Journal of Applied Science and Engineering Innovation, Vol.5, No.3, 2018, pp. 84-89
ISSN (Print): 2331-9062
ISSN (Online): 2331-9070

Research on the Effect of Environmental Improvement on Prefabricated Housings Based on DSR Model

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Abstract: Based on the analysis of the environmental model and the characteristics of the prefabricated construction method, the "drive-state-response" model is constructed to highlight the advantages of the prefabricated construction method in environmental protection and energy conservation. At the same time, based on the model, the environmental evaluation system of residential areas is created and reflected in the response model in the form of ecological value.

Keywords: The DSR Model; Prefabricated Housings; Environmental Assessment System

INTRODUCTION

With people's attention to environmental quality, real estate development enterprises gradually incorporate the housing environmental quality factor into the enterprise competition factor. However, the environmental quality evaluation and management of residential projects in China lags behind. At present, the residential environmental assessment generally uses the evaluation methods and criteria of industrial construction projects to evaluate the environmental quality of traditional residential buildings, focusing on whether the emission is up to standard and whether environmental protection measures are feasible.

Since 1999, China has gradually implemented the development model of residential prefabricated houses, and the national policy has increasingly strengthened the regulation of prefabricated houses. However, the evaluation model of the prefabricated house is not yet mature. In the process of construction and operation, the advantages and improvement effects of the prefabricated house in terms of production efficiency, energy saving, environmental protection and resource recycling cannot be reflected. The author believes that the evaluation of the improvement effect of the prefabricated residential environment can provide new ideas for residential environmental assessment, and is also conducive to the construction of prefabricated residential buildings.

In accordance with the principle of scientific systematization and objective operability, the author selected municipal units to evaluate the community environment of the city based on DSR model. In the D-S-R framework, the housing environment problem is expressed as three different but interrelated models, and the target system is divided into criterion layer, factor layer and index layer. In the response model, the concept and composition of ecological value are constructed from four aspects of energy consumption, resource reuse, local environment and indoor environment, according to the indicators of the driving force model and state model and characteristics of the prefabricated house, to analyze the contribution of the assembly house in ecological improvement.

MODEL ANALYSIS

In the late 1980 s, the organization for economic cooperation and development (OECD) together with the United Nations environment programmers (UNEP) put forward the concept of environment index of P - S - R model, namely the pressure (pressure) - state (state) - response (response) model. Within the framework of P-S-R, environmental problems can be expressed as three different and interrelated indicator types: pressure indicators reflect the environmental load caused by human activities; Status indicators represent the existing environmental quality and technical status. Response indicators represent the countermeasures and measures taken by human beings in the face of environmental problems [Tong C, 2010]. From the interaction and influence between human and environmental system, the P-S-R conceptual model organizes and classifies environmental indicators, which has a strong system.

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Many domestic scholars used this model as the theoretical basis for evaluating a certain ecological environment. Qiu Wei et al. studied the ecological security evaluation of Heilongjiang province based on "pressure-state-response" model[Qiu Wei et al., 2008].Study on health evaluation of Lanzhou city ecosystem by Zhang Xiaoqin and Shi Peiji [Zhang Xiaoqin et al.,2010] and research on the influence of real estate regulation policy on housing price Li ling et al.[Li ling et al.,2012] ,both of them are based on PSR model. Zhang Miao et al. evaluated the low-carbon intensive utilization of urban land based on DSR model[Zhang Miao et al.,2015].Wang Jing et al. constructed the evaluation index system of water-saving green ecological residential community based on the "D-P-S-R" model[Wang Jing et al.,2011].

In order to describe in more detail the origin and result of environmental problems as well as their mutual relations and dynamic mechanism, the Western Sydney Regional State of Lid in Australia in the 1990s changed the "pressure" model to the "driving force" model based on the P-S-R model. In the D-S-R (Driving force-state-response) model, "Driving force" refers to the cause of system changes, that is, the "Driving force" generated by human social and economic activities exerts certain pressure on natural resources and the environment. It is more directly related to the "Response" model, and provides people with clear ideas through the feedback mechanism of model indicators. Therefore, the D-S-R model [Zhang Miao et al., 2015] has received certain response and recognition in environmental evaluation.

