The sustainable Development of Intelligent Building in China

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ABSTRACT: This paper introduced some typical projects of ecological buildings, introduced the elementary researches on the building intellectualization, analyzed the barrier of introducing advanced theory and technology from European to China, and commended an IB evaluation suitable for China. It emphasized such following points: the essence of IB (Intelligent Building) is building itself; For the purpose of sustainable development of intelligent building the architecture design should be considered as primary element and all the fields of architecture, structure, equipment and information technology should cooperate with each other. To actualize sustainable development of intelligent buildings in China, the concept of IB must exceed the narrow sense which is in BIS (Building Information System) pattern and treat the strategy of sustainable development as the core of IB designing.

Key words: Sustainable development intelligent building ecological building Chinese mod

1. THE DEVELOPMENT OF INTELLIGENT BUILDING CONCEPT IN CHINA

The intelligence quotient of buildings put forward by IBRG must satisfy four requirements including the individual requirements of users, the requirements of leagues or institutions, the requirements of local environment and global environment. In 1998, the famous expert in intelligent building Zhu Jingguo pointed: "intelligent building will be the requirement of the information and sustainable development society in 21st century whose basic symbols are that the first requirements of scaling the intelligence quotient of intellectualized building system are harmony to natural ecological balance, energy saving and pollution prevention". After visiting USA in 1999, China Delegation of Construction Ministry pointed that: "if the understanding of intelligent building merely rests on the level of having artificial intelligence, the development of intelligent building may fall on the complexion of intellectualizing buildings just for intellectualizing", and pointed further that: "intellectualizing is just a means, through outfitting the building with the function of intelligence to emphasize high efficiency, low consumption and low pollution. The purposes of saving energy, protecting environment and sustainable development must be achieved in the people oriented precondition." USA Government has strict restricted measures in energy conservation and environment protection. It can be said that energy conservation and environment protection have become the main premises and the most important guidance to develop the sub function of intelligent building, without which the so called "intelligent building" can not exist. The intelligence degree of a building is not decided by the intelligence degree of equipments but by its ability to fulfil the needs of people. In the end of 2000, an IB delegation sent to European summarized that: "Designing a resident building must start from sustainable development strategy, pay attention to ecology and environment protection, which is the eternal theme of sustainable resident building. China has outstanding achievements in construction but has far insufficient performance in ecology and environment protection. It is necessary to introduce the advanced concepts of building design into China.

2. THE SUSTAINABLE DEVELOPMENT OF INTELLIGENT BUILDING

Though there is not a uniform definition of intelligence of human, it must be an integration of important abilities influencing the survival and development of humanity. When buildings are required to respond to outside change automatically and learn from historical statistics to make a best solution which can cope with problems in the future and fulfil the requirements of human sustainable development, we must deal appropriately with the relationship between building and local environment as well as the relationship with global environment. In this field, Europe has done lots of work which can be an important reference for China; Promotion Centre of Construction Industry in China has enacted "CONSTRUCTION POINTS AND TECHNOLOGY PRINCIPLES OF GREEN ECOLOGICAL RESIDENTIAL ZONE".

Sustainable development stratagem was formally brought forward in "Word Congress on Environment and Development" in 1987, the definition is that: sustainable development is not only to satisfy the modern needs but also not to damage the ability of offspring to fulfil theirs. The idea of sustainable development is the conclusion of rethinking of the serious damages to nature resulted from the wrong actions which are guided by the wrong concepts and views of nature in the industrialization process. Results of researches issued that building industry as main industry in modern society is the main source of environment pollutions and greatly ruins the natural ecology balance.

Therefore, in the purpose of sustainable development, intelligent building must be energy conservation, without environment pollution and keeping ecological balance. In this sense, the intelligent building is certainly also the green and ecological building.

3. ECOLOGICAL BUILDING

3.1 The consideration of ecological design

The ecology in the term "Ecology building" is mainly referred to the relationship between human and nature. The considerations of sustainable development of ecological building are generalized in Table 1.

3.2 Practicing of Ecological building which has demonstrative and enlighten effect to China.

① Building Research Centre In France puts forward separately four design standards of energy conservation in 1974, 1982, 1998 and 2000, required residential building to reduce energy consumption on the base of former' by 25% at first, then 25%, then 25%, 8% at the fourth time. That was realized through enhancing heat preservation of maintenance and diminishing air infiltration to reduce heat loss. At the same time, the heating system was promoted and the solar energy was used appropriately.

