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Height and construction costs of residential buildings in Hong Kong and Shanghai

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ABSTRACT

A widely recognised theme of construction economics suggests that the cost of construction per square metre increases as building height rises. However, after many years, research conducted regarding the height and cost issue have established a classic relationship between those two, well known as a U-shaped curve. This paper describes the study of height-cost relationship of high-rise residential buildings in Shanghai and Hong Kong. Initial findings indicated that the curved relationships of height-cost of residential buildings in Shanghai and Hong Kong exhibit different profiles. The differences suggest that, Hong Kong contractors have more expertise in multi-storey and high-rise construction than contractors in Shanghai. The dissimilarities also imply that different sets of criteria should be applied in the judgement of height affects cost in different locations. Many factors could be contributors, such as the history and experience in constructing residential high-rise buildings, location, linkage and relationships to the neighbourhood provinces, design and construction regulations, and government policy on residential construction.

Keywords: high-rise, residential building, height-cost, economics.

1. INTRODUCTION

The study described in this paper focused on the height and cost relationship of high-rise residential buildings in the Asia Pacific region. Two cities were chosen—Shanghai and Hong Kong.

In the 19th century, after defeat in the First Opium War, Shanghai was opened as one of the treaty ports for international trade. The Chinese government was forced to accept Hong Kong as a Crown Colony of Great Britain on a 99-year lease. Shanghai and Hong Kong are frequently described as places where East meets West. Western culture is deeply ingrained in both cities and coexists with the traditional philosophies and practices of the Chinese.

After the Chinese Civil War and Chinese Revolution in 1949, with a large amount of migrants moving into Hong Kong from fear of persecution by the Communist Party, many corporations in Shanghai and Guangzhou also moved to Hong Kong including many architecture and construction companies. The colony became the sole place of contact between mainland China and the Western world. After the transfer of sovereignty in 1997, Hong Kong is still governed as a special administrative region. The autonomous status enables Hong Kong to serve as an exchange bridge for investments and resources flowing into and out of the mainland.

Shanghai started its economic reforms in 1991. Today, Shanghai and Hong Kong bridge trade and investment flows to different regions in China and the Asia Pacific. As Shanghai's largest foreign investor, Hong Kong has brought not only capital to the city, but also the management expertise and business experience of its companies, as well as other foreign partners via their investment and co-operation with local firms. Shanghai is increasingly seen as Hong Kong's competitor. This competitive environment creates more opportunities with rising transactions between the two cities (HKTDC, 2008).

Hong Kong and Shanghai are both high-density cities, sharing a similar cultural heritage and both are regarded as the fastest growing cities in the world. In Emporis Corporation (2008) a ranking of cities is presented in terms of "most compelling skyline". Essentially, it identifies those cities with a significant number of tall buildings and the visual impact that this presents.

Hong Kong, famous for its dynamic building developments, is reorganised as having the most compelling skyline in the world. Shanghai, currently experiencing a major high-rise building boom, is ranked at 7th. These observations led to the selection of Shanghai as the city for comparison in this study.

Today, the world's tallest building proposals are of concrete construction and of residential or mixed-use functions (Oldfield, 2007). High-rise residential building developments have become the main focus of high-rise construction, due to the constraints of high-density, shortage of land, and lack of space in Hong Kong and Shanghai. The overall magnitude of high-rise residential projects is reaching levels seldom seen before. Today, projects in Shanghai and Hong Kong very often include a series of 10, 20, 30 or more similar buildings, and comprise several thousand dwellings. Residential buildings will commonly reach heights of 60 or 70, even 80 storeys (Binder 2002). Binder (2002) also suggests that a "hierarchy of spaces, elegant proportions, and quality detail" is commonplace and will continuously stand as the gold standard for high-rise luxury, residential living in Hong Kong and Shanghai.

Over the years, various studies have been conducted to examine the height-cost relationship, mainly sourcing data in western countries. However, having examined the wider research carried out in other aspects of high-rise buildings (for example, the technologies involved), there appears to be a dearth of investigations looking at the relationship between height and cost in high rise buildings. In particular, Hong Kong and Shanghai with their heavy concentration of tall buildings have had limited attention.

