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Research on the Solution of Stereo Garage in Urban Parking Problem

Cheng Ou

China University of Petroleum (East China), Qingdao 266400, China

Abstract

This paper explores the crucial role of three-dimensional garages in enhancing the urban static traffic system. It highlights their significant advantages in alleviating urban parking challenges, optimizing land use efficiency, and improving overall urban traffic management and order. By utilizing vertical space, three-dimensional garages offer a sustainable solution to limited ground parking and urban congestion. The paper provides a comprehensive analysis of the structural characteristics, technical principles, and common types of three-dimensional garages, such as the lifting and transverse type, vertical circulation type, and plane moving type. Each type's adaptability to various spatial and environmental conditions is elaborated to demonstrate their applicability in different urban settings. The study emphasizes several key factors that must be considered in the development and widespread adoption of three-dimensional parking systems. These include the standardization of technical specifications, ensuring system safety and reliability, optimizing operation and maintenance management strategies, improving user experience for convenience and accessibility, and enhancing policy and regulatory support to facilitate industry growth. By addressing these critical aspects, the paper aims to provide practical recommendations and a scientific reference for the development and modernization of urban parking infrastructure, ultimately contributing to more efficient, organized, and livable cities.

Keywords

Three-dimensional Garage; Static Traffic; Develop.

1. Introduction

With the rapid development of China's automobile industry, coupled with the government's active promotion of private car ownership and the implementation of a series of supportive policies, the number of private vehicles has grown exponentially. This surge in car ownership is particularly evident in large cities, where the rapid advancement of the economy and urban modernization has further intensified the demand for parking infrastructure. As cities expand and urban populations continue to rise, the issue of static traffic-referring to parking and vehicle storage-has become an increasingly prominent challenge. Urban traffic congestion and the difficulty of finding adequate parking spaces are not merely inconveniences; they have evolved into significant factors that influence and even restrict the progress of urban planning, economic development, and overall quality of life. If left unaddressed, these issues can lead to a host of secondary problems, such as increased fuel consumption, heightened carbon emissions, and a decline in urban livability. To effectively alleviate these pressing challenges, it is essential to vigorously promote the development and adoption of three-dimensional garages, or vertical parking systems. These innovative parking solutions make use of vertical space, significantly enhancing land utilization rates and offering a practical, space-saving alternative to traditional flat parking lots. By integrating three-dimensional garages into urban traffic management systems, cities can take meaningful strides toward improving their static traffic

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conditions, reducing parking difficulties, and creating a more sustainable, efficient, and modernized urban environment.

2. The Role of the Three-dimensional Garage in the Static Traffic of the City

The Development Research Center of the State Council currently predicts that China will enter a period of rapid increase in automobile ownership, and by 2010, the number of automobiles will reach 71.67 million, with an average annual growth of 15.2 percent, and the number of cars will reach 20.7 million, with an average annual growth of 16.3 percent. According to the current state of car use, 50% of vehicles will be driven in the city. However, according to the incomplete survey statistics of the departments concerned, there is only one legal parking space for every 4.84 motor vehicles in cities across the country, only one parking space for every 31 vehicles in some cities, and only one parking space for every 3.9 vehicles in the urban area of Beijing.