② Malaysia architect Yang Jingwen formed a unique design theory according to climate conditions in Asian: introducing green and spacious space into high building; designing "two layers" outside wall to form complex space or air interstratifications; setting adumbral roof garden and so on. Energy distribution and running fees of typical air-condition office building that he analyzed as figure 1 and 2. The design of biology climate he created can save 20% ~ 40% energy fees of the whole building lifespan.

③ In Denmark, a low energy consuming house built in 1992 whose envelope was processed with heat preservation measures took advantage of the intelligent system to regulate and control the solar energy and conventional heating system and made full use of ventilating system and heat compensating in night to reduce heat lose, installed water meter, energy meter and double channels stop valve as well as equipment for saving water, took advantage of rain water to compensate water to the waterscape in the sub-districts. Appling such technical measures save separately 60%, 30% and 20% of the gas, water and electricity of the sub-district and improved the environment of the entire sub-district.

Table 1: Meaning of Sustainable Development

Accretion with nature environment	Nature protection	▲Society and ecological environment protection
	Use of nature	▲ Full use of sunlight, solar energy and wind energy ▲ of water resource ▲ use efficiently of green plant to improve air quality
	Recovery of nature	▲ Heat and cold insulation, shading ▲ Fireproofing and damping measure
Energy conservation and environment protection	Diminish energy consumption	▲ Use energy Efficiently and recycle
	Longevity	▲Building longevity
	Materials harmony with environment	▲ Use local materials or use none polluted materials ▲ Reuse or recycle materials
	None pollution project	▲ methods limit harm to environment ▲ make the by-product harmony to the surroundings
Recycle and regeneration	Use of building	▲economically and no harmfully
	Regeneration of building	▲ Renewing building ▲ Reusing building
	waste of building	▲Disorganization with no maleficent
Comfort and health	Healthy environment	▲ Healthy and comfortable life environment ▲ Good air quality
	Comfortable environment	▲comfortable temperature, humidity, light, sight, sound, water and electricity environment
Be in harmony with social and cultural environment	Inheriting history	▲ Inherit of city history ▲ Organic combination with agrestic culture
	Be in harmony with city	▲ Interfusion with city texture ▲ Inherit and improvement of city landscape
	Activating territory	▲ Keep and improve inhere life style ▲ Inhabitants take part in building design and updating ▲ Keep and strengthen eternal charm and energy

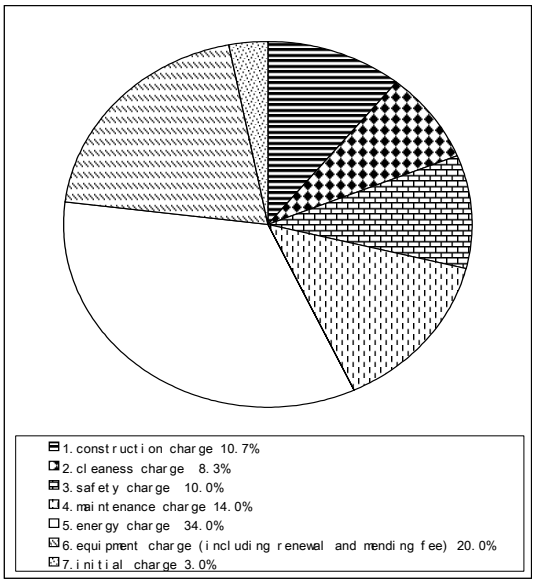

Figure 1: Charge distribution of 50 years of a typical commercial skyscraper.

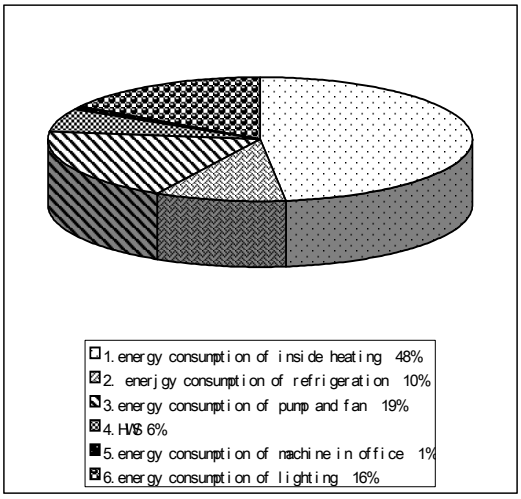

Figure 2: Distribution of energy consumption of a typical office building.

