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Procedia Engineering 00 (2017) 000–000

Procedia Engineering

www.elsevier.com/locate/procedia

International High-Performance Built Environment Conference – A Sustainable Built Environment Conference 2016 Series (SBE16), iHBE 2016

Using Parametric Modelling in Form-Based Code Design for High-dense Cities

Marc Aurel Schnabel[a], Yingyi Zhang[a]* , Serdar Aydin[a]

[a]*Victoria University of Wellington, Schoolo of Architecture, 139 Vivian Street, Wellington 6140, New Zealand*

Abstract

With the development of parametric design practices in the larger built environment, this paper proposes to merge parametric methodology with Form-Based Code in high-dense cities. Form-Based Code is a recent place-making approach which critically response to conventional zoning. It aims to prescribe urban-rural environments and implement mixed used developments by figures instead of texts. Compare with conventional zoning, Form-Based Code is more practical and flexible for contemporary urban design processes as it emphasizes on “form” rather than rigid segregation “land-use”. Form-Based Code has been adopted in many cities successfully, but there is no adoption in high-dense cities. Due to the complicated nature of population concentration, urban planning of high-dense cities is in great need of efficient approaches like Form-Based Code. This paper presents the necessities, misconceptions, and challenges of applying Form-Based Code in high-dense cities, and then evaluates the parametric modelling methods which can support Form-Based Code generation in high-dense cities. In this respect, the paper promotes parametric modelling methodologies allow Form-Based Code to be smarter in building high-performance environment.

Peer-review under responsibility of the organizing committee iHBE 2016.

Keywords: Parametric modelling; Form-Based Code; high-dense cities; built environment.

1. Introduction

With the launch of New Urbanism in the 1980s, Form-Based Code was created as an alternative approach to conventional zoning and land use regulations by addressing the public realm and urban form (Ben-Joseph, 2005). It

* Yingyi Zhang. Tel.:+64-022-366-8231.
E-mail address: yingyi.zhang@vuw.ac.nz

Peer-review under responsibility of the organizing committee iHBE 2016.

is a land development regulation that fosters predictable built results and a high-quality public space by using a physical form as the organizing principle for the code, which was developed by the Form-Based Codes Institute (FBCI, 2014). Compare with traditional land-use zoning focusing on building use and development capacity, Form-Based Code deals with the typology of a block, street, open space, and building façade (Kim, 2011).

Form-Based Code has been developed specifically to empower communities both to enable and to require better development patterns and individual projects (Parolek, 2008). From the Duany Plater-Zyberk & Company (DPZ) created the first contemporary Form-Based Codes for Seaside, Florida in 1981 to Miami 21, the first Form-Based Code creation for a major city in 2007, then to the latest Beaufort Development Code in South Carolina in 2015, there are hundreds of projects adopted Form-Based Code as a guidance theory. Most of these projects are for sparse American counties (a few of them are for counties of England, Romania, Canada, etc.). As Form-Based Code is a relative young and novel place-making theory, we hypothesizes it also can be applied in high-dense cities beyond America.

Hong Kong here works as a high-dense city example. Form-Based Code has the potential to be an interactive planning principle to improve the public space quality. The current planning methods of Hong Kong are primarily land use-based as conventional zoning. Form-Based Code should be a cutting-edge supplement for helping generate a more livable and multi-functional urban space. In Form-Based Code theory, Transect Matrix defines the hierarchical development scales (Kim, 2011). It assigns the built site into seven parts: T1 is the natural zone; T2 is the rural zone; T3 is the suburban zone; T4 is the general urban zone; T5 is the urban centre zone; T6 is the urban core zone; and SD is the special districts (Fig.1).

