

A

Seminar report

On

SKYSCRAPES

Submitted in partial fulfillment of the requirement for the award of degree
Of Civil

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Preface

I have made this report file on the topic **SKYSCRAPES**; I have tried my best to elucidate all the relevant detail to the topic to be included in the report. While in the beginning I have tried to give a general view about this topic.

My efforts and wholehearted co-corporation of each and everyone has ended on a successful note. I express my sincere gratitude towho assisting me throughout the preparation of this topic. I thank him for providing me the reinforcement, confidence and most importantly the track for the topic whenever I needed it.

Acknowledgement

I would like to thank respected Mr..... and Mr.for giving me such a wonderful opportunity to expand my knowledge for my own branch and giving me guidelines to present a seminar report. It helped me a lot to realize of what we study for.

Secondly, I would like to thank my parents who patiently helped me as i went through my work and helped to modify and eliminate some of the irrelevant or un-necessary stuffs.

Thirdly, I would like to thank my friends who helped me to make my work more organized and well-stacked till the end.

Next, I would thank Microsoft for developing such a wonderful tool like MS Word. It helped my work a lot to remain error-free.

Last but clearly not the least, I would thank The Almighty for giving me strength to complete my report on time.

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1. INTRODUCTION:

The word "SKYSCRAPER" originally was a nautical term referring to a tall mast or its main sail on a sailing ship. The term was first applied to buildings in the late 19th century as a result of public amazement at the tall buildings being built in Chicago and New York City. The traditional definition of a skyscraper began with the "first skyscraper", a steel-framed ten-storey building. Chicago's now demolished ten-storey steel-framed Home Insurance Building (1885) is generally accepted as the "first skyscraper".

The structural definition of the word *skyscraper* was refined later by architectural historians, based on engineering developments of the 1880s that had enabled construction of tall multi-storey buildings. This definition was based on the steel skeleton—as opposed to constructions of load-bearing masonry, which passed their practical limit in 1891 with Chicago's Monadnock Building. Philadelphia's City Hall, completed in 1901, still holds claim as the world's tallest load-bearing masonry structure at 167 m (548 ft). The steel frame developed in stages of increasing self-sufficiency, with several buildings in Chicago and New York advancing the technology that allowed the steel frame to carry a building on its own. Today, however, many of the tallest skyscrapers are built almost entirely with reinforced concrete. Pumps and storage tanks maintain water pressure at the top of skyscrapers.

A loose convention in the United States and Europe now draws the lower limit of a skyscraper at 150 meters (500 ft). A skyscraper taller than 300 meters (984 ft) may be referred to as *supertall*. Shorter buildings are still sometimes referred to as skyscrapers if they appear to dominate their surroundings.

The somewhat arbitrary term *skyscraper* should not be confused with the slightly less arbitrary term high-rise, defined by the Emporis Standards Committee as "...a multi-storey structure with at least 12 floors or 35 meters (115 feet) in height." Some structural engineers define a high-rise as any vertical construction for which wind is a more significant load factor than earthquake or weight. Note that this criterion fits not only high rises but some other tall structures, such as towers.

2. SUSTAINABILITY:

The skyscraper as a concept is a product of the industrialized age, made possible by cheap energy and raw materials. The amount of steel, concrete and glass needed to construct a skyscraper is vast, and these materials represent a great deal of embodied energy. Tall skyscrapers are very heavy, which means that they must be built on a sturdier foundation than would be required for shorter, lighter buildings. Building materials must also be lifted to the top of a skyscraper during construction, requiring more energy than would be necessary at lower heights.

Furthermore, a skyscraper consumes a lot of electricity because potable and non-potable water must be pumped to the highest occupied floors, skyscrapers are usually designed to be mechanically ventilated, elevators are generally used instead of stairs, and natural lighting cannot be utilized in rooms far from the windows and the windowless spaces such as elevators, bathrooms and stairwells.

