

An Examination of the Technological Aspects of Constructing Tall Buildings: A Research Conducted in Hong Kong

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Abstract: A plethora of solutions were devised to tackle the problem of Hong Kong's constrained space and resources. Unfortunately, many mishaps occurred due to the misuse of technology. Consequently, the government of Hong Kong establishes a plethora of COPs and rules to control the construction industry. To maintain tight supervision over building projects, the government draughts a plethora of regulations and laws. Detailed drawings, practical notes (PN), and requirements were prepared to guarantee a safe and high-quality job. Due to worker malfeasance and mistakes, a battery of tests was used to ensure high-quality craftsmanship. As an example, the TDR testing was created to guarantee that the soil nail length matches the plan. Three tests—the cube test, the core test, and the hammer test—were devised to evaluate the concrete's quality and craftsmanship. The test for tensile strength was employed to assess the grade of the steel. Both the bleeding test & the flow cone test were used to determine the cement's grade.

Keywords: Buildings, Hong Kong, Code of Practice, Construction Technologies, Mishap.

1. INTRODUCTION:

A large portion of the world's energy consumption & carbon emissions are caused by the construction industry. As to the information provided in, it accounts for 30% of the total energy used worldwide and 28% of the carbon emissions attributed to the energy sector. The construction industry is responsible for more than 60% of carbon emissions in densely populated areas like Hong Kong (Hu et al., 2022), where the skyscrapers dot the skyline. In order to reach the sustainable development targets established by the International Energy Agency, it is essential to reduce energy consumption and greenhouse gas emissions in the building sector. Researchers need to cut down on half of the world's carbon emissions and around a thirteenth of the world's energy usage in the construction industry by the year 2040 (Pan et al., 2021). It is important to address both the structural stability of tall structures and the heat gained through solar radiation that passes through opaque wall surfaces when designing buildings with extensive vertical façade areas. It is possible to greatly increase the energy efficiency of the whole building by increasing the thermal insulation capacity of opaque wall surfaces (Guo et al., 2021). A potential solution to the problem of building energy efficiency or carbon reductions is radiative sky refreshing technology, which is one of the new

renewable energy utilisation forms. This technology uses the atmosphere as a window for dissipating heat from terrestrial items into space and reflects incoming solar radiation significantly. Researching radiative sky cooling's passive uses in tall structures might hasten its introduction to the Hong Kong construction industry (Cheng et al., 2022). Therefore, this study has the potential to provide light on the best ways to incorporate radiative sky cooling into building walls in order to maximise the energy-saving potential of buildings and decrease carbon emissions, both of which are important for achieving sustainable development (Cheng et al., 2022).

2. BACKGROUND:

There are around 6.9 million people living in Hong Kong, which is situated on a land area that is little more than one hundred square kilometres. As a consequence of this, the availability of land is of utmost significance to the people who live in Hong Kong. Despite the fact that this location is quite densely inhabited, individuals are nonetheless able to take up high-rise buildings. The structure must have a stable foundation in order to be sturdy (Hu et al., 2020).

In spite of its little size, Hong Kong is home to a significant number of hills. As an additional point of interest, Hong Kong

is permanently susceptible to typhoons. In French, this phrase is "June to September." It is inevitable that the slope's stability will be influenced by the weather conditions. As a consequence of this, a number of slopes will give way after a significant amount of rain. By way of illustration, Kotewall Road was the location of a significant number of deaths on June 18, 1972. The government invests a significant amount of money on the slope in order to make it safer and to reduce the number of fatalities that occur there. As a result of the limited availability of land in Hong Kong (Chastas et al., 2018), it is expected that owners and developers would build skyscrapers with very large floor layouts. As a consequence of this, skyscrapers made use of a variety of methodologies and technology. high-strength concrete, pre-stressed slabs and beams are some examples of such materials. Additionally, the government offers financial incentives to developers that make use of innovations in technology (Urge-Vorsatz et al., 2020). In light of the fact that developers borrow money from banks in order to purchase real estate, they would employ a more expedient method to lower the interest rate.