CONSTRUCTION OF D-S-R MODEL

Driving force model building

Considering the commonality and characteristics of traditional residential and prefabricated residential buildings, combined with the impact of the construction industry on the environment, the factors of the driving force model are divided into five aspects: housing demand, energy saving demand, environmental protection demand, labor demand, and household experience. Specific indicators are shown as Table 1.

Table 1. Specific Indicators of Driving Force Model

Criterion layer	Factor layer	Index layer (In annual terms)	Unit	The data source
Driving force	Demand for housing	Residential development investment	100 million yuan	Statistical yearbook
	Demand for energy conservation(Total energy consumption in the construction industry)	Coal consumption	10kt/m2	Statistical yearbook
		Gasoline consumption	10kt/m2	Statistical yearbook
		Diesel fuel consumption	10kt/m2	Statistical yearbook
		Power consumption	twh/m2	Statistical yearbook
		Water consumption	10kt/m2	Statistical yearbook
	Demand for environmental protection	Construction solid waste disposal rate	10kt/10kt	Statistical yearbook
		Construction waste water discharge	10kt/m2	Statistical yearbook
		Construction TSP emissions		Converted from building materials
		Construction site noise Leq(A)	db	Field test statistics
		Construction industry carbon emissions	kg	Carbon emission factor conversion
		Urban sewage emissions	10000m3	Statistical yearbook
	Demand for labor force	Labor productivity for all staff in construction	yuan/person	Statistical yearbook
	Residents experience	Indoor air quality (benzene, formaldehyde, TVOC)	mg/m3	The field test

State model building

In order to highlight the improvement effect of prefabricated residential buildings, the author chose the development and technology of prefabricated residential buildings as the factor layer, emphasizing the improvement effect of the development of prefabricated housing on the environment. Specific indicators are shown as Table 2.

Table 2. Specific Indicators of State Model

Criterion layer	Factor layer	Index layer(In annual terms)	Unit	The data source
State model	Development	Construction industry development CIDD	100 million yuan/100 million yuan	Statistical yearbook
	Technology	Prefabrication rate of building	m2/m2	Provided by the designer
		Modulus coordination degree	-	Provided by the designer
		Component integration degree	-	Provided by the designer
		Construction equipment utilization	%	Provided by the designer
		Thermal insulation property of prefabricated wallboard	level	Provided by the designer

Indicator interpretation:
(1) Construction industry development (CIDD): ratio of gross domestic product of construction industry to gross domestic product.
CIDD = total value of construction/gross domestic product
(2)Prefabrication rate of building: it refers to the proportion of prefabricated components in residential structures such as walls, beam columns, floor boards, stairs and balconies. It usually expressed in terms of area ratio and volume ratio.
(3) Module coordination degree: it is an important index to describe the standardization and industrialization degree of prefabricated components. It consists of module and number series, modular network, positioning principle, tolerance and joints.
(4) Component integration degree: mainly through decorative surface, doors and Windows, pipelines, integrated kitchen and health, etc.
(5)Construction equipment utilization: The ratio of prefabricated professional equipment to all equipment used in the construction of a house.

Response model building

Response model index

In order to reflect the response of the society to the driving force model, the author selected two aspects of environmental protection and education as the factor layer. According to the driving force model and the characteristics of the prefabricated house, the concept of ecological value of residential buildings is constructed from five aspects: design stage, component production plant, concrete mixing station production, construction site construction and completed residential environment, starting from the whole life cycle of the prefabricated house. The response model is shown in Table 3 below.

