International Journal of Applied Engineering Research ISSN 0973-4562 Volume 13, Number 18 (2018) pp. 14003-14008

Proposal for Automation of a Bicycle Parking Lot

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Abstract

This article shows the proposal of a bicycle parking, considering that sustainable transport alternatives are measures that are implemented by the need to provide mobility options to citizens, these must have a positive impact on the environment and the community. However, they must be accompanied by systems that provide the necessary comfort and reliability to users, bicycle parking facilities are usually mechanisms that fulfill their function, however most are unsafe and occupy a large amount of space. The objective of this project is to implement a series of automated parking spaces that maximize space, increase user safety and provide an efficient method of bicycle lending; In the first phase of the project, the conceptual and mechanical design of the parking lot was developed with the respective calculations that allow to evaluate the correct operation of the same, this from the collection of information of the advances and structures used in these purposes. Likewise, the conceptual idea of the operation of the platform that will automate the parking system, making it more effective and friendlier with the user, was developed.

Keywords. Automation, smart cities, parking bike.

INTRODUCTION

Due to natural phenomena and the consequence of climate change, there is a greater awareness of the environmental impact generated by all human interventions on the planet. Faced with the increase in mobility problems that have arisen in recent years in the city of Bogotá, different social groups have been working to promote the bicycle as an alternative means of transport, demonstrating the many benefits that this overcrowding can bring. medium. Among those that are exposed are those of an environmental, urban, economic nature, the evident improvements in terms of mobility and in terms of the health of their users, among many others [1] [2] [3].

Today cities have traffic and pollution problems among other problems, and one of their biggest challenges is focused on the search for balance and satisfaction of transport needs [4], [5]. For this reason, many cities have taken up the idea that the bicycle is an option to use as a daily means of transport, among others, because it is a safe and practical means of transport, non-polluting.

Using the bicycle as a personal alternative vehicle use offers many benefits, it has no demand for petroleum derived fuel, relieves traffic congestion, reduces pollution generated by noise, and requires less space for storage or parking [6] [7] [8] [9]. The bicycle is one of the most important inventions since the cost of maintenance and acquisition is low, as well as being a silent and sustainable transport.

In this way this project is generated by automated parking for bicycles, since the issue of security in Colombia is of utmost importance to us as citizens. This project shows the calculations and design of the rotary automated parking prototype (eco-Parkbike), in order to provide greater security to users who use the bicycle as a means of transport.

The bicycle is currently emerging as part of the solution to the improvement of Bogota's mobility situation, allowing, among other things, the accessibility condition to increase and thus improve. With the development of this project it is intended to

present alternatives that contribute to solving the problem of bicycles in the street. For the implementation of the prototype a metallic physical structure was used, which carries a system of trays in which the bicycles go and in turn are chained to an axis that performs the procedure of rotation of the platform in a practical and efficient way, using a cogwheel system like the chains of a bicycle.

With the aim of incorporating the bicycle into the public transport system and with the idea of controlling vandalism and theft, a high-tech information technology proposal was developed, used to create an automatic bicycle loan system. The function of which is to register in a database, the user must be banked (have a credit or debit card), and with that, he / she obtains a smart card which will be used to withdraw the bicycle as a loan, as well How to make your return. By forming part of a database, the user's anonymity is lost, and he is co-responsible for the bicycle, which reduces its deterioration; however, this parking has the advantages of providing the necessary space for the use of this external people who have their own bicycle and want to protect them. The current situation of the environment requires considering sustainable urban transport options, in which the motorized private vehicle displacement does not represent the main component of the city model, but instead plays a minimal complementary role among a set of options, which other experts call, sustainable mobility.

It is evident that improving the mobility situation in cities and counteracting the negative effects generated by the associated problems, is increasingly a need throughout the world. It is understood that the impact of the irrational use of the car is one of the factors that affect the problems associated with mobility in cities, to counteract these effects, they have found strategies to reduce their circulation, effective actions such as restriction to the circulation of vehicles in a few hours, increased collection of parking fees, charges for circulating in some areas of the city, among others. As well as the implementation of sustainable transport systems, such as public bicycle systems that today play a predominant role as part of the solution.

