ON THE SKYSCRAPER AS A BUILDING TYPE IN AN ERA OF UNCERTAINTY, GLOBALIZATION AND ENVIRONMENTALISM

By

BRANDON THOMAS MOORE

A THESIS PRESENTED TO THE GRADUATE SCHOOL
OF THE UNIVERSITY OF FLORIDA IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE IN BUILDING CONSTRUCTION

UNIVERSITY OF FLORIDA

2006

To Colonel William Aiken Starrett, a true master builder and skyscraper man who gave all he had to the Empire State Building.

ACKNOWLEDGMENTS

I would first like to thank my high school basketball coaches Mr. Randall Leath and Mr. David Thorpe; and the brothers of Lambda Chi Alpha, both alumni and undergraduate, for making me the man I am today. I would also like to thank Dr. Abdol Chini, Dr. Charles Kibert, and Dr. Robert Stroh for serving on my supervisory committee. I thank the M.E. Rinker Sr. School of Building Construction faculty and staff for truly caring about the welfare of their students. Lastly, I thank my mother, who has always been there.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Abstract of Thesis Presented to the Graduate School
of the University of Florida in Partial Fulfillment of the
Requirements for the Degree of Master of Science in Building Construction

ON THE SKYSCRAPER AS A BUILDING TYPE IN AN ERA OF UNCERTAINTY, GLOBALIZATION AND ENVIRONMENTALISM

By

Brandon Thomas Moore

December 2006

Chair: Abdol R. Chini
Major Department: Building Construction

As a nation looked on, both One World Trade Center and Two World Trade Center fell from their lofty heights on September 11, 2001. After that attack, and the destruction of such famous skyscrapers, there was fear and speculation that there would be nearly a moratorium on tall buildings and their construction. Today however, more skyscrapers are being built than ever previously known in the history of the world. Why has the skyscraper continued to be the building type of choice for many developers and owners in the face of terrorism? Is the public view of the skyscraper as optimistic as that of the developers and owners of these tall buildings? The economical, social, and cultural aspects of the skyscraper must be taken into consideration when asking why one builds tall. Further, the skyscraper is now a building not only of America, but also of the world. The skyscraper is also now becoming increasingly environmental in today's concern with sustainability and green building. Our study explained and synthesized the economical, social, and cultural aspects of skyscrapers through the building type's storied history versus the owner's impetus to build tall and the public's willingness to embrace such structures in uncertain times. We also examined the developments and future of skyscrapers in foreign markets. Finally, we analyzed the growing field of sustainable skyscrapers and possibilities for the future of tall green structures.

CHAPTER 1
INTRODUCTION

September 11, 2001

On September the 11th, 2001, the world as Americans knew it was changed forever. At 8:46 a.m. that fateful morning American Airlines flight 11 crashed into the North Tower of the World Trade Center in New York City. What seemed initially to be a horrific accident, turned into a deliberate and premeditated attack as United Airlines flight 175 ripped through the South Tower of the World Trade Center at 9:03 a.m., a mere 17 minutes after the initial North Tower collision. Since both planes were bound for a transcontinental destination in Los Angeles, they carried thousands of gallons of highly flammable jet fuel that became the source of a raging inferno in both One World Trade Center and Two World Trade Center. With the combination of missing columns that were taken out by the planes, and the softening or weakening of the steel supports that supported each floor from the intense heat of the jet fuel fires, the Twin Towers were terminally ill and bound to fail explosively.

At 10:05 a.m., Two World Trade Center disintegrated before the eyes of the world. A 1,362 foot tall iconic building that took 7 years (1966-1973) to build was reduced to shards of rubble in just a few seconds (Emporis Buildings, 2006). Thousands of tons of steel, glass, concrete and other materials were pulverized, instantly trapping and crushing nearly all of the people that remained in the building. Dust clouds blew down lower Manhattan turning day into night and causing thousands to flee running through the streets of the nation's and the world's business capital. The 1,368 foot One World Trade Center soon followed suit as it too fell at 10:28 p.m. in an equally terrible and awful display. Thousands of tons of what once was a beautiful piece of modern architecture now were deadly pieces of debris.

When the dust finally settled, and the events at the Pentagon and in Pennsylvania were finished, 3,056 people from 90 different countries had lost their lives (U.S. Department of State, 2002). Most of those who perished were at the World Trade Center, where 2,823 people were buried in the tangled ruins that once were the tallest buildings in the world and quintessential symbols of America's fiscal strength and world power (U.S. Department of State, 2002). In addition to the Twin Towers, a third building, 7 World Trade Center, also collapsed at 4:10 p.m. due to effects of its collapsed neighbors, but fortunately the building had been evacuated and no casualties resulted therefore. In the end a total of 3,301 feet and 267 floors of skyscraper vertical space had been erased from the Manhattan skyline (Emporis Buildings, 2006).

It was a moment in the United States of America's and the world's history that will be remembered for generations. It is the type of moment that those who were alive during its unfolding will remember and tell to their children as they grow older much like when President John F. Kennedy was assassinated in Dallas or when the Japanese bombed Pearl Harbor on December 7, 1941. You knew where you were and what you were doing as you saw those planes hit and saw the tallest skyscrapers in the world's greatest city ripped from the sky. Americans across the nation were tuned in at home, in the conference room, in the cafeteria. All at once the world had been turned upside down and terrorists with planes were destroying those things we believed to be safe, things we believed would be there day in and day out as we went about our lives. All that remained of these once proud civic symbols was rubble and ruins. The space in lower Manhattan was replaced only by emotional heartache and the jagged shrapnel of the bottom floors of the tubular structure of the World Trade Center.

Many questions rose out of the wreckage September 11th left behind. Who had carried out these treacherous acts? What would the United States response be? Was it safe to fly? What terrorist protection would be in place to prevent future attacks? Fear and hysteria were at a maximum and the questions about security in America were many. A question that perhaps was not necessarily at the forefront of America's mind was the future of the skyscraper as a building type in a post-9/11 world. Could a building type that was synonymous with such a public, tragic event survive?

Problem Statement

Initially following the collapse of the Twin Towers, there was uncertainty about the tall building in America and in the world. Would there be an initial moratorium on skyscrapers with the fear of further extreme terrorist attacks? Would developers take the chance to build tall? Further, would renters and employees now feel comfortable living or working in a skyscraper? As the fifth anniversary of September 11th passes not only is the skyscraper alive and well, but the tall building in America and in the world is thriving. High-rises are being erected in greater numbers than ever before, and at heights and complexities that surpass any on this earth (Post, 2005). In fact, currently under construction there are 132 buildings over 650 feet tall, 37 buildings over 950 feet tall and impressively 10 buildings over 1,300 feet tall (CTBUH Database, 2006). Having 10 buildings currently under construction that are over 1,300 feet is an astounding fact since there are currently only 6 buildings over that height, those buildings are listed in table 1-1. Moreover, more skyscrapers than ever before are also being proposed and will soon dot the skylines of the world (Post, 2005).

Table 1-2 shows that in the 5 years before September 11th and the five years following September 11th the skyscraper as a building type in the world has grown exponentially. Nearly double the skyscrapers have been or are scheduled to be completed for the years 2002 to 2006 as compared with the number that were built from 1996 to 2000. The United States accounts for a good portion of the world's building of these high-rise structures. Table 1-3 displays that during the years 2002 thru 2006 the United States put into place 1,334 skyscrapers which is more than double the 593 skyscrapers put into place from 1996 to 2000. Also, table 1-3 conveys that of all the skyscrapers built in the world, the United States accounted for an average 10.16% of them from 2002 up to and including 2006. In contrast, from 1996 until 2000 America accounted for only 8.37% of the world's tall buildings. It is important to point out that buildings that were already under construction or in the final stages of planning up to September 11th would be completed regardless of the terrorist attacks since financing, drawings and parties are all secured. Therefore, the numbers for 2002 thru 2006 do contain buildings that were obviously not halted and completely stopped permanently. Nevertheless, the data shows that skyscrapers really did not cease or even suffer a depression as being a viable option for designers, developers and owners.

So why in the face of terrorism and uncertainty has the tall building in America and the world done so well? Why continue to build tall when the worst has truly happened? What factors are incorporated into building tall and building skyscrapers? Does the public react with the same zeal, enthusiasm and optimism that developers and owners obviously have in constructing, working and living in and around these structures? Where are the world's tall buildings being conceived and built? What development is there of sustainable skyscrapers? What does the future entail for the skyscraper? Is the skyscraper's longevity realistic in an ever changing, increasingly populated, increasingly dense, terrorist stricken world?

Scope and Limitations

Scope

The skyscraper as a building type involves a wide range of topics, people, technologies and influences. It is the intention of this work to not cover the gamut of all the possible considerations and angles to research and construct the skyscraper but rather to provide a concise explanation of the building from a historical, present and future standpoint. This work will begin with a historical look at the tall building, what constitutes a high-rise and the factors that influenced its creation. Technological innovation pertinent to the erection of the first skyscrapers and its continued success will include brief overviews of structural steel members, elevators, communications, foundations and interior lighting. By no means will this overview be a treatise on every technical and mechanical aspect of these systems. In essence the skyscraper as a static structure will be examined and the initial steel skeleton concept will be discussed. Skyscraper focus then shifts from Chicago to New York where the race for the world's tallest building begins. Throughout, social, economical and cultural factors will be discussed to include financial prosperity or recession influences, ego and awe of the public. Historical timelines will be developed to record technological progress and the world's tallest building status as the years pass. The pride, finances and power associated with the world's tallest building cannot be ignored when looking at skyscrapers. Therefore, specific case studies of the world's tallest buildings will include

- Masonic Temple
- Park Row Building
- Singer Building
- Metropolitan Life Insurance Company Tower
- Woolworth Building
- Chrysler Building
- Empire State Building
- One World Trade Center
- Sears Tower
- Petronas Towers 1 and 2
- Taipei 101

The Chicago based Council on Tall Buildings and Urban Habitat rules for measuring the world's tallest are important in determining the world rankings and thus will be presented.

Accompanying research into the world's tallest buildings will be a look into the "Asian Tiger" communities of the Far East and the shift in skyscraper construction that has accompanied their purchasing power and population dominance. The global use of the skyscraper will be discussed within the realm of the countries constructing or having already completed some of the world's tallest buildings to include

- China
- Malaysia
- Taiwan
- United Arab Emirates
- United States of America

The percentage of the world's skyscrapers each year will be analyzed along side the rate of skyscraper construction during recessions and booms in respective parts of the world. Global population statistics and gross domestic product comparisons with skyscraper counts in countries throughout the world will be plotted against one another as well and results will be inferred.

The work will then reach the present state of the skyscraper in today's modern world. An up to date historical timeline will be finalized. Tabulations will be made for skyscraper counts in the top countries of each geographical region using the Emporis online database. These regions include

- Asia
- North America
- Europe
- South America
- Oceania
- Africa

These tabulations will then be cross-referenced with current population and gross domestic product data using the Population Reference Bureau and the CIA's World Factbook. Tallest buildings according to categories and per continent will also be presented.

As architecture, engineering and construction progress and advance so too has the complexity of the skyscraper. The days of the "glass box" are numbered if not extinct and several buildings challenge the limit of design and structure. Complex buildings to be reviewed include

- Burj Dubai
- Central Chinese Television Building
- Hearst Building
- Turning Torso
- Taipei 101
- Swiss Re Headquarters
- Burj Al Arab
- Bank of China

A caveat to structural and aesthetic complexity is the symbolism accompanied with many modern buildings including the use of local architectural influences and customs. However, symbolism in a skyscraper is not a new endeavor and as such past examples of the skyscraper as a symbol or adorned with symbols will be considered. Today's examples of symbolic skyscrapers and their influence will further be addressed.

The demands on the earth increase year after year as more is built, more are born and more is consumed. Sustainability and its position within the skyscraper cannot be excluded in any discussion of the future of high-rise buildings. Inherent sustainability and the future of the tall building as the answer to the need for denser populations and more condensed city environments is paramount to the survival of habitable life on this planet. The creation of vertical space when the horizontal space runs out will be accompanied by a number of systems, materials and devices which must have the least amount of impact on the earth while still providing a sound, safe, pleasing environment in which to live, work and play. The inner workings of passive and active sustainable systems will be reviewed along with case studies of buildings that already include sustainable practices. These buildings primarily include

- Bank of America Tower
- Hearst Building
- Swiss Re Headquarters
- The New York Times Building
- The Solaire
- Commerzbank

Aside from components of individual building systems such as the envelope, energy use and building materials, a large portion of this section will be concerned with the world's population growth and the how the smaller footprint of the skyscraper and close proximities will allow for more sustainable lifestyles. Only select systems and their implementation will be covered in the context of a blanket look at sustainable skyscrapers in place and in theory. Sustainable skyscrapers are certainly the future of the downtown environment, but what else is on the horizon for the high-rise?

The correlating portion of this work will concern itself with possible future aspects of the tall building in the world. First off, the population projections of certain high-rise heavyweight countries will be computed and opinions drawn on their high-rise count in the future. The projected world population and urban versus rural lifestyles will also be shown and further conclusions shall be drawn. Who are the up and coming countries in skyscraper building? Which countries might possibly have exponentially more high rises than they currently do? What type of structures can be expected and to what heights? In relation to the previous question important future high-rise buildings will also be analyzed to include

- Burj Dubai
- Freedom Tower
- Fordham Spire

As previously stated, more skyscrapers are currently under construction and more are being proposed than ever before (Post, 2005). There is an obvious enthusiasm for high-rises within owners and developers who employ like-minded architects and engineers who in turn build taller, more complex and more powerful structures. But what about the businesses, clients, employees and residents that work, live and play around these structures? Are they concerned about possible future terrorism? Do they prefer the downtown environment as opposed to the suburban environment? Do they even like the look of a skyline? Can they even identify these so called “symbols” of commerce and strength? Are they as proud of tall building innovation and feats as those who are personally involved and instrumental to the completion of tall structures? These questions need to be answered in order to draw conclusions about the high-rise as a building type. However, it does seem that the downtown urban lifestyle will become more and more the norm rather than the exception and suburban living will become the luxury. A protocol entitled The Public Opinion of Skyscrapers and the Downtown Environment sought out to answer just those questions about what the public and what the users of skyscraper construction had to say about the tall building and its surroundings. The protocol took place in the city of Tampa, Florida, U.S.A. and therefore results are solely limited to members of that region. It did provide insight into the American average psyche however and the results have been statistically analyzed and displayed for use in conclusions about the popularity of the skyscraper in a terrorist threatened and every shrinking world. Explanation and review of each question asked will be conducted, along with conclusions drawn for each question and how that relates to what is actually happening in the skyscraper world.

Limitations

As mentioned before, the work is not intended to be a complete and extensive guide to designing, engineering or constructing a skyscraper. The numerous length and breadth of such a topic is beyond the capabilities of such a limited volume of work. Within each skyscraper are thousands of components, working with thousands of multiple other systems, designed by thousands of others and constructed by thousands more. There are several quantitative features mentioned within the work but primarily the work looks toward the qualitative aspects of why the world is so enamored with building tall? Therefore, technical or mechanical workings of systems and processes are not to be included. Also, the systems that govern the harmonious being that is a skyscraper will not be dissected completely, if considered at all. Systems of particular interest that will be excluded will be the fire safety, mass damping and wind engineering of the building. These systems will be glazed over briefly but technical consideration will not be given.

Upon the inception of the skyscraper there were several architects, engineers, contractors and owners that helped further the idea of building tall. Their accomplishments are commendable and vast, and provide the foundation by which we now are able to know the tall buildings of the world. A few prominent figures have made their way into the work for explanation purposes but the following is not intended to cover nor shall it attempt to cover the countless men and women who have made the skyscraper what it is today. Current skyscraper figures also will only be casually looked at to expound on the factors discussed in the lure and lore of the skyscraper.

As with most construction endeavors the goal is to have an attractive return on investment. However, there are problems created with building millions of square feet of office or residential space if there is not a fervent demand for it. The work does not take into account depressing real estate markets by skyscraper construction or any other real estate factors that are a resultant of building tall.

Regardless of the “glass box” nickname given to many skyscrapers, architecture and beautiful design do exist for tall buildings. The work does admire certain symbolic, complicated and substantial architectural, engineering and construction feats within the building type of the skyscraper but there will be no discussion of what type of architecture buildings represent such as classical, post-modern etc… On that same note there will be no reference to supposed "Chicago" or "New York" schools of skyscraper design. It is true that Chicago and New York have had the most influence on the tall building but the work is not only about these two cities and their buildings in America. Rather, the work attempts to look at the beginnings of the skyscraper in Chicago and New York, which has now morphed into skyscrapers of the world.

For sustainable skyscrapers in this work the focus has been on the possible systems and systems in place that can reduce energy and material consumption. The work is not intended to look at the energy, materials and overall impact that high-rises have as compared to mid-rise or low-rise buildings whether residential or commercial in nature. Rain water runoff, heat island effects and air quality will not be a part of this study. In particular, elevator energy consumption as an inhibitor to building tall versus building low is not a consideration. Further, employee and resident quality of work space or living space as a qualitative aspect of high-rises is only briefly mentioned. Indoor air quality, indoor lighting quality and detachment from the street and outdoor environment issues also are not discussed. Lastly, life-cycles of the skyscraper is not considered.

The work also does not encompass considerations for what could halt skyscraper construction around the world aside from fiscal recessions. Telecommunications and information technology as ways around building tall for concentrated business zones have therefore also not been taken into account for the future of skyscrapers. A future for the skyscraper in a terrorist afflicted world includes special design and engineering considerations to ensure minimal damage and danger to the humans using skyscrapers. This study will not delve into what is being done to "terror-proof" buildings and make them as safe as possible. The associated cost and architecture accompanied with fortress-like buildings also will not be a concern in this work.

The case studies and examples given are by no means the only examples of the type of building factor in question. All systems and procedures discussed do not represent completely the systems that go into a skyscraper. Those systems that are listed are also not the only options for designers and engineers. The various options for foundations, structural steel designs, concrete designs and other building options are far too many to explain in detail and therefore have not been covered in depth. Moreover, numbers computed for 2006 include those buildings currently under construction and scheduled to be completed in 2006.

Finally, cities other than Tampa, Florida, U.S.A. were not surveyed and therefore not considered. The survey was limited to only those people present in downtown Tampa on August 14, 2006 and generally included the professional working force age range of Tampa area residents.

Layout

An exhaustive literature review will be presented in Chapter 2 to expound on the skyscraper's history, present status and future possibilities. The review will discuss the important factors that go into the skyscraper that still hold true through today such as social, financial and cultural factors. Historical timelines, technological advances, global trends and environmental impacts all will be analyzed and computed. Chapter 3 discusses the protocol: The Public Opinion of Skyscrapers and the Downtown Environment, and how it was carried out. Location, constituency, means and methods of the protocol all will be considered. Further, each question given to the survey respondents will be mulled over and discussed. Possible discrepancies and positive influences on the survey will also be prevalent. Suggestions for a revamped survey also will be offered. Chapter 3 also provides the statistical analysis of the survey data and what each question resultant was. Results will then be turned into conclusions about the responses that the Tampa residents gave giving further insight into the future of the skyscraper and its primary home, downtown. The final chapter 4 will provide a summary of the data collected and analyzed through the protocol, databases and literature review. To represent the work as a whole, several main points will be drawn. As the literature review was conducted, and more and more data was looked at, several opportunities for future studies came about. Therefore, recommendations for future research will accompany chapter 4 so that more facets of such a complex building can be looked at, not only from a building construction standpoint but possibly an architectural, engineering, business and even sociological stand point as well.

Table 1-1: Buildings Over 1,300 Feet

Building	Height (ft)	Height (m)	Location	Year
Taipei 101	1,671	509	Taipei, Taiwan	2004
Petronas Tower 1	1,483	452	Kuala Lumpur, Malaysia	1998
Petronas Tower 2	1,483	452	Kuala Lumpur, Malaysia	1998
Sears Tower	1,451	442	Chicago, Illinois, USA	1974
Jin Mao Tower	1,380	421	Shanghai, China	1998
Two International Finance	1,362	415	Hong Kong, China	2003

Emporis. Emporis Buildings Database. http://www.emporis.com/en/. (July 31, 2006)

Table 1-2: Skyscrapers Constructed in the World 1996-2000, 2002-2006

Years	Skyscrapers Built	Average Per Year
1996-2000	6,880	1,376
2002-2006	13,247	2,649

Council on Tall Buildings and Urban Habitat. CTBUH Database.
http://join.emporis.com/?nav=signin&lng=3. (July 31, 2006)

Table 1-3: Skyscrapers Constructed in the United States 1996-2000, 2002-2006

Years	Skyscrapers Built	Average Per Year	World %
1996-2000	593	119	8.37
2002-2006	1,334	267	10.16

Council on Tall Buildings and Urban Habitat. CTBUH Database.
http://join.emporis.com/?nav=signin&lng=3. (July 31, 2006)

CHAPTER 2
LITERATURE REVIEW

Stone to Steel

There are perhaps no more historically significant items than the structures that each civilization has chosen to surround themselves with. The pyramids of ancient Egypt, the temples of the Mayans, the Great Wall of China, the Coliseum of Rome, all great structures that attract millions each year. One would be hard pressed to think of ancient history and not remember the types of buildings associated with time periods and human endeavors of the past. Church structures such as Notre Dame and Cologne Cathedral taking hundreds of years and thousands of hands exalting God and faith, spires stretching to reach the heavens as monuments of man's devotion to religion and God's omnipresence so that all in the town and in the fields could see (Ali and Armstrong, 1995). The pagodas, obelisks and minarets of Eastern civilizations shot upward to mark relics and shrines of the past (Jencks, 1980). The urge to build tall, iconic structures is an ancient aspect of man and man's built environment.

Man looks at the world and wants to conquer. Conquer the land, sea and air. With satellites and space shuttles man utilizes the air. With telescopes and observatories man explores and expands the knowledge of our world. With parachutes and hang gliders man enjoys the air. With large jumbo jets man defends and traverses our air. With derricks, cranes and lifts man builds into the air. With elevators and stairwells man utilizes the air to live, work and play vertically.

The tall structures of ancient worlds are strikingly similar to today's tall structures. Their symbolism and reasoning of cultural, social and powerful contexts plays very well towards many of today's same reasons that the world builds tall and will continue to build tall. In the same spirit that the Pharaohs built the Sphinx or that the Tower of Babel was attempted, so too has the tall building in modern society been built and conceived. Accordingly the cities of New York, Hong Kong, Dubai and Taipei are the Athens, Rome, Cairo and Paris of yesterday. The skyscraper will be remembered as the building of modern history and of an industrialized world. Using steel where there was once stone and using air once again as a medium.

What is a Skyscraper?

Skyscraper, the word itself invokes images of the Empire State Building, the Sears Tower, and the Bank of China. However, buildings need not be thousands of feet above the ground in order to be termed a skyscraper or a high-rise. The varied definitions for a tall building are as varied as the architecture and construction of these buildings. Perhaps one knows a skyscraper when they see it. In science, only slightly more concrete definitions are given in the following.

Dating back to 1891 in Maitland's American Slang Dictionary, the earliest known definition, a skyscraper is "a very tall building such as now are being built in Chicago" (Starrett, 1928). Equally vague is the prominent early skyscraper architect Louis Sullivan's definition of a skyscraper.

> "It must be tall. The force and power of altitude must be in it, the glory and pride of exaltation must be in it. It must be every inch a proud and soaring thing, rising in sheer exaltation that from bottom to top it is a unit without a single dissenting line" (Sullivan, 1896).

The builder of the Empire State Building and The Manhattan Company Building, William A. Starrett describes the skyscraper as "any tall building, implying a steel skeleton incased in a wall that is merely a drapery" (Starrett, 1928). Means Illustrated Construction Dictionary defines a high-rise as a "building having many stories and serviced by elevators" (Greene and Marchetti, 2000). A further definition by the Council on Tall Buildings and Urban Habitat states that

> A tall building is not defined by its height or number of stories. The important criterion is whether or not the design is influenced by some aspect of "tallness." It is a building in

> which tallness strongly influences planning, design, construction, and use. It is a building whose height creates conditions different from those that exist in "common" buildings of a certain region and period (Ali and Armstrong, 1995).

For the purpose of this work a skyscraper, tall building or high-rise will be defined in accordance with the Emporis database definition of any building that is able to be occupied and is over 12 stories in height. Within such a definition, structures such as the Eiffel Tower and the Statue of Liberty are not considered. Currently, Emporis lists 107,948 buildings that have been completed and are over the 12 story lower limit. Further, Emporis also lists a total of 129,879 buildings over 12 stories that are in one of the following categories

- Completed
- Under Construction
- Proposed
- Approved
- Never Built
- Demolished
- On Hold
- Under Reconstruction
- Visionary
- Under Demolition.

Emporis is a trusted name in the real estate and building industry. Its website and database made in conjunction with help from the Council on Tall Building and Urban Habitat indexes the world's buildings and thus is a credible source for skyscraper information (Emporis Buildings, 2006).

The Great Chicago Fire

The city of Chicago was founded in 1804, destroyed in 1812 by Native Americans and was incorporated as a city in 1837 and today is the third largest city in America (Malden, 2006). Lying on the banks of Lake Michigan with the Chicago River weaving throughout some of the tallest buildings in the world; Chicago is where the skyscraper was conceived and born. But where did the impetus to build tall come from, what were the underlying factors in going vertical instead of horizontally within the city? It all began one fateful Sunday evening in 1871.

