High Rise Building Design Considerations

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High Rise Building Design Considerations

- Planning and design urban area with its specialty has significant improvement role in the history of architecture.
- Many factors and rules are considered in this design and improvement such as environment, culture and region.
- Nowadays, technology and its process also have the role in architecture and urban planning.
- Tall buildings with this height that seen today is one of the outcomes of technology impacts.
- It is measured as one of the trends that drive tall buildings to develop.
- There is no debate that urban area having a skyscraper is not like those areas that majority of the buildings are in low rise buildings.

High Rise Building Design Considerations

Site Assessment & Alignment With Regulations

- Your starting point should be to understand — and to work within — the building location's local compliance requirements and geological realities.
- In terms of compliance, you should verify factors such as building height restrictions, the city's design preferences, and other requirements, such as adherence to LEED.
- Regarding geology, you must acquire survey information (e.g., soil stress-strain, groundwater dynamics, etc.) about the area's ability to handle load bearing strain.

High Rise Building Design Considerations

Structural Integrity

- In terms of ensuring structural integrity, you should validate elements such as your building's spatial rigidity and load-bearing.
- Validating the vertical and horizontal load-bearing is essential: the building must not lose its overall integrity from the loss of a few internal load-bearing structures due to accidents.
- In general, a civil engineer will be on-hand to do these calculations. In practical terms, structural integrity issues should register as design clashes in your computer-aided design (CAD) suite; it is imperative that you address them during the design process.

High Rise Building Design Considerations

Energy Efficiency

- The question of energy efficiency builds off MEP. If you are responsible for achieving a LEED certification, for example, then you will need to identify ways to lower your building's electricity and water usage. You can make strong in-roads by targeting the most significant energy user.
- For example, an HVAC system in an office building could consume as much as 39% of the building's total energy (it's followed by lighting at 25%).
- You can reduce energy costs by up to 30% by integrating an underfloor air distribution (UFAD)– -based HVAC system. By leveraging raised access floors, UFAD systems lower energy usage by diffusing air from the floor-level, i.e., closest to the occupant.

High Rise Building Design Considerations

Sustainability & Green Friendliness

- The energy savings you accrue through an efficient HVAC system (as well as other methods, such as promoting the use of natural sunlight) will elevate your building's green friendliness.
- The HVAC system alone will result in the reduction of electricity usage and water waste.
- Additionally, you can also improve your sustainability level by selecting eco-friendly suppliers and sustainable materials, such as recycled steel, insulated concrete forms, etc.

High Rise Building Design Considerations

Occupant Comfort

- In terms of occupant comfort, you will need to look at ensuring good indoor air quality (IAQ) as well as high levels of thermal comfort and acoustic comfort.
- You can address all three through an effective HVAC solution.
- For example, an floor-based HVAC system will diffuse warm air from the floor (i.e., closest to the occupant) and use warm air's natural upward flow to heat the room. The occupants do not need to crank-up their fans to maximum (and bear with the noise) to keep themselves warm.
- Likewise, HVAC with ductwork is essential for pulling polluted air from rooms and replacing it with freshly conditioned air.

High Rise Building Design Considerations

Aesthetic Appeal

- You can influence the visual appeal of the building's exterior through your design work and by selecting the right materials.
- In terms of the interior, you can free up floor space by leveraging raised access floors to house the HVAC ductwork as well as electrical wiring and cables.
- It's clear that HVAC systems play a significant role in influencing a high rise building's design. However, integrating HVAC systems into your building's design is a complex task; going at it alone could put your project risk of delays and cost overruns.

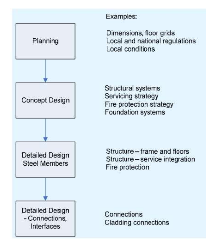
Hierarchy of design decisions

In multi-storey buildings, the design of the primary structure is strongly influenced by many issues, as defined below:

- The need to provide clear floor spans for more usable space
- The choice of the cladding system
- Planning requirements, which may limit the building height and the maximum floor-to-floor zone
- The services strategy and effective integration of building services
- Site conditions, which dictate the foundation system and location of foundations
- Craneage limitations and storage space for materials and components
- Speed of construction may influence the number of components that are used and the installation process.

