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Design and Application of Prefabricated Basic Components of Additional Elevators in Existing Buildings Based on BIM

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Abstract:

In order to solve the elderly people's difficulty in getting up and downstairs who are living in multi-storey houses without elevators, our government and related departments are planning to install elevators. However, the traditional method of installing elevators is too expensive and the construction period is too long. This paper focuses on improving the design and the construction technology of the prefabricated basic components of the elevators, by which the influence of the additional elevator structure, on the mechanical properties of the original structure is reduced. The improvement can not only shorten the production cycle, reduce the manufacturing cost, but also meet the requirements for safety without affecting the life of the original residents during the construction because of flexible installation. The shortcomings of the traditional method of installing elevators can be well overcome.

Keywords*: Existing building renovation, Install elevator, Prefabricated basic components, Construction technology.*

I. INTRODUCTION

From the late 1980s to the early 1990s, housing per capita in China was extremely scarce. Therefore, solving the problem of housing has become a key issue related to people' s livelihood and well-being. A large number of multi-storey houses have been built from government departments to grassroots units, and about 80 % of them have not designed and installed elevators. One of the reasons is the guidance of construction policy. The ' residential building design specification' issued in 1987 clearly stipulates that multi-storey houses with 6 floors and below 6 floors are not allowed to design and install elevators. The second reason is due to the economic situation, limited by the economic conditions at that time, the installation of elevator prices. In the early 1980s, the elevator in China is still a luxury goods, six-storey station elevator installation costs up to 400,000 yuan, while the original first-tier city house prices per square of about 600-700yuan, investment capacity is far from enough. As of 1980, the country had fewer than 20,000 elevators, and the vast majority were concentrated in buildings such as hotels and important office buildings. In the 21st century, China' s population aging has become increasingly serious. More than 70 % of the urban elderly live in old buildings without elevators, and the elderly travel becomes more and more difficult. Up and down stairs have become the biggest difficulty in travel. It can be seen that the

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installation of prefabricated elevators in existing buildings is one of the important livelihood tasks in China [1, 2].

In order to solve the above problems, since the introduction of relevant policies by the central government in 2015, all regions have generally followed up and increased support, and installing prefabricated elevators in existing buildings has become an important task for urban work [3]. In 2017, led by the China Association of Old Scientific and Technological Workers, special research was conducted nationwide to solve the problem of installing elevators. In 2018, the General Office of the State Council issued ' Opinions on Strengthening the Quality and Safety of Elevators' (No. 8, 2018), and proposed to strengthen the formulation and revision of relevant technical standards for the installation of elevators in existing residential buildings and promote the installation of elevators in existing residential buildings. In October 2019, the Deputy Prime Minister of the State Council, Ordered the Ministry of Housing and Construction to carry out special studies with relevant departments to actively promote the aging improvement of public building nodes such as ramps, stairs, elevators and armrests. In the reconstruction of existing buildings, in order to facilitate the daily life of residents, make residents live comfortable, convenient, and do not need to invest a lot of money, you can use the method of adding elevators. It can be seen that promoting the installation of elevators in existing residential buildings can improve people ' s livelihood, save energy and reduce emissions, and transform the environment. It is the concrete embodiment of our party and government leading the people to create a happy life, which is in line with the practical requirements of ' supply-side structural reform ', and is also an important measure to solve the risk of pension [4]. In recent years, various provinces and cities have actively explored and practiced the installation of prefabricated elevators in existing buildings, and have achieved initial results [5-7].