Near 9 p.m. on Sunday, October 8, 1871 in Patrick O'Leary's barn located in an alley behind 137 DeKoven Street a cow allegedly kicked over a lantern (Chicago Municipal Reference Library, 2005). That small flicker of flame was the spark that would eventually ignite the entire city of Chicago and engulf the heart of the city leaving only ruins. By 1:30 a.m. the fire had jumped the river and the business district was ablaze (Chicago Municipal Reference Library, 2005). Following the business district, the fire headed north and continued to lay siege to the city. Finally, by midnight on Monday the 9th, with the help of some rainfall the last flames were extinguished (Chicago Municipal Reference Library, 2005). Much of the city at the time was comprised of wooden-framed low level buildings and many so called "fireproof" commercial buildings (Douglas, 1996). Regardless of material, both types of buildings perished amidst the ravaging fire. The final numbers were staggering; 300 Chicagoans dead, a third of the population or roughly 90,000 left homeless and a damage estimate of $200 million dollars, an enormous sum of money in that day (Chicago Municipal Reference Library, 2005).

At the time Chicago was a vibrant, young city, acting as a significant traffic, trading and material hub for the Midwest and the entire country (Eisele and Kloft, 2003). Chicago had to be rebuilt and it had to be built in such a manner as to truly resist fire and prevent another disaster from demolishing the city in its entirety. The primary building material relied on therefore was steel, which was not a new material but was now being used in new applications (Douglas, 1996).

From Bridges to Buildings

Drawing inspiration from the bridge builders of the era, steel began to be implemented into structures as a viable alternative to stone materials (Douglas, 1996). Sir Henry Bessemer, the

English engineer, had developed the technique known as the Bessemer process and steel had been around since. The process involved blowing cold air through molten pig iron to decrease carbon content and impurities. The result was a material that now had greater compression and tension properties compared to wrought and cast iron (Bascomb, 2003). Also, the process made steel more durable and resistant to fatigue and corrosion (Bascomb, 2003). Steel exhibits the following properties

- Elastic: 22,000 pounds/ square inch
- Plastic: 36,000 pounds/ square inch
- Tension Failure: 45,000 to 60,000 pounds/square inch
- Compression: 30,000 pounds/ square inch

The compression property listed above is fifteen times greater than that of stone components (Sabbagh, 1989). Therefore, with strong and stiff steel, buildings had the possibility to be carried taller and taller without the restraints of load-bearing masonry construction. The upper limit of masonry was in fact 16-stories demonstrated by the Monadnock Building in Chicago (Starrett, 1928). However, with a tall masonry structure the base of the supporting masonry walls had to be 6 feet thick while sacrificing window space and the ever-important rental floor area (Sabbagh, 1989). Architects and engineers did attempt to lessen the sizes of these walls with cast and iron reinforcement within masonry walls, but lack of tensile strength compromised their long lasting structural integrity (Starrett, 1928). Thus, a new type of building was on the horizon, one in which steel would be the sole means of support and strength.

The First Skyscraper

With the advent of steel shapes and forms, the dungeons of masonry structures of old were no longer necessary. The skyscraper in comparison was actually well lit and airy. The place was Chicago, the year was 1883, the man was the architect and engineer William LeBaron

Jenney and the building was the Home Insurance Building (Douglas, 1996). Jenney had the impulse to take the dead load off of the masonry walls and place them solely on the structural steel and iron components that made up the building (Starrett, 1928). After erection of the 6th floor, Jenney was urged by the Phipps Steel Company out of Pittsburgh to use Bessemer type steel beams for the remaining floors in replacement of the wrought-iron beams that made up the first six stories (Starrett, 1928). Columns and beams were bolted together using angle-iron brackets. Although the Home Insurance Building was by all means a humble building at a mere 10 stories in height with an additional 2 stories added on later, the resulting "cage design" or steel "skeleton" was a tremendous breakthrough, one which has paved the way for today's high-rises and world's tallest buildings (Emporis Buildings, 2006). Now that the exterior walls acted only as a "curtain", large windows allowing the optimal amount of light in were possible. In fact, using alternative or reduced amounts of traditional masonry materials, a savings of 15% on normal building costs could be realized (Jencks, 1980) Also, the curtains were even capable of being transformed to include no masonry or supporting structure at all. The first example of this is in Ludwig Mies van der Rohe's Lakeshore Drive Apartments in Chicago, completed in 1951 (Ali and Armstrong, 1995). They are the first high-rises to be covered completely in glass and to define what we think of today as a true curtain wall.

Social Factors

Why build tall in the first place? Sure the technology was there and available but it was only made possible or even thought about because there was a demand for tall structures. Where did this demand come from? How did societal and population factors affect the advent of the skyscraper and its use as a viable building type?

As Chicago grew, so too did the need for the tall building grow. Following the Civil War that ended in 1865, Americans migrated in large numbers to large city centers such as New York and Chicago (Douglas, 1996). Between 1870 and 1890 alone, Chicago grew from 298,977 people to a city of 1,098,570, a 367% increase (Douglas, 1996)! The central hub of the Midwest with connections to the eastern seaboard needed more office space and more vertical space to combat an ever-increasing population and concurrently an ever-increasing business sector. Developers and owners saw a need and addressed it with multiple-storied buildings that were bolstered by Jenney's new found design. It was not practical or feasible to go horizontally so they instead went vertically.

Economic Factors

Cass Gilbert, the man who would be the architect behind the future world's tallest building, the Woolworth Building in New York City, made the statement that the modern skyscraper or high-rise was the "machine that made the land pay" (Willis, 1995). Escalating land values, property taxes and renter demands to be in close proximity to downtown business districts resulted in the growth vertically of city centers, particularly in Chicago who started with a fresh landscape after the Great Fire of 1871 (Starrett, 1928). In order to get the appropriate amount of return on investment, investors needed to build multiple stories of rentable floor area. Basically, skyscrapers are the result of that surplus need for more rentable area to justify the price of buying and building upon highly-valued land. It takes no hard reasoning to realize that a ten story building can bring ten times as much revenue as a one story structure. As discussed previously structural steel also allowed for more rentable area as opposed to bulky, costly masonry installations. Figure 2-1 shows that with increased stories the gross floor area increases incrementally, which allows for more rentable floor area. The figure represents a typical midtown Manhattan office tower, 1.6 million square feet in size for rentable floor space with a high central tower and setbacks.

It is a simple idea, build taller to offset land and development costs in order to increase revenues and operating incomes. However, that is not to say that one should construct a building into excess above the ground. There is a balance offset between building tall to recoup land and associated expenses versus the design, engineering and construction costs of technically and physically challenging buildings. That balance is termed the “economic height” of the skyscraper (Clark and Kingston, 1930).

> The true economic height of a structure is that height which will secure the maximum ultimate return on total investment (including land) within the reasonable useful life of the structure under appropriate conditions of architectural design, efficiency of layout, light and air, “neighborly conduct”, street approaches and utility services (Clark and Kingston, 1930).

Table 2-1 shows that as a buildings height increases and therefore the rentable floor area increases, so does the return on investment up to a particular point. At 63 stories investors can expect to receive a 10.25% actual return on investment on a typical midtown Manhattan high-rise. As this number is surpassed and the number of stories increases, the construction costs also increase and return on investment dwindles. In fact, at 131 stories it is evidenced that an investor would actually receive no normal computed return on investment and lose money at -0.02%. Once again, despite being an antiquated piece of literature the work still demonstrates that financial benefit remains a paramount factor in the decision on how high to build.

Technological Innovation

It is very much true that Jenney’s new design of placing the load of buildings onto structural steel supports thus allowing curtain walls is of prime importance. However, it is also important to note that several other systems were necessary to allow building to new heights. Without steel, skyscrapers would not have been possible but without proper engineering and technology they would not have been feasible or attractive as a building type. Of particular note are the inventions of the elevator, telephone, modern foundation systems, air conditioning and fluorescent lighting.

At the 1853 world's fair, Elisha Otis Graves unveiled a new invention, the first passenger elevator with a safety device (Bascomb, 2003). This invention came 32 years prior to Jenney's design with structural steel, but it allows for passenger movement well above the normal carrying capacity of the human legs day in and day out. The practical limit for building even masonry supported structures was six stories and rental rates amongst floors above the 3rd were much lower (Starrett, 1928). Thus, the elevator allowed owners to build as tall as desired in a safe manner and to a practical degree depending on the engineering at the time. As elevators have evolved so too have the skyscrapers that embody them. Typically, with every new world's tallest building it seems that the world's fastest elevators follow within. In fact, the current world's tallest building Taipei 101 in Taipei, Taiwan house the world's fastest elevators which travel at 3,281 feet per minute (Lepik, 2004).

Elevators are a complicated endeavor and require a separate design professional as a specialist elevator consultant on the design team (Yeang, 2000). Different orientations of the service core, elevator banks, sky lobbies, elevator zones and elevator systems must all be taken into account. How many people are to be serviced and what can be done about congestion for morning and work closing conditions? The elevator is the life blood for a tall building, for without it the skyscrapers we know today would not be fathomable. The following is a brief early historical timeline of the elevator

- 1853 – Elisha Otis Graves unveils 1st safe passenger elevator (Bascomb, 2003)
- 1871 – 1st passenger elevator installed at 120 Broadway in New York City (Abramson, 2000)
- 1887 – 1st electric elevator in use

- 1904 – 1st gearless traction elevator installed
- 1924 – Variable voltage elevator introduced allowing quick movement without jerking and speeds of 1,100 feet per minute (Jencks, 1980)

The invention of the telegraph had made long distance communication possible for business and company communication. However, Alexander Graham Bell's telephone invented in 1876 was a breakthrough in local interpersonal communication. This invention meant that coworkers and colleagues no longer needed to meet face to face (Wells, 2005). Even in the same building, large and expansive buildings in particular, the telephone was a practical means of communication that allowed for widespread offices even within very tall structures.

Underneath these mammoth structures lies an entire web of foundation systems that really is a mega structure under a mega structure. A problem facing early skyscraper designers, engineers and contractors was how the weight of the tall buildings was going to be transferred into the ground which supported the structure. The esteemed architecture and engineering firm of Burnham and Root in Chicago had an answer and implemented a steel grillage design that was a reaction to the realization that former pyramid stone and cement structures were no longer practical, nor were they feasible for such loads as were required under tall buildings (Starrett, 1928). Rail-road ties laid at right angles were embedded in concrete with steel I-beams at the upper courses. In essence, The Rookery Building in Chicago was the first modern floating foundation using Burnham and Root's design (Starrett, 1928). Today's foundations are now filled with rebar and concrete which is very emblematic of foundations of old. The modern foundations found under today's skyscrapers are decedents of the original answer to securing high-rise buildings and include

- Pad foundations
- Deep foundations
- Raft foundations
- Caisson foundations

- Pile and raft foundations
- Pile, raft and slurry wall foundations

The air conditioner also changed the way that skyscrapers were built and where. After its invention in 1939 by Willis Carrier in America natural means of ventilation and cool air were no longer necessary (Abel, 2003). This provided the opportunity to design now without a further restraint due to air. Now how were these large structures going to be lit? Outer offices and locations were obviously no problem since they were in close proximity to windows. However, inner spaces far from windows needed adequate lighting as well. Initially, these concerns were met by light courts placed inside high-rises to allow light into all offices and into multiple sides of the building. The invention of interior fluorescent lighting then allowed light into interiors not near windows at all. The boundaries created by designing around natural lighting were no longer prevalent and thus new structures with new architecture could be developed in the 1940's as this technology was available (Willis, 1995). Recently, the modern skyscraper has gone back to a policy of natural lighting as much as possible in a sustainably conscious world, but the fluorescent light still abounds for cloudy days and night work shifts.

The design consideration was there, the technology was there and questions were no longer if high-rise building was possible but rather how high and how fast? Building tall was now a measure of resolve and owners took that resolve and started making skyscrapers at a feverous pace. Where better to build tall than the great American cities of Chicago and New York?

Chicago to New York

Flying into O'Hare International Airport you see home after home and strip mall after strip mall. But then the ground starts to swell and the buildings get taller and taller and the skyline emerges. Names like Sears, John Hancock and ATandT extrude from the waters of Lake Michigan. Currently housing America's tallest building, the Sears Tower at 1,451 feet to its structural top, Chicago is where the world first saw tall buildings being constructed (Emporis Buildings, 2006). Beginning with William LeBaron Jenney's Home Insurance Building in 1885, Chicago was an experimental think tank of innovation and invention for how to build tall. The architects, engineers and contractors in Chicago at the time were developing new designs and implementation techniques as fast as the buildings were being demanded, higher and higher and higher still.

The First World's Tallest Anything

Seven years following the Home Insurance Building, the first building to be touted as the world's tallest anything was built. This building was the Masonic Temple built in 1892 (Emporis Buildings, 2006). The "tallest commercial building" in the world started what has been a heavily combated race ever since (Moudry, 2005). Prior to completion, the competing organization of the Independent Order of Odd Fellows, claimed that they were going to build not only the world's tallest commercial building but the tallest building of any kind in the entire world (Moudry, 2005). Once again, a precedent had now been set and the spectacle side of the skyscraper was now coming to fruition. The Independent Order of Odd Fellows in fact, like many future world's tallest buildings, never realized their structure and thus the Masonic Temple held the crown. It drew public attention and wonderment, which has only pervaded to this day creating a public advertisement that had no equal.

The World's Tallest Heads East

The year after Chicago held the world's tallest commercial building, the city council actually limited building height due to a recession in the real estate market. 1893 saw the height limited to 130 feet, or around 10 to 11 stories (Willis, 1995). Such a limit would for sure doom the future chances of Chicago to hold the world's tallest anything once New York approved skeleton steel construction into their building code. As such, 1899 saw the definitive shift from building the tallest in Chicago to New York. The Park Row Building completed in that year was the first of many world's tallest buildings to be completed in New York City. With it there would be no question of tallest with a lantern, spire or other architectural detail. The title would not return to Chicago for another 75 years. The restrictions on skyscrapers in Chicago put them behind New York forever and as such Chicago has been America's second city in skyscraper construction and design regardless of the Sears Tower. Currently, New York City has nearly five times as many skyscrapers with 5,053 as compared to Chicago's 1,050 tall buildings (Emporis Buildings, 2006). True, New York is much more populated and contains the nation's financial center, but perhaps that capacity came with the ability to construct tall structures without severe restrictions. It is also true that lot sizes in Chicago were much larger than in New York due to the Great Fire of 1871 and therefore going up was more practical and inevitable in New York City (Willis, 1995).

The New York Era

Once the New York area got a hold of the skyscraper there was no stopping the massive amount of tall building construction taking place in Manhattan. In 1890 there were 6 buildings over 10 stories in New York, by 1908 there were 538 (Nash, 2005). In those 18 years tall buildings in the city grew by nearly 900%! This count was taken at 10 stories but the number is still staggering to acknowledge.

New York City Skyward

In that year 1908, another structure in New York was built that took the title of world's tallest building. The Singer Building built for the infamous sewing machine company was 612 feet, placing it 221 feet above the formerly world's tallest Park Row Building (CTBUH Database, 2006). It was a public exhibition this building of the world's tallest building. An advertisement of the largest kind. For a few cents even, the public could get to the 40^{th} floor of the Singer Building and look out over New York City (Lepik, 2004). But fame was fleeting for the Singer Building and the following year in 1909, the 700 foot Metropolitan Life Insurance Building took the title of world's tallest building (CTBUH Database, 2006). It too was complete with viewing tower on the 46^{th} floor (Lepik, 2004). Insurance companies were widely expanding and needed more office space to house their large work forces following the trend that skyscrapers were a response to business needs (Ali and Armstrong, 1995). These large structures not only served a practical purpose, but also served as a positive attribute of wealth and security (Abramson, 2000). Constructing the world's tallest building was also a prime way to get free advertising into the public eye to attract possible new customers.

It was not only the heights of these structures that were attractive, but also the romantic fervor emanating from large, symbolic structures such as the Flatiron Building of 1902. The building was originally the Fuller Building, but with a stark resemblance to a flat-iron the building has taken on a more suitable name (Nash, 2005). Other buildings with symbolic elements placed into them included the American Radiator Building of 1924 and the City Bank Farmers Trust Building of 1931. The American Radiator Building was made of black brick so that when the lights were on in the inside at night it glowed to convey the metaphor for home heating that the company was involved in (Nash, 2005). The City Bank Farmers Trust Building on the other hand contained the 14 giants of finance at the 19^{th} floor setback. Each giant alternated smiling and frowning to portray the business cycles of bust and boom (Abramson, 2000). Also, numerous famous building competitions were taking place to generate publicity and public involvement. Two notable competitions were the New York Times Building competition of 1913 and the Chicago Tribune competition of 1922. These sparked publicly celebrated events and people skied the building as soon as possible to get a glimpse of the view they offered. For the Chicago Tribune competition alone 263 architecture proposals were received (Abel, 2003). The architects were to design the world's greatest building for the "World's Greatest Newspaper", an indication of the symbolic nature that the Chicago Tribune was after as an icon for their newspaper.

As the public became enraptured, so too did developers and building owners. Frank W. Woolworth the self-made millionaire of the popular five-and-dime stores wanted a structure to go above all others. The answer was the 1913 Woolworth Building. It was a symbol of Woolworth's fiscal strength and business success over the years. For its completion Woolworth even paid 13.5 million dollars in cash for his building which was quickly nicknamed the "Cathedral of Commerce" (Emporis Buildings, 2006). The 792 feet were not necessarily a financial consideration or a true real-estate transaction, but rather a testament to the influence of ego and power within the skyscraper. Woolworth was supposed to have said to make it 50 feet taller than the Metropolitan Life Building which had denied him a much needed bank loan years prior, he succeeded by 92 feet instead but the message had been sent (Lepik, 2004). The construction and completion of the building was such a tremendous national affair that President Woodrow Wilson turned on the lights himself on April 24, 1913 to be an ornament of the city of New York (Lepik, 2004). Of course the building also had its own viewing platform on the 55th floor, open to the public (Lepik, 2004). The competition for world's tallest was heating up and the attractive nature of building tall for space, notoriety and power was taking hold.

Skyscraper after skyscraper continued to be raised and at such a pace that there grew concerns with air quality and illumination for the streets below. The Equitable Building was a behemoth twin towered structure that is said to have caused the 1916 New York zoning law to be enacted (Moudry, 2005). This zoning allowed one-fourth of the lot to be unlimited in height and the rest to be setback accordingly, resulting in a “wedding cake” look (Willis, 1995). Some of New York’s most famous and powerful skyscrapers were about to be constructed under this setback zoning law.

Race into the Manhattan Sky

Following World War I a young America was out to prove itself and its prosperity, what ensued has been termed the “roaring 20’s”. The tallest buildings typically occur at the end of large economic or real-estate booms. One such boom was the “roaring 20’s”, which ended in the Great Depression that began in October, 1929 and whose effects were truly felt by 1930 (Willis, 1998). The peak that accompanied this race into the sky occurred in August, 1929 right in the middle of planning, designing and constructing the buildings that challenged for the world’s tallest (National Bureau of Economic Research, 2003). Prior to that catastrophic economic downturn however, a race for the world’s tallest building ensued, the likes of which have not been replicated. There were three runners each with a sincere belief and determination to be the world’s tallest building regardless of all comers. These three buildings were the Manhattan Company Building, the Chrysler Building and the Empire State Building all completed within the same time period. Today, they still stand as three of the four tallest buildings in New York City (Emporis Buildings, 2006). But how did they get there?

Initially, there were two buildings in the race for the world’s tallest; the Manhattan Company Building and the Chrysler Building. The architects for each building, H. Craig Severance and William Van Alen, were once successful partners from 1914 till 1925 who had a rather harsh falling out and now were competitors not only for work but also for the title of world’s tallest (Bascomb, 2003). The owners were both wealthy businessmen. Walter P. Chrysler was another self-made millionaire whose car company had become one of the top three car companies in America at the time. The developer of the Manhattan Company Building, George Ohrstrom, was termed the "boy wonder" of Wall Street and set out with Starrett Brothers and Eken to build not only the world's tallest building but to build it within one year.

The Chrysler Building was a testament to the company's wealth, success and prosperity. Brick mosaics included cars, metallic elements dotted the exterior, the interiors were emblematic of the modern automobile and above all it was to be the world's tallest building towering over the 26-story General Motors building (Bascomb, 2003). Now, the Manhattan Company Building may have lacked ornamental symbolism, but it was nevertheless to be the tallest building in the world and not only that, it was to be constructed at a break neck speed. Its green copper top is today an identifiable symbol in the lower Manhattan skyline.

The papers and the public followed each step closely but before the race could be any further underway a new player entered the arena. The Empire State Building was announced by a team of former governor Alfred Smith and John Raskob, the head of General Motors. Now the race was three pronged and featured car companies, opposing design professionals and a place for only one to take the crown of world's tallest. Since the Chrysler Building had begun in 1928 and the Manhattan Company Building had begun in 1929 they were ahead of the Empire State Building which began in 1930 (CTBUH Database, 2006).

As the first two reached completion it appeared that the Manhattan Building would beat out the Chrysler Building. However, not to be done by boundaries of money or material Chrysler and Van Alen set out to make a new design, a secret design to finish the top of the Chrysler building and overtake the Manhattan Company Building. Van Alen is quoted as saying "if this is to be a skyscraper, why not make it scrape the sky" (Bascomb, 2003)? So that is what they set out to do, and after a redesign in secret, Chrysler and Van Alen had a plan to overtake

Severance and Ohrstrom and hopefully take care of the Empire State Building's future height competition. The Manhattan Building was topped out and proclaimed the world's tallest building in all the papers and on the tongues of New Yorkers. However, the Chrysler team remained quiet and thereafter raised their secret nirosta covered obelisk that had been constructed within the upper portion of the building away from view (Bascomb, 2003). On October 16, 1929 the Chrysler Building was officially the world's tallest building without question…for now at least.

What about the Empire State Building and its endeavors? Originally, the structure was to be just under 1,000 feet tall (Willis, 1998). With the new tip of the Chrysler Building at 1,046 feet why not just go that much taller and become the tallest building in the world (Emporis Buildings, 2006)? The design was changed to a 1,050 foot building with a mooring mast of 200 feet for zeppelins (Willis, 1998). Would this add to the economical value of the building, would this mast ever really be used by zeppelins? The answer is no and as such the ego and pride factor of building tall is evidenced. When the men building and purchasing the building were that close to being the world's tallest how could they turn away from such a feat? Raskob was particularly perturbed that the United States still had no structure that was taller than the Eiffel Tower in Paris, France (Bascomb, 2003). This mindset followed the American builder mindset of outdoing, out designing and out building the old world of Europe. So they went forward, completing the building in record time with record feats, including finishing the structural steel in 11 months (Willis, 1998). The Empire State Building rose as quickly as both the Manhattan Company Building and the Chrysler Building despite being twice the size (Willis, 1998). At the point when the contracts were first signed with the architects in 1929 to when the building was opened May 1, 1931 there had spanned only 21 months (Willis, 1998). From the original 80 to

85 stories planned to the 102 stories completed, the Empire State Building was termed the "Eighth Wonder of the World" (Empire State Building, 2006). It was a pinnacle of American endeavor, service, hard work and grit. In the 75 years since the opening of the building in 1931, 117 million people have visited its observation deck (Empire State Building, 2006). In the first year alone, one million dollars came from observation deck fees, which equaled the amount generated from the rent in that year (Willis, 1998). The builder, Starrett Brothers and Eken, received the title of world's tallest in the Empire State Building that was not realized within the Manhattan Company Building project. Colonel William Aiken Starrett who passed away shortly after finishing the building perhaps sums up best the reason New York and America grew up quickly in the early 20th century.

> We Americans always like to think of things in terms of bigness; there is a romantic appeal in it, and into our national pride has somehow been woven the yardstick of bigness. Perhaps that is one of the reasons why we are so proud of our structures; they are big, very big, certainly the tallest and certainly the most complex and the most compelling the world has ever seen. They fairly personate the hustle and bustle of our modern accomplishment and postulate our ideal of efficiency, and they are our national pride because they are so completely American. So the bigness of the business as a whole we enjoy gasping over.
>
> -Colonel William A. Starrett

The New Challengers

With the onset of the Great Depression finally hitting the finances of construction and lenders, it would be 41 years before another world's tallest building took the place of the Empire State Building. America would resume building tall after World War II but the tallest skyscraper construction still would occur around peaks of business cycles such as the peak in 1973 (National Bureau of Economic Research, 2003). The desire to build tall is inherent as discussed before, and building tall remains dormant for only so long. For too long the United States and the world had not constructed a new world's tallest, a building that defied nature and that drew the attention of the public.

One World Trade Center and Two World Trade Center were the final world's tallest buildings to be located in New York City. Awe-inspiring, aluminum supports adorned the exterior and it shone like a lighthouse indicating their position in lower Manhattan as the shining star above the world's business capital. The story of their demise is well known, but their birth and life were tremendous achievements. On a given business day as many as 200,000 visitors came to the buildings and the buildings themselves held 500 businesses compromising 50,000 employees (Stephens, 2004). It was a city thrown up vertically into the sky.

In the heated world's tallest races of the early 20th century no one building lasted very long as the world's tallest until the Empire State Building. In that fashion One World Trade Center being just 6 feet above Two World Trade Center at 1,368 feet lasted only about 2 years as the world's tallest building (CTBUH Database, 2006). Alas, Chicago reclaimed its title of having the world's tallest building with the Sears Tower in 1974 (Emporis Buildings, 2006). An icon among icons, the Sears Tower was built by the mighty Sears Roebuck Company and remains the tallest building in America and ruled the world from 1974 until 1998, a period of 24 years. On a clear day there were views of four states; Illinois, Indiana, Wisconsin and Michigan (Pridmore, 2002). The Sears Tower has become not only a symbol of the fiscal strength of Sears or of Chicago, but also a symbol of the entire Midwest. The Sears Tower sets itself apart magnificently and is inseparable from the city of Chicago. The designer and structural engineer Fazlur Khan who also designed another significant building in the John Hancock Center was concerned with making the buildings he created human (Ali, 2001). High-rises have tremendous human appeal. They inspire and demonstrate the ultimate strength and reaches of human existence and so there is an attachment that is all too human to these tall structures of glass, steel and concrete. From America to abroad, the human aspect to build tall is omnipresent. The next period and waves of tall buildings now were going to come from across seas.

