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Design and Modelling of Disaster Relief Vehicle using Rocker Bogie Mechanism

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Abstract*: *This paper discusses using a rocker-bogie mechanism in the field of post-disaster relief management. An incident took place in June 2014 in Chennai, India where a 12 storey building collapsed which led to severe loss of human life due to an inadequate facility in the rescue operation. Similarly in December 2015, the southeast of India, Chennai has been through a destructive flood due to heavy rains leading to massive damages and has been responsible for many irredeemable losses to both lives and properties. The flooding along with huge quantities of water also carries dirt, trees, and derbies from along their path. This damages the roads and standing structures, leaving the roads unusable. In these circumstances, the relief teams that bear the aids required during post relief missions find it is difficult to access these places. This paper here presents an insightful idea to overcome the complications faced during these critical life-saving operations.

Index Terms*: *Disaster relief management, flood, rescuing operation, rocker bogie mechanism

I. INTRODUCTION

This paper focuses on design and development of mechanical system that have a considerable features of being amphibious. An incident took place in June 2014 in Chennai, India where a 12 storey building collapsed which led to severe loss of human life due to inadequate facility in rescue operation. Similarly Chennai, one of well-known southeast part of India, has faced huge permanent loss of belongings and caused life from heavy downpour. This heavy downpour turned to flood, it grounds the road surface uneven since the debris, soil and trees along their path, damaging the road and building structure.

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During post disaster relief management this situation gives most difficult task to force bearing aids [2]. To avoid the aforementioned failings this paper intends an intellectual way to overcome hurdles faced during rescuing operation. The vehicle must be able to traverse at rough terrains and uneven surface. The aerial monitoring machines are unconventional for such purposes. The ground vehicles pave better way to collect environmental data. This paper focuses on design and development of mechanical system that have a considerable features of being amphibious. For such conditions the wheels are extended to improve the stability in the water surface. On the land-dwelling mode, the vehicle should be able to traverse effortlessly on the uneven surface and overpass the obstacles. To overcome such situations, a vehicle implemented with Rocker-bogie mechanism could be used. Rocker-bogie mechanism favours with a high stability due to the presence of passive linkages. This even favoured NASA to use in Mars exploration [3].

A. Need for Rocker Bogie Mechanism

It's most remarkable advantage is its obstacle climbing capability. It can climb vertical heights equal to twice of its wheel diameter. Normal vehicles can hardly climb heights up to half of their diameter. Rocker bogie was designed in this proposed design without using any energy storing devices like spring, and vibration absorbed devices like sub axle or damper. For designing a vehicle the vibration absorption and energy storage devices are very important, but the proposed mechanism has developed with independent suspension to minimize the mass of the vehicle [4]. In rough terrain very heavy springs and dampers were used as suspensions, it increased the height of center of gravity making the system unstable [5].

If the spring based suspensions used for an unmanned rough terrain vehicle, it will oscillate causing rolling, yawing and pitching of the vehicle [1], [6]. For vehicles used in excavation, spring based suspensions cannot be used. The suspension minimises the sideways tilt by almost half when traversing two different obstacles on two sides of frame. When the frame on the one side is climbing a higher obstacle frame of the other side is pressed downwards, hence the normal reaction on wheels not climbing becomes zero and none of its wheels are ever lifted above the ground. This helps in maintaining equal reaction on all the wheels. That is the Rocker bogie was designed in this proposed design without using any energy storing devices like spring, and vibration absorbed devices like sub axle or damper. For designing a vehicle the vibration absorption and energy storage devices are very important, but the proposed mechanism has developed with independent suspension to minimize the mass of the vehicle. The proposed design has an independent mechanism for motion on six wheels each on the vehicle. To turn the vehicle by turning ratio of zero degree the steering mechanism has applied on two front and two rear wheels separately [5]. Hence

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it provides a better substitute instead of existing designs.

The vehicles based on the rocker bogie suspension can traverse terrains like desserts, snow and swamp easily because of higher tractive force obtained due to presence of 6 wheels. Rocker bogie suspension is combination of both walking as well as wheeled robots .They have both climbing and moving capability of the robots and stability and load carrying capability of wheeled robots. Rocker bogie system can bear a tilt of 50 degree in any direction. The design is simple, have separate motor for all wheels [5], [7]. Hence no bulky transmission system is needed to transfer power.