II. RESEARCH STATUS

There are many studies on the installation of prefabricated elevators in existing buildings, Huang Sibai [8] et al. In view of the pilot project of installing prefabricated elevators in existing buildings in a certain area, this paper introduces the implementation process and key points of the project from the aspects of planning, design, construction and acceptance of the additional elevator project, summarizes and analyzes the engineering cost, accumulates the practical experience of adding elevators in existing multi-storey residential buildings, and provides reference for the development of similar projects. Xia Tian [9] et al. take the construction project as an example to discuss the feasibility of elevator flat people from the aspects of architectural design, structural design and key and difficult construction schemes. From the perspective of structural system, structural calculation and structural construction, Deng Jiaping [10] and others analyzed the key points of structural design of prefabricated elevators installed in existing buildings, and analyzed with engineering examples. Xiong Haifeng [11] et al. in order to improve the assembly rate of site construction, put forward the installation of elevators and existing residential ' weak connection ' form, and verified. Based on the actual case, Liu Gerui [12] analyzed the influence of the installation of prefabricated elevator on the original structural system and the corresponding measures through SATWE module analysis. Combining with the actual case review, Liu Wei [13] analyzed the typical problems in the structural design of the existing building equipped with prefabricated elevator projects, introduced the

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process of finding and solving problems in the construction drawing review, and summarized the methods of comprehensive application of norms and the problems that should be paid attention to in the structural design of similar cases. And Yang Zhenyu [14] summed up the research on the installation of prefabricated elevators in old residential steel structures in the past three years, and expounded the overall and partial new design of prefabricated elevators in existing buildings, as well as various complex problems and solutions during construction. For the installation of elevators in old buildings with no machine room space, two solutions are proposed: the technology of machine roomless and the technology of side-mounted machine room.

In general, additional elevators need additional elevator foundation construction. The existing elevator foundation components are basically excavated, poured and maintained on site. After the foundation components reach the service strength, the superstructure is installed. The whole process needs a long period of time. Therefore, this project is mainly aimed at reducing the influence of the external elevator structure on the mechanical properties of the original structure. The design of the prefabricated foundation component with the assembled elevator and the construction technology of the prefabricated foundation component with the assembled elevator are adjusted. The purpose is to shorten the production cycle, reduce the manufacturing cost and strive to create better social benefits.

III. PROJECT SITUATION

The total building area of a project in Dongguan is 4586.82 square meters. There are five multi-storey residential buildings with five stories in height. The building safety level is level 2. The building seismic fortification category is level C. The seismic fortification intensity is 7 degrees. The structural seismic grade is level 2. The space schematic diagram of the elevator is shown in Fig 1 and the plane position is shown in Fig 2.

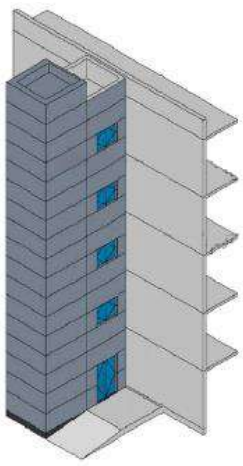

Fig 1: Installing elevator space schematic

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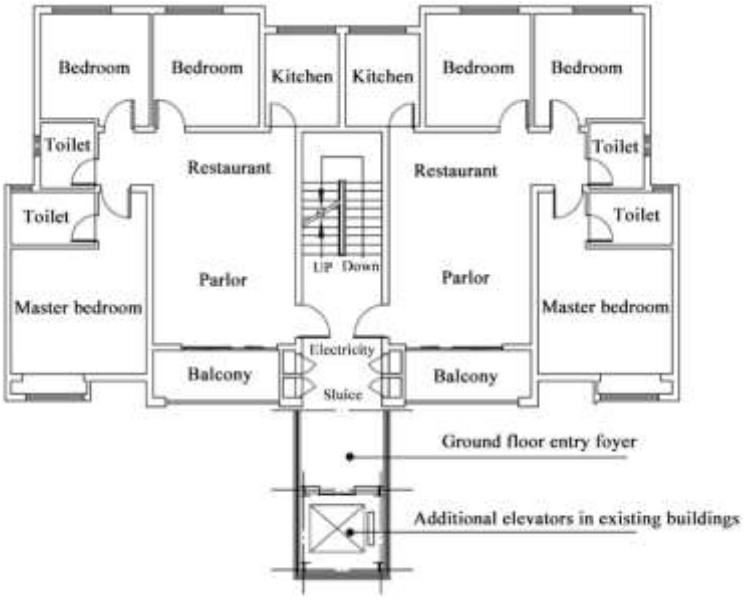

