

The Impact of Use-based Categorization in Building Control on Architecture Design of Buildings - A Study of Hong Kong

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Abstract

Under current Hong Kong building control regulations, all buildings are classified as domestic or non-domestic, which imposes control barriers to any mixed-use or merged-use buildings. Furthermore, the profit-oriented market in HK always pushes building design to follow regulations tightly. Design innovations are thus limited and sacrificed for the maximization of development potential. This paper will investigate the principles of use-base categorization in building regulation control and its impact on the architectural design of buildings. Regulation review and comparative data analysis are used as methods. The study uncovers key control aspects and variables in current HK building control and proposes recommendations in code making.

Keywords: use-based code making, building control, domestic building, non-domestic building

1. Introduction

1.1 Building control

1.1.1 Origin of building regulations

The statement of “form follows function” by Louis Henri Sullivan declares the key principle of ideology of modernism in architecture in 1930s. However, when the buildings are significantly valued as commodities in a highly commercialized society, the “form will then follow finance” (Willis, 1995). Such diversion will lead a distinctive inflection to building designs. In a high commodity-based economy society like Hong Kong, the buildings are highly endowed with excessive commercialized identities. Thus, architecture design becomes so vulnerable under such conditions, and it is further interpreted as the case of “form follows building control” (Wong, 2002). Such excessive influence of finical considerations has to be limited; otherwise there is only freedom from the economical power but no control for the public concerns in building designs. What indeed in the building control that makes such critical restrictions to architecture design, and how to improve the building controls accordingly? To find out the answers, this research paper will investigate the principle of current occupancy-based categorization in Hong Kong building control, and its impact on the architecture design of buildings. It will uncover the relationship between architecture design and building regulation controls, and identify the key reasons of the problem in contemporary HK context. Furthermore, recommendations would be made.

Building control was originated to protect the safety of human life and property. Hammurabi’s Code of Laws (1750 BC) stated this principle thousands of years ago. In Code No. 229 of the laws, it states, “If a builder builds a house for someone, and does not construct it properly, and the house which he built falls in and kills its owner, then that builder shall be put to death.”

Historically, people have learnt lessons from failures and disasters that happened to buildings. Knowledge and experiences was accumulated, and it formed the foundation of a building control system. Today, building control typically includes both building regulations as a main component and building administration as a support part. There have been many means to implement building control in history. Building occupancy is widely used in many current building legislation systems, and it has a history of over 100 years in Hong Kong. In current building ordinance (2009), two types of buildings are identified: domestic buildings and non-domestic buildings.

1.2 Architecture design of building

Architecture design includes site planning, building layout/space design, environmental design and specific designs. Additionally, it is a base that supports human activities, coordinating with people’s lifestyles, work, and entertainment. New building types, refreshing concepts and original programming are introduced and reflected in design experiments. Architecture design is controlled by building regulations for certain objectives such as safety, health and density.

2. Building control

This study will not take its approach from the perspective of traditional building occupancy classifications. Instead, a review of origins of building law leads the research to a new approach of re-classification of building controls with three major aspects: building density control, building safety control and building environmental health and sustainable design control.

2.1 Building control on density

2.1.1 What is density?

Density is defined as mass per unit volume. In the planning or building field, density is defined as a measure of the number of people living in a given area, the number of buildings, dwelling units, land uses, modes of transportation, connections, etc. within a prescribed area.

Population intensity is usually measured as the number of persons per hectare. At the macro city planning level, it is an important variable that controls a prescribed area with planned population. At the micro level, such variables help to provide reference data for city infrastructure design such as transportation, urban space, etc. Hong Kong, with an average population density of about 6400 people per square kilometre, is one of the densest cities in the world.

Building density represents the denseness of buildings in a prescribed area. Typically, two control variables regulate buildings: the floor area or plot ratio and the building coverage ratio (BCR). As stated in Hong Kong's building regulations (2006), the plot ratio of a building shall be obtained by "dividing the total amount of gross floor area of the building by the area of the site on which the building is erected." BCR is also known as "site coverage or lot coverage." It controls the horizontal extension coverage of the built-on-site structure. The formula for plot ratio and site coverage is as follows:

Plot Ratio = Maximum permissible gross floor area/site area

Site Coverage = The covered area from the building/site area

As cities grow denser in urban areas, the concerns of nature, environment and living quality become crucial. As a result, new concepts of "green/landscape density," "water density" and "open space provision intensity" have been created and have become important variables in building control.

2.1.2 How to enforce building density control

2.1.2.1 Historical development of building density control

Historically, as Wong (2003) summarized, there have been three levels of development control: land lease, planning and building.