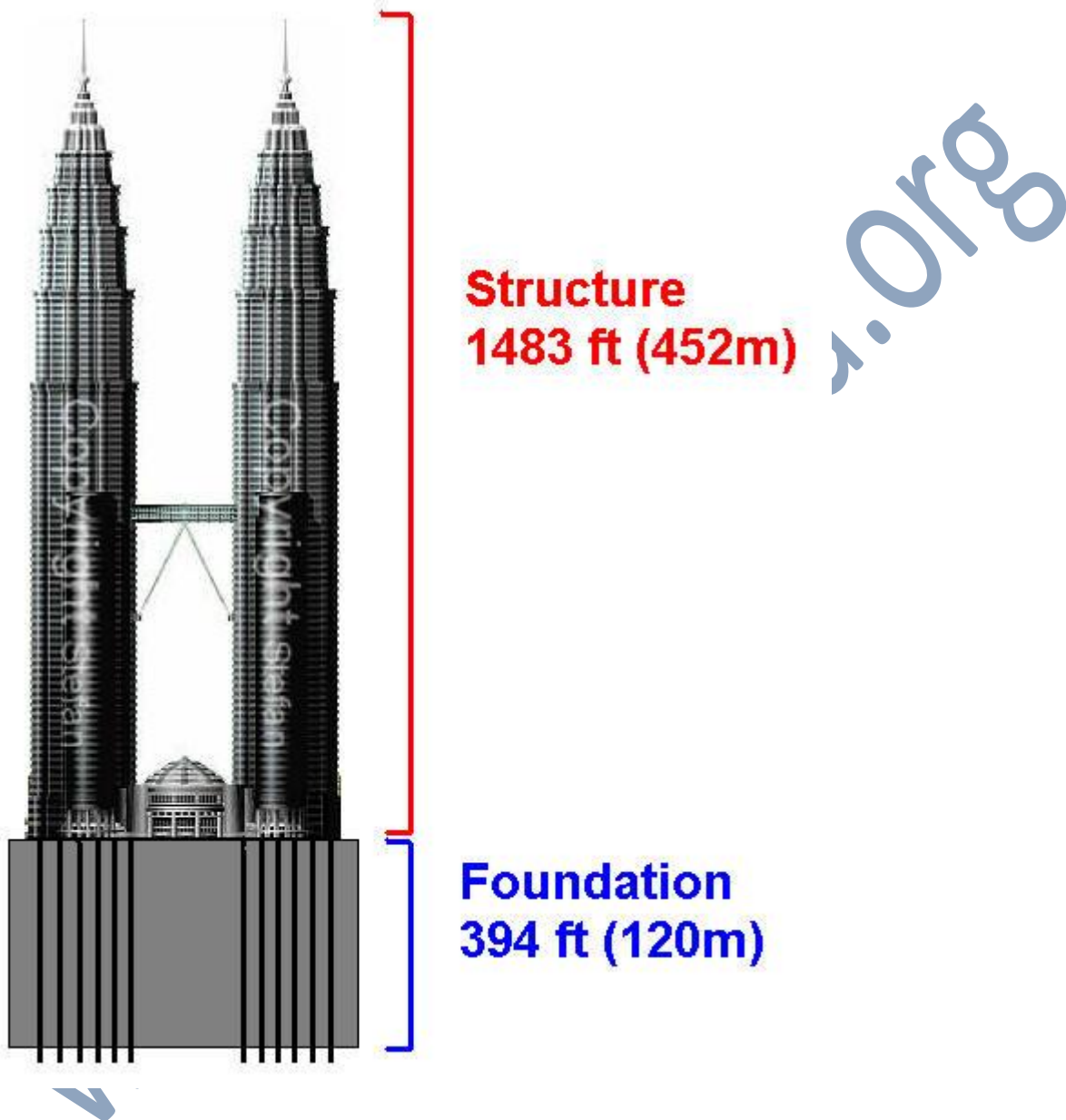
Despite these costs, the size of skyscrapers allows for high-density work and living spaces, reducing the amount of land given over to human development. Mass transit and commercial transport are economically and environmentally more efficient when serving high-density development than suburban or rural development. Also, the total energy expended towards waste disposal and climate control is relatively lower for a given number of people occupying a skyscraper than that same number of people occupying modern housing.

