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Interactive control of land use intensity for hierarchical regulatory plan

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ABSTRACT

With the implementation of technical systems of "total constraint, hierarchical control, partitioning equilibrium " which is under the full coverage of regulatory control, land use intensity, as a core aspect of regulatory plan, its scientific and rationality of indictor become to be the focus. In order to find a reasonable method of regulatory control to determine the intensity of land use, the paper elaborates different forms and characteristics of land use intensity in all aspects of hierarchical control, summed up by theoretical, empirical analysis and other methods to study the interaction between them. The results show that there is a mechanism of "longitudinal control, lateral balance" between the intensity of land use in the three levels of regulatory control, and different levels' attributes determine the different factors and then act on appropriate indicators of intensity at every level, thereby it can affect the determination of volume ratio at the appropriate level. Based on this, the article found the interaction mechanisms of land use intensity in hierarchical control, made its determination method, and completed the test in case study. The research has certain reference value on the quantify of land-use intensity indicators of hierarchical control and also can provide a reference for the control of land-use intensity of regulatory plans.

KEYWORDS

Hierarchical regulatory plan; Land use intensity; Interaction; Control method.

INTRODUCTION

Regulatory plan is an important part of China's urban planning system, with the implement of "Urban, Town Regulatory Plan Approval Approach", many cities are vigorously pursue the formulation of full coverage regulatory plan", such as Beijing, Shanghai, Guangzhou, etc., are all proposed the technical formulation system of "Total Constraint, Hierarchical Control, Partitioning Balance" to adapt to their own development. It enriched connotation of regulatory plan. Land use intensity, as a core aspect of regulatory plan, its scientific and rationality of indictor become to be the focus of the field, while the emergence of the current hierarchical regulatory plan also provides new ideas and methods to the drawbacks of the determination of land use intensity in the traditional regulatory plan system. However, there are some issues in various types of hierarchical research practice are not clear, such as the concept of land use intensity, the hierarchical relations and control methods, hence it is necessary to sort out the different connotation and characteristics of land use intensity of hierarchical regulatory plan, and to explore the relationship between them, as well as to find a clear control methods of land use intensity in hierarchical control system, and then we should test it in case study at last.

HIERARCHICAL CONTROL SYSTEM AND CHARACTERISTICS OF LAND-USE INTENSITY

Theory and practice of land use intensity under the hierarchical control

(1)Theoretical study

In recent years, Chinese scholars have been studied mainly in three aspects on land use intensity control. On the hierarchical control system: Cai Zhen[1], Tang Hairu[2], Ren Kay[3], Wei Dong[4], who proposed regulatory plan should be introduced in a top-down hierarchical regulatory control formulation, while emphasizing the implementation of hierarchical control over land use intensity, and the introduction of total control of the regulatory control system; On land use intensity connotation: Xian Baolin[5], Duan Zhaoguang[6], Huang Minghua[7] and others give the analysis and definition of the concept on volume ratio and make scientific and rational numerical methods to determine the volume ratio. On the hierarchical control of land use intensity: Liu Huijun[8] and others discussed on the mechanisms of volume ratio under hierarchical control; Xu Fang[9] proposed a land use intensity method based on regulatory control unit under hierarchical system and establish the appropriate model to provide a basis for the control of all levels of land use intensity; Sun Feng[10] and others considered that land use intensity of regulatory plan should be determined by the total amount of inheritance, in order to avoid the fallacy of composition; Ding Liang[11], who proposed the use of GIS platform to quantify spatial analysis, and then established the land use intensity baseline model.

(2) Practice research

In recent years, the practices of control for land use intensity occurred mainly four methods : hierarchical control, unit control, block control and statutory plans. Some big cities such as Beijing, Shanghai, have been on the use of hierarchical control, which is classified as "Area–Unit–Block" three spatial levels, then made hierarchical implementation on different levels of purpose and mission requirements, and as a result of the statutory plan forms, including two parts of technical documents and legal documents. "Technical document" is mainly related to land use intensity, and "legal documents" is a core part of the statutory plan system, while "technical document" is a technical support to "legal document".