The earlier development control was mainly focused on land layer and was carried out through the land lease conditions that covered land-related issues such as forms of indenture, conditions of sale, exchange, grant, tender and re-grant (Nissim 1998). The first city planning blueprint was brought to the HK government by Surveyor Gordon in 1843. He suggested that the city centre be divided into different zones for residential, administrative, and commercial use. In 1935, a Town Planning Office was established, and four years later on June 30, the Town Planning Board was appointed and the City Planning Ordinance was published. Hong Kong had been a colony since January of 1841, and since that time there had been two major phases in the development of building control. The first phase from 1841 to 1955 was a stage of original exploration in building control with few control ordinances published. The second phase started in 1955, with the formation of the Building Ordinance (1955), which set the foundation for the current building control system.

The first Building and Nuisances Ordinance was published in 1856 in HK with 19 clauses regulating issues of building definition, construction material and requirement, structure and fire safety, health issues, maintenance, and surveying concepts. In the Building Ordinance of 1889, overcrowding was defined as less than 300 cubic feet of living space per person. Thus, the control of density based on building bulk was established.

The Building Ordinance of 1955 formed the basic foundation of the current building regulation mechanism. Together with three other important regulations, Building (Administration) Regulations, Building (Construction) Regulations and Building (Planning) Regulations (1956), the Hong Kong building development and design control system was established. In the Building Planning regulations (1956), building density control was kept as building bulk control, which was subject to the site area, site conditions like open spaces and lanes, building height, volumes, and building usage.

The formula was as follows: $\text{Volume} = \text{Factor (F)} \times \text{Street Width} \times \text{Site Area}$.

The factor (F) differed according to the site usage. In 1962, the building control through building bulk was changed to plot ratio and site coverage. These systems are still being used in current building control system.

2.1.2.2 Building density control in the current building legislation mechanism

The following introduction will present a few key building control variables that are widely used in Hong Kong's current system.

- Site Classification

According to HK Building (Planning) Regulations, the first priority of all building control variables is site classification. Three types of sites are identified as Class A, B and C sites based on abutting street conditions. Generally, Class A sites are less accessible to the public than class C sites.

- Site/Building Occupancy

Building occupancy is the second important control variable in Hong Kong's building control system. Once a site is classified, the site coverage, plot ratio, and building height are all defined according to building occupancy. Occupancy groups are classified as either domestic buildings or non-domestic buildings.

- Site Coverage

Site coverage refers to the area of the site that is covered by the building that is erected thereon, and, when used in relation to a part of a composite building, refers to the area of the site on which the building is erected that is covered by that part of the building (2006). The concept of this variable is, on one hand, to formulate an important part of building density control, and on the other hand, to provide a direct control of the building in relation to the site.

- Building Overall Height/Floor to Floor Height

Building height is a variable that controls vertical density of a building. The overall building height is usually controlled by a land lease at the planning stage. HK building ordinance also regulates the floor height as not less than 2.5 m for habitation and office use floors.

- Set Back and Open Space

Set back and open spaces are designed to control the building's external space in the immediate surrounding environment. Furthermore, they ensure the minimum openness and building distance in regard to fire prevention.

- Plot Ratio

As previously explained, plot ratio is a given numerical value according to site classification, building occupancy, and building overall height. Figure 1 below shows the plot ratio and site coverage requirements based on site classifications and building occupancy groups.

First Schedule of Percentage Site Coverages and Plot Ratios												
Height of building in metres	Domestic buildings						Non-domestic buildings					
	Percentage site coverage			Plot ratio			Percentage site coverage			Plot ratio		
	Class A site	Class B site	Class C site	Class A site	Class B site	Class C site	Class A site	Class B site	Class C site	Class A site	Class B site	Class C site
Not exceeding 15 m	66.6	75	80	3.3	3.75	4	100	100	100	5	5	5
Over 15 m but not exceeding 18 m	60	67	72	3.6	4	4.3	97.5	97.5	97.5	5.8	5.8	5.8
Over 18 m but not exceeding 21 m	56	62	67	3.9	4.3	4.7	95	95	95	6.7	6.7	6.7
Over 21 m but not exceeding 24 m	52	58	63	4.2	4.6	5	92	92	92	7.4	7.4	7.4
Over 24 m but not exceeding 27 m	49	55	59	4.4	4.9	5.3	89	90	90	8	8.1	8.1
Over 27 m but not exceeding 30 m	46	52	55	4.6	5.2	5.5	85	87	88	8.5	8.7	8.8
Over 30 m but not exceeding 36 m	42	47.5	50	5	5.7	6	80	82.5	85	9.5	9.9	10.2
Over 36 m but not exceeding 43 m	39	44	47	5.4	6.1	6.5	75	77.5	80	10.5	10.8	11.2
Over 43 m but not exceeding 49 m	37	41	44	5.9	6.5	7	69	72.5	75	11	11.6	12
Over 49 m but not exceeding 55 m	35	39	42	6.3	7	7.5	64	67.5	70	11.5	12.1	12.6
Over 55 m but not exceeding 61 m	34	38	41	6.8	7.6	8	60	62.5	65	12.2	12.5	13
Over 61 m	33.33	37.5	40	8	9	10	60	62.5	65	15	15	15