The skyscraper as a building type is an entirely American invention and as such much pride has been taken in the tall building across the nation. The skyscraper departed from the old world and dared to go above and beyond anything that had been seen prior. For roughly 113 years America reigned supreme as the tallest nation in the world. From Chicago to New York, and back the skyscraper transformed the American city, and the world was to follow. The following is a historical timeline of skyscraper history thus far

- 1885 – Home Insurance Building becomes the first skyscraper
- 1892 – Masonic Temple touted as first of world's tallest commercial buildings
- 1899 – Park Row Building shifts tallest building race from Chicago to New York
- 1902 – Flatiron Building demonstrates literal symbolic architecture
- 1908 – Singer Building constructed to take world's tallest title
- 1909 – Metropolitan Life Insurance Building takes world's tallest title
- 1913 – New York Times building competition
- 1913 – Woolworth Building built to world's tallest height
- 1922 – Chicago Tribune building competition
- 1924 – American Radiator takes literal symbolic architecture to new heights
- 1929 – Great Depression begins
- 1930 – Manhattan Company Building takes bronze medal in world's tallest race
- 1930 – Chrysler Building becomes the world's tallest building temporarily
- 1931 – City Bank Farmers Trust Building "giants of finance" constructed
- 1931 – Empire State Building begins 41 year world's tallest reign

- 1972 – One World Trade Center is completed as the world's tallest building
- 1974 – Sears Tower becomes the world's tallest building and restores the skyscraper crown to Chicago

The Asian Tiger

Just as the skyscraper spread from Chicago to New York and across the United States, so too has the skyscraper gone to the far reaches of the entire globe. The global skyscraper has a particular stronghold in the Asian Pacific rim countries such as China, Japan, Malaysia and Taiwan. The truth is that there are more skyscrapers being constructed and being constructed at greater heights in Asia today than in America (Emporis Buildings, 2006). Tables 2-2 and 2-3 show that America's tall buildings were built in the average year of 1972 as opposed to China's tallest buildings being built at the average year of 1998, a 26 year difference. Further, China's average building height for their top ten buildings is 63 feet over the average of America's height at 1,109 feet. America's saving grace is that 9 of the 10 top ten tallest are above 1,000 feet while only 7 of China's top ten are above 1,000 feet. Regardless, the current rate and height of construction demonstrates the construction ability and power that China and other Asian countries around them are exerting in such a short period of time. The days of the pagodas and shrines may be extinct but a new structure in the skyscraper has taken their place. With the design, implementation and construction of their tall buildings Asian countries have added their own recipe for skyscraper image and structure. Asian countries have taken the skyscraper into a new light in accordance with their beliefs, symbolism, politics and culture.

Asian Trends

With increasing population, decreasing free land and increasing economic prosperity it is no wonder why many Asian nations are taking the lead in skyscraper construction. While America still remains strong and healthy in its development of urban, downtown environments, the Chinese are building out of necessity and policy. In the same manner that New York and Chicago grew up in huge fits of construction booms and civic pride the Chinese in Shanghai, Hong Kong and Beijing are building their communities at a feverish pace. The skylines and city centers that took decades upon decades and generations upon generations in America is taking the Chinese and other Asian communities only a single generation to complete. New York took 50 years, Hong Kong took only 30 years and soon other fast growing cities will take even less time to grow up vertically (Abel, 2003).

Excluding the year 2006, the skyscraper has had a 120 year history. China's first tall buildings over 12 stories as listed by the Council on Tall Building and Urban Habitat Emporis database occurred 44 years after Jenney's Chicago skyscraper in 1929. That year saw two 13-story hotels go up in Shanghai termed the Peace and Jin Jiang Hotels (CTBUH Database, 2006). Following those two hotels, China's skyscraper inventory did not increase exponential and only increased very mildly at best. Therefore, for the sake of this discussion the skyscraper's history has been divided into two 60-year periods, from 1885 to 1945 and from 1946 to 2005 respectively.

Table 2-4 demonstrates that from the inception of the skyscraper in 1885 until the end of World War II the United States of America erected 5,600 skyscrapers which accounted for an average of 84% of the skyscrapers built throughout those years in the world. In contrast, the years after World War II to the present have showed a sharp average decrease in America's skyscraper construction compared to world skyscraper growth. Those years exhibit an average of 35% for the 11,981 buildings built in America, as compared to the amount of skyscrapers built in the world during that time period. This is not to say that America is building fewer skyscrapers, but that the world is catching up in a global fashion, in particular China portrays the

Asian tiger quick growth of population, economy and thus skyscrapers. With only 10 skyscrapers from 1929 until 1945 China was a non-factor in any skyscraper diatribe. However, in the second half of skyscraper history, China has taken their tall building numbers from a meager 10 to 8,453. This number accounts for an average of 13% of all skyscrapers built in the world during those 60 years. Obviously, this trend shows that not only are emerging countries like China building tall, but also that the rest of the world is accounting for a large percentage of high-rises.

China may be half a world away but themes of power, aesthetic, pride and symbolism that were very present in the American skyscraper pervade the Chinese skyscraper. The economic, social and cultural implications are still felt. China is a dynamic, constantly changing country and as such its high-rise architecture is invocative of the new found strength and power China wishes to exude and that China does in fact possess. With the release from British colonial rule for Hong Kong in 1997, several financially powerful structures were being erected in the years leading up to the Hong Kong release. The Hong Kong and Shanghai Bank Headquarters demonstrated some of the global architecture of the region. The Bank of China constructed in 1989 was for a while the tallest in Hong Kong (Abel, 2003). The legendary architect of the Bank of China, I.M. Pei, described the building as a symbol of the "economic awakening" that was to befall China in the coming years (Lepik, 2004). Both buildings brought on a feng shui expert in the design and planning stages to ensure acceptance by the public (Lepik, 2004). The fifth tallest building in the world located in Shanghai is the Jin Mao Tower, completed in 1998 (Emporis Buildings, 2006). In addition to the recognition garnered from building to the height of 1,380 feet, the tower exudes carefully planned Chinese characteristics (Emporis Buildings, 2006). The number 8 in Chinese culture is significant for luck and as such the designers of the Jin Mao used it multiple times in the floor plan of the skyscraper. The core of the building is actually an octagon and the base size is at 1/8th scale in regards to the height of the building (Lepik, 2004). The shape of the exterior structure represents the classic Chinese pagoda step-down appearance as well. Even young, developing towns are taking part in the skyscraper to put themselves on the map so to speak. This idea of using height to gain recognition and notoriety for a region or country is truly exemplified in the Petronas Towers and Taipei 101 yet to be discussed. As such, the new town of Shenzhen located in southern China wanted a building that symbolized their spirit and resolve as a community to be recognized (Gissen, 2002). They placed no height restrictions on the building and named it the Di Wang Commercial Center whose height was intentionally set at 33 feet higher than the Bank of China in Hong Kong (Gissen, 2002). The ribbon-window banding at the corners gives the building the look of traditional kung fu jackets and the green color of the entire building symbolizes prosperity (Gissen, 2002). Even the shape of the building as a whole reads as the Mandarin word "mei", which translated means beauty (Gissen, 2002). Now with the tallest building in Shenzhen, there has to be an observation deck, the 69th floor acts as such (Emporis Buildings, 2006).

The Petronas Shift

Amazingly enough, China was not the country to produce the tallest building in the world outside of the United States. That sole distinction fell on a much lesser known country, Malaysia, in 1996. With the topping out of the Petronas Towers in Kuala Lumpur, building the tallest building in the world shifted from an American endeavor to a worldwide one. The Petronas Towers were the quintessential statements in the Asian shift of skyscraper building.

At 1,483 feet to the architectural top of the classic Islamic minarets that adorn each building, the Petronas Towers eclipsed the Sears Towers by only a mere 32 feet (Emporis Buildings, 2006). Those 32 feet made all the difference in the world however and the little known country and capital of Malaysia and Kuala Lumpur were truly put onto the map. After all, that was the intention of the developers, designers and builders of these twin beauties.

The buildings themselves were constructed by the state petroleum company and located distinctly in the newly developed commercial center of the Golden Triangle area in Kuala Lumpur (Lepik, 2004). The towers while serving as the obvious functional office space serves several qualitative purposes. The Petronas Towers are said to be part of a larger plan to shift technology and to transform the image and enterprise of the whole nation of Malaysia (Reina and Post, 1996). An image that puts Malaysia on the same level as only the most developed nations (Reina and Post, 1996). The towers with their pedestrian bridge on the 41st floor, which serves as an observation deck, demonstrate a large gateway into the economy of Malaysia (Emporis Buildings, 2006). The gateway is meant to lead the mind and eye into the commercial heart of Kuala Lumpur and therefore Malaysia (Robison, 1994). Further symbolism reveal cultural and social impacts of the Malaysian people. Being an Islamic state, the footprint resembles the 8 point star popular in Islam and the exterior has a classic scalloped pattern as well. The elements that actually put the Petronas Towers up and over the architectural top of the Sears Tower were the aforementioned Islamic minarets (Engineering News Record, 1996). Lastly, the towers can be described as "tropical" towers that reflect the Kuala Lumpur climate and actually shimmer in the sun (Post, 1996).

The topping out of the Petronas Towers in 1996 was a nationally celebrated event in Malaysia complete with fireworks and national fervor. Like the topping out of buildings in America, the nations flag was flown and the final beam signed by those pertinent to the project. For the first time, a building had been eclipsed from abroad, and not only that, but it was the first time two buildings held the world's tallest title. With the same tradition and excitement that

America “tops out” its buildings, so too had the elation of height gone global. All of sudden the United States had dropped from 1st to 3rd in the race to be the world’s tallest. However, America had one last hope prior to the Petronas Towers being christened the world’s tallest buildings, the Council on Tall Buildings and Urban Habitat.

Council on Tall Buildings and Urban Habitat (CTBUH)

The Council on Tall Buildings and Urban Habitat originally began as the “Joint Committee on Tall Buildings” formed between the International Association of Bridge and Structural Engineers and the American Society of Civil Engineers in 1969 (Council on Tall Buildings and Urban Habitat, 2006). Beginning in 1973, the Council listed the 30 tallest buildings in the world and in 1980 the Council expanded its listing to the more well-known 100 world’s tallest buildings (Engineering News Record, 2004). The mission of the council explains the connection that the CTBUH has with both skyscrapers and the downtown urban environment as a whole.

> The Council on Tall Buildings and Urban Habitat, an international non-profit organization sponsored by architectural, engineering, planning, and construction professionals, was established to facilitate professional exchanges among those involved in all aspects of the planning, design, construction and operation of tall buildings and the urban habitat.
>
> The Council's primary goal is to promote better urban environments by maximizing the international interaction of professionals, and by making the latest knowledge available to its members and to the public at large in useful form.
>
> The Council has a major concern with the role of tall buildings in the urban environment and their impact thereon. Providing adequate space for life and work involves not only technological factors, but social and cultural aspects as well.
>
> While not an advocate for tall buildings per se, in those situations in which they are appropriate, the Council seeks to encourage the use of the latest knowledge in their implementation (Council on Tall Buildings and Urban Habitat, 2006).

Now, the measurement of height for each building was determined from the sidewalk level of the main entrance to the architectural top of the building which included penthouses, spires and pinnacles, but not masts, flagpoles and television or radio antennas (Engineering News

Record, 2004). This stipulation was decided upon to always apply to the Sears Tower by the Council and by Fazlur Khan, the designer and structural engineer of the building (Engineering News Record, 1996). The idea was that antennae are only temporary structures and that minarets, for example, are in fact permanent (Gill, 2005). As such a highly contested battle as the world's tallest building has been since the inception of the skyscraper, it is no wonder why Americans and in particular Chicagoans wanted a shifting of the rules to not include the minarets that make the Petronas Towers taller than the Sears Tower. The Chicago Committee on High Rise Buildings wined and dined the Council on Tall Buildings and Urban Habitat and proposed a "hats off" approach to measuring the buildings (Engineering News Record, 1996). Hundreds of local school children even wrote letters to the CTBUH, but in the end these actions which occurred very near to when the CTBUH named the Petronas Towers the world's tallest had no effect on the final ruling and thus the world's tallest in Chicago was reduced to third tallest.

Out of the debacle that was naming the Petronas Towers the world's tallest buildings, the Council on Tall Buildings and Urban Habitat decided to expand the categories from one to four. Rather than solely relying on the structural or architectural height of a building the Council decided that buildings could also be measured by highest occupied floor, top of roof and top of the antennae (Gill, 2005). By these rules the Petronas Towers retained the title of world's tallest building to the architectural top. However, the Sears Tower now held the title in the other three categories. With the new CTBUH rulings, the world's tallest landscape looked as follows:

- World's Tallest Building to the Architectural/Structural Top: Petronas Towers – 1,483 feet
- World's Tallest Building to the Highest Occupied Floor: Sears Tower – 1,355 feet
- World's Tallest Building to the Roof: Sears Tower – 1,451 feet
- World's Tallest Building to the Antennae: Sears Tower – 1,729 feet

The Shift Continues

Further demonstrating that the construction of tall buildings requires an enormous amount of financial backing and clout, the skyscraper surge in Asia took a tremendous dip in the same year that the Petronas Towers were completed. 1998 saw numerous volatile highs and lows in stock markets around the world (Zukowsky and Thorne, 2000). In addition, there were drastic downturns in Asian economies which led to the direct cancellation and the postponing of several tall buildings (Zukowsky and Thorne, 2000).

However, with the completion of Taipei 101 or the Taipei Financial Center in Taipei, Taiwan in 2004, the Asian skyscraper was back. Along with this tall building, was also the desire to be the world's tallest. Upon its completion, Taipei 101 held three of the four, Council on Tall Buildings and Urban Habitat, world's tallest titles. The four categories are currently as follows:

- World's Tallest Building to the Architectural/Structural Top: Taipei 101 – 1,671 feet
- World's Tallest Building to the Highest Occupied Floor: Taipei 101 – 1,473 feet
- World's Tallest Building to the Roof: Taipei 101 – 1,440 feet
- World's Tallest Building to the Antennae: Sears Tower – 1,729 feet

Taipei 101 stands much taller than even its title of the world's tallest building. The city of Taipei located in northern Taiwan contains only 167 high-rise buildings and the second tallest building, Shin Kong Life Tower, is nearly half the height of Taipei 101 (Emporis Buildings, 2006). Therefore, Taipei 101 stand as a giant able to be seen from all points in the city. The building obliges views at the 89th and 91st floors which both act as observatories (Emporis Buildings, 2006). The sight is one that must have been similar to when the Empire State Building was constructed amongst the low and mid-rises in midtown Manhattan.

The building itself encompasses a landmark symbol of Taiwan's economic success and national pride. Taipei 101 is a very vibrant centerpiece to the newly formed Hsingy financial and government district in the area (Gissen, 2002). It stands as the first world's tallest building of the 21^{st} century and within the structure lie once again several other symbolic gestures toward culture and social aspects of the Taiwanese people. At the topping out of the building the Taipei mayor at the time and now president of Taiwan installed a golden bolt much like the ceremony at the Empire State Building in which Alfred Smith laid the cornerstone using a golden spade for the mortar (Bascomb, 2003). It was the mayor's idea to build the tallest building in the world, which shows how significant leaders of the world think having the world's tallest building is (Lepik, 2004). With Taipei 101 it also becomes increasingly evident that smaller countries feel that by building tall they can show the world they are not quite so non-influential.

Overall, the architecture is invocative of the Chinese and the dominant color in the green-tinted cladding is designed to impersonate jade (Howeler, 2003). The Chinese lucky number 8 can be found again in this building. There are 8 mega-columns with supporting mega-truss outriggers per every 8^{th} floor (Gissen, 2002). The entire structure resembles many things including bamboo sprouts and the traditional pagoda design (Lepik, 2004). At night the stepped surfaces make the building glow like a lantern. The unfolding petal styling is not only important to make the building look like a lantern at night, but also is a sign for prosperity in Chinese symbolism (Gissen, 2002). Dragons meant to bring luck adorn the building as well (Lepik, 2004). In keeping with themes from other skyscrapers, the building also contains the world's fastest elevator at 3,281 feet per minute (Lepik, 2004).

The following displays the Asian skyscraper historical timeline thus far

- 1929 – First 2 skyscrapers constructed in China, Peace Hotel and Jin Jiang Hotel
- 1989 – Bank of China completed, tallest building in Hong Kong at the time
- 1997 – Hong Kong released from British colonial rule
- 1998 – Petronas Towers completed in Malaysia to become world's tallest buildings, first world's tallest buildings outside of America

- 1998 – Asian financial downturn cancels or delays many skyscrapers
- 2004 – Taipei 101 completed in Taiwan to become world's tallest building

State of the Skyscraper

The world, and not just Asia and America, is building skyscraper after skyscraper. The global building is becoming a force wherever land is scarce, populations are booming, economies are thriving, power is garnered and a message wants to be sent. The American invention has taken hold and to build up is to be modern. The factors that influenced construction of the tall building from the past are still paramount in the built world today. Even proposals of the world's tallest building draw the attention of writers and readers everywhere. What are the tallest buildings and tallest buildings by usage? How do the populations compare for countries that build tall? How does a country's gross domestic product (GDP) and skyscraper construction compare? Where are the completed tall buildings located in the world, which particular continents and nations? Where does the skyscraper as a building type stand in the world, in individual countries? Questions answered in this section show that the skyscraper is engrained within civilization throughout the world as a global building type. As globalization continues, it appears the skyscraper is likely to stay in the hearts, minds and structures of developed and developing nations in the world.

The Power of Proposal

Staggering amounts of publicity followed the Manhattan Company Building, the Chrysler Building and the Empire State Building during the race to the world's tallest building at the end of the 1920's and the beginning of the 1930's. Building the world's tallest building draws the attention of the public and therefore the attention of the papers that serve the public. Following suit during the construction of those buildings, several others paid lip service to building the world's tallest building themselves. Included in these plans that hit the headlines day in and day out, was the 100 story skyscraper of a not yet determined height for the Manhattan Life Insurance Company, developer A.E. Lefcourt was proposing a 150 story tall building and developer Charles Noyes even proposed going a quarter of a mile into the sky and two blocks wide (Bascomb, 2003). The Great Depression certainly derailed any proposed plans but who knows if these dreaming structures would have been constructed regardless. The point is building tall is exciting and draws the loftiest of expectations, even if they may be unrealistic.

The super tall buildings built in New York in Chicago during the 1970's also drew their fair share of news coverage. A building finally taking over the Empire State Building after 41 years such as One World Trade Center was news to New Yorkers and to the nation. The following Sears Tower in Chicago therefore, was a direct news catcher as well as it overtook One and Two World Trade Center in 1974. The public and the press cannot help themselves; they look to the sky in awe. Young and old, big and small, all are captivated regardless of decade or design.

As the turn of the century neared closer and closer several buildings were being proposed to eclipse any heights attained thus far. There seemed to be a trophy for having the tallest building as the year 2000 drew to a beginning. This race for the millennium entailed several buildings that shot for the 2,000 foot mark, several others that sought simply to be the world's tallest and others who sought simply to be the tallest in their region. Notable buildings that were envisioned but never happened in the fever that was the years before and around the millennium included

- Miglin-Beitler Tower – Chicago, 2,000 feet tall, would be world's tallest
- Millennium Tower – Tokyo, 2,754 feet tall, to house 60,000 people
- Millennium Tower – London, 1,265 feet tall, would be European record
- Tours San Fin – Paris, 1,377 feet tall, would be European record
- Grollo Tower – Melbourne, 1,625 feet tall, would be world's tallest
- Bionic Tower – Shanghai, 4,029 feet tall, to house 100,000 people

- 7 South Dearborn – Chicago, 2,000 feet tall, would be world's tallest (Lepik, 2004)
- Maharishi Tower – Sao Paulo, 1,662 feet tall, pyramid to house 50,000 people (Civil Engineering, 1999, November)

Several of these towers demonstrated no significant financial gain and could only be explained by the pride that would be associated with creating each building. Most world's tallest buildings edge the previous record holder by an average of around 100 feet; the buildings proposed for the millennium race for the world's tallest however edged the current world's tallest by several times this number (Civil Engineering, 1999, April).

The press and publicity received for producing buildings of monumental size that shape skylines is something that will continue for as long as any kind of interesting, nature-defying structure is even conceived in the brain of a designer. For example, Frank Lloyd Wright's Mile High Skyscraper of 1956 was never realistically proposed to be constructed, but it got people thinking and it got people excited about building tall again (Zukowsky and Thorne, 2000). In that same spirit, it takes people to ask how high and how complex, rather than maintaining the same "glass box". Buildings will continue to challenge the current, to realize the buildings of the future.

The World's Tall Buildings

There can be only one world's tallest building. One could argue that there could be four world's tallest buildings with the Council on Tall Buildings and Urban Habitat rules, but the most prestige seems to be in the tallest to the architectural top such as Taipei 101. However, building tall is an endeavor in itself. They cannot all be the world's tallest buildings. Table 2-6 demonstrates that since the first touted world's tallest building, the Masonic Temple built in the year 1892 in Chicago, there have been only 11 world's tallest buildings. All building heights are taken at their architectural or structural top and all years are taken as when the building was actually substantially complete, not topped out. That is 11 buildings out of thousands in the world. Therefore, there is simply a pride regardless of whether or not the building is the absolute tallest in all of the world.

There is however, the omnipresent pride of having the world's tallest building or at least being in the top ten. Table 2-7 lists the world's current top ten tallest buildings measured from the architectural or structural top. Only 2 are in the United States and the remaining 8 are located on the Asian continent. The 2 United States skyscrapers in the top ten have an average age of being built in 1953. The Asian skyscrapers on the other hand have an average age of being built in 1998. The pride of having the world's tallest buildings in America lasted 113 years and now the new era of Asian influence can certainly be seen.

Figure 2-2 shows what percentage of skyscrapers each continent contains to date. Asia does include the Middle East and Oceania is inclusive of Australia and surrounding Pacific islands. The figure shows that those two continents contain 56% of the world's skyscrapers and that Asia with 33,819 high-rises now has more skyscrapers than North America at 25,983. Figure 2-3 conversely shows that the United States at least has a hold on the top 100 world's tallest buildings. Out of those 100 the U.S. has 34 within its borders, as compared to 30 for the Chinese nation. This figure also demonstrates that in terms of tallness, the United States and China are the only two real contenders, since the next closest countries only have 5 in the top 100. Finally, Figure 2-3 portrays the fact that Hong Kong with 7,548 buildings is the skyscraper capital of the world with New York City a couple thousand behind at 5,501 buildings. Globalization of tall buildings also can be seen, since in the top ten skyscrapers only Brazil has more than one city on the list. From Japan to Argentina, the skyscraper is a global building type.

Even if a building does not rise to the height of Taipei 101 or the Sears Tower, it still can claim some notoriety. Tallest this and tallest that matters to the designers, contractors and residents of these great structures. It takes a tremendous amount of materials, manpower and energy to create any tall building. Tables 2-8 and 2-9 both show other categories where tall buildings can gain recognition and admiration. In addition to the buildings listed, there are numerous other categories possible within continents, countries, cities and sectors.

In an attempt to look at skyscraper construction compared to population size the top ten skyscraper countries were taken and then compared against their population rank. Figure 2-12 demonstrates for countries it seems that while there are several that are very high in population rank and skyscraper rank, some are scattered as far back as 119th in population. Singapore is the country with that distinction and the high-rise buildings there may be explained by the limited land available to construct on. Obviously, having a large congested population is going to drive construction skyward and other factors that may allow or disallow the proliferation of tall buildings include

- Political climate
- Social climate
- Cultural climate
- Historical climate
- Land availability
- Population size
- Business centers
- Economic power
- Ego

Moving closer to home and looking at cities individually in America and China, shows a bit more correlation between population of cities and skyscraper construction. The smallest city with skyscraper clout in America is Honolulu as the 47th largest city in the United States. Otherwise, 6 of the 10 tallest cities in America are in the top ten in population, including the top

5 most populous cities in the nation. China also has 7 of its top ten skyscraper cities in the top ten of China's populated cities. The top four populated cities in China also are within the top ten skyscraper cities in the region. Population may be misleading due to differing city sizes and densities and thus skyscraper construction can be prolific in surprising areas. Also, whether or not a country is developed or not does not change the size of their population. The second most populated country in the world is India and yet it remains absent from any skyscraper list (Population Reference Bureau, 2006).

In Figure 2-13, when comparing gross domestic product or purchasing power parity to skyscraper production, the correlation becomes more and more clear. Singapore once again produces an outlier, but still is fairly high in GDP at number 56 in the world. Otherwise, the other 9 countries are within the top 18 GDP's in the world. The top three of the United States, China and Japan are also included. India has the 4th largest GDP in the world but still remains absent in this comparison as well.

With respect to pride, prestige and success, skyscrapers can come in all different forms and sizes. Only a select few have the honorable distinction of being the worlds tallest building. For the thousands of others that are left, other distinctions do remain. The population and GDP comparisons shown here are not good indicators of tall building construction, nor do they take factors of city layouts into account. Of significant note is that the countries that have produced the last three world's tallest buildings are drastically absent from any population or GDP comparisons. Taiwan and Malaysia therefore demonstrate that skyscrapers are not only about how many people or how high a GDP a country has but rather how big the desire to build tall is. There are still further ways that tall buildings can be set apart regardless of height; the sustainable skyscraper is now taking shape in the built environment.