II. 3D DESIGN ANALYSIS

To avoid the vibrations and shocks caused by the inhospitable environment had minimized by designing roger bogie completely in Polyvinyl chloride (PVC). This also helps to increase its capability where it is operated on. Fig. 1 and Fig. 2 shows the 3D Solidworks structure of our Rocker-bogie model been made.

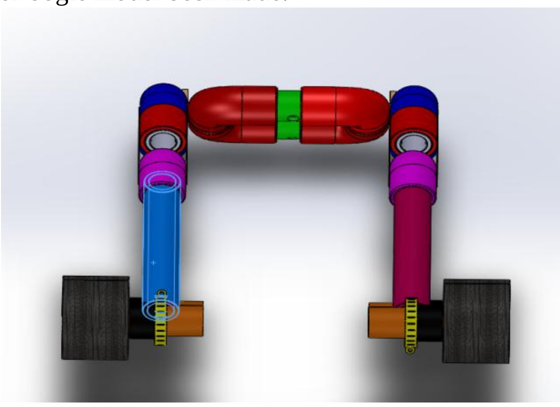

Figure 1. Front view - 3D Model using Solidworks Software

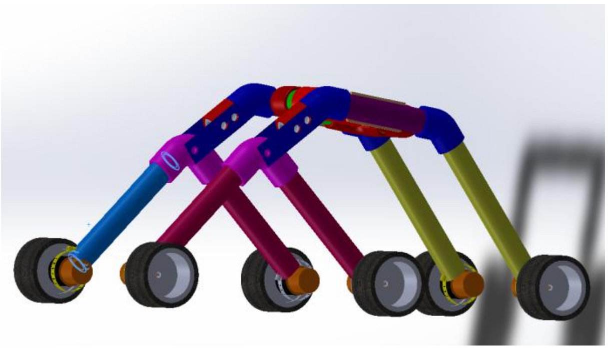

Fig. 2 Orthographic view - 3D Model using Solidworks Software

III. STABILITY CONDITIONS AND DERIVATIONS

Various factors governing the stability and capability of the Rocker-bogie model has been made and tested.

A. Static Stability Factor (SSF)

The SSF of the vehicle is expressed by the following formula [8],

$$SSF = \frac{Track\ width}{2[Centre\ of\ gravity]}$$

The value of SSF suggests that that the vehicles would be more likely to experience a rollover. A vehicle with a higher SSF value is considered to be more geometrically stable [9].

The SSF of our paper is given by,

$$SSF = \frac{1000}{2*3000}$$

$$= 0.16$$

The angle of tilt of the vehicle prior to rollover,

$$= \frac{Tw}{2*h}$$

Where,

Tw = Track width

H = Height

Now,

$$\tan\theta = 0.16$$

$$\theta = 9.09$$

B. Tractive Force of Wheels

Tractive or traction force is the force used to generate motion between a body and a tangential surface [10]. The main component of the vehicle is wheel to manoeuvre in both water surface and land-dwelling surface. The vehicle is supported by the radius of wheel for climbing an obstacle and width avoids the vehicle from sinking in muddy places. Table 1 shows the vehicle specifications. One of the merits of Rocker bogie is that Due to presence of 6 wide wheels the weight of vehicle is transmitted to ground through a large area of contact, decreasing pressure on ground. Hence it has less chances of getting struck in desert or swampy tracts.

Table 1. Vehicle specifications

Vehicle load	2.3 kg
Tire width	40mm
Tire radius	60 mm
Tire circumference	90 mm
Motor torque	7 Nm

The advantage of the rocker bogie mechanism is that load is equally distributed in all wheels.

C. Tractive Force

The calculations are based on a single wheel [11]. The tractive force is given by,

$$Fz = \frac{2\pi * Mt * N}{c}$$

Where,

Fz = Tractive force on the single wheel in N

Mt = Motor torque

N = Efficiency in the drive train

c = Circumference

D. Force Required to Overcome Rolling Friction

Frictional force is nothing but the contrasting force that is produced between two surfaces that try to move in same direction or that try to move in opposite directions.