Figure 1: First schedule of percentage SC and PL (HK Building Regulation, 2009)

- Control on Floor Area

As reviewed earlier, building density control in HK was first carried out through building bulk control and then transferred to plot ratio and site coverage in the Building (Planning) (Amendment) Regulation of 1962. Such changes led to more specific controls in building density. The earlier building bulk control did not pose enough requirements on internal spaces, particularly the vertical layers of floors. In fact, people use the building more in horizontal manners. The new plot ratio and Gross Floor Area GFA control focused more on built floor areas rather than building bulk, which created a close and reasonable linkage to people's activities in relation to building spaces. Such changes can be viewed as a milestone that transfers building density control from a simple physical construction level to a more complex human behaviour level.

- Control on Projections and Surfaces

Current building regulations also include controls on building projections such as eaves, cornices, balconies, verandas, canopies, bay windows and etc.

2.1.3 Discussions

2.1.3.1 Structure of building density control

The diagram below summarizes key building density control variables in Hong Kong's current system. All variables can be classified into two categories within a clear hierarchical structure: quality control variables and quantity control variables.

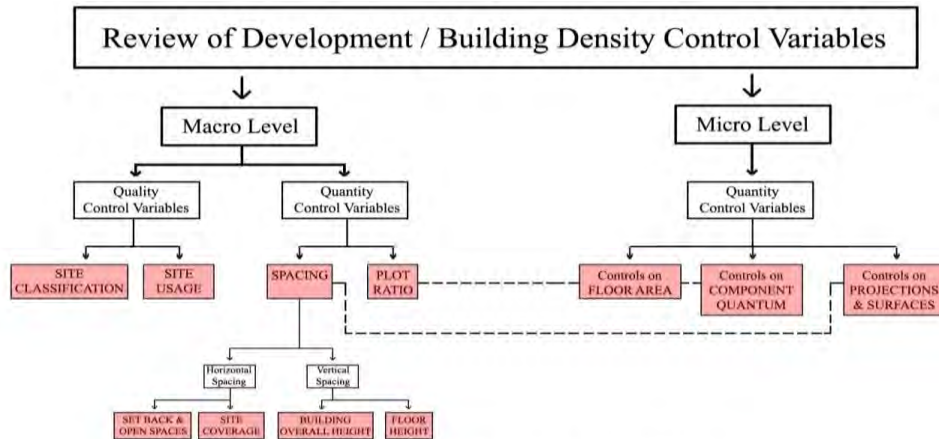


Diagram of Hierarchical Analysis of Density Control Variables

Figure 2: Diagram of hierarchical analysis of density control variables

At the macro level, both quality control and quantity control are enforced. The two main variables in quality control, site classification and site usage or building occupancy, link control from a planning level to a building level. In quantity control, the built up quantum and spacing to surroundings are controlled through site coverage, set backs, and the overall building height. At the micro level, controls on the internal content of the building, such as floor area, component quantum and projections are regulated.

2.1.3.2 The objective of density control and the implementation tools

In residential buildings, for example, the original objective for density control in domestic buildings is to limit the dweller population and maintain good liveable conditions. However, such goals have not been maintained very well throughout the history of building control development. As the city grew faster and denser, controls on either built bulk or built floor area could not control the habitant population without enforcing a clear minimum standard for individuals. The earlier code in the 1900s required a minimum of 300 cubic feet of living space per person. However, with more dwellers, denser build-up structures and heavier rentals, such controls were becoming tighter and tighter. In the 1950s and 1960s, it dropped to around 34 square feet per person, while now, no clear requirement is enforced. Building authorities want to control building density through plot ratio and GFA. Furthermore, they wish to control the people and activity density by modifying building density with plot ratio and GFA. However, this did not work very well as Chan and Wong analyzed (2001). Using

building space to control the geographical distribution of the population is a very indirect mechanism. It is hard to direct people's residences in a free society.