Taking these studies it can be konwn: the land use intensity which is under the regulatory control between different levels has interaction, whose interactive mechanism mainly for longitudinal land hierarchical pass–feedback mechanism and horizontal partition balance–conduct mechanism. In Longitudinal and horizontal two-way mechanism, we can determine the indicators of land use intensity hierarchically.

Hierarchical system of regulatory control

Hierarchical regulatory control system mainly divided into " Area–Management Unit–Block" three levels to meet the "Total Constraint, Hierarchical Control, Partitioning Balance" control system (Figure1). In this system, every area is divided into a number of management units, and every management unit is divided into several blocks. Longitudinal "Hierarchical Control" is to make decomposition and implemented from one level to next through guidelines and rules of statutory documents and guidance documents. Horizontal partition is in accordance with three levels, the indicators should be involved in a certain range adjustment, which follow the principle of "Partitioning Balance"[9].

Connotation of land use intensity

Land use intensity refers to the process of urban development for the utilization of land, including volume ratio, building height and building density three target[12], while the volume ratio as the core manifestation of this study is also the

main content. In every stages of land use planning, the indicators of land use intensity have different meanings. Xian Baoling[5], who summed up the concepts of volume ratio for more than 10 kinds that existed in the current urban planning system, which have different connotations in different types of plans. In this paper, considering with the hierarchical system of regulatory control technology as well as the selection of the type of volume ratio, we determine the connotation of volume ratio in three levels of regulatory control in this study (TABLE 1).

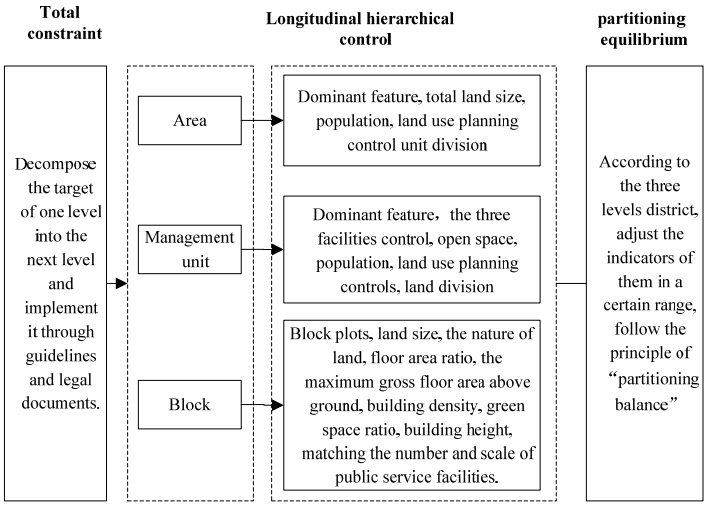


Figure 1 : Technology system of interactive regulatory control

Characteristics of land use intensity of the hierarchical control

Under the premise to meet the total amount, land use intensity at every stages of control has different characteristics. It is mainly reflected in two levels in the regulatory control (TABLE 2).

(1) Area level–evenly distributed

Due to the intensity of zoning regulatory requirements which controlled by master plan, the land use intensity of the area level is mainly based on the total amount of inheritance, which is showing evenly distributed overall.

(2) Management unit level–even internal and different external

Due to further refining the nature of land and the different distribution of population distribution, the land use intensity differs from each other, but it's evenly distributed inside every management units. The total amount of every management unit within the area is equivalent to the area amount.

(3) Block level–significantly differentiated

At Block level, the intensity become more different due to the emergence of differences of other factors affecting the distribution, but it still meet the same amount of principle.