3. THE PURPOSE OF THE RESEARCH:

Despite the fact that buildings are erected for a wide range of reasons, the primary reason for their construction is to provide people with a place to live, work, and shelter. Buildings have been constructed by humans for thousands of years, yet the causes for the construction of these structures have changed throughout the course of history. Buildings, such as fortresses & castles, were created in ancient times with the primary aim of providing a protective defense against intruders. This was done in order to safeguard both people and resources. Along with the development of cultures came the construction of structures for religious & ceremonial reasons. Examples of such constructions include pyramids and temples (Chastas et al., 2018).

Buildings are erected in contemporary times for a broad variety of reasons, including residential structures, commercial structures, institutional structures, and industrial structures. Commercial buildings are created to house companies such as stores, offices, & restaurants, while homes are designed to offer dwellings for individuals (Lethbridge, & Hong, 2022). Commercial buildings were constructed to house businesses. Industrial buildings are developed for manufacturing as well as other industrial reasons, while institutional buildings are built for use by organisations such as schools, hospitals, & government offices. Institutional buildings are built for use by these organisations. Museums, art galleries, & cultural centres are examples of buildings that may be erected for aesthetic & cultural objectives. These

types of buildings serve the aim of promoting art, history, & cultural identity when they are established. In general, buildings serve as an essential component of human society's infrastructure (Cheng et al., 2022), since they allow for the provision of shelter, space, and functioning for a diverse variety of activities and requirements.

4. LITERATURE REVIEW:

The evolution of building technology has made glass curtain walls an essential component of modern building designs. The usage of glass curtains as outside walls is particularly popular among high-rise buildings and skyscrapers. The glass curtain wall is used by over 2,000 buildings in Hong Kong. But there are a few issues with this architectural plan, the most significant of which being the light pollution that it causes (Li et al., 2018). As a decorative element, the glass curtain wall resembles a massive glass mirror that stands tall beside the sidewalk. The city's worth and status might be enhanced by this architectural design, which is both contemporary and aesthetically pleasing (Mattoni et al., 2018). Hong Kong is among the world-class cities thanks to several prominent skyscrapers as the International Finance Centre, Nina Tower, Central Plaza, Bank of China, The Centre, and so on.

Nevertheless, light pollution might have a significant impact on people's lives, particularly transportation, since the glass curtain wall reflects light, blinding people's eyes. Even a 4- to 6-degree temperature gain is possible with a glass curtain wall. Consequently, the air conditioners will need more power. Penangites tend to choose using more concrete when constructing external walls, in contrast to Hong Kong residents (Zou, 2019). With its concrete facade and a few glass windows, Komtar is Penang's tallest structure. This design blends in well with its natural setting. It would be easy for people to feel uneasy when seeing Komtar tower. In addition, the concrete outer wall is an architectural element of the Petronas Twin Towers. During the day, the Petronas Twin Towers seem stunning against the backdrop of the clear sky. Light pollution is therefore nonexistent in the built environment (Huang et al., 2019).

5. RESEARCH QUESTION:

i. How can health and safety for employees be addressed via the creation of new technology?

6. RESEARCH METHODOLOGY:

GEO plays a crucial role in making sure the design of earthworks is in compliance with the latest criteria, particularly in terms of slope safety. The geotechnical

inspection in Hong Kong is carried out by three district divisions of the GEO: the Mainland West Division, the Mainland East Division, and the Island Division.

The District Divisions conduct inspections to assess the quality of site preparation, slope upgrading, earth retention structures, and extensive excavations carried out by private sector entities, public authorities, and government departments.

On a daily basis, professionals in the District Division handle various geotechnical challenges that are often found in very difficult terrains. Slopes and reclaimed terrain need extensive earthmoving operations and significant excavations, respectively. Consequently, the team maintains ongoing connections with engineers and architects from the business sector, as well as professionals from different government organisations.

The Buildings Department exercises geotechnical oversight over private sector projects by using its legal jurisdiction, thus approving design submissions prior to the commencement of construction. The geotechnical oversight of public infrastructure projects is conducted by the District Divisions in compliance with Government administrative guidelines, adhering to the same level of quality as that required for private sector endeavours. The construction of a basement is supervised by a minimum of two governing bodies. Competent staff will conduct spot inspections to verify adherence to the designs. Members of the team also possess supervisory abilities.

