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# Application of Assembly Building Technology in Military Building Structural Design

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**Abstract:** With the development and maturity of assembly building technology, more and more fields begin to use this method for structural design. Assembly building technology can also be used in military building structures. For example, block building structure design, slab building structure design, box building structure design, skeleton board building structure design, lifting board building structure design can be used in the design. In this way, the construction of military buildings can be carried out quickly and environmentally, and the safety requirements of anti-riot and anti-seismic for military buildings can be satisfied.

## 1. Overview of Assembly Building Technology

### 1.1 Brief Introduction of Assembly Building Technology

What is assembly building technology? It mainly refers to the new building technology that can be assembled into buildings through prefabricated components on the site, and the buildings it builds are called assembly buildings. According to the form and construction method of prefabricated components, it can be divided into five types: block building, board building, box building, skeleton board building and lifting board building. The development of assembly building technology benefits from the development of modern industrial technology. In modern times, building houses can be manufactured in batches like machine production, typically represented by 3D printing technology. That is to say, now people can prefabricate the components outside the construction site, then transport the corresponding housing components to the site and assemble them, and a modern building is completed. Assembled architecture began to enter the vision of architects in the early 20th century, and in the 1960s, Britain, France, the Soviet Union and other countries have begun to try in practice.



Figure 1. Assembled Architectural Style



## 1.2 Advantage Analysis of Assembly Building Technology

### 1.2.1 Advantage Analysis of Assembly Building Technology

Compared with traditional building technology, assembly building technology has realized four major changes in product production: 1. Production technology, from manual production to mechanical production technology, has realized industrialization and scale. 2. The production site shall be transferred from the site to the factory. In this respect, it can not only reduce the dependence on the site area of the construction site, but also centralize the construction site to produce building components in the form of factories. 3. Construction mode, from site construction to site assembly. This method directly shortens the construction cycle, as long as the construction workers directly assemble the components in the construction site, they can complete the construction of the building. 4. Construction workers, from migrant workers to industrial workers and operators.

### 1.2.2 Assembled building realizes three controllables in the process of project development

First, the quality can be controlled. In fact, the industrial production of assembled buildings replaces manual work with machines, which can be considered as eliminating the opportunity for workers to make mistakes in the production process. Because the reliability of mechanical equipment is much higher than the reliability of workers'on-site operation and construction. In the traditional construction mode, the quality risk caused by workers'quality, technical ability and sense of responsibility can be effectively avoided, and the quality can be controlled.

Second, the cost can be controlled. Industrial production, in the use of raw materials, machinery and equipment, manual use, etc., can achieve accurate calculation, which is of great help to the cost budget and control. In addition, the process of on-site construction is simple, and the whole process of construction can be simulated by computer. Compared with traditional construction methods, the cost risks of raw material price fluctuation, labor cost change and on-site visa change can be more effectively avoided and cost can be controlled.

Third, progress can be controlled. In the case of sufficient equipment capacity and raw material supply, industrial production makes the production schedule of components almost completely controllable. The process of field assembly is simple, and the traditional construction method is vulnerable to the shortage of labor force, the poor supply of materials, and even the weather factors such as rainy, foggy, typhoon and so on. However, the application of assembly building technology can effectively avoid these progress risks and make the progress controllable.

### 1.2.3 Environmental Protection Characteristics of Assembly Building Technology

According to the project calculation in Fangshan District of Beijing, the application of assembly building technology has higher efficiency in the use of natural resources and can save material resources. Compared with traditional building technology, it has greater advantages. It can be said that assembly building technology and modern environmental protection concept are perfectly integrated, so its application prospects will be bright.

