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Conceptual effectiveness criteria in Design Processes of tall buildings

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Abstract: **-** Nowadays high-rise buildings are of the important approaches of the major world cities. High population growth and expense of land and urban horizontal development problems can be, as reasons for the move to be making vertical and high-rise development. The approach of the past 50 years the country has also been considered as an important element in the larger cities. Firstly, the expression of urban growth was then introduced as the need for high-rise buildings of the history of these buildings have been over the world and Iran Sublime advantages and disadvantages from the perspective of experts examined the terms and provisions of these projects has been evaluated. While the definition of dense urban areas and their characteristics high-rise building as one of the solutions to improve quality conditions in these areas are introduced and an approach to improve the laws and regulations in these areas is investigated the problems and challenges facing these projects in dense urban areas have been identified. Methodology is descriptive-analytical which the firs pay to definitions of key topic, also discus design theory, modeling constructions, structure, and sustainable city success and achieve high standards by architecture and urban planning experts and then will consider effective criteria in tall buildings design. Eventually to regarding criteria and also it will analysis design alternatives and give strategies on improvement of design and construction style in high-rise buildings.

Keywords: ***- high-rise building, design criteria, modeling, structure of design.***

I. INTRODUCTION

The twentieth century experienced an unprecedented demographic shift. The world population more than doubled in the last 40 years. A 2004 United Nations report predicts that by 2050 the world population is expected to exceed 9 billion, and by 2010 the world's urban population for the first time will surpass the rural one. Across the globe, low-density urban sprawl is the solution to population growth. There is mounting consensus among the scientific community that urban sprawl has significant negative social, economic and environmental implications.

Four billion additional people will need housing and work places in just a few decades. An immediate way to address population growth is for cities to support high-density buildings, Particularly high-rises. Over the past century, high-rises have successfully and increasingly responded to this need. We calculate that housing for 4 billion people will require constructing close to 4 million 40-storey high rise buildings (each with 1,050 occupants in 350 units). Yet most high-rises perform poorly in terms of lifecycle cost, environmental impact and social benefit. According to Yeang, in a 50-year lifecycle of a high-rise, energy costs contribute 34% of the total cost. Close to 50% of energy use in high-rises comes from artificial illumination. Kaplan indicates that a typical high-rise building is made of poor quality materials and is aesthetically mundane. Successful high-rise designs need to use a minimum of nonrenewable energy, produce limited pollution, and minimize their carbon footprint, without diminishing the comfort, health, functional needs, and safety of the people who inhabit them. To respond to these mounting environmental, economic, and social pressures, the Architecture, Engineering, and Construction (AEC) industry needs to revise traditional high rise design and analysis methods. Recent advances in computer-based methods promise vastly improved design processes, but current teams are ill equipped to take advantage of these new opportunities. To help them understand the reasons behind current inefficiencies and develop and implement more integrated design and analysis methods we must first document and measure existing conceptual high-rise design processes in terms of quantifiable metrics on which to base and compare the performance of prospective improvements. Little research has been carried out in this area; the goal of this paper is to fill the gap. Through literature review and industry-based case studies, this paper develops a definition and relevant metrics describing conceptual high-rise design processes, and applies this definition and metrics to a set of contemporary case studies and survey data. We find that conceptual design teams generally operate with low project goal clarity, and generate very few formal design options and analyses that neglect environmental and life-cycle economic considerations. We conclude with a discussion about the potential causes and costs of today's greatly underperforming high-rise design processes.

In this section, we look to design theory for a theoretical definition of high-rise design processes; to process modeling for a method to describe and measure these processes; and to high rise specific literature for classification and key design criteria.

