

Design of Automatic Stereo Garage

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Abstract

With the development of the national economy in our country, more and more cars are entering the common families. Stereo garage becomes the first choice for solving the problems of hard parking. Especially, lift-sliding type stereo garage is the most widely used. The main content of this design is the design of automatic stereo garage, the stereo garage is including lift-sliding type, vertical circulation type, level of circulation, plane mobile, laneway type, vertical lifting, simple movements and etc. The main contents of this paper is about the design structure of two layers of lifting and transferring automatic stereo garage and the force analysis and check by the key parts of stereo garage. Four-column type steel structure garage has a large range of use because of its simple structure. The main content of this paper is the force analysis and check by the beams, stringers, support columns and car carrying boards. In addition, automatic stereo garage use hydraulic system for driving, it has difference between using the motor-driven automatic garage. Because of the advantages of hydraulic transmission, the garage will be more stable in process. This makes it suitable for more occasions. The design of the garage is also introduced the safety protection device in the running of garage. In addition, the paper includes drawn up the assembly diagram, parts diagram.

Keywords

Automatic stereo garage, structure design, hydraulic.

1. Introduction

Automatic three-dimensional garage is a new industry in China, and has a broad prospect for development. With the rapid development of economy in China, city traffic congestion and parking problem has become one of the important factors affecting the development of the city, the traditional garage has been unable to meet the requirements of the development of the city, coupled with the increasing car ownership in China, automatic stereo garage become inevitable way to solve this problem [1]. The mechanical solid garage has high utilization rate of space and saves the limited land resources of the city. It has the advantages of low construction cost and short construction period. The vehicle is fast and convenient to park in the garage, safer and more energy efficient. At the same time automatic stereo garage can park more vehicles in a limited land, to facilitate centralized management, reduce management costs and personnel and other advantages, in each cell or space can be the construction of stereo garage according to the local actual situation, can greatly alleviate these side parking problems, the public places in the garage now tight quarters and other personnel more provides a good solution. Therefore, the mechanical stereoscopic garage has a broad application prospect[9].

2. The Overall Design Scheme of Automatic Stereo Garage

At present, the three dimensional garage has the following main forms: lifting and traversing, vertical circulation, simple lifting, vertical lifting, plane mobile and roadway stacking [2]. In China, there are more elevating and shifting automatic three-dimensional garage and simple lifting garage. The lifting and shifting automatic three-dimensional garage has the advantages of quick and convenient access, simple structure and so on. The simple lift type garage can not be used for large scale applications and

can not meet the large space layout. So we choose the lifting and transversal automatic three-dimensional garage to be designed[3].

2.1 Type Selection of Lifting and Transversal Automatic Stereo Garage

The lifting and transversal automatic three-dimensional garage can be divided into two types according to the main frame. 1. four column structure type: the steel structure of this type of parking equipment has good stability, good strength and stiffness, especially for multi-storey or heavy lifting parking devices. 2. the two column structure, also called the rear cantilever type solid garage, is shown in Fig. 2.1. The biggest advantage of this type of parking equipment is wide vision and convenient access. The disadvantages are the stability of the operation of the equipment and the strength, stiffness and design requirements of the structural frame.