Table 1. Contrast Table of Carbon Emissions

Resources	Carbon Emission Factor	Traditional residence	Assembled Residence
Steel products/kg	2	110.08	109
Concrete/m <sup>3</sup>	260	161.478	111.886
wood/kg	0.2	2.89	0.84
mortar/kg	1.13	18.306	3.028
Thermal insulation material/kg	11.2	34.27	17.36
energy/kg	0.68	275.38	247.50

#### *1.2.4 Other Advantages of Assembly Building Technology*

The construction site cancels the external frame, the plastering process of indoor and external walls, the uniform distribution of reinforcing bars by factories, the cancellation of floor formwork, the replacement of traditional wood formwork by wall plastic formwork, and the construction waste on site can be greatly reduced. PC components are prefabricated in the factory, and are hoisted and positioned by large cranes after being transported to the construction site. Operators only need to carry out supporting plate positioning, temporary fixing and other work, greatly reducing the labor intensity of operators. The reserved dimensions of doors and windows have been completed in the factory. The size deviation is completely controllable, the positioning is accurate, the site installation is simple, and the installation quality is easy to guarantee.

## **2. Basic Requirements for Structural Design of Military Buildings**

### *2.1 Safety Requirements for Earthquake Resistance and Breakdown Resistance*

The anti-explosion design of structures may not need special design treatment for civil buildings and ordinary industrial buildings, but for military buildings, it is necessary to introduce anti-explosion requirements, which play a very important role in the basic safety of military buildings. Take an example of a terrorist attack, which happened in the United States around the world famous event: September 11. On September 11, 2001, at the World Trade Center in New York, the United States, two civilian airliners hijacked by terrorists crashed into World Trade Center Building 1 and World Trade Center Building 2, respectively. Two buildings collapsed one after another after being attacked. The remaining five buildings of the World Trade Center also collapsed and damaged. In a short time, another hijacked airliner crashed into the United States. The Pentagon of the U.S. Department of Defense in Washington, D.C. The Pentagon collapsed due to partial structural damage. Although this did not happen in the real military building, it can give the military inspiration: if the more important military building can not resist structural burst, then when the enemy attacked a part of the building, the whole building will collapse.

The effect of explosive load on military building structure is mainly manifested in the interaction between explosive load and structure. Generally speaking, even in the case of partial destruction and deformation of a good military building structure, such as doors, windows, roofs and other building structures are damaged, or even key components are damaged, there will be no secondary disasters caused by partial destruction. For example, the continuous collapse of the whole structure is caused by local damage. Therefore, the explosion resistance of building structures plays a very important role in military building facilities. Some countries in the world have carried out a lot of research on the explosion resistance of military building structures, and also formulated corresponding national standards. For the anti-explosion of military fortifications and important military buildings, corresponding standards have been formulated for different anti-explosion problems. These standards have been applied in the field of military design and scientific research. In the standard, researchers have given the calculation methods of explosion load for different explosion modes, such as chemical explosion, nuclear explosion, chemical explosion, etc., and focused on the anti-explosion design methods of basic structural components and key components. Of course, the standards also give suggestions on how to prevent explosion-induced disasters and secondary disasters.

### *2.2 Safety Requirements for Earthquake Resistance and Breakdown Resistance*

#### *2.2.1 Rapid construction is the basic style of military work*

The military pursuit of speed has existed from ancient times to the present. During the Yuan Dynasty in China, Genghis Khan began nearly a hundred years in Mongolia. Why is he the most successful militarist in world history? That is closely related to the speed and mobility of its unrivalled cavalry. The same was true in World War II, when German and Japanese motorcycles and armored forces were separated in Europe and Asia for their excellent maneuverability. For military buildings, if rapid

prototyping can be used to quickly build standard front-line bases and logistics sites for the military, it will be of great significance for war or peace years.

### *2.3 Concept of Environmental Protection*

Although the number of military buildings is not as large as the number of civilian houses, it has at least a certain scale. As far as the protection of ecological environment is concerned, military buildings still need to take green environmental protection into account in peacetime, so as not to cause environmental damage due to military construction. So from the point of view of military building structure design, we should optimize the structure, reduce the use of raw materials, and design a reasonable structure to protect the ecological environment on the premise of ensuring the use space and safety.