In this study, a comparative study was carried out, based on a sample of 35 Hong Kong buildings and 36 Shanghai buildings. The 35 Hong Kong buildings also included the 24 buildings which were examined in a previous study by Picken and Ilozor (2003). The comparison was conducted to analyse the differences and similarities of height-cost relationship in Hong Kong and Shanghai. The aim was to examine the theory put forward by Picken and Ilozor that different sets of criteria should be applied in the judgement of the height affects on cost depending on location, function and commonality of the tall buildings under considerations. This comparison also suggests that there are many other factors which need to be considered in addition to location, function and commonalities, such as the history and experience gained in the construction of residential high-rise buildings, and design and construction regulations, and government development policies.

2. CONSTRUCTION HEIGHT AND COST

Building economics and cost planning professionals are aware of the traditional theories related to the influence of building height on the cost. The belief that the construction cost of high-rise buildings is greater than that of low-rise buildings offering a similar amount of accommodation has become a rule of thumb. A typical perspective would be that a tall structure should only be considered when the land price is expensive. A selection of theories from building economics literature demonstrates the traditional view of height and cost:

The two-storey building performs as cheapest. (Nisbet, 1961) (This statement included in an early study of height and cost, and only referred to buildings in the low-rise range.)

Prices per square foot tended to rise as the number of storeys increased in Britain. Housing in tall multi-storey blocks is around 50 percent more expensive than those in two-storey dwellings. (Stone, 1967)

The cost of a building per square metre of floor area increases with a rise in the number of storeys. (Bathurst and Butler, 1973)

Multi-storey buildings/high-rise buildings would be a design choice only if they could make saving from the tremendous land cost by building upwards. (Cartlidge, 1973)

It is more expensive to build high-rise buildings than low-rise buildings, which offer the same accommodation. (Ferry, Ferry and Brandon, 1999)

Ashworth (2004) concluded some reasons for the assertion of these authors. This contributes to these above viewpoints regarding the height-cost relationship of buildings, with respect to matters such as the higher vertical transportation cost; the delay in site set up; and the increased amounts payable to operatives working at height and the related safety requirements.

In examining the high-rise building literature, many research studies taking a design perspective can be identified, and are focused on construction techniques, energy issues, and the logistics aspects, for example, ‘Overview of sustainable design factors in high-rise buildings’ by Ali and Armstrong (2008) in proceedings of the Council on Tall Buildings and Urban Habitat international 8th congress, Dubai. Compared to the literature published on these areas, studies on the relationship between height and cost in high-rise buildings appear to be limited. Nevertheless, some research has been accomplished.

Tregenza (1972) carried out a height and cost analysis based on 10 different office buildings, from one to eighteen storeys high. The research found that tall building costs were greater than a low compact building having the same internal floor area. He suggested that the low compact building would give better value for money than a tall building unless the land cost is high. A linear regression line was implied.

Around the same time, Steyert (1972) made a similar study in the USA. He applied a dynamic model instead of a statistical model to analyse the relationship. He concluded that different elements of a building would have different responses to the cost, when the height changed. He also suggested that the cost of some element might decrease with height. Steyert summarized two reasons for cost reduction. Firstly, there would be a learning curve effect. Secondly, the total cost of some items would increase less than proportionately with gross floor area, such as the roof and foundations.

The contrary discoveries between the UK and USA research raised attention from other scholars in the same field. Flanagan and Norman (1978) took the topic further. They used 15 office buildings more than two storeys height, which were built between 1964 to 1975. They included the 10 buildings used by Tregenza (1972). Their conclusions were that the cost per square metre decreased initially as the number of storeys increased, but eventually it would rise. The U-Shaped curve became well-known as a classic curve in the building economics field to describe the height-cost relationship. Flanagan and Norman firmly suggested that the study above was only a basic theoretical structure, and the precise nature of the impact of height on construction cost needed further investigation. Figure 1 below shows the conclusion of their study.