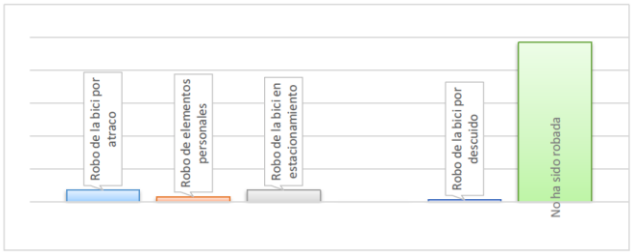

Figure 1. Reason of theft on the bicycle female user

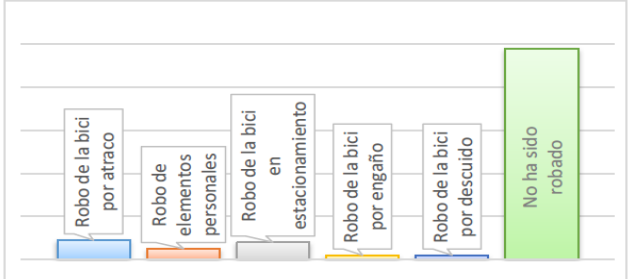

Figure 2. Reason of theft on the bicycle male user

This article has the methodology that was considered at the time of designing the parking considering the benefits, the advantages and the evolution of the parking systems; The mechanical design will be found with the corresponding calculations as well as specifying the details of the use of the platform. Finally, the results of the project and the corresponding future works are evidenced. In the article presented in the article "Cycle-inclusion in Latin America and the Caribbean," it can be seen that Bogotá is one of the cities with the most bicycle infrastructure [10].

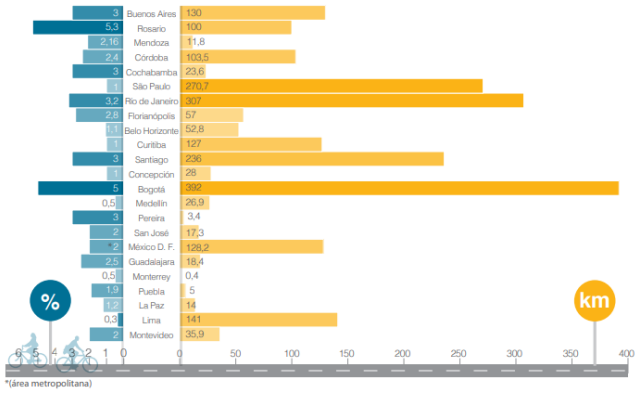

Figure 3. Percentage of trips made on bicycles and Km of infrastructure

METODOLOGY

The society of today is filled with cars that increasingly invade the lanes of the cities. The space occupied seems to be insufficient, because every time the number of motorized vehicles is higher, and administrations have to constantly expand infrastructures to meet demand [11]. Bicycles are presented as the most efficient alternative to handle the mobility problem that afflicts most cities, this is because its implementation has a large number of benefits, among these can be mentioned the decrease in the budget used in transport , the reduction of hours lost in traffic jams, the improvement of the user's health by the exercise that accompanies the use of the bicycle, the saving of the renewable resources used in the maintenance of the vehicles among others. These benefits are accompanied by some disadvantages which are the difficulty to carry cargo and passengers, risks of accidents, vulnerability to violence and theft, complications to use in formal presentation [12] and others, however this article aims to provide a solution in terms of security and recovery of public space which benefits the community in general both people who use the bicycle as a means of transport as well as those who do not, this solution will be used through the construction of automated parking lots which will have the advantage of protecting bicycles from any form of theft while they are parked, as well as using the least amount of space for this purpose, however it is necessary to know the structures and types of parking used, these can now be classified into the following types that are shown in table 1.