INTERACTIVE MECHANISMOF LAND USE INTENSITYINTHEHIERARCHICALCONTROL

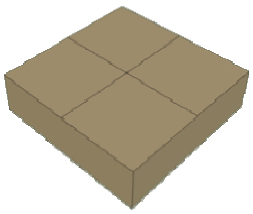
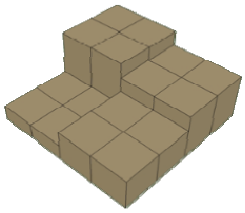
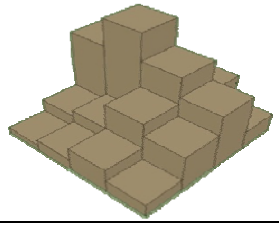
Land use planning has transitivity at all stages. That means it have a connecting role overall master planning, regulatory planning and construction of detailed planning as well as special programs. In every stage of planning, the next stage must undertake the principles and do further refinement of upper layer, be based on their requirements and cannot be contrary to the direction, as well as guarantee its rational distribution levels within the target range on a mission. Specific in the regulatory control, there is the following interaction mechanism (Figure 2).

TABLE 1 : Volume ratio indicators of land use planning at every stage

Land-use planning level		Indicator Type		Indicators connotation
Regulatory Plan	Area level	Volume ratio	Area average volume ratio	Descript the overall land use average intensity of Area
	Management unit level		Unit reference volume ratio	Descript land use average intensity of management unit

	Block level	Block volume ratio	Descript land use intensity of specific block

TABLE 2 : Characteristics of land use control intensity at three levels

Urban planning levels		Intensity distribution	Characteristics
Regulatory Plan	Area level		Inheriting the total amount of the master plan, areas are distributed evenly within one itself.
	Management unit level		Constrained by the total amount of area, management units present differences with others and be distributed evenly within one itself.
	Block level		Constrained by the total amount of area, corresponding with the amount of management unit, showing differences with other blocks.

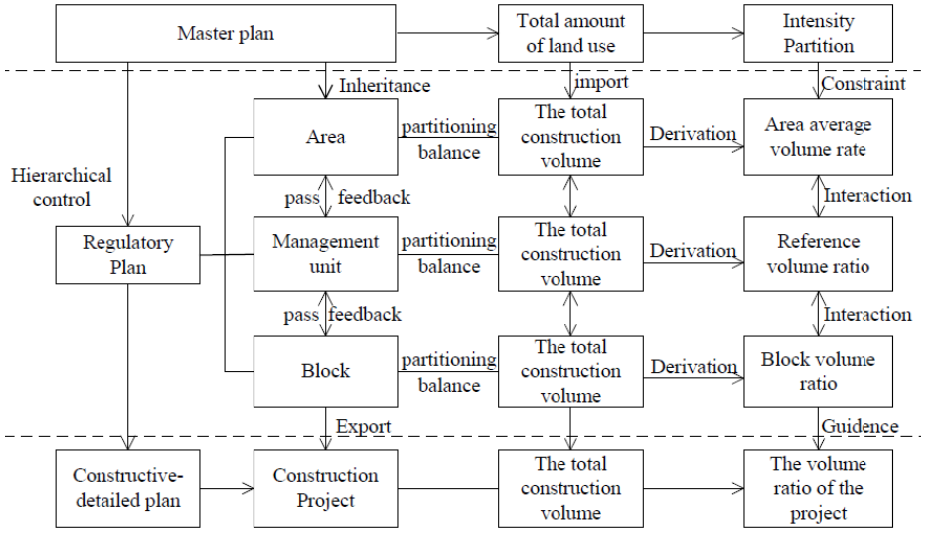


Figure 2 : Mechanism of hierarchical control of land use intensity interaction

Longitudinal control, Bi-crossfeed

The so-called "Longitudinal control, bi-crossfeed" means that the land use intensity has hierarchical interactions in three levels, which are area level, management unit level and block level.