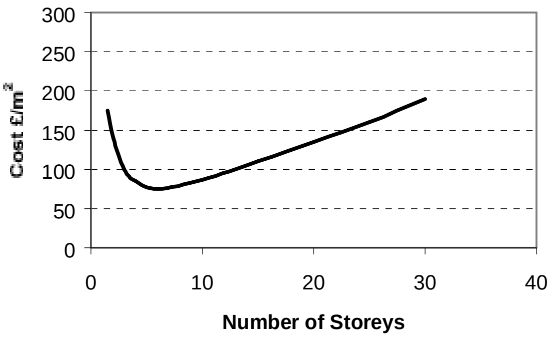

Figure 1. Cost £/m^2 of gross floor area versus number of storeys.
(Source: Flanagan and Norman, 1978)

Newton (1982) carried Flanagan and Norman’s study a step further. Although he agreed with their hypothesis, he argued that the relationship varies depending on whether it was the plan area (building footprint) or the gross floor area under consideration. Newton’s curves indicate that for constant footprint areas, the increase of height would not cause costs to increase so quickly as for the gross floor areas. Figure 2 below shows the results of his study.

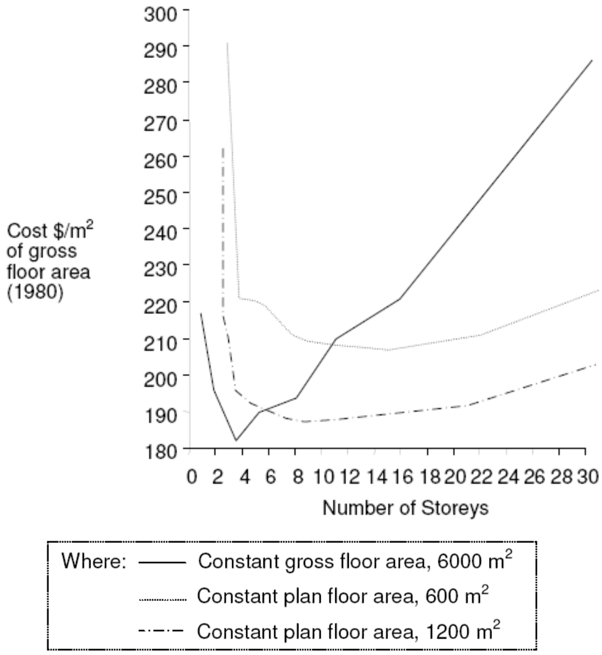

Figure 2. Selected relationships between cost $/m^2 of gross floor area and height. (Source: Newton, 1982)

The work of Tan (1999) showed how a simple analytical model could be used to determine construction cost variation with floor level. He described how cost variation with a rise in building height is not only affected by technology, and building design, but is also influenced by demand and institutional factors. Furthermore, Tan strongly recommended that finding the causes of the variation of construction cost and building height is useful for controlling costs or improving the productivity of high-rise construction. His paper contains essential mathematical method analysis. However, his work is theoretical and he does not apply his method to any data relating to actual buildings.

In recent years, research on the height and cost issue was reported by Picken and Ilozor (2003). Instead of commercial buildings, their work used cost figures from 24 residential buildings in Hong Kong completed in the early 1990s, ranging from 3 to 39 storeys. An apparently contradictory result was discovered that increasing height did not appear to cause the expected level of cost increase, showing that, based on the study's Hong Kong data, the total building cost declined until the height reaching 100m based on the study's Hong Kong data.

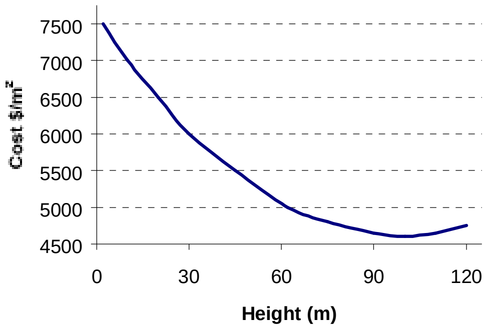

Figure 3. Cost $/m^2 of gross floor area versus height (Hong Kong data).
(Source: Picken and Ilozor, 2003)

Although Picken and Ilozor still regarded the theory of Flanagan and Norman (1978) as the guideline of studying the relationship between height-cost of high-rise building, they indicated, ‘a different set of criteria should be applied in the judgment of how height affects cost depending on the context and commonality of buildings in the location under consideration.’ (Picken and Ilozor, 2003)

Almost at the same time, Warszawski (2003) analyzed the height and cost relationship of tall buildings from two different viewpoints—those of the developer and of the dweller. 10 to 40 storey high buildings and 5 to 7 storey high buildings were used to make the comparison. The parameters were from much broader perspectives, which included the land and financing cost, risk, costs during use, and even connecting with the intangible impacts of tall buildings on scenery, open spaces, safety, and accessibility.