Table I. Clasification of Parking for Bikes [13-14]

Bicycle parks	Concept
Public supports	These supports are usually found in the streets, these are made of metal, any user has easy access to this parking system and can be found in support type "M stand", horizontal wheel support.
Parking lots	These parking lots are designed to store a large number of bicycles with personal surveillance, these parking can be outdoors or underground.
BICEBERG Systems	It is an automatic and underground parking for bicycles; this parking lot is able to store other objects, have a capacity of up to 92 bicycles and 100% guarantee against theft.
BIGLOO Systems	Bigloo is an automatic parking for bikes, this is able to store backpacks, helmets and other transported items. This system is controlled by means of an RF card which facilitates the user's handling.
Sistema ECO cycle	This underground bicycle parking facility, implemented in Japan, by the Giken company, has a cylindrical shape, which reaches 11.5m deep, with a diameter of 8m and has an approximate capacity of 204 bicycles.
Parking lot in the matrix form	The concept of this parking is due to the fact that the bicycles are housed in a shelf that has the form of a matrix in which an elevator is responsible for moving through all sections of the same and store or remove bicycles according to the order required.
Parking lot in the form of carrousel	In these parking lots the bicycles are hung by the front wheel in hooks which move in a path given by a rail
Parking lot in the form of a wheel of fortune	The concept of this parking consists of mobile platforms which resemble the mechanical game of the wheel of fortune in this parking lot, the user will deposit his bike on the platform that is at ground level, while at the upper end there will be bicycles that are already stored.

DESIGN AND SIMULATION

The parking lot consists of a rotary system with a space that can hold an approximate amount of 24 bicycles, its operation is based on turning them mounted on a structure as shown in figure 4, by means of a chain transmission system , with which you rotate one by one of the bicycles inside the parking lot, similar to that of a carousel system, with this movement the user should only wait for this turn to be made in order to claim his cycle, at the moment that is in the lower level.

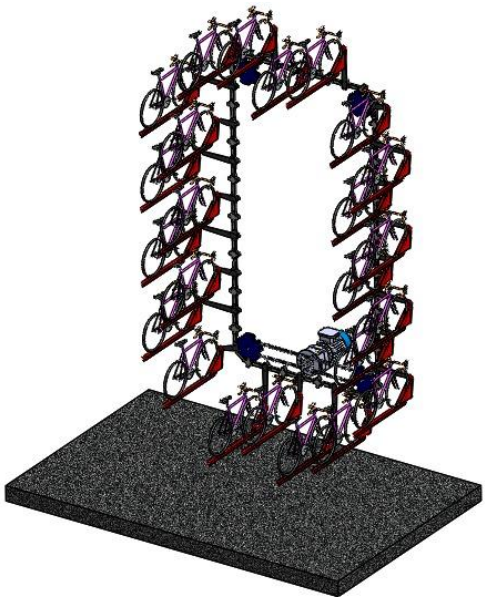

Figure 4. Vertical rotating system.

This parking generates benefits in terms of optimization of parking areas and increased security given the difficulty of access by people outside the place where the bicycles are located, reducing the possibility of theft on the street.

Then, Figure 5 shows the engine which performs the function of transferring the power to the pinions by means of a chain, i.e. the transmission shaft will be responsible for transmitting the power to the other end on the gear (pinion) to raise the loads of bicycles. The power reaches the arrow through a transmission by roller chain and gear wheel which transmits the power of the motor, in figure 6 you can see the tree diagram.

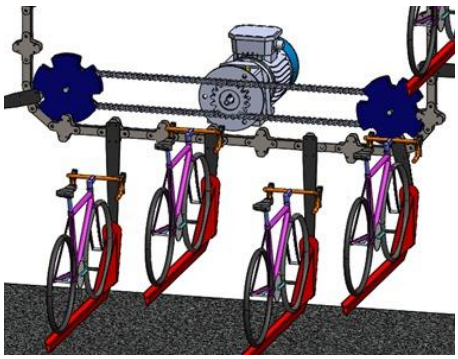

Figure 5. Chain distribution pinion and Catarina

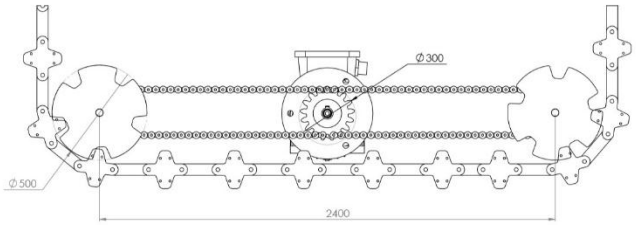

Figure 6. Transmission diagram.

The frame can be thought of as the skeleton of the structure. It is a system of united elements that supports the loads imposed by its own weight. According to the structural system we speak of reticular, laminar, massive and special structures.

