with vast green areas at the base of the tower and utilize extensive energy conservation and recycling systems to minimize its impact on the environment. It will be a “social condenser” that will function as a stage for city life in the twenty-first century, and will be designed for flexibility to respond to in social life and functions of the inhabitants. The concept of “holon” will be applied to its design and construction, and also will be carried through the variety of systems for its operation. The four corners of the tower will be huge mega-columns equipped with Sky Terminals that act as central plazas. They will also contain aerial gardens and a variety of leisure, recreational, and cultural facilities for residents. The exterior shell and interior walls will feature double-wall construction to regulate the tower’s micro-climate. Interior spaces will provide *plein air* environments in which the four seasons can be experienced in the same way as outside the building.

A “variable space system,” based on flexibly-designed standard units, will support changes in function in which each unit will have a standard height of 33 ft. (20m), a width of 187 ft. (57m), and a depth of 95 ft. (29m). Floors for each modular unit can be reconfigured according to use. For residential or hotel functions, for instance, a typical unit would have five floors, whereas office spaces would be accommodated on four floors. Commercial spaces, such as retail or banking functions, would be accommodated on as few as two or as many as four floors depending on need. An extraordinarily large freight elevator for construction purposes will be incorporated into the common core section, while an assembly plant will be established below ground. This basement-level factory will incorporate both the materials carrying-in yard and a fabrication facility. Assembled materials will be loaded onto the freight elevator and transported directly to the floor where they are needed. The rack-type elevator will also be operational in times of disaster, such as during earthquakes, and may be used as an evacuation elevator in times of emergency.

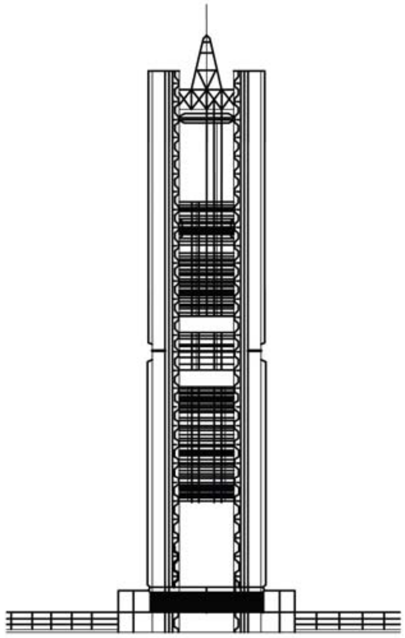

Fig. 3: Holonic Tower

The mechanical system in the Holonic Tower will actively incorporate natural energy sources and cogeneration processes using separate fuel cells to promote resource and energy conservation. A network of lifelines will be set up in the form of an energy bus between each system, thereby creating a highly independent and reliable network which will provide mutual backup. The Holonic tower will generate its own energy from wind and solar power. Small wind-powered generators will be fitted in ventilation voids. Solar cells will be incorporated into the exterior surfaces of the southern, eastern, and western facades to generate energy from the sun. Heat from the combustion of waste will also be recovered to generate power, and excess heat will then be diverted to the regional heating supply. Additionally, a water recycling system will be implemented to conserve the energy required to transport water to upper floors.

Millennium Tower: This visionary megastructure, designed for Tokyo by Foster and Partners in collaboration with Ove Arup and Partners, is a 170-story mixed-use tower that will rise 2,756 ft. (840m) above the city (Figure 4). The tower is shaped like a cone and employs a helical steel cage as a structural and aesthetic solution. Its circular, tapered form provides a very stable structure as a response to destabilizing wind forces.

It represents a remarkable solution to the social challenges posed by the urban expansion of Tokyo, which has a very large population and an acute land shortage. The proposed site for the tower is a man-made artificial island near Tokyo. The tower's organizational strategy challenges prevailing assumptions regarding future megacities in which as many as 60,000 people will need to be accommodated. It will generate its own energy and power and process its own wastes. With its own transportation center, this city in the sky will be completely self-sufficient. It will also incorporate a high-speed metro transportation system that will be capable of moving both horizontally and vertically. The lower levels of the tower will house offices, light manufacturing, and similar industries. The topmost part of the tower will be a communication systems hub. Penthouse floors will accommodate restaurants and observation galleries. Mezzanines, terraces, and gardens provided throughout the building will create an ecological environment and promote

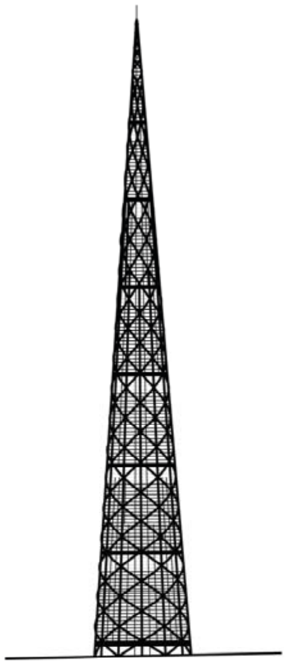

Fig. 4: Millennium Tower

a sense of place. This city-in-a-tower will be a demonstration of how sustainable megastructures could be the potential solution for future megacities.