Lee (2005) briefly analysed the relationship of height and cost based on the Chinese situation. In China, residential buildings are separated into 3 categories based on the difference in the number of storeys—4 to 6 storeys multi-storey building, 7-9 storeys middle-rise building, and over 10 storeys high-rise building. He concluded that the impact of height on cost of building depended on all sorts of different aspects, such as building type, shape, and structure. In principle, if adding one storey does not cause a change of building shape and structural requirements, the unit rate might reduce. However, when the height reaches a critical point, for example, when the existing structure could not uphold the whole building due to the change of height, the structural requirements would change accordingly, and would cause the unit rate to increase.

When carring out the study described in this paper, the most recent research identified were published in 2007 by Jong, Oss and Wamelink (2007) and by Chau, Wong, Yau and Yeung (2007).

Jong *et al* (2007) studied the economic context of high-rise office buildings in the Netherlands by interviewing experts working on high-rise projects and cost modelling techniques. They analysed seven elemental costs and total construction cost against increases in height.

Structure, installations (building services), and elevator costs were the main factors contributing to the total cost increase with an average of 16%, 25% and 3% respectively. Site costs were also heavily influenced by height. The research discovered that eight storeys is the height of the lowest cost per square metre of the façade structure of the category 'high-rise' building in the Netherlands, in effect, the lowest point of their u-curve. They noted that 8 storeys is regarded as the starting point for the experts studying such buildings. Jong *et al.* introduced the term "high-rise-ability" and suggested that building cost is one of the important factors influencing this. They expressed the view that a good understanding of these issues is important in seeking cost reductions during the design process.

Chau *et al* (2007) examined the determination of the building height without the restrictions from the regulation in Hong Kong. Cost data for 54 residential buildings were chosen to test their module $C = C(H, FP, Q_B; \beta)$, where C is the real total construction cost of a project, H is building height, FP is footprint area, Q_B is building quality and β is a vector of unknown parameters. Their study showed that the estimating of the total construction cost is depended not only on the volume of the building (i.e. total floor area), but also on the building shape (i.e. vertical and horizontal dimensions). Additionally, they indicated that market forces can also set a limit on how height the building should be built based on the analysis of the rate of change of the marginal construction cost comparing to the marginal revenue from property sales. However, the 54 buildings were sampled from the public sector and the private sector in Hong Kong. This could cause disparities in cost. Chan and Kumaraswamy (1995) suggested that in Hong Kong, the financing of government projects experiences more rigorous control than private projects. The design deviations, and construction time variations can be effectively minimized by extending standardization and using large prefabricated assemblies for public housing estates. Therefore, the results were not as reliable as expected.

3. METHODOLOGY

This research was developed as an extension of the previous study by Picken and Ilozor (2003). Therefore, the perspective taken in this paper is the relationship between height and total construction cost. Since the previous studies were undertaken in the UK and Hong Kong, it was believed as described above, that the investigation of a third city would be valuable. Picken and Ilozor (2003) suggested that there is a need to enlarge and extend the study in order to explore the height-cost relationship further. They also advised that a larger data sample is needed together with more data on higher buildings. Therefore, their buildings from Hong Kong were included in this study. And were supplemented by a further eleven buildings. The comparison between Hong Kong and Shanghai were set out in Section 1 and identified the basis for selecting Shanghai as a city for comparison.

It is important to note that the area of this research is multi-storey to high-rise buildings. Low-rise buildings are not the main concern. However, the so-called classic U-shape curve by Flanagan and Norman (1978) suggested that the cost per m^2 falls initially with height changes from single storey to five or six storeys. Therefore, it is not necessary to define multi-storey, merely to indicate that the Hong Kong and Shanghai study described in this paper was not concerned with those height-cost phenomena associated with low-rise buildings. An example of such would be the substructure. The same substructure can be applied to a single storey building or a 2-storey building of the same plan (footprint) area. There is a point where this fall in cost would reach the lowest, when the cost per m^2 of substructure starts to reflect the need for stronger and more complex structure in higher buildings. It is this latter behaviour that was the form of the study described in this paper.