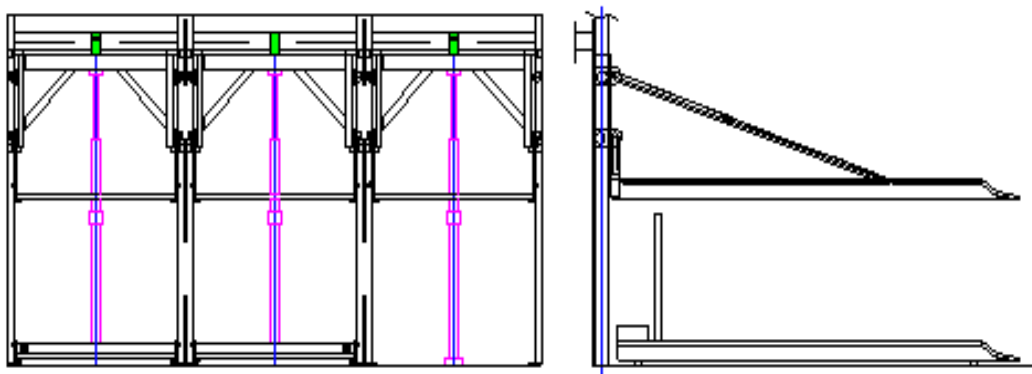


Fig.2.1 Schematic diagram of a rear cantilever type stereoscopic garage

According to the layout of the parking space, it can be divided into full floor arrangement, half underground layout and heavy column arrangement. There are two floors, three floors, four storeys and five storeys, which are generally not more than five floors, but some of them are seven or more. Some of them have also done 18 layers, but the speed of lifting is higher than that of the lower ones, so as to ensure the customers' use requirements. Half underground layout: this arrangement can build more parking space than all ground layout, high space utilization rate, but large investment in civil construction. Rearrangement type arrangement: (for only one lane, or two lane too wasteful, but can park two or two rows above the length of the vehicle parking, the layout) this arrangement can make full use of the plane to reduce the lane area, but more trouble some import car.

Because of the simple and full use of the land in the garage, the two layer three-dimensional garage of the fourth column structure is designed [5].

2.2 Selection of Lifting Method for Automatic Stereo Garage

There are six ways of lifting the lifting and transversal automatic stereo garage.

- (1) hoisting type of wire rope
- (2) chain type lifting type
- (3) hydraulic lift type
- (4) screw type lifting type
- (5) combined lifting type of hydraulic motor and wire rope
- (6) the combination of chain and wire rope lifting type

2.3 Selection of Lifting Method for Automatic Stereo Garage

Other parts of the automatic stereo garage also includes a car carrying board, security system, transferring system, moving control system system.

The car carrying board is used for vehicle parking and carrier mobile lifting vehicles, so the board must be designed for user parking safety. The board in accordance with the structure can be divided into two kinds, one is assembled a whole [4]. The assembled board mainly use ordinary steel plate

bending forming board panel using wave plate stamping, and bolted. Integral loading plate using tread steel plate welded on the reinforcing ribs and. The integral board processing is convenient, stable and high safety. So the garage in the design of integral board.

A security system is used to prevent the upper and lower car carrying vehicles falling smashed vehicles or injured driver of the important part of the garage. Can be divided into Anti falling and falling prevention hook frame upper carrier plate safety system. The anti falling from the upper carrier plate for upper carrier plate in place to fix the car crashed into the rear hook to achieve the purpose of installation of anti dropping hook[3]. The anti falling bracket is fixed on the lower floors, but larger vehicles parked in the lower layer for user. After the above analysis, the anti - drop hook is selected for the safety protection of the vehicle personnel[6].

The transversal system is the main component for the transversal of the ground floor. The control system is a system that controls the movement of vehicles.

2.4 Design Parameters of Automatic Stereo Garage

The maximum size of the parking space is 5200mm x 2250mm x 1600mm.

The maximum parking quality is 1800kg.

The two layers of the garage can be parked with 3 cars, the lower layer can be parked with 2 cars, the garage is controlled by PLC.

The garage car carrying lifting time 10s;

The lower board shifting time 10s.

2.5 The Contents and Requirements of the Structure Design of Automatic Stereo Garage

The main frame steel structure of the automatic three-dimensional garage is composed of the front and rear support columns, the front and back beams, the longitudinal beams and so on. The transmission system is installed on the longitudinal beam and post column of the main frame, including the hydraulic cylinder, the chain chain sprocket drive, the chain tensioning device and the wire rope. The car carrying board and the wire rope is connected to lift, and a lower car carrying board to move transversely through the motor and the guide rail. The automatic three-dimensional garage must have enough strength and stiffness to work safely and steadily. Structure design of automatic three-dimensional garage up-down and translation mainly includes: main frame, transmission system, loading plate and safety protection device.

