

## Research on building modular design to deal with meteorological disasters

Tian Wang<sup>\*1</sup>, Shanshan Zhang<sup>2</sup> and Tong Wu<sup>3</sup>

<sup>1</sup>PHD, <sup>2</sup>Professor, <sup>3</sup>PHD, School of Architecture, Harbin Institute of Technology; Key Laboratory of Cold Region Urban and Rural Human Settlement Environment Science and Technology, Ministry of Industry and Information Technology, China

### Abstract:

China's high latitude cold region has a vast land area, bad weather conditions, and frequent meteorological disasters. The existing research on the design of building disaster response space is lack of targeted research results. Therefore, starting with the modular design of buildings, this paper puts forward design countermeasures for the building space of disaster response and rescue, which can realize the rapid functional transformation of different rooms during the disaster, so as to cope with the the medical treatment requirement of the residents when there are disasters .

**Key words:** disaster response design , modular design, medical building, emergency treatment

### 0 Preface

Modular architecture is an architectural design method guided by the concept of modules and it can form a complex with multiple functions through the orderly combination and assembly of common units, so as to meet various use needs. The core of modular architecture is the smallest unit with generality and flexibility.

The modular design method originated from industrial production, and was initially applied to the design of industrial products. Its purpose is to enhance the universality of unit components, so as to increase the audience of products in disguise and realize the purpose of profit. Gradually, the idea of modularization was introduced into the theory of architecture and widely accepted[1].

The mode of modularization originated from the time of industrial production in the last century, and was initially applied in the field of industrial production. According to the needs of the owner, the modular units are combined and assembled according to some logic to generate complete industrial products. This method greatly reduces the cost of industrial production and improves production efficiency. Gradually, this design method was applied to the architectural theory[2]. Modular buildings are made up of the same modular units. This high-throughput modular unit can carry a variety of functions. The modular units are built according to needs of forming a composite multi-functional and multi-purpose complex. The modular building can be produced and assembled quickly. More than this, the internal function can be changed quickly according to the change in demand, which is very complex to meet the space requirements of the medical disaster responding building[3].