Compared to other industries, the construction and building industry is unique. No two outputs are exactly the same. Residential buildings have similar functions and structures, which reduce the variations between data. The data studied in this study were categorised as ordinary quality residential buildings. This nomenclature is taken from the Approximate Order of Construction Costs in Hong Kong of Quarterly Hong Kong Construction Cost Report September 2007 published by Rider Levett Bucknall (RLB, 2007).

The study was concerned with the analysis of the relationship between two variables—height and cost. Therefore, regression analysis was employed. Traditionally, the previous studies have hypothesised the presence of a nonlinear relationship with quadratic curved estimation, such as Picken and Ilozor (2003) and Flanagan and Norman (1978). This research also employed the specified relationship—polynomial regression (RICE, 2008). The statistical test used in this study is the Pearson product moment correlation coefficient, since the relationship between two interval level variables were examined (Corty, 2007). Two variables are considered. The independent variable X is height in metres. The dependent variable Y is construction cost (cost/m^2 = total construction cost divided by gross floor area (GFA)). The hypothesis is nondirectional, so a two tailed test is applied.

4. THE HONG KONG PERSPECTIVE

35 residential buildings were gathered and used in the analysis, ranging from 3 to 73 storeys, including number of storeys, gross floor area (m^2), height (m), and cost per square metre (HK\$/m^2). They included the 24 residential buildings investigated by Picken and Ilozor (2003). The data for the other 11 buildings were identified in Binder (2002). The buildings were completed between 1990 and 2004, and the data were taken from bills of quantities. Cost figures were adjusted to March 2007 using the Building Works Tender Price Index published by the Hong Kong Government's Architectural Service Department (HKASD, 2007). Table 1 below sets out the data that were collected for the Hong Kong study.

Table 1. Construction cost and height data for Hong Kong buildings.

Project	No. of Storeys	GFA (m^2)	Height (m)	HK\$/m^2
1	3	355	9.45	5766
2	3	753	10.72	5324
3	4	3593	10.64	5624

4	4	3590	13.85	6347
5	4	1160	15.70	8808
6	6	1880	18.28	8163
7	7	4180	27.40	5155
8	7	2047	30.00	6108
9	16	6841	43.00	4042
10	16	10330	47.30	5478
11	19	7470	53.80	6741
12	24	28130	72.96	2806
13	28	100228	94.85	10454
14	30	11329	90.00	5630
15	30	94500	101.00	7466
16	31	16265	84.45	2677
17	34	15314	98.00	6616
18	35	21121	94.10	3842
19	35	39845	167.00	13603
20	36	35288	98.50	3474
21	36	19560	107.80	5135
22	36	21831	108.50	6661
23	37	42745	111.55	3795
24	37	43258	111.55	4281
25	37	42849	112.00	3655
26	39	44678	107.35	3789
27	39	42302	108.20	3758
28	39	169950	120.00	18017
29	39	67738	135.00	8971
30	40	40780	128.00	11189
31	45	65099	178.00	17451
32	47	13277	165.00	21081
33	47	60000	183.00	11415
34	50	68948	139.00	16048
35	73	128845	251.00	19416

Figure 4 shows the graph plotted from the Hong Kong data. This is a diagrammatic representation of a quadratic regression line resulting from our preliminary studies (where $y = 0.404x^2 - 29.620x + 5944.749$ with an $R^2 = 0.510$). It can be observed that the curve is beginning to flatten as it approaches 36 metres, using a differential coefficient to calculate the bottom of the U-shaped curve.