Shard London Bridge Tower or "The Shard of Glass". This megastructure project by Renzo Piano Building Workshop, when completed in 2012, will have a height of 1,017 ft. (310m) and 72 stories, forming an instantly recognizable symbol for London (Figure 5). According to a report by the City of London, putting sustainability at the heart of the design, construction and operation of buildings would make economic and business sense. The report also advocates density in the location of business operations. Clustering already provides numerous business advantages but it can also improve sustainability in areas such as transportation, energy efficiency, and land use. Known as The Shard of Glass or The Shard, because of its slender glass pyramid shape, it will be the tallest skyscraper in London on the south bank of the Thames and the tallest in Europe. The program is a multifunctional high-rise standing on the busy traffic junction of London Bridge Station and is directly linked with the station at its base. The building will be used by many commuters between railway stations, the area will extend with stores and new traffic zones. The 66 stories of the tower will be subdivided into several functional layers. Public areas in the sky will be located between 34th and 36th floors as well as between the 65th and 66th. They will contain winter gardens, stores, restaurants, and exhibition spaces. Offices will be located between the 4th and 31st floors, hotel between the 37th and 51st floors, and 114 exclusive apartments between the 52nd and 64th floors. The structure is a combined system of steel mega-supports running immediately behind the glass facades and a rigid central concrete core. The spire-like shape ensures that the building does not give off a too "block-like" impression in the cityscape. Not an entirely closed skin, it is composed of several layered glass surfaces. It contains a newly developed heating and air-conditioning system, using 30% less energy than comparable buildings.

Fig. 5: Shard of Glass as it will appear at different times of the day
(Source: Wikipedia.com)

Dense development is only sustainable if it occurs where the existing infrastructure of the city makes it possible and desirable. The London Bridge Tower will be situated at the intersection of a transportation infrastructure system comprised of railways and streets at the ground level and underground network of railways and utilities. Because the population of the tower will use public transportation—the energy-carriers of the city—no public car parking or additional traffic is planned. The tower has been estimated to use 30-35% energy below that which would be expected from a normal building of a similar nature. This would be achieved by reusing energy expelled from the office area to heat the hotel and residential areas. Surplus heat would be removed naturally via the "radiator" on the top of the building. The building would achieve a reduction in potable water use by utilizing boreholes. Embodied energy is the most widely used measure of environmental burdens of the materials used in the construction of a building. The tower's design aims at minimizing the use of materials with high-embodied energy. When completed, it will represent a successful example of integration of a sustainable megastructure with the transportation infrastructure of a megacity. The current major project planning in London concentrates on the high-rise structures placed over high-traffic transportation centers. The logic behind this planning would allow for the population to live in one city and quickly travel to work in another city. This plan would also reduce the need for personal transportation.

Burj Khalifa: In Dubai, UAE, Burj Khalifa, completed in 2010, is a mixed-use megastructure designed by Skidmore, Owings and Merrill (SOM). Adrian Smith is the principal architect and Bill Baker is the chief structural engineer. At 2,717 ft. (828m) height with 160 stories, it is the tallest building in the world (Figure 6). The building functions will include residential, commercial, hotel, shopping, entertainment, and leisure outlets. There will be 492 hotel rooms, 354 residences, 232 luxury apartments, 36 floors of office space, and 3 floors of communication systems. The structure derives its geometry from a well-known, indigenous desert flower, and the plan of the building mimics the Y-form of the flower to maximize the views. The concrete tower is composed of three elements arranged around the central core. The structure can be described as a buttressed tube. As the tower rises, setbacks occur at each element in upward spiraling patterns, thereby decreasing the mass of the tower as it rises skyward. The central core emerges at the top and forms a spire.

Fig. 6: Burj Khalifa, Dubai
(Source: Wikipedia.com)

Burj Khalifa combines historic and cultural elements with advanced technology to achieve a "high performance building." It reminds us of Frank Lloyd Wright's mile-high visionary Illinois Tower of 1956 because of its needle-shaped appearance. The mixed-use functions are combined with green, park-like elements including open garden spaces, terraces, and water features. Pedestrian boulevards are also located within the building, providing spaces for social interaction. The tower is a vision for a supertall megastructure that has now actually been realized. It is a trend-setter for future megastructures reaching to the clouds.

