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Finite Element Based Structural Design and Stress Deformation Analysis of a Rotary Electric Bike Parking System for Urban Space Optimization

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ABSTRACT: India is a country where population growth is enormous and along with increasing population there is significant growth in travelling. Rise in travelling allocates automobile resources to the citizens. Approximately there is ratio of 1:3 with respect to vehicles and citizens of India. Considering huge number of vehicles in our society the facility for parking is not yet developed. Due to the lack of space for parking along with inappropriate systems available there is always conflicts at parking spaces. Most people park their vehicles on road sides which has led to accidents many times. In order to solve parking issue this project work is focused. I have analyzed the rotary parking system which accommodates 6 to 8 bikes in a space required for parking 2 bikes. This system is easy to maintain, can be operated automatically without any need of human supervision. It stacks the bikes with motorized systems without any chances of accidents during parking. This facility can be effectively used at malls, offices, residential complexes and many more. The analysis of such system for its structures and load calculations was yet to be done in research works submitted till now. So I have made attempt of analyzing and understanding complete loads, structural aspects and performance parameters using mechanical software's like Solidworks and Ansys along with analytical calculations..

KEYWORDS: Ansys, Electric Bike, Parking System

I. INTRODUCTION

Parking problems have always been an issue since the very first automobiles were invented. But it got even worse with the progressing urbanization and population expansion. Thanks to a rapid economic and population growth, Indian metropolises are staring at a mobility crisis. Today, urban areas face tremendous pressure on parking spaces, resulting in issues such as traffic congestion, disproportionate demand and supply, and environmental hazards, to name a few. Because of poor parking management and policy, India struggles with chaotic situations like overcrowded footpaths, illegal parking, and criminal activities due to improper surveillance.

Commuter in Delhi spends over 80 hours every year looking for parking spaces. The problem is simple - even as the number of vehicles has expanded, parking space in Indian cities has remained constant or reduced due to a growing population. Especially when land is limited and expensive, like in metropolises, rising parking demand spaces puts immense pressure on it. Sample this, in New York midtown area, road area per person stands at 33.3 sq-m while in Mumbai's Null Bazaar, it is no more than 1.7 sq-m. This means that a vehicle in Mumbai imposes a cost nearly 20 times as much as one in New York.

The demand for parking in Indian metros is seeing no signs of stopping. Because land resources are limited, it isn't possible to conveniently plan parking spaces according to demand. Instead of increasing available parking spaces, an effective technology-based solution must be employed to optimize the use of available spaces.

In peak hours drivers in large cities have to circle around for about 30 minutes to find a place where they can leave their vehicles. Those who run out of time might park illegally.



Parking Problem in india

As we can see from the image above one of the serious ill effect of improper parking's is traffic congestion on road and loss of street space. The capacity of street is reduced, journey speed drops down and journey time and delay increases. The operational cost of vehical increases thereby causing serious economic loss to the community.

The consequences associated with wrong parking and un parking are known to cause road accidents. Careless opening of doors of Parked vehicles ,moving out of a parked vehicles and bringing the car to the parking location from mainstream of traffic are some of common causes of parking accidents..

II. LITERATURE SURVEY

Sonali sonkar et al. In this paper, the researchers implemented the concept of lift mechanism. The main components of lift is the pallet on which vehicle is placed according to the weight of cars the pallet is being design. Then there was a chain mechanism the pulling force on it. Then after the selection of motor and se lection of gear is being done by taking the factor of safety according to power required and selected motor power. The proposed project will provided a safe and comfortable place for parking of vehicle in the Aakash Ganga Complex, Supela Bhilai (Chhattisgarh) and resolve all the difficulty arising due to random parking of the vehicle. Up to 12 vehicles can be accommodated within the space normally taken up by two vehicles. It is not applicable by the regulations of building coverage. There is no need for an attendant because of its simple one touch operation method. Senses where vehicle is closer and rotates bidirectional for fast retrieval time. Extremely safe and reliable. Impossible for Vehicles to fall with endless chain and pallet drop prevention system.