Fig 2: Plane position of elevator

IV. SOLUTION

4.1 Design of Prefabricated Foundation Components with Assembled Elevator

On the premise of meeting the construction quality, in order to shorten the construction period, improve the construction speed and reduce the construction cost, prefabricated foundation components are adopted for the foundation plan of the existing buildings with elevators. The existing prefabricated foundation components are generally poured directly in the factory, and then transported to the installation site, directly hoisted and installed on the pre-prepared ladder position cushion. Such a one-time pouring molding of the foundation components, need to be measured in advance in the installation site and draw drawings, and then accurate pouring according to the drawings, and the later foundation component volume is not easy to transport, while the weight is large and not easy to hoisting installation. Even after hoisting to the installation site, a lot of welding and other work is still needed to fix the foundation components on the cushion, and then backfill soil. This prefabricated foundation member is very limited to the selection of the site, and the foundation member formed by one-time pouring cannot adapt to a variety of different sites.

In view of the existing problems of the project, the main solution is to provide a prefabricated foundation component that can be hoisted and installed on the pre-built ladder position cushion. The additional assembled elevator shaft structure components include valve plate foundation body 2, concrete shear wall 3 and steel column 4. The design requires that the main body of valve plate foundation 2, concrete shear wall 3 and steel column 4 should be poured together. The concrete shear wall 3 and steel column 4 are both perpendicular to the main body of valve plate foundation 2. The steel column 4 is

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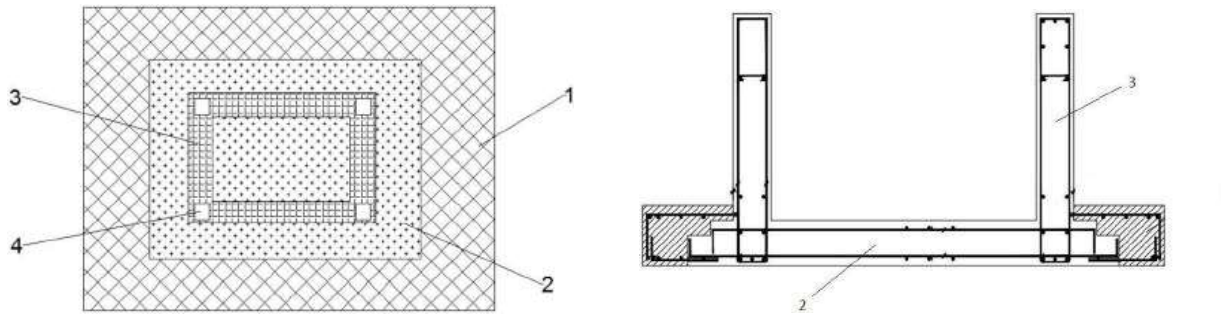
arranged at the corner of the main body of valve plate foundation 2, and the concrete shear wall 3 and steel column 4 are formed in one. The outer side of valve plate foundation body 2 is provided with removable reserved reinforcement layer 1 for secondary pouring at the installation site. The prefabricated foundation components are shown in Fig 3, and the reserved reinforcement layer structure of the valve plate foundation is shown in Fig 4.