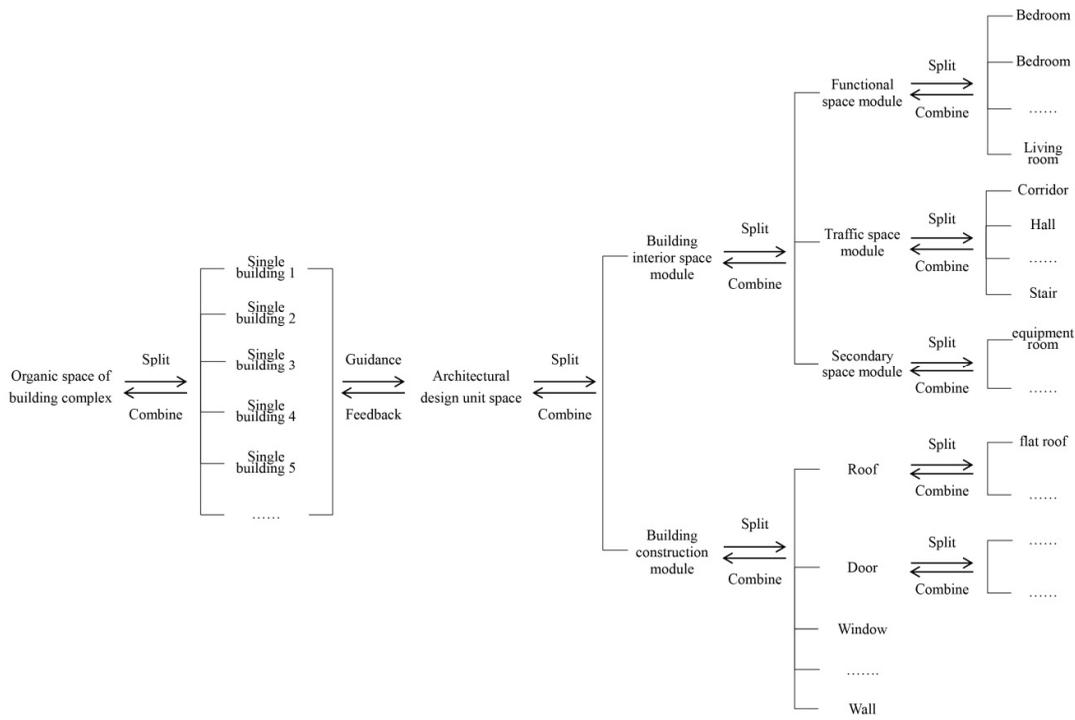


Figure 1-1 schematic diagram of modular building space construction

**1. Application of modular design in building design of disaster response**

**1.1 the application advantage of modular design**

In multi-purpose space modular architecture has two important parts, namely modular unit and composition logic. The core is the modular unit. This module unit can produce quickly, build and combine quickly, and transform the function of internal space according to the change of external environment[4]. Fig.1-2

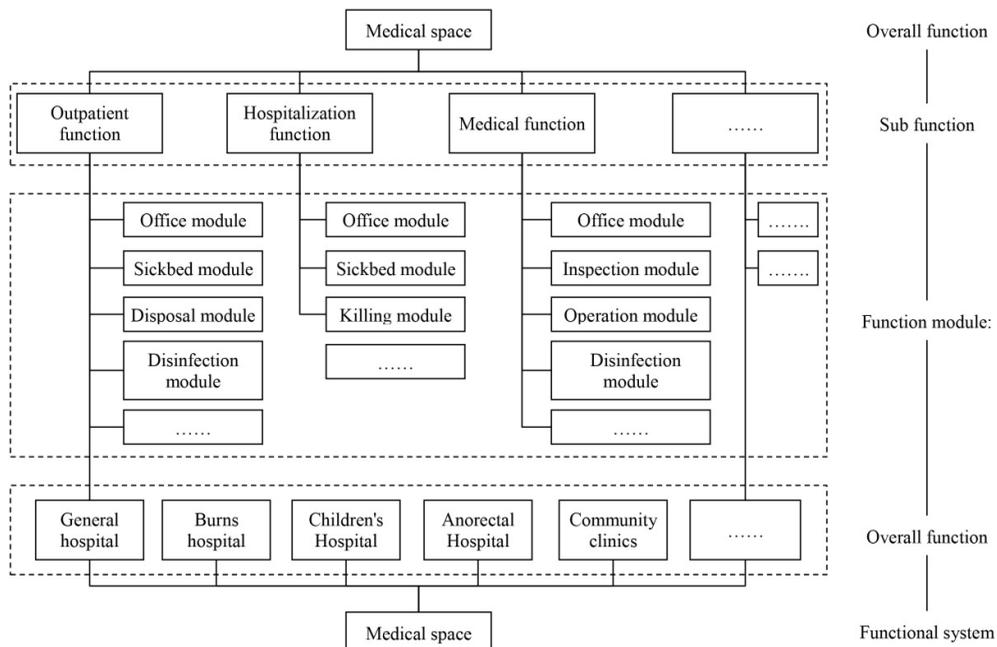


Figure 1-2 modular design flow chart of medical space

The advantages of modular design are as follows:

- (1) Relative independence. In the modular building, each module unit is a relatively independent component, which can be designed, prefabricated, produced, debugged and modified in advance to form the final module unit. Therefore, this independence makes the modular building more scientific and reasonable[5].
- (2) It is interchangeable. In order to make the combination construction stage go smoothly and realize the overall function of the building, standardized treatment is generally adopted in the connection part of module units, so as to ensure the rapid splicing of any module unit[6].
- (3) Universality. Module units with universal modules often need to undertake a variety of internal functions, so it has a high degree of universality, the same module unit can be successfully built into two different buildings[7].

### **1.2 application process of modular design method in medical space .**

internal space of medical building is very complex. Therefore, when modular design of medical building is carried out, the whole medical building is disassembled and divided into parts from macro to micro, and the design goal is gradually completed[8].

(1) Firstly, the functions of medical buildings are disassembled to form multiple sub functions. For example, we can divide a general hospital into outpatient, emergency, medical technology, inpatient and other sub functions, each of which contains various functions with strong tendency.