II. BRIEF EARLY HISTORY OF TALL BUILDINGS

Many 19th century American architects went to Paris for training and education and brought back with them ideas that influenced their architecture. In Paris, the Eiffel Tower, at 300m (984 ft) in 1889, was surely a catalyst for new heights with its remarkable architectural qualities and became known as an engineering masterpiece. The U.S. also exported cultural and architectural ideas and developments to Europe that included the skyscraper, a clearly American innovation with its beginning in Chicago. The steel-framed structure of the 10-story Home Insurance Building is generally recognized as the first skyscraper, built in Chicago in 1885. A series of tall buildings, relatively large at the time of their construction, were built at the turn of the century. These include the Wainwright Building of 1890 in St. Louis, the Guaranty Building of 1895 in Buffalo, New York, and the Reliance Building of 1895 in Chicago. This trend continued in New York with the Flat Iron Building of 1903, continuing to the

Chrysler Building of 1930 and the Empire State Building of 1931. Following a pause in construction during the Great Depression and World War II years, tall building construction re-appeared in Chicago in the 1960s. Enormous progress was made in the development of tall buildings after World War II, first in the U.S., followed much later by some Pacific Rim countries, parts of Europe, and the Middle East. Although technology has advanced and the architectural style of tall buildings has evolved, the architectural planning concept of vertically stacking a series of floors and achieving spatial efficiencies by increasing the net-to-gross floor area has remained almost the same. Despite architecturally ambitious thinking, as well as technical and structural advancement, the primary focus remained on economic viability and technological and constructional limitations. Beginning with the last decade of the 20th century, this has changed, however, in favor of sustainability, innovative façade treatment, free-form massing, and iconic architectural vocabulary.

III. DESIGN THEORY

Akin formulates conceptual design as a five-step process: 1) identifying a set of requirements; 2) prioritizing among these requirements; 3) developing preliminary solutions; 4) evaluating solutions; and 5) establishing final design requirements, preferences and evaluation criteria. Haymaker and Chachere further formalize these distinctions in the MACDADI (Multi-Attribute Decision Assistance for Design Initiatives) framework, which includes: 1) *organizations* – a project's stakeholders, designers, gatekeepers and decision makers; 2) *goals* – these organizations' constraints, objectives, and preferences; 3) *options* – design options and methods to generate them; 4) *analyses* – the methods, timing, and types of analyses performed; and 5) *decisions* – rationale and process for making decisions. This paper is structured using these MACDADI distinctions.

Design is an unbounded process; there are infinite numbers of organizations, goals, options, analyses, and decisions that a team potentially can consider. Simon in his behavioral theory of bounded rationality describes people as partially rational when making decisions, due to computational limitations in gathering and processing information. Woodbury and Burrow also argue that designers typically consider a very small number of alternatives in their work as a result of cognitive limits. As a result, designers often make decisions without fully understanding their implications. To develop solutions, designers first establish a design space. Krishna Murti defines a design space as the sum of the problem space, solution space, and design process. A **problem space** includes only the candidate solutions that satisfy the established design requirements. A **solution space** includes all candidate solutions for a given design problem. A **design process** consists of methods used to develop candidate solutions from requirements. The extent of the design space is highly dependent on the designer's interpretation of the design problem, the choice of design criteria (project goals and constraints), and the employed design process. Two prevailing strategies emerge to describe the design process: breadth first, depth next or depth first, little breadth. The breadth first strategy entails generating multiple design options first, and then analyzing them to determine which ones meet the sought requirements. Depth first strategy entails generating a single option and analyzing it in depth. Goldschmidt argues in favor of the depth versus breadth strategy, in which both known architects and novice students deliberately choose a limited design space to conduct their exploration. The goal is refining and enriching a "strong idea" supported by well-developed design rationale. In contrast, Akin argues that in solving problems expert designers prefer the breadth first, depth next strategy. As a result, multiple alternatives help reveal new directions for further exploration. Each strategy has significant implications in the way teams generate designs. Currently there is no consensus about which strategy performs best, although in light of rapidly evolving project teams, goals, options, and analyses, many researchers argue that the sheer quantity of options generated by a breadth first search enables designers to find more successful solutions in terms of multi-criteria and multidisciplinary performance. Design theory helps us understand design processes, but it does not help us understand how to specifically represent and measure them. A widely accepted method for this kind of Representation and analysis is process modeling.

