Off-street residential parking organisation – a review of current practices

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Abstract: This paper is part of a research paper series which focuses on parking organisation in urban environment. It contains a review of the off-street residential parking organisation practises in 6 cities around the world namely: Bangkok, Hong Kong, London, Singapore, Tokyo and Vienna. It consists a finding that the Minimum parking space provision requirement standard is used in most cities except London. Variation in parking policies and regulations can be observed, together with different innovative measures and parking standard adjustment methods. A study to compare number of parking spaces required by different standards is carried out. This paper contains recommendation that further research in other elements of parking organisation such as residential on-street parking or destination on and off-street parking organisation should be carried out. Parking organisation is an effective ‘push’ measure to drive the current transport system towards sustainability.

Key Words: parking policy, parking standard comparison, parking management, sustainability

1. INTRODUCTION

It is undeniable that car has become a necessity rather than a luxury in many cities around the world (Kenworthy and Laube, 1999). Increases in the number of cars have contributed towards an increase in the consumption of energy and other limited resources. Space is one of such resources. The risen number of car has added pressure on demand for parking spaces, both at the trip origins and trip destinations. To ensure effective use parking space available, some forms of structured arrangement of parking space or parking organisation has been developed. Parking organisation differs from parking management in that the latter is normally used to refer to various programmes and policies that increase the efficiency of the existing parking resources. Parking organisation can be designed to provide an effective and efficient ‘push’ to deter car use and car ownership for achieving a shift away from the high energy consumption modes of transport to the lower energy consumption modes (Topp, 1994; Fujimoto, 2008).

This paper sets out a review of off-street residential parking organisation in 6 cities around the world: namely: Bangkok, Hong Kong, London, Singapore, Tokyo and Vienna. It contains reviews on parking policies, parking standards and parking space requirement rates currently in practice in these countries (Section 2). These terms can be defined as:
• Parking policy, an overall strategy that determine the objective of the parking organisation e.g. demand driven or demand controlled
• Parking standard specifies location and provision of parking space e.g. minimum parking space provision or maximum parking space allowance. It may also include other regulation or requirement of other facility e.g. bus stops.
• Parking space requirement rate, a ratio that determines the number of parking required or allowed either per residential unit or per unit’s area.

This paper is specifically dealt with the off-street residential parking organisation. It includes an outline of any unique policies and practices observed. The paper includes a comparison study of parking space requirement set by different standards (Section 3) and the categorisation of the parking standards observed in the samples cities (Section 4). It ends with a summary of the review, conclusion and recommendation (Section 5 and 6). The relationship between the sample cities’ parking organisation and transport network performance is not within the scope of this paper but will be dealt with separately.

2. RESIDENTIAL DEVELOPMENT PARKING STANDARD REVIEWS

2.1 Bangkok

Since the first automobile was imported into Thailand in 1915, the country has issued three sets of laws related to parking provision in residential developments. The first regulation was the Ministerial Regulation Number 7 issued in 1974. The regulation was an addendum to the 1936 Building Construction and Regulation Legislation Act. The regulation defined parking standards for area inside Bangkok Municipality and area within other municipalities. The boundary of these two areas was defined by 1936 Legislation Act. The standard imposed that residential buildings with floor space of more than 60m² per unit are required to provide parking spaces, turning facilities and entrance and exit points. The required parking provision rate is 1 space per 1 residential unit. The regulation contained recommendations on location and geometries of entrances, exits, turning facilities and parking bays. It also specified that parking spaces should locate within the development building or within a 200m radius distance. Access paths should be provided if parking spaces are provided outside the building.