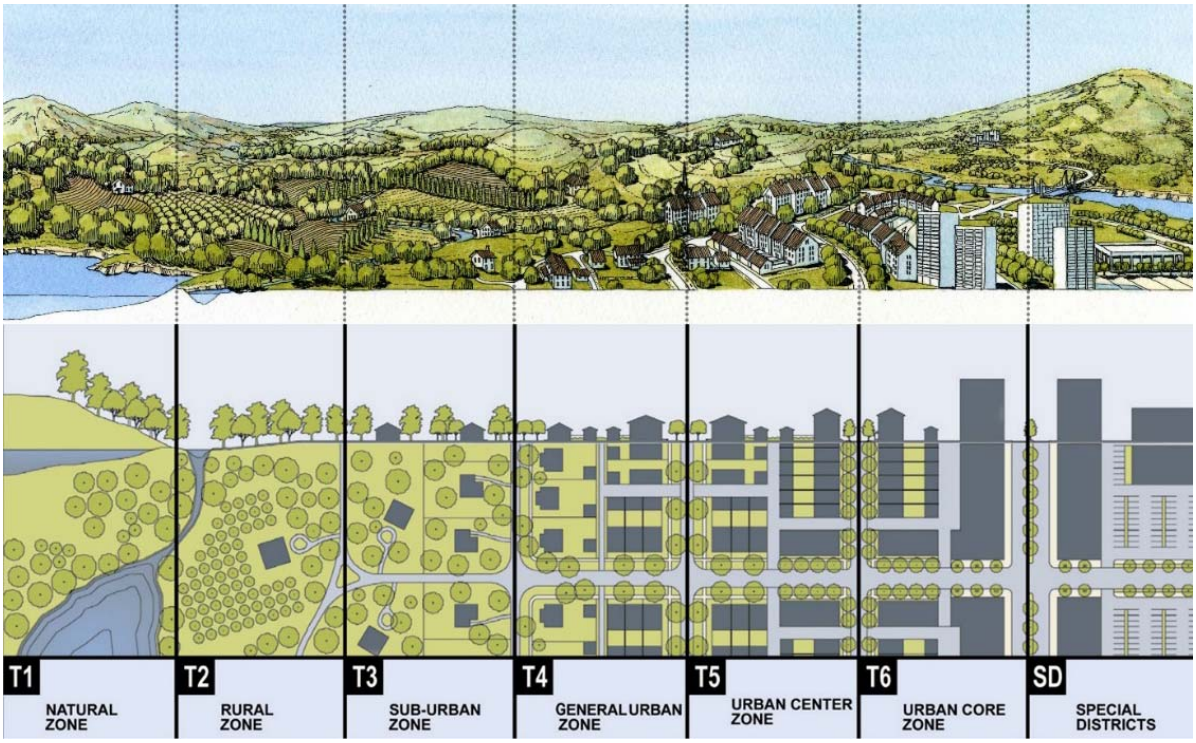

Fig. 1. Standard transect zoning model of Form-Based Code (Parolek, 2008; Plater-Zyberk, 2009).

According to the geographic limitation and population concentration, Transect Matrix of Hong Kong cannot be generalized in a common pattern. Most of the areas only have the T1-natural zone, T3-suburban zone and T6-urban core zone (Fig.2). Besides, different from the projects adopted Form-Based Code before, high-dense cities like Hong Kong have more complex coding parameters in terms of the volumetric urban environment both on the ground and

underground. That makes the code-making process take relatively longer time than sparse counties' projects. In this situation, Form-Based Code generation in high-dense cities needs the assistant of parametric modelling tools.