(2) Secondly, the sub functions are further subdivided into functional modules. For example, the medical technology part can be divided into office module, operation module, inspection module, killing module and so on. Function module is the smallest module unit of the whole medical building and each of them bears a single and independent function.

(3) At last, for modular architecture, this combination is not immutable, but can be flexibly transformed according to different needs of different periods. If all the functional modules of outpatient service and medical technology can be transformed into inpatient function, then a general hospital will be transformed into an inpatient center.

## **2 Adopt modularized medical space design method**

### **2.1 modular design of consulting room, inpatient department and office space**

(1) dimension of module space.

The size of module space is determined by the functional requirements of consulting room, inpatient ward and office. For the consulting room, the module space shall be able to accommodate the space needed for a doctor and patient who are being diagnosed and a waiting patient; for the inpatient room, the module space shall be able to accommodate the space used by at least two beds and two patients' families for waiting; for the office room space, the module space shall be able to accommodate the space used by at least four staff.

(2) the general facilities of the modular space

The function of the module space covers the diagnosis, treatment, hospitalization and office, so the general facilities should be set up in the module space to meet the three usage needs. First, the strategy of functional transformation in disaster time requires that all the furniture and equipment in the room should be easy to dismantle or move during the design, so as to reduce

the time consumed by the transformation function and increase the medical efficiency. Second, in addition to the common power interface, heating facilities and other general facilities, each module space should also be equipped with tap water interface for the use of the consulting room; oxygen delivery interface for the use of the ward. Under normal conditions, the unused interface is closed, and only enabled when the disaster function transformation countermeasure is started. Combining the above two points, in the module space, the consulting room, inpatient and office space can form the following layout mode.

① in the consulting room module space, we should set a doctor's office area that can be used by a pair of patients, a diagnosis area that can be used to check one person and has a diagnosis bed, a waiting area that can be used for two people to wait at the same time, and a standardized storage and cleaning area that can be provided for doctors separately. In the consulting room module space, the oxygen delivery interface on one side of the wall is closed; while the tap water interface connected with the tap water is open.

② in the module space of inpatient ward, two single beds, rest area for patients' families to wait around each bed and two standardized lockers are set to provide storage space for patients and their families. In the modular space of inpatient ward, the oxygen delivery interface is connected to the instrument board of the hospital bed and is in the open state; the tap water interface is blocked behind the locker and is in the closed state.

③ in the office module space, six single desks are set, and the office personnel are equipped with standardized lockers. In this mode, the oxygen delivery interface on the wall is closed, and the tap water interface is blocked behind the locker and is also closed.

## **2.2 refined design of module internal space**

(1) in the face of meteorological disasters, the interior space refinement design of consulting room module, as the most critical station of medical treatment, often has problems such as patient privacy, diagnosis and treatment efficiency, diagnosis and treatment order. In order to improve the efficiency of medical treatment, the above problems should be solved by means of refined design of the space.

① Set up secondary waiting space. After the occurrence of meteorological disasters, people's facial tension and psychological anxiety are more common. The staff gathering caused by the transitional care and curiosity will even affect the efficiency of medical staff's diagnosis and treatment. The second waiting can help to calm the mood of patients and their families and ensure the relative quiet of the diagnosis and treatment space by buffering the waiting space.

② Adopt the design means such as setting soft partition to cover the line of sight. In the case of a large number of patients, the phenomenon of onlookers urging medical staff often occurs. The interference of onlookers to medical staff and patients' needs to be further blocked, so as to improve the treatment efficiency and better protect the privacy of patients.

③ Adopt the principle of barrier free design. The internal space of barrier free design is mainly to meet the medical needs of disabled patients or patients with weak mobility due to injury.

④ Use electric device. When the patients who are inconvenient to move due to the disaster are treated by the medical staff, the efficiency of the treatment will often be reduced, or the degree of pain and injury level of the patients will be increased due to the movement, which will be optimized by equipping with electric mobile device, lifting device, steering device, etc.

⑤ Provide cleaning facilities. The post disaster rescue task is heavy, doctors often do not have

time to go to the disinfection room frequently for disinfection and cleaning treatment, which is not only not conducive to the diagnosis and treatment of medical staff, but also increases the possibility of indoor space pollution or cross infection of the injured and the sick. Simple and easy-to-use cleaning facilities are set in the module space of the consultation room, which is conducive to effective prevention.