Two other laws related to parking have been issued since 1974, the 1978 Bangkok’s Multi-storey Car Park Building Ordinance and the 2001 Bangkok Building Ordinance which superseded the 1978 Ordinance. The 2001 Ordinance only applies to buildings within Bangkok Metropolitan area; buildings in other areas are still regulated by the 1974 Ministerial Regulation. The 2001 Ordinance includes car parking standards for different types of developments and regulations on multi-storey car parks. It provides an improvement on the classification of developments from the predecessor document, for examples types of resident developments increased from two to eight (Mayor of Bangkok, 2001). However, the parking standard remains unchanged from the 1974 Ordinance. It does not take into account the development and the change in land use, public transport system and urban environment that have occurred since 1974. The current parking provision standard rate for residential development in Bangkok is show in Table 1.
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Table 1: Parking standard requirement for residential development within Bangkok

<table>
<thead>
<tr>
<th>Type of building</th>
<th>Number of parking space</th>
</tr>
</thead>
<tbody>
<tr>
<td>Development with floor space per unit more than 60 m²</td>
<td>1 : 1 unit</td>
</tr>
<tr>
<td>Development with Large Size Building planning permit (total space more than 10,000m²)</td>
<td>1 : 120 m²</td>
</tr>
</tbody>
</table>

Note:
1. Regulate by Ministerial Regulation Number 7 issued in 1974 with in Bangkok metropolitan area defined by notice number 25, 21 December 1971

It is arguable that the current standard lacks circumspection and is out-dated. The increase in urban density and land price resulted in the reduction of room size typically provided by developments, a report by Jones Lang LaSalle in 2008 shows that on average the area for 1 bedroom residential unit in Bangkok is between 44 and 55m² (Property Focus, 2008), while the smallest unit reported was 30m². This means that developments located in the centre of Bangkok which offer units with less than 60m² are exempted from the requirement to provide any parking spaces for these units. Another ambiguity of the standard is that if the development has a total floor space of more than 10,000m², it is eligible to apply for a Large Size Building planning permission, hence reducing the number of parking space required per floor space to 1:120m². This may seem like a merit as it discourages car ownership. In reality it lowers the construction cost per unit for the developers as car ownership is likely to remain the same. This is because alternative modes of transport in Bangkok cannot provide adequate incentive as a substitute to car (Kenworthy, 2000). The lower provision of car parking spaces will result in a shortage or an overspill of parking into adjacent neighbourhood.

2.2 Hong Kong

It is unclear when the first Hong Kong’s parking regulation was established but the earliest version of its ordinance can be traced back to 1952 (Hong Kong Legal Information Institute, 2010). The current Hong Kong’s residential parking standard’s objectives are expressed in the Statement of Intent of the Parking Standard 2009 which can be summarised with the following sentence: “The overall intention of the standards is to ensure that subject to road capacity considerations, future residential developments should have sufficient parking provision to match the car ownership of residents” (Planning Department of Hong Kong, 2006).

The calculation of the parking space requirement for Hong Kong’s residential developments is based on the number of residential units. It is calculated from three elements: the Global Parking Standard (1 car per 6-9 flats), Demand Adjustment Ratio (varies between 0.6 to 9) and Accessibility Adjustment Ratio (1 or 0.85). The multiplication of these three elements results in the number of parking spaces required for the development. The Adjustment Ratio values take into account flat size, allowing less parking spaces for flats with smaller size and good public transport accessibility. A 15% discount is applied to the number of required parking space if over 50% of the development area falls within a 500m radius of rail stations regardless of the topographic condition. The current standard superseded the previous zonal parking standard which resulted in an overall surplus of 82,000 parking spaces during night time in the year 2000 (Hong Kong Transport Department, 2002). The current parking standard for residential development in Hong Kong is shown in Table 2.
Table 2: Hong Kong Parking Standards for Residential Developments

<table>
<thead>
<tr>
<th>Global Parking Standard (GPS)</th>
<th>1 space per 6-9 flats</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demand Adjustment Ratio (R1)</td>
<td></td>
</tr>
<tr>
<td>Flat Size (GFA)</td>
<td></td>
</tr>
<tr>
<td>&lt; 40 m²</td>
<td>0.6</td>
</tr>
<tr>
<td>40 – 69.9 m²</td>
<td>1</td>
</tr>
<tr>
<td>70 – 99.9 m²</td>
<td>2.5</td>
</tr>
<tr>
<td>100 – 159.9 m²</td>
<td>5</td>
</tr>
<tr>
<td>&gt; 159.9 m²</td>
<td>9</td>
</tr>
<tr>
<td>Accessibility Adjustment Ratio (R2)</td>
<td></td>
</tr>
<tr>
<td>Within a 500m-radius of rail station (see Note 2)</td>
<td>0.85</td>
</tr>
<tr>
<td>Outside a 500m-radius of rail station (see Note 2)</td>
<td>1</td>
</tr>
</tbody>
</table>

Parking Requirement = GPS x R1 x R2

Source: Table11 Hong Kong Parking Standard – Section 1.