④ The mechanical hall, laboratory and office of the De Montfort University in Leicester makes use of wind pressure to ventilate directly, report hall and lobby as well as other capacious rooms take advantage of stack effect to proceed natural draught, the design temperature of the report hall is 27°C. When the indoor temperature get close to the design temperature, the electricity apparatus which connect with the temperature sensor will open the ventilating valve automatically, this will provide fresh air volume of 10L/S for every person. Because the maintenance architecture is thick and heavy, through natural draught, air-condition is seldom used.

These demonstrative projects are inspiring for the energy conservation design of intelligent building in China. When The North Hot-Spring No.9 Villa which is invested by China Residence Property Investment Ltd was built, the inorganic adiabatic heat preservation material WFB-HS which have good performance was used. In summer whose average temperature of the hottest month is 28.1°C or winter whose average temperature of the coldest month is 8.1°C the indoor temperature is lower or higher than outdoor by 5°, and the effect of sound insulation is outstanding. The heat island effect and the high electricity cost of owner are eliminated. In addition, Fu Xiangzhao in Chongqing University practiced three-dimensional greening of four aspects including environment greening, roof greening, west wall greening and veranda greening in the project of Tianqi Garden, he creatively made use of the roof covered with soil to plant and hold water and gained excellent sound insulation effect. This project becomes a national energy conservation model project.

In the field of building intellectualization experts in China have done some elementary research.

Based on the research on the intelligent office building, Dou Zhi and Zhao Min put forward that the height of story should be confined between 3.8m~4.2m. If the technical and economic conditions permit, the height of suspended ceiling and structure should be minimized, the ceiling height should be increased properly so as to be more comfortable and leave space for flexibility. In designing the calumniation net of intelligent building the distance between the calumniations should be appropriate for the style of structure and the bay size should match the modulus of the indoor office unit. In term of rationality of use and economic structure, the depth should not be smaller than l0m and can be increased properly but should not be larger than 15m. Furthermore, the criterions of areage and the requirements of location of the plant room of the intelligent building were provided.

Table2 : Reference Criterion about the Areage of Function Space

Assort-ment	Item	Criterion		
Areage Criterion		At Least	Com-mon	Recommen-dations
	living room	14	18	22
	Main bedroom	12	14	16
	Secondary bedroom	8	9	10(single)/ 14(double)
	kitchen	5	6	7
	dining-room	8	10	12
	single toilet	3.5	4	4.5
	Double toilet	6	7	8
	repository	1.5	2.5	3
	sanctum	6	8	10

Ding Dan concluded the characteristic of intellectualization of residential building and provided a reference criterion about the areage of function space in the intelligent residential building (Table2) and probed into the plane design of various function spaces and the environment design of intelligent block with the purpose of adopting the changes that will happen since the intelligent techniques entering the block.

Chen Bingzhao probed into the sustainable design, design of residential building integrated with solar water heater system and the design of house pattern of common family in the information society, which provided theory basis for the intellectualization design of intelligent residential block.

In terms of academic research, the investigation of integrations of all the fields involved in intelligent building need to pay more attention. It is the actual demonstration to make the construction technology and information technology work together to meet the people's requirements. Hence, an integrated "intelligence assessment system" for intelligent building is necessary to evaluate and promote IB.