3. CONCRETE FOUNDATIONS IN SKYSCRAPERS:

Due to the great height of skyscrapers, huge foundations are needed to support these structures. First, a large hole is dug into the ground to reach a point of stable soil (often bedrock). After some stability is reached, large steel footings are placed, and from these, vertical steel beams are placed along with a network of rebar. This is an image in actual proportion; the foundation of the CN Tower is 50 ft (15m) deep, to support the 1,815 ft (553m) structure. The foundation itself is almost five floors deep! Most house foundations are only one to two feet deep. Compare that to a skyscraper!



But this is nothing compared to the worlds deepest foundation! The Petronas Towers has a foundation that is 394 ft (120 m) deep!



The unusually deep foundation needed for the Petronas Towers was because of the areas bedrock. The bedrock in Kuala Lumpur, Malaysia is quite deep, causing many headaches for construction companies.

4. SKYSCRAPERS DESIGN AND CONSTRUCTION:

The design and construction of skyscrapers involves creating safe, habitable spaces in very tall buildings. The buildings must support their weight, resist wind and earthquakes, and protect occupants from fire. Yet they must also be conveniently accessible, even on the upper floors, and provide utilities and a comfortable climate for the occupants. The problems posed in skyscraper design are considered among the most complex encountered given the balances required between economics, engineering, and construction management.

5. BASIC DESIGN CONSIDERATIONS:

Good structural design is of importance in most building design, but especially among skyscrapers since even a small likelihood of catastrophic failure is unacceptable given the number of individuals served by skyscrapers and the resulting price of failure. This presents a paradox to civil engineers: the only way to assure a lack of failure is to test for all modes of failure, in both the laboratory and the real world. The only way to know of all modes of failure is to learn from previous failures. In this way, no engineer can be absolutely sure that a given structure will resist all loadings that could cause failure, but can only be sure, that given large enough margins of safety, that a sufficiently small percentage of the time will a failure ever occur. When buildings do fail, engineers question if the failure was due to some lack of foresight on their part or some unknowable factor that would have never been expected to have been designed for.

6. LOADING AND VIBRATION :

The load a skyscraper experiences is largely from the force of the building material itself. In most building designs, the weight of the structure is much larger than the weight of the material that it will support beyond its own weight. In technical terms, the dead load, the load of the structure, is larger than the live load, the weight of things in the structure (people, furniture, vehicles, etc). As such, the amount of structural material required within the lower levels of a skyscraper will be much larger than the material required within higher levels. This is not always visually apparent, or borne out visually.

The wind loading on a skyscraper is also considerable. In fact, the lateral wind load imposed on super-tall structures is generally the governing factor in the

structural design. Wind pressure increases with height, so for very tall buildings, the loads associated with wind are larger than dead or live loads.

7. STEEL FRAME:

When one thinks of a skyscraper, the steel frame design comes to mind. This design is characterized by a large steel box, containing smaller steel boxes inside. This 3D grid is simple and efficient for most low-rises, but has its' drawbacks for high-rise structures. As the building's height increases, the space between steel beams must decrease to compensate for the extra weight, resulting in less office space and the need for more material.

Tube Frame:

The tube design is a recent innovation used to maximize floor space and increase resistance to lateral force in any direction. The buildings skin (outside) consists of closely aligned supporting columns. This design only leaves about one-half of the building's exterior left for windows. Depending on the designer's outlook, this can be an advantage or disadvantage. The decreased window space helps those who suffer acrophobia (a fear of heights) comfortably occupy the space; however, it decreases the visibility and openness offered by other designs.