Certain exemptions are made for redevelopment in the built-up urban areas where space may constraint the provision of the parking spaces required by the standard. The standard recommended that exemptions should be grant, taking into account of the following factors:

- Distance and quality of pedestrian access to local public transport stations,
- Availability of public transport services,
- Availability of public car parks,
- Projected road capacity and traffic volumes in close vicinity and wider district,
- Feasibility of safe access points provision,
- Area and shape of the site, and
- Parking space demand and supply conditions in the vicinity.

Each district of Hong Kong is permitted to set its own district-based parking standard. The district based standard must be within the limit set by the Global Parking Standards with adjustment in according to the prevailing demand/supply conditions in respective districts.

2.3 London

The first regulation related to parking organisation in London was the London Traffic Act 1924. It did not give any specific regulations with regard to parking but it established the London and Home Counties Traffic Advisory Committee. The committee was advisors to the Minister of Transport. The act also empowered them to make inquiries and issued a number of reports into transport matters such as congestion and car-parking (Davidge, 1924).

Since 1924, the scope of the Traffic Acts cover has extended out to cover the whole of UK. There have been a total of 29 Traffic Acts and amendments since 1924, the most significant change was the Traffic Management Act (TMA) introduced in 2004. The Traffic Management Act is the government’s policy to tackle urban and inter-urban congestion on road network. However, the regulation and guidance concerning commercial and residential developments are not included in the Traffic Acts. Instead, they are covered by the planning policy of the local authorities. In London, it is the Greater London Authority (GLA) which is the administrative body for Greater London that has the responsibility to carry out a strategic planning for London.

The current objective of London parking strategy is set out in the Parking Strategy Policy (Policy 3C.23) in the London Plan 2008 which is a spatial development strategy plan for London, produced by the GLA. The policy stated that the Mayor and the borough of London
“will seek to ensure that on-site parking at new development is minimum necessary” and that there is “no over-provision that could undermine the use of more sustainable non-car mode in London” (Greater London Authority, 2008).

The current parking standard for London which is the manifestation of the policy above is outlined in the *London Plan 2008*, Annex 4. The standard specifies the maximum number of parking space allowance that must not be exceeded by developments in London and provides guidelines to determine appropriate maximum parking standard according to the Parking Strategy Policy for London Boroughs (Greater London Authority, 2008). It made allowance for the local authority to interpret the standard to suit their localities by providing the maximum parking allowance values as range values. Each borough must decide a rate of parking that is suitable for its locality, and state the preferred parking provision rate in its Unitary Development Plan (UDP). The UDP is a statutory document prepared by the local government which set out its planning policies. The UDP contains guideline for development, conservation, regeneration and environmental improvement activities within each local government area. It is however, due to be replaced by a Local Development Framework (LDF) under the planning system introduced by the Planning and Compulsory Purchase Act 2004 (Westminster City Council, 2010).

Table 3 shows the maximum car parking standards for residential development in London. The standard recommends that “public transport accessibility should be used to assist in determining the appropriate level of car parking provision, particularly for major developments” (Greater London Authority, 2008).

<table>
<thead>
<tr>
<th>Predominant housing type bed units</th>
<th>4+ bed units</th>
<th>3 bed units</th>
<th>1 – 2 bed units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car parking provision per unit</td>
<td>2 – 1.5 spaces</td>
<td>1.5 – 1 space</td>
<td>1 to less than 1 space</td>
</tr>
</tbody>
</table>

Note: All developments in areas of good public transport accessibility and/or town centres should aim for less than 1 space per unit. The needs of disabled residents will need to be taken into account in developments with low car parking provision, so that adequate spaces, either on site or convenient dedicated on-street spaces, are identified for occupants.