Table 3. Specific Indicators of Response Model

Criterion layer	Factor layer	Index layer(In annual terms)	Unit	The data source
The response model	Environmental protection	Ecological value	-	Related data processing
		Green investment as a percentage of GDP	%	Statistical yearbook
	Education	The education degree of designer	%	Statistical yearbook
		Professional and technical personnel ratio	%	Designing institutions and construction enterprises to provide

Construction and composition of ecological value

Considering driving force model and the differences in construction methods between prefabricated housing and traditional housing, the author highlights the design and production mode of components, the construction mode of construction site, the energy consumption emission during operation and maintenance, and the resource reuse in the demolition stage based on the full life cycle, and collect the environmental data related to the design unit, component production plant, concrete mixing station, prefabricated residential construction site, indoor and outdoor environment, atmospheric emission and waste disposal during the residential use period, to construct the environmental evaluation index system of the community, and reflect the environmental quality of the residential whole life cycle in the form of ecological value. Figure 1 shows the model of the indicator layer constructed from five aspects of ecological value.

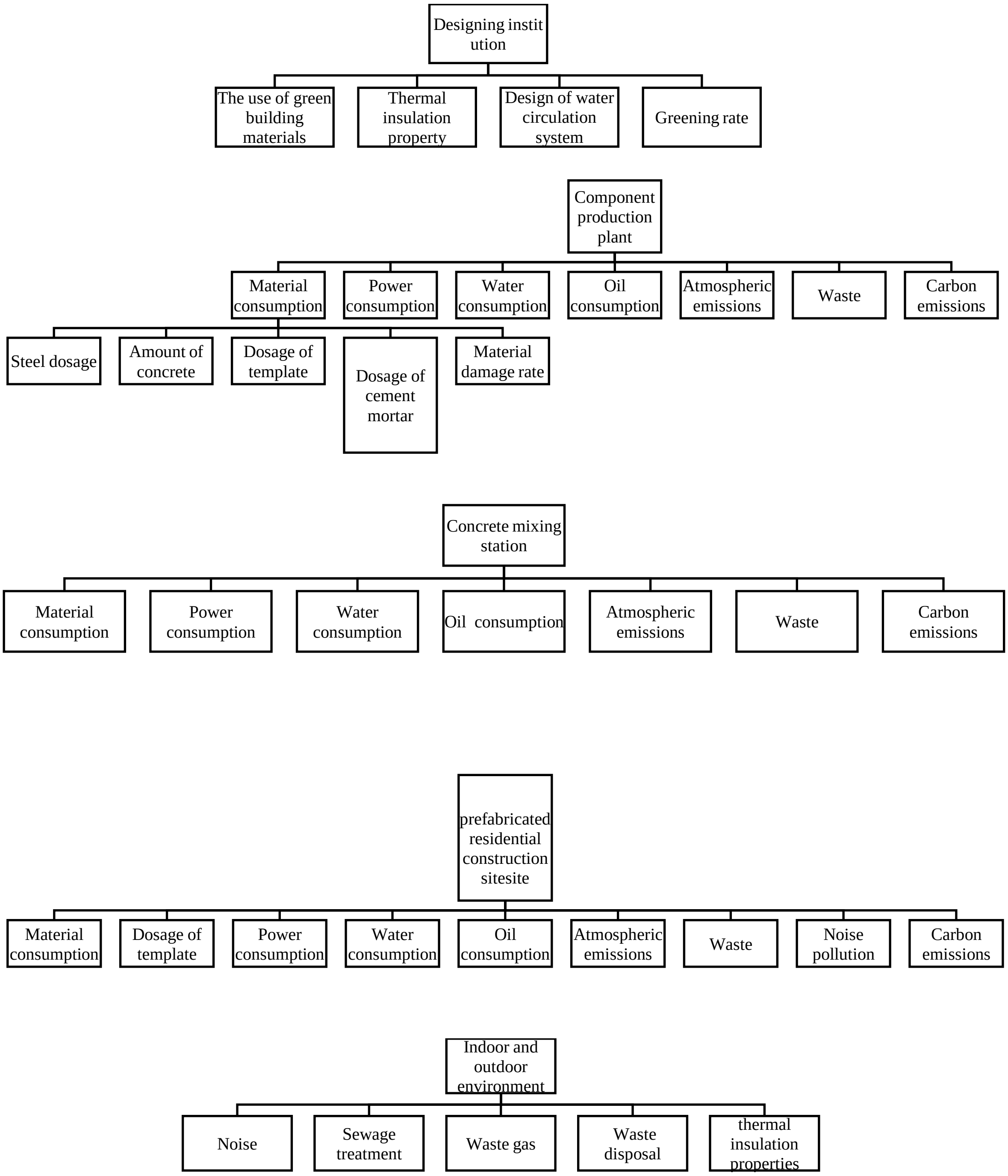

Figure 1. The Model of Ecological Value

(1) Data collection and index quantification

Data collection: 1) the data of the designing institution shall be provided by the design drawings and the modified drawings;

2) All material consumption shall be subject to the final project quantity list;

3) Water consumption, power consumption, oil consumption and waste amount of the plant and concrete mixing station are respectively provided by the plant and the mixing station;

4) All data of atmospheric emissions, noise pollution at the construction site, indoor and outdoor environment during the residential use period shall be monitored by the company department on quantitative index data;

5) The utilization rate of 3R materials was used as the evaluation factor for the use of green circulating building materials in the water recycling system of the designing institution;

6) Thermal insulation performance: select the utilization rate of thermal insulation materials as the evaluation factor;

7) The water-saving effect shall be represented by the utilization rate of medium water;

Index quantification: 1) Leq (A) is adopted as the noise evaluation factor in the residential use period;