Hierarchy of design decisions

- The development of any proposal for a construction project requires a complex series of design decisions that are inter-related.
- The process should begin with a clear understanding of the client's requirements and of local conditions or regulations.
- Despite the complexity, it is possible to identify a hierarchy of design decisions, as shown in Figure.



Hierarchy of design decisions

Hierarchy of design decisions

- Firstly, planning requirements are likely to define the overall building form, which will also include aspects such as natural light, ventilation and services.
- The principal design choices that need to be made in close consultation with the client are:
  - The depth of the floor zone and the overall structure/service interaction strategy
  - The need for special structural arrangements in public spaces or circulation areas
  - The provision of some tolerance between structure and services, to permit future adaptability
  - The benefit of using longer span structure, at negligible extra cost, in order to enhance flexibility of layout.

Hierarchy of design decisions

- Based on the design brief, a concept design is then prepared and is reviewed by the design team and client.
- It is this early interactive stage where the important decisions are made that influence the cost and value of the final project.
- Close involvement with the client is essential.

Client requirements

Spatial Requirements

- Client requirements may be defined firstly by general physical aspects of the building, e.g. the number of occupants and their range of functions, planning modules or floor-to-floor zones.
- Minimum floor loadings and fire resistance periods are defined in national regulations, but the client may wish to specify higher requirements.
- Examples of general client requirements are:
  - Occupation density 1 person per 10 m to 15 m2 Useable floor area :
  - Total area 80 to 90% typically Floor-to-floor zone 3.6 m to 4.2 m
  - Floor-to-ceiling zone 2.7 m to 3 m typically
  - Planning module 1.2 m to 1.5 m
  - Imposed loading 2.5 to 7.5 kN/m2
  - Fire resistance
  - The floor-to-floor zone is a key parameter, which is influenced by planning requirements on overall building height, natural light, cladding cost and other aspects.

Client requirements

- Service requirement Other client requirements may be defined under the heading of 'servicing', which includes Information Technology and other communication issues in addition to ventilation, lighting and other servicing requirements.
- In most inner city projects, air conditioning or comfort cooling is essential, because noise limits the use of natural ventilation.
- In suburban or more rural sites, natural ventilation may be preferred.
- Design requirements for building services are usually determined by regulations in the country where the structure is to be constructed and are a function of the external and internal environments.
- Typical examples of client requirements for the design of the primary building services are:
  - Fresh air supply
  - Internal temperatures
  - Cooling load
  - thermal insulation (walls)

Client requirements

Economics

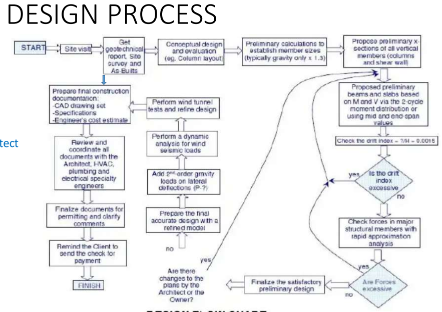
- Cost of construction A breakdown of construction costs for a typical office building is approximately as below:
  - Foundations 5-15%
  - Superstructure and floors 10-15%
  - Cladding and roofing 15-25%
  - Services (mechanical and electrical) 15-25%
  - Services (sanitation and other services) 5-10%
  - Finishes, partitioning and fitments 10-20%
- Preliminaries represent the costs of the site management and control facilities, including cranes, storage and equipment.
- Site preliminaries can vary with the scale of the project and a figure of 15% of the total cost is often allowed for steel-intensive construction reduced to 12% for higher levels of offsite prefabrication.
- The superstructure or framework cost is rarely more than 10% of the total, but it has an important effect on other costs. For example, a reduction of 100 mm in the ceiling floor zone can lead to a 2,5% saving in cladding cost (equivalent to 0.5% saving in overall building cost).

The design of multi-storey buildings is increasingly dependent on aspects of sustainability, defined by criteria such as:

- Efficient use of materials and responsible sourcing of materials
- Elimination of waste in manufacturing and in
- construction processes Energy efficiency in building operation, including improved air-tightness
- Measures to reduce water consumption
- Improvement in indoor comfort
- Overall management and planning criteria, such as public transport connections, aesthetics or preservation of ecological value.