Source: Table A4.2 in (Greater London Authority, 2008)

In order to calculate public transport accessibility, the London Boroughs use an indicator called Public Transport Accessibility Level or PTAL. The PTAL value reflects the walking distance from a point of interest (POI) to a public transport service access point (SAP), the number of difference services passing though SAP and the frequency of the services. The indicator was initially developed by London Borough of Hammersmith and Fulham to assess commercial development parking provision proposal (Beaumont, 2002). It was adopted by Transport for London (TfL); the statutory body established by the GLA to oversee transportation system in London. TfL integrated the PTAL concept with its public transport network information and GIS capabilities and produce the PTAL map for the Greater London Area. Figure 1 shows the PTAL diagram for Greater London Area.
Figure 1: Public Transport Accessibility Level diagram for London

![Access to public transport](image)

Source: (Greater London Authority, 2008)

### 2.4 Singapore

The first road traffic regulation of Singapore was the *Ordinance 26 of 1961* or *Road Traffic Ordinance 1961* (Attorney General's Chambers, 2010). The country has since been through 37 revisions of traffic ordinances and acts. Due to its limited land area, Singapore is faced with an unavoidable challenge to control and restrain the growth of private car dependency. In the 1970s, it started to implement various traffic restraint schemes which can be classified into three groups: (Asian Development Bank, 2008).

- Measures to restrain car ownership,
- Measures to restrain car use and,
- Measures to improve traffic flow

During the 1990s, parking control was seen as a key element in Singapore transport policy, despite the failure of isolated measures to limit road or parking capacity during the 1970s. The authority imposed restriction on the provision of parking spaces on developments and buildings while actively provided and operated off-street public parking lots through the process of urban redevelopment. This resulted in excess parking space capacity while improved the traffic flow in the central area (Asian Development Bank, 2008).

The current parking policy of Singapore enforces minimum parking provisions on development to ensure that it provides sufficient parking space to meet its demand. The parking place provided is required to be located within the development area. (Development & Building Control Division Roads Group, 2005). The parking standard for residential developments in Singapore is shown on Table 5. This minimum parking provision rate takes into account the accessibility to public transport service by using a Range-base standard. The standard makes allowance for developments locate in Zone 1 and 2 a lower level of parking provision up to 20%. For this purpose the area of Singapore is divided in to three zones: Zone 1 comprises the city (Restricted Zone) and the Marina Bay, Zone 2 refers to the areas in close proximity (400m radius) of rapid transit system (RTS) stations outside Zone 1, and Zone 3 the rest of Singapore.
Table 4: Parking provision standard for residential development in Singapore

<table>
<thead>
<tr>
<th>Use Categories</th>
<th>Minimum Parking Provision Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>1 car space per 1 residential unit</td>
</tr>
<tr>
<td>Flat, non-flats, Service, Apartment and home office</td>
<td></td>
</tr>
</tbody>
</table>

Source: (Development & Building Control Division Roads Group, 2005)

Developers may provide more parking spaces than required by the parking standard to meet the demand of the site, but a deficiency charge is payable if the number of parking spaces provided is less than the parking standard’s requirement. The rate of deficiency charge per parking space below the requirement varies according to the location of the development and is shown in Table 5.

Table 5: Rate of deficiency charge per parking space provides below the standard

<table>
<thead>
<tr>
<th>Location of Development Proposal</th>
<th>Rate of Deficiency Charge</th>
</tr>
</thead>
<tbody>
<tr>
<td>i) Within Central Area</td>
<td>SG$32,000 (US$24580) per deficient car parking space</td>
</tr>
<tr>
<td>ii) Outside of Central Area</td>
<td>SG$16,000 (US$12290) per deficient car parking space</td>
</tr>
<tr>
<td>iii) Whole of Singapore</td>
<td>SG$40,000 (US$30720) per deficient lorry, loading / unloading or coach space</td>
</tr>
</tbody>
</table>

Source: own modification based on (Development & Building Control Division Roads Group, 2005)

2.5 Tokyo

Large buildings’ off-street parking spaces in Japan are regulated under its Parking Act, Article 20. The act does not enforce owners of buildings directly but empowers the local authority to carry out the enforcement. Owners of buildings with floor space of more than 2000m² and buildings classified as ‘special purpose’ including theatres, department stores and office buildings are obligated to provide off-street parking facilities. These facilities must provide adequate spaces to meet the parking demand of the building (Morikawa, 2010).