4. THE EVALUATING OF THE INTELLIGENT QUOTIENT OF INTELLIGENT BUILDING

After considering the sustainable development of buildings and integrating the methods which people evaluate the intelligent quotient of IB in the past, D.Boyd & L.JonKvic in IBRG offered an evaluating method which represent adequately the ecology intelligence of buildings and are commended by us greatly. It divides all the factors of intelligence requirement into four kinds and each kind includes several minor terms. The first kind is the requirement of single user's which includes 9 indexes; the second kind is the requirement of institution's which includes 16 indexes; the third is the requirement of local environment's which includes 6 indexes; the fourth is the requirement of global environment which includes 10 indexes. The requirement factors make up of the elements of evaluating the intelligent quotient of IB. According to that, Boyd etc give a formula to calculate the intelligent quotient of IB:

$$IQ = 1 + IQ^{+} + IQ^{-}$$

IQ^{+}, IQ^{-} represent separately the plus, minus difference of the intelligent quotient gained by evaluating of one building and the default intelligent quotient of the same kind buildings. The method which is able to evaluate the intelligent buildings according to all aspects is extremely helpful for us to completely realize and qualitatively evaluate the modern IB. However it is necessary to do in-depth and careful basic inquiries and researches. The practical setting values of the indexes are different when the classification, the area, the culture background and the time are different, and how to set values and how to get a weighted value are also need to do steady basic researches. Moreover, we argue that it is the fundamental method which is convenient for operating and is suitable for calculating the intelligent quotient of IB in China to use the IB demand factors by D.Boyd etc. That is very helpful for promoting the sustainable development of the intelligent building in China and also very helpful to the designers, investors and users. At present no actual work has been in this field in China

5. THE OBSTACLE ANALYSES OF INTRODUCING THE SUSTAINABLE DEVELOPMENT CONCEPT OF CONSTRUCTION DESIGNING AND BUILDING

Currently, the main factors which affect the development of building intellectualizing in China are shown by figure 3.

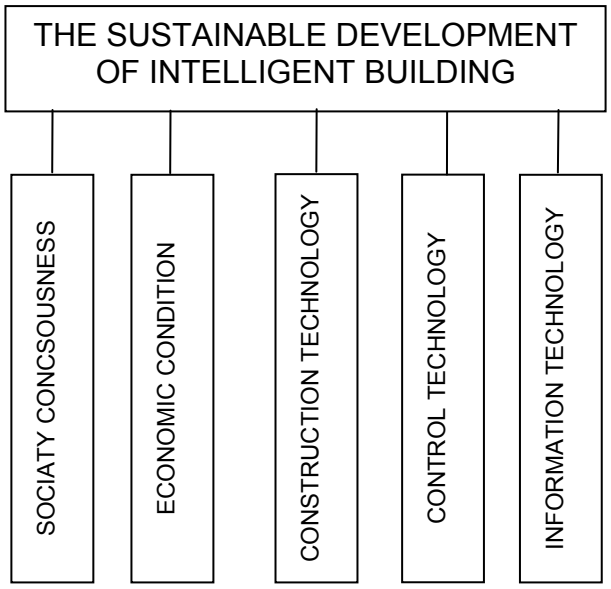

Figure 3: the main factors which affect the development of building intellectualizing in China.

5.1 Social environment and consciousness

At present there is blindness in the development of construction industry of China, especially in the development of the intelligent building. That is to say, intellectualizing buildings is just for the purpose of intellectualizing but not for needs. That is wasteful in using energy. On the other hand, intelligent buildings are generally considered as buildings with the 3A function without paying attention to the ecological intelligence.

There are 6 problems which need to be dealt with in the development of intelligent building in China:

1) At present the requirement for function is proposed by owner, designing institutes are usually responsible for the designing, but design deepening of intellectualizing and practical pursuing are completed by the system integration merchants, there are generally inconsistency even disjoint, which result in falling short of the expectant purpose of the project.

2) There are short of relevant supporting standard and technological codes in the segments of project programming, designing, and construction, managing,

quality supervising, project checking and accepting, and so on. It is inadequate to pay attention to the aspects of ecology, saving energy and protecting environment.

3) The aspect of technical production is lack of necessary guidance, coordination and support in the extension from the technology study of intelligent building to production developing. There are inadequate hardware and software productions of intelligent building which are not in possession of independence intellectual property.

4) The technical services including techniques and production evaluating, consultation and management are inadequate.

5) It is prevalent that to pay more attention to construction than management. The relevant policy, management standard and service system is lacking. The technical levels of realty management personnel can not meet the requirement that the intelligent systems function normally.

6) The true sense of intelligent building is to content the practical need, which are not widely mastered in China.

