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Economical High-Rise Building And How It Works: Engineering Perspectives On The Shanghai Tower: A Case Study

Zhang Yan[1*], Dr. Aiman Al-Odaini[2]

1*Research Scholar, Lincoln University College, Malaysia
2Lincoln University College, Malaysia
Email: zhangyan@lincoln.edu.my

Abstract

A staggering 292 million additional people will call China home by the year 2050, according to the UN's urban population projections. This prediction is sure to have an effect on Shanghai, the country's most populous city. The very dense urban topology and limited available land of Shanghai, a megacity with an inhabitant of over 24 million people, make very-rise buildings the probable first option for minimising the effect on land utilisation. Although buildings have many beneficial uses, they also use a lot of energy and contribute to pollution. For the benefit of generations to come, sustainable construction methods priorities low maintenance costs, high quality, and maximum energy efficiency. This article aims to gain an improved awareness of the Evaluation Standard for Green Building in China and its respective assessment system, Green Building Evaluation Label (GBEL), also known as "Three-Star," by identifying guidelines and orientations to sustainable construction in Shanghai and by comparing GBEL to the American LEED rating system as well, which is widely used and recognised in China. The second-tallest building in the world, the newly built Shanghai Tower, will also be used as a case study. The largest green high-rise now in operation is not the biggest, but it is the tallest. The highest possible GBEL score, and LEED Gold accreditation were both bestowed on the Shanghai Tower. Sustainable design elements of Shanghai Tower include a tri-generation system, ice storage climate control, a double-skin façade, and many more. These solutions have the potential to enhance the building's performance throughout its useful lifetime.

Keyword: *Shanghai Tower, Building, Sustainable, Assessment System.*

1.1 Introduction:

Midway through the eighteenth century saw the beginning of the proliferation of tall buildings in the USA. In the field of architecture, these constructions have gone viral. More specifically, in Asian countries such as Malaysia, China, & Korea. There will inevitably be more skyscraper development in large urban areas, particularly in so-called megacities, since the world's population is predicted to continue increasing. The United Nations projects that by 2050, metropolitan regions will be home to approximately 65 percent of the world's population. By that point, an additional 292 million people will call China's metropolitan regions home. This will have far-reaching consequences for the country's housing, transportation, and social service infrastructures, particularly in the megacity of Shanghai. Tall structures are the best option for minimising the impact on cityscapes. Buildings have several beneficial effects on society, but their high energy consumption and trash production make **(Amiri, 2019)** them a big part of the problem with environmental deterioration. In a year, the construction sector consumes a quarter of the world's wood and forty percent of its aggregates (gravel, sand, and stone). Buildings not only use a quarter of the world's freshwater and forty percent of its energy, but they also release thirty-three percent of the GHGs into the atmosphere. Power use in structures, such as houses and companies, accounts for over two-thirds of the total. Not only that, but buildings also account for 40% of landfill trash and air pollution. The present energy and resource needs of the construction sector are just unsustainable.
There are 40 billion square meters of domestic buildings in China, with as much as 95% of those being high energy consumption buildings. The country's building construction rate is two billion square meters per year, based on data compiled by the nation's Ministry of Residence and Urban-Rural Development (MOHURD). For the sake of future generations, we must lessen the impact of conventional building methods that priorities immediate financial gain. To guarantee efficiency, quality, and cost-effectiveness in the long run, begin financing projects according to sustainable design principles **(Ali, 2018).**

1.2 Background:

The Ministry of Housing & Urban-Rural Renewal (MOHURD) for the People's Republic reports that over two billion square feet of buildings are constructed annually in China, with 80 percent of them being high-energy-consumption structures. In addition, almost every one of China's 40 billion square feet of residential construction uses a lot of energy. In order to leave a better world for generations to come, researchers need to enhance the environment by cutting down on conventional construction practices that are **(Xu, 2020)** driven by immediate financial gain. Start investing in sustainable building techniques that priorities long-term cost, efficiency, and quality. In order to gather information for this thesis,

they were going to Shanghai Tower on many occasions. This paper's goal is to examine the sustainability features of the Shanghai Tower—the world's second-tallest building—including its double-skin façade, refrigeration and air conditioning system, energy-efficient lift, tri-generation system, and numerous other eco-friendly technologies—as well as Shanghai's building codes and orientations towards high-rise sustainable constructions. A building's performance will be improved during its entire lifetime by using these techniques **(Choi, 2019).**