The number of parking spaces required in a residential development is defined in Tokyo Parking Ordinance. The ordinance was first issued in 1958 and the latest revision was made in 2002. The document contains the regulation on loading and unloading bays provision in new buildings, the geometry of parking facilities and parking facilities for cargo handling, the management of parking facilities, disciplinary measures of the enforcement, and the parking standard for different types of developments. The ordinance only applies to buildings located within Tokyo Metropolitan Government area. For residential developments, the ordinance provides two formulas to calculate the number of parking spaces required (Equation 1).

\[
\begin{align*}
\text{If } s & \geq 6000 \text{m}^2 \\
N &= \frac{s}{k}
\end{align*}
\]

\[
\begin{align*}
\text{If } 2000 \text{m}^2 < s < 6000 \text{ m}^2 \\
N &= \frac{s}{k} \left(1 - \frac{6000 - s}{2s}\right)
\end{align*}
\]

\[s \text{ – Net floor space of building m}^2\]
\[k \text{ – Constant value, 300 in central districts and 250 in other area}\]
\[N\text{ – No. of minimum required parking lots, the minimum value of N is 2}\]
\[\text{If } s < 2000, \text{ the development does not require to provide any parking}\]

Equation 1: Minimum No. of parking space provision require in Tokyo

The formulas take in account of the accessibility level to public transport facility by vary the constant value (k).
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Proof of parking regulation was imposed in 1950s for most urban areas of Japan. It required car owners to show a proof of ownership or lease of a parking space within 2km radius of the owner’s address at the local police station. The police then issue a Confirmation of Storage Badge permit which together with the vehicle registration documents legitimize the usage of the car on public roads. The aim of the regulation was initially to prevent the narrow residential street from clogging with parked cars.

2.6 Vienna

The current parking provision standard for resident development in Vienna is outlined in the Vienna Garage Regulation (City of Vienna, 2008), first issued in 1957, the document was last revised in 2008. The regulation imposes that new constructions and additional developments must provide parking spaces in accordance with the parking standard, failing to do so will result in compensatory payment to the City of Vienna. The maximum penalty payable is EUR 18,000 per parking space. An exemption from the standard is possible for redevelopment in the inner city area or area which physical constraints prohibited the provision of required space, in such case a reduction of 90% from the standard’s value is applicable (City of Vienna, 2008). The parking spaces provided must be retained for 20 years from their commencement. Application can be made to the authority for the change of use after this period is fulfilled.

Table 6: Parking provision standard for residential development in Vienna

<table>
<thead>
<tr>
<th>Type of unit</th>
<th>space per unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apartment (Wohnung)</td>
<td>1:1</td>
</tr>
<tr>
<td>Residential home (Beherbergunsbetriebe)</td>
<td>1:5</td>
</tr>
<tr>
<td>Residential development (Heimen)</td>
<td>1:10</td>
</tr>
<tr>
<td>For developments with 30 or more room 1 bus stop is required</td>
<td></td>
</tr>
</tbody>
</table>

Source: Wiener Garagengesetz (City of Vienna, 2008)

Vienna parking space management system was introduced in 1994. The scheme proposed a reduction in long-term parking and parking spaces available in the central districts (1-9th and 20th districts). The Vienna garage program was simultaneously developed, resulting in the creation of 160 commercial garages with around 50,000 parking spaces (Stadtentwicklung Wien, 2003).

Since the beginning of the scheme’s implementation in 1993, free public parking spaces have been completely removed from the central districts (district 1-9th and 20th). On-street parking can only be used for short term, loading, and residential parking. Other long term parking must utilise the off-street parking facilities. The scheme contributed significantly toward an improvement of residential parking situation, the daytime (morning) occupancy rate decreased by around 25% and the evening time by 10%, increased of parking turnover rate, shortened of average search time from nine to three minutes, and illegal parking level became insignificant (Asian Development Bank, 2008).