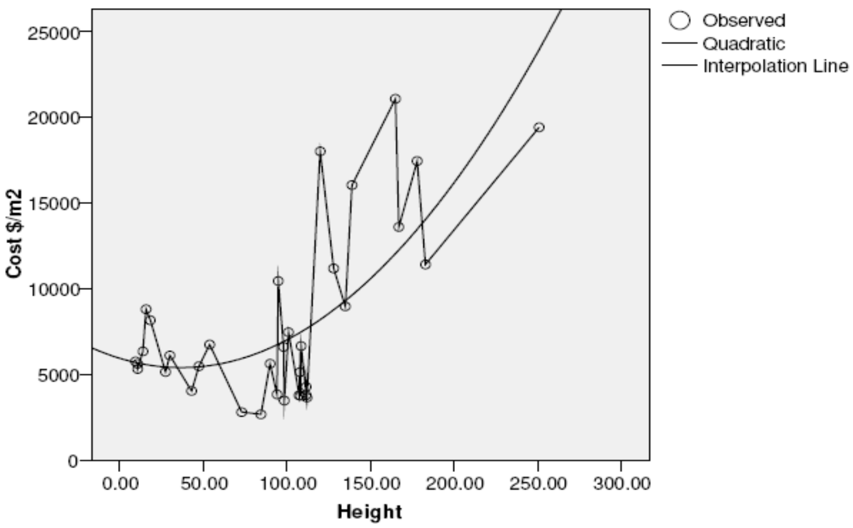

Figure 4. Cost $/m^2$ of gross floor area versus height (Hong Kong data).

5. THE SHANGHAI PERSPECTIVE

36 residential buildings, ranging from 2 to 37 storeys, were analysed. They were completed between 2000 and 2007. The data included number of storeys, gross floor area (m^2), height (m), and cost in per square metre (¥/m^2). Height and cost information is based on bills of quantities data. All the cost figures were adjusted to March 2007 values using the cost index published on SHCECI (Shanghai Construction Engineer Cost Information, 2007). Table 2 below sets out the data that were collected for the Shanghai study.

Figure 5 shows the graph plotted from the Shanghai data. This is a diagrammatic representation of a quadratic regression line resulting from our preliminary studies (where $y = 0.110x^2 - 5.334x + 1375.471$ with an $R^2 = 0.369$). It can be observed that the curve is beginning to flatten as it approaches 24 m.

Table 2. Construction cost and height data for Shanghai buildings.

Project	No. of Storeys	GFA (m^2)	Height (m)	¥/m^2
1	2	257	6.0	1558.39
2	2	283	6.6	1712.19
3	2	300	6.6	1834.56
4	2	682	6.7	1725.89
5	3	764	8.7	1897.11
6	5	3467	15.2	1090.21
7	5	2689	15.6	1141.96
8	6	2344	16.8	842.74
9	6	3329	16.8	963.98
10	6	2443	16.8	1020.35
11	6	2663	16.8	1026.26
12	6	2898	16.8	1131.00
13	6	2575	18.0	862.60
14	7	1824	21.0	1147.15
15	7	6570	24.3	865.05
16	7	4947	25.4	1719.62
17	10	3503	28.0	1288.35
18	11	7664	30.8	1167.90
19	11	7052	33.8	1151.35
20	13	9480	36.4	1248.80
21	14	7882	39.2	1479.97
22	15	8757	41.6	1820.79
23	18	12392	51.8	1611.48
24	18	6481	52.7	1149.72
25	18	9434	53.2	1443.54
26	18	19848	54.0	1622.74
27	23	18240	66.7	1318.46
28	25	17250	75.0	1641.37
29	25	105390	75.0	1764.81
30	27	12492	75.6	2206.84
31	28	54088	84.9	1630.37
32	28	29093	87.0	1744.89
33	29	32530	91.3	1859.69
34	34	35000	95.7	1785.33
35	30	74989	105.0	1808.50
36	37	131349	115.3	2134.85

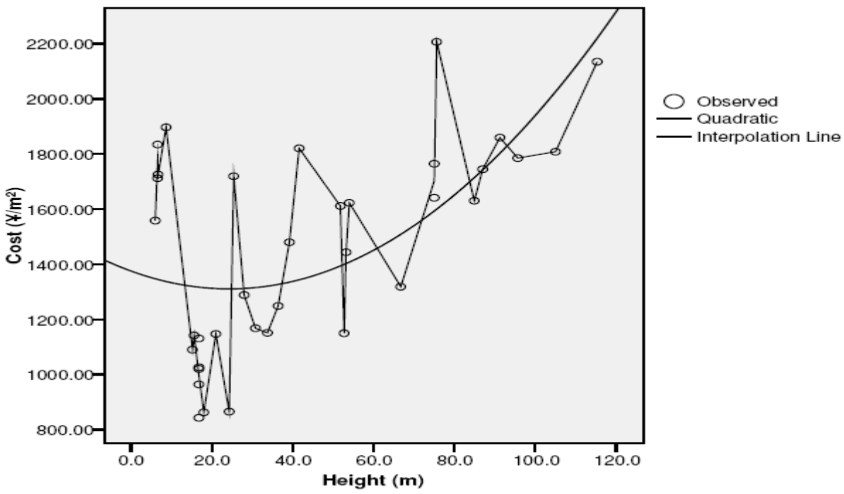

Figure 5. Cost ¥/m^2 of gross floor area versus height (Shanghai data).