1.3 Purpose of the Research:

Sustainable construction approaches, such as using wind and solar energy, and recycling rainwater and wastewater, as well as bioclimatic dwellings, are attracting an increasing number of interested individuals. Over the last decade, these styles have become more fashionable. Sustainable construction is an excellent investment since it improves the quality of life for people, the environment, and the economy during the building's entire existence. A green building seeks to minimise the detrimental impacts of buildings on individuals and the surroundings by using minimal water, raw materials, electricity, and land. A sustainable building, on the other hand, adheres to these principles. To promote sustainable construction projects and increase efficiency in the industry, governments should collaborate with industry executives and other interested parties to implement appropriate efficiency measures and provide financial incentives for such endeavors. Efforts to address the environment, energy, raw material, water, land use, carbon emission, greenhouse gas, and waste challenges lead to better overall performance.

1.4 Literature Review:

The significance of high-rise structures in modern architecture is growing. Because of the strong demand for real estate in city centres and the fact that the population is growing and congregating in urban areas, its cultivation is essential. You can see how their building has evolved over time, both in terms of number and quality. The CTBUH (Council on Tall Buildings and Urban Habitat) Global Tall Buildings Database reports that, as of this writing, 1,647 structures over 200 metres in height have been constructed. Complex engineering and a high requirement for construction technologies are hallmarks of high-rise building construction. Designers in modern architecture want to provide unique aesthetic experiences by pushing the envelope of conventional, standardised building practices. To achieve this, modern material technologies and imposing geometric designs are used, allowing skyscrapers to be categorised as eco-buildings. Within the framework of similar approaches to evaluating structures using different criteria (quality evaluation tools, such as Leed), models for creating an environmentally friendly and energy-efficient setting have emerged, reflecting the shift in thinking in building design over the last 20 years. A number of texts attest to these shifts; these include the White Handbook of the Architects' Council of Europe, the European Charter of Renewable Energies in Building and Urban Planning, and the Aalborg Charter. Notable architects including Norman Foster, Gilles Parading, Thomas Herzog, and Renzo Piano advocate for environmentally friendly and energy-efficient building designs **(King, 2020).**

The primary goal of many new high-rise projects is to get LEED certified, which means they must use zero energy. The world's highest sustainable construction standard may be achieved with Leed v4 accreditation at the Platinum level. The world's first skyscraper to get this certification is Bryant Park in New York, NY, USA. The Shanghai Tower is among the numerous structures that have obtained the Leed v4 certification. Bioclimatic skyscrapers, which have public terrace or multi-level atrias to promote occupant comfort with vegetation, are one example of a pro-ecological architectural design (Oasia Hotel, Singapore).

Issues with the building's spatial stiffness, foundation, resistance to dynamic wind action, and seismic impacts are at the heart of the high-rise design dilemma. Horizontal displacements are also a major worry. When dealing with active loads **(Navaratnam, 2019)**; the most important design consideration is choosing the right structural system while maximising its geometrical dimensions. The transmission of horizontal stresses from wind and tectonic impacts to the foundations is where the current building methods mostly diverge. Built on man-made land (United the Tower, Manama; the Marina Bay Sands complicated Singapore) or in seismically active places with high winds (Tokyo Sky-tree, Tokyo) is possible thanks to an advanced construction method. This study introduces a paradigm shift in architecture towards more environmentally friendly practices by analysing the design and construction details of a few prominent examples of contemporary skyscrapers **(Hu, 2019).**

1.5 Research Questions:

- In China, what are the standards for evaluating green buildings?
- How the Green Building Evaluation Label (GBEL) is implemented?