Concrete Core:

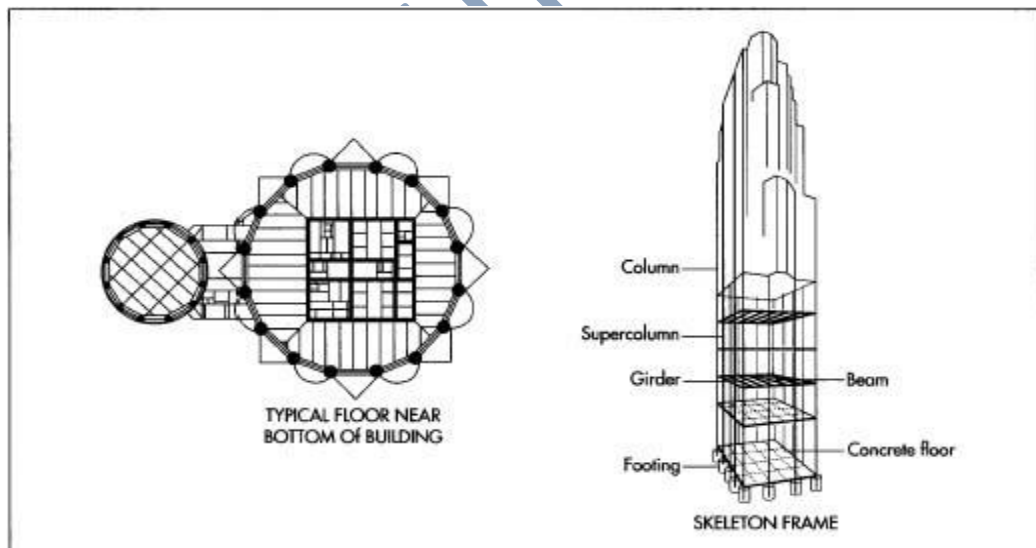
This is the most common design for modern skyscrapers as it is fast to build and provides a strong center. All the utilities, elevators, and stairwells are centralized in this design, making it easier for building modifications and repair. This design can be dangerous. If a part of the core is damaged, everything above that section will be cut off from ground access. This happened in the WTC during the September 11, 2001 terrorist attacks, making it impossible for many people to escape the burning towers.

8. DESIGN:

Designing a low-rise building involves creating a structure that will support its own weight (called the dead load) and the weight of the people and furniture that it will contain (the live load). For a skyscraper, the sideways force of wind affects the structure more than the weight of the building and its contents. The designer must ensure that the building will not be toppled by a strong wind, and also that it will not sway enough to cause the occupants physical or emotional discomfort.

Each skyscraper design is unique. Major structural elements that may be used alone or in combination include a steel skeleton hidden behind non-load-bearing curtain walls, a reinforced concrete skeleton that is in-filled with cladding panels to form the exterior walls, a central concrete core (open column) large enough to contain elevator shafts and other mechanical components, and an array of support columns around the perimeter of the building that are connected by horizontal beams to one another and to the core.

Because each design is innovative, models of proposed super tall buildings are tested in wind tunnels to determine the effect of high wind on them, and also the effect on surrounding buildings of wind patterns caused by the new building. If tests show the building will sway excessively in strong winds,



An example of a skyscraper ground floor design and building frame.

designers may add mechanical devices that counteract or restrict motion.

In addition to the superstructure, designers must also plan appropriate mechanical systems such as elevators that move people quickly and comfortably, air circulation systems, and plumbing.

9. THE CONSTRUCTION PROCESS:

Each skyscraper is a unique structure designed to conform to physical constraints imposed by factors like geology and climate, meet the needs of the tenants, and satisfy the aesthetic objectives of the owner and the architect. The construction process for each building is also unique.