Conclusion: There are two options for lift one is hydraulic lift and other is traction lift. The hydraulic lift is suitable up to moderate height when height increases it becomes very costly in that case traction lift is better option.

Nikhil Shetty et al. In this research paper, they have utilized space for parking so that space for parking of 3 cars can hold more than 9 cars by adopting rotating mechanism so as to minimize vibration and noise. There are different types of automated parking structure available such as Rotary parking, Multi Circulation parking, Tower parking, Puzzle parking, etc. From these types present study is about Puzzle parking structure. In this structure there are number of floors and each floor can be divided horizontally and also there are number of sections vertically in each floor. In this Puzzle parking system controller software based computer can be used for controlling all the movements of parking system. In addition to these two plates mechanism are used in which one plate used for park the two-wheeler and other one is used for providing base for the electromagnet. Each top plate is used to carry two-wheeler between floors. In which electromagnet is used for holding the two-wheeler. By this parking system there will be good space utilization. By the help of this parking system we can reduce the retrieving time of the vehicle to approximately 3 minutes as compared to manual.

Conclusion: . This study presents a simulation based feasibility study for development of fully automated parking structure with a group of plates using electromagnet. Fork lift can be used for moving two wheeler horizontally and vertically in the parking system without need of driver while the engine is off

Chetan S. Jiotode et al. In this paper we study the multilevel car parking system using Geneva mechanism which will operate the whole rotary parking system. A Geneva wheel mechanism has been used to intermittent movement of a rotation by using DC motor which helps to rotate the Geneva wheel in clockwise and anticlockwise direction. The multilevel car parking system using Geneva Mechanism has been Study. The design system could be applied everywhere due to its ease of usage and effectiveness. The car are much safer in such parking system as other do not have an access to the car. The multilevel car parking system is best substitute for car parking area.

Conclusion: A Geneva wheel mechanism can be used for intermittent movement of a rotation by using DC motor. We can increase the time limit of each full rotation by increasing the slots in Geneva wheel. The total system can handle manually by one person by handling the power supply.

Sanders McDonald et al. In this research paper, problem of the land (space) minimization is solved and which material should be taken and how much is the sustainability. How to utilized space in better way and how to park maximum bike in less space. In which Policy, automated vehicles, and physical planning were analyzed concurrently as a comprehensive system. Many practical ideas and options emerged along with two very divergent futures from the day's discussions: one quite utopian in its vision, where automated vehicles could create an entirely new lifestyle and sustainable physical environment while the other assessed possibly-dystopian outcomes where sprawl increased. The parking scenario highlighted genuine uncertainties, with visions of reduced parking on the one hand, but potentially also mechanisms that could increase parking and roads on the other.

III. METHODOLOGY

3D Modeling: -

Software:

SOLIDWORK

Version: - 2017

Following parts used for rotary parking system.

- 1) Bike holding pallet
- 2) Side structure
- 3) Supporting shaft
- 4) Plummer block
- 5) Outer side structure
- 6) Roller Chain and Sprocket (For Transmission)
- 7) Electric motor
- 8) Bush Bearing
- 9) Square bar

Pallet design

Information about pallet

The pallet is used for holding the bike. On pallet, bikes are park and this pallet is made with frame by using various type of sections like C-sec, L-sec, only for plate. These sections are made up of mild steel. The following specified dimensions are used for the platform for parking four bikes.

Length (L) =3500mm, Width (B) =2000mm.

The load applied on steel sheet is maximum when the platform is completely filled with bikes (5 bikes)

Total load imposed on full parking considering the weight of each bike to be approximately = 200Kg