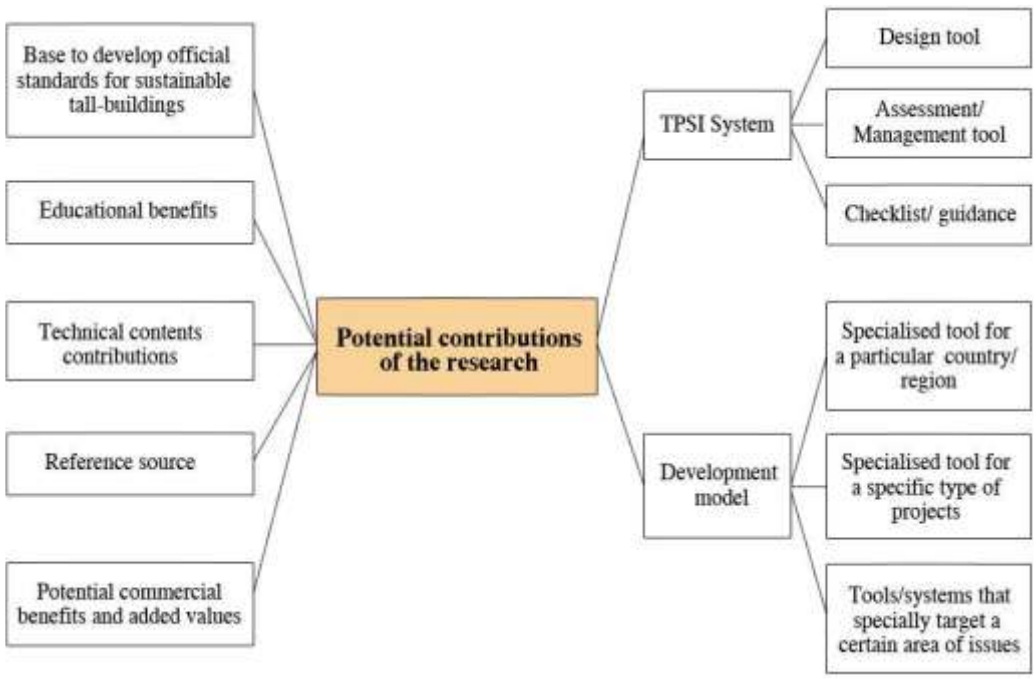
1.6 Methodology:

An analysis of the development of global building rating systems, particularly those applicable to tall buildings, is the subject of this research. Environmentally friendly building is ranked according to each country's standards. Here we may find much debate over the historical development of rating tools and the specific nations and rating tools that have played a role in their widespread use across the world. Following these studies, the procedures and structure for TPSI's evolution will be established. The overarching plan for creating a new grading system is defined by the research issues that need to be addressed. This approach will influence TPSI's research techniques and methodology.

• **Sampling and data collection:**
Under the Data "dimension" is the whole procedure for carrying out a literature review. This dimension incorporates all of the main rating systems that are currently in use. This study compares and analyses the features of global environmental instruments from across the globe. Is a five-star structure with one system of rating instantly comparable to a four-star rating with another system? This is only one example of how it primarily focuses on how metrics from different countries may be directly compared. Investors, developers, tenants, and government agencies may all benefit from having access to this information in order to make more informed decisions on environmentally friendly skyscrapers. By clearing up some of the confusion around these "sustainability tall buildings," they may hope to increase their popularity among stakeholders.

• **Data analysis:**
Using a case study effectively allows one to acquire comprehensive, "multi-faceted knowledge" about a complex topic. Correlational design is among the most popular research methods, especially in the field of social sciences. Always keep in mind that case studies are meant to conduct in-depth investigations of events or phenomena in their natural environments. This kind of study is regarded as "naturalistic" research since it does not include any efforts to control or modify a variable of interest, unlike "experimental" designs like Randomised controlled trials.