THE DESIGN PROCESS

Architect



DESIGN FLOW CHART

Structural Engineer

STRUCTURAL FORMS FOR TALL BUILDINGS

Ideally, a structural engineer should choose the most efficient structural elements to resist gravity and lateral (wind and seismic) loadings.

The structural engineer must accommodate the following restrictions for the most efficient design:

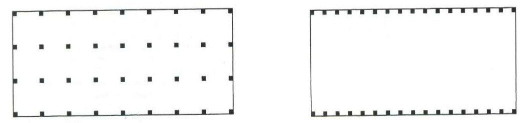
- the architect's internal planning of space,
- the materials selected,
- the methods of construction common to the area,
- the architect's choice of external cladding and decorations,
- the restrictions of the site,
- the locations of MEP (HVAC, electrical and plumbing) systems,
- the magnitude of the expected horizontal loads, and the proportions and height determined by owner and architectural preferences.

STRUCTURAL FORMS FOR TALL BUILDINGS

- The efficiency of the structural systems are compared via their weight per unit floor area. The floor framing is a gravity load dependent only on spans and not on height.
- The weight of the columns is also a gravity load, linearly proportional to the building height.
- Finally, the weight of the structure used to resist horizontal loads (wind and seismic) is at least a quadratic function of load, highly dependent on height.

MEASURES OF STRUCTURAL EFFICIENCY

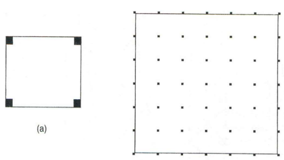
- A tall building acts simplistically as a cantilevered beam with the foundations fixed to the earth.
- From this model, it is evident that the typical cross-section of a building shown at the left in (a) with interior and exterior columns, is not as stiff as a building where all the same columns have been moved to the perimeter of the "box" as shown at left in (b).
- This bending efficiency is described via a new parameter called the **Bending Rigidity Index (BRI).**



(a) (b)

MEASURES OF STRUCTURAL EFFICIENCY

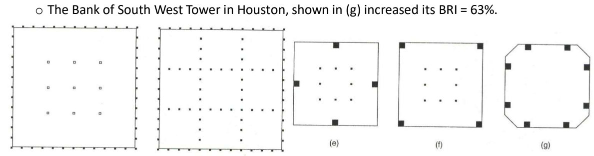
- In order to compare the bending efficiency of different floor plans, the highest BRI = 100 is given to (a) at the right for a square with four corner columns.
- **The BRI is the total moment of inertia of all the building columns about the centroidal axes**. The Empire State Building used all its columns, interior and exterior, to resist lateral loads.
- That arrangement is shown in (b) at right, with an array of regular bays. Its BRI = 33, which means that the structure is only 33% efficient.



(a) (b)

MEASURES OF STRUCTURAL EFFICIENCY

- Modern buildings have closely spaced exterior columns and clear spans to the elevator core, thus forming a "tube".
- The first use of this method was the World Trade Center (c), whereas the Sears(d) was formed from 9 "bundled" tubes, shown in (d).
- Citicorp Tower is shown in (e) did not use its corners, and its BRI dropped to 31%. The same columns move to the corner (f) would produce a BRI of 56%.
- The Bank of South West Tower in Houston, shown in (g) increased its BRI = 63%.

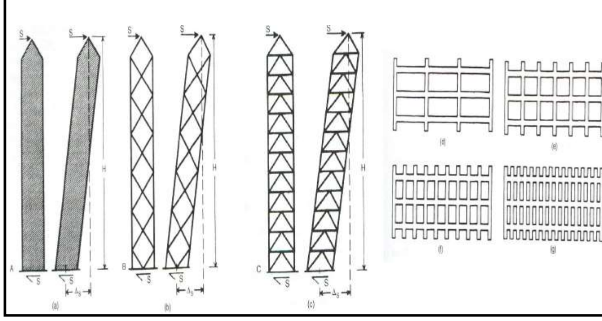


(c) (d) (e) (f) (g)