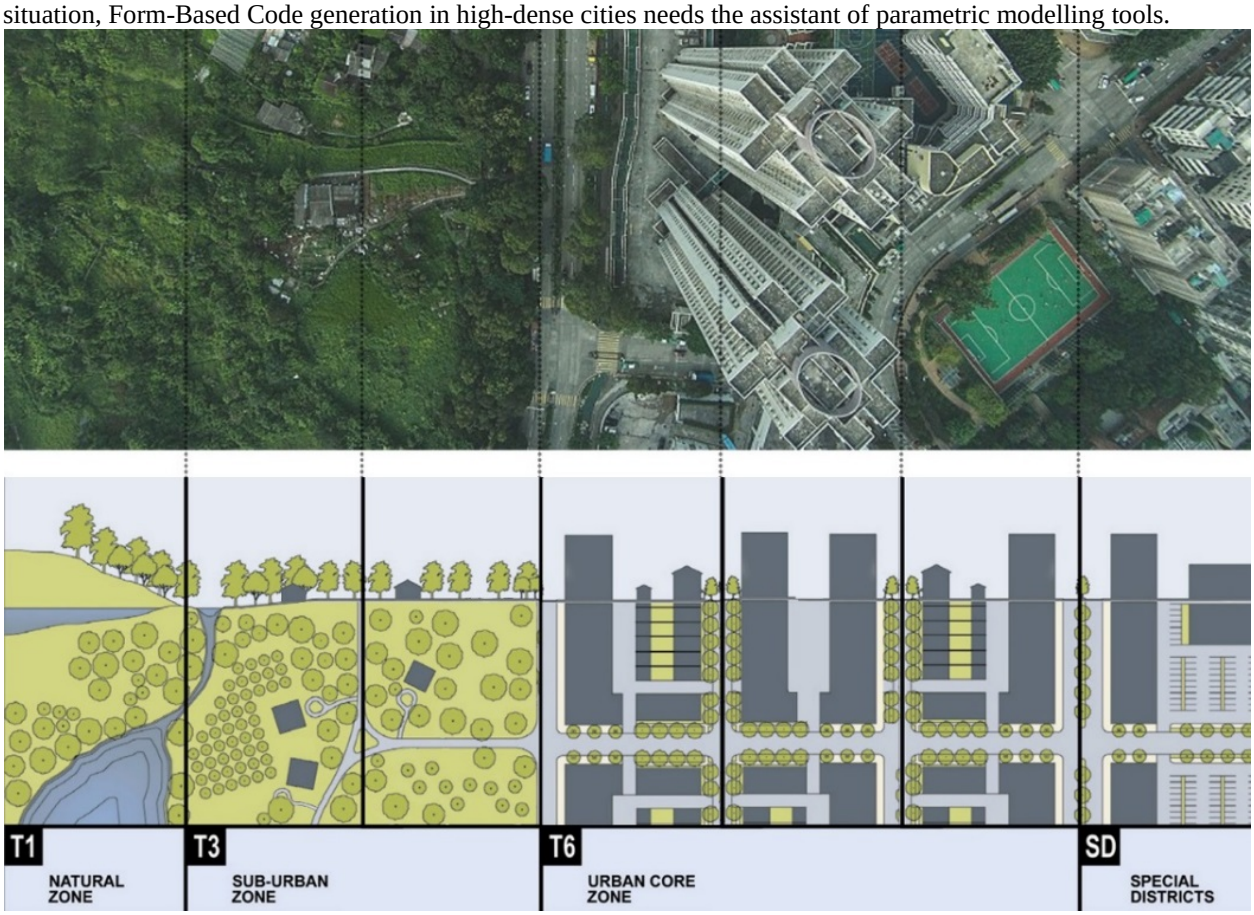

Fig. 2. Transect zoning model in Hong Kong.

Through comparing the current parameter-based modelling methods, we argue BIM (Building Information Modelling), GIS (Geographic Information System), and CIM (City Information Modelling) can partly support Form-Based Code. BIM ties all of the building components together imbedded with information (Eastman, 2008). Revit, as one of BIM software, contributes to the Form-Based Code projects in Texas. GIS offers a series of fundamental datasets for code makers. The software ArcGIS are applied in real Form-Based Code projects of Florida. CIM has been discussed by scholars from TU Delft and the Bartlett recently. While BIM offers a new paradigm in building design, the current urban design paradigm is still rooted in drafting and illustration methods eventually supported by information technologies of CAD, 3D modelling and visualization (Gil et al., 2011). There is a new generation of CIM tools emerging (Gil, 2013). In this paper, we use CityEngine as a representative software to explore the possibility of CIM to support Form-Based Code.