Figure 7. Support axis.

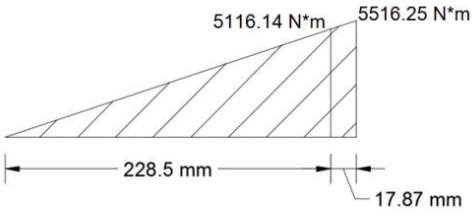

Figure 8. Axle diagram.

A solid shaft of ⌀50mm; ⌀60mm is selected, the transmission steel AISI / SAE 4340

$Fy = 725.20\ Mpa\ (AISI/SAE4340)$

$Fx = 1029{,}00\ Mpa\ (AISI/SAE\ 4340)$

With the help of the SolidWorks program, the following properties are obtained:

$$A = 1.96\,x\,10^{-3}\ m^2$$

$$i = 3.06\,x\,10^{-7}\ m^4$$

$$q = 2.08\,x\,10^{-5}\ m^3$$

The shear force, bending moment is calculated. Is obtained:

$$V = P = 22390.13\ N$$

$$M\,max = 5516.25\ N.m$$

$$\sigma x = 0$$

Normal effort is calculated.

$$\sigma y = 450.67\ Mpa$$

The shear stresses.

$$\tau xy = 30.43\ Mpa$$

The most important factors to take into account in the rotary operation of the parking lot are the applied load, the speed of operation and the resistance of the mechanism with the friction that can be generated.

$$L = 5.4m$$

$$r = 250mm$$

$$Wt\ máximo = 1000kg$$

Total length of the parking lot is:

$$Lt = 5.4m + (\pi \times r)$$

$$Lt = 6.1854m$$

Where:

$$T: tiempo$$

$$D: distancia = 6.1854m$$

$$V: velocidad\ lineal = 4.8m/min$$

The time to make a turn in ideal conditions:

$$t = \frac{D}{v}$$

$$t = 1.289min$$

Angular velocity:

$$\omega = \frac{V}{2\pi r}$$

$$\omega = 3.056rpm$$

$$\omega = 0{,}32\,\frac{rad}{s}$$

Motor power require:

$$F = masa \times aceleración$$

$$T = F \times d$$

$$F = 9810N$$

$$d = 150mm$$

$$T = 1471.5Nm$$

Where (P) is power, (T) is torque and (ω) is angular velocity.

$$P = T \times \omega$$

$$P = 470.88w \times \frac{1.34HP}{Kw}$$

$$P = 0.631HP$$

To couple an engine with these conditions, it is necessary to perform a speed reduction stage using gears.

In addition, the rotary parking system is designed using the advantages of high speed of operation, multiple safety devices, also has a polycarbonate housing that provides protection to bicycles and the environment as shown in Figure 9.

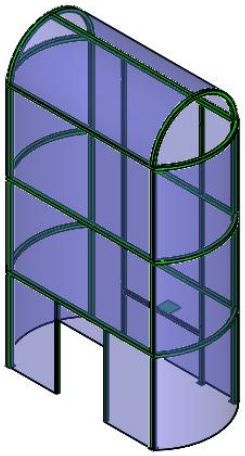

Figure 9. Structure and housing of the parking lot.

The model consists of an automated mechanical system, which rotates at an angle perpendicular to the ground. It is driven by a chain, motor, chain system and moves in a rotating manner. When one wants to park or retrieve the bicycle, the required parking tray will rotate until it reaches ground level. Then the bicycle can be parked or retrieved directly by the user. As shown in figure 10 and 11 you have the door to enter the bicycle.

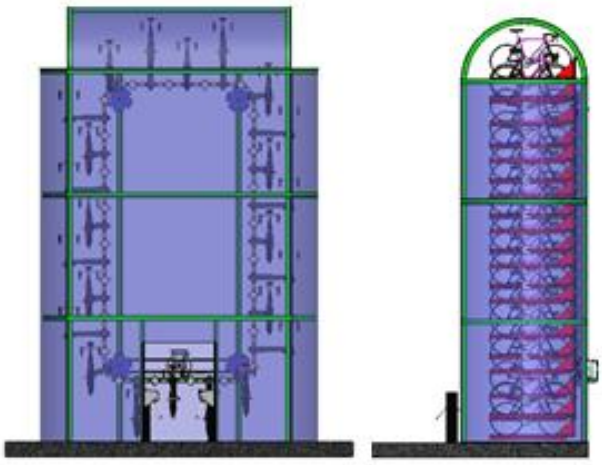

Figure 10. Rotary parking design.