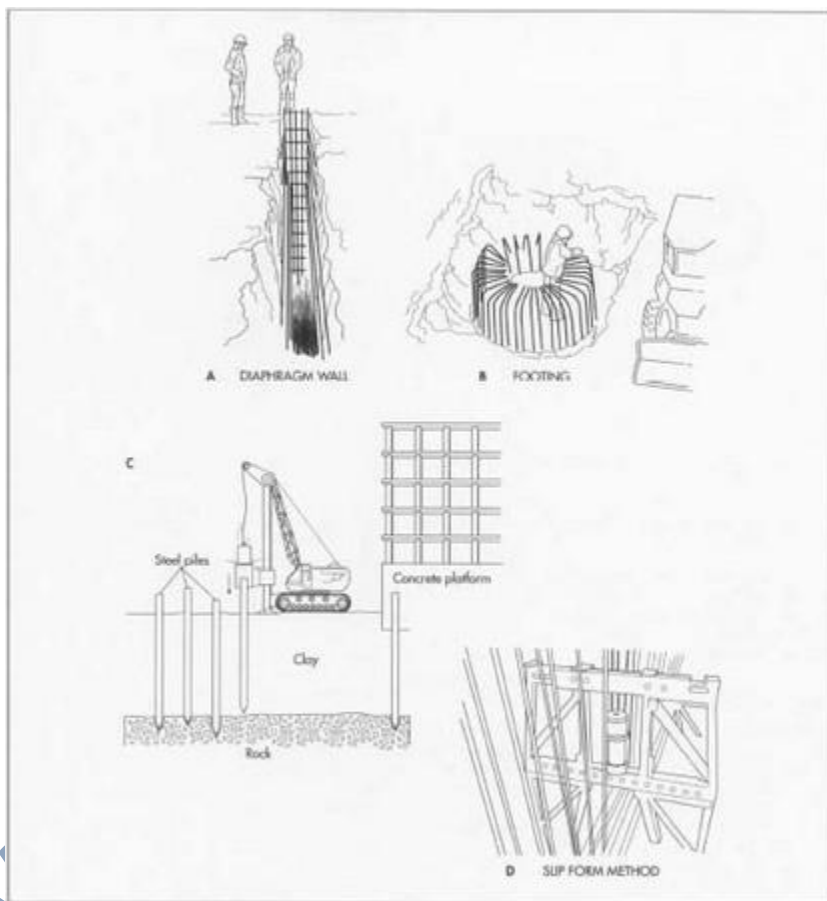
The following steps give a general idea of the most common construction techniques.

The substructure:

- Construction usually begins with digging a pit that will hold the foundation. The depth of the pit depends on how far down the bedrock lies and how many basement levels the building will have. To prevent movement of the surrounding soil and to seal out water from around the foundation site, a diaphragm wall may be constructed before the pit is dug. This is done by digging a deep, narrow trench around the perimeter of the planned pit; as the trench is dug, it is filled with slurry (watery clay) to keep its walls from collapsing. When a section of trench reaches the desired depth, a cage of reinforcing steel is lowered into it. Concrete is then pumped into the trench, displacing the lighter slurry. The slurry is recovered and used again in other sections of the trench.
- In some cases, bedrock lies close to the surface. The soil on top of the bedrock is removed, and enough of the bedrock surface is removed to form a smooth, level platform on which to construct the building's foundation. Footings (holes into which the building's support columns can be anchored) are blasted or

drilled in the bedrock. Steel or reinforced concrete columns are placed in the footings.

- If the bedrock lies very deep, piles (vertical beams) are sunk through the soil until they are embedded in the bedrock. One technique involves driving steel piles into place by repeatedly dropping a heavy weight on their tops. Another technique involves drilling shafts through the soil and into the bedrock, inserting steel reinforcing rods, and then filling the shafts with concrete.



A. Diaphragm wall. B. Footing. C. One type of foundation for a skyscraper uses steel piles to secure the foundation to the ground. D. The slip form method of pouring concrete.