The government actively oversees the utilisation of the new technology to ensure its safe and proper utilisation. The use of cutting-edge construction technologies ensures public safety since the government oversees both the design and building phases.

• **Research design:**

CBA buildings often have a subterranean level and are connected to other buildings and public transit networks, such as the MTR. Both top-down and bottom-up construction approaches will be used throughout the construction phase. Due to its shorter completion time, the top-down construction approach is gaining popularity.

Since the slabs serve as horizontal supports for the excavation, there is no reason for the use of strutting. Put simply, it is an additional advantage of the top-down design methodology. As the height of a structure increases, the building supplies and methods need to be adjusted to accommodate the increased requirements. For instance, a prestressed concrete beam with reinforcement may be used to

minimise the beam's depth and/or the slab's depth with the purpose of conserving space.

Prior to casting, pre-tensioned "high-tensile" tendons are employed to provide support for the concrete. Wires are deployed to provide compressive stress relief after the concrete has reached the necessary degree of strength. Proper curing may expedite the process of enhancing the strength of concrete. Steam curing serves as an illustration of this concept. High-rise development is prohibited in some regions due to unfavourable soil conditions. Engineers want to use deep foundations, such as a big-diameter bore pile (LDBP) or a driven H-pile, to resolve this problem.

• **Data Analyse:**

Soil is a Nail's Natural Habitat.

In order to safeguard the soil, the government of Hong Kong allocates significant financial resources towards boosting the safety of the city and improving its slopes. Hence, Soil Nail Works outlets are widely distributed in Hong Kong. To get more insights on the topics addressed in this research, kindly refer to the "GEO" section for further information.

The primary responsibilities of Soil Head are safeguarding the soil nail and serving as a suitable location for hydroseeding.

Removing Blockages

Subsequently, after they have finished pounding, proceed to rake the drain. If the rake drain is pre-constructed, there is a possibility that the drain may get obstructed by the cement grout to a certain degree.

When raked, drains are handled in a manner similar to the use of soil nails.

Steel reinforcement is produced in a standard length that is restricted due to logistical constraints related to transportation and weight. Given this situation, splicing may be categorised into three distinct classes:

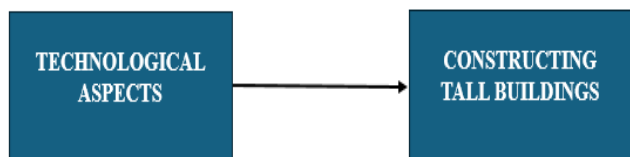
Splicing at the lap necessitates a complete connection between the two lapping bars at the lap.

In this example, two mechanical sleeves are attached by threading on the ends of the bar prior to its mechanical attachment. The need for items of this kind arises because of limited entry to the region or the presence of large, fortified structural elements.

Furthermore, a fusion welder. Welding alters the properties of the bar in the vicinity of the weld owing to the elevated temperatures concerned, so it is not advisable for use with high tensile reinforcement. Engineers must specify "specific

reinforcement that is appropriate for welding if the steel bars are to be welded together.

• **Theoretical Framework:**



RESULTS:

The most popular construction technology in Hong Kong is discussed below. Examples include deep piles, sheet piling, top-down basement building, soil nails, prefabricated units, the prestressing process beams & slabs, slope stabilisation, and government technological control. Hong Kong developers and owners will build skyscrapers with large floor designs to maximise land use. Skyscrapers employed technology extensively. Developers that use new technology get government incentives. Developers, who borrow from banks to acquire property, might lower interest rates quicker.

Building higher buildings has always been a human goal. Ancient landmarks including the Tower of Babel, Rhodes' Colossus, Egypt's pyramids, Mexico's Mayan ruins, and others made rare appearances. Skyscrapers have grown in three eras. The Guaranty, Reliance, & Carson Pirie Scott shopping centres were built during the first phase. The brick walls all most of these buildings were thick and dirty. These structures' brick walls largely withstood horizontal and lateral strains.

The minimum masonry barrier thickness is 2.13 meters. Walls take up 15% of this level's overall floor space. Thick walls limit flooring, lighting, and airflow.