In the "top-down" control, area level mainly link up the upper levels of the planning, inherited the intensity and total compliance requirements for total control of master planning, by checking the factors of public service facilities and municipal facilities, we can determine the capacity of overall development[8] and the land use intensity of area; In management unit level, the volume ratio is following the development of area indicators, and then performing for the initial distribution of land use intensity through the layout of urban land use and design, landscape space, historic preservation and other needs. During this term, the total amount of land is converted to a total construction volume, and then to determine the reference volume ratio; block is the smallest unit in regulatory control, we can identified further distribution according to the

total construction volume of every management unit, and ultimately determine the volume ratio of blocks. The indicators of every level provide direction for the determination of the next level.

The "bottom-up" control mainly emphasis for the survey of "Block" level can feeding back to "Management Unit" and "Area" level, and indicators in this system react to the previous level to correct the indicators of it. Such as determining the volume ratio at block level can feed back to adjust reference volume ratio of management level, thereby affect the average volume ratio of area level. The indicators of every next level provide amendment for the higher level[13].

Horizontal coordination, balance effect

The horizontal coordination of land use intensity indicators mainly coordinate interaction of different factors at the same level, the combined effect will determine the land use intensity of corresponding level. The goal is to propose different requirements of land use intensity for different characteristics of the land nature. The determination of indicators is the result of the combined effect of multi-factors.

(1) Area level

The total amount of area level is on the principle of inheriting the total amount of master planning, but it is an amount based on land, it must be translated into the total construction volume in the area level. By the total amount of all kinds of facilities and urban design requirements, the inherited total amount can be constrainted, and then we can determine land use intensity in area level, which is named “Area Average Volume Ratio”.

(2) Management unit level

In the management unit level, combined with all kinds of factors, the amount of the total construction volume should be redistributed. Because of every management unit has different factors and conditions, it is bound to lead to uneven distribution of the allocation, which produces a horizontal differentiation while the difference of total construction volume results in the land use intensity of management unit, which is named “Unit Reference Volume Ratio”.

(3) Block level

For specific block, due to the different service radius and quality of specific service facilities, the effect of which on the amount allocated to the construction of the land is not the same. The facilities and the service level, as well as the inheritance of the intensity on management unit level make the land use intensity of blocks which range within the certain management unit produce a more precise differences, which is named“ Block Volume Ratio”.

THE CONTROL METHOD OF INDICATORSOF LAND USE INTENSITY AT ALL LEVELS

Study of influencing factors

(1) Influential factors

For the inheritance of master plan, the main factors affecting the determination of land use intensity, which is including: (1) nature of land- the different nature of land has different requirements of land development; (2) facility capacity-the impact of different facility capacity on land development is different. By summarizing the literatures can we divided it into public service facilities capacity, municipal services capacity and transportation facilities capacity; (3) environment-including urban vision and spatial landscape; (4) inheritance of intensity partitions-including the requirements of building height and building density; (5) per capita land targets.

(2) The crossfeed and transfer of influential factors at three levels of regulatory control

Through these studies, we can learn that specific influential factors of land use intensity at three levels, and they also have interaction with each other between the three levels, such as the determinaion of the “Unit Reference Volume Ratio” at management unit level will be fed back to the area level, thus there will be adjustments of layout or demographic in the area and pass again to the management unit level, which can correct the “Unit Reference Volume Ratio”. This feedback control throughout all stages of regulation. In such a dynamic crossfeed-transfer mode, the interaction will achieve a relatively stable state of equilibrium ultimately in order to determine the volume ratio of blocks and to build the ultimate guide to determine the detailed planning of the project volume ratio (Figure 3).