The Sustainable Skyscraper

> (The skyscraper) alone will enable us to achieve the urban densities necessary to live sustainably on this planet (Howeler, 2003).

Sustainable design and construction is defined as design and construction which “seeks to create spaces where materials, energy and water are used efficiently and where the impact on the natural environment is minimized” (Greene, 2000). Recently, green building has become a buzz word in the architectural, engineering, construction and real estate realms. It therefore should be of little surprise that the largest buildings in the world would follow suit and have an impact on green building themselves. As more and more skyscrapers are being constructed and proposed across the globe, so too are more and more skyscrapers being drawn and built with sustainability and the environment in mind.

Many reasons exist for any owner and for any building to go green. These notions of energy, material, resource and land conservation extend across all building types. The desire to build in an environmentally conscious manner are the results of several factors that influence not only construction, but in particular high-rise construction. How can the exorbitant amounts of energy consumed by buildings in the world be helped, mitigated and improved upon? Where is the growing global population going to be housed, where will they work and how will they interact? What type of city densities does the future hold? What space impacts result from building vertically, rather than horizontally? As energy becomes scarce and becomes increasingly and possibly prohibitively expensive, how will the world’s city planners, designers and constructors respond? How can condensing populations with the skyscraper as a building type assist in the fight for freedom from or at least provide less reliance on oil?

The Numbers for Going Green

Energy consumption pertains not only to the actual construction and commissioning of a building for an owner or developer, but also to the life of the building as it serves its useful purpose to society. Populations continue to grow millions upon millions and billions upon billions. The numbers for consumption and population convey that the skyscraper is not the sole savior of our world's built environment but can assist from a spatial, energy efficient and practical point of view. Currently, there is no other economically viable option for owners and therefore for the public (Yeang, 2002).

The Energy of the Built Environment

Buildings account for much of the energy consumed not only in the United States, but also in the world. Daily activities of driving to work and running errands also are contained within the sphere of energy necessary to use and make buildings useful in the first place. In the United States of America, buildings account for the following in energy and resource usage

- 36% of total energy
- 65% of electricity consumption
- 30% of raw materials
- 30% of waste output
- 12% of potable water (USGBC, 2006).

The highly urbanized, developed nations that build skyscrapers make up only about 25 percent of the global population and yet they account for 70 percent of the world's consumption of energy, 75 percent of metals and 85 percent of the world's wood (Yeang, 2002). The skyscraper designed and constructed with a sustainable approach can lessen these figures and lessen the impact that the developed nations have on the rest of society.

The layout of the built environment creates the framework of energy use for a community (Foster, 2006). The alternative to centralized cities are those such as Los Angeles and Miami that are spread out between suburban tracts and only connected through highways and interstates, that in turn require large amounts of personal transportation by automobile to commute to and from work or recreation.

In regards to carbon dioxide emissions, which leads to the warming of the globe, buildings are the prime emitter. The emissions produced by human activities on a global scale are broken down as follows:

- 50% attributable to the built environment
- 25% attributable to transportation to include work commuting
- 25% industrial sources (Gissen, 2002).

When the cities of the globe grow horizontally rather than vertically, more and more roads are needed to connect the people of a community (Foster, 2006). These greater distances have a directly harmful effect on the environment and consequently the quality of life in regions that involve hours upon hours of commuting. Convenience is the American way, but somehow since the widespread boosterism of the automobile, the desire for the convenience of being able to walk or take mass transit to destinations in fractions of the time and in close proximity to the home has gotten lost. Skyscraper construction allows for several uses or mixed-use so that retail space, office space and residential space can all be very close together if not in the same building. The world renowned architect Norman Foster has even proposed that the technology is available today to put entire horizontal blocks into the air as super-tall structures (Foster, 2006). Foster’s building of multiplicity could encompass

- Housing
- Shops
- Restaurants
- Cinemas

- Museums
- Sporting facilities
- Green spaces
- Transportation networks (Foster, 2006).

The previously mentioned 2,754 foot Millennium Tower proposed for Tokyo was a prime candidate of Foster's for such a radical and revolutionary undertaking.

City or Country

People are flocking to the city and densification of the population is inevitable. In particular, young couples and single persons are choosing urban living over the "fading attraction" of a suburban lifestyle (Abel, 2003). Now, denser populations require buildings that lie in close proximity to one another and that lend themselves to mass transit and alternative means of transportation, which includes walking and biking. The tall, slender structures of skyscrapers are just the building type for the return of the city and of the return of the human as the prime means of transport rather than the automobile. Denser populations per capita also consume the least amount of energy (Howeler, 2003). Prime examples are the cities of New York, Tokyo and Hong Kong. Table 2-14 actually shows that Hong Kong is the tallest, densest city in the world with 36,896 people per square mile. The table also reveals that Asian cities are much more dense in response to higher populations and limited land availability. This trend will inevitably find itself in American and European cities, as the West's population increases and land availability decreases. Another factor in becoming denser, is quality of life. When everything a typical human needs throughout the week is close by, then the urban densities produce a convenience that cannot be realized in the suburban sphere (Foster, 2006).

For future communities and nations, the tall building will become a necessity. Table 2-15 demonstrates the distribution of populations in the world in term of living environment, urban or rural. By the year 2025, 62% of the world's total population will be contained within the urban environments of the earth. That percentage equates to an urban population of around 5 billion people! Of particular interest, table 2-16 shows that in developed countries such as the United States the urban population will contain 85% of the world's developed country population. In contrast, developing nations will be at 57% urban population concentrations. The developing nations in 2025 however, house a much larger portion of the world's population at 6.75 billion people which unearths a topic for another time; housing the world's developing nations.

Skyscraper as a Space Saver

Long before there were double-skinned facades, low-flow fixtures and energy efficient appliances, the skyscraper was a more sustainable building typology. The tall building stands as a structure that is inherently sustainable due to its condensed nature in providing the same services that can be found spread out elsewhere. Simply put, if you have a 60 story building with each story taking up an acre of space, then that same building would take up 60 acres in a suburban environment. Placing more people, services and units in a single structure ultimately saves the roof space as well, reducing 60 exposed roofs of an office park to one roof exposed to the sun, therefore saving energy, materials and space.

Now it may be said that building tall costs more in terms of design, construction and actual implementation of the building due to its extreme height. However, it cannot be denied that in the skyscraper century or so that has unfolded, skyscrapers are not the type of building to be knocked down after 20, 30 or even 50 years thus making them resilient in aspects of life cycle costing. Exact data has not been computed as to the costs comparison of low-rise life cycle costs versus high-rise but a future study would do well to do so. The complex webs of systems, materials and interactions within a skyscraper are beyond the scope of this work. The restoration and maintenance on skyscrapers also is not a topic to be discussed here. It still remains though that skyscrapers are engineered and built to last. For example, the Empire State Building celebrates its 75th birthday this year, the Chrysler Building its 76th, the Woolworth its 93rd. Who is to say how long they will stand, but they are still examples of old, but still functioning structures that serve the same purpose and save the same space as they did upon their completion.

In a more concrete example of the space and accompanying energy savings that can be produced by high-rises such as Four Times Square that was recently built in New York City, William Browning is looked upon:

> A high-rise of 1.6 million sft on 28 floors sits on one acre, if it were divided into individual structures in suburbia it would take up 140 acres, not including the required infrastructure for access and utilities. The incredible concentration on a small piece of land, which 95 percent of the workers, of whom there are 6,000, get to by public transportation in itself, makes it sustainable. The single-roof surface of Four Times Square with all of its thermal exposure would be 48 times larger in a one-story building (Gissen, 2002).

Now, this example could not apply everywhere, it especially could not occur in areas without viable means of public transport. It still is interesting to note that with the advent of large downtown environments that can be built and planned to accommodate residences and also mass transit, there is a greater chance of reduction of the strain on transporting by automobile and the emissions, time and distances that accompany them.

Mr. Browning also goes on to speak of elevators as a means of moving people once inside the skyscraper. While not explored too thoroughly in this work, Mr. Browning claims that because elevators are counterweighed that they are the most energy efficient means of movement from floor to floor (Gissen, 2002). Compared to low-rise buildings that require no vertical lifts, the skyscraper will obviously fair worse, but other factors such as cooling load, land use and transportation problems must be taken into account, another topic for a future study. The embodied energy, or energy used for the components and construction of the skyscraper also lends itself to being of lesser impact due to the high-quality of design, materials and craftsmanship that accompanies tall buildings (Foster, 2006).

Skyscraper Sustainable Systems

Green skyscrapers can help in the fight for a sustainable future in the world. Their small footprint, potential for large vertical space and housing of a large numbers of workers, residents and customers make them attractive candidates for inherent sustainability. In addition to the inherent features of the tall building, several systems are in place that are greening the tallest structures in the world even further. The systems include passive or natural and non-mechanical design elements and active systems with mechanical or electrical means. New approaches to designing and maximizing skyscraper efficiency through its lifetime are also being proposed by architects such as Kenneth Yeang. Several of the systems discussed are actually already being implemented in skyscrapers across the globe. In particular, Europe and America are leading the way in sustainable skyscraper design and construction. The following will explore some of those skyscrapers and the systems which they encompass, to create a healthier, more hospitable, sustainable skyscraper.

Passive Design

Passive design implements the properties of natural elements, materials and structures to create an environmentally responsive building or skyscraper in these cases. The following is not intended to be a complete list of the passive design and structure elements that may be incorporated into a building but it meant to provide an overview of the range of systems and the idea behind them. That idea is to use the world's natural processes, in addition to sensible practices to have a skyscraper that is more harmonic with the environment in which it resides.

The layout and orientation is the largest portion of the building that can be adjusted to provide for a building that works more with nature and in particular the sun or cooling loads that accompany it. Orienting the building's large faces in a north-south manner can limit the cooling loads that are placed on the east-west sides of the building. Additionally, the windows on the "hot" sides of a building may mitigate the heat gained by recessing the windows within the external wall (Yeang, 1996). In contrast, if a skyscraper is located in a particularly cool area that is cool throughout most of the year then the opposite could be imposed and the east-west sides could be the larger sides to absorb as much heat as possible. The layout and location of critical skyscraper elements can also be paramount in making the building energy efficient. In particular, the service cores for the building may be placed on the exterior east and west portions of the structure acting as a heat buffer (Yeang, 2000). Service cores are the spine of any skyscraper. They contain all communications, electrical, plumbing, mechanical and most importantly elevator works for the building. They are typically not air-conditioned and thus are a radiant heat load when located in the center of the skyscraper. Placing them on the exterior only, places these spaces in a manner in which they actually act in a favorable manner for not being air-conditioned. Further, tapering the building at the bottom can reduce reflection and improve the transparency and day lighting aspects of the ground floors (Foster, 2006). Tapering at the top of the building reduces reflections of the sky as well (Foster, 2006).

Lighting for a skyscraper has always been a primary concern. With the inception of fluorescent lighting in the 1940's, that problem was thought to be solved (Willis, 1998). However, why use artificial lighting that costs energy when you could simply open a shade and use the natural light given from the sun? Awnings that can control where the sun hits and where it is able to be harnessed, provide the necessary sun control needed in particularly humid, heat rampant climates (Yeang,1996). Large floor to ceiling windows also allow optimum light in and with the right façade the heat that comes with the light provided by the sun can be managed. Using the sun and being in control of how it affects the building is a major factor in controlling the loads on a building's conditioning systems and lighting systems. Natural lighting also provides for improved quality of life within the building as the occupants are actually opening their shades and letting the natural world in.

The skin of the skyscraper is the most exposed portion of the building to the natural elements and is subject to insolation. In designing the proper façade the tall structure can harness the properties it needs and prevent the properties it does not want from entering the building. Operable windows are actually making a comeback so that now the occupants have control over their own individual environment (Abel, 2003). Double-skin facades are also the answer to the increased heat gained from exposure to the sun in day lighting activities. With these double-skins there is a thermal buffer created. In winter months the solar penetration available is allowed in, but the heat inside the building is not compromised by exposure to the outside cold air (Gissen, 2002). In temperate months, the skin can be opened and natural ventilation can take place and fresh air can replace conditioned air and the energy associated with it (Gissen, 2002). In the hotter summer time, the façade can then be closed again and the layer between the two portions act as another thermal buffer but this time protecting from the heat while still providing day lighting (Gissen, 2002). In the United Kingdom it has been shown that double-skin facades can reduce energy consumption by 65 percent and reduce carbon dioxide emissions by 50 percent in the cold, temperate climate (Gissen, 2002). Specially coated single-skin facades also can introduce light to the environment while rejecting the heat from the sun.

With the option to now open the windows, a new design element of natural ventilation is available. Using computational fluid dynamics, the flow of air within a building can be examined and adjusted to provide fresh air and cooling throughout the skyscraper (Gissen, 2002). The solar energy or hot air that rises are the source of movement in natural ventilation systems. Wind scooping from the roofs or from openings in the sides of the building provide the fresh air and force it into the building. Hollow core ventilated slabs also can provide for reducing the heat intake taken on by the materials that make up the building, in particular concrete. Also within the structure it would be possible to include the air-conditioning shafts and ducts, eliminating the requirement to cool or heat the interstitial space, while increasing ceiling height (Eisele and Kloft, 2003). Another option in natural ventilation, is completely opening the building up at night to provide night cooling and cool down the building components that were heated up during the course of the day such as the ceilings, walls and floors (Eisele and Kloft, 2003).

Water features, rooftop gardens and "sky gardens" also can benefit the skyscraper by means of their inborn natural features. First off, these elements can bring work and nature back together again by means of the office, thus improving the working conditions and hopefully the performance, well-being and productivity of employees (Foster, 2006). Rockefeller Center built in part during the 1930's and 40's actually housed the first rooftop gardens in a skyscraper capacity (Emporis Buildings, 2006). Since then, it has come to light that besides the qualitative aspects of bringing the park to the sky for employees, these places provide several environmental benefits. Effectively, plants clean the air and therefore can manage emissions (Gissen, 2002). Plants convert carbon dioxide to oxygen and treat any acid rain type, chemically saturated water. Also, run-off that usually would go through dirtier city streets and pick up chemicals are now contained and absorbed in a more efficient manner, perhaps to be used in an active sustainable practice such as rain water harvesting for bathrooms. Green roofs also help negate the effects of the solar heating on a buildings roof and thus keeps the building and its upper floors cooler. It may also be possible to have a carbon dioxide cycle equilibrium if enough plants are present and can absorb the carbon dioxide produced by building operations (Foster, 2006). Water and water features, while also being good for a working environment's employees, can clean the air by making particulates too heavy to float (Giseen, 2002).

Using the soil in which a skyscraper rests also can be beneficial to improving the sustainability of the tall building. At the depths which foundations rest on, the seasonal temperature fluctuations are negligible and thus the soil is an ideal geothermal heat exchanger (Eisele and Kloft, 2003). Heat can be stored during summer months and vice versa for the winter months. That heat can then be utilized appropriately as necessary.

Material selection and structure design also influences the sustainability of the building. Materials that take less embodied energy to produce and erect in the first place are ideal. Of course, recycled or recyclable materials are always necessary elements in discussing sustainable buildings and skyscrapers. Materials that are produced primarily off-site in a precast manner can be helpful in reducing jobsite energy use and environmental disruption. Low conductivity materials can also help in maintaining energy requirements and not having materials that absorb a lot of heat. Nontoxic materials with low amounts of volatile organic components (VOCs) should be used extensively to prevent off-gassing and compromising the indoor air quality of the building (Giseen, 2002). Also, using mechanical units that do not contain harmful atmospheric or ozone-depleting elements such as CFC's or HCFC's not only betters the building, but the environment in which the building is located. Finally, designing for the use of fewer materials such as a reduction in the necessary amount of steel or concrete can alleviate the material extraction impact a skyscraper may have.

Possible passive elements of a sustainable skyscraper discussed include

- Orientation
- Layout
- Service cores
- Sun-control awnings
- Operable windows
- Single-skin coated façade
- Double-skin façade
- Natural ventilation
- Wind scoops
- Hollow-core slabs
- Ducts within structures
- Night cooling
- Rooftop gardens, green roofs
- Sky gardens, atrium gardens
- Water features
- Soil geothermal heat exchangers
- Material selection
- Recycled materials
- Precast, low conductivity materials
- VOC content consideration
- Design consideration, material efficiency maximization

Active Design

Using engineered systems for sustainability also has its place within the modern day skyscraper. By combining passive elements with theses active systems, buildings are able to achieve a more sustainable outcome in their performance over time. These active systems are primarily used in the realm of water savings, air purification and energy savings. Energy savings encompasses many things from automated blinds to photovoltaic cells that actually supply power to the building and possibly to the overall power grid.

Water conservation and utilization is becoming a prime concern within the sustainable skyscraper. As such, rain water storage for later applications takes place on all of the roof areas. The water is then stored in tanks for use as irrigation for green roofs, nearby parks or for toilets and cooling tower water. The goal for many structures is to minimize the impact on surrounding stormwater systems, while also lessening demand for water from the utilities. Therefore, installed within the bathrooms are low-flow fixtures or possibly waterless urinals. Along those same lines some buildings contain their own waste water treatment plants. Now these plants do not make the blackwater potable necessarily, but can make the water usable for other non-potable applications as stated above. Also, by placing tanks strategically throughout tall buildings, the pumping necessary for water delivery can be greatly reduced (Hucal, 2004).

Air conditioning requirements and fresh air stipulations are also a concern for the owner and therefore the inhabitants of tall buildings. Locating air-conditioning systems on a floor-by-floor system will create a more hospitable atmosphere for the direct people using that space, while optimizing efficiency. Buildings are also taking in outside air and filtering it multiple times so that the air they expel is actually cleaner than the air they intake. The air is also being considered as a possible energy supply. Tall buildings are located at heights where winds are blowing at higher speeds than at ground level. To harness and harvest this power, wind turbines have been proposed on several buildings With the advent of such a system it would be possible to energize the surrounding community power system, as well as operate the building (Aveni, 2001).

The reality of energy saving systems in buildings that are erected currently is an exciting prospect. Photovoltaic cells, utilizing sun power, in combination with fuel cells, whose only by-product is water, are providing natural, free power from the environment to the super structure (Gissen, 2002). Gas-absorption chillers, which run on natural gas instead of electricity, also contribute to energy savings by reducing air-conditioning costs and they help the environment because they use no ozone-depleting components (Eisele and Kloft, 2003). Occupancy sensors throughout each room regulate lighting control automatically by determining if the room is occupied or not. Buildings also incorporate other electronics such as programmable thermostats, Energy Star fixtures and day lighting sensors that control the intensity of artificial light necessary. For the potential geothermal heating or cooling passive elements discussed above, there are heat exchangers which offer a wider range of usable temperatures (Eisele and Kloft, 2003). Within some concrete slabs from floor to floor, buildings are incorporating polyethylene tubing that provides radiant heating and cooling which is a more efficient means of air-conditioning (Post, 2005).

Possible active design elements for the sustainable skyscraper discussed include

- Blackwater treatment plants for non-potable applications
- Rain water storage/harvester tanks for non-potable applications
- Staggered tank stations to reduce pumping need
- Local air-conditioning control
- Air filtration per floor and from the street level
- Wind turbine energy harvesting (future possibility)

- Photovoltaic cells
- Fuel cells
- Gas-absorption chillers
- Occupancy sensors
- Programmable thermostats
- Energy Star appliances
- Day lighting intensity sensors
- Geothermal heat exchangers
- Polyethylene tubing for radiant slab heating and cooling

The Ecology of the Skyscraper

Within the same length and breadth of providing passive energy systems and a sustainable built environment, is the idea of making the skyscraper fit the region that it occupies. Skyscrapers should not look the same all over the world. Yes, they should reflect the social, cultural and economic pulse of a certain region, but in addition to that they should attain the position of being in tune with its surroundings. Kenneth Yeang is an architect who has proposed a new look into not only skyscrapers, but the sustainable skyscraper. No longer can the proliferation of largely wasteful type buildings be allowed to operate. Energy must be treated as precious as the money that is so carefully conserved and looked over during design and construction. Tiny, segmented offices within a dark, dingy skyscraper cannot be allowed because they result in a highly "internalized" environment that exists at the expense of large amounts of energy (Yeang, 1996). The skyscraper must be able to adapt and utilize the environmental impacts that can be felt within the local built environment. The tall building must have operable windows, proper ventilation, and so on as discussed. But more importantly, high-rises must truly interact with the land, water and air that encompasses the surroundings of the building. Kenneth Yeang therefore, proposes a bioclimatic skyscraper that is sustainable in terms of specific environment. The sustainable or bioclimatic skyscraper of the future is described as the following:

> The bioclimatic skyscraper is a tall building whose built form is configured by design, using passive low-energy techniques to relate to the site's climate and meteorological data, resulting in a tall building that is environmentally interactive, low-energy in embodiment and operations, and high quality in performance (Yeang, 1996).

Mr. Yeang postulates that with the enactment of these design features that a building could save between 30 and 60 percent of the costs over its lifetime (Yeang, 1996). These lower life-cycle energy costs would come at the expense of higher, earlier capital expenses but would pay off eventually. Climatic responses to the skyscraper therefore more than justify the expense. The skyscraper functions as a portion and contributing member of the environment rather than working against the environmental aspects it is surrounded with.

Current Sustainable Tall Buildings

A sustainable skyscraper is not just lip-service from industry designers and contractors. Several of these environmentally conscious buildings are being erected and many are already completed. The environmentally progressive nations in Europe such as the United Kingdom and Germany account for many sustainably designed tall structures. The United States also is contributing with several high-rises that are following the Leadership in Environmental and Energy Design (LEED) criteria set forth by the United States Green Building Council (USGBC). These buildings exemplify many of the passive and active sustainable design elements spoke of previously.

Currently under construction, the Bank of America Tower at One Bryant Park in New York City is to be the first high-rise building in America that will have the platinum level LEED designation, which is the highest attainable designation a building can have (Spillane and Pinch, 2004). Upon its completion, the skyscraper will also be the second tallest building at 1,200 feet in New York, showing that sustainable can be just at tall as conventional (Hucal, 2004). Notable systems and strategies within the building include

- 4.6 megawatt co-generation plant
- Filtered air intake
- Floor-by-floor air handling units
- Rainwater reuse and harvesting
- Waterless urinals, low-flow fixtures
- Recyclable and renewable building materials
- Green roofs
- Double-skin curtain wall

The 54-story tower actually will act as a 54-story air filter which will make the streets of New York that much cleaner and the employees that much healthier (Hucal, 2004). Upon the design completion, the goals of the design team will hopefully be met and the tower will be the most sustainable tall building in the world. The goals as compared to a typical tall building include

- 50% energy consumption reduction
- 50% potable water consumption reduction
- 95% storm water contribution reduction
- 50% recycled material components
- 50% of building materials within 500 miles of the site (Hucal, 2004).

New York, once thought of as a dirty, grimy city is making a particular resurgence and there are multiple towers, and multiple green towers at that, dotting the skyline. Another green skyscraper that is already in place is the Hearst Building, also located in the Big Apple. The Hearst Building is actually the first office building located in the city to obtain a gold LEED rating (Nobel, 2006). The building is to be a beacon for the Hearst Corporation, housing 2,000 employees from 10 separate locations (Post, 2005). The building also is a beacon of hope for what innovative design can produce in a sustainable mindset. Sir Norman Foster designed the building so that it actually uses 20% less steel than comparable steel buildings (Nobel, 2006). Foster also used the original art deco building façade for the bottom floors as an architectural skin for the building. Other notable features of the Hearst Building include

- 25% less energy use
- 30% less potable water through rain water harvesting
- Radiant heating and cooling through slab tubing
- Large atrium water feature to clean air and condition the lobby
- Office space exhaust air used to condition lobby atrium, reclaims energy and minimizes use of outside air (Post, 2005).

Going across the Atlantic several other buildings demonstrate sustainable practices. The Swiss Re Headquarters located in London, England was also designed by Sir Norman Foster. The building has now become a symbol for London and is also a symbol of the possibility for future skyscraper construction in a classic low and mid-rise city. The building itself is conical in shape which minimizes air resistance around and especially at the base of the building (Gissen, 2002). In contrast, square buildings tend to cause wind gusting at street level. The tall building also incorporates the following components

- Interior green spiraling atriums that breakdown the building and improve natural ventilation
- Natural ventilation through cladding slots
- Air conditioning not needed for much of the year, natural ventilation provided for 40% of the year
- Double-skin façade (Gissen, 2002).

Commerzbank is yet another Foster sustainable skyscraper and it too contains many of the elements found in his other buildings. Of special note is that Commerzbank is the second tallest building in Frankfurt, Germany and the first environmentally sensitive building of its kind (Emporis Buildings, 2006). There are 9 hanging gardens throughout the building, which is meant to reconcile tall buildings with human and ecology (Gissen, 2002). It also contains a double-skin curtain wall for further sustainability.

Returning back to New York City, two additional buildings represent sustainable structures. It may seem that New York contains a good share of sustainable buildings, but really Europe contains many more buildings that have sustainable systems. They are not listed here due to repetition but as Germany is still recovering and rebuilding from World War II and the fall of the Berlin Wall, they are the most active green skyscraper builder in the world today (Emporis Buildings, 2006). However, New York is increasingly building green and becoming the "Green Apple" instead of the Big Apple.

The New York Times is moving its world famous newspaper and they have chosen to make their future new building into a world class, sustainable skyscraper. The building's exterior is the primary exciting feature. Instead of a classic curtain wall, the building will be covered in a double-skin façade that will then be covered by aluminum silicate tubes that allow for increased day lighting and natural lighting for those inside (Hagberg, 2006). The glass that these tubes cover is also low-iron, low emissivity and spectrally selective which will make the building actually change colors throughout the day (Gissen, 2002). It will be bluish after the rain, red after sunset and it will overall be a vibrant symbol in midtown (Gissen, 2002). The tubes, glass and reflective metal of the building all help in reducing heat or solar gain (Gissen, 2002).