(2) the detailed design of the internal space of the inpatient ward module inpatient ward is an important space for patients with serious illness to receive treatment and recover , but there are often problems such as ignoring patient privacy, diagnosis and treatment efficiency.The refined design of the internal space of the inpatient ward module is conducive to improving the medical environment of patients, accelerating the recovery rate of patients, so as to improve the medical treatment efficiency of township hospitals in cold areas.

①Take necessary measures to block the sight to protect the privacy of patients. Effective screening measures in advance can avoid the cross transmission of anxiety between patients, not only protect the privacy of patients in the ward, but also ease the disease.

②Barrier free design. In order to meet the medical needs of disabled people, and also to meet the medical needs of patients who are inconvenient to move due to injuries after the disaster, barrier free space is set up to fully reflect the same humanistic care for all kinds of people.

③Use electric device. When the disabled or the patients who are inconvenient to move due to the disaster are treated by the medical staff, the treatment efficiency will often be reduced, or the degree of pain and injury level of the patients will be increased due to the movement, which will be optimized by equipping with electric mobile device, lifting device, steering device, etc.

④Adopt humanized design to reflect humanistic care. Taking care of the psychological emotions of the patients after the disaster, through the humanized space design, the restless emotions of the patients can be relieved, which is helpful for the recovery of the patients.

### **2.3 cold adaptability design of the module**

(1) improve thermal performance of enclosure

Under the condition of meteorological disaster, it is very important to ensure a good thermal comfort in the module. For module space, it is the most effective way to improve the thermal performance of maintenance structure, which can reduce the energy consumption of heating equipment such as air conditioning and ensure good indoor comfort. The methods to improve the thermal performance of the maintenance structure outside the module space are as follows

(2) technical measures to prevent infiltration of cold air

The infiltration of cold air will have a very bad impact on the development of internal medical work. The cold wind will affect the recovery rate of the patients, and thus affect the efficiency of the whole rescue work. For the cold air penetration at the door and window of the module space, the sealant strip shall be added at the reasonable position of the door and window, and the sealant strip shall be made of materials with good cold resistance; for the cold air penetration at the pipeline, the check components such as the sleeve can be added; for the cold air penetration at the module connection, the overall sealing can be realized by setting the protective layer.

### **3 conclusion**

The same room can not be transformed into other functional rooms, but modular space

design can make each room standardized, unified and universal, so as to ensure the smooth implementation of functional transformation countermeasures in disaster. Therefore, the modular space design strategy is the prerequisite for the transformation of different room functions. It can realize the fast functional transformation of different rooms in the disaster, ensure the efficient implementation of the functional transformation countermeasures in the disaster, and better undertake the external support of the medical force.

**Reference:**

- [1] Isaac S, Bock T, Stoliar Y. A methodology for the optimal modularization of building design[J]. *Automation in Construction*, 2016,65.
- [2] Yu H, Bai G. Research on Modularization and Sustainable Design of Temporary Housing[J]. *Art and Design Review*, 2018,06(03).
- [3] Pati D. Could Designing a Hospital Like a Medical Device Contribute to Patient Safety?[J]. *HERD : Health Environments Research & Design Journal*, 2016,9(4).
- [4] Blackwell T, Bosse M. Use of an Innovative Design Mobile Hospital in the Medical Response to Hurricane Katrina[J]. *Annals of Emergency Medicine*, 2007,49(5).
- [5] Cheng B, Shi R, Du D, et al. Mobile emergency (surgical) hospital: Development and application in medical relief of “4.20” Lushan earthquake in Sichuan Province, China[J]. *Chinese Journal of Traumatology*, 2015,18(1).
- [6] Silva J B, Santos C, Sequeira J. Developing a timed navigation architecture for hospital delivery robots[J]. 2013.
- [7] Price A D F, Lu J. Impact of hospital space standardization on patient health and safety[J]. *Architectural Engineering and Design Management*, 2013,9(1).
- [8] Ernst J, Schleiter A J. Standardization for patient safety in a hospital department: killing butterflies with a musket?[J]. *Qualitative Research in Organizations and Management: An International Journal*, 2018,13(4).