3. Main Frame Design of Automatic Stereo Garage

3.1 The Working Principle of the Stereoscopic Garage

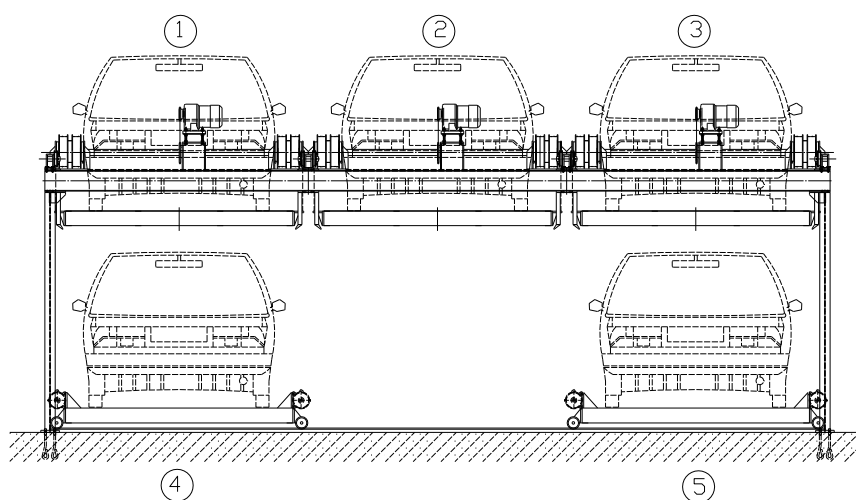


Fig. 3.1 working principles of a three-dimensional garage

The up-down and translation stereo garage is refers to the use of the car carrying the mechanical parking equipment lifting or transverse translation parking access. As shown in Fig. 3.1 the upper carrier plate only move up and down, lower car carrying board only transverse.

The principle of the three-dimensional garage work when the vehicle enters the garage, the user selects the required parking position according to the needs. When the user selects the upper floors at no-load as No. 1 car, the control system will control 5 car carrying board to move, 5 car carrying mobile control system in place after the No. 4 car moves to the right and lower car carrying board cannot move at the same time. At 1, the car carrying space, the control system of No. 1 car carrying down vehicles will wait for the user, the user will be the vehicle is parked and confirmed after the lifting device drives the car carrying up to two layers of fixed position. A lower car carrying board only for the upper sliding down the garage room, so there is a lower vacancy. The user selects the lower parking spaces, the vehicle can be directly into the garage, but no car can not enter the vacancy. The user take the car, parked in the lower car carrying board car can be directly pulled out of the garage, the car parked in the parking operation process and the process is similar to the upper carrier plate. The lift and transversal automatic stereo garage can use the land more effectively through this parking mode, and increase the number of parking cars per unit area.

3.2 Steel Structure Design of Automatic Three Dimensional Garage

The three dimensional garage is mainly mainly steel structure and reinforced concrete, and the steel frame structure or reinforced concrete can be used in the lifting and transversal garage. Compared with other building structures, steel frame structure has many advantages, such as high reliability, high strength of materials, small weight of steel structure, good plasticity and toughness of materials, simple fabrication of steel structure, short construction period and so on. And the use of reinforced concrete garage, the construction period is too long, but also can not meet its precision requirements. Because the automatic three-dimensional garage has a high requirement for its structure accuracy, the steel structure is selected for design [4].

3.3 Material Selection and Checking of Support Column

According to table 4 of Appendix II of material mechanics, 20A hot rolled I-steel (GB 706 - 88) is selected and Q235A is used in the material [9].

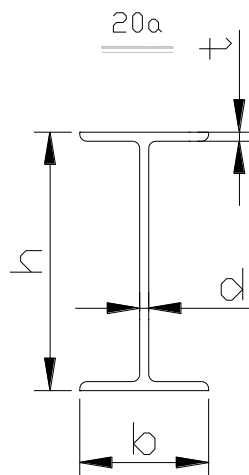


Fig. 3.2 20A hot rolled steel diagram

20A hot rolled I-steel parameters:

Yield limit $\sigma_s = 235\text{Mpa}$;

Modulus of elasticity $E = 206 \times 10^5\text{Mpa}$;

Proportion limit $\sigma_p = 200\text{Mpa}$;