1.7 Conceptual Framework:



1.8 Results:

Situated on a 30,370 square foot block in Shanghai's Pudong neighborhood, the 632-meter-tall Shanghai Tower was designed by the US design company Gensler. With 127 stories, this megamall structure offers a variety of retail, office, lodging facility, observation deck, and dining options.
Based on the numbers presented, it seems that all six performance areas in China's GBEL generally equally split, with energy utilisation and material and material efficacy receiving somewhat larger shares of the total. When it comes to LEED certification, the most important factors are location, transportation, electricity, and environment. Material and resource conservation come in a close second. Due to disparities in national circumstances, the two grading systems place

differing weights on the different credit and option categories within each category. Please see appendices A–N for more reading. While GBEL choices provide a focus on utilising rainwater, recovered wastewater, and recycled saltwater, LEED credits place an emphasis on water conservation planning, sewage recycling, and water supply conservation.

An innovative approach to living in ultra- and supertall structures is embodied by Shanghai Tower, the world's first super high-rise skyscraper covered with sky gardens. Pictured above is the plan for the skyscraper, which has a glass exterior covering nine interlocking cylinders. Each room's square footage is detailed. This does not include MEP and refuge floors. The double-skin façade conceals public areas that, like plazas and squares, rise upward from a "sky hall" at the bottom of the structure and serve as gathering spots for inhabitants at all times. Furthermore, by incorporating natural light and air, the "sky lobbies" honor the original open courtyards of the city. Each one of the Shanghai Tower's sections has its own set of elevators, and their heights vary from twelve to fifteen stories. Every town serves a primary purpose and is supplemented by other services. At the very top of the skyscraper, on the world's highest single-lift elevator, guests may reach performing arts centers and a viewing area that provide amazing panoramas of the Shanghai countryside and cityscape. Zones 7 and 8 have an upscale business complex and a five-star hotel. Zones 2–6 are home to high-performance workplaces; they are well-lit and open to the garden atriums; each "sky lobby" has a café and store, which cuts down on energy use by reducing the need for escalators to ground level. The first two floors below ground and the top four levels make up the retail podium close to the base. For all of your eating and shopping needs, the mall is the place to be. The ground floor is a "downtown market," and pathways leading to the subway and the adjacent skyscrapers are available to pedestrians.

1.9 Discussion:

Still, some building developers chose LEED over GBEL in the beginning because of concerns about GBEL when it was a younger certification system compared to LEED. A growing number of Chinese developers choose GBEL over LEED since it was specifically designed to tackle China's specific environmental issues. This is not surprising given that GBEL was born out of China's unique environmental concerns. Many high-rise developers in South and East China have considered incorporating sustainable practices into their building designs by meeting the standards of GBEL or LEED, or perhaps both, as a result of financial incentives offered by the government.
In recent years, green building practices have quickly become the norm in China. The fundamental goal of the Chinese government was to reduce environmental pollution, and they have achieved this by putting the theory of green building as well as sustainable construction into practice across the country and, more importantly, by creating green buildings that perform better than before. Sustainable and ecologically friendly building practices have seen considerable growth in China in recent years. Sustainable construction is more than just a trend or "brand" for entrepreneurs; it's a declaration of intent to improve the world in the long run.

1.10 Conclusion:

Findings from this research primarily center on green building policies implemented in China and strategies that improved the sustainability of high-rise structures. The article presents sustainable practices based on an investigation in Shanghai; nevertheless, similar practices might be used, with minor adjustments, in other cities experiencing a subtropical monsoon climate.
Shanghai Tower's energy-efficient design incorporates a number of eco-friendly elements, such as a sky lobby, a ground-source heat pump, integrated cooling down, heat and electricity, a double-skin curtain wall, a recycling system for both rainwater and grey water, as well as a building information modelling (BIM) the lift. These upgrades may lead the building to consume less resources, produce less greenhouse gas, and have a smaller carbon footprint than typical skyscrapers. Based on their findings, the authors concluded that wind is quite important in this setting because of the correlation between wind and building height.

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