In sum, Form-Based Codes are turning a page in zoning history with their new approach to development regulation (Parolek, 2008). It reforms conventional zoning approaches, which encourage suburban sprawl through the promotion of low density and single-use development (Barry, 2008). Akin to a utopian urban design solution, Form-Based Code optimizes the planning process and outcomes. It has a practice potential in high-dense cities and helps make a quality public urban space. There is no specific instruments for Form-Based Code purpose so far. Software with various features provide different functions to make the coding process more effective and accessible.

2. Misconceptions, necessities and challenges

Before addressing the necessities and challenges of adopting Form-Based Code in high-dense cities, some misconceptions of Form-Based Code should be discussed. Even Form-Based Code has been adopted in various scales and places, it is still not accepted by many researchers. The main misconceptions are clustered in the land-use, Transect Matrix and code-making aspects.

2.1. Misconceptions

- Land-use is omitted in Form-Based Code

Although Form-Based Code emphasizes on “form” rather than “land-use” for its principle and framework, it regards land use as a very important element as well. Land-use tables are included in the form-based coding process. It simply becomes tertiary to the form standards instead of being the primary regulation, and they are simplified and vetted by the code writer so as not to compromise the intent of the Form-Based Code (Parolek, 2013).

- The Transect Matrix is too simplistic

Transect Matrix is the main feature of Form-Based Code and it is invented by form-based coders. So “Form-Based Code” is also called as “Transect-Based Code”. Some people think the rural-to-urban transect including seven types (T1-T6, SD) is too simplistic to express the characters of complex space. However, for example, in Miami 21 Codes, the Transect Matrix is designed into T1, T3, T4, T5, and T6-1, T6-2 … to T6-24. Place makers can designate sub-branches as many as they need. The codes in Birmingham, Alabama, and Beaufort, South Carolina clearly illustrate the complexity and effectiveness of the Transect as a zoning tool and its ability to reinforce unique characteristics and patterns of a wide range of places (Parolek, 2013).

- Form-Based Code is too confusing

Conventional zoning that people are familiar with is a typical text-based method. It consists of land-use colour lumps, specific sheets, and data. Urban design and zoning are separated and implemented by different groups. However, urban design works as an integral part of the form-based coding process. Form-based Code makers need to have the ability to engage the unique building characteristics of communities, urban space details, and coding documents that everyone can easily understand together. To avoid the complicated situation, designers may start from small scale then extend the coding region.

2.2. Necessity

Form-Based Code has been implemented mainly in sparse counties for decades. Miami 21 Code is the only project for a relatively high-dense city. There are many compact cities with concentrated population and super vertical morphology around the world. Researching on Form-Based Code in high-dense contexts is necessary for the theory itself and the development of high-dense cities.

For the Form-Based Code theory system, testing it in high-dense cities beyond North America is an extension. Comprehensive examine is imperative in creating and maturing Form-Based Code as a relatively new theory. For high-dense cities, especially the developing cities in Asia, Form-Based Code is an alternative approach to creating or recreating public space. High-dense, multi-level and population concentration have made the urban problems more complex than ever before, such as the lack of public realm, impropriate walking connection between ground and underground, and the compact living environment growing into sky. Form-based regulation has a potential to solve the existing urban problems. However, Form-Based Code is not fully considered in the current planning and management system. We appeal to architects, urban designers, developers and government to pay more attention to the new planning approaches.

2.3. Challenges

The components of Form-Based Code include Regulation Plan, Public Space Standards, Building Form Standards, Frontage Type Standards, Block Standards, Building Type Standards, Architectural Standards, Code Administration, etc. The principles of generating these components are similar no matter to dispersed or high-dense urban form. Density is omitted in the whole coding procedure. While, density is one of the most vital indicators in urban development analysis (Zhang & Schnabel, 2016), especially for high dense metropolis. The research of implementing Form-Based Code in high dense cities is at the start stage.