IV. PROCESS MODELING

There are three general applications for process models: a) *descriptive:* for describing what Happens during a process; b) *prescriptive:* for describing a desired process; and c) *explanatory:* for describing the rationale of a process. Faroese presents a comprehensive overview of AEC-specific process models, including IRMA (Information Reference Model for AEC, BPM - Building Project Model), ICON (Information / Integration for Construction), and GRM (Generic Reference Model). Most of these are based on EXPRESS-G modeling language, which provides a foundation for graphically representing process models. Other significant process modeling languages relevant to this paper are: IDEF0, used to model decisions, actions, and activities of an organization or system; Narratives, which model information and the sources, nature, and status of the dependencies between information; and Value Stream Mapping [18], which describe the flow of actors, activities, task duration, and information that produce value in a given process. With these process-modeling languages, we can describe design processes but not establish process measurement metrics. To address this problem various techniques have been proposed; for example, to evaluate BIM (Building Information Model) users practices and processes, to measure benefits from VDC (Virtual Design and Construction) use and factors that contribute to its successful implementation, or to simulate the impact of improvements to the engineering design process. In spite of the wealth of existing process modeling languages, none can describe and measure design processes in terms of all the distinctions included in the MACDADI framework. This paper later synthesizes a process model and metrics to describe high-rise design team size and composition, the clarity of their goal definitions, the number of design options they generate and analyze, the prevailing objectives used in their decision making, the conceptual design duration, and the discipline-specific time invested.

V. HIGH-RISE CLASSIFICATION AND KEY DESIGN CRITERIA

In the late 19th century a wave of innovations in the building industry led to the development of the first high-rises in Chicago and New York. The elevator, the steel frame, and later the curtain wall and HVAC, along with the demand for new office space on expensive and limited land, made the development of high-rises possible and necessary. Despite the success of high rises, the AEC industry lacks a consistent definition of the building type. The American Society of Heating, Refrigeration and Air-conditioning Engineers (ASHRAE) defines high-rises as buildings in which the height is over three times the width , whereas structural engineers define high-rises as buildings influenced primarily by wind loads. High-rises can be categorized according to their function, structural system type, and environmental control strategies. From a functional standpoint, there are four types: residential, commercial, hospitality, and mixed-use. This section briefly describes what is currently known about the organizations, goals, options, and analyses of high-rise design processes.

VI. ORGANIZATIONS

In high-rise design the developer is often the main decision maker. The developer outlines the architectural program and the budget constraints, and may specify a desired design language and construction start date. Future tenants are often involved at the conceptual design stage, and many cities require a design to be approved by neighbors. Gatekeepers such as city planning and building departments determine building height and construction limitations.

Design firms involved in the design process include architects, structural and mechanical engineers; later design phases include other consultants such as landscape, egress or LEED. The majority of design firms are single disciplinary, offering either architectural or engineering services, and are typically organized in a hierarchy. A design director makes high-level design decisions that help determine the design space and therefore guide the design team, and represents the firm in client review meetings. Any decisions made at such meetings are then conveyed verbally or through sketches to the senior design and technical architects who oversee the design process. Most of the drawings and calculations are done by mid level and intern architects. The coordination between engineering and architectural drawings is generally done by the senior technical architect.

VII. GOALS (DESIGN CRITERIA)

Several key design criteria must be considered when designing a high-rise. The Floor-Area- Ratio (FAR) is calculated by dividing the gross floor area allowed on a site by the net area of the site. FAR helps designers determine the maximum allowable building height. Building area efficiency is calculated as a subtraction of the building's non-sealable area (core, circulation corridors, etc.) from its gross area. Generally, this number must be at least 75% and represents the net saleable or rentable area. The *lease span*, defined as the distance from the unit's inner wall to the exterior glazing, varies according to the building function. For residential high-rises, a maximum lease span of 10m is recommended given the daylight factor considerations. Office buildings with an open plan allow for deeper spans of up to 14m or more when atriums are provided. In the case of modular office layout a building depth of over 13m is considered excessive.

The main criterion in choosing a load-bearing system is the lateral stiffness for resisting the wind and earthquake forces, which is governed by the total height. Additional criteria include building height-to-width aspect ratio, floor-to-floor height, interior layout, exterior wall, foundation systems, fire safety, construction methods, and budget constraints. The criteria in choosing the foundation type are the gravity loads, quality of the site's subsoil, water table level, and wind loads. Wind loads lead to significant vibration in the upper floors, which provides additional stresses on the bed soils. The foundation piles often determine the location of the structural grid and therefore may affect the overall building efficiency. Fire safety is another important criterion. The core design needs to satisfy the number and size of escape stairwells by determining the building occupancy, as well as address the smoke extraction. Budget constraints often influence the structural material choice. Multiple design criteria exist to help improve environmental control strategies of high-rises. High level concepts include maximizing reliance on natural ventilation and daylight illumination, while depending upon the season and geographical location minimizing or maximizing the heat gain from direct sunlight along the building's perimeter areas.