MEASURES OF STRUCTURAL EFFICIENCY

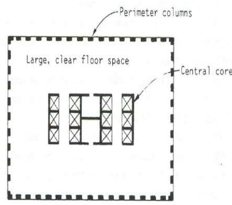
- In order for columns to work as elements of an integrated system, they must interconnect to form an effective shear-resisting system, represented by the **Shear Rigidity Index (SRI).**
- An ideal SRI = 100 is shown in (a) with solid walls without openings.
- The diagonal-web system in (b) with 45° angles has SRI=62.5.
- The common bracing in (c) that combines diagonals with horizontal girders has SRI = 31.3.
- The modern shear systems that employ the rigidly joined frames shown in (d thru g) have higher SRIs, depending on the proportions of the member's lengths and depths.
- When all four faces have these frames, they form "tubes", which is presently most advanced structural system.

MEASURES OF STRUCTURAL EFFICIENCY



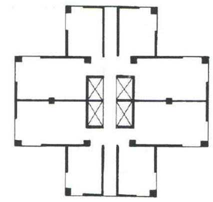
FUNCTION VERSUS STRUCTURAL FORM

- **OFFICE SPACES** should be large and open, with as many external views are possible, to be subdivided with lightweight partitions in order to satisfy different tenant leasing.
- The main vertical elements are placed around the perimeter.
- Services are distributed horizontally within the ceiling space.
- Thus, office story heights are typically *11'- 6" (3.5 m) or more.*
- Therefore, a typical 40 story office building will have an approximate height of *460 feet.*



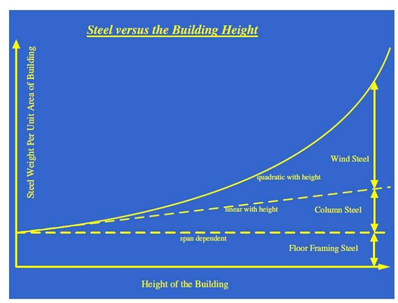
FUNCTION VERSUS STRUCTURAL FORM.

- **RESIDENTIAL AND HOTEL SPACES** have permanent subdivisions.
- Continuous vertical elements can thus be hidden within the partitions.
- The services also run vertically hidden within the partitions to emerge where required.
- Ceiling spaces are thus not required except in corridors.
- Typical story heights are 8'-8" (2.7m) or more.
- Therefore, a typical 40 story residential building will have an approximate height of 350 feet, or 80% of the height of an office building with the same number of floors.



THE PRINCIPAL LOAD RESISTING ELEMENTS

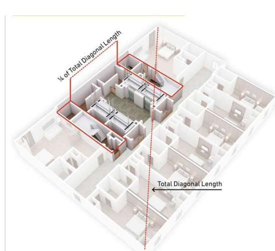
- The two primary types of vertical load resisting elements of tall buildings are columns and walls.
- Walls may act either independently as shear walls, or in assemblies as shear wall cores, around stairwells and elevators.
- Columns will be provided in otherwise unsupported regions to transmit gravity loads, and in some types of structures, lateral loads (wind and seismic).
- Since the gravity loading on different floors tends to be similar, the weight of the floor system per unit floor area is constant, regardless of building height.
- Since the load on a column is cumulative of the floors above it, the weight of the column per unit area increases linearly with the building height.
- The bending moments caused by lateral loads increase with at least the square of building height, becoming more important as building height increases.



High-Rise Design Requirements

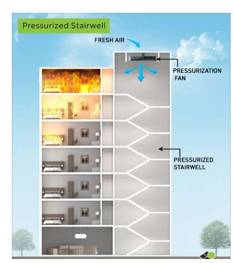
EGRESS POINTS:

- **Remote Stairway Locations –** There must be at least two exit stairways separated by a distance greater than 30' or at least one-fourth of the maximum overall dimension of the served area.



High-Rise Design Requirements

- **Fire-Service Requirements –** High-rise buildings must have a minimum of two fire-service entrance elevators and include a minimum 150sf elevator lobby and a direct connection to a stairway with a fire hydrant.
- **Smoke –** Stairs for exiting should be designed as smokeproof enclosures, usually requiring a pressurized stair shaft.