5.2 Integration System

Most of building designers in China are in defect of a general understand and comprehension of the intelligent building, it is difficult for them who consider the BIS only as the work of electricity engineers to realize the new requirement and development in recent future, to integrate the BIS and the building structure as a whole, and to consider appropriately for floor height, column net, plane design as well as technical floor (room), pipeline well, electricity well and so on. But there are a few of engineers who begin to realize some efficient measures. They adopt large space which can be divided neatly for the work place, pay attention to flexible wiring in the horizontal direction, leave appropriate spare upright well in the vertical direction, adopt biggish design over-measure of total electricity capacity, consider the load of the partial floor to support larger communication and control equipment in the future.

The sustainable of intelligent building is also embodied by intellectualized alteration of non-intelligent building. But alterations are unnecessary and difficult for old style buildings which have small bay, low floor height and small scale and the actual effect of alteration is not distinct. At present some office buildings, school buildings and commercial building which were built in late 1980s have the probability of alteration, it is suited to intellectualize such buildings by adopting the wiring form which occupy little spaces such as ceiling wiring or flat cable wiring. But the work of alteration is rather difficult because there are so many restrictive conditions. Furthermore most of the engineers of altering buildings are computer engineers or electricity engineers who have no interests and consciousness to understand the plane arrangement, space scale and structure design of old buildings in depth and in detail, they are merely accustomed to simple surface stick of the wiring system.

In addition, according to the function, managing requirement and investing standard of diversified buildings, the China intelligent building design standard divides every intellectualized system of intelligent building into three classes and considers synthetically of the application situation and the facility which make up of the system and classifies it synthetically. It breaks the concept of totally integrating of BIS, represents the thought that the subsystem should be designed according to actual situation. In this kind of classification, the integration system can be carried out through the way that the designers program and design on the whole in advance and adequately take properly leading integration projects and each layered integration subsystem which will present spaces and interfaces for development into account. At present the way usually adopted is to process basic information induction based on the telephone network that has already existed. Rebuilding the information network is not an easy task. Although the network takes little space, the rebuilding project is related to the whole building.

5.3 The cost of intellectualized building

In China, it is difficult to reinstall or replace the components of control system in intelligent building. One reason is that the intelligent facilities are imports which are different in standard and very expensive. In order to decrease the cost of project, the imports should be adopted when the apparatus such as sense organ, implement organ, damper, transmitter and so on are not developed in series in China, but the system controlled by computer are developed independently. The more important reason is that the developer of real estate or investors, the corporations of property management and the owners do not understand the organization's economic cooperation theory, the obstacle in notion extremely obstruct the development of intelligent building in China. In addition, Chinese have the bred-in-the-bone conception of considering the weak electricity control system which could implement the intellectualized building as high consumption, therefore the intelligent building for the common consumer is hard to come true, that need to calculate exactly the lifecycle cost of intellectualized system, to make the investors and the developers including property managers and the users see clearly the benefit which intellectualizing brings to the selling, operating, management and use of the building.

However, in China the lifecycle cost analyses method is merely instructed at schools as a theory method on the whole, for the inconsecutive processes of construction and management, in fact the method is not used widely. Lifecycle cost is mainly made up of purchasing cost and operating cost, but we usually concentrate on the purchasing cost only, to save investment is mostly to save the purchasing cost, which often lead to the many intelligent systems in buildings running abnormally in China. Along with the market gradually perfecting itself, the lifecycle method as practical means will be used to control the investment holistically. Such problems will be dealt with.

6. CONCLUSION

According to forecast, in twenty-first century about a half of the intelligent buildings will be built in China. Here will be a very large market. None can accommodate the advancement in future society other than understanding, developing, managing intelligent building correctly. It makes great practical sense for promoting the concept renovation in the building intellectualizing industry of China to learn the advanced idea and concept of design from Europe, especially the method to evaluate the intelligent quotient of the intelligent building, and to improve and progress it in details according to the situation of China. IB in China must exceed the narrow sense of BIS, make developer, designer and manager hold tightly the core of development of the intelligent building, construct and develop the intelligent building in the way that is oriented by the need of people's work and life and accord with the practice. To develop the Chinese series production of BAS (Building Automatic System), experts in China must start with extending application of Chinese computer control technology and developing sense organ. Only in this way can we actualize sustainable development of intelligent building.

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