- A foundation platform of reinforced concrete is poured on top of the support columns.

The superstructure and core:

Once construction of a skyscraper is underway, work on several phases of the structure proceeds simultaneously. For example, by the time the support columns are several stories high, workers begin building floors for the lower stories. As the columns reach higher, the flooring crews move to higher stories, as well, and finishing crews begin working on the lowest levels.

Overlapping these phases not only makes the most efficient use of time, but it also ensures that the structure remains stable during construction.

- If steel columns and cross-bracing are used in the building, each beam is lifted into place by a crane. Initially, the crane sits on the ground; later it may be positioned on the highest existing level of the steel skeleton itself. Skilled workers either bolt or weld the end of the beam into place (rivets have not been used since the 1950s). The beam is then wrapped with an insulating jacket to keep it from overheating and being weakened in the event of a fire. As an alternative heat-protection measure in some buildings, the steel beams consist of hollow tubes; when the superstructure is completed, the tubes are filled with water, which is circulated continuously throughout the lifetime of the building.
- Concrete is often used for constructing a building's core, and it may also be used to construct support columns. A technique called "slip forming" is commonly used. Wooden forms of the desired shape are attached to a steel frame, which is connected to a climbing jack that grips a vertical rod. Workers prepare a section of reinforcing steel that is taller than the wooden forms. Then they begin pouring concrete into the forms. As the concrete is poured, the climbing jack slowly and continuously raises the formwork. The composition of the concrete mixture and the rate of climbing are coordinated so that the concrete at the lower range of the form has set before the form rises above it. As the process continues, workers extend the reinforcing steel grid that extends above the formwork and add extensions to the vertical rod that the climbing jack grips. In this way, the entire concrete column is built as a continuous vertical element without joints.

- In a steel-skeleton building, floors are constructed on the layers of horizontal bracing. In other building designs, floors are supported by horizontal steel beams attached to the building's core and/or support columns. Steel decking (panels of thin, corrugated steel) is laid on the beams and welded in place. A layer of concrete, about 2-4 in (5-10 cm) thick, is poured on the decking to complete the floor.

The exterior:

- In most tall buildings, the weight of the structure and its contents is borne by the support columns and the building's core. The exterior walls themselves merely enclose the structure. They are constructed by attaching panels of such materials as glass, metal, and stone to the building's framework. A common technique is to bolt them to angle brackets secured to floor slabs or support columns.

Finishing:

- When a story of the building has been enclosed by exterior walls, it is ready for interior finishing. This includes installation of such elements as electrical wires, telephone wires, plumbing pipes, interior walls, ceiling panels, bathroom fixtures, lighting fixtures, and sprinkler systems for fire control. It also includes installation of mechanical components like elevators and systems for air circulation, cooling, and heating.
- When the entire superstructure has been completed, the top of the building is finished by installing a roof. This may be built much like a floor, and then waterproofed with a layer of rubber or plastic before being covered with an attractive, weather—resistant layer of tiles or metal.

10. QUALITY CONTROL:

Various factors are taken into consideration when assuring quality control. Because of the huge scale of skyscrapers, a small positioning error at the base will be magnified when extended to the roof. In addition to normal surveying instruments, unusual devices like global positioning system (GPS) sensors and aircraft bombsights may be used to verify the placement and alignment of structural members.