VIII. OPTIONS

Facades have a significant influence on the aesthetics and symbolism of high-rises. Two main types can be distinguished: curtain wall (butt glazed, conventional mullion system, composite - glass and cladding), and facades as expression of structure (reinforced concrete, prefabricated panels, exoskeleton, etc.). Circulation patterns influence the building's efficiency. They are determined by the configuration, number, and positioning of the service core(s). A typical core includes elevators, fire-protected stairs, electrical / cable closet, riser ducts, and sometimes washrooms. The core positioning will determine the floor plan configuration, given the maximum allowable distance from the outermost point of the corridor to the escape stair(s). When designing cores an important consideration is the *elevator cab aspect ratio*. The preferred range is between 1:2 and 1:3 for maximizing loading and unloading efficiency. The Council on Tall Buildings and Urban Habitat (CTBUH) defines three major structural systems: steel, reinforced concrete, and composite. The choice of structural system determines the building aspect ratio limitations. Until recently, a 6:1 aspect ratio was a constraint. Currently, there are precedents for 10:1 or higher. Floor heights in residential high-rises are generally smaller than in commercial, and range between 2.5-3.5m. In commercial high-rises, floor heights range between 3.3-4.5m. To maximize efficiency, interior layouts may often seek a minimal presence of structural elements, which help choose alternative strategies (exoskeleton, concrete tube, etc.). Generally, the architect's choice of exterior wall system will impact the structural solution. Until recently, the rule of thumb in curtain wall-based high-rises was to vertically divide the façade into 1.5m increments due to ease of assembly, cost savings, and flexible planning. Today, geometrically complex high-rise designs demand variability in the exterior wall panel sizes and novel structural solutions. Engineers can choose among multiple foundation types depending on the building design and soil properties. Examples include cast-in-place telescoping piles, caissons, slab-pile, piled-raft, mat foundation, etc. Cost often can determine the design's final choice of material. For example, reinforced concrete is preferred in the developing world, given its cheaper cost and lower construction skill requirements than for steel structures.

Two types of high-rises can be distinguished according to employed environmental control strategies. First relies entirely on mechanical systems and is a net energy consumer. The second type responds to the climate and site context. The Chartered Institution of Building Services Engineers CIBSE distinguishes four

types of natural ventilation systems: a) **cross ventilation**, with windows on both sides; b) **single-sided ventilation**, with all the windows on one side; c) **stack ventilation**, in which fresh air is drawn through windows and hot air is exhausted through the roof; d) **mechanically assisted**, to increase the airflow in any of the first three systems. In high-rises stack ventilation is the preferred strategy given that the building's height helps create a chimney effect. However, a good understanding of the environmental conditions is important, as, for example, in hot and dry climates the stack effect may not function during the day. Light shelves or reflectors can be used to diminish the energy use in high-rises. Their performance is subject to optimal orientation, determined by the building orientation and geometry. Joachim presents an extensive study of how daylight is affected by the high-rise geometry and the floor plan proportions as related to the core design. He concludes that triangular footprints perform best by having the least amount of dark spaces within a 10m span, followed by the square and circular configurations. This study, however, is limited to centrally located cores. Yeang [4] stresses the importance of peripheral core location on east and west facades used as thermal "buffer-zones," leading to important reductions in air-conditioning loads and operation costs. Additional benefits include access to daylight and natural ventilation into the core area, making the building safer in case of power failure, and eliminating the requirement for mechanical fire-fighting pressurization ducts.
Considering their height and external surface area, high-rises are well suited to take advantage of emerging energy generation technologies. Integrating photovoltaic cells (PVs) into the building's exterior wall or louver system, for example, may become feasible after understanding the local climate and context. This knowledge helps choose optimal building orientation and location of PVs (i.e., non-shaded sections of the building). Similarly, given substantial wind velocities at high altitudes, high-rises can be volumetrically shaped to maximize the performance of integrated wind turbines (i.e., Zero Energy Tower in Guangdong, China by SOM). Other technologies include geothermal energy and thermal storage, evaporative cooling systems for arid climates, etc.