The final building focused on in New York is the Solaire, which was completed in 2003. The Solaire is actually the first green high-rise residential building in the United States. It was able to achieve the second best ranking in LEED, gold. Overall, the residences are 38 percent more efficient than New York building codes prescribe (Gissen, 2002). Systems and practices encompassed within the building include

- Photovoltaics
- Geothermal energy recovery system
- Blackwater waste treatment system
- Gas-absorption chillers
- Occupancy sensors
- Lighting control
- Climate control
- Low or no VOC materials
- Recycled materials
- Roof gardens (Gissen, 2002).

The building also was designed for certain energy and utility use percentages as follows:

- 35% less energy use
- 65% reduction in peak energy demand usage
- 50% less potable water use
- 5% of building's energy provided by photovoltaics (Gissen, 2002).

Burj Dubai and Beyond

As the world grows and countries develop, so too will skyscraper construction around the world be furthered. In looking at future populations and the ability to house such vast numbers, skyscrapers and going vertical with construction will be the answer. The American invention will soon be prominent in every large, developing country on the globe. Even in countries where skyscrapers abound such as China, further development and high-rise buildings are being constructed to send a message. Complexity in design and huge construction endeavors in skyscraper erection are also becoming more and more apparent. The "glass box" is no longer the building that the owner or developer wants to build; curves, spirals, pinnacles and sharp angles embody the new skyscraper architecture. In the world of tall skyscrapers fame is fleeting. Many world's tallest buildings have lasted only a few short years and in some cases even less than a year in their reign. In following with that tradition of skyscraper booms and world's tallest building, spurts of competition between several buildings in the not so distant future will be again vying for the title and striving to overtake Taipei 101. What will become of the World Trade Center and Lower Manhattan? How will the first world renowned skyscraper city respond to attacks on this building type?

Skyscraper Cities of Tomorrow

True, the developed countries or 1st world countries of the world that already have plenty of high-rises will continue to build tall. But they will begin to have more and more company, as countries expand and become more financially advanced with greater economies and greater quality of life. Also, the buildings going up all over the world, do not contain the traditional garb of old. The skyscraper is being reinvented in a new light, with not only sustainable practices as discussed earlier, but also in architecture and construction difficulty. Combined with new locations and new complexities, the skyscraper is creating the cities of tomorrow.

Indian Shift

With exponential population growth in the coming years in certain countries, both developed and developing skyscraper construction will be highly visible. Where there are flows of people spilling over into the billions and where there is a shortage of land, there will be skyscrapers. As already discussed, high-rises allow large populations to sustain themselves in a regulating manner. Condensed, modern cities of millions upon millions cannot survive without soon implementing tall building construction, energy costs and transportation costs all but prevent spread out establishments. This fact is particularly true in very large developing country cities. Table 2-17 shows the current top ten world's largest countries. Table 2-18 as a supplement shows what the rankings will be by the year 2050 and the percentage change in population according to the Population Reference Bureau. Table 2-19 also demonstrates the top four gross domestic product, or purchasing power parity countries in the world and what their GDP's will be by the year 2030.

The glaring country that lacks in skyscraper construction is India, which by the year 2050, table 2-18 shows will be the world's most populated country and by the year 2030, table 2-19 shows will have the 3rd largest GDP. Table 2-20 shows that India today has a total of 1,253 tall buildings which makes the it the 23rd tallest nation in the world. The United States, China and Japan on the other hand rank as the 1st, 3rd and 5th tallest countries in the world while maintaining top GDP's and top populations. India also is smaller than both China and the United States. The inevitable conclusion in India will be a growth in skyscraper construction. In fact, India had already proposed an India Tower that would dwarf all other buildings in the race for the world's tallest building (Civil Engineering, 1999, April). Although the India Tower was never built, it would not be surprising if the next world's tallest does in fact come from this emerging world power.

Chinese Games

Coming in 2008, the nation of China will host its first ever summer Olympic games in Beijing. In addition to the mammoth amounts of construction for stadium facilities, Olympic parks and Olympic villages, the Chinese will also have some new high-rise buildings on display for the world to see. These buildings are intended to show the symbolic progress that the Chinese have made as their power on the global stage increases.

In particular, two buildings that will draw the eye of the world are the Central Chinese Television Building (CCTV Building), located in Beijing and the Shanghai World Financial Center located in Shanghai which will have some Olympic participation. The same elements of symbolism, culture and strength will emanate from these structures to the world.

The Shanghai World Financial Center is to be a 1,614 foot tall skyscraper that will rank as the second tallest building in the world upon its completion in 2007 (Lepik, 2004). What little the skyscraper lacks in height to be the world's tallest, it makes up for in being perhaps the most complex tall structure in the world. The top of the building will be a square plan with a round hole though the middle of it so that wind pressures are reduced, but also for a symbolic purpose. It follows the Chinese conception of the earth as a square and the sky as a circle, a true "sky"scraper (Abel, 2003).

The other building that is certain to be regarded as a breakthrough of architecture, engineering and construction is the CCTV Building, in the primary Olympic city of Beijing. The building will only stand at 768 feet as its tallest point, but will be a self-contained mini-city upon completion by the Olympic games (Post, 2005). The allure of the building comes in its new concepts in spatial layout and statics (Lepik, 2004). The building is hard to describe but will be a skyscraper vertically and a "landscraper" horizontally with cantilevered portions and angles that are unlike any building seen thus far.

Ultra Modern Skyscrapers

It has been demonstrated that just as the skyscraper has progressed, so too has the technology to make it the building that it is today progressed. Initially it was steel and elevators, then lighting and air-conditioning and now glass and sustainable systems. Just as technology of the skyscraper has advanced to give the buildings the modern amenities of today, so too has architecture progressed over the years to give use the most profound, unique, tall structures on this earth. It used to be that due to sheer size, the skyscraper would be recognized and admired from afar. However, as symbolism and pride in the tall building progressed, designs got ever-more complicated and many of the new skyscrapers being constructed today resemble a new, ultra modern civilization.

One building that exemplifies new innovations in art for architecture's sake is the Turning Torso in Malmo, Sweden. The building was actually inspired by a sculpture that the architect, Santiago Calatrava, had produced. At 623 feet, the building is one of the world's largest sculpture pieces (Emporis Buildings, 2006). It actually twists 90 degrees from the base of the tower to the tip of the structure. The building also has tremendous pride value, aside from being a symbol for the country of Sweden and its tallest building. The Turning Torso lies across the Oresund Strait from Copenhagen, Denmark. Copenhagen has a height restriction of 10 stories within their city and therefore it was the intent of the Swedes to make a building that was tall and beautiful so that Denmark would look on with envy (Nobel, 2005). Evidence that not only Denmark, but the world admired the Turning Torso came when it was awarded the Emporis Skyscraper Award in 2005.

The Emporis Skyscraper Award has been given every year since 2000. It is given to the designers of an outstanding skyscraper and

> seeks to identify and encourage achievements from the previous year in the building trades, which successfully address the needs and aspirations of societies through real estate, design, and construction. The selection process favors solutions that not only provide for people's physical, social and economic needs, but that also stimulate and respond to their cultural and spiritual expectations. Particular attention is given to building schemes, products, and corporate activities that use local resources and appropriate technology in an innovative way, and to projects likely to inspire similar efforts elsewhere (Emporis Awards, 2006).

The Emporis awards over the years shown in table 2-21 demonstrate that height is not the only factor in great skyscraper construction. The average height of the winners actually has only been 787 feet, which was drastically brought up with Taipei 101 (Emporis Awards, 2006). Height combined with beauty in these sleek, sharp, angled buildings are replacing the "glass box" that has been so popular for so long.

The Race Continues

Throughout the skyscraper's storied past, the battle for world's tallest has more or less always been there. From the Masonic Temple in Chicago to Taipei 101 in Taiwan, the prestige and pride that accompanies the design, construction and implementation of the tallest man-made inhabitable buildings, is comparable to the financial clout and power necessary to even get these buildings out of the ground. So as it goes, a new challenger has risen and challengers for other positions in the world's top ten tallest skyscrapers are also in the works.

Liquid Gold Structures

The United Arab Emirates was formed on December 2,1971 and thus is a very young country (Emporis Buildings, 2006). The country itself is small, only about the size of Rhode Island and is termed the "jewel" of the Arab world. Eventually, however, the country's primary resource will run out, oil. As such the country is attempting to develop an economy that will last with business and tourism. When a city and a nation wants to be recognized, and grow up in a big way, they build skyscrapers. The country actually now contains 432 skyscrapers (Emporis Buildings, 2006). This is quite a feat considering the country did not have more than 20 skyscrapers until 1992 (CTBUH Database, 2006).

Currently, Dubai is the country's largest city and also contains most of the tall buildings with 190 skyscrapers (Emporis Buildings, 2006). It also contains Burj al Arab Hotel which is the second tallest hotel in the world at 1,053 feet, 31 feet away from being the world's tallest (Emporis Buildings, 2006). The hotel is actually built on a man made island out into the ocean and is designed as a giant sail billowing in the wind (Lepik, 2004). It is one of the many construction endeavors in the region that wishes to bring luxury tourism to Dubai (Lepik, 2004).

Skyscrapers, man made islands and tourist attractions do not seem to be the stopping point for Dubai however. Their wish is to build the world's tallest building and that undertaking is currently under construction. Burj Dubai, which translated means the Tower of Dubai, embodies all of the characters of why the world is building tall. Socially, culturally, politically, financially and symbolically the tower will be the pinnacle of what Dubai and the United Arab Emirates can achieve on a skyscraper scale. It is to be part of a planned city of 500,000 within the Dubai waterfront area (Post, 2005). The building is such an important economic and political symbol for the United Arab Emirates that the height of the structure is currently secret, reminiscent of the race to the top in New York in the 1930's. Some report the building as 2,296 feet (Post, 2005), others report at least half a mile up into the sky (Nobel, 2005). Regardless, the developers of the building want it to be known that the title of the world's tallest building is coming back to the Middle East. Some may say that there had never been a world's tallest building in the Middle East, but the developers refer to when the pyramids of Egypt were overtaken by the buildings of Europe hundred of years ago (Nobel, 2005). The company developing the building proclaim that this structure is one that will change history (EMAAR, 2006). In fact, the building will be the first over 2,000 feet tall and will be the first to hold all of the CTBUH tallest building categories. The developers also state

> The goal of Burj Dubai is not simply to be the world's highest building. It's to embody the world's highest aspirations.
>
> Burj Dubai looks different depending on where you're standing. For those living nearby, it is a shining accomplishment – tangible proof of Dubai's central role in a growing world. For those standing in other global capitals, it is a shining symbol – an icon of the new Middle East: prosperous, dynamic, and successful.
>
> In fact, Burj Dubai is both. It is a fact – an unprecedented example of international cooperation – and a symbol – a beacon of progress for the entire world (EMAAR, 2006).

The developers opinion of Burj Dubai strengthen the position that skyscrapers are more than just a place to work or live, but rather they are also statements.

Up and Coming

There are also several other buildings under construction in the world set to attack titles aside from world's tallest. As the skyscraper goes global, more and more competition is coming from outside of the United States. As shown in table 2-7 previously, the United States occupies only 2 of the top ten tallest buildings in the world, at 4^{th} and 9^{th} tallest. With the completion of some of the numerous tall buildings under construction shown in table 2-22, the top ten tallest building's in the world will look completely different. Table 2-22 also shows that of the tallest 15 buildings going up, only 2 are in America. The majority of tall structures seem to be consistently on the Asian continent and in the Middle East, with a few scattered elsewhere. Dubai especially, is building taller and taller with 4 buildings going up that are all over 1,000 feet tall, including the world's tallest building. Table 2-23 now shows what the top ten world's tallest buildings shall look like at the completion of the buildings listed as under construction in table 2-22. Come that time, the United States will be a non-factor with only one building in the top ten, the once mighty Sears Tower in position 10. The Chinese will still hold the majority of the world's tallest and the Middle East's new skyscraper power will also be felt a bit.

Alas, the torch may seem to have been officially passed to the rest of the world but, not to be outdone Chicago may come back with a building that could challenge for the world's tallest building, if not second place. As Burj Dubai's final height is top secret, it is difficult to speculate, but Santiago Calatrava is taking his art as architecture to a new level. The Fordham Spire is the possible world's tallest building that would return the crown to the United States of America. In the design, each floor slab would turn 2 degrees from the floor below it, thus making a complete 360 degree turn up the building (Emporis Buildings, 2006). Calatrava's impetus was fire billowing from Indian settlements that used to line the Chicago River. Omnipresent, as always this symbolic return to America may never occur, but the hope is there and the desire to build the tallest still lies in Americans despite past attacks on the skyscraper as a building type.

The Story of Lower Manhattan

More than five years after the attacks of September 11, 2006 there are still no structures occupying the locations where One World Trade Center and Two World Trade Center stood. This highly public, highly sentimental plot of land in Lower Manhattan means a lot of things to a lot of people and thus has been thoroughly and prohibitively mulled over in a bureaucratic fashion. Only recently is there some light at the end of the tunnel for what is to be done with the World Trade Center land that remains currently vacant. In the end the area will have 29 projects worth an anticipated 21 billion dollars completed before 2015 (Post, 2006, September 11).

With the myriad of projects a few towers in particular stand out in Towers 2, 3 and 4, the already completed 7 World Trade Center and the Freedom Tower. Upon completion the area that once was the scene of such horror will be an architectural and civic masterpiece.

Towers 2, 3, 4 and 7 World Trade Center

Recently, three of the four towers that are to be completed at the World Trade Center site were announced. These towers are currently numbered simply towers 2, 3 and 4 and will reside at the east side of the site. The trio constitute only a portion of the massive undertaking going on in Lower Manhattan. However, being part of the world's most symbolic and most attention gathering rebuilding of any area, draws only the best in the business. Architects Foster and Partners, Fumihiko Maki and Maki and Associates and the Richard Rogers Partnership represent the top quality architects whose designs are planned to be implemented. The Rogers tower would be the tallest at 1,555 feet tall, making it the second tallest building in New York, after the to be completed Freedom Tower (Engineering News Record, 2006, September 18). The Foster tower would be constructed to 1,254 feet making, it the third tallest building in New York and only 4 feet above the Empire State Building (Engineering News Record, 2006, September 18). Lastly, the Maki tower would be 61 stories and rise to 947 feet tall (Engineering News Record, 2006, September 18). All three would demonstrate how America can rebuild and the resolve with which Americans build tall in the face of foes.

One building that was destroyed that day has actually already been rebuilt, 7 World Trade Center. It is a 52 story white glass building that reflects the sky above and allows tremendous amount of color changing depending on the time of day (Jacobs, 2006). The building also achieved a gold level LEED certification and is the only other high-rise in New York besides the Hearst Building to achieve such a rating (Jacobs, 2006). The building is an indicator of the beauty and achievement that is to come around the rest of the World Trade Center area. It also demonstrates designing and constructing with terrorism in mind with blast-absorbent glass and energy-absorbing steel springs incorporated into the structure (Jacobs, 2006).

The Freedom Tower

By far, the most significant structure going up at the World Trade Center site is the Freedom Tower. It is to be the most symbolic skyscraper the world has ever seen. It will show America triumphant in the face of terrorism, it will rise to 1,776 feet symbolizing the year of the Declaration of Independence, it will be the quintessential building of and for America and Americans everywhere.

For the design, the joint city and state organization of the Lower Manhattan Redevelopment Corporation held an international design competition in 2002. There were 406 entries received initially (Lepik, 2004)! It was a whose, who of architecture firms all fighting to be the group chosen to construct a memorable piece of world and human history. Oddly enough, a good number of the entries featured soaring skyscrapers to replace the tall buildings that had fallen (Stephens, 2004). In the end Daniel Libeskind's design was selected. The design involved a 1,776 tower that was asymmetrically built taller on one side to resemble the Statue of Liberty's torch (Chamberlain, 2006). In the end though the building's landlord rejected the design as uneconomical and today the design stands as a symmetrical 77 story, still 1,776 foot tall glass enclosed structure (Chamberlain, 2006). In regards to terrorism the entire base 200 feet will be mechanical equipment only and will be fortress-like in design (Chamberlain, 2006).

The building and the area has its problems and pitfalls, with astronomically rising costs due to structural modifications to fight terrorism. The area also still has a stigma and the argument of whether the entire building will be occupied is still in question. Although, recently 1,000,000 square feet of the tower was confirmed to be rented out by United States agencies and other state agencies (Bagli, 2006). Regardless of terrorism concerns, financial concerns and public concerns the buildings are going through. According to the governor of New York, George E. Pataki the Freedom Tower "will be built and it will be occupied" (Bagli, 2006). The land, the area, the stories and the buildings that are to follow mean too much to go by the wayside. It is this symbolic aspect of skyscrapers which enraptures the minds of constituents who build tall. It is this symbolic aspect of skyscrapers that wills buildings such as the Freedom Tower into the New York skyline.

Table 2-1: Building Height and Percentage Return on Investment

Story Height	Actual Percentage Return (%)	Normal Computed Percentage Return (%)
8	4.22	4.69
15	6.44	6.10
22	7.73	7.31
30	8.50	8.45
37	9.07	9.23
50	9.87	10.13
63	10.25	10.33
75	10.06	9.90
85	-	9.08
100	-	7.08
110	-	5.22
115	-	4.14
120	-	2.95
125	-	1.66
130	-	0.27
131	-	-0.02

Clark, W., & Kingston, J. (1930). *The skyscraper: A study in the economic height of modern office buildings.* New York, NY: American Institute of Steel Construction Inc.

Table 2-2: Top Ten Tallest Buildings in the United States of America

City	Building	Height	Year
Chicago	Sears Tower	1,451 ft	1974
New York City	Empire State Building	1,250 ft	1931
Chicago	Aon Center	1,136 ft	1973
Chicago	John Hancock Center	1,127 ft	1969
New York City	Chrysler Building	1,046 ft	1930
Atlanta	Bank of America Plaza	1,023 ft	1992
Los Angeles	US Bank Tower	1,018 ft	1989
Chicago	ATandT Corporate Center	1,007 ft	1989
Houston	JP Morgan Chase Tower	1,002 ft	1982
Chicago	Two Prudential Plaza	995 ft	1990
Average		1,106	1972

Council on Tall Buildings and Urban Habitat. CTBUH Database. http://join.emporis.com/?nav=signin&lng=3. (July 31, 2006)

Table 2-3: Top Ten Tallest Buildings in China

City	Building	Height	Year
Shanghai	Jin Mao Tower	1,380 ft	1998
Hong Kong	Two International Finance	1,362 ft	2003
Guangzhou	CITIC Plaza	1,283 ft	1997
Shenzhen	Shun Hing Square	1,260 ft	1996
Hong Kong	Central Plaza	1,227 ft	1992
Hong Kong	Bank of China Tower	1,205 ft	1990
Hong Kong	The Center	1,135 ft	1998
Shenzhen	SEG Plaza	957 ft	2000
Shanghai	Plaza 66	945 ft	2001
Shanghai	Tomorrow Square	934 ft	2003
Average		1,169	1998

Council on Tall Buildings and Urban Habitat. CTBUH Database. http://join.emporis.com/?nav=signin&lng=3. (July 31, 2006)

Table 2-4: Average Percentage of Buildings Worldwide per 60 years

Years	U.S.A	Percentage	China	Percentage
1885 - 1945	5,600	84%	10	0%
1945 - 2005	11,981	35%	8453	13%

Council on Tall Buildings and Urban Habitat. CTBUH Database. http://join.emporis.com/?nav=signin&lng=3. (July 31, 2006)

Table 2-5: Average Percentage of Buildings Worldwide per Decades

Years	U.S.A	Percentage	China	Percentage
1996-2005	175	9.19%	291	17.21%
1986-1995	167	16.52%	278	27.68%
1976-1985	224	25.64%	188	21.71%
1966-1975	316	32.68%	64	6.48%
1956-1965	230	49.06%	25	4.21%
1946-1955	79	74.46%	0	0.33%

Council on Tall Buildings and Urban Habitat. CTBUH Database. http://join.emporis.com/?nav=signin&lng=3. (July 31, 2006)

Table 2-6: List of World's Tallest Buildings Past and Present

Building	Location	Height (ft)	Year
Masonic Temple	Chicago, Illinois	302	1892
Park Row Building	New York, New York	391	1899
Singer Building	New York, New York	612	1908
Metropolitan Life Building	New York, New York	700	1909
Woolworth Building	New York, New York	792	1913
Chrysler Building	New York, New York	1,046	1930
Empire State Building	New York, New York	1,250	1931
One World Trade Center	New York, New York	1,368	1972
Sears Tower	Chicago, Illinois	1,451	1974
Petronas Towers 1 and 2	Kuala Lumpur, Malaysia	1,483	1998
Taipei 101	Taipei, Taiwan	1,671	2004

Emporis. Emporis Buildings Database. http://www.emporis.com/en/. (July 31, 2006)

Table 2-7: Top Ten World's Tallest Buildings

Building	Height (ft.)	Location	Year
Taipei 101	1,671	Taipei, Taiwan	2004
Petronas Tower 1	1,483	Kuala Lumpur, Malaysia	1998
Petronas Tower 2	1,483	Kuala Lumpur, Malaysia	1998
Sears Tower	1,451	Chicago, Illinois	1974
Jin Mao Tower	1,380	Shanghai, China	1998
Two International Finance	1,362	Hong Kong, China	2003
CITIC Plaza	1,283	Guangzhou, China	1997
Shun Hing Square	1,260	Shenzhen, China	1996
Empire State Building	1,250	New York, New York	1931
Central Plaza	1,227	Hong Kong, China	1992

Emporis. Emporis Buildings Database. http://www.emporis.com/en/. (July 31, 2006)

Table 2-8: World's Tallest Buildings Per Continent

Continent	Building	Height (ft.)	Location
Africa	Carlton Centre Office Tower	730	Johannesburg, South Africa
Asia	Taipei 101	1,671	Taipei, Taiwan
Europe	Triumph Palace	866	Moscow, Russia
North America	Sears Tower	1,451	Chicago, Illinois
Oceania	Q1 Tower	1,058	Gold Coast City, Australia
South America	Parque Central Torre Oeste	725	Caracas, Venezuela

Emporis. Emporis Buildings Database. http://www.emporis.com/en/. (July 31, 2006)

Table 2-9: World's Tallest Buildings per Categories

Building Type	Building	Height (ft.)	Location
Office	Taipei 101	1,671	Taipei, Taiwan
Hospital	Guy's Tower	449	London, England
Residential	Q1 Tower	1,058	Gold Coast City, Australia
Educational	Moscow State University	787	Moscow, Russia
Lodging	Ryugyong	1,083	Pyongyang, North Korea

Emporis. Emporis Buildings Database. http://www.emporis.com/en/. (July 31, 2006)

Table 2-10: United States Top Ten Skyscraper Cities versus Population

City	Buildings	Population	U.S Rank
New York	5,503	8,143,197	1
Chicago	1,050	2,842,518	3
Los Angeles	469	3,844,829	2
Honolulu	425	377,379	47
San Francisco	398	739,426	14
Philadelphia	342	1,463,281	5
Houston	329	2,016,582	4
Washington	298	582,049	27
Boston	258	559,034	24
Dallas	237	1,213,825	9

Emporis. Emporis Buildings Database. http://www.emporis.com/en/. (July 31, 2006)

Table 2-11: China Top Ten Skyscraper Cities versus Population

City	Buildings	Population	Chinese Rank
Hong Kong	7,458	6,943,600	3
Beijing	845	7,746,519	2
Shanghai	793	9,145,711	1
Guangzhou	460	4,111,946	10
Wuhan	396	4,550,000	8
Shenzhen	334	1,245,000	NR
Macau	325	453,733	NR
Chongqing	299	6,300,000	4
Xiamen	175	1,370,000	NR
Shenyang	162	4,649,490	7

Emporis. Emporis Buildings Database. http://www.emporis.com/en/. (July 31, 2006)

Table 2-12: Worldwide Top Ten Skyscraper Countries versus Population

Country	Buildings	Population	World Rank
U.S.A.	19,187	296,483,000	3
Brazil	12,236	184,184,000	5
China	12,142	1,303,701,000	1
Spain	7,484	43,484,000	30
Japan	5,285	127,728,000	10
Canada	4,967	32,225,000	36
Singapore	3,703	4,296,000	119
South Korea	3,068	48,294,000	24
United Kingdom	3,033	60,068,000	22
Turkey	2,863	72,907,000	17

Emporis. Emporis Buildings Database. http://www.emporis.com/en/. (July 31, 2006) and Population Reference Bureau. Population Reference Bureau Database. http://www.prb.org/datafind/datafinder7.htm. (June 22, 2006)

Table 2-13: Worldwide Top Ten Skyscraper Countries versus GDP

Country	Buildings	GDP (trillions)	World Rank
U.S.A.	19,187	12,360	1
Brazil	12,236	1,556	10
China	12,142	8,859	2
Spain	7,484	1,029	13
Japan	5,285	4,018	3
Canada	4,967	1,114	11
Singapore	3,703	124.3	56
South Korea	3,068	965.3	14
United Kingdom	3,033	1,830	6
Turkey	2,863	572	18

Emporis. Emporis Buildings Database. http://www.emporis.com/en/. (July 31, 2006) and CIA. CIA World Factbook Database. https://www.odci.gov/cia/publications/factbook/index.html. (June 27, 2006)

Table 2-14: Comparative Population Densities Around the Globe

Region	Population	Area (mile^2)	Population/ (mile^2)
Asia Pacific			
Hong Kong	5,693,000	23	245,747
Jakarta	9,882,000	76	129,920
Ho Chi Minh City	3,725,000	31	120,596
Shanghai	6,936,000	78	88,931
Bangkok	5,955,000	102	58,422
Manila	10,156,000	188	54,012
Seoul	16,792,000	342	49,087
Taipei	6,695,000	138	48,571
Beijing	5,762,000	151	38,168
Singapore	2,719,000	78	34,862
Osaka-Kobe-Kyoto	13,872,000	495	28,025
Tokyo-Yokohama	27,245,000	1,089	25,014
Europe and North America			
Paris	8,720,000	432	20,183
New York	14,625,000	1,274	11,478
Berlin	3,021,000	274	11,020
London	9,115,000	874	10,427
Los Angeles	10,130,000	1,110	9,126
Chicago	6,529,000	762	8,566
Houston	2,329,000	310	7,512

Abel, C. (2003). *Sky high: Vertical architecture.* London, United Kingdom: Royal Academy of Arts.