The Modern City and Its Transformation

Most critics can agree on one thing in general: The modern city has become so vast and encompasses so many different densities of development, different kinds of activity, and such a variety of communities, that it is unlikely that any single design concept could emerge to give form to a metropolitan area (Barnett, 1986). Some of the cities become megacities with a very large number of people typically exceeding 10 million. In the first half of the twentieth century, New York was the prototypical "City of the Future" but clearly the initiative has passed to cities such as Los Angeles, Houston, Atlanta, and many other North American cities where decentralization and the automobile have created fragmented cities with multiple centers (Broadbent, 1990). One thing is clear: The concept of the nuclear city where everything is focused on a single downtown area with its CBD is being replaced by decanted "instant cities." Today urban planners encourage us to think in terms of "poly-centers" in which the old city is but one of many centers (Muller, 1976). Instant cities have four factors in common:

1. Knowledge-based industries have replaced manufacturing industries.
2. Road transport systems have replaced centralized rail systems.

3. Advanced telecommunications are replacing the need for travel and commuting to work.
4. Land cost for suburban sites tends to be less than that for congested urban sites.

Exponential growth of cities, especially those in developing countries, is creating megacities at a rapid rate. In order to provide housing and work spaces for these new urban inhabitants, architects have turned to megastructures as a possible solution. The Metabolism Movement in Japan, inaugurated by Kiyonoru Kikutake, Masato Otaka, Fumihiko Maki, and Kisho Kurokawa, postulated cities to grow and change with time and different conditions. The underlying structure would be permanent, but the units of the city would be attached to the structure as flowers to a stalk or leaves to tree.

As cities grow outward to suburbs interconnected by expressways, they also tend to grow towards one another as development occurs along transportation corridors. The resulting megalopolis is an interconnected urban fabric comprised of cities, suburbs, and island cities that have merged into one, undifferentiated urban system. Megalopolises typically evolve in cases where cities grow toward one another, such as Chicago growing to the north along Lake Michigan and the cities of Milwaukee, Racine, and Kenosha in Wisconsin expanding southward toward Chicago. New York, constrained by Manhattan Island, incorporated its Five Burroughs into a single megalopolis. Atlanta, Georgia and Los Angeles are megalopolises that have expanded to include surrounding suburban communities, as well as outlying perimeter centers.

A new trend in skyscraper design is underway. New developments in materials, information technology, and sustainability are changing the built environment. Three dimensional cities in which towers are connected by horizontal skybridges envisioned by architects, notably Antonio Sant'Elia and proponents of Russian Constructivism in the early twentieth century, recently implemented in the Linked Hybrid Complex in Beijing and Pinnacle @ Duxton in Singapore, will likely be a future trend. Cities will have more of these new skyscrapers and megastructures. As future cities will be poised to experience smart growth, buildings will be designed as artifacts of smart architecture. Smart materials, integration techniques, nanotechnology, and computer-based knowledge management systems—these are the current opportunities for architects, engineers and planners to realize sustainable development of cities and their vertical urban forms. These collectively represent the new design reality of future skyscrapers in cities. Making tall buildings livable and high-performance is the idea whose time has come. Also, the effects of greenhouse gas emission from the built forms on the environment are now being vigorously studied. The ultimate aim is to create a carbon neutral environment around tall buildings which will have zero net-energy use in which technologies can be employed to avoid drawing any energy from the region's power grid (Zisko-Aksamija and Ali, 2007; Ali, 2008).

Conclusion

Today, older planning ideas about the city are being revived including monumental city design, such as devising modern buildings that will fit into more traditional urban relationships, creating enclosed spaces that are given definitive form, and a revival of picturesque principles that lay behind the designs of the garden-city and the garden-suburb (Barnett, 1986). New ideas about how to incorporate tall buildings into existing urban fabrics are beginning to emerge. Although the faint image of the isolated skyscraper-in-the-park introduced by Le Corbusier still persists, many new tall buildings constructed today are contained within a matrix of pedestrian-oriented uses, integrated city transportation infrastructure, and adjacent public spaces that are designed to attract use, not simply to provide a setting for these mammoth buildings.

There are two alternate directions which each of today's cities can take that will determine how successful they become in the future. In the past, the focus has been on what a utopian city of the future would be. This optimistic path seems fascinating when not contrasted with a stark prediction of what is horribly possible if the problems of cities were to be ignored. The pessimistic representation of a deficient city of the future is as fantastic as that of a utopian city. The reality is that increasing population and limited natural resources pose serious constraints on the development of future megacities, and solutions for their mega-problems must be incorporated in their design and planning.