In our case rolling resistance is one of the important parameters of the tires under optimum conditions of use to rate the performance of the vehicle.

The force required to overcome the rolling friction is [12],

$$F = fr\ x\ [w/R]$$

Where,

fr = coefficient of rolling friction

w = load on the wheel

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R = radius of the wheel

E. Velocity

$$V = \frac{\pi * D * N}{60}$$

$$V = \frac{\pi * 6.5 * 4.5}{60}$$

$$V = 15.3\ cm/s$$

IV. RESULT AND DISCUSSION

From the 3D model simulation and various stability factor we come to the conclusion that Rocker-bogie mechanism is better suitable to be implemented in disaster relief vehicle. Its spring free suspensions and the traverse movement of the vehicle will help in smooth and safe travel.

V. CONCLUSION

The trainability is a key representative should embedded in an amphibious vehicle during the post disaster incidence. This skill helps the vehicle reducing a slippage and flipping back while it is on an assignment since the land-dwelling surface after a disaster is unpredictable. Thus, applying the controller algorithm will optimizing the vehicle ability to man oeuvre in any surface condition with minimum risk.

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REFERENCES

1. K. Lumpur, L. The, and G. Musang, "More people evacuated as east coast floods worsen," 2014.
2. L. Bruzzone and G. Quaglia, "Review article : locomotion systems for ground mobile robots in unstructured environments," *Mech. Sci.*, no. 3, pp. 49–62, 2012.
3. J.G. Marquardt, J. Alvarez, and K. D. Von Ellenrieder, "Characterization and System Identification of an Unmanned Amphibious Tracked Vehicle," *IEEE J. Ocean. Eng.*, vol. 39, no. 4, pp. 641–661, 2014.
4. A. Seeni, B. Schäfer, and G. Hirzinger, *Robot Mobility Systems for Planetary Surface Exploration – State-of-the-Art and Future Outlook : A Literature Survey*, no. January. 2010.
5. S. Wang and Y. Li, "Dynamic Rocker-Bogie : Kinematical Analysis in a High-Speed Traversal Stability Enhancement," *Int. J. Aerosp. Eng.*, vol. ID: 518109, pp. 1–8, 2016.
6. F. Ali, B. Ugurlu, and A. Kawamura, "Center of Mass based Inverse Kinematics Algorithm for Bipedal Robot Motion on Inclined Surfaces," *11th IEEE Int. Work. Adv. Motion Control*, vol. March, pp. 396–401, 2010.
7. D. Kim, H. Hong, H. Soo, and J. Kim, "Optimal design and kinetic analysis of a stair-climbing mobile robot with rocker-bogie mechanism," *Mech. Mach. Theory*, vol. 50, pp. 90–108, 2012.
8. S. Ahmad, N. H. Siddique, and M. O. Tokhi, "Modelling and simulation of double-link scenario in a two-wheeled wheelchair," *Integr. Comput. Aided. Eng.*, vol. 21, pp. 119–132, 2014.
9. T. Thueer and R. Siegwart, "Mobility evaluation of wheeled all-terrain robots," *Rob. Auton. Syst.*, vol. 58, no. 5, pp. 508–519, 2010.
10. A. Krebs, F. Risch, T. Thueer, and R. Siegwart, "Rover control based on an optimal torque distribution - Application to 6 motorized wheels passive rover," *IEEE/RSJ Int. Conf. Intell. Robot. Syst.*, vol. October, pp. 4372–4377, 2010.
11. A. Yamsani, "Gradeability for Automobiles," *IOSR J. Mech. Civ. Eng.*, vol. 11, no. 2, pp. 35–41, 2014.
12. J. Zhu, Y. Wang, H. Yu, W. Wang, and Y. Wen, "Sensing Incline Terrain for Mobile Robot Autonomous Navigation Under Unknown Environment," *Proc. 2010 IEEE Int. Conf. Inf. Autom.*, vol. 1, no. June, pp. 2296–2301, 2010.

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