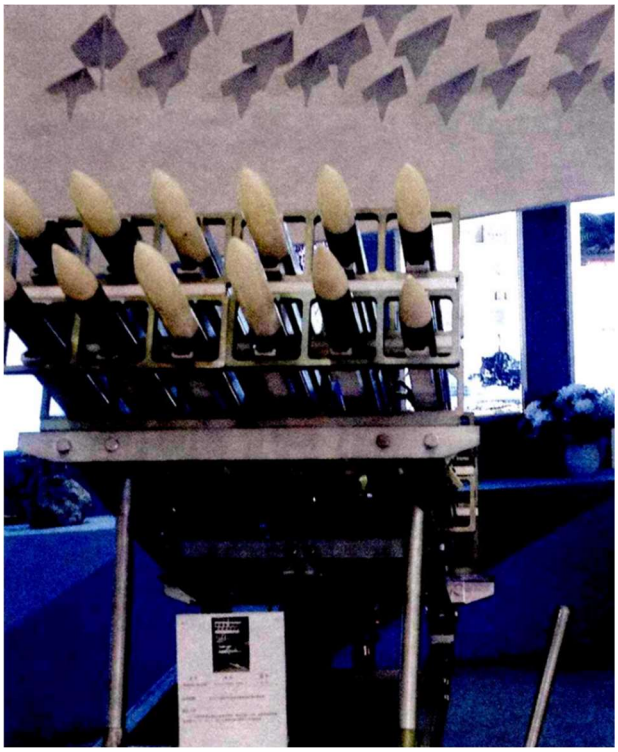

Figure 1. Stacked Applications in Chinese Military

As shown in Figure 1, China has long been paying attention to the development of the automobile industry. Submission Date:2002-03-07 About author:Shi Lihua (1969a).Female, from Anshan, Liaoning Province, engineer of Anshan Iron and Steel Institute School of Mechanical Engineering and Automation. In the past, there were few cars, and even if they were parked casually, they could not constitute a parking problem, and because of this, people did not pay attention to the construction of garages, resulting in a serious lack of urban parking lots. With the rapid increase in automobiles, "parking difficulties" have become a social problem. According to the research of urban geography and urban economics, the city itself has its ideal scale under certain technical conditions, and no matter how large it is, it will produce diseconomies of scale. And the land allocated to the transportation system for use, including roads and parking lots, also has a certain proportion, generally in the total land area of 15% ~ 25% is more reasonable. However, some new residential buildings, commercial outlets, public facilities, etc. do not have parking lots at all, and some even if they do, the number is very limited, and they simply cannot meet the needs of the rapid increase in the number of cars. How to build more parking lots on limited land to meet the needs of the problem of "parking difficulty" after the rapid increase of cars? Japan has provided us with an experience that we can learn

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from - the development of three-dimensional garages. As a country with dense population, more vehicles, and poor road conditions, Japan strictly controls the occupation of roads to set up parking lots when planning and construction of parking lots. It is in the world's leading position in the technical research and development, manufacturing, construction, regulations and management of the three-dimensional garage[1].

3. Advantages of a Three-dimensional Garage

Figure 2. Traditional Steel Frame Parking Structure

Due to the significant advantages of efficient use of space, alleviating parking difficulties and improving land utilization, countries have accelerated the development of mechanized parking equipment - three-dimensional garage, and developed the traditional plane parking mode vertically to form a more three-dimensional and intensive parking mode. As shown in Figure 2, This mode can not only alleviate the parking pressure in the core area of the city, but also improve the convenience and safety of parking through intelligent management and operation. Therefore, the three-dimensional garage has gradually become an important part of the static transportation system of modern cities. According to its structure and operating principle, the three-dimensional garage has various forms, mainly including the following common types[2].

3.1 Save Floor Space and Save a Lot of Investment

The floor area of the three-dimensional garage is equivalent to 1/3~1/20 of the same surface parking lot. For example, if a self-propelled surface parking lot is built, each parking space occupies an average of 25m of land, while the elevator garage with 40 parking spaces occupies only 50m. , the average parking space covers an area of 1.25m. For the small area of the city, the construction of a garage is undoubtedly the only option, and the economic benefits are considerable.

Formula for Land Use Efficiency (LUE):

$$LUE = \frac{Total\ land\ area\ required\ for\ traditional\ parking}{Total\ land\ area\ required\ for\ three-dimensional\ garage}$$

For the above example:

$$LUE = \frac{25 \times 40}{50} = 20$$

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This indicates that the land use efficiency of the three-dimensional garage is 20 times higher than that of a traditional surface parking lot[3].

3.2 Convenient Inbound and Outbound Management, Saving Time and Effort

It does not require the owner to find the car, the itch management is all controlled by the computer, the operation is simple, the number of cars in the library, the location of the car, the time of the car, etc. can be displayed on the operation panel, at a glance[4]. The degree of automation is quite high, and the access time of the car is generally not more than 120 seconds, saving time and effort.

3.3 Loss and Damage to the Vehicle Can Be Avoided

The perfect locking device can ensure that the car is safe and sound, and outsiders are safe. Employees cannot enter and exit at will, and the car will not be damaged and lost by man. Car owners can rest assured[5].

3.4 Flexible Configuration

The scale can be large or small, can be set up separately or side by side, can be attached to the building can also be in the building, can be located on the ground, underground, can also be located in the semi-underground, various forms, wide adaptability. It is precisely because the three-dimensional garage has so many advantages that it has become an important way and development direction to solve the problem of "parking difficulty" in today's society[6].