IX. ANALYSES AND DECISIONS

Designing high-rise buildings is a complex process as illustrated by the criteria discussed above. As a result, many prototypes have been developed in academia and practice to address aspects of the design processes as heuristic rules that automate some of these processes and help designers make decisions more efficiently. Danaher argues that by not being well defined the conceptual design is reserved only to senior, experienced designers. He proposes the use of knowledge-based expert systems in facilitating the access of junior designers to expert knowledge, in which the system guides them towards good solutions. Several such systems surveyed by Danaher are Hi-Rise, Tallex, Conceptual, Predes, and Archie.
Tall building pioneer in sustainable city success and achieve high standards as well as the buildings are proposed:

Shape
The shape of a tall building determines its cost effectiveness, and value efficiency at least as much as (and usually more so) than its height. The key efficiency ratios in the cost and value of a tower, wall: floor and net: gross, are both directly affected by geometry. This means that a 70-storey tower may cost less per square meter than a 30-storey building.
Shape is critical in cost terms, not least because it has a significant influence on the two key elements, structure and façades (and their effect on time as well as cost).

Façades
There is an intense — and sometimes political — relationship between high-rise aesthetics and performance, which is no more evident than in their façades. The form and envelope of a tower create its identity, and its external walls play a critical role in its passage through the town planning process. But they also have to satisfy a number of performance criteria, all of which exist in a certain tension. Our façades team is lead by Steve Mudie, based in London and First Vice President Jim McDonnell, based in New York, and is able to advise on any global project. We have a unique mix of technical and commercial expertise in this respect.

Structure
Tall buildings need to overcome particular difficulties such as severe wind loads and increased dead loads. Design solutions must also take due consideration of the typically Grade-A nature of tall buildings and the requirement to create an iconic structure. A number of structural forms may need to be analyzed early in the design stage to establish whether a core, tube, outrigger, mega brace, bundled tube — or a combination of these — may be most appropriate, together with which materials are best.

Schedule

Optimizing a design for efficiencies can shorten the construction program, easing the financing costs and reducing the risk of price rises during the construction phase. Greater savings can be made through phasing of works to allow phased opening (and thus earlier income streams), and to allow works that would normally be carried out sequentially to be carried out concurrently. Maximizing build ability requires the early planning and programming of the construction project, with detailed consideration of alternative methodologies. Importantly, this should be reinforced through on-going constructability reviews through Tishman which has in-house expertise across all these areas.

X. BUILDING INFORMATION MODELING (BIM)

Building Information Modeling (BIM) and other virtual construction services are a critical part of executing tall and super tall buildings. Using these techniques means more efficiencies and accuracy in pre-construction planning and strategies, and equally important, during construction. In addition to innovative methods for coordination of structural and mechanical engineering, our project teams now take advantage of extracting information from the model to facilitate estimating, procurement, clash detection and field management. Furthermore, elements of a project's 3-D model are used to identify and avoid safety hazards. Through continuous syncing of information in cloud-based servers, the model is updated and available to all project team members in real time. This enhances our overall productivity, provides instant clarification and offers important cost savings in high-rise construction.

1. Procurement strategy

Two key features of tall buildings tend to dictate the procurement strategy to be adopted: Firstly, the critical path for the construction of the whole project flows through a single structure, as opposed to two or more shorter buildings with the same total floor area. The resultant extended construction period pushes up not only the contractors' preliminaries costs, but also the developer's financing costs. Therefore, any solution which offers shorter construction times means an overall lower project cost. Secondly, the iterative nature of building one floor repeatedly on top of another gives huge opportunity for repetition of floor layouts and the incorporation of pre-fabricated construction techniques into the design. Ultimately, a procurement strategy which allows an early start on site, phased completion and occupation all helps to drive up value.