Besides, conventional zoning is a text-based approach using words, tables and numbers to describe design scenarios. Form-Based Code tends to use visual files and graphics to control urban form development. In Form-Based Code creating process, the first step is documenting in macro scale and micro scale. Then to the visioning step, including illustrative plan, imagery, regulating plan and regulations. Last step is assembling for splicing and formatting. The manners to express form-based coding more intuitively have the direct bearing on communications between different sectors (Zhang and Schnabel, 2016). Form-Based Code needs an effective and smart platform to share data and allow people to access design information in multiple ways (Zhang and Schnabel, 2016).

3. Parametric modelling in Form-Based Code

Computer-aided tools lead to better decisions and expressions in generating Form-Based Codes. Visualization for efficient planning and decision making is possible with 3D analysis (Ahmed and Sekar, 2013). Now there is no software specifically for customization for Form-Based Code purpose. Current parametric modelling instruments which can partly support Form-Based Code include CityEngine, Revit, and ArcGIS.

3.1. CityEngine

CityEngine is a typical software of CIM. It is a 3D model making instrument for the urban environment, which focuses on visualization aspects of realistic cityscapes for the movie and video game industries (Procedural, Inc., 2015). As the participatory planning becomes a significant step in Form-Based Code-making process, web-based codes are regarded as a next format of Form-Based Codes (Parolek et al., 2008). CityEngine helps to imbed regulation information in a web interface. Various sectors such as planners, property owners, and stakeholders are allowed to access the codes even from long distance (Fig.3, Fig.4). However, CityEngine only provides a limited interface for editing the regulation parameters without any analysis features (Kim, 2011). Form-Based Code in high-dense cities is a complex process with various parameters. CityEngine may be applied for the Form-Based Code projects in dispersed cities. However, it will be a challenge to apply CityEngine fully and exactly in high-dense cities.

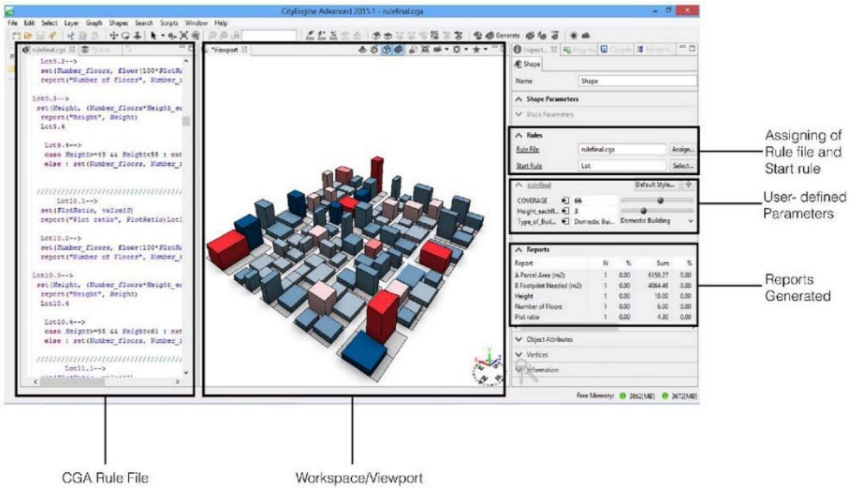

Fig. 3. Working interface of CityEngine in Sai Ying Pun, Hong Kong (Diwan, 2015).