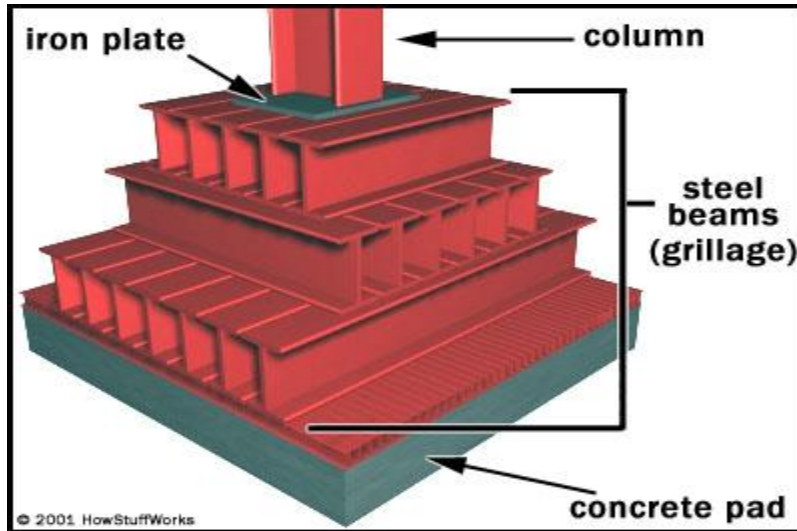
Soil sensors around the building site are used to detect any unexpected earth movement caused by the construction activity.

11. GIANT GIRDER GRIDS:

The central support structure of a skyscraper is its **steel skeleton**. Metal beams are riveted end to end to form vertical **columns**. At each floor level, these vertical columns are connected to horizontal **girder** beams. Many buildings also have diagonal beams running between the girders, for extra structural support.

In this giant three-dimensional grid -- called the **super structure** -- all the weight in the building gets transferred directly to the vertical columns. This concentrates the downward force caused by gravity into the relatively small areas where the columns rest at the building's base. This concentrated force is then spread out in the **substructure** under the building.

In a typical skyscraper substructure, each vertical column sits on a **spread footing**. The column rests directly on a **cast-iron plate**, which sits on top of a **grillage**. The grillage is basically a stack of horizontal steel beams, lined side-by-side in two or more layers (see diagram, below). The grillage rests on a thick concrete pad poured directly onto the hard clay under the ground. Once the steel is in place, the entire structure is covered with concrete.



The pieces of a skyscraper's spread footing

This structure expands out lower in the ground, the same way a pyramid expands out as you go down. This distributes the concentrated weight from the columns over a wide surface. Ultimately, the entire weight of the building rests directly on the hard clay material under the earth. In very heavy buildings, the base of the spread footings rest on massive concrete piers that extend all the way down to the earth's **bedrock layer**.

One major advantage of the steel skeleton structure is that the outer walls - - called the **curtain wall** -- need only to support their own weight. This lets architects open the building up as much as they want, in stark contrast to the thick walls in traditional building construction. In many skyscrapers, especially ones built in the 1950s and '60s, the curtain walls are made almost entirely of glass, giving the occupants a spectacular view of their city.

12. MAKING IT FUNCTIONAL:

In the last section, we saw that new iron and steel manufacturing processes opened up the possibility of towering buildings. But this is only half the picture. Before high-rise skyscrapers could become a reality, engineers had to make them practical.

Once you get more than five or six floors, stairs become a fairly inconvenient technology. Skyscrapers would never have worked without the coincident emergence of elevator technology. Ever since the first passenger elevator was installed in New York's Haughwout Department Store in 1857, elevator shafts have been a major part of skyscraper design. In most skyscrapers, the elevator shafts make up the building's central core.

Figuring out the **elevator structure** is a balancing act of sorts. As you add more floors to a building, you increase the building's occupancy. When you have more people, you obviously need more elevators or the lobby will fill up with people waiting in line. But elevator shafts take up a lot of room, so you lose floor space for every elevator you add. To make more room for people, you have to add more floors. Deciding on the right number of floors and elevators is one of the most important parts of designing a building.

Building safety is also a major consideration in design. Skyscrapers wouldn't have worked so well without the advent of new fire-resistant building materials in the 1800s. These days, skyscrapers are also outfitted with sophisticated sprinkler equipment that puts out most fires before they spread very far. This is extremely important when you have hundreds of people living and working thousands of feet above a safe exit.