EMERGENCY SYSTEMS

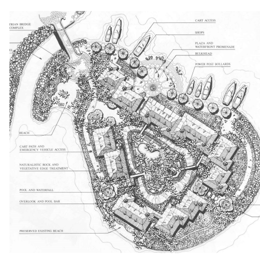
- **Fire Command Center (FCC) –** An FCC is required for all high-rise buildings and must be at least 200sf with minimum widths of 10’ in any direction. The location of the FCC must be approved by the local fire official.

High-Rise Design Requirements

Alarms – The following four types of communication systems for an emergency are required in all high-rise hotels buildings:

- Systems for Smoke Detection
- Voice Alarm
- Emergency Radio
- System for Fire Department Communication

What is Site Planning



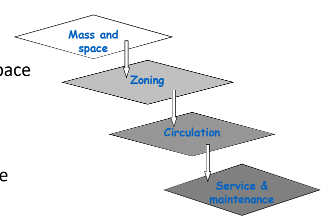
- Buildings
- Roads
- Walkway
- Trees, garden, pool (landscape)
- Water
- Plaza
- Environment
- Etc.

Definition

- Site planning is the art and science of arranging the structures on the land and shaping the spaces between, an arts of arranging **USES** of land linked to architecture, engineering, landscape architecture, and city planning. Site plans locate objects and activities in **SPACE** and **TIME**. These plans may concern a small cluster of houses, a single building and its grounds, or something as extensive as a small community built in a single operation.
- **Kevin Lynch, Gary Hack; Site Planning, MIT press, Cambridge 1996**

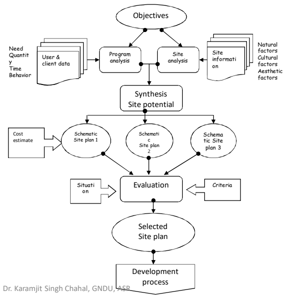
Layers of Site Planning

- Mass and space
- Zoning
- circulation
- Service & maintenance



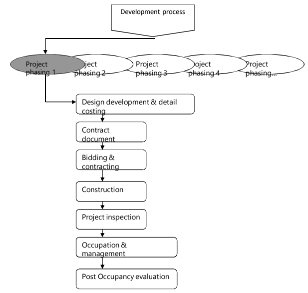
The model of Site planning process

❖In site planning, as in other forms of problem solving, the critical thinking process of research, analysis, and synthesis makes a major contribution to the formation of design decisions process.



Flow chart of development process

- ❖ Defining the problem
- ❖ Site & program analysis
- ❖ Schematic design w/ prelim cost estimate
- ❖ Design development
- ❖ Development process



Site selection

- Site selection is a critical step of the overall site acquisition process
- When does site selection really begin? Site issues are considered early in the capital development process and often are part of preplanning discussions with the customer agency and public officials

Site Selection

Site information

- area, location, present use, ownership
- quality, quantity, location of water
- geology, topography, flooding potential
- population, vegetation, wildlife
- access to transportation networks
- local workforce, potential socio-economic problems during construction phase, …….

Site selection

The selection elements are grouped into three major categories as follows:

❖*Social and Land Use Factors*

❖*Construction Cost Factors*

- ❖*Soils/Foundations*
- ❖*Utilities*
- ❖*Other*

❖*Operations and Maintenance Cost Fact**ors***

Maintenance and Operating Cost Factors

- Site Drainage
- Flooding
- Site Erosion
- Sun Orientation
- Protection from Elements
- Proximity to Natural Hazards
- Alternative Energy Sources

Site Evaluation

- Accessibility
- Locational advantages
- Terms of occupancy
- Legal considerations (e.g. environmental considerations, zoning restrictions, building codes, signs, licensing requirements)

Infrastructure: Public Sector Perspective

- The Public Sector is heavily involved in infrastructure provision, monitoring, and upgrading. In considering infrastructure investments, the public sector must take into account:

--Public safety issues	--Total cost
--Economic development	--Who benefits/who pays
--Political issues	--Community priorities
--Growth management	--Fiscal situation

- In short, the public sector "must take the broadest possible view of the proposed development and its implications".