Table 2-15: Urban versus Rural World Populations

Year	Urban (%)	Rural (%)	Total (billions)
1950	30.00	70.00	2.50
1975	38.40	61.60	4.07
2000	47.20	51.80	6.12
2025	62.00	38.00	8.06

Ali, M., & Armstrong, P. (1995). *Architecture of tall buildings: Council on tall buildings and urban habitat.* New York, NY: McGraw- Hill, Inc.

Table 2-16: Developing and Developed Nations Urban versus Rural Concentrations

Years	Urban (%)	Rural (%)	Total (billions)
1950 Developed Countries	44.00	56.00	0.85
1950 Developing Countries	17.00	83.00	1.67
1975 Developed Countries	69.00	31.00	1.10
1975 Developing Countries	27.00	73.00	2.96
2000 Developed Countries	77.00	23.00	1.25
2000 Developing Countries	40.00	60.00	4.85
2025 Developed Countries	85.00	15.00	1.39
2025 Developing Countries	57.00	43.00	6.75

Ali, M., & Armstrong, P. (1995). *Architecture of tall buildings: Council on tall buildings and urban habitat.* New York, NY: McGraw- Hill, Inc.

Table 2-17: Current World's Top Ten Populated Countries

Country	Population (millions)
China	1,311
India	1,122
United States	299
Indonesia	225
Brazil	187
Pakistan	166
Bangladesh	147
Russia	142
Nigeria	135
Japan	128

Population Reference Bureau. Population Reference Bureau Database. http://www.prb.org/datafind/datafinder7.htm. (June 22, 2006)

Table 2-18: World's Top Ten Populated Countries in 2050

Country	Population (millions)	Percentage Change (%)
India	1,628	31
China	1,437	9
United States	420	29
Nigeria	299	55
Pakistan	295	44
Indonesia	285	21
Brazil	260	28
Bangladesh	231	36
Dem. Rep. of Congo	183	NR
Ethiopia	145	NR

Population Reference Bureau. Population Reference Bureau Database.
http://www.prb.org/datafind/datafinder7.htm. (June 22, 2006)

Table 2-19: GDP Trends 2010-2030 in Trillions

Country	2010	2015	2020	2025	2030
United States	13,043	15,082	17,541	20,123	23,112
China	10,116	13,538	17,615	22,592	28,833
India	5,162	6,694	8,644	11,059	14,102
Japan	3,858	4,192	4,438	4,653	4,878

Energy Information Administration. World Gross Domestic Product by Region.
http://www.eia.doe.gov/oiaf/ieo/pdf/ieoreftab_3.pdf. (June 18, 2006)

Table 2-20: Current Skyscraper Rank versus Population and GDP

Country	Skyscrapers	Rank	Population	GDP
U.S.A.	19,187	1	3	1
China	12,142	2	1	2
Japan	5,285	5	10	3
India	1,253	23	2	4

Population Reference Bureau. Population Reference Bureau Database.
http://www.prb.org/datafind/datafinder7.htm. (June 22, 2006) and Energy Information Administration. World Gross Domestic Product by Region.
http://www.eia.doe.gov/oiaf/ieo/pdf/ieoreftab_3.pdf. (June 18, 2006)

Table 2-21: Emporis Skyscraper Award Winners

Awarded	Building	Location	Height (ft.)
2000	Sofitel New York Hotel	New York, New York	356
2001	One Wall Centre	Vancouver, Canada	491
2002	Kingdom Centre	Riyadh, Saudi Arabia	992
2003	Swiss Re Headquarters	London, United Kingdom	590
2004	Taipei 101	Taipei, Taiwan	1,671
2005	Turning Torso	Malmo, Sweden	623
		Average Height:	787

Emporis. Emporis Awards Listing. http://awards.emporis.com/?lng=3. (June 22, 2006)

Table 2-22: Tallest Buildings Currently Under Construction

Name	Location	Height (ft)	Year Complete
Burj Dubai	Dubai, U.A.E.	2,296	2008
Busan Lotte Tower	Busan, South Korea	1,620	2009
Shanghai World Financial Center	Shanghai	1,614	2007
Abraj Al Bait Hotel Tower	Mekkah, Saudi Arabia	1,591	NA
International Commerce Centre	Hong Kong	1,588	2009
Nanjing Greenland Financial Center	Nanjing, China	1,496	2008
Dubai Towers Doha	Doha, Qatar	1,450	2007
Trump International Hotel and Tower	Chicago	1,361	2008
23 Marina	Dubai	1,246	2009
Bank of America Tower	New York City	1,200	2008
Wanhao Financial Center	Chongqing, China	1,171	2006
Almas Tower	Dubai	1,148	2007
Federation Complex Tower A	Moscow	1,132	2010
Palacio de la Bahia	Panama City	1,102	2009
Rose Tower	Dubai	1,092	2006

Post, N. (2005, October 31). Skyscraper envy lives on, globally. *Engineering News-Record*, 255(17), 10-11.

Table 2-23: Future Top Ten World's Tallest Building List

Name	Location	Height (ft)	Year Complete
Burj Dubai	Dubai, U.A.E.	2,296	2008
Taipei 101	Taipei, Taiwan	1,671	2004
Busan Lotte Tower	Busan, South Korea	1,620	2009
Shanghai World Financial Center	Shanghai, China	1,614	2007
Abraj Al Bait Hotel Tower	Mekkah, Saudi Arabia	1,591	NA
International Commerce Centre	Hong Kong, China	1,588	2009
Nanjing Greenland Financial Center	Nanjing, China	1,496	2008
Petronas Tower 1	Kuala Lumpur, Malaysia	1,483	1998
Petronas Tower 2	Kuala Lumpur, Malaysia	1,483	1998
Sears Tower	Chicago, Illinois	1,451	1974

Council on Tall Buildings and Urban Habitat. CTBUH Database. http://join.emporis.com/?nav=signin&lng=3. (July 31, 2006)

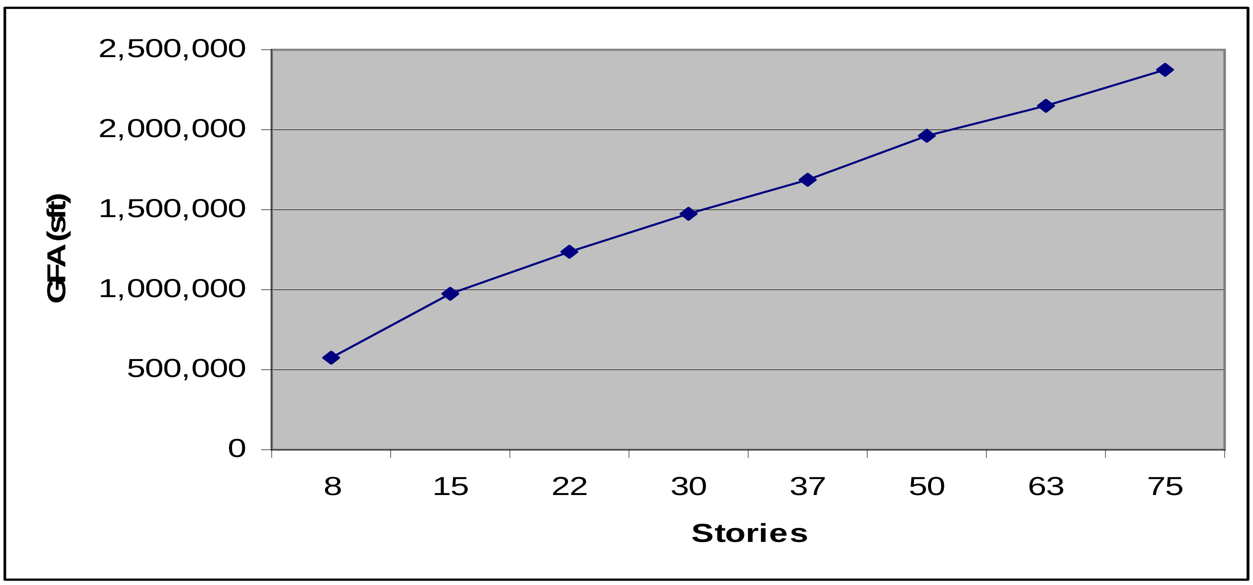

Figure 2-1: Skyscraper Gross Floor Area Comparison

Clark, W., & Kingston, J. (1930*). The skyscraper: A study in the economic height of modern office buildings*. New York, NY: American Institute of Steel Construction Inc.

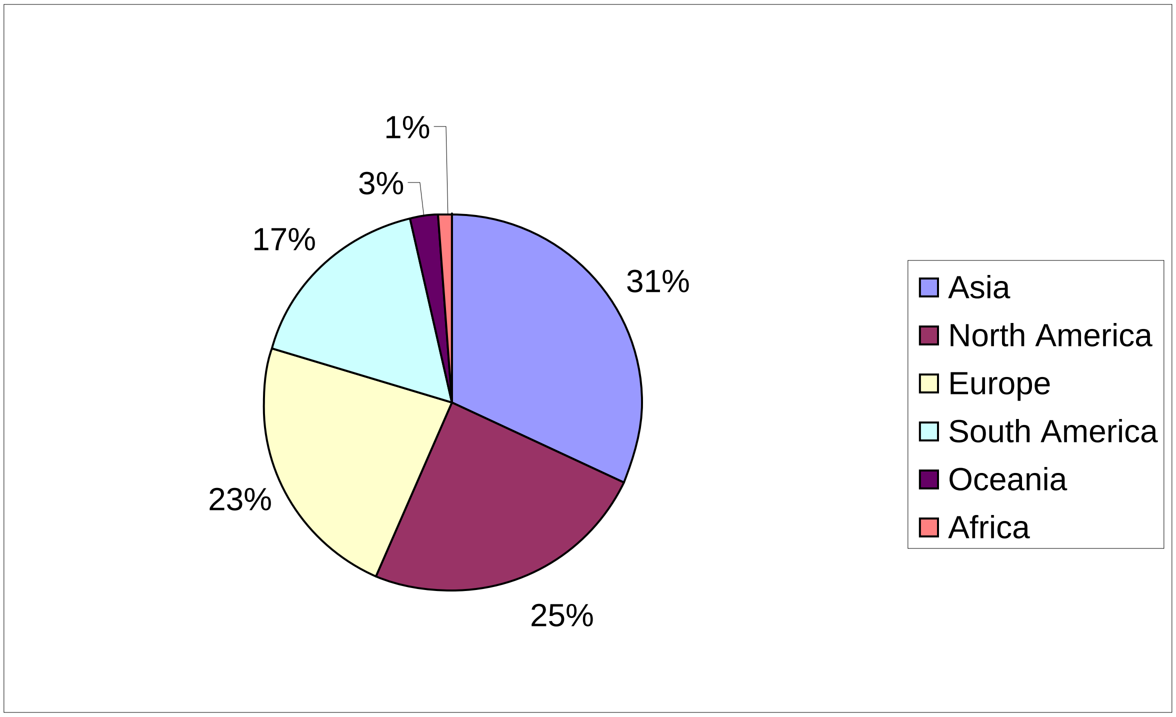

Figure 2-2: High-rises per Continent
Emporis.Emporis Buildings Database. http://www.emporis.com/en/. (July 31, 2006)

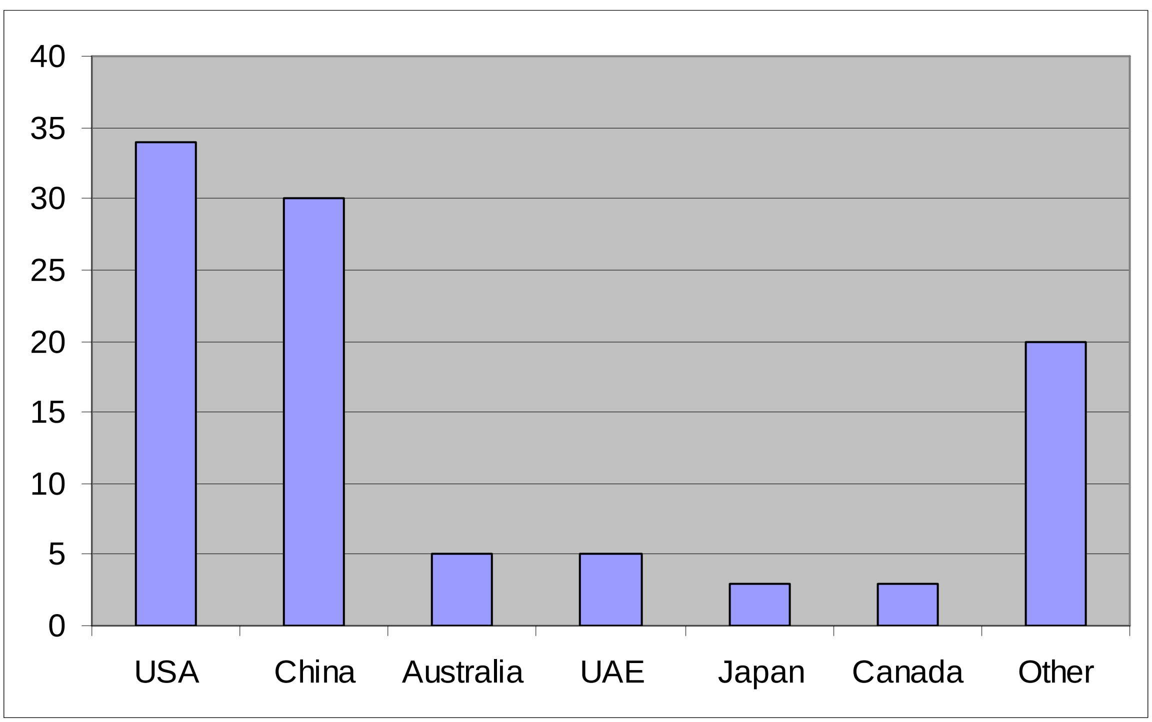

Figure 2-3: Number of Top 100 World's Tallest Buildings per Country
Emporis. Emporis Buildings Database. http://www.emporis.com/en/. (July 31, 2006)

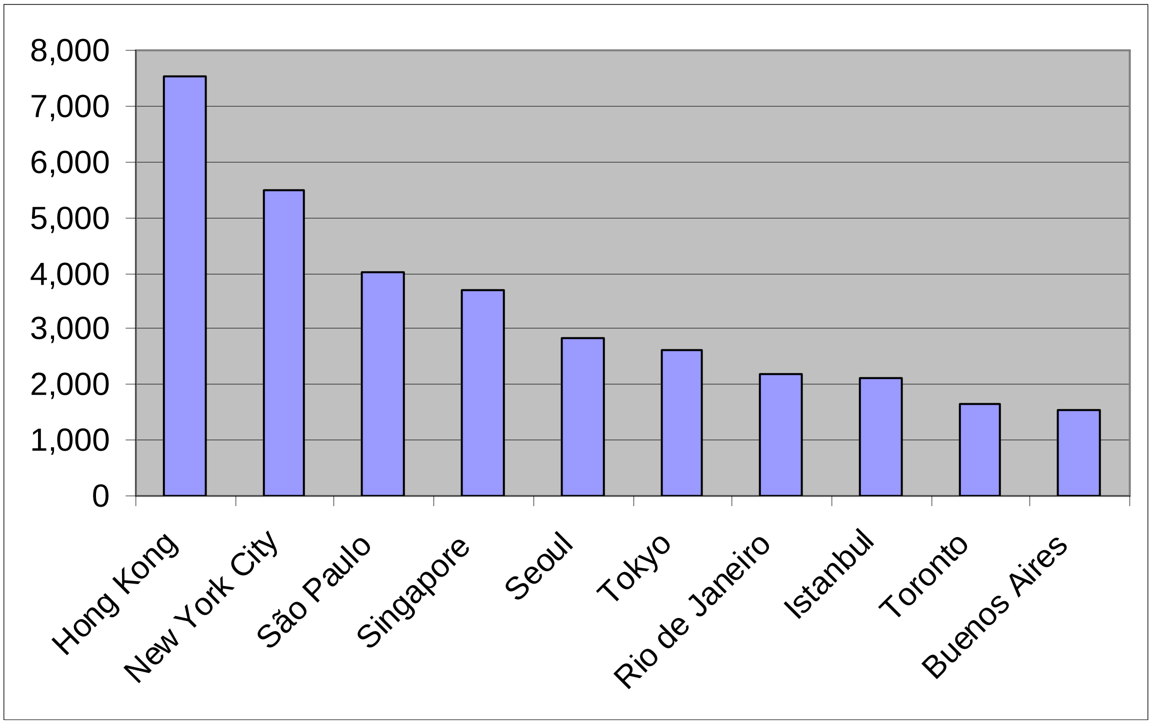

Figure 2-4: Top Ten High-Rise Cities in the World
Emporis. Emporis Buildings Database. http://www.emporis.com/en/. (July 31, 2006)

CHAPTER 3
METHODOLOGY AND RESULTS

The Public Opinion of Skyscrapers and the Downtown Environment

As demonstrated, the progression of the skyscraper into today's world has been accompanied with widespread public admiration, awe and approval. Owners and developers hold the finances in constructing tall buildings, but the public holds the true dollars as tenants and renters of the commercial or residential space that a skyscraper provides. The goal of every tall building regardless of symbolism and impact is to return an attractive amount of money back to those who are investing in the building. Therefore, public acceptance and support in the construction and implementation of high-rises is paramount.

As more skyscrapers are reaching new heights of construction, as more skyscrapers are being erected and as more are being proposed than ever before, the public mindset towards the tall building must be taken into account. The public makes up the constituents that work, live or recreate around tall structures. Their influence and opinion matters most in the acceptance and utilization of tall buildings.

In the five years that have passed since September 11th, what is the public's opinion of the tall building? How do they feel about the many aspects of the tall building and the environments that they are set against? Such questions are intended to gauge the success with which the tall building stands in a modern, terrorism-ridden world. The power of the public's view on the skyscraper is the true measure of how well a skyscraper expresses safety, symbolism and pride. This study, entitled The Public Opinion of Skyscrapers and the Downtown Environment was designed to capture public sentiment and thinking of the tall buildings that have dotted so many American cities. The city thus chosen to represent the public was Tampa, Florida

Tampa, Florida

Tampa might as well represent any typical, mid to large-sized American city. The city itself represents 303,477 residents according to the 2000 census which makes Tampa the 56^{th} largest American city in the nation (Population Reference Bureau, 2006). The area of Tampa Bay, which includes Tampa, St. Petersburg and Clearwater, contains 2,647,658 people in the entire metropolitan area (Emporis Buildings, 2006).

The city itself contains 57 completed skyscrapers, with its tallest building being the AmSouth Building at 579 feet (Emporis Buildings, 2006). The city also has an additional 16 skyscrapers under construction at this time (Emporis Buildings, 2006). Now, it is realized that these figures do not make Tampa necessarily a high-rise mecca. However, the tall buildings and those people surrounded by them in downtown Tampa do give credibility to answers given for the study. A tall building is a tall building, whether it be in Taiwan or Tampa. The typical Tampian could very well be transplanted into downtown Houston and have the same feelings and opinions on skyscrapers.

Skyscraper Sample Size

As stated above, the size of Tampa, Florida from the 2000 census was 303,477 residents within city limits (Population Reference Bureau, 2006). In determining the sample size necessary to be statistically significant and to estimate the size of the sample of the population that needed to be studied, the basic calculation of n=(Z/Delta)^2 * p * q was used. In this equation n represents required sample size, Z represents the Z-value for a particular confidence level, Delta represents the estimate interval, and where p and q are given as equal at 0.5. The resulting sample size was calculated as 384 participants with a confidence interval of 95 percent (Ostle and Malone, 1988).

Execution of the Protocol

The protocol was conducted in the downtown area of Tampa, Florida on Monday, August 14, 2006. With strict emphasis placed on surveying only those people that were coming in, going out of or that were currently located inside of a skyscraper, the protocol's credibility and objectivity remains in tact. The protocol consisted of a short, Likert scale, seven-question survey. The Likert scale contained within the protocol ranged from answer responses of one through five and the accompanying verbiage was as follows:

- 1 – Strongly Disagree
- 2 – Disagree
- 3 – Undecided
- 4 – Agree
- 5 – Strongly Agree

The seven questions were also simple to understand and interpret, they read as follows:

- I would/do feel safe working or living in a skyscraper.
- I enjoy the sight of skyscrapers and believe they enhance a city's skyline.
- I feel that skyscrapers of the world are still a terrorist threat.
- I would/do prefer living in an urban, downtown environment.
- I would/do prefer living in a suburban, grid system environment.
- I can identify cities by their skylines.
- I am proud of our nation's tall skyscrapers.

The intention of the above questions will be discussed along with the results in regards to statistical analysis and testing. Both the informed consent portion and the actual protocol questions can be viewed as Appendix A. This appendix represents the actual questionnaire format given to all participants.

The protocol was carried out during the course of the entire day within skyscraper lobbies, elevator zones, entrances or exits and actual offices within high-rise buildings. Specific buildings near which and in which the protocol was carried out include

- AmSouth Building
- Bank of America Plaza

- One Tampa City Center
- SunTrust Financial Center
- Park Tower
- Rivergate Tower
- Hillsborough County Center

Together, these buildings constitute the seven tallest buildings in Tampa, which was the intention when delivering the protocol (Emporis Buildings, 2006). This listing also includes perhaps Tampa's most famous building in the Rivergate Tower. This cylindrical building is meant to mimic or symbolize a lighthouse on the skyline of old Tampa Bay (Emporis Buildings, 2006). At days end, all 384 necessary responses had been gathered, with results that lend themselves to prevailing notions of the many factors that contribute to skyscraper longevity and sustenance as a building type in a world that holds threats to Americans and the world every day.

Skyscraper Protocol Question Analysis

Each question contained within the protocol dealt with a specific aspect of skyscrapers and their existence. In order to relay the findings, statistical analysis using chi-squared testing was performed. First, each question was mulled over to determine significance in the Likert answer distributions. Then that analysis was taken a bit further in regards to how those people who preferred suburban or urban environments responded. In using a question that contained the potentially vague terms of urban or suburban, discretion was given to those taking the protocol. Defining the boundary between urban and suburban can only be realized in the minds of the respondents. These areas are the type of thing where you know which area you are in when you see it and as such the public was left to decide for themselves.

Question 1: Are they safe?

The intention of question one was to gauge how safe those people occupying and using skyscrapers felt while they were within the building. Table 3-1 shows the distribution of answers that were recorded from the protocol and table 3-2 shows those same results in percentage forms. In order test whether that the 60.43 percentage of answers that agreed with the question of feeling safe, working or living in a skyscraper, was statistically significant, a Chi-squared test was performed. Disregarding respondents that answered 3, or undecided, the expected column was the sum of responses that were 1, 2, 4 or 5 and then divided by 2. The division by 2 represents the 2 main categories of agreed versus disagreed or 1 and 2 versus 4 and 5. if the public had no opinion, the two groups would have equal numbers of responses. Such a response, would indicate a random response to the five Likert possibilities. The observed column represented the actual number of responses per those people that strongly agreed, 5, and agreed, 4, and those people that represented disagreement with a strongly disagree, 1 and disagree, 2 as their answer. Then taking the differences between observed and expected, squaring it and then dividing it by the expected number the Chi-squared testing was complete. Now since each category, 1 and 2, and 4 and 5, calculated above the 3.84 chi-squared distribution for 95 percent confidence and 1 degree of freedom, at 34.08, the null hypothesis that the answers were distributed evenly was rejected (Ostle and Malone, 1988). The calculations are all provided within table 3-3 for all questions. This also means that the difference is statistically significant, and that the 60.43 percent shown in Figure 3-1 as the majority of responses for agreeing with the safety of skyscrapers is statistically significant as well. The Chi-squared testing for all questions followed the same steps mentioned.

Question 2: Are they beautiful?

Skyscrapers are some of the largest buildings on earth and therefore it is important for them to be aesthetically pleasing as their image projects upon many people, local and visiting alike. The intent of question 2 was to gauge how the public viewed the tall building as a piece of the urban landscape. Once again, the null hypothesis of even distribution over the Likert responses was rejected by Chi-squared testing and the majority of answers that turned towards agreeing that skyscrapers are beautiful pieces of the built environment, was found to be a departure from random. Figure 3-2 shows the percentage of respondents that answered strongly agree, 5 and agree, 4 was 70.06 percent as opposed to the 9.9 percent of the public who do not like the look of the tall building.

Question 3: Are they a threat?

In an America and a world that has been attacked by faceless terrorists and groups that support such carnage, the public must have an opinion on how likely they feel more skyscrapers are to be targeted as places of battle in a never-ending war. Question 3 addressed the issue of terrorism and tall buildings. It was found that the 57.3 percent shown in figure 3-3 of the public who agreed with the statement that skyscrapers are still terrorist targets is statistically significant and differs significantly from the 21.09 percent that do not agree that skyscrapers are still terrorist targets. A question that perhaps should have been included in the protocol would be whether or not this threat of terrorism would preclude the public from working or living in a high-rise structure. Regardless, the people surveyed were leaving, going into or occupying a tall building at the very moment of filling out the protocol. Therefore, their fear of terrorist acts, at least in the skyscrapers of Tampa, was not preventing their high-rise use.