(a) Schematic diagram of overlooking structure (b) Structure diagram

Fig 3: Prefabricated foundation components

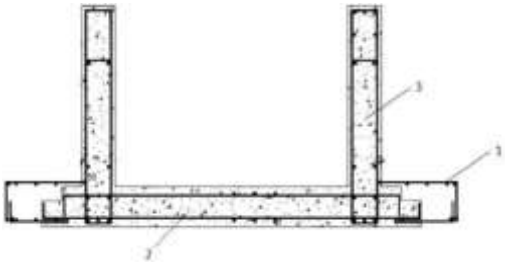


Fig 4: Structure diagram of retained reinforcement layer for main installation of valve plate foundation

4.2 Construction Technology of Prefabricated Foundation Component with Assembly Elevator

(1) The steel bars needed for prefabricated foundation members are bound, and the steel columns are arranged and fixed;

(2) The formwork is poured and checked and corrected, and then the concrete is poured. After the main body of the valve plate foundation is poured and formed, multiple thread holes are reserved at the outer side of the main body of the valve plate foundation;

(3) Bonding and welding the reserved steel layer;

(4) Make the cushion layer in advance of the position of the elevator prefabricated foundation

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components to be installed;

(5) The prefabricated foundation components are hoisted, installed on the pre-treated cushion, and the appropriate position is adjusted;

(6) The reserved reinforcement layer is installed on the outer edge of the valve plate foundation body through bolts;

(7) The reserved reinforcement layer is poured, and the components formed with the main body of the valve plate foundation are the valve plate foundation;

(8) Installation of upper components.

4.3 Construction Requirements for Prefabricated Foundation Components with Assembled Elevators

(1) Thread hole 5 is reserved on the outer side of valve plate foundation body 2, and the reserved reinforcement layer 1 is installed on the outer side of valve plate foundation body 2 through bolt disassembly. Retained reinforcement layer 1 includes horizontal reinforcement and stirrup, and vertical reinforcement and stirrup. The distance between column 4 and edge 2 of valve plate foundation is 100 ~ 300 mm.

(2) Steps are arranged on the outer side of valve plate foundation body 2, and the thickness of steps is smaller than that of valve plate foundation body 2. The main body 2 of the valve plate foundation is a concrete pouring with a thickness of 350 mm, a length of 2000 mm and a width of 1800 mm, and the reinforcement is φ12 × 200 mm double-layer bidirectional full cloth.

(3) The horizontal and vertical distribution bars in the concrete shear wall are arranged in double rows of φ12 × 200 mm, and the tie bars are φ12 × 200 mm, and are poured together with the steel column. Steel column 4 is embedded in the concrete shear wall 3. The size of steel column 4 is 200 mm × 200 mm, and the steel column 4 is welded with a stud at each interval of 150 mm in the vertical direction of the center position of the four sides, and then the whole casting is carried out.

(4) The main body of valve plate foundation 2 and concrete shear wall 3 adopt dense waterproof concrete, the concrete strength grade is C30, and the impermeability grade is not less than P6.

The structural diagram of the valve plate foundation is shown in Fig 5.

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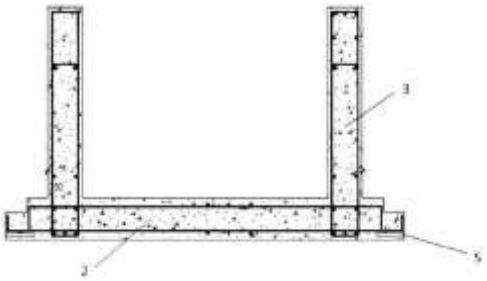

Fig 5: Structure diagram of valve plate foundation body

V. CONCLUSION

The valve plate foundation includes the main body of the valve plate foundation and the reserved reinforcement layer. The reserved reinforcement layer can be disassembled and connected with the main body of the valve plate foundation. In the transportation process, the reserved reinforcement layer is removed from the main body of the valve plate foundation. When the main body of the valve plate foundation is hoisted and installed on the cushion, the reserved reinforcement layer is installed on the main body of the valve plate foundation, and then the secondary pouring is carried out, so that the prefabricated foundation component is fixed on the cushion. The upper structure adopts steel structure, which is convenient to connect with prefabricated foundation components, and has small self-weight load and simple foundation. In general, the use of prefabricated foundation components shortens the construction period of the installation of prefabricated elevators, improves the construction speed and reduces the construction cost. Moreover, the construction does not affect the daily life of the original residents, and the installation of elevators is free and flexible.

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