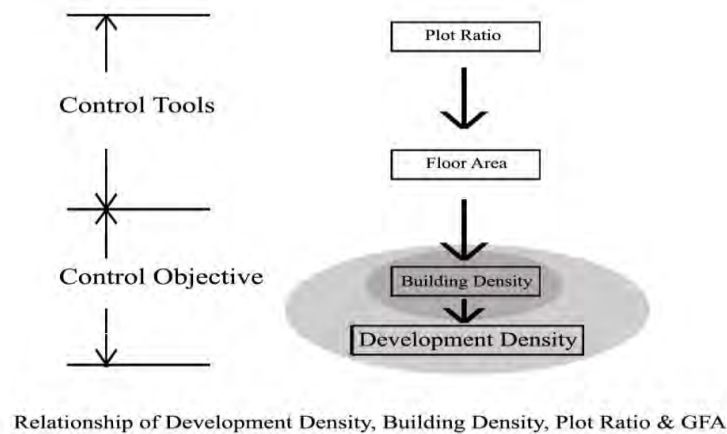


Figure 3: Relationship of development density, plot ratio and GFA

In dense areas, controls on minimum space/area for a habitant need to be established to secure the basic living quality. In other building types with large numbers of users, similar conditions apply. In general, plot ratio and GFA can be used in building density control, particularly in the physical aspect of buildings. However, despite building occupancy differences, it is very indirect to use such variables to control the building occupants' population intensity and their activity density. A possible solution is to further regulate minimum space/area for single occupants based on different building occupancy characters. By raising the concern of building occupation conditions, the current building control strategy would be diverted from a "use-based" to a "user-based" concept. Furthermore, this could also make the predefined building occupancy more flexible and transferable after building occupation.

As an overall conclusion, building density control has a very strong impact on architecture design of buildings, but the building occupancy classification is not a very good base in code making for the building density concerns.

2.2 Building control on safety

2.2.1 What are the building safety issues?

Basically, building safety control has three major concerns: disaster-safety concerns, such as safety protection from fire, earthquakes, floods, and even terrorist attack etc.; user safety concerns, such as skid-proof design, safety designs for the handicapped, handrails and other building-elements etc.; and management-safety concerns, such as security control, maintenance safety etc.

2.2.2 How to enforce building safety control

2.2.2.1 Disaster safety control

Fire safety, as one of the most prevalent concerns in disaster safety, will be addressed in this study. There are two principles in fire code writing: to secure people's lives, including the building occupants, fire fighters and neighbours; and to protect the property and the neighbours' property from fire. Typically, a fire code will address three aspects in code writing: prevention of fire, evacuation of people, and fire fighting.

Prevention of fire occurrences in building control does not impose many requirements on the building plan layout. It is more focused on construction, mechanisms and materials. Prevention of fire expansion requires some building controls in space design/plan layout to ensure that the building has a certain resistance to the spread of fire.

In evacuation of people, two issues are important: means of egress and occupant load. The concept of means of egress provides a continuous and unobstructed safe channel for building users to exit from the building to safe areas (or safer parts of the building, like refuge floors in sky-rise buildings) in fire or other emergency cases. The safe channel includes three parts: the exit access, the exit, and the exit discharge. It is important to have a clear building occupant population and its peak limit before designing a building egress system. The design reference for occupant load is interpreted as minimum floor area per person in code writing. Furthermore, the occupant status and their familiarity to the building are also considered in code writing. For example, as required in HK fire code (Building Department 1996), the refuge floor for high-rise buildings should be provided in all buildings exceeding 25 storeys. However, for domestic buildings, such requirements could be up to 40 storeys if there is a roof refuge. This is because the building dwellers here are considered to have a greater familiarity to the building in which they live, which would reduce evacuation problems. Occupant load also affects the architecture design of buildings. Three aspects in the building exit system are controlled: the number of exits; the egress capacity like the egress minimum width and maximum amount of people; and the arrangement of exits, which is reflected in the controls of travel distance, compulsory optional exit provisions and access, dead-end spaces, and common path etc.

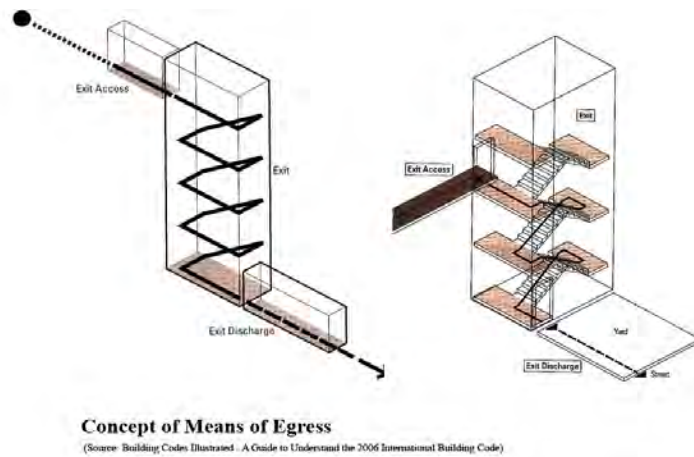


Figure 4: Safety channel design in fire control (Source: Building Codes Illustrated, 2007)

Fire fighting is mainly conducted by firemen. So, the building occupancy has little impact on this issue.