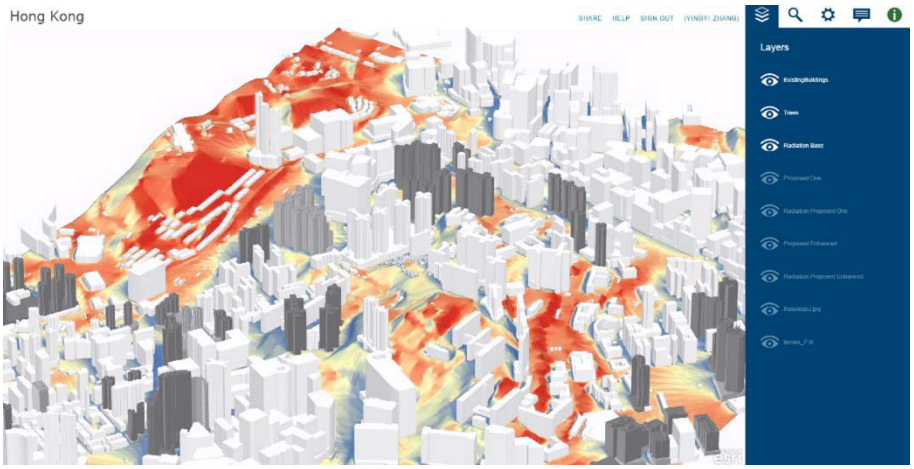

Fig. 4. Online platform of CityEngine in Hong Kong (http://www.arcgis.com).

3.2. Revit

BIM can regenerate objects by changing parametric values and save the construction information as a database. Parametric modelling is one of the main features of BIM that has been widely used in Architecture, Engineering, and Construction (AEC) industry, and has a potential to support the implementation of Form-Based Codes (Kim et al., 2011). A number of BIM software has been working for urban design, like ArchiCAD, Autodesk Revit, and Micro Station. We use Revit as an instance.

Since Form-Based Code consists of a plenty of graphics, creating it for high-dense cities takes longer time than the text-based conventional zonings. Besides, many numeric parameters are included in Form-Based Codes. If designers want to change part of them, other related parameters need to change as well. For instance, if citizens and planners conclude that the front setback should increase from 2ft to 4ft in the design charrette, road sections, building form sections, and public space sections need to be changed again (Kim, et al., 2010). Revit enable planners to avoid spending time to redraw illustrations again (Kim, et al., 2010). By creating Revit projects and storing the object information as parameters, elements of Form-Based Code may be regenerated according to any parametric values (Eastman et al. 2008; Smith, 2009).

BIM helps Form-Based Code makers record feedbacks and try various design scenarios (Fig.5). However, BIM more focuses on architectural details, like windows and doors, materials, and façade details. It can partly assist Form-Based Code generation in microscale.

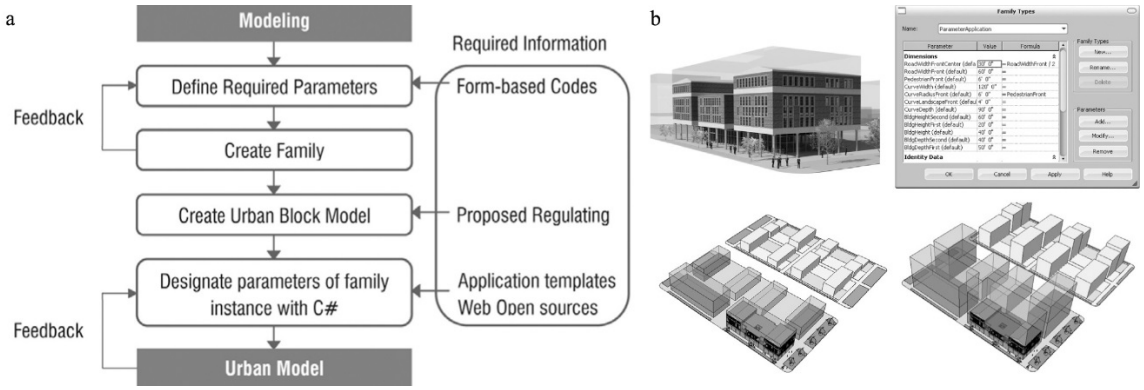

Fig. 5. (a) The development process of the urban model; (b) Using Revit to support Form-Based Code (Kim and Clayton, 2010).

3.3. ArcGIS

GIS is a comprehensive used tool for information mapping and geographic spatial analysis. It is strong at collecting data, storing and sharing information, which contribute to support Form-Based Code in macro scale. By gathering the physical data, conditions base map, framework diagram and other base drawings with lot lines, building footprints, sidewalk locations, etc. will be summarized for understanding the target area in macro scale. ArcGIS is employed to work as a data editor and container of existing physical elements by using point, line, and polygon (Table 1).