Architects also pay careful attention to the **comfort of the building's occupants**. The Empire State Building, for example, was designed so its occupants would always be within 30 feet (ft) of a window. A building is only successful when the architects have focused not only on structural stability, but also usability and occupant satisfaction.

WWW

13. WIND RESISTANCE:

In addition to the vertical force of gravity, skyscrapers also have to deal with the **horizontal force of wind**. Most skyscrapers can easily move several feet in either direction, like a swaying tree, without damaging their structural integrity. The main problem with this horizontal movement is how it affects the people inside. If the building moves a substantial horizontal distance, the occupants will definitely feel it.

The most basic method for controlling horizontal sway is to simply tighten up the structure. At the point where the horizontal girders attach to the vertical column, the construction crew bolts and welds them on the top and bottom, as well as the side. This makes the entire steel super structure move more as one unit, like a pole, as opposed to a flexible skeleton.

For taller skyscrapers, tighter connections don't really do the trick. To keep these buildings from swaying heavily, engineers have to construct especially strong cores through the center of the building. In the Empire State Building, the Chrysler Building and other skyscrapers from that era, the area around the central elevator shafts is fortified by a sturdy steel truss, braced with diagonal beams. Most recent buildings have one or more concrete cores built into the center of the building.

Making buildings more rigid also braces them against earthquake damage. Basically, the entire building moves with the horizontal vibrations of the earth, so the steel skeleton isn't twisted and strained. While this helps protect the structure of the skyscraper, it can be pretty rough on the occupants, and it can also cause a lot of damage to loose furniture and equipment. Several companies are developing new technology that will counteract the horizontal movement to dampen the force of vibration.

Some buildings already use advanced wind-compensating dampers. The Citicorp Center in New York, for example, uses a **tuned mass damper**. In this complex system, oil hydraulic systems push a 400-ton concrete weight back and forth on one of the top floors, shifting the weight of the entire building from side

to side. A sophisticated computer system carefully monitors how the wind is shifting the building and moves the weight accordingly. Some similar systems shift the building's weight based on the movement of giant pendulums.

14. FACTORS FOR STABILITY:

A structure is a body that will resist being deformed by external forces except for that due to the elasticity of the material (Hutchinson & Karsnitz, 1994). Therefore strength and stability are two important factors to be considered in designing structures. Structural damage prevention is a major concern for architects and engineers because it is hard to predict with certainty how forces will act on a structure; for example, several tornadoes may hit a building several times in one year, at different speeds and from different directions. Thus, the effect on the structure will always be different. However, if we could predict the direction and magnitude of the force every single time a tornado hit, then we could also predict the damage that would be done to the structure.

15. WHAT STRUCTURAL DAMAGE CAN MEAN ?

the tragic events in September 11 to remind us what structural damage can mean for the people inside and outside large structures. The underlying principles of engineering are responsible for both the resistance and the weakness of the towering buildings.

The strength of the materials, as well as the architectural integrity are both required to produce a structure that can handle stresses even beyond its perceived limits. Applied loads or forces that press upon a solid structure are distributed throughout the body of the structure. This is how large skyscrapers survive winds and the ravages of the natural elements. The strength of a structure is not only the result of the materials used, but also of how the different structural systems are designed for stability.

16. ELEVATORS:



fig. elevators

Many improvements have been made to the elevator specifically in concern to speed and safety. Today's elevators can travel up to 25 mph and some can even hold up to 60 people! With skyscrapers growing taller each year, elevators will have to keep up.

17. CONCLUSION:

Newer and improved methods of construction materials especially iron and steel and innovative methods in construction catalyzed the skyscrapers construction.

Building more and more skyscrapers would add beauty and enchanting view to the city. But meanwhile utmost care should be taken while constructing and after it, otherwise it may result in huge loss of both human lives and property.

In future skyscrapers would become the part of every metropolitan city. Although height may not be the problem there, but still sky is the limit.

18. REFERENCE

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