In addition to fire-safety, building control also has other disaster-safety concerns that affect the building design. Hong Kong's building authority requires that projects located in certain areas of central HK island need a registered geographical engineer as a professional consultant. Building codes in Japan and some of China's cities have controls on earthquake safety.

2.2.2.2 Control on user safety and management safety

Disaster safety is mainly focused on emergency circumstances, while user safety and management safety are focused more on the safety issues of a building's everyday usage. In both aspects, the architectural design is regulated. However, the building occupancy is not the first concern in code writing for the safety issues of the above two aspects. In fact, the user-based concept is more frequently applied; for example, accessibility control in building design.

2.2.3 Discussion

In this section, building safety control is discussed based on two scenarios: the emergency circumstances and the normal daily usage and management. The first scenario is mainly addressed through cases of fire safety control; while the second is highlighted by the issues of accessibility, materials and designs. The following diagram summarizes building controls on materials, designs and planning.

Scenarios \ Considerations		Prevention Controls on			Evacuation Controls on		Controls on Salvation		
		Materials	Designs	Planning	Materials	Designs	Materials	Designs	Planning
Emergency Circumstances	FIRE-Safety	Yes	Yes	Yes	No	Yes	No	Yes	Yes
	EARTHQUAKE-Safety	No	Yes	Yes	No	No	No	No	No
	COAST-Safety	Yes	Yes	Yes	No	No	No	No	No
	TERRORIST ATTACK Safety	Yes	Yes	No	No	Yes	No	No	No
		Building Controls on							
		Materials	Designs	Planning					
Daily Usage & Management	ACCESSIBILITY	Yes	Yes	Yes					
	BUILDING-ELEMENT Safety	Yes	Yes	No					
	MANAGEMENT Safety	No	Yes	Yes					

Figure 5: Building safety control variables in building regulation

2.2.3.1 Controls for emergency circumstances

Fire safety control has three key considerations in the occurrence of a disaster: prevention, evacuation and salvation.

For prevention, building codes mainly focus on the control of materials, designs and planning. The objective is to protect everyone from each other. Therefore, at a planning level, building setbacks and material controls are used; at the building design level, controls on fire zones, occupancy separations etc. are used. For evacuation, the building code focuses on the design of “safe channels” for the occupants. Accessibility, content capacity and protection time limits of the channel are required. For salvation, building codes have special requirements for fire fighters’ operations. Some of these codes could be shared with evacuations while some are separated from the first two provision requirements.

2.2.3.2 Impact on architecture design

The above study shows that many building safety control variables are not designed based on building occupancy. In fire safety, as an example, only the prevention requires a consideration of building uses. In the evacuation and fire fighting part, building occupancy is not a key control variable that determines the fire code. According to fire engineering strategy, the concern on the anticipated risk of a fire, the combustible, explosive or toxic content of a building, the ability of the structure, the consequential and possible danger, the occupant load, and the occupant characteristics are more important. Building use has very little impact. For other concerns of daily usage safety, there are also very weak linkages between building use and building control.

In conclusion, the building safety control has a strong impact on architectural design of buildings, but the building occupancy classification is not a key concern in the code making of building safety issues.

2.3 Building control on environmental health and sustainable design

2.3.1 What are the issues?

Historically, hygiene control has been a key concern in building code making. Today, more issues are included. In this section, these issues will be divided into two groups: environmental health and sustainable design. Building control on environmental health includes issues of lighting, ventilation and air quality, internal temperature, acoustic issues, moisture, restroom design etc. Technical references are used in designing building control variables. Creating a good physical environment is a basic requirement for building design. Furthermore, with today's fast development and increasing load on the natural surroundings, sustainable development is critical. Building and construction are major consumers of the resources and energy. Therefore, more researchers and building code writers have begun to integrate sustainable thinking and strategies into building control. In this aspect, building control could be more supportive.

2.3.2 How can this be accomplished?

2.3.2.1 Environmental health control

- **Lighting Control**

There are two ways of lighting internal spaces, natural lighting and artificial lighting. Natural lighting is always a key concern in building design, and artificial lighting usually compensates by achieving the required lighting standards. However, a good building design could reduce artificial lighting and create favourable natural lighting environment for building occupants. Building control on lighting is mainly focused on the facade or roof design. The differences of lighting standards in building control among various building occupancies are minimal.

