ROLLOVER STABILITY OF THREE-WHEELED VEHICLES

S. Mukherjee, D. Mohan, T. Gawade
Transportation Research & Injury Prevention Programme
Indian Institute of Technology Delhi
Hauz Khas, New Delhi 110016, India

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INTRODUCTION

THE ROLLOVER STABILITY OF THREE-WHEELED VEHICLE (TWV) used extensively in South East Asian countries including India is commonly perceived to be poor. Rollover stability analysis has been conventionally carried out on the basis of Static Stability Factor. Our results, based on dynamics and FE indicate that the suspension details and consequently the traction model are significant in determining rollover stability for the TWV.

A systematic investigation of the rollover characteristic for four wheeled vehicles is now available using the Slowly Increasing Steer (SIS), NHTSA J Turn, and Road Edge Recovery maneuver [1]. We have conducted equivalent simulations on a 1F/2R (one wheel on the front and two wheels on the rear axle) model of TWV to evaluate the rollover characteristics. The objective is to understand the anomaly between public perception and statistically reported results of injury probabilities.

RIGID BODY SIMULATIONS

RECOMMENDED PROCEDURES like the NHTSA J-Turn take well over 8 seconds to complete. Carrying out Finite Element (FE) simulations for the TWV for this duration is not practical. So a 6-DOF rigid body model, coded in MATLAB® is used for the initial portion when there are no impacts. The equations of motion have been formulated to enable large displacements such as rollovers to be modeled. Rigid body model has been validated against acceleration measurements of a vehicle passing over a speed-breaker. The experimental set-up and results have been shown in Figure 1 and Figure 2 respectively.

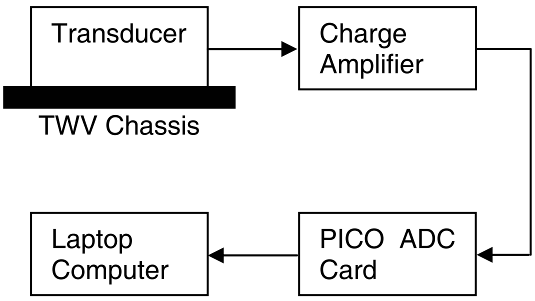


Figure 1 Experimental set-up for vertical acceleration measurement

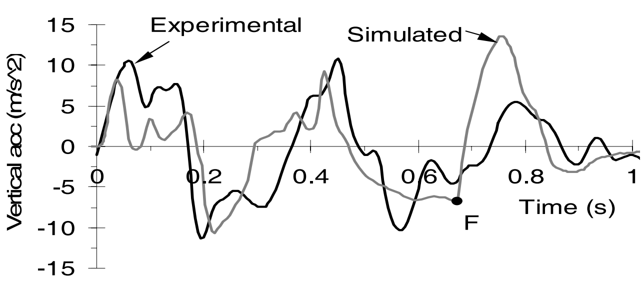


Figure 2 Comparison of simulation and experimental results

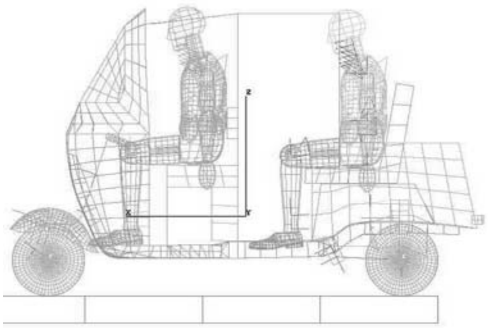
Rigid body simulations show that beyond some combinations of speed, steer angle and steering rate the TWV does not respond to steering input. This is due to lateral sliding at the saturation limit of lateral force on tire. A differential torque control is designed to maintain constant speed during manoeuvre [2]. If the TWV is forced to move with the same combination of speed, steering angle and without cutting the traction it leads to rollover. This is the start of the rollover event, as specified in the NHTSA tests, the wheel lift-off. A comparison of TWV having rollover resistance rating of one star which matches that of the 2001 Chevrolet Blazer in [1] is shown given below.

Vehicle	Minimum maneuver entrance speed resulting in inner wheel(s) lift-off (m/s)	
	NHTSA J-Turn	**Road Edge Recovery**
TWV	7.98	9.00
2001 Chevrolet Blazer	-- (17.29[2])	17.82[1] (16.09[2])

Note: [1]Nominal Load configuration; [2]Reduced Rollover Resistance configuration

FINITE ELEMENT SIMULATIONS

COMPONENT DATA from the manufacturer as well as independent test and measurements are used to build the model. A FE model of the vehicle has been developed in PAM-CRASH™. The state variables at the start of the rollover event in rigid body simulations, that is the inner wheel lift, serve as the boundary conditions to FE model. The FE model is executed for about 500 ms. to study the full rollover event. This combination allows us to study the rollover impact of the TWV effectively.



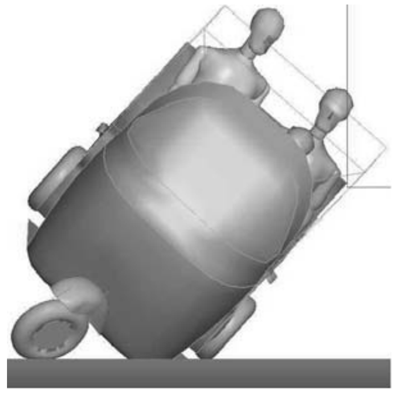


Figure 3 FE model of TWV

Figure 4 Shield of TWV behaves as an outrigger

It is observed that on flat road, the FE model of TWV *does not roll over*. The shield mounted on chassis of TWV impacts the ground and does not allow TWV to tip over. Thus the shield behaves like an outrigger. For rollover to event to lead to the vehicle ending on its side, the front wheel while negotiating the turn has to encounter a depression on the road. Additionally there has to be sufficient momentum so that the rear wheel that initially lost contact does not regain contact with the ground after the impact with the shield.

CONCLUSIONS

IT IS SEEN that the initiation of the TWV tip-over for the model considered occurs earlier than commercial four wheeled vehicles. The same is perceived by the common man on the street. However, the TWV does not eventually rollover, except when a depression is encountered on a turn. The objective to understand the difference between the commoner perspective and available statistical data has been resolved through a scientific investigation.

REFERENCES

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