Tensile strength $\tau = 375 \sim 500\text{Mpa}$;

Height $h=200\text{mm}$;

Leg width $b=100\text{mm}$;

The thickness of the waist is $d=7\text{mm}$;

The cross-sectional area of the $W=35.578\text{cm}$ facility;

The moment of inertia $\tau = 375 \sim 500\text{Mpa}$ $I_y = 158\text{cm}^4$;

Cross section coefficient $W_x = 237\text{cm}^3$ $W_y = 31.5\text{cm}^3$;

The inertial radius, $i_x = 8.15\text{cm}$ $i_y = 2.12\text{cm}$;

$I_x : S_x = 17.2$;

Support column yield strength check:

$$\sigma = \frac{P}{W} = \frac{25200}{35.578 \times 10^{-4}} = 7.08\text{Mpa} < \sigma_s = 235\text{Mpa} \quad (1)$$

The yield strength of the support column is far greater than 7.08Mpa, so it meets the yield strength requirements.

Stability checking of support column:

The length factor u of the pressure bar, because the constraint condition of the press rod is the free end fixed at one end, so;

The inertial radius $i_{\min} = i_y = 2.12\text{cm}$;

Support column length $l = 230\text{cm}$;

The flexibility of the supporting column:

$$\lambda = \frac{ul}{i_{\min}} = \frac{2 \times 230}{2.12} = 216.98 \quad (2)$$

$$\lambda_1 = \sqrt{\frac{\pi^2 E}{\sigma_p}} = \pi \sqrt{\frac{E}{\sigma_p}} = \pi \sqrt{\frac{206 \times 10^5}{200 \times 10^2}} \approx 100 \quad (3)$$

Formula (3.2) (3.3) is a formula for calculating the flexibility of a supporting column.

According to table 9.2 of material mechanics:

$a = 304\text{Mpa}$ $b = 1.12\text{Mpa}$

$$\lambda_2 = \frac{a - \sigma_s}{b} = \frac{304 - 235}{1.12} = 61.6 \quad (4)$$

Formula (3.4) is the formula for calculating the minimum flexibility of the linear formula.

The flexibility of the support column is λ greater than that of λ_1 and λ_2 , $\lambda = 133.51 > \lambda_1 = 96 > \lambda_2 = 61.6$, and the front column is a slender rod and the critical load should be calculated according to the Euler formula P_{cr} .

The critical pressure is obtained by Euler formula.

Safety factor of pressure bar in metal structure $n_w = 1.8 \sim 3$, 取 $n_w = 3$

$$P_{cr} = \frac{\pi^2 EI}{(2l)^2} = 15813\text{N} \quad (5)$$

Formula (3.5) is the formula for calculating the critical pressure.

Stability safety factor of front support column.

$$n = \frac{P_{cr}}{P_{max}} = \frac{151813}{25200} = 6.02 > n_{\omega=3} \tag{6}$$

Formula (3.6) for calculating the safety factor .

So it meets the requirements of stability.

3.4 The Car Carrier Board Force Analysis

According to table 4 of Appendix II of material mechanics, 14b hot rolled channel steel (GB 706 - 88) is selected and Q235A is used in the material [10].

As shown in Fig. 3.3, the total length of loading plate is 5.5m, and the car carrying board by force, the force of length. On board bending deformation checking.

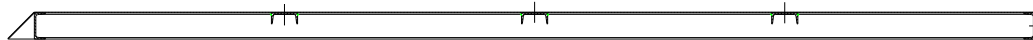


Fig. 3.3 Car carrier board drawings

The stress analysis of loading plate, as shown in figure 3.4:

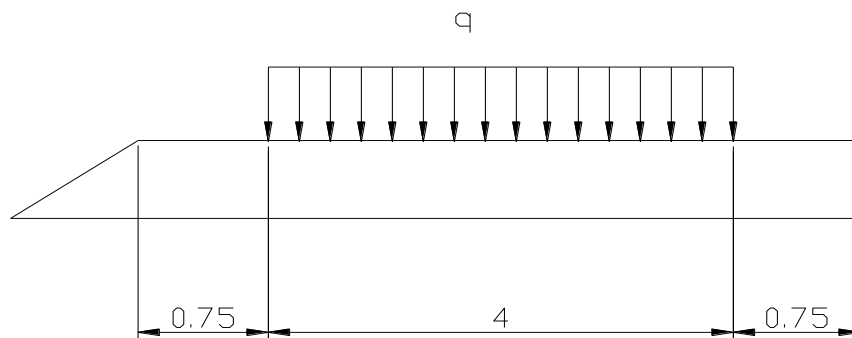


Fig. 3.4 stress analysis of the beam

The upper carrier plate using wire fixed lifting, the load after deformation is too large, otherwise it will affect the normal operation, impact on vehicle safety. So to check the car.

According to the book of mechanics of materials,

The deflection equation is:

$$f_x = \frac{ql^2 x^2}{24EI} \omega^2 \tag{7}$$

The formula (3.7) is a flexure calculation formula.

The maximum deflection is:

$$f_{max} = \frac{ql^4}{384EI} \tag{8}$$

Formula (3.8) is the maximum deflection formula.

Modulus of elasticity $E = 206 \times 10^5 \text{ Mpa}$;

The moment of inertia $I_x = 609 \text{ cm}^4$ $I_y = 61.1 \text{ cm}^4$ $I = I_y = 61.1 \text{ cm}^4$;

Force length $l = 4 \text{ m}$;

It is calculated that:

$$f_{\max} = \frac{ql^4}{384EI} = \frac{1800 \times 4^4}{384 \times 206 \times 10^{11} \times 61.1 \times 10^{-8}} = 9.533 \times 10^{-5} \text{ m}$$

After checking the deformation of loading plate is only $9.533 \times 10^{-5} \text{ m}$, meet the requirements.

4. The Supporting System of the Garage

4.1 Safety System

The safety protection of the garage is very important for the normal operation of the whole garage. The value of the vehicle in the garage is often very different. Some of the vehicles are often of high value and need to be well protected. At the same time, in the process of parking vehicles, the vehicle drivers and the people around should be effectively protected [7].

For the lifting and transversal automatic stereo garage, the following safety protection devices must be included:

1. fire protection device: in the garage some inflammable goods store must install temperature sensor or smoke sensor, such as hydraulic oil tank, automobile fuel tank, and connect these sensors to the alarm or control system.
2. car stop device: in the three-dimensional garage parking, the driver of the car must be parked in the car carrying the right position, due to the limited size of the car, the parking process becomes cumbersome. So at the end of the car carrying the installation on board a high resistance to help the driver to stop. Also the limit switch installed in the rear of the car, when the car tail will alarm to remind the user of more than. At the same time, the limit switch should be installed at each motion device to prevent failure during operation.
3. emergency stop device: in the garage operation process abnormal situation, can make the garage immediately stop running. This device should be installed in the eye - catching place with relevant hints.

4.2 The Control System of the Stereoscopic Garage

The three-dimensional garage is controlled by PLC. PLC is an electronic device designed for digital operation, which is specially designed for application in the industrial environment. It can be programmed using the memory used to implement logic sequential computing timing counting and arithmetic operation in its internal storage instructions, and through digital or analog input and output, machinery or production process control of various types [8].

The control system of the automatic stereo garage includes the weak power system and the strong power system. The weak power system mainly includes all kinds of information collection system, alarm system and control output input device. The strong power system includes the motor line of the hydraulic pump, the line of the lighting device and the pipeline of the drainage device. After processing the input signal, PLC outputs the required signal to the AC contactor to control it, so as to control the corresponding circuit. The three-dimensional garage parking space detection device for fast vehicle with lifting device support car and car carrying board to the specified location. The system has emergency stop switch on the panel. When an accident happens, press the emergency stop switch to break all the motor's power, so that the carrying disk can't continue to run, so as to protect the safety of personnel and equipment.

5. Conclusion

Through the practice research, the three-dimensional garage, can play a great role in China, and it has a great development prospect in China. We should make more research on the design of the three-dimensional garage, and let the three-dimensional garage better serve the city.

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