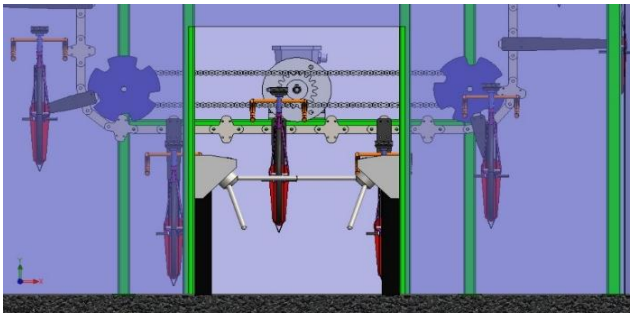

Figure 11. Sistema Automatizado por ticket y talanqueras.

This model has a cabin which has a screen where the user can interact with the platform that consists of saving or giving a loan with the bicycle. It has a compartment which gives a card where it says where the bicycle is, also informs what time it should be delivered, as can be seen in figure 10 and 11.

Next, figure 13 is shown which corresponds to the design of the HMI interface, the system has two buttons that allow the user to request the bicycle or simply store the bicycle.

Figure 13. Ticket interface

Finally, the final design of the eco-parbike can be observed as shown in figure 14.

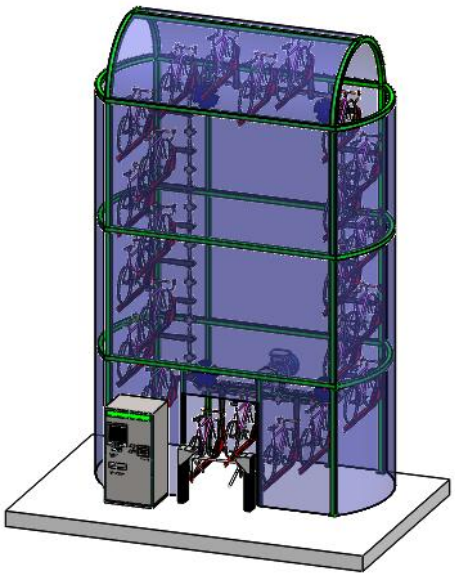

Figure 14. Design of vertical rotary parking.

RESULTS

The methodology that was implemented was a key factor in the development of the project since this allowed us to use the information obtained in the design conception which has as characteristic to be the model that best adapts to the conditions and needs of society in Bogotá.

The mechanical calculations that were used in the design made it possible to select the appropriate materials with which the construction was viable, in addition to verifying and validating the proper functioning of the parking lot.

The design used allows the recovery of public space currently used in the existing parking spaces since it uses vertical space, which maximizes the operation and efficiency of the parking lot, also guarantees the safety of bicycles from theft by opting for an automated design that provides greater protection of the goods of the users of this means of transport.

A control system for carrousel type parking was established and developed.

It was identified as the most suitable design alternative, with which it is possible to take advantage of and optimize the area available for bicycle parking, that corresponding to a mobile duplicating lift system.

CONCLUSIONS

In Bogota the use of bicycles has been promoted, the growth of these at the transport level as a source of contribution to the health of the user and the state of the environment, the parking lot proposed by eco-parkbike is a solution that implies a design feasible and with a non-excessive cost. It is planned to do it in real prototype, since the calculations and the simulation of the system are carried out, implementing it in crowded public areas of the city such as parks, universities, offices and sectors close to the cycle routes.

In addition, the user platform and a mechanized system must be implemented, which has a database consisting of two operating modes, administrator and user that allows recording data on the web and the administrator has the ability to review if it is in good condition the bicycle borrowed.

However, it is intended to implement the platform connected to the cell phones of each person, to make the user remember through a text message how much time he has left to deliver the bicycle.

ACKNOWLEDGMENTS

The research for this paper was supported by InnovaTIC Research Group of Pilot University.

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