4. Types and Features of Three-dimensional Garages

4.1 Horizontal Circulation Three-dimensional Garage

Figure 3. Research and Manufacturing of Smart Parking Equipment

The main structure of horizontal circulating type three-dimensional garage is a chain conveyor that is placed horizontally, and the vehicle is parked on the pallet of the chain conveyor belt, along with the entry and exit of the vehicle, all vehicles make circular movement according to the fixed order simultaneously, ensure that the vehicle is always in the horizontal state by the translational mechanism, and the whole system is driven separately by a large motor[7]. As shown in Figure 3, horizontal circulation type three-dimensional garage shape is long and narrow, by adopting two-layer parking structure, can effectively improve the land utilization rate of the long and narrow lot. Since there is only one horizontal circulation action in the whole garage, the electrical control system is simple and easy to maintain. But because its translational mechanism guide rail is easy to wear, thus increases the maintenance workload. The number of horizontal circulation type stereo garage parking is limited by single drive motor power and structure, generally around a dozen cars, can be combined, to reach the required parking number[8].

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4.2 Vertical Circulation Tower Three-dimensional Garage

Figure 4. New Concept Parking Push Device

The main body of vertical circulation type tower shaped stereo garage is vertical rotary chain conveyor, and vehicle is parked on the pallet Tec hnol ogy & Econ omy i n Area s of Commu nic ati onsf TEAC (TEAC) that is in circular or oblong configuration, is driven by the chain that does vertical circulation movement, and keeps the parking space level under the control of translational mechanism[9]. As shown in Figure 4, this kind of garage is driven by a single large motor, and the electric control system is simple, but its translation mechanism also has the problem that the guide rail is easy to wear, thereby causing the phenomenon of running jamming. The number of vertical circulation tower three-dimensional parking garage parking is limited by factors such as driving motor power and structure, and generally can park 10-40 cars. The biggest advantage of this kind of three-dimensional garage is that the motion relationship and electrical control are simple, but its shortcomings are also obvious, the transmission noise is large, the structure is easy to deform, the access car speed is slow, the access car compartment is narrow, the environment is poor, and the energy consumption is high. Therefore, there is a trend of phasing out, and it will be replaced by the elevator type that has mature technology and the price is gradually decreasing.

4.3 Lifting and Traversing Three-dimensional Garage

Lifting traversing type three-dimensional garage is mostly medium and small garage, the number of parking vehicles varies from a few to dozens, generally adopts 2-5 layer structure, can also be called two-layer lifting traversing type and multi-layer lifting traversing type cubic garage. There are generally two types of two-storey lifting and transverse three-dimensional garage: (1) no translational double-layer lifting simple parking garage. It is the miniature three-dimensional garage that is made up of hydraulic transmission device, when lowering the upper floor in and out of the car, when ascending the lower floor in and out of the car, is a kind of commonly used family garage. (2) there is translational double-layer lifting type simple parking garage. Its lower layer leaves a vacant space, and the vehicle-containing disc can only move left and right, and the upper vehicle-containing disc can only rise and fall up and down. The device of traction vehicle-carrying disc for lifting and lowering movement has the form of wire rope, chain, hydraulic pressure. Two-storey lifting and transverse type three-dimensional garage is most suitable for underground parking lot and open-air parking lot, the number of parking can be increased or decreased at will, the control system is simpler, the modular structure is combined at will, the installation is fast, the construction period is short, the disassembly and assembly are convenient, in case of scale or site change, only need to assemble or dismantle on the original basis. Therefore, it has been playing a leading role in mechanical parking equipment, and the sales volume is large. Multi-storey lifting and traversing type stereo garage is expanded by two-layer lifting and traversing type cubic garage, and its top floor only lifts, and the bottom floor only moves horizontally, and the middle layer both lifts and moves horizontally. It has the advantages of simple two-layer structure, easy to install and combine, easy to control, etc., and

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saves several times the land than the two-layer type[10]. The selling price is generally in 4"-'50,000 yuan/parking space, and other such as installation and commissioning, fire protection, foundation and exterior decoration investment is very little, so it is widely used in various occasions such as residential quarters, public places and government agencies, and is widely used in all types of parking garages. Due to the limitation of chain (or wire rope) and access time, the multi-layer type is currently mostly 3-5 layers, and rarely has more than 5 layers.