## **3. Application of Assembly Building Technology in Military Building Structural Components**

### *3.1 Structural Design of Block Buildings*

Prefabricated block-like materials are used to build assembled buildings with walls. It is suitable for ordinary military buildings, such as logistics rooms, and the height of 3-5 stories is the best. Some temporary military buildings can be well constructed by this method. If the military building wants to make a breakthrough in height, it can be accomplished by improving the strength of the block or configuring steel bars. Block building has strong adaptability, simple production process, simple construction and low cost. It can also take local materials and even use industrial waste for construction. In block building structure, building blocks can be divided into small, medium and large ones. Small-sized blocks are suitable for manual handling and masonry, with a low degree of industrialization, and can be quickly completed with the participation of military personnel. Medium-sized blocks can also be constructed by small machinery, which can effectively improve the construction efficiency and meet the speed requirements of military buildings. Large-scale blocks have been replaced by prefabricated large-scale plates, which will be described in detail below. There are two kinds of solid and hollow blocks, the solid ones are mostly made of light materials. In order to ensure the strength of the masonry, cement mortar is recommended to be used at the joint of the masonry. Small blocks can also be built by sleeving instead of mortar, thus reducing the wet operation in construction.

### *3.2 Design of Sheet Building Structures*

The slab building structure is assembled by prefabricated large-scale interior and exterior wall panels, floor panels and roof panels. Because the main material is slab-like, it is also called large-scale slab building. It is the main type of fully assembled buildings in industrial architecture. In military buildings, slab buildings can reduce the weight of structures. In this way, not only can the construction speed be faster, but also can expand the use area of buildings and improve the seismic capacity of military buildings, which has practical significance for military buildings. The inner wallboard of slab building can be made of reinforced concrete, solid slab structure or hollow slab structure. When making the exterior wall, the reinforced concrete composite board with insulation layer, or lightweight aggregate concrete, foam concrete or large hole concrete will be adopted, which will enhance the warmer indoor environment for the military in the northern area. Under the plate building structure, indoor equipment can use centralized indoor pipe fittings or box toilets to improve the degree of assembly. The key problem of large slab building is joint design. In structure, the integrality of components can be improved by welding, bolt connection and integral connection of post-poured concrete. In rainy areas, waterproofing should be considered in military buildings. This is mainly to solve the waterproofing problem at the joints of exterior wall panels, as well as the thermal treatment of floor joints and corners.

### *3.3 Design of Box Architecture Structure*

With the development of technology, building technology has gradually developed from the basis of plate building to box building, which is also a kind of assembly building. Because of the high degree of industrialization of this kind of building, it can be widely used in the unified military building construction. Because in general, not only can we complete the structural part of the box in the construction factory, but also we can install the interior decoration and equipment of the building facilities, such as furniture and carpets. After lifting the box and connecting the pipeline, it can be put into military use, which has great advantages for the use of temporary military buildings. The assembling forms of box-type buildings are: full box-type buildings, which are composed of overlapping load-bearing boxes. Plate box type, small bay kitchen, bathroom or stairwell into load-bearing boxes, and then with the walls and floors and other components of the building. Core box type, with load-bearing bathroom box as the core body, around which floor, wallboard or skeleton are used to form the building. The skeleton box type, many residential units or single-room boxes made of light materials, is supported on the load-bearing skeleton to form a building. There are also bathroom boxes made of lightweight materials, including equipment and pipes, which are placed in buildings with other structural forms. Although box building has a high degree of industrialization, it is inconvenient to transport and needs heavy lifting equipment, so it also has certain limitations.