- **Internal Temperature Control**

Similar to lighting control, building codes on thermal comfort issues also have similar standards for all building types including domestic, office and commercial buildings. The control standard is within a range of plus/minus 4 degrees of 22 centigrade.

- **Acoustic Noise Control**

Building codes have different decibel (dB) requirements according to the space usage. For example, in habitation space, the maximum noise allowed is 45 dB in the daytime and 35 dB at night. For office space, the maximum is 55dB.

- **Ventilation and Air Quality**

Building ventilation has two means: natural ventilation and mechanical ventilation. In natural ventilation, building codes have requirements on the openings of facade design. In mechanical

ventilation, mechanical systems are regulated. In many building types, such as offices and commercial buildings, natural ventilation cannot provide enough fresh air, so the mechanical ventilation system is required by regulation.

2.3.2.2 Sustainable design control

- Sustainable Energy Efficiency - Overall Thermal Transfer Value (OTTV)

Hong Kong's Building (Energy Efficiency) Regulation uses the overall thermal transfer value (OTTV) to control issues of building energy efficiency. In OTTV control, trade-offs are allowed. As long as the OTTV achieves the required standards, there are no specific requirements regulating the detail aspects of each variable in the above formula. For example, if the design needs a large unthrifty energy window, which would not achieve the standard, it could substitute higher class insulation walls to balance the additional energy cost from the window component and maintain the overall value within the requirement. Such control strategy gives designers much more freedom and allowance for innovation.

- Nature and Communal Space Control

To improve the environment and natural conditions, Hong Kong's building authority has enforced new building controls on architectural design and provisions of natural communal space in high-rise buildings. In 2001 and 2002, the first and second "Joint Practice Note" (JPN) regarding "green and innovative buildings" was issued by Hong Kong's Building Department, Lands Department, and Planning Department. A few aspects were highlighted in such controls, such as the overall life cycle approach strategy, the usage of natural materials and green renewable resources, energy consumption issues and construction and demolition controls.

- Open Design

Many building regulations are designed and enforced based on building occupancy classifications. However, building use can be changed many times throughout its life cycle. How can we make appropriate building controls to secure the architectural design with enough flexibility and openness for such changes? Flexibility in code making is thus becoming very important. However, traditional use-based strategy in building codes may not be able to provide such space. Therefore, new strategies and exploration are needed. In this process, strategies from performance-based fire code making and objective-based architecture preservation codes provide good references.

- Culture, History, Identity and Other Intangible Issues

It is always difficult for building code writers to integrate intangible issues into code making. Issues like culture heritage, building identity and historic preservation are mainly qualitative in nature and hard to quantify in regulation control. However, for conservation building codes, it would be easier if the key preserved object were clarified. Like the US Columbia Pike Codes establishment, researchers helped the local government to set up a conservation building code of "form-based coding," which is

mainly based on streetscape preservation objectives. In this case, the code requirements are designed based on building form rather than building occupancy classifications.

2.3.3 Discussion

2.3.3.1 Control development and principles

Originally, building codes were designed to protect people's safety and health. Looking back on the history of building code development, a clear picture is seen, showing the evolvement of building health controls that started with basic hygiene requirements, such as clean water supply, drainage issues etc. and advanced to more complicated personal needs, such as private belongings and social and natural interactions.

Building Control Variables for Building Environmental Health and Sustainable Control						
Hierarchy of Building Health Considerations	Control Aspects	Control Variables	Prescriptive-Based Control Variables	Performance-Based Control Variables	Quantitative Aspect	Qualitative Aspect
(1) Basic Survival & Living Needs - Min. Physical Level (People)	Temperature Control	Celsius Degree	Yes		Yes	
	Acoustic Control	dB (Decibel)	Yes		Yes	
	Lighting Control	Lux	Yes		Yes	
	Ventilation Control	Openable Window Area	Yes		Yes	
(2) Advance Development Needs - Higher Mental Level (People)	Air Quality				Yes	
	Private-Belonging			Yes		Yes
	Green / Nature Interactions	Floor Area	Yes	Yes	Yes	Yes
	Social Interactions	Floor Area & Facilities	Yes	Yes		Yes
(3) Sustainable Development Needs - Long Term evolution (People & Nature Harmony)	Energy Efficiency	OTTV Formular Caculation	Yes	Yes	Yes	
	Open Design	Floor Area Ratio	Yes	Yes		Yes
	Intangible Issues like Culture, History, Identity etc.	Facade, Form, Color, Materials etc.	Yes	Yes		Yes

Figure 6: Building control variables for building environmental health and sustainable design

Today, with even more sustainable considerations, the concept of environmental health has been expanded and further classified. As summarized in the above chart, the regulated items cover both technical quantitative data and intangible qualitative aspects. The controlled issues cover both physical human health and mental needs. The code-making strategy covers both the human and natural environment. It is more difficult than ever before for code makers to tackle all of the concerns.