4.4 Elevator Lifted Three-dimensional Garage

It is like an elevator, lifting the car to a certain height, and then using a traversing mechanism (also known as a manipulator) to store the car in the berth. These garages are several tens of meters high and have 2 or more berths on each floor. According to the size, there are two types of elevator type: (1) tower elevator type. This type of garage is generally 28 floors below (30 floors in Hyundai Korea). It requires fast lifting speed and good structural rigidity. One adopts an industrial computer or a high-grade programmable logic controller to form its automatic control system, realizes the functions of automatic control of access vehicles, automatic billing, etc., and can also realize unmanned operation. Its land utilization rate is high, but the foundation and fire protection requirements are high, and the cost of a single vehicle is high. (2) Multi-storey elevator type. This type of garage is generally on the 5th-10th floor. Its lifting speed can be as low as 5-20m/min, the car system is simplified as much as possible, the structure is lightweight, generally does not set up a turntable, do not strictly decorate, the foundation investment is less, and the fire protection system is simple. Due to the limitation of access time and chain (wire rope), the cost of multi-storey lifting and traversing garages with more than 5 floors has increased significantly. If replace with multi-storey elevator type, its single parking space cost is even lower than the multi-storey lifting and traversing type below 5 floors, and its access time is less than multi-layer lifting and descending traversing type. Compared with the vertical circulation type of the same specification, the structural rigidity is good, the access car efficiency is high, the bottom access car compartment environment is good, the power consumption is low, and the noise is small. Therefore, its development prospects are very good, Guangdong, Shanghai, Changsha and other places have such garages appeared, according to China's current national conditions, people are more reasonable to pay attention to it.

4.5 Roadway Stacking Three-dimensional Garage

The roadway stacking type three-dimensional garage is an advanced form of mechanical parking equipment that combines parking spaces with a lifting device in a cubic configuration. The lifting device, which plays a central role in the system, is designed to move laterally in its entirety or to have its carrier move laterally. The parking spaces are positioned on both sides of the liftway, allowing vehicles to be efficiently stored and retrieved with minimal ground space usage. This design takes inspiration from the structure and functionality of a three-dimensional warehouse, making it highly efficient for vertical parking solutions. This type of garage system first originated in the United States, where it was initially developed by adapting elevator technology to include walking machinery capable of handling the movement and storage of vehicles. Its operational design is particularly suitable for high-density parking, as it generally has a capacity exceeding 100 vehicles. Furthermore, the system is highly versatile when it comes to transferring vehicles from the lifting device to individual parking spaces. There are typically two modes of vehicle transportation in such garages: one involves the vehicle being driven into position by the driver, while the other relies on an automatic conveying mechanism to transport the vehicle into its designated space. By leveraging its compact design, large storage capacity, and automation capabilities, the roadway stacking type three-dimensional garage is particularly suitable for urban areas with high land costs and limited available parking space. It offers a practical solution to alleviate parking shortages and improve the efficiency of urban static traffic management, making it an integral part of modern urban planning and transportation infrastructure development.

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5. Conclusion

Although the three-dimensional garage has its outstanding characteristics, there is also a potential market in our country, but due to the lack of management regulations and other reasons, the application is not yet popular. The author has the following suggestions for the development of three-dimensional garages in China: First, set up a unified government management organization and formulate unified policies and regulations. The planning, construction, management of parking lot is an important part of municipal construction, involves the interests of all aspects, is a systematic project. In terms of the management system, we should not one-sidedly pursue the regulating role of the market economy, but should strengthen the government's macroeconomic control, set up a management organ under the direct leadership of the government in accordance with the goal of combining social and economic benefits and focusing on social benefits, coordinate well the municipal, public security, land, planning, price, taxation, and other functional departments, and formulate unified policies and regulations. Second, encourage the construction of self-provided garages, encourage the construction of garages to the outside world, implement the strategy of privatization of social garages, and implement preferential treatment and exemption in land requisition fees, depreciation expenses, income tax, business tax, and other items. Third, the policy of building garages should be strictly enforced (parking generated by new buildings should be borne by buildings). Fourth, strengthen industry management. Mechanical parking equipment technology is relatively complex, and safety, reliability requirements are very high. Therefore, the production of parking equipment enterprises to strictly control, should refer to Japan's management methods, the establishment of quality certification system.

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