Some have argued that designers and planners should reconsider the roles of megastructures and center-city atriums when addressing the problems of population density in today's megacities. They point out that technology and automated transit have improved to the point that it is now possible to build some of the ideas imagined by the megastructuralists decades ago. But Banham (1976) cautioned three decades ago that megastructures were an invention of architects as a way of imposing a form of order on "the chaos of our cities," and that the concept was abandoned by them because it generated a form of order they themselves could not manage. On the other hand, attempts to reshape the city to static patterns will fail as economic and social changes have become too rapid and too complex to be contained. What is needed now, writes Barnett (1986), are new ways of integrating city design with the process of economic transformation and social dynamics.

Two concurrent forces are active and ongoing at present. These are the "livable city" and the "green design" movements. Debates and discussions in different forums are common now on sustainable cities and sustainable architecture. It is held that the built forms must be sustainable to render the entire city sustainable. Tall buildings and cities are interdependent and need to be viewed together in future urban planning. In this vein, conventional master plans of cities in plain view are no longer sufficient. Cities must also be planned and developed within a comprehensive, multi-level framework with an eye for the future. The skylines of cities must be closely scrutinized by urban designers.[8] To understand the obvious and subtle relationships between the skyscraper and the city and the intricate issues underlying them, there is no greater challenge than to perceive, appreciate, and envision the realities on micro and macro scales and what lies in between the polarities of the ideal and the traditional city.

Economic development and future planning of cities will warrant radical thought, creativity, and exchange of ideas in a symbiotic manner to achieve solutions to complex, multi-faceted problems of modern cities that are prevalent worldwide. The second half of the twentieth century has demonstrated rapid transformation and change with the infusion of technology, humanistic concerns, and a longing for a better living in livable cities and tall buildings defining urban civilization. Technology will continue to improve the physical systems of the skyscraper and the city. However, although application of new technologies and innovations to the built environment will improve our cities and living conditions gradually, humanism will indeed define their future.

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Notes

1. A common question is: Why tall buildings? Beedle (1977) explains that the reason is clear: We live in an "Age of Awareness". Compared to our ancestors we are more aware of the

effect of our creation on the environment and we are conscious of the growing shortages that dictate the prudent use of resources. He lists a number of reasons. See also Ali and Armstrong (1995) and Beedle, Ali and Armstrong (2007).

2. See Areggar and Glaus (1967) for a detailed discussion on the relationship between urban design and the high-rise building.

3. Today, megacities exist all over the world, especially in developing countries where the population is growing exponentially. In Dhaka, Bangladesh, for example, slums in 1996 had a population of 1.5 million people living in 3,007 clusters out of a total Dhaka Metropolitan Area (DMA) population of 5.5 million. According to Nawaz (1999) in 2005 the slum population has grown to 3.4 million people living in 49,996 clusters out of a total population of 9.13 million inhabitants. In other words, while the overall population in the same geographical area of 360 km^2 is growing at the rate of 4.5% to 5.0% per year, the slum population is growing at the rate of more than 10% per year. The percentage of the slum population within the overall population has also increased from 25% in 1996 to 37.4% in 2005. Yet these squatter villages occupy only about 4% of the total DMA. Furthermore, 77% of the slums are on private land.

4. Politics will play a major role in the success or failure of cities of the future. It is governments today which implement environmental controls and bring economic possibilities to a city. In the past cities were centers of economy by virtue of their location. Though location still serves as a factor in industrial economies it is not as important as it has been in the past and for modern economies depending on digital and information technologies location is hardly a factor because “distance is dead”.

5. According to Ken Yeang, tall buildings as a built form consume one-third more material and energy resources in their construction, operation, and demolition than the low-rise or mid-rise buildings (Beedle, Ali, and Armstrong, 2007). However, they have many merits such as agglomeration, reduction of urban sprawl, savings in auto fuel and travel time, and reduction in losses in power lines, etc.

6. Some common problems of all large cities in various degrees are pollution, traffic gridlock, energy shortage, water and power shortage, and deteriorating civic infrastructure. In cities of the developing countries there is an additional problem of human migration from the countryside to urban centers resulting in urban sprawl and slum-dwelling for the poor.

7. The technological advancements of the Crystal Palace served as inspiration for the geodesic dome designed by Buckminster Fuller during the 1960s and 1970s. His most ambitious proposal, however, was to cover most of Manhattan Island with a geodesic dome.

8. Skyline studies are important for skyscraper design in any city. Clearly skyscrapers represent practical considerations at the ground level and their silhouettes display the iconic character and symbolic features at great altitudes. Cities are identifiable by their skyscrapers that are space markers and define their skylines. See also Ali (2003).

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