Question 4: Downtown?

Skyscrapers are synonymous with downtown, dense urban areas. The relationship between the two is unbreakable and thus for the skyscraper of tomorrow to be successful, a movement into more of an urban and less suburban environment would be inevitable. How does the public in Tampa feel about downtown as their place of residence? Analysis shows that the 56.25 percent of respondents shown in figure 3-4 that answered that they disagreed with preferring to live in an urban environment is statistically significant. Over 26 percent of Tampa respondents did agree with preferring to live in an urban environment and such a percentage would possibly rise in other locations. The mindset in preferring a downtown environment over a suburban environment will be analyzed further.

Question 5: Suburbia?

If Tampa residents do not prefer living downtown, in high-rise living then the innverse area of suburbia is where they would chose to live given the option. Over 47 percent of respondents indicated that they agreed with the statement that they preferred to live in a suburban, grid system environment. This percent was found to be statistically significant and led to the rejection of the hypothesis that the responses were random with no bias with respect to skyscrapers. About a quarter of the public sampled did disagree with this statement as shown in Figure 3-5 with 26.82 preferring not to live in suburbia. Once again, location and local cultures could dramatically alter the results of such a question.

Question 6: Are they memorable?

Part of the recipe for building tall is to be symbolic and to be remembered in the chaos that is the real world. How well does the public identify with tall buildings across America and across the globe? Have the intentions to create instantaneous landmarks been realized in the eyes of the public? Question 6 asked Tampians how well they could identify the skylines of the world with regards to tall buildings and the indelible memories they may implant in those that come into view or contact with them. More than half of the respondents at 56.51 percent as shown in figure 3-6 answered that they agreed that they could identify cities by the skylines and skyscrapers that accompanied them. In a continuing trend of all questions analyzed, this percentage was found to be statistically significant. It seems that the intentions of building with height and power is conveyed and burned into the memories of the public.

Question 7: Are they proud icons?

Another variable in the skyscraper equation is the element of pride in building to great height. The parties involved in implementing skyscrapers are proud in the end of their gravity-defying product, but how does the public feel about the nation's most famous tall buildings? Does the Sears Tower and Empire State Building come to represent a buoy of pride for the American public or Tampians? With a resounding agreement at 65.37 percent, a statistically significant percentage, the public in Tampa is proud of the tall buildings that make up American urban areas. A mere 11.46 percent shown in figure 3-7 disagreed with being proud of the nation's skyscrapers.

Question Overview

What has been learned in this protocol? Using the limit of Tampa Bay residents and visitors, it was found that the majority of the public surveyed conveyed the following in regards to the skyscraper as a building type

- Tampians feel safe working or living in a skyscraper
- Tampians enjoy the sight of skyscrapers and the addition they make in skylines
- Tampians still believe that skyscrapers are a terrorist target
- Tampians do not prefer living in a downtown environment
- Tampians do prefer living in a suburban environment
- Tampians can identify cities by their skylines and tall buildings
- Tampians are proud of America's tall buildings.

It seems that despite fears of terrorism, the public is ready and willing to accept the skyscraper as a building type not only prior to September 11th, but also after it. Perhaps, working or living in a skyscraper is like the many risks humans take everyday in driving a car, flying in an airplane and crossing the street. Perhaps, skyscrapers are just a part of life and the minute occurrence of terrorism in the tall building is just dealt with. It is interesting to note that the 12.76 percent of people who disagreed and the 9.38 percent of people who strongly disagreed that they felt safe in skyscrapers were also occupying, coming out of or going into a tall building. Regardless, it seems that the public, along with developers, will continue building tall and that such endeavors will be supported despite terrorism or other concerns. Figure 3-8 shows that in questions 1, 2, 6 and 7 which regard the safety and vitality of tall buildings, the majority of the Tampa public see the skyscraper in a positive light and despite not wanting to live in downtowns and skyscrapers, they still enjoy them. In the end the null hypothesis was rejected for all questions which showed that one way or another a significant majority of people either agreed or disagreed with the questions of the protocol. This is no surprise, because the urban or suburban environments we choose to surround ourselves with is paramount to our quality of life, which for more people is the most important aspect of their lives, and their family's lives.

Downtown versus Suburban Viewpoints

Looking into the data gathered from the protocol, it can also be observed that there is a distinct shift in thinking between those groups that preferred living in a downtown environment versus those that preferred living in a suburban environment. It makes sense that those people that preferred living in and around low lying residential homes would also not be as apt to be a skyscraper supporter. On the other hand, those Tampians that supported living in downtown environments would likely be more attracted to high-rises and the features that accompany tall structures. Once again, it is important to realize that the public's own view of what constituted suburban and urban areas was used.

To divide these two groups, question number four, which was the most clear cut in terms of urban versus suburban, was used. Only those respondents who answered 1 and 2 versus 4 and 5 were considered. Answers 1 and 2 represented disagreement with urban living, and 4 and 5 represented agreement with urban living. Agreement with living in an urban environment was taken as the observed frequency response, while the expected column contained the data for disagreement with urban living amongst the questions. The null hypothesis used in this Chi-squared testing was that there would be no significant difference in the answers given by those who supported urban living when compared to those who did not support urban living. Using all five possible Likert answer choices the analysis had 5 degrees of freedom which allowed for a chi-squared distribution number of 11.1 when used at 95 percent confidence (Ostle and Malone, 1988). It was found that throughout the 6 questions, that all responses between the two opposing groups did in fact differ significantly and thus the null hypothesis was rejected. Therefore, the alternative hypothesis that different viewpoints equals different feelings on skyscrapers was confirmed. The statistically significant findings are all pictured in table 3-4.

Protocol Limitations and Improvements

The protocol was intended to represent most any American viewpoint in most any American city of moderate population with moderate amounts of skyscrapers. With that goal in mind, the protocol was carried out and the results are solid data for areas that resemble Tampa Bay. However, there are factors contained within the protocol that limit its effectiveness and range in terms of an American or global skyscraper. These factors include

- Proximity
- Finances
- Location
- People
- Environment
- Culture
- Age
- History

Due to the limits of where the protocol could be carried out and where the protocol administrator could afford to travel, the location was limited to Tampa. Now Tampa, as previously stated could very well represent most mid-sized to large-sized American city complete with all the amenities and attractions of any metropolitan area. However, in terms of skyscraper numbers and population numbers Tampa is not comparable to locations such as

- New York City
- Chicago
- Los Angeles
- Hong Kong
- Tokyo
- Sao Paulo
- Sydney
- London

These locations also have different people who come from different mindsets and upbringings. It is very possible that growing up in suburban Tampa influences fondness, or dislike for skyscrapers and downtown environments. Growing up in New York would certainly bias people one way or the other. However, a review of the cities listed was not feasible. Being totally immersed in a skyscraper environment that has thousands and thousands of tall buildings is certain to change the mindsets of those people who come into contact with them. A skyscraper "culture" so to speak, that is so celebrated in Chicago leads one to believe that Chicagoans would be prone to support tall buildings and live downtown. The people of Tampa who come from all over the world into the growing state of Florida are perhaps in search of more space and more room and do not prefer the vertical, limited space of the world's large cities. On the other hand, young people may be more open to the idea of living downtown in places such as New York, so age may have an effect that was not accounted for in this protocol. Lastly, history of skyscrapers within cities may have an affect on views towards tall buildings. In Chicago, where the skyscraper is synonymous with their growth as a city, the skyscraper is welcomed, whereas in London tall buildings have only up until recently been denounced. Also, New Yorkers may have the most to say about tall buildings after September 11th. Tampa, Florida was far removed on that day. New Yorkers had friends and family perish in those attacks. Their loved ones still work in those downtown areas where even the smallest skyscraper now has security. It would be interesting to judge the New Yorkers take on skyscrapers in an era of uncertainty.

Table 3-1: Protocol Question and Answer Distribution

Answer/Question	1	2	3	4	5	6	7
1	36	16	26	100	50	26	18
2	49	22	55	116	53	59	26
3	67	77	83	67	100	82	89
4	143	137	133	60	129	146	140
5	89	132	87	41	52	71	111
	384	384	384	384	384	384	384

Table 3-2: Protocol Question and Answer Percentage Distribution

Answer/Question	1	2	3	4	5	6	7
1	9.38%	4.17%	6.77%	26.04%	13.02%	6.77%	4.69%
2	12.76%	5.73%	14.32%	30.21%	13.80%	15.36%	6.77%
3	17.45%	20.05%	21.61%	17.45%	26.04%	21.35%	23.18%
4	37.24%	35.68%	34.64%	15.63%	33.59%	38.02%	36.46%
5	23.18%	34.38%	22.66%	10.68%	13.54%	18.49%	28.91%
	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Table 3-3: Chi Squared Testing for Protocol 1 and 2, 4 and 5 Question and Answer Distribution

Question	Observed	Expected	O-E	(O-E)^2	Chi^2	Distribution	Pass/Fail
1							
1 and 2	85	158.5	-73.5	5402.25	34.0836	3.84	Fail
4 and 5	232	158.5	73.5	5402.25	34.0836	3.84	Fail
2							
1 and 2	38	153.5	-115.5	13340.3	86.9072	3.84	Fail
4 and 5	269	153.5	115.5	13340.3	86.9072	3.84	Fail
3							
1 and 2	81	150.5	-69.5	4830.25	32.0947	3.84	Fail
4 and 5	220	150.5	69.5	4830.25	32.0947	3.84	Fail
4							
1 and 2	216	158.5	57.5	3306.25	20.8596	3.84	Fail
4 and 5	101	158.5	-57.5	3306.25	20.8596	3.84	Fail
5							
1 and 2	103	142	-39	1521	10.7113	3.84	Fail
4 and 5	181	142	39	1521	10.7113	3.84	Fail
6							
1 and 2	85	151	-66	4356	28.8477	3.84	Fail
4 and 5	217	151	66	4356	28.8477	3.84	Fail
7							
1 and 2	44	147.5	-103.5	10712.3	72.6254	3.84	Fail
4 and 5	251	147.5	103.5	10712.3	72.6254	3.84	Fail

Table 3-4: Chi-Squared Testing for Question Four Difference Distribution

Question	Observed	Expected	O-E	(O-E)^2	Chi^2	Distribution	Pass/Fail
1	4	27	23	529	19.59		
	10	36	26	676	18.78		
	14	36	22	484	13.44		
	37	81	44	1,936	23.90		
	35	36	1	1	0.03		
					75.74	11.10	Fail
2	1	12	11	121	10.08		
	4	17	13	169	9.94		
	21	46	25	625	13.59		
	29	83	54	2,916	35.13		
	44	58	14	196	3.38		
					72.12	11.10	Fail
3	7	13	6	36	2.77		
	20	29	9	81	2.79		
	26	44	18	324	7.36		
	36	73	37	1,369	18.75		
	10	57	47	2,209	38.75		
					70.43	11.10	Fail
5	14	30	16	256	8.53		
	23	27	4	16	0.59		
	23	36	13	169	4.69		
	27	86	59	3,481	40.48		
	11	37	26	676	18.27		
					72.57	11.10	Fail
6	7	17	10	100	5.88		
	10	42	32	1,024	24.38		
	18	50	32	1,024	20.48		
	35	80	45	2,025	25.31		
	28	27	-1	1	0.04		
					76.09	11.10	Fail
7	3	13	10	100	7.69		
	5	20	15	225	11.25		
	19	54	35	1,225	22.69		
	26	90	64	4,096	45.51		
	47	39	-8	64	1.64		
					88.78	11.10	Fail