2.3.3.2 Control variables and building occupancy

The above study shows that in the aspect of health control, many variables are not designed and enforced based on building occupancy classifications. The building occupancy in most control aspects is only a reference, but not a base for controls.

3. A Survey of building control on HK buildings

In previous sections of this study, building controls have been studied regarding aspects of density, safety and environmental health and sustainable design. The impact of use-base classification in code making on architecture design has also been analyzed. This section will present a survey of building control on architectural design. This survey is based on a previous pilot study, literature review and interviews to the professionals and authorities. The pre-study helps to indentify the building sub-control aspects and building occupancies as key issues for further investigation. So the general professional opinions of building control intensity on architecture design of different building types are collected. In the survey, data are collected and categorized in different building sub-control aspects according to domestic and non-domestic buildings.

To make comparisons easier, only office buildings will be used in the survey for non-domestic buildings. The survey is conducted in four aspects of building control: density, safety, environmental health and sustainable design. Eighty answers from about 600 experienced designers, architects and authority experts are the informants in the survey. The purpose of the analysis is to quantify the building control intensity of various building types for comparison analysis. Therefore, the questions are designed with a 5-point level of evaluation for quantification, and a new building control stringency index, an arithmetic mean of the sum of surveyed data, is described for comparison.

3.1 Comparison of building control index

As a summary of the survey, the following diagram shows the result of data analysis.

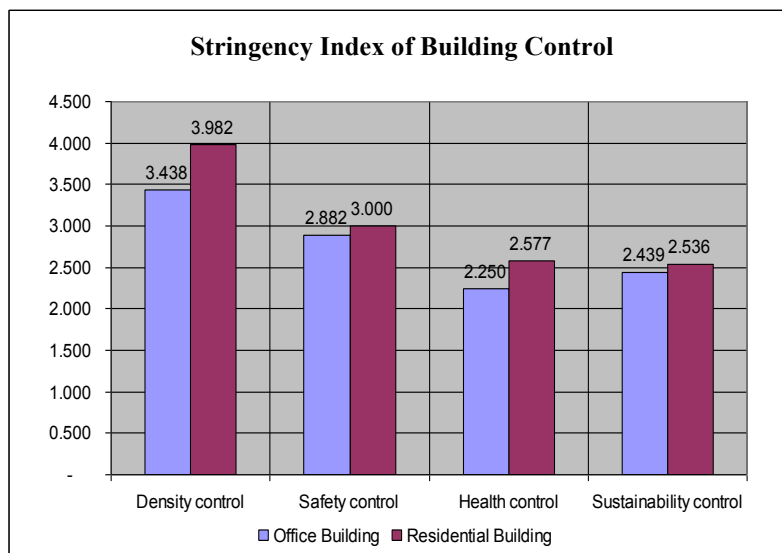


Figure 7: Stringency index of building control in HK

Generally, building control on domestic buildings and office buildings have close control stringency in the four surveyed aspects. In building safety and sustainable design control aspects, domestic buildings and office buildings have very close control stringency. The difference is only less than 4 percent according to the highest index. It indicates that in these aspects, building regulations on both building types share many similar control requirements or standards. On the other hand, in density and health control aspects, the control stringency of two building types has some deviations. In health control, the stringency index of office buildings is about 12.7 percent lower compared to the residential index. In density control, the office index is even lower at 13.7 percent of the residential index.

In fact, all surveyed control variables are the same for both building types. Therefore, such deviation only shows the difference in control standards according to building types. In health aspects, the surveyed variables are lighting, ventilation, air quality, thermal comfort and acoustic control standards. These are all parameters that scale basic environmental comfort of human beings, and did not vary greatly according to building occupancies. However, the deviation comes from the differences of building designs. Office buildings in HK are mainly designed to be enclosed from nature, which requires more mechanical support and building controls to secure the internally built environment quality. In residential buildings, most domestic units are not mechanically controlled built areas. For example, many external windows are operable and central air conditioning systems are not required. Therefore, fewer building controls are imposed on residential buildings.