2) Sewage during the use period is mainly catering wastewater and domestic sewage. According to its water quality characteristics, SS, nh3-n, CODcr, BOD5 and grease can be selected as evaluation factors.

3) The outdoor waste gas of the community is mainly automobile exhaust and catering fume, so NO2, CO, HC and TSP, PM10, SO2 and NO2 are selected as evaluation factors respectively.

4) Indoor waste gas can be evaluated by benzene series, formaldehyde and ammonia TVOC.

5) The amount of domestic waste and the rate of waste disposal are selected as evaluation factors for waste treatment;

6) Select heating and air conditioning energy consumption as evaluation factors for thermal insulation performance;

(2) Determination of evaluation index weight

It is difficult to obtain effective residential environmental data because the city-level unit community is relatively scattered. Therefore, Delphi method is adopted to select a number of experts who have been engaged in environmental research for many years to evaluate the indicators. The results are shown in Table 4.

Table 4. Specific Indicators of Ecological Value and its Weight

Criterion layer	Factor layer	Index layer(In annual terms)	Unit	Weight	The data source
Design (0.33)	The use of green housing materials	3R total building materials/total building materials	%	0.09	Designing institution provide
	Thermal insulation properties	-	level	0.10	
	The presence of water circulation system design	-	-	0.60	
	Greening rate	-	%	0.60	
Construction （0.49）	Material consumption	Consumption per square meter/average level of construction	%	0.08	The project quantity list and China statistical yearbook shall prevail
	Dosage of template	Consumption per square template/average level of construction	%	0.03	Corresponding units and China statistical yearbook
	Power consumption	Electricity consumption per square meter/average level of construction	%	0.03	
	Water consumption	Water consumption per square meter/average level of construction	10kt	0.04	
	Oil consumption	Fuel consumption per square meter/average level of construction	kl	0.05	
	Atmospheric emissions	-	m3/m2	0.06	
	Solid waste emissions	-	tons/m2	0.06	
	Carbon emissions	-	kg/kg	0.08	Converted from building materials
	Noise pollution	-	db	0.06	Field measurement
Operation （0.18）	Sewage utilization	Medium water utilization rate	%	0.04	Provided by property companies and residents
	Waste disposal	Waste disposal rate	%	0.03	
	Indoor air condition	Formaldehyde concentration	kg/m3	0.03	
	Insulation situation	Air conditioning energy consumption	kwh	0.05	
	Outdoor noise pollution	Leq(A)	db	0.03	

Note: some indicators refer to [Liu Meixia et al.,2015],[Qi Baoku et al.,2016],[Zhang Zhihui et al.,2004],[Yu Weiyang et al.,2007],[Li Su et al.,2009].