Table 1. ArcGIS layer list example in Form-Based Coding of Hong Kong.

Number	Layer name	Feature	Number	Layer name	Feature
1	District boundary	Polygon	13	LRT railway	Line
2	Building polygons	Polygon	14	LRT station	Point
3	Greenland	Polygon	15	Museum	Point
4	Road line	Line	16	Public playground	Polygon
5	pavement	Polygon	17	Swimming pool	Point
6	KCR railway	Line	18	Urban service complex	Point
7	KCR station	Point	19	School	Polygon
8	MTR railway	Line	20	Temple	Point
9	MTR station	Point	21	Supermarket	Point
10	Car park	Point	22	Stadium	Point
11	Church	Point	23	Jockey club (Betting Centre)	Point
12	Market	Polygon	24	Hotel	Point

The ArcGIS map generated in documenting phase is an important database in the holistic research as Parolek mentioned in 2008 (Table 2). However, some scholars argue that ArcGIS is not accurate enough. The parcels, streets and building footprints cannot be used directly since many edge lines are overlapped. Similar with ArcGIS in macro scale, CityCAD (developed by Holistic City) has been created specifically for the needs of the city design and planning community (Holistic City Software, 2015). It has built-in object libraries to help set façade types. The built-in objects are based on parametric techniques, but users can access limited parameters of the site information and urban typologies (Kim et al., 2011). Besides, CityCAD does not offer programming interfaces that allow its extension (Gil, et al., 2010).

Table 2. List of the background documents (Parolek, 2008).

	List of background documents
Existing conditions maps	Aerial photo Topographic map Street map Survey Layers of information in a GIS format
Existing planning documents (including plans and accompanying regulations)	Zoning map and regulations Comprehensive/General plan Downtown plan Area plan(s) District plan (s) (e.g. campus plan) Streets master plan Parks and open space master plan Historic conservation plans Historic maps

Each of the parametric modelling tools has different features and emphasis. There is no “right” or “wrong” tools. Form-Based Code makers should choose the appropriate one(s) through measuring advantages and disadvantages. Generally speaking, ArcGIS and CityEngine can be employed in macro scope documenting in Form-Based Code, and Revit can be employed in micro scope assembling and expressing building form standards. The customized computer-aided instruments for Form-Based Code are expected to generate and practice as well.

4. Discussion and conclusion

According to the analysis above, we propose that Form-Based Code has the opportunity to be adopted in high-dense cities with the support of parametric modelling instruments. There is a gap that no mature Form-Based Code project in a high-dense city beyond America. Using parametric tools in Form-Based Code generation process is still at the beginning stage. Through the previous analysis, we can see:

- Compare with conventional zoning, Form-Based Code has obvious advantages. More and more scholars and researchers are involved in the Form-Based Code theory research and implementations;
- High density has been omitted in Form-Based Code theory system. There is no mature Form-Based Code practice in high-dense cities so far;
- Creating diversity and compactness form is quite important for high-dense cities’ development. However, land use is over-focused and urban form is under-focused in most of the current planning ordinance and process;
- The Form-Based Code study tendency is transforming to parametric methods. Scholars are exploring appropriate parametric tools for Form-Based Code making.

As Form-Based Code has been applied in various urban planning and design projects, it already has substituted conventional zoning gradually. Extending Form-Based Code to high-dense cities is significant for supplementing the theoretical system and comprehensive implementation. Through analyzing the misconceptions, necessity, and challenges, this paper argues that parametric modelling has the potential to support Form-Based Code in high-dense cities. The parametric methods, like CIM, BIM, and GIS, have advantages and disadvantages. Designers choose the appropriate one(s) as they need in various scales and depth.

In further research, a Form-Based Code model for high-dense cities is expected to be generated. That’s beneficial to demonstrate our hypothesis – Form-Based Code can be fully imbedded in high-dense cities’ planning system. Besides, the parametric modelling instruments should be discussed deeper to support creating codes and building livable environments.

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