Comparatively, building controls in residential buildings are slightly more stringent than those on office buildings. Only two control variables show the reverse result. They are shading, heat insulation and internal thermal comfort in health control aspects and energy consumption in sustainable control aspects. Reasons for the variables in the health control are that most office buildings are enclosed with artificial internal environments, which certainly requires more building codes to secure the environmental quality. Higher standards of mechanical and electrical codes are imposed on office engineering. Most units in residential buildings are not designed as enclosed from the natural environment, and natural adjustments are promoted. Therefore, thermal comfort controls are more critical in office buildings than in residential buildings. The second variable of energy consumption further proves this since more energy will be used to secure the physical environmental quality.

Building control on density is the most stringent among all control aspects. The diagram shows that building density control in HK is the strongest with a stringency index of 3.438 for office buildings and 3.982 for domestic buildings. It is followed by building safety control with an index of 2.882 for office buildings and 3.000 for domestic buildings. The health and sustainable design control is the least stringent control aspect with stringency indexes of 2.250 and 2.439 for office buildings and 2.577 and 2.536 for domestic buildings. Moreover, the control on health and sustainable design aspects are very close with an approximate average of 2.500.

4. Conclusion and discussion

This study investigates building controls and their impact on the architectural design of buildings. By reviewing the origin of building controls, it is evident that there is a re-emphasis on the key principles of safety and hygiene concerns in the development of building control and code making. Based on that, four aspects of building control, density, safety, environmental health and sustainable design, have been identified as the core study of this research. Current use-based code making strategy is reviewed and evaluated accordingly. Furthermore, the impact of such control on the architecture design of buildings is studied, and a case-based survey is carried out for the in-depth analysis and comparison.

The study shows that the impact of building regulation controls on architecture design are majorly in the following areas: In building density design aspect, the regulation control affects the built floor area, space height, site set-back, site coverage and building projections. In building safety design aspect, it controls the exit system design such as design of common corridors, staircases and life, fire mechanical and electrical systems etc. In building environmental health and sustainable design aspect, the control impacts are represented as the provision of different building facilities, green provisions and material utilizations.

A holistic review shows that current building control in HK is highly limited by density considerations, and imposes the strongest influence on architecture designs. It further debases the status of the original concerns of building design on safety and health aspects, in particular, the environmental health and sustainable design have conceded to the density design aspect.

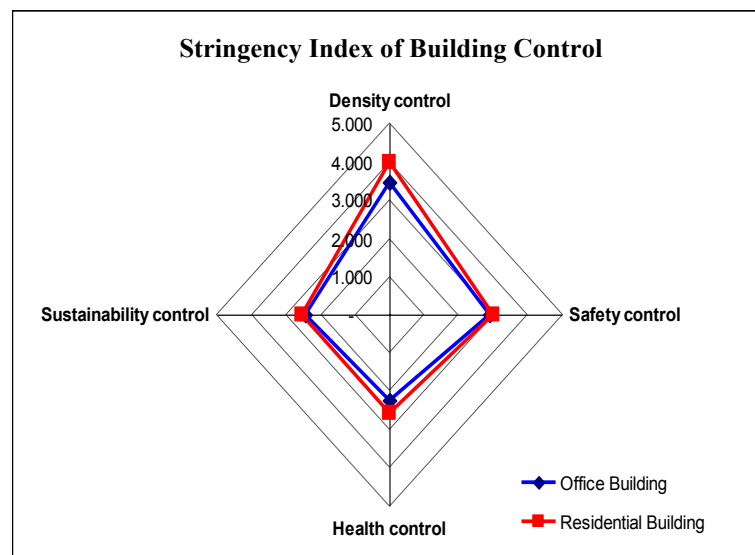


Figure 8: Comparison of stringency index of building control in HK

Secondly, differences in the impact of building control on architectural design of two building types are major from the standpoint of building user distinctness, but not building use variations. Thus, a

user-based strategy in code making is suggested. This concept may further change current code design principles by joining similar building occupancies as a united and complex mixture (or mixed use buildings). In this aspect, the current use-based building occupancy classification may be replaced by population-based or occupant-based building classifications. In fact, many buildings may have functional transactions in their life cycles, while the population-based code would reduce the obvious deviation in density control from different building use types. Furthermore, the control can be more focused on the safety and health issues for the users. For example, the recreation of loft buildings in New York led to a special formulation of the NY building code, which prioritizes safety and health issues as key concerns in the transactions of factories into loft-living studios, and releases density (floor area) control, relaxing the previous regulations. Another case of architecture preservation brings us the form-based building regulations, which also provide building user flexibility in building occupancy, but again, maintains the basic safety and health controls.

Lastly, if we review the original principles of building control and maintain the safety, health and sustainable development as universal thinking in building code making, then building density control would not be an invariable aspect and would be even more important than the others. The significance of building uses in code making may also be degraded. In fact, an X-based building code making strategy with the engraved universal principles in building control would be more possible.

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