3. PARKING STANDARDS COMPARISON

An empirical analysis was carried out to compare the parking space requirement standards of the sample cities. Each city’s parking standard was used to calculate the highest and lowest numbers of require parking spaces (or parking spaces provision range) for developments with a varying amount of residential units. The calculations’ assumptions are detailed in the following paragraphs while the results of the analysis are shown on Figure 2a and 2b.
Bangkok’s parking spaces provision range included the rate for buildings with *Large Size Building* planning permit. The rate only valid for developments with total net floor space more than 10,000m²; hence the graph for Bangkok’s lowest number of parking space requirement commences from developments with 167 units onward. It should be noted that the conversion between the net floor space and the number of residential units for Bangkok assumes an average floor area per unit of 60m².

To calculate London’s parking spaces provision range, it is assumed that the average number of beds per residential unit is 1.7. This value is an average number of bedrooms of properties sold in London during 2008 reported by Nationwide Bank, UK. The highest maximum car parking space provision per unit is therefore 1 space per 1 unit, and the lowest value is zero parking space per unit.

Hong Kong’s highest number of parking spaces required by its standard is calculated with assumptions that the GPS value is 1 parking space per 6 flats, the demand adjustment ratio is 9 (for flat size of more than 159.99m²), and the accessibility adjustment ratio is 1. The lowest number of parking space requirement calculation assumes the GPS value of 1 parking space per 9 flats, the demand adjustment ratio of 0.6 (for flat size smaller than 40m²), and the accessibility adjustment ratio of 0.85.

Singapore’s highest number of parking spaces required by its standard are calculated with an assumption that the development is located outside the 400m cordon of the nearest rapid transit system station. The lowest require parking spaces’ calculation assumes the development is located within the cordon, hence received 20% parking spaces requirement reduction.

To calculate Tokyo’s parking spaces provision range, an average floor area value of 64.5m² per unit was used to convert Tokyo’s parking standard rate that based on parking space per area to parking space per unit. The value used is an average size of house in Tokyo Core area obtained from 2003 Housing Data (Ministry of Internal Affairs and Communications, 2005). The highest parking spaces require values are calculated with an assumption that the developments’ locations are within the central districts. The lowest values are calculated with an assumption that the developments’ locations are outside the central districts.

Vienna’s highest number of parking spaces required by its standard is calculated with an assumption that the developments locate outside the inner city area. The lowest required parking spaces’ calculation assumes developments’ locations are within the inner city area, hence they are eligible for 90% parking spaces requirement reduction.
It can be observed from Figure 2a that the number of development units and parking spaces required has a positive linear relationship for all cities. Figure 2b provides a more closed-up illustration of the relationship between developments and number of parking space required for developments with residential units below 50.

Figure 2b: Graph showing a close-up illustration for development with 50 and less residential unit.
The closed-up illustration of the graph in Figure 2b shows that the rates of increase for many parking space requirement values are fluctuating. These inconstant rates of increases are due to the rounding up errors of the calculations which was set to round the figures up to the nearest integer (to the nearest 1 parking place). The rate of increase for Bangkok’s, London’s, Singapore’s, and Vienna’s highest requirement values are not fluctuated as their rates of parking spaces required per unit have no rounding up errors. The extracts of the calculation results for developments with 20, 50 and 200 residential units are shown Table 7.

Table 7: Extract of the lowest and highest number of parking spaces requirement by the parking standards of the sample cities

<table>
<thead>
<tr>
<th>No. Of unit</th>
<th>20 Units</th>
<th>50 Units</th>
<th>200 Units</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lowest</td>
<td>Highest</td>
<td>L:H Ratio</td>
</tr>
<tr>
<td>Bangkok</td>
<td>20</td>
<td>20</td>
<td>1.00</td>
</tr>
<tr>
<td>London</td>
<td>0</td>
<td>20</td>
<td>n/a</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>2</td>
<td>30</td>
<td>15.00</td>
</tr>
<tr>
<td>Singapore</td>
<td>16</td>
<td>20</td>
<td>1.25</td>
</tr>
<tr>
<td>Tokyo</td>
<td>0</td>
<td>0</td>
<td>n/a</td>
</tr>
<tr>
<td>Vienna</td>
<td>2</td>
<td>20</td>
<td>10.00</td>
</tr>
</tbody>
</table>