Number of section used for pallet design

A Plate

B. L-section frame

C. C-section frame

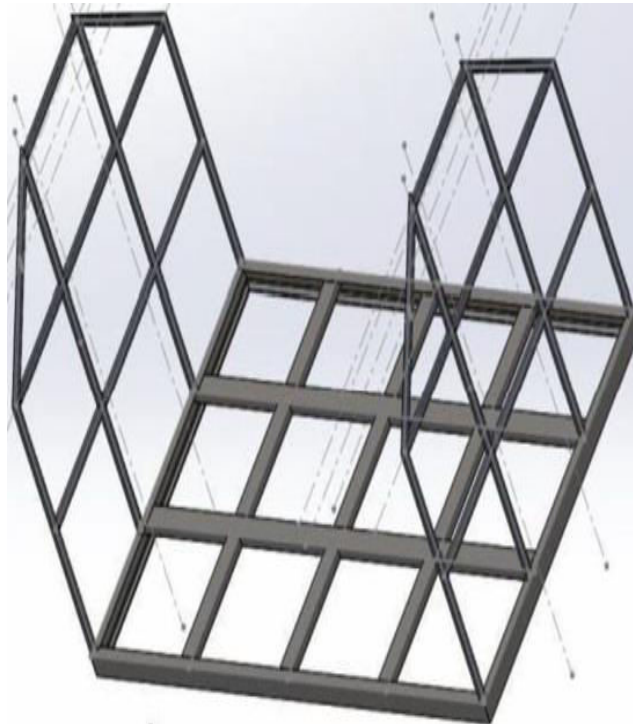
Plate

The plate is design with dimensions of 3500x2000 mm and total load on the one pallet is 5x200 Kg. The load may be considered as uniformly distributed load (UDL) under full parking.

Side Structure

Side structure of pallet

For making side structure the square tube is used having dimensions 40x40x 10 mm.



Side structure

IV. EXPERIMENTAL RESULTS

Following parts are designed by analytical calculation

I .Bike holding pallet

Pallet side structure

Supporting shaft

Outer side structure

Electric motor

Bike holding pallet:

Self-weight of pallet is 1882N.

Components	Analytical Calculations	FEA Calculations	Results
Bike holding pallet	L-section: Stress O ^{all} = 166.66 MPa C-section: O ^{all} = 166.66 MPa Shear stress T ^{all} = 83.33 Mpa.	L-section: Stress O ^{max} = 169 MPa C-section: τ ^{max} = 2.52e7 Pa Shear stress T ^{max} = 14.45 Mpa	O ^{max} < O ^{all} O ^{all} > O ^{max} T ^{all} > T ^{max} Hence C section is selected.
Side structure	Stress: σ ₁ = 10.42 Mpa σ ₂ = 6.82 Mpa σ ₃ = -0.0388 Mpa Shear stress: τ _{per} = 3.41 Mpa Deformation: q ₁ = 110 mm q _s = 61 mm	Stress: O ^{max} = 30.33 Mpa Shear stress: T ^{max} = 23.32 Mpa Deformation: q _{act} = 0.0327 mm	O ^{max} > O ^{per} T ^{max} > T _{per} q _{th} > q _{act} Actual stress is less than theoretical stress hence design will be safe.
Supporting shaft	Stress : σ _{cr} = 12.47 Mpa Critical load F _{cr} = 9.28 N	Stress: O ^{max} = 21.08 Mpa Critical load: F _{max} = 9.89 N	O ^{max} > O ^{per} F _{max} > F _{cr}
Outer Side Structure	Stress : O ^{all} = 166.66 Mpa Deformation: y = 0.2544 mm	Stress : O ^{max} = 0.7071 Mpa Deformation: y _{act} = 141.4 mm	O ^{all} > O ^{max} Y < Y _{act}

V. CONCLUSION

The major enablers or drivers for smart parking essentially are the problems of urban liability, transportations mobility and environmental sustainability. Some of the underlying benefits could be lowering operation costs, while building values for customer to drive occupancy, revenues and facility value. To solve all the bike parking issues rotary bike parking system has been designed, by considering the actual size and dimensions and weight of the bikes. It has been understood that L section frame will not be much suitable for pallet design as it may lead to failure when subjected to critical loading. Hence C section Frame is utilized and with dimensions considered the above design is safe. The above design is analyzed in Ansys as well as mathematical calculations is done in order to eliminate any failure possibility. The parking structure is thus designed and considering all the required stresses the designed structure is safe for implementation in actual physical design. Analysis of important parts like pallet, joints, supporting shaft and frame has been done at actual dimensions.

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