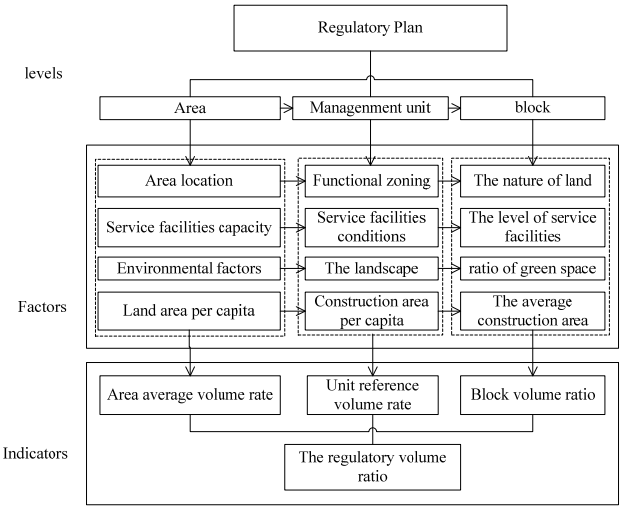


Figure 3 : Factors of land use intensity in regulatory plan

Research of stratification method for controlling land use intensity

Regulatory plan as a meso-level planning, it need for the convergence of the master plan (macro level) and detailed planning (micro level) under the guidance of the construction of which scientificalness of the land use intensity has became a priority. No matter what method is used, the system of “total amount” has been the consensus of the academic circles. They generally considered the Master Plan (macro), Regulatory Plan (meso) and Construction of Detailed Plan (microscopic) have a “top-down” transmission and constraint relationships with each other, and, the key phase to determine the land use intensity is in the regulatory plan.

Under the "total constraints, hierarchical control, partitioning balance" technology system, the total amount of the city is getting from the inheritance of master plan. First, we should determine the factors affecting weight values using AHP and get the score of actual situation, then superimpose these two result to get the evaluation values of land use, which ultimately determine the dimension of land use intensity (Figure4).

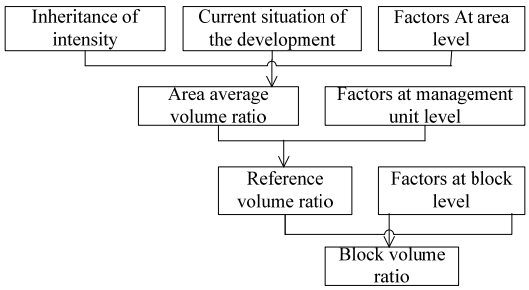


Figure 4 : Hierarchical framework of land use intensity determination

(1) Area level

The main work at area level is to determine the total area construction amount, and then to determine the “Area Average Volume Ratio”. From the perspective of transitive law in the land use planning, the total Area should inherit the master plan, but it is based on the whole city which is difficult to do everything, so in Regulatory plan’s area level, the total construction amount required to build patches for further quantified. There are three main ways to determine the total area construction currently: first, do the total construction volume forecast through statistical analysis of survey data and status information directly; second, forecasting method of metrics with the residential pattern; third forecasting methods of metrics with public facilities. On the basis of the total area construction, considering the influential factors of area level at different ranks (Figure 5), integrating land per capita indicators as well as the construction situation of intensity constraints, and get the “Area Average Volume Ratio” by correcting the gross volume ratio of the area ultimately.