The result from Table 7 shows that parking spaces requirement for Hong Kong is the lowest and the highest possible. This also reflects in the highest value of ratio between the lowest number and the highest number of parking spaces requirements (L : H Ratio). However, this alone cannot be used to conclude that Hong Kong’s parking standard required the highest number of parking space as the highest and lowest parking requirement values were calculated assuming extreme and single flat size values, when in reality a residential development tends to have more variations in unit size.

4. CATEGORISATION OF RESIDENTIAL PARKING STANDARD

In this section categorisation of the residential parking standards observed from the reviews is carried out. It yielded 4 different types of organisation described below and summarised in Figure 3:

Type A: Maximum parking provision standard.
London is the only city in the sample that fit into this category. This type of parking standard imposes maximum or capped number of parking spaces allowable on the development.

Type B: Minimum parking provision requirement standard with adjustment ratio
Singapore and Hong Kong are the two cities that fitted into this category. Minimum parking provision requirement standard imposes the number of parking spaces that must be provided on the development. It is normally employed in response to a parking policy that emphasise on the importance of providing sufficient parking space to meet the demand in developments. This type of organisation however, recognises the influence of the flat size or household size and the accessibility level of public transport have toward the demand of parking space. It provides adjustment ratios to reduce the amount of car parking spaces require based on the fulfilment of set condition (i.e. 15% reduction of car parking spaces is eligible, if the development locate within 500m radius of a railway station – Hong Kong).
Type C: Minimum parking provision requirement standard with no adjustment ratio, low rate
The third category is similar to Type B. The development is obliged to provide a minimum number of parking spaces which calculated from either number of units (Vienna) or total net area of the development (Tokyo). The difference is that this type of organisation does not provide adjustment ratios according to the unit size or public transport accessibility.

Type D: Minimum parking provision requirement standard with no adjustment ratio, high rate
This last category is similar to Type C but its high rate of parking space provision distinguished them apart. The rate of parking space per residential unit observed in Bangkok is 1 parking space:1 unit (1 parking space:60m²) which is nearly 5 times more than that of Tokyo (1 parking space:4.3 units or 1 parking space:300m²) and 10 times more than Vienna’s lowest value (1 parking space:10 unit).

![Figure 3: Categorisation of parking organisation observed in sample cities](image-url)
5. SUMMARY AND CONCLUSIONS

This paper reviews the off-street residential parking organisation currently practice in 6 cities. The summary of this review is shown in Table 8. The provision of parking spaces in residential developments in most cities except London, are controlled by the minimum provision parking requirement. In London the number of parking space provides must be below the maximum number set by the standard.

Table 8: Summary of residential parking policy reviewed

<table>
<thead>
<tr>
<th>City</th>
<th>No. Of parking place provided is controlled by</th>
<th>Adjustment of parking space require based on</th>
<th>Deficiency penalty payable</th>
<th>Requirement on the location of parking space provide</th>
<th>No. Of parking space per unit / Area</th>
<th>Other measure / Note</th>
<th>Year that first parking related issued</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bangkok Thailand</td>
<td>Minimum</td>
<td>No</td>
<td>No</td>
<td>1 : 1 for unit with more than 60 or 120 m²</td>
<td>n/a</td>
<td>1974</td>
<td></td>
</tr>
<tr>
<td>Hong Kong PRC</td>
<td>Minimum</td>
<td>Yes</td>
<td>Yes</td>
<td>within the development</td>
<td>n/a</td>
<td>1952</td>
<td></td>
</tr>
<tr>
<td>London U.K.</td>
<td>Maximum</td>
<td>Yes</td>
<td>No</td>
<td>less than 1-2 unit per space (depending on No. of bedroom of unit)</td>
<td>public transport accessibility assessment using PTAL value</td>
<td>1924</td>
<td></td>
</tr>
<tr>
<td>Singapore</td>
<td>Minimum</td>
<td>No</td>
<td>Yes</td>
<td>within the development</td>
<td>n/a</td>
<td>1961</td>
<td></td>
</tr>
<tr>
<td>Tokyo Japan</td>
<td>Minimum</td>
<td>No</td>
<td>Yes</td>
<td>depending on total net floor area</td>
<td>confirmation of Storage Badge permit</td>
<td>1952</td>
<td></td>
</tr>
<tr>
<td>Vienna Austria</td>
<td>Minimum</td>
<td>No</td>
<td>No</td>
<td>not specified</td>
<td>1 : 1</td>
<td>provision of 1 bus stop per development that has more than 30 units</td>
<td>1957</td>
</tr>
</tbody>
</table>