Building height restrictions were lifted in the second phase owing to steel construction and high-tech features like motorised lifts and ventilation. Large constructions became popular as firms noticed the PR or marketing benefits of having their logos associated with spectacular office skyscrapers. They believed it was an excellent investment due

• **Some technologies used in Hong Kong:**

Problems are addressed by using a range of tools. The following methods and tools were used in Hong Kong.

Most buildings in the CBA have basements and links to nearby structures and public transit lines. mid-term review. Both bottom-up and top-down building strategies were utilised throughout the construction phase. The top-down method has grown in favour due to its ability to shorten

to its potential rental revenue. When the height of the contest started, New York and Chicago were the focus. Famous structures from this time include the Woolworth and Chrysler structures. Construction on the Empire State Building ended the race. The highest part of the skyscraper was 381 meters.

1. Reinforced concrete gained its own character in the 1950s, coinciding with the third modernist phase in building history. Unlike previous times, architecture focused on

- For what reason
- Facts that are functional, and
- Facts related to technology.

The World Trade Centre in New York City in 1972, the Sears Tower in Chicago in 1974, and the most recent Twin Towers in Kuala Lumpur in 1996 are all examples of this new breed of structures.

Table 1: Efficiency of Structural systems of tall buildings

Building Cases	Year	Stories	Slender	kN/m ²	Structural
Empire State Building	1931	102	9.3	2.02	Braced rigid frame
John Hancock Centre	1968	100	7.9	1.42	Trussed tube
World Trade Centre	1972	110	6.9	1.77	Framed tube
Sears Tower	1974	109	6.4	1.58	Bundle tube
Chase Manhattan	1963	60	7.3	2.64	Braced rigid frame
US steel Building	1971	64	6.3	1.44	Shear walls + outrigger + belt trusses
IDS Center	1971	57	6.1	0.86	
Boston Co. Building	1970	41	4.1	1.01	K- braced tube
Alcoa Building	1969	26	4.0	1.24	Latticed tube

construction duration. It is not necessary to employ strutting during excavating since the blocks provide horizontal support. It follows that there is yet another advantage of the top-down method of construction. Difficulty arises due to the shallow excavation headroom. So, specialised equipment could be needed while construction is underway. As buildings increase in height, their materials and structure will change to better fit their intended function. As an example, a prestressed concrete reinforced beam will replace the original reinforced

concrete beam in order to shorten the depth of the beam or floor. The intentional application of internal, long-term stresses and pressures is known as prestressing, and it enhances the behaviour and strength of a building or assembly when put to service. Because concrete is strong in compression yet fragile in tension, it might be used to counteract the tensile stresses caused by external loads by subjecting the concrete to compressive stress by steel prestressing.