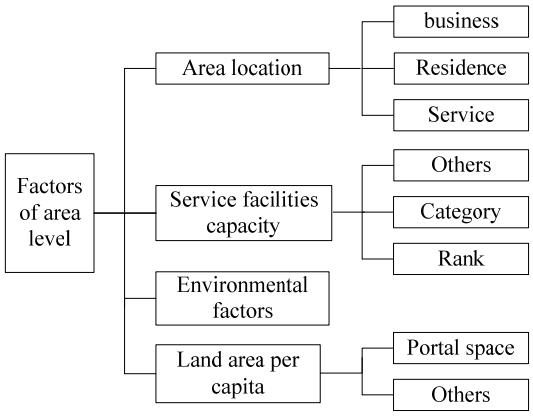


Figure 5 : Rank of factors at area level

(2) Management unit level

The indicator that it need to quantify at management unit level of land use intensity is the "Unit Reference Volume Ratio". To determine it, you first need to determine the overall development capacity. Among them, we need to know the extent of the impact of all kinds of factors, so it need to be quantitatively evaluated. Specifically using AHP, at first, rank the factors with influence extent (Figure6), and then compare factors based on the relative importance of the assignment and establish the judgment matrix (TABLE 3) to get the weight values of factors obtained through calculating and verifying the consistency of feature vectors (TABLE 4). Then based on the score of actual situation of various factors in every management unit, we will get the evaluation values of land use at management unit level. Combined with the intensity partition and per capita floor space requirements etc., we can allocate the amount of the total construction into areas unevenly, in which way can we be guided to determine the "Unit Reference Volume Ratio" ultimately.

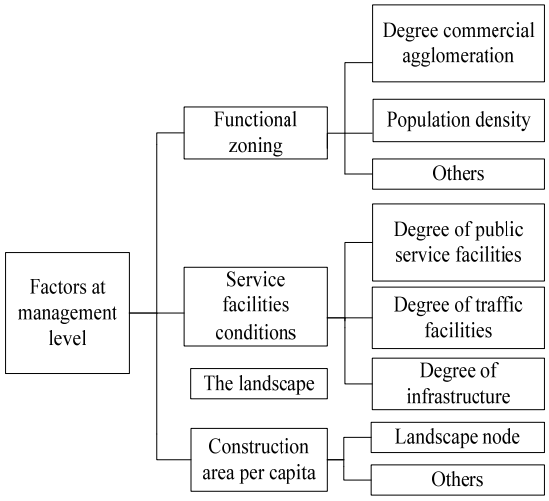


Figure 6 : Rank of factors at management unit level

TABLE 3 : Judgment matrix of factors at management unit level

Factors	Zoning	Level of services and facilities	Per capita gross floor area	Space landscape	Weights
Zoning	1	2	3	5	0.472
Level of services and facilities	1/2	1	2	4	0.285
Per capita gross floor area	1/3	1/2	1	3	0.170
Space landscape	1/5	1/4	1/3	1	0.073

TABLE 4 : Factors' weight at management level

First target A	Secondary target B		Guidelines layer C		Weights of the layer C to A
		weights	Facility name	weights	
Factors'weight at management Unit level	Zoning	0.472	Commercial aggregation	0.512	0.242
			The population density	0.365	0.172
			Others	0.123	0.058
	Level of services and facilities	0.285	Degree of public service facilities	0.350	0.100
			Degree of road traffic facilities	0.350	0.100
			Degree of infrastructure facilities	0.300	0.086
	Per capita gross floor area	0.17			0.170
	Space landscape	0.073	Landscape node	0.600	0.044
			Others	0.400	0.029

(3) Block level

"Block Volume Ratio" is the direct basis to management in regulatory plan and the final stage to quantify the land use intensity of regulatory control stage. Also we can get the weights of factors affecting (TABLE 5) by AHP to determine the reference coefficients of blocks, and then combine them with the ratio of green land and the average floor area requirements to determine the "Block Volume Ratio" by building height and building density finally, which is based on the reference volume as well.

AN CASE STUDY

Baoji city chencang group controlling detailed planning overview

This study of Chencang group in Baoji range from: East to Maotui drainage, west to Fengjiaozui, south to the Weihe River, north to Zhou Yuan. The area is like a ribbon with a total land area of 3040.50ha. Chencang group is under the regulatory control principle of "Total Constraint, Hierarchical Control, Partitioning Balance" which distribute total amount layer by layer to get the land use intensity.