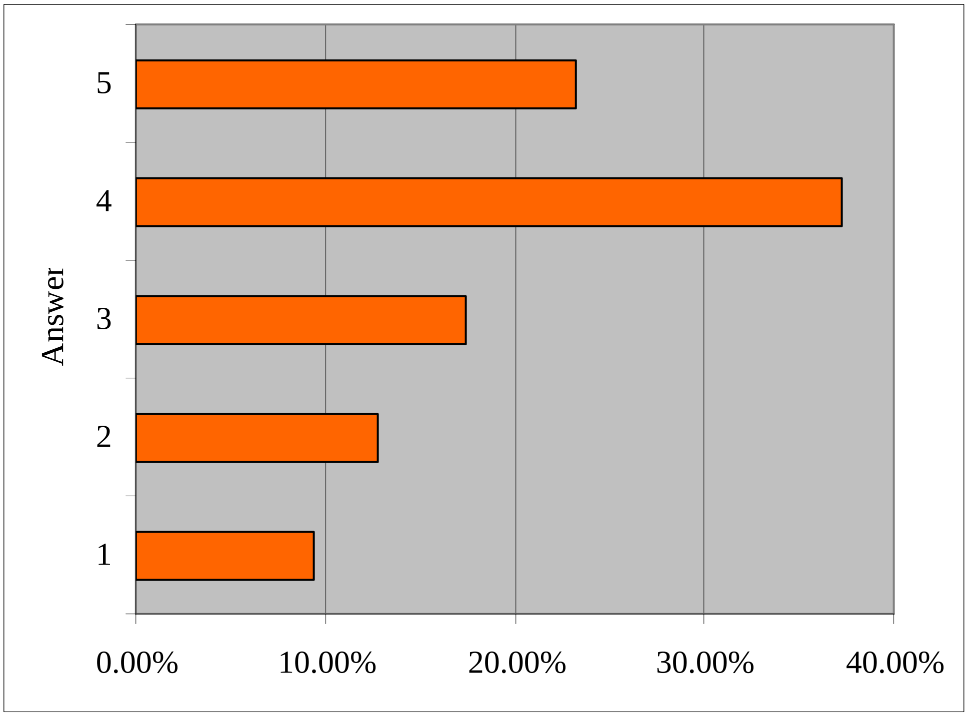

Figure 3-1: Protocol Question 1 Distribution

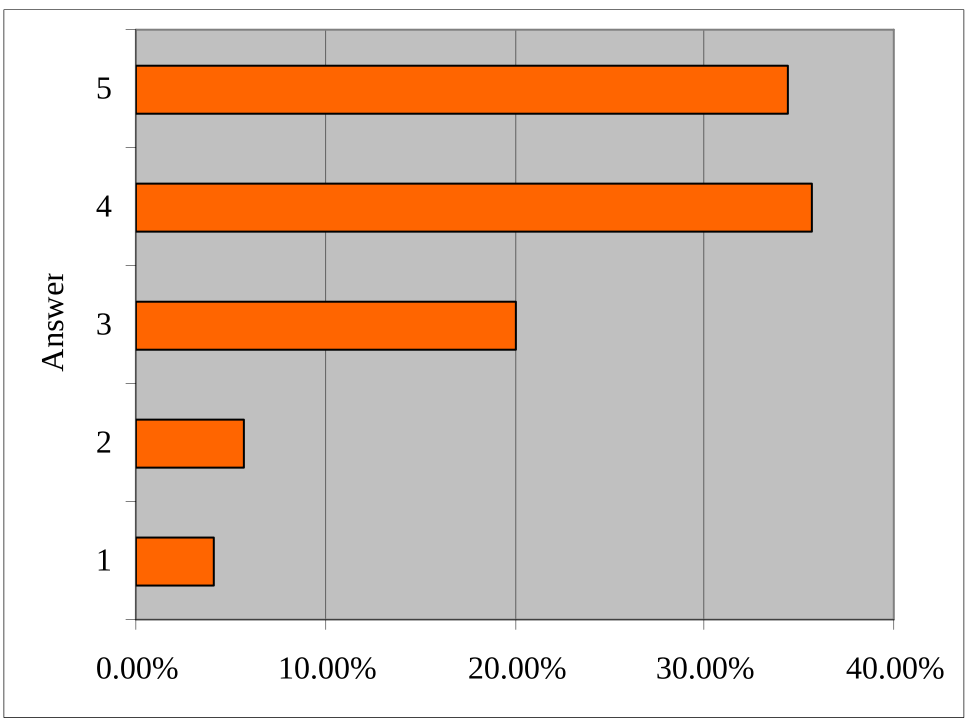

Figure 3-2: Protocol Question 2 Distribution

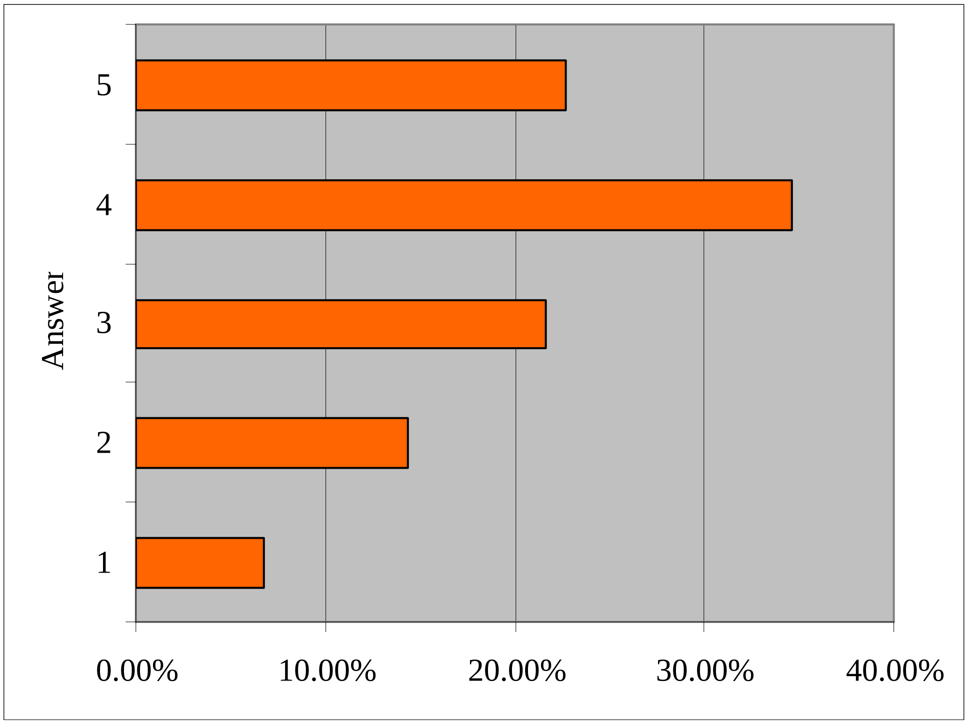

Figure 3-3: Protocol Question 3 Distribution

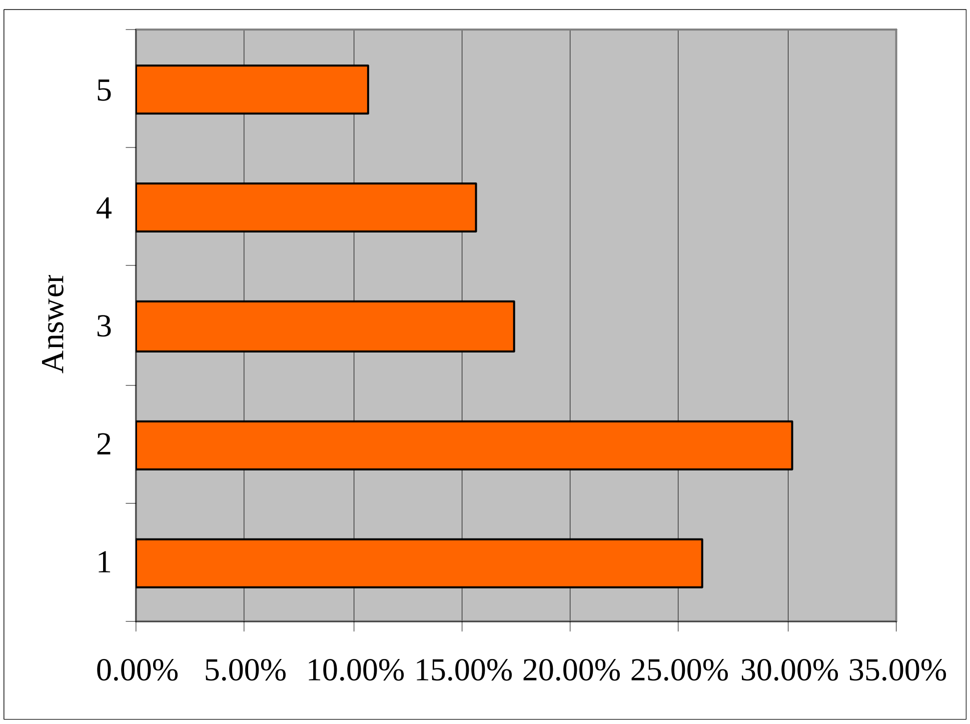

Figure 3-4: Protocol Question 4 Distribution

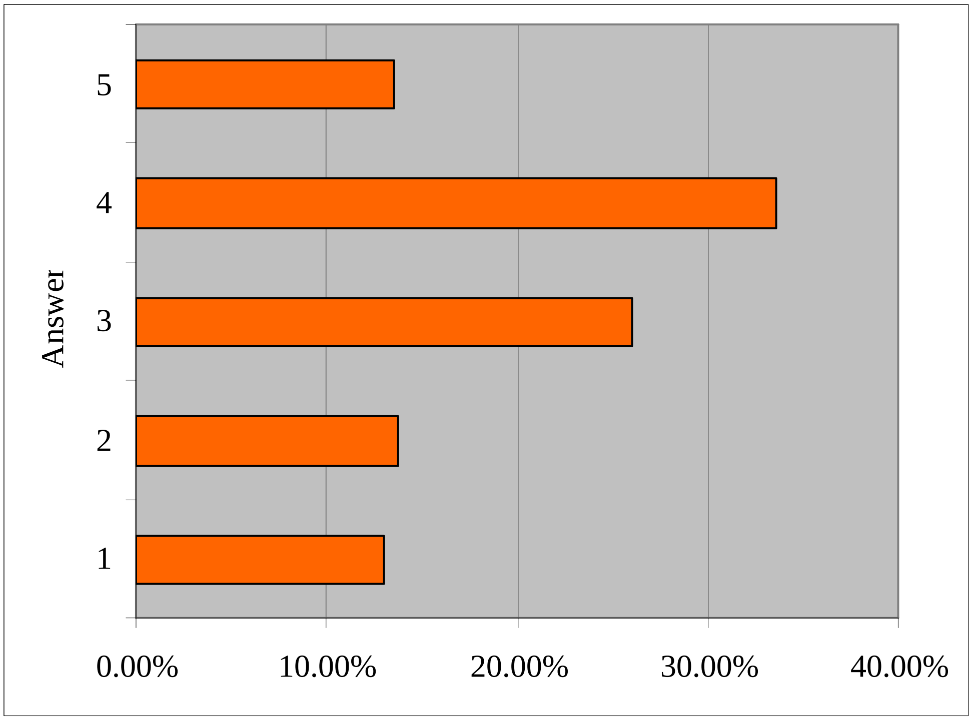

Figure 3-5: Protocol Question 5 Distribution

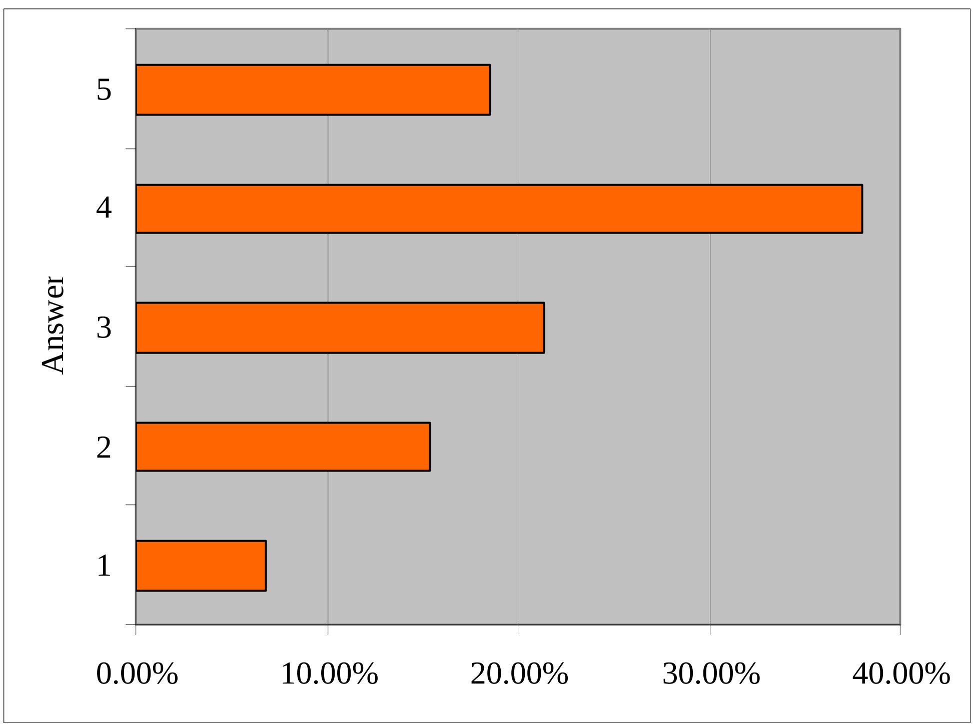

Figure 3-6: Protocol Question 6 Distribution

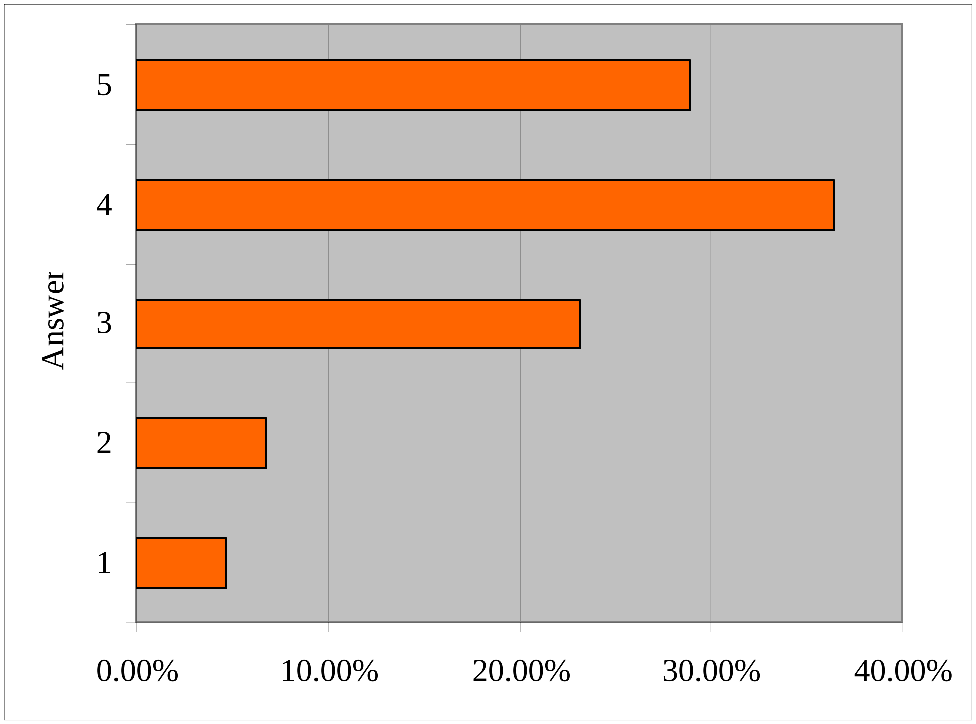

Figure 3-7: Protocol Question 7 Distribution

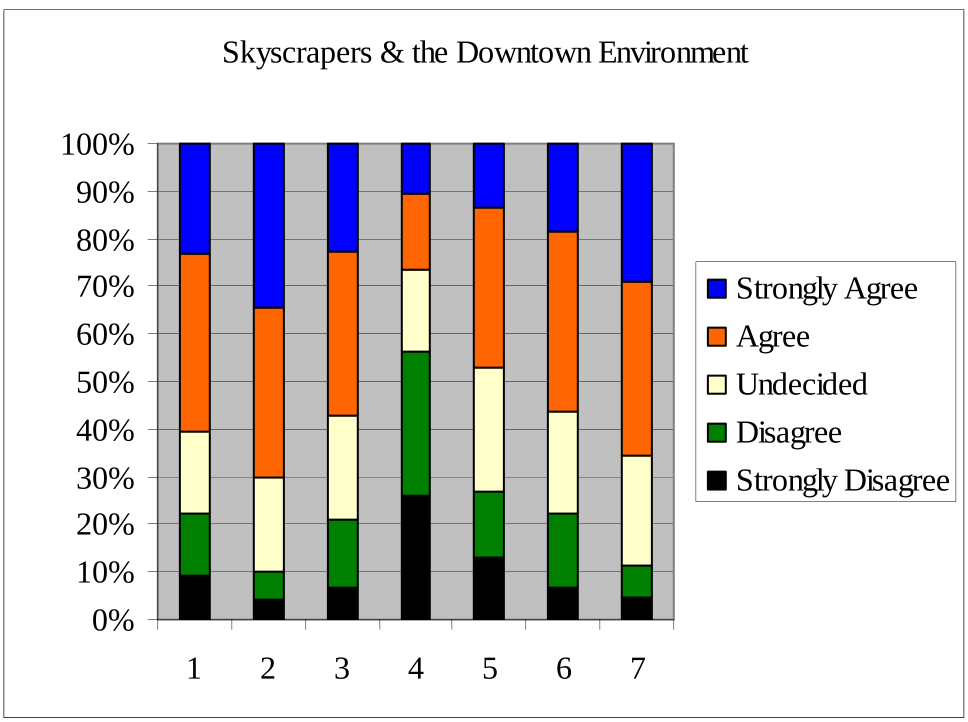

Figure 3-8: Protocol Question and Answer Percentage Distribution

CHAPTER 4
FINDINGS, SUGGESTIONS AND CONCLUSION

The skyscraper as a building type contains thousands upon thousands of systems all working together to produce a unique, remarkable structure to house workers and residents. In researching the tall building it would take several volumes to run through the gamut of systems, architecture, engineering, construction and factors that go into realizing skyscrapers. The future of skyscrapers in an environmentally conscious world and the systems that accompany the greening of the skyscraper also raise questions about individual systems. As a result, there are several opportunities for future high-rise research, of which a few possibilities will be discussed.

Throughout this work underlying factors have been referred to using case studies and insight. These factors provide the impetus for building tall and will be given as the foundation for skyscraper proliferation and future dominance. From inception to continued construction, these factors have survived over the 121 years of skyscraper construction and remain as true today, if not truer, as they were back in Chicago in 1885.

Findings

The skyscraper as a building type has been exhaustively researched and explained throughout this work. The history of the tall building, the engineering behind it and the technological innovation that has led to its widespread acceptance, all convey the several factors that lie within the realm of building tall. Whether a skyscraper was built in 1906 or 2006, the factors involved are by all means the same. Societal factors, such as large city populations and diminished land supply still apply whether it was 1890 Chicago, or 1990 Hong Kong. Cultural and political factors, in terms of a community's willingness to accept skyscraper construction; leads to their proliferation still today as they did yesterday. Financial success and power also retain their stronghold as omnipresent factors in the skyscraper. Modern skyscrapers still read

AT&T, Bank of America, and Sears Tower just as the skyscrapers of the past read Woolworth, Singer, and Chrysler. Countries wishing to establish themselves in the largest way possible choose the tall building as their medium. It was not much different in the original rash of skyscraper construction that the United States had while trying to break the ties of old Europe. Countries wish not to break ties of a host country these days, but rather of their lower statuses of their country on a global stage. The pride and enthusiasm felt by Americans and their tall buildings has transcended time, and place, and has taken hold in the rest of the world.

Skyscrapers are a part of modern life. High-rises allow the maximum amount of people in the smallest amounts of space. For the world's growing populations and diminishing land supplies, the tall building is the answer. As the world develops, as countries better design urban centers, the skyscraper will continue to be the building type of the earth and its people. Placing green systems into an already heralded building type, that allows for an inherently sustainable building to begin with, only will further the success of the skyscraper.

Though Tampians may prefer suburban living, they still exhibit common threads of skyscraper support and encouragement. Tampians believe skyscrapers to be relatively safe, beautiful additions to any skyline and symbols of communities. In addition, there is a certain pride that comes from building tall that goes beyond the idea of financial returns and business logic. It may be that skyscrapers are still at risk for terrorism, but so are subways, stadiums and airplanes. Yet, these items still abound in our post-September 11th world. So too, will the skyscraper abound. The tall building is too symbolic, political, cultural and powerful to be toppled by terrorists.

Future Study Suggestions

From foundation to pinnacle, the skyscraper is a marvel of architecture, design and construction. The interactions and intricacies of these systems are complex and require superior knowledge and insight into each individual system. Any one of the following systems and their design deserve further thought and inference for improvement and sophistication in a modern skyscraper world

- Foundation Systems
- Structural Steel Systems
- Concrete Structural Systems
- Composite Structural Systems
- Curtain Wall Systems
- Elevator Systems
- Plumbing Systems
- Mechanical Systems
- Electrical Systems

Now, these systems can makeup other mid-rise and low-rise buildings, but within the realm of high-rise construction special consideration must be garnered prior to putting these systems into place. Innovations and experiments in these systems can mean a skyscraper that functions and performs better with less material or energy usage.

In regards to making the skyscraper the most efficient building possible, the factors of the sustainable skyscraper come into play. It has been said that the cities that are denser, and denser by the use of the skyscraper, such as New York and Hong Kong also use the least amount of energy per capita (Howeler, 2003). Studies regarding the electrical requirements for skyscrapers versus other low and mid-rise buildings of the same square footage are necessary to purport this statement. How do the elements of elevators, vertically moving water or air and construction difficulty in building tall compare to the same elements in other buildings that do not require vertical capabilities?

Building tall requires cranes, vertical lifting and transportation during construction. In terms of construction costs what are the differences in construction of similar square footages between low and mid-rise buildings versus high-rise buildings? Also, what difference in materials whether more or less in high-rise construction is there? What specific systems and materials require more materials in skyscrapers versus other buildings? How much waste does a skyscraper comparably generate compared to other building types?

Further, in terms of sustainability how does the public feel about greening the structures of the world? Do they consider the sustainable aspects of the skyscraper, or buildings in general, when they choose to rent or occupy a building as an employee? Further, what is the developers take on the sustainable skyscraper? Developers and owners are the driving force behind making tall, green structures and therefore their thinking and development trends are important.

As the world's population swells and countries continue to develop, skyscrapers are being built in locations that pose new natural threats. Mass damping to prevent the sway of skyscrapers is a complex endeavor that requires further study. In locations that have a high probability and occurrence of earthquake, mass damping is necessary to design, construct and occupy a skyscraper with any confidence. Research in making the skyscraper "earthquake-ready" or even "earthquake-proof" is necessary for the safety and further use of the skyscraper. Research into resisting certain magnitudes of earthquakes and the materials accompanied with designing these structures is also required. Seismically active areas that currently contain skyscrapers include

- Dubai, United Arab Emirates
- Taipei, Taiwan
- Mexico City, Mexico
- Tokyo, Japan
- Los Angeles, California
- Oakland, California
- San Diego, California
- San Jose, California
- San Francisco, California
- Seattle, Washington

With the same thinking regarding research of a seismically responsive skyscraper, so too must the engineering and elements of a hurricane or tropical cyclone responsive skyscraper be explored. Resistance to the high winds and rains that accompany these natural disasters is something that must be analyzed and researched especially for the following skyscraper areas

- Bangkok, Thailand
- Beijing, China
- Hong Kong, China
- Shanghai, China
- Seoul, South Korea
- Taipei, Taiwan
- Tokyo, Japan
- Miami, Florida
- Tampa, Florida
- New Orleans, Louisiana

Designing and constructing for human factors and elements also require a further look. Since September 11th, what "terrorist-conscious" steps have been taken in terms of materials and engineering in the skyscraper world. How do the materials and systems, that are already in place in the skyscrapers of the world, hold up to blasting and other terrorist acts? What materials and engineering endeavors could provide a more terrorist resistant skyscraper?

The ever-present factor of fire within any building, but especially the skyscraper, should also be expounded upon. What fire and escape systems are currently in place? How would these systems perform under true fire situations? What fire prevention or containment techniques can be employed in the high profile buildings of skyscrapers? How do experimental materials and systems perform that could help in the future of skyscraper fire system design?

The Final State of the Skyscraper

On September 11th, 2001 when One World Trade Center and Two World Trade Center fell from their lofty positions in the world's greatest super power's, greatest city, the future of the skyscraper was placed into question. In terms of performance, the 9/11 Commission reported that the buildings actually held up quite well considering the nature of the attack and the resulting damage those airplanes caused to the superstructure. It is interesting to also think that during that same day not only skyscrapers were attacked. The five-story Pentagon building was also targeted and attacked. September 11th was about destroying American symbols and endeavors, not about the destruction of skyscrapers. In terms of that day, it is unfortunate that the skyscraper acting as a symbol for a country was so prevalent. However, that is what many of our buildings whether tall or small do, they represent society and are a symbol of the surrounding community and even of the surrounding nation.

Five years later, the skyscraper as a building type is not going into extinction. The world is building taller and building more frequently than ever before. Countries that are still developing, are doing so by utilizing the skyscraper. Skyscrapers speak of a country's power and progress. Companies develop towers to also prove their fiscal strength. Communities develop the world's tallest structures to garner the attention of the international community. Skyscrapers house ever-growing populations. The populations of our most populated nations are accepting the skyscraper and embracing the high-rise as part of their culture and part of their lives. The tall building has come to symbolize modernity and technological advancement in many forms. From Le Baron Jenney to Calatrava, the skyscraper continues to evolve architecturally and continues to be designed in more complex engineering endeavors. Elevators are faster, foundations deeper, beams thicker and exteriors more multifaceted. Sustainable elements allow the skyscraper to be sustainable in terms of densities and in terms of sustainable systems. The world gets denser and the skyscraper abounds, the world gets more modern and the skyscraper abounds, the world competes and the skyscraper abounds.

The public also finds itself in general support of the tall building. Thus, justifying the continued success and presence of the tall building in America, and also the world. In the face of terrorist acts and uncertain times, the skyscraper shines as a beacon of hope and strength. Other countries are taking that symbol of strength and using it for their own statements. Do not be surprised to see emerging nations such as India take the skyscraper to new levels. Or maybe there is hope still for the United States, in Chicago or maybe a place like Las Vegas, to recapture the world's tallest building title. The attention and prestige accompanied with such an undertaking would certainly be a prime driving force. The fame is fleeting and in order to prove themselves communities and countries will continue to battle using buildings. Structures will be taller, more dynamic and more encompassing as the world's population grows and as the world's available land shrinks.

The American invention and the American building type will not be stopped so long as it is the most viable structure to maximize land space and rental revenues. The skyscraper has roots in many elements of the human and in many elements of society. The tall building is part social, part economical, part cultural, part environmental, part symbolism and part political. It is for all of these reasons that the fear of terrorism, or any other fears that have belabored the skyscraper in the past, will not stop skyscraper support and skyscraper construction. The skyscraper as a building type is the building type of the past, the present and particularly the future.

APPENDIX: PROTOCOL INFORMED CONSENT AND QUESTIONNAIRE

Protocol Title: The public opinion of skyscrapers and the downtown environment

Please read this consent portion carefully before you decide to participate in this study.

Purpose of the research study:
The purpose of this study is to gauge the public's opinion on various aspects of skyscrapers and the urban environment.

What you will be asked to do in the study:
Participants will be asked to complete a seven (7) question survey and circle the answer that best represents their opinion on the topics. The answers to be circled range from 1 to 5, with 1 being strong disagreement and 5 being strong agreement.

Time required:
5 minutes

Risks and Benefits:
There is no risk or benefit for you in participating in this study.

Confidentiality:
Your name is not necessary for this study and therefore all answers will not be linked back to any participant.

Voluntary participation:
Your participation in this study is completely voluntary. There is no penalty for not participating.

Right to withdraw from the study:
You have the right to withdraw from the study at anytime without consequence.

Whom to contact if you have questions about the study:
Brandon T. Moore, Graduate Student, M.E. Rinker Sr. School of Building Construction, 727.798.3997.
Dr. Abdol Chini, Director, M.E. Rinker Sr. School of Building Construction, 352.273.1165.

Whom to contact about your rights as a research participant in the study:
UFIRB Office, Box 112250, University of Florida, Gainesville, FL 32611-2250, ph 392-0433.

Circle One

1 = Strongly Disagree
2 = Disagree
3 = Undecided
4 = Agree
5 = Strongly Agree

1. I would/do feel safe working or living in a skyscraper.	1	2	3	4	5
2. I enjoy the sight of skyscrapers and believe they enhance a city's skyline.	1	2	3	4	5
3. I feel that skyscrapers of the world are still a terrorist threat.	1	2	3	4	5
4. I would/do prefer living in an urban, downtown environment.	1	2	3	4	5
5. I would/do prefer living in a suburban, grid system environment.	1	2	3	4	5
6. I can identify cities by their skylines.	1	2	3	4	5
7. I am proud of our nation's tall skyscrapers.	1	2	3	4	5

REFERENCES

Abel, C. (2003). *Sky high: Vertical architecture.* London, United Kingdom: Royal Academy of Arts.

Abramson, D. (2000). *Skyscraper rivals: The AIG building and the architecture of wall street.* New York, NY: Architectural Press.

Ali, M. (2001). *Art of the skyscraper: The genius of Fazlur Khan.* New York, NY: Rizzoli International Publishing.

Ali, M., & Armstrong, P. (1995). *Architecture of tall buildings: Council on tall buildings and urban habitat.* New York, NY: McGraw- Hill, Inc.

Aveni, M. (2001, February). Tall Building to Use Wind Power for Energy Efficiency. *Civil Engineering*, 10.

Bagli, C. U.S. and state plan to occupy freedom tower. (2006, September 17). *The NewYork Times*, p. A1 and A40.

Bascomb, N. (2003). *Higher: A historic race to the sky and the making of a city*. New York, NY: Doubleday.

Chamberlain, L. (2006, July). Idling at Ground Zero. *Planning-The Magazine of the American Planning Association*, 7(72), 12-15.

Chicago Municipal Reference Library. (2005). Chicago: 1871 The Great Fire. Retrieved June 14, 2006, from Chicago Public Library Web site: http://www.chipublib.org/004chicago/timeline/greatfire.html.

CIA. (2006). CIA – The World Factbook. Retrieved June 27,2006, from Central Intelligence Agency Web site: https://www.odci.gov/cia/publications/factbook/index.html.

Civil Engineering. (1999, April). India tower would dwarf others in race for worlds tallest structure. *Civil Engineering*, 16.

Civil Engineering. (1999, November). Brazilian tower could win race to be world’s tallest building. *Civil Engineering*, 12.

Clark, W., & Kingston, J. (1930). *The skyscraper: A study in the economic height of modern office buildings.* New York, NY: American Institute of Steel Construction Inc.

Council on Tall Buildings and Urban Habitat. (2006). Brief History. Retrieved June 20, 2006, from Council on tall Buildings and Urban Habitat Web site: http://www.ctbuh.org/.

CTBUH Database. (2006). Emporis Login Gateway. Retrieved May 29, 2006 – July 31, 2006, from CTBUH Database – Powered by Emporis Web site: http://join.emporis.com/?nav=signin&lng=3.

Douglas, G. (1996). *Skyscrapers: a social history of the very tall building in America.* Jefferson, NC: McFarland & Co.

Eisele, J., & Kloft, E. (2003). *High-rise manual*. Basel, Switzerland: Birkhauser-Publishers for Architecture.

EMAAR. (2006). Burj Dubai: EMAAR. Retrieved July 8, 2006, from EMAAR Web site: http://www.burjdubai.com/.

Empire State Building. (2006). Empire State Building History. Retrieved June 24, 2006, from Empire State Building Web site: http://www.esbnyc.com/tourism/tourism_history.cfm?CFID=15175007&CFTOKEN=26561642.

Emporis Awards. (2006). Emporis Awards Home. Retrieved June 22, 2006, from Emporis Buildings - International Database about Buildings, Construction and the Real-Estate industry Web site: http://awards.emporis.com/?lng=3.

Emporis Buildings. (2006). Emporis Buildings - The Building Industry Platform. Retrieved May 29, 2006 – July 31, 2006, from Emporis Buildings - International Database about Buildings, Construction and the Real-Estate Industry Web site: http://www.emporis.com/en/.

Energy Information Administration. (2006). World Gross Domestic Product (GDP) by Region using Purchasing Power Parity. Retrieved June 18, 2006, from Energy Information Administration Web site: http://www.eia.doe.gov/oiaf/ieo/pdf/ieoreftab_3.pdf.

Engineering News Record. (1996, April 22). Petronas takes the title. *Engineering News-Record,* 12.

Engineering News Record (2004, April 26). 508-m taipei megatower ‘anointed’ world’s tallest. *Engineering News-Record*, 15.

Engineering News Record. (2006, September 18). Ground Zero Office Designs Hailed as Hopeful Symbols. *Engineering News-Record*, 257 (11), 12.

Foster, N. (2006). Architecture and Sustainability. Retrieved June 30, 2006, from Foster and Partners Web site: http://www.fosterandpartners.com/internet_site/public_html/download.php?f=data/information/Architecture_and_Sustainability.

Gill, R. (2005). What is the world's tallest building? (CTBUH Rules). Retrieved June 23, 2006, from All About Skyscrapers Web site: http://www.allaboutskyscrapers.com/Tallest_Building.htm.

Gissen, D. (2002). *Big & green.* New York, NY: Princeton Architectural Press.

Greene, M., & Marchetti, J. (2000). *Means illustrated construction dictionary*. Kingston, MA: R.S. Means Company, Inc.

Hagberg, E. (2006, May). NY's Green Horizon. *Metropolis,* 52.

Hampton, T. (2006, March, 27). Chicago Builders Ride Next 'Supertall' Wave. *Engineering News-Record,* 12(256), 10-11.

Howeler, E. (2003). *Skyscraper: Vertical now.* New York, NY: Universe Publishing.

Hucal, M. (2004, December). Transforming the skyline and the green building market. *Environmental Design + Construction.* 9(7), 28-31.

Jacobs, K. (2006, July). Ground Zero's Saving Grace. *Planning-The Magazine of the American Planning Association*, 7(72), 64-67.

Jencks, C. (1980). *Skyscrapers-skyprickers-skycities.* New York, NY: Rizzoli International Publications, Inc.

Lepik, A. (2004). *Skyscraper.* New York, NY: Prestel.

Malden, J. (2006). Chicago: Historical Information About Chicago. Retrieved June 14, 2006, from Chicago Public Library Web site: http://www.chipublib.org/004chicago/chihist.html.

Moudry, R. (2005). *The American skyscraper: Cultural histories.* New York, NY: Cambridge University Press.

Nash, E. (2005) *Manhattan skyscrapers*. New York, NY: Princeton Architectural Press.

National Bureau of Economic Research. (2003). Business Cycle Expansions and Contractions. Retrieved June 19, 2006, from National Bureau of Economic Research Web site: http://www.nber.org/cycles.html/.

Nobel, P. (2006, May). Norman Foster v.s. New York. *Metropolis,* 70-74.

Ostle & Malone. (1988). *Statistics in research.* Ames, IA: Iowa State University Press.

Population Reference Bureau. (2006). Population Reference Bureau DataFinder. Retrieved June 22, 2006, from Population Reference Bureau Web site: http://www.prb.org/datafind/datafinder7.htm.

Post, N. (1996, January 15). Architects passion is space between towers, not their height. *Engineering News Record,* 55.

Post, N. (2005, October 31). Skyscraper envy lives on, globally. *Engineering News-Record,* 255(17), 10-11.

Post, N. (2006, September 11). Traffic, concrete deliveries, crowding are key concerns for WTC area. *Engineering News-Record,* 257(10), 30-31.

Pridmore, J. (2002). *Sears tower: A building book from the Chicago architecture foundation.* Rohnert Park, CA: Pomegranate Communications, Inc.

Reina, P., & Post, N. (1996, January 15). Malaysia cracks height ceiling as it catapults into future. *Engineering News-Record,* 36-54.

Robison, R. (1994, July). Malaysia's twins: High-rise, high-strength. *Civil Engineering,* 63-65.

Sabbagh, K. (1989). *Skyscraper*. London, United Kingdom: Macmillan London Limited.

Spillane, J., & Pinch, L. (2004). 2004 top projects of interest. *Construction Executive,* 29-35.

Starrett, W. (1928). *Skyscrapers and the men who build them.* New York, NY: Charles Scribner's Sons.

Stephens, S. (2004). *Imagining ground zero: Official and unofficial proposals for the world trade center site.* New York, NY: Architectural Record.

Sullivan, L. (1896, March). The tall office building artistically considered. *Lippincott's Magazine.*

U.S. Department of State. (2002, August 15). September 11: Basic Facts. Retrieved June 5, 2006, from U.S. Department of State Web site: http://www.state.gov/coalition/cr/fs/12701.htm.

USGBC. (2006). USGBC: Why Build Green? Retrieved June 30, 2006, from U.S. Green Building Council Web site: http://www.usgbc.org/DisplayPage.aspx?CMSPageID=291&.

Wells, M. (2005). *Skyscrapers: Structure and design.* New Haven, CT: Yale University Press.

Willis, C. (1995). *Form follows finance*. New York, NY: Princeton Architectural Press.

Willis, C. (1998). *Building the empire state.* New York, NY: W.W. Norton & Company.

Yeang, K. (1996). *The skyscraper bioclimatically considered: A design primer*. London, United Kingdom: Academy Eds.

Yeang, K. (2000). *Service cores*. West Sussex, United Kingdom: Wiley-Academy.

Yeang, K. (2002). *Reinventing the skyscraper: A vertical theory of urban design.* Chichester, United Kingdom: Wiley-Academy.

Zukowsky, J., & Thorne, M. (2000) *Skyscrapers: The new millennium* New York, NY: Prestel.

BIOGRAPHICAL SKETCH

Brandon Thomas Moore was born in Biloxi, Mississippi on September 27, 1982. Coming from a military family Brandon moved around the nation and the world. After Mississippi, the Moore family moved to Bitburg, Germany. Then to San Bernardino, California; and finally settled into the Tampa Bay area.

In Tampa Bay Brandon attended Countryside High School where he graduated Summa cum Laude and was captain of the basketball team. After high school, Brandon attended the only place he applied, the University of Florida, and chose a concentration in building construction. In that time Brandon also joined Lambda Chi Alpha fraternity and has remained an active and faithful brother throughout his college career. Brandon graduated Summa Cum Laude with a Bachelor of Science in Building Construction in May of 2006. Opting to participate in the combined degree program offered, Brandon graduated in December 2006 with a Master of Science in Building Construction.

Upon graduation it is Brandon’s sincere hope and desire to construct and manage the erection of America’s tall buildings. In late December Brandon will move to Las Vegas, Nevada to begin his career constructing the tall buildings and casinos of The Strip. Ultimately, Brandon wishes to return someday after years of field experience to the University of Florida and earn a Doctor of Philosophy in Building Construction and spend the remainder of his days teaching tomorrow’s builders.