6. DISCUSSION

Figure 4 and 5 show that both plotted graphs from the Hong Kong and Shanghai data follow a similar trendline. The cost per square metre initially decreases with an increase in height, eventually, the cost/m^2 starts to increase after the height reaches a certain point. In other words, every curve has a 'bottom-out' point. This result supports the conclusion from the previous research by Flanagan and Norman (1978) and Picken and Ilozor (2003). It also matches the basic building structural concept, that changes in the height of a building within a certain range do not require the alteration of specifications regarding numerous building elements.

Differential analysis shows that $\frac{dy}{dx}$ in Shanghai is 0.220, and $\frac{dy}{dx}$ in Hong Kong is 0.808. This supports the conclusion that the trendline of the Hong Kong data appears rather dramatic in its increase once it passes the 'bottom-out' point. However, based on the observation of both curves, this transition for Shanghai is much more gentle.

If we use '3 metres' as the average storey height of the residential building in Shanghai and Hong Kong (Davison, Gibb, Austin, Goodier and Warner, 2006), the lowest cost per square metre in Shanghai is around 8 storeys, however, the lowest cost per square metre (that is the bottom of the U-curve) in Hong Kong is around 12 storeys.

There are several interesting factors shown in these plots and calculations. Firstly, the different positions of the 'bottom-out' point generated from the analyses according to the locations, such as Shanghai 24 metres, Hong Kong 36 metres, and UK 5 to 6 storeys. These differences among cities supported the theory of Picken and Ilozor (2003) that a different set of criteria should be applied in the judgement of how height affects cost depending on the context and commonality of tall buildings in the location under consideration. Secondly, the scatter plot points of the Shanghai data alternate either side of the trendline. On the contrary, in Hong Kong, the scatter points are separated into two sections. One section is that buildings from 3 to 31 storeys gather at the downside of the plot. Another section is that buildings over 31 storeys assemble at the upside of the plot.

6.1 Comparison of Hong Kong and Shanghai Analysis

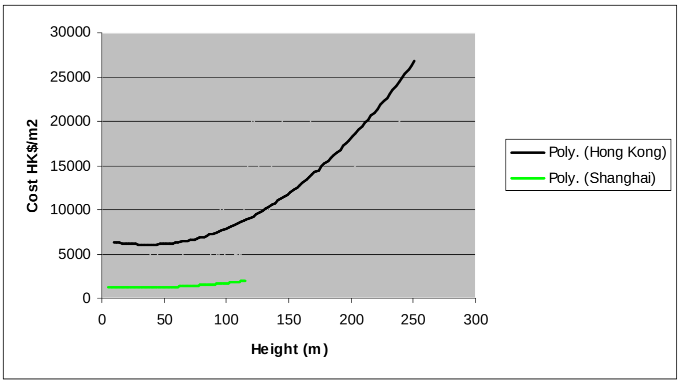

Figure 6. Cost HK$/m² of gross floor area versus height (Hong Kong and Shanghai data).

Figure 6 combines the cost data from Hong Kong and Shanghai together. The cost of Shanghai buildings ¥/m² was converted into HK$/m² using the exchange rate published by the Bank of China on 19th May 2008 (Bank of China, 2008).

The work of Picken and Ilozor (2003) identified what appeared to be some unusual relationships between height and cost. The rationale behind this research was to take their work and extend the sample with a view to reviewing their findings in the light of a larger sample. The next step was to consider the matter of another, separate urban centre which had a similar high-rise built environment and to make an examination comparing the two locations.

The possible reasons for differences between Hong Kong and Shanghai are suggested below:

- The Chinese Code for Design of Civil Buildings (2005) divides residential buildings into low-rise (1 to 3 storeys), multi-storey (4 to 6 storeys), middle-rise (7 to 9 storeys), and high-rise (over 10 storeys). Additionally, buildings under 24 metres are included in the single or multi-storey range. This leads to the appearance of the 'bottom-out' point being close to 24 metres in Shanghai. Nevertheless, no such a general rule could be found in Hong Kong.