TABLE 5 : Factors' weight at management level

First target A	Secondary target B		Guidelines layer C		Weights of the layer C to A
	Classification of factors	weight	Facility name	weight	
Factors' weights at block level	Nature of land	0.357	Commercial land	0.472	0.169
			Residential land	0.285	0.102
			Service land	0.170	0.061
			others	0.073	0.026
	Level of services and facilities	0.286	Public service facilities	0.637	0.182
			Municipal facilities	0.258	0.074
			traffic facilities	0.105	0.030
	Average floor area	0.214			0.214
	Green ratio	0.143	Public green	0.725	0.104
			Attached green	0.275	0.039

(1) Area level

"Chencang Group Regulatory Plan" shows that at the end of construction, Chencang group is controlled within 2879.09ha, 115.16m^2 of construction land per capita. That means on the basis of 1062.22ha current urban construction land it

get a increase of 1816.87 ha, planning a total population of 25 million people. Based on the estimating of factors, it determines a total of about 29000000m^2 of construction in order to determine the average volume ratio of about 1.0.

(2) Management unit level

Based on the method above for determining the "Reference Volume Ratio", through the inheritance of "Area Average Volume Ratio" and the weights of factors determined above, we can get the intensity values of management units (TABLE 6).

Based on the calculations above, we can designate CC02 and CC03 is at the first level, CC01, CC05 and CC06 is at the second level, CCO4, CCO7, CC09, CC10 and CC11 is at the third level, CC08 and CC12 is at the last level. According to the constraints of "Area Average Volume Ratio", the "Unit Reference Volume Ratio" can be derived (TABLE 7, Figure 7).

TABLE 6 : Values of chencang group management unit level intensity

Unit number	CC01	CC02	CC03	CC04
Evaluation value	3.42	4.54	4.87	2.57
Unit number	CC05	CC06	CC07	CC08
Evaluation value	3.67	3.44	2.25	1.31
Unit number	CC09	CC10	CC11	CC12
Evaluation value	2.18	2.45	2.23	1.44

(3) Block level

Using the same method above and based on GIS platform, we can get the three-level evaluation model of land use intensity in Chencang. The intensity of the model will be divided into five levels, namely, high intensity construction area, mid-high intensity construction area, medium intensity construction area, low intensity construction area and the open space. The depth of colors indicates the degree of the intensity (Figure 8).

TABLE 7 : Reference volume ratio of chencang group management unit level intensity

Indicator Type	management unit	CC02 CC03	CC01 CC05 CC06	CCO4 CCO7 CC09 CC10 CC11	CC08 CC12
Reference volume ratio	Residential land	3.0	2.5	1.8	1.5
	Business facility land	4.0	3.5	3.0	2.5
	Public service facility land	2.0	1.6	1.2	0.8
	Office and hotel land	4.0	3.5	3.0	2.5
	Industrial and warehousing land	—	—	1.3	1.1

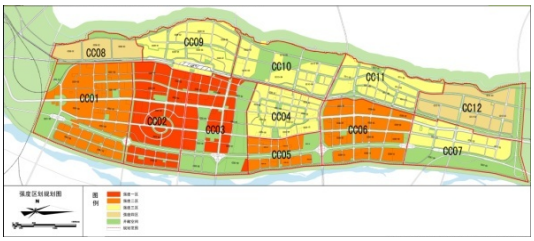


Figure 7 : Intensity zoning of Chencang group management unit level

Figure 8 : Intensity control at block level of Chencang group

CONCLUSION

Based on the regulatory control system of "total amount constraint, hierarchical control, partitioning balance", the paper sort the connotation and characteristics of land use intensity at three levels of regulatory planning, and clearify the control mechanism of the interaction. Through selecting and analyzing its impact on all aspects of the of factors, we get its quantitative indicators and proposed quantitative methods of land use control at three intensity levels at the phase of regulatory planning. Finally, it take the regulatory planning of Chencang group for demonstration examples. The hierarchical

control method of land use intensity this paper proposed can be a reference to determine the land use intensity more scientifically and rationally, as well as put forward a new thought in the field.

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CONFLICT OF INTERESTS

The authors declare that there is no conflict of interests regarding the publication of this article.

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