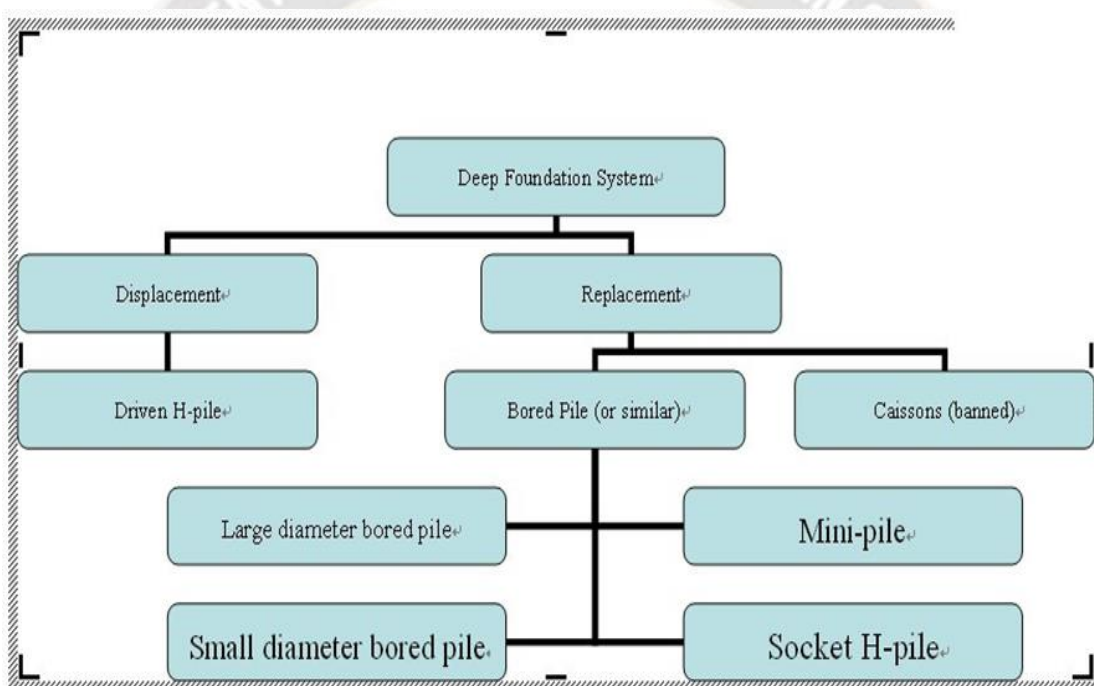
• **Transfer Mechanism:**

In order to make the retail centre spacious, the loads will be transferred to a column using a transfer structure. As a means of transfer, pile caps are used in Hong Kong. mound The column's load is transferred to the mound by use of caps.

• **Deep Foundation:**

Sometimes, the ground is just not ready for a skyscraper. A driven H-pile or large diameter bored pile (LDBP)—two types of deep foundations—will be designed to address this issue.

Figure 1: Classification of Foundation in Hong Kong Building



7. DISCUSSION:

Hong Kong adopted several technologies due to the various restrictions. People may enhance their standard of life by doing this. Less vibration and noise are produced by bored piles, for example. Additional space may be achieved by constructing in the basement. Soil nails are employed to bolster the stability of hillside structures and to enhance their aesthetic appeal. Given the potential benefits and drawbacks, the government set up many GN and COP to regulate their use. The advantages of these instruments much outweigh the disadvantages, on the whole. Companies and governments are receptive to new technologies because of this. As an example, the use of hydraulic power to build sheet piling has

become widespread in Hong Kong. Construction sites in Hong Kong are closely monitored by several government agencies, ensuring the safety of the people. Due to the scarcity of land, increasing the height of buildings might lead to more useable floor area, which would have a positive impact on the benefits. A serious accident in 1995 led to the implementation of a Technical Competent Person (TCP) system in Hong Kong. A problem with the foundation was noticed in the year 2000. (such as when the pile's length differs from the design picture, or the concreting is of low quality). Since its inception in 2001, the Quality Supervision Plan (QSP) has served to monitor quality. It wasn't until 2005 that these two approaches were merged into one new strategy for supervision. Additional research may be conducted to

ascertain the optimal degree of supervision for Hong Kong building.

Future tall buildings will likely be unprecedentedly tall using an original structural system & material, a new version of current systems, or a mix of multiple systems & materials. The nature of people who will be forced to live in these vertical jails apart from the natural environment, the financial strength of the communities, and the ambition of those who want to own the world's tallest building are the three answers to this question. The height of a tall building is determined by market-driven real estate, environmental or aviation variables, ego-driven prestige and competition, and practical factors like structural system or material availability, fire safety, demand for energy, etc. Today, technology allows 1000-m-tall skyscrapers. Designers must remember that ultra-tall skyscrapers will house nature-lovers. So human nature is the only constraint.

8. CONCLUSIONS:

Developers and owners in Hong Kong will construct enormous (high-rise, expansive) skyscrapers to make the most of the city's limited land resources. Hence, technology was heavily used by skyscrapers. The government grants developers rewards when they employ new technologies. Developers would use a faster way to reduce the interest rate since they borrow cash from banks to buy property. Numerous services were located below ground. Consequently, exposed cuts were used seldom in Hong Kong. There was a heavy reliance on machinery for excavation and lateral support. There is a lot of stabilisation in Hong Kong as well. Because of the scenario in Hong Kong, engineers will be putting innovative technologies to the test.

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