- In Shanghai, any building over 100 metres is referred to as a super-high tower, which requires a different set of fire prevention measures for design including a refuge storey for fire escape purposes. These limitations could be the reasons why Shanghai does not have as many buildings over 100 metres as Hong Kong, especially in the residential high-rise category. Based on the 'Code of Practice for the Provision of Means of Access for Firefighting and Rescue Purposes 2004' by the Hong Kong Building Authority (2004), 30 metres is the boundary above which special fire restriction measures are required. This is closest to the 'x' value of the 'bottom-out' point from Hong Kong data analysis. There are no special regulations set up for buildings over 100 metres in Hong Kong.

- The number of 6 storey buildings in the whole Shanghai sample is relatively large. It is because 6 storey buildings are widely built in Shanghai. Lee (2005) reported that there is no regulation requiring the installation of lifts in residential buildings up to and including 6 storeys. Once a high-rise residential building is over 11 storeys, a minimum of 2 lifts should be installed (Code for Design of Civil Buildings, 2005). In Hong Kong, a more mathematical approach is applied for the calculation of the lift installations required by the Hong Kong Building Authority.

- The incidence of high-rise residential building developments is different between Shanghai and Hong Kong. Furthermore, as noted above Hong Kong is already recognized as one of the cities having so called the most compelling skyline in the world, along with Chicago and New York. However, Shanghai is only known as a city currently experiencing a major building boom involving skyscrapers. High-rise residential building has already become common in Hong Kong. Most of the public sector housing is high-rise due to the need for extremely high densities. In contrast, high-rise living is still a relatively new and, to an extent, fashionable concept in Shanghai.

- The intensity of using smaller plots and building higher is greater in Hong Kong than Shanghai, due to the various densities of these two cities. High-rise residential buildings, typically constructed in compact groups in Shanghai usually contain 10, 20, 30 or more similar buildings with a height, of less than 100 metres. Residential buildings in Hong Kong are commonly reaching heights of 60 or 70, even 80 storeys (Binder, 2002).

- Shanghai has strong support from neighbourhood provinces, such as Jiang Su and Zhe Jian. It is easy to commute between the major cities of those provinces and Shanghai. More and more people from Shanghai are moving to the major cities in the nearby provinces, and this will ease the high-density pressure. This has slowed the speed of building high-rise residential buildings in Shanghai. A similar thing has happened in Hong Kong. Due to the high cost of living, many people have moved from Hong Kong to Shenzhen. However, Hong Kong people wishing to travel to any part of mainland China (in this case a move to Shenzhen), must obtain a special pass similar to a passport, and this increases the inconvenience. Therefore, most of Hong Kong people enter into China for travelling and business, instead of living.

The differing history and current extent of property development, considered with the conflicting results found in the studies comparing Shanghai and Hong Kong also suggest that Hong Kong has a higher expertise in the multi-storey and high-rise building construction than Shanghai, which supports the theory of Picken and Ilozor (2003). The amount of expertise in multi-storey building work could generate significantly different results when comparing various locations.

7. SUMMARY AND CONCLUSION

As mentioned before, this paper is an extension of the study by Picken and Ilozor (2003). If the curves shown in Figure 5 and Figure 6 are truly representative of height-cost relationships in Hong Kong and Shanghai, some of the questions asked by Picken and Ilozor (2003) could be answered:

- Shanghai and Hong Kong exhibit similar distinct height-cost relationships. However, the profiles of the curves are different. This shows that different sets of criteria should be applied in the judgement of height affects on cost in different locations depending on the context and commonality of tall buildings.

- Hong Kong contractors have more expertise in multi-storey and high-rise construction than contractors in Shanghai.

The dissimilarities from the comparison investigated above could be contributed to by many factors, such as the history and experience in constructing residential high-rise buildings location, linkage and relationships to the neighbourhood provinces, design and construction regulations, and government policy on residential construction.

In general, as with all the other statistical studies, the collection of a larger size sample is necessary for replicating an earlier investigation. On the one hand more cases should be collected which focus on buildings higher than 100 metres in Shanghai. On the other hand, in Hong Kong, data from several sources should be assembled, and this was not available in this research.

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