PROSPECT AND SUMMARY

The characteristic analysis of different models and the selection of quantitative indicators are the key to apply DSR model to the environmental evaluation of urban residential areas. Fully grasping the characteristics of each model is conducive to closer selection and evaluation of environmental requirements. Through the study of environmental pressure, the author listed the environmental indicators of the community from the design stage to the operation stage, and divided them into different layers to avoid the drawbacks of the chaotic indicator system. Based on the study of the driving force model and the state model, and combined with the characteristics of the assembly building model, a theoretical evaluation system for municipal residential quarters was established, highlighting the environmental improvement effect of the assembly building model, and making efforts to evaluate the environmental advantages and disadvantages of the community in a city from the perspective of the whole life cycle. At the same time, the evaluation system can be used to compare and study the environment of each city or each province in the province, so as to guide the construction of the community to better participate in the macro-control. It is also possible to compare the differences between the traditional construction mode and the prefabricated construction mode, popularize the prefabricated construction mode and promote the sustainable development of the environment.

The author chose city-level units for analysis because the data source of the driving force model was limited to city-level units. However, future research should not be limited to the municipal level and provincial level, but should consider evaluating the housing environment from a smaller scale. Moreover, the data of the evaluation system involve many units, and some indicators are difficult to monitor, so it is worth further study on the selection of indicators.

ACKNOWLEDGMENT

Supported by Plan Fund for Humanities and Social Sciences Research of the Ministry of Education (17YJAZH069)

REFERENCES

Li Ling, Zhu Daolin, Hu Kelin, 2012, "Application of PSR model to the effects of real estate regulation policy on house price:a case of Beijing", Resources science, vol.34,no 4,pp 787-793.

Liu Meixia, Wu Zhen, Wang Jiening, Liu Hong'e, Wang Guangming, Peng Xiong,2015, "Energy efficiency and carbon emissions evaluation of prefabricated construction in housing industrialization", Building structure, vol.45,no 12,pp 71-75.

Li Su, Shi Tiemao, Zhou Le, 2009, "Scales methods and technical analysis of China's residential environmental evaluation", Journal of southeast university(English edition), vol.25,no 2,pp 271-277.

Qi Baoku, Zhu Ya, Ma BO, Liu Shuai, 2016, "Analytic method study of comprehensive benefit of precast building", Construction technology, vol.45,no 4,pp 39-43.

Qiu Wei, Zhao Qingliang, Li Song, Chang Cheinchi, 2008 "Ecological security evaluation of heilongjiang province with pressure-state-response model", Environmental science, vol.29,no 4,pp 1148-1152.

Tong C, 2000, "Review on environmental indicator research", Research on environmental Science, vol.13,no 4,pp 53-55.

Wang Jin, Zhang Yajun, 2011, "Construction of evaluation index system for water-saving green ecological residents' living quarters based on "D-P-S-R"model", Environmental protection and circular economy, pp 45-49.

Yu Weiyang, Liu Cui, 2007, "Research on the assessment of the environmental performance of green ecological residential quarters, vol.17,no 4,pp 76-80.

Zhang Zhihui, Wu Xing, 2004, "A building environmental impact assessment system based on LCA", Urban enbironment & urban ecology, vol.17,no 5,pp 27-29.

Zhang Xiaoqin, Shi Peiji, 2010, "The assessment of urban ecosystem health based on PSR model", Journal of arid land resources and environment, vol.24,no 3,pp 77-82.

Zhang Miao, Chen Yinrong, Zhou Hao, 2015, "Evaluation for the Low-Carbon and Intensive Urban Land Use Based on the DSR Model", Research of soil and wate conservation, vol.22,no 5,pp 169-175.