2. Environmental strategy

The property industry is becoming increasingly aware of the costs and benefits of building "green." Knowledge in this area is advancing rapidly, and the higher visibility, status, and design quality of tower buildings means that they are often the forefront of research and implementation of sustainable strategies. The adoption of LEED-type methods are helping to develop the efficiency of individual buildings as "products", though there are many aspects of sustainability that are not included in these methods. Davis Langdon's research in sustainability feeds directly into our advice to clients, and is used to direct industry organizations and government legislation. When we address sustainability, we are looking not just at the energy efficiency of buildings, but also their relationship to infrastructure and their long-term financial viability.

3. Vertical transportation

One of the key considerations in the design of a vertical transportation system in tall buildings is to reach the optimum balance between the quality and quantity of lift service provided (usually expressed in terms of waiting times) against the capital cost of the lifts themselves and the loss of revenue-earning, tenantable space taken up by the provision of lift cores and plant rooms. This becomes even more critical as buildings become taller than 50–60 storeys'.

The public Square office tower attached to the residential tower and the lightness of the structure relative to the coverage area of glass used in the field of building frontage possible view of the structural of the Sydney Opera Sydney is. Environmental issues and sustainable development, and materials recovered from the other issues that have been raised today with more objectivity.

Office project residential building in Sydney piano for an overview of the glass surface to form a continuous layer that has used ¬ creates relatively invisible eastern facade of the glass it artistic expression towers a gridding beautiful a space of your URBAN piano it describes a moving sculpture . The product of this cooperation specializing in glass bottle networking groups, building structures and the design of each of the glass network as a binder with each clamp, special to the clamps top or bottom rows of the structure of nearly building, backed on each of these sensor networks are placed in sensitive to dislocation movement and possibly warn those of glass in the building, repair and replacement parts so it can take action .composite steel and concrete columns at the corners of a triangular -shaped building plan are transferred . In the turrets, towers and other structures that foster self- employed structural engineer with the product of joint cooperation with the Department of Computer Simulations of three- dimensional building is that ultimately led to build.

XI. CONCLUSION

High-rise buildings within the urban fabric of the building were a secondary issue .new attention to the manner and style of the drainage density was noted in the hinterland tall. Valves are required to evacuate the density of tall building and vehicle traffic creates other major issues were noted It will be interesting of the New York skyscrapers sits of the metro area large and connects suburb.

Position office tower residential Philip Sidney Street along the main street of the city demonstrated it by making other tall buildings in urban areas , unlike the rules are somewhat Construction Engineering , which allows the similarity in different parts of the climatic conditions of social, cultural etc. The desired range is also continuing to high-rise building in the city and fits the general culture prevailing in the region .urban, architectural styles and periods are double neighboring and other issues of importance.

The connection is obvious as the Sydney Harbour Tower is designed in such a way that the shadow of the tower to a height of approximately 90 meters to the botanical gardens around it does not In fact; interactive communication tower with respect to the Botanical Garden has a special form. Architectural issues in designing terraced towers are crucial for Commerce Bank Tower in Frankfurt, the possibility of watching the city from different directions at different altitudes and building permit the site also allows transparency created using glass in various categories based view provides a visual communications. The way that employees in various classes, such as a collection of visual communication with each other the buildings are employed in different classes according to the type of unity.

tall building in various fields indicate the importance in today's world of high rise buildings papers in different fields such as systems and concepts, structures, tall buildings , high-rise office buildings , innovation in the field of tall building design , modular systems , do Reviews and buy aesthetic design of tall buildings , vertical social behavior of urban residents in tall buildings , saving energy costs immunization against fire, wind, earthquake and seismic monitoring in the field were presented , all of which indicate entailed a variety of specialties the design and implementation of the towers . As it observed, through case studies and a survey, that design organization during the conceptual design of high-rise building treat goals informally and search through a relatively narrow part of the design space. Design theory and our own experience suggest that significant better performing buildings are remaining undiscovered. Deficiencies in current conceptual design process lead to solutions with mediocre day lighting, and excessive thermal loads and energy demands, thus making the cost of operating or retrofitting traditional high-rises prohibitive. The lack of a comprehensive and systematic method of defining multi-stakeholder multidisciplinary goals, meaning their evolution, and generating and choosing among design options that respond to identified goals is a major impediment to more successful design.

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