Infrastructure: The Developer's Perspective

- A developer almost always approaches a project from the "site level". They are not nearly as interested in issues of equity, service levels, etc. as the Public Sector, unless these impact the success of a given project.
- This simple difference must be kept in mind by both parties when determining project impacts and identifying necessary infrastructure upgrades.
- At the site level, developers usually review (at minimum):
  - Topography
  - Climate
  - Vegetation
  - Soils
  - Hydrology
  - Local land uses
  - Zoning
  - Demand for development
  - Existing infrastructure

Site analysis

Factors influencing site planning

What is each factor?

How important it is?

How does it influence on Site Planning?

Where to get the information?

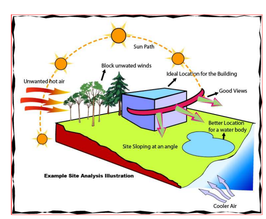
What are the typical areas of concerned?

Goal of site analysis

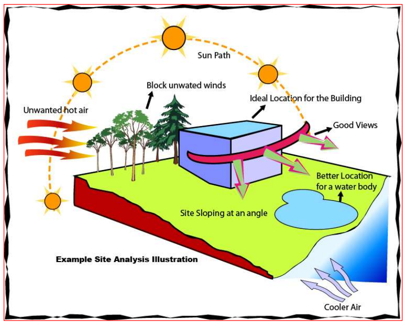
- To achieve a successful design, site analysis is a must & should be done carefully
- Site Analysis involves taking an inventory of site elements and analyzing these factors relative to the clients needs & aims
- Gather relevant information about the properties of the site, from topography to climate to wind pattern and vegetation
- Analyze these features and incorporate them into the design

Example Site Condition:

- Under Topography, 5 degree slope is noticed
- Analyzing the conditions, an ideal location for the building can be established
- The high spot might be right for building & a low spot for the water body
- For prevailing hot winds, trees would act as a buffer



- Openings in building could be placed to absorb cooler winds



Site Analysis: Inventory List

- Subsurface Features
  - Geology: Geological history of the area, bedrock type & depth etc.
  - Hydrology: Underground water table, aquifers, springs etc.
  - Soil Genesis: erosion susceptibility, moisture (pF), reaction (pH) organic content, bearing capacity etc.

Site Analysis: Inventory List

- Natural Surface Features
  - Vegetation: Type, size, location, shade pattern, aesthetics, ecology etc.
  - Slopes: Gradient, landforms, elevations, drainage patterns
  - Wild Life: ecology, species etc.
  - Climate: precipitation, annual rain/snow, humidity, wind direction, solar intensity & orientation, average/highest/lowest temperature

Site Analysis: Inventory List

- Cultural & Man-made Features
  - Utilities: sanitary, water supply, gas, electrical etc.
  - Land use: Usage of site, adjacent use, zoning restrictions, easement etc.
  - Historic notes: archeological sites, landmarks, building type, size, condition
  - Circulation: linkages an transit roads, auto & pedestrian access, mass transit routes etc.
  - Social Factors: population, intensity, educational level, economic & political factors, ethnicity, cultural typology etc.

Site Analysis: Inventory List

- Aesthetic Factors:
  - Perceptual: from an auto, by pedestrian, by bike etc.
  - Spatial Pattern: views of the site, views from the site, spaces existing, potential for new areas, sequential relationship
  - Natural Features: significant natural features of the site, water elements, rock formations, plant materials

Site selection

- **For every site there is an ideal use,**
- **For every use there is an ideal site.**

- Suitable site for suitable program
  - The matching of a given program for a project (…school, resort etc.) with a suitable site is a function of site analysis
  - Site selection is determined by a comparative analysis of several available sites for the same determined program to see which site can best fit the requirements.

Factors influencing site planning

1. Natural factors : Geology and soil, topography, habitat, microclimate, Hydrology
2. Man-made factors : existing uses, man-made features, legal regulations and historical associations.
3. Aesthetic factors : visual qualities and relationship.

- The categories of data and its interpretation is related to the proposed project. The level of detail depends on the nature of the program --how simple or complex and the type of site --rural or urban