### *3.4 Structural Design of Skeleton Plate Building*

This kind of building structure consists of prefabricated skeleton and slab. Its load-bearing structure generally has two forms: one is a frame structure composed of columns and beams, and then shelves floor slabs and non-load-bearing inner and outer wallboards; the other is a slab-column structure composed of columns and floors, and the inner and outer wallboards are non-load-bearing. In military buildings, some buildings require higher floors, so the use of such structures will be very suitable. Because the load-bearing skeleton of skeleton and slab building is usually a heavy reinforced concrete structure, or steel and wood skeleton and slab combination. There are two types of reinforced concrete frame and slab structures: fully assembled, prefabricated and cast-in-situ integrated. Whichever structure is adopted, it can ensure that the structure of military buildings has sufficient stiffness and integral connection. The important connections between columns and foundations, columns, beams and slabs should be constructed according to the needs of structures and construction conditions.

### *3.5 Structural Design of Lifting Floor Building*

Strictly speaking, the floor-lifting building is also a kind of slab-column structure system, but the construction methods of the two are somewhat different. This kind of building repeatedly pours floor slabs and roof slabs on the bottom concrete floor, so that prefabricated reinforced concrete columns can be erected. Then the floor and roof slabs are lifted to the design height and fixed by using the hydraulic jack placed on the column as the guide rod. A large number of operations are carried out on the ground during the construction of lifting slab, which can reduce the operation at high altitude and vertical transportation, save formwork and scaffolding, and reduce the area of construction site. Lifting slab buildings generally have large column spacing and strong floor bearing capacity, so they can be used in military buildings with military warehouses, large military construction sites and multi-storey garages.

## **4. Improvement and Application of Assembly Building Technology in Structural Design: A Case Study of a Military Museum**

The basic requirements for earthquake resistance of military museums can be summarized as follows: under small earthquakes, the museum structure is intact and can be used continuously without maintenance, not to mention the loss of property and casualties caused by earthquakes. In moderate earthquakes, minor damage, such as slight cracks, is allowed to occur in weak and important parts of the structure. But other parts of me, the problem is not big, after inspection and maintenance can continue to use. When a high-level earthquake occurs, all obvious damages are allowed, such as

obvious cracks and serious damage to some components, but at least the whole building will not collapse.

#### 4.1 Performance improvement methods and performance objectives of key components.

Most enterprises in China still retain relatively extensive management methods. The functions of procurement, warehousing and distribution are not fully integrated, and integrated internal supply chain management cannot be implemented. As a result, the responsibility of logistics cost is unclear, and the benefits of logistics management are difficult to highlight.

Table 2. Key Component Performance Objectives

Position	Frequent earthquakes	Fortification intensity	Rare earthquake
Side-Crossing Column at Exhibition Hall Entrance	elastic	Bearing capacity meets elastic design requirements	Bearing capacity meets the requirements of non-yielding design
Steel columns supporting long-span steel beams, steel trusses and cantilevered beams	elastic	Bearing capacity meets elastic design requirements	Bearing capacity meets the requirements of non-yielding design

#### 4.2. Design of Seismic Structural Collapse

The safety level of the military museum is one-level high-rise building structure. Considering the continuous collapse of earthquake resistance, the following measures can be taken in conceptual design. The main structure can use steel structure to improve the ductility of the structure. The steel structure can be fabricated by using the design style of skeleton plate in the design of assembly building structure. It can not only meet the seismic requirements, but also design and process quickly. The floor slab is set up with concrete slab reinforcement, and through the structural design of assembled building, the floor slabs and roof slabs are repeatedly poured on the bottom concrete floor, and then assembled after completion, which can better meet the seismic performance requirements. Other common partition panels adopt common board building structure design, which can quickly complete the production of internal and external wall panels and meet the requirements of rapid processing.

### 5. Conclusion

With the development of assembly building technology, its application forms are more and more diverse, and its application fields are more and more extensive. In the structural design of military buildings, considering the safety performance, such as anti-seismic and anti-blasting, rapid construction and environmental protection, assembly building technology can be used in structural design. This can not only ensure the performance requirements of the building itself, but also ensure the timely and rapid completion of tasks.

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