Hong Kong, London and Singapore employ different methods to take into account the size of the residential unit or accessibility to public transport or both. In London, the use of Public Transport Accessibility Level (PTAL) was observed, in Hong Kong Demand and Accessibility Adjustment Ratios were used, in Singapore the required parking space is reduced by 20% if the development locate within 400m radius from a Rapid Transit System station (Zone 2) or within a Restrictive zone (Zone 1).

It is observed that there are relationships between parking policy and parking standard. For instance, the objective of London’s parking policy is to ensure that “there is no over-provision of parking space” and that “the provision will not undermine the use of other more sustainable modes of transport.” London parking standard controls the maximum number of parking allowable for each development and take into account both the flat size and the level of public transport accessibility. In contrary, Bangkok, Hong Kong and Singapore’s parking policies emphasis on sufficient provision of parking spaces on developments. Their standards reflect their policies as they enforce the provision of minimum parking spaces requirement.

The specifications on the location of parking spaces provided is observed to be difference across the sample cities, in Hong Kong and Singapore parking spaces must be provided within...
the developments. Bangkok and Tokyo allow parking spaces to be provided within certain distances, while in London and Vienna the distances are not specified.

The parking standard in most cities is based on the number of residential units. Only in Tokyo and Bangkok (rate for building with Large Size Building permit) that the rate are calculated from the total area of the development.

An empirical study was carried out in order to compare the parking standards of the different cities. Figure 2a and 2b show the result of the analysis; the relationship between number of residential development units and the number of parking spaces required by the standards of different cities. The highest and the lowest parking spaces requirement values for each city were calculated.

The review records unique features observed in the parking organisation of the sample cities. In Singapore and Vienna, a penalty for each parking deficiency space from the requirement is payable. It is a mandatory in Tokyo to provide a proof of parking space ownership or lease contract in order to obtain legitimate right to use public road. In Vienna, developments with more than 30 residential units must provide one bus stop within the development’s proximity. In London, the level of car parking spaces provision for residential development in some boroughs is set according to the Public Transport Accessibility Level (PTAL). The indicator reflects the accessibility by walking to the nearest public transport service access point and the frequency of service serving the access point.

The review categorised the residential development parking standards observed in the sample cities into four different types: Type A: Maximum parking provision standard, Type B: Minimum parking provision requirement standard with adjustment ratio, Type C: Minimum parking provision requirement standard with no adjustment ratio, low rate and Type D: Minimum parking provision requirement standard with no adjustment ratio, high rate

6. RECOMMENDATIONS

This paper only presented parts of the parking organisation of the 6 cities reviewed. Future research should include more samples and other elements of urban parking organisation to gain a complete understanding of the influence parking organisation has toward the urban transportation system. Large sample size will allow trends analysis to be carried out. Figure 4 depicted the elements within urban parking organisation and highlights the area that this paper covers.

![Figure 4: Parking organisation at origin and destination](image-url)
The knowledge in the parking organisation field is currently limited in comparison to other areas of transport research. Most research efforts in this field are directed toward studying the behaviour of moving car. It is as if an assumption was made that private vehicle would magically appear at the origin and vaporise at the destination of a trip (Shoup, 1997). Parking organisation has a potential to drive the current transport system towards sustainability rather than just a measure to meet an ever increasing parking space demand or to ensure effective use of parking space in urban areas.

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