ISSN: 2278 – 7798
International Journal of Science, Engineering and Technology Research (IJSETR)
Volume 2, Issue 5, May 2013

Analysis of Passenger Car Suspension System Using Adams

S.Pathmasharma[1], J.K.Suresh[2], P.Viswanathan[3] and R.Subramanian[4]
PG Scholar[1], Assistant Professor[2], Professor & Head[3] and Professor & Dean[4]
Department of Mechanical Engineering,
Sri Krishna College of Technology, Coimbatore

Abstract **- The past few decades have witnessed rapid technological growth in the area of automobile engineering. One way of improving the market share is to provide a vehicle with maximum comfort which may be achieved by modifying the suspension system. Passenger car commonly use coil suspension system in their vehicles to absorb road shocks and provide comfort to passenger. Nonlinear springs are most commonly used in vehicle suspension system. Much research work has been carried out on coil spring with the objective of getting optimized designs to improved passenger comfort. This paper discusses about the analysis of the existing of the suspension system and improved design is suggested for achieving maximum comfort. Passenger vehicle suspension system data from the existing vehicle are collected and a model is created using UG. Automatic dynamics Of Mechanical System (ADAMS) has become an important feature of roadside hardware design and analysis in recent year. Using ADAMS analysis of existing model is carried out to determine the forces acting on components of suspension system. With the view of minimizing the forces acting on the components of the suspension system all of the critical components of the suspension system such as mounting points, track width and mass were modified and incorporated into the new model along with the capacity to make the most important components force act with time by carefully modeling the geometric details such as mounting points. It is believed that these modifications significantly improve the performance of simulating impacts with off road side.**

Keywords **- suspension modeling, road side simulation, ride comfort, steering system, ADAMS**

I. INTRODUCTION

Suspensions are used in vehicles to support the load, protect the passenger from shock and vibration arising from tire and road interaction to provide the directional stability and yaw control of the vehicle. However these entire objectives require conflicting parameter are difficult to achieve.

The suspension systems are thus designed to achieve a compromise among these conflicting requirements. The prime objective of using suspension is to improve the ride quality, directional stability and handing of the vehicle.

Vehicle suspension requires soft spring for comfortable ride, while hard springs are needed to attain good handlings and directional control. Anti roll bar are frequently used with nonlinear springs to achieve enhanced directional stability without affecting pure bounce motions. This paper discusses about the analysis of the existing of the suspension system and improved design is suggested for achieving maximum comfort.

Passenger vehicle suspension system data from the existing vehicle are collected and a model is created using UG. Automatic Dynamics of Mechanical System (ADAMS) has become an important feature of roadside hardware design and analysis in recent year.

Using ADAMS analysis of existing model is carried out to determine the forces acting on components of suspension system. With the view of minimizing the forces acting on the components of the suspension system all of the critical components of the suspension system such as mounting points, track width and mass were modified and incorporated into the new model along with the capacity to make the most important components force act with time by carefully modeling the geometric details such as mounting points. It is believed that these modifications significantly improve the performance of simulating impacts (e.g. [1], [2]) with off road side.

II. ANALYSIS OF EXISTING SUSPENSION SYSTEM

Analysis of existing model is carried out to determine the forces acting on components of suspension result given by graph.

A. Front suspension data

TABLE I

PASSENGER CAR SUSPENSION DATA EXISTING MODEL

Wheel Base	2175mm
Spring Mass	1kg
Drive	Front wheel
Braking Ratio:Front:Rear	60:40
Center Of Gravity Height	3inch
Tire Unload Radius	12inch
Stiffness	1.4kg/mm
Wheel Mass	4kg
Ground Clearance	170mm
Gross Weight	1000kg
Krebs Mass	650kg(non A/C)
Over All Length	3335mm
Over All Width	14450mm
Over All Height	1405mm
Front Tread	1215mm
Suspension Type	Front strut
Tire Size	145/7R12
Damping Coefficient	0.2374
Spring Dimension	472.08mm
Wire Data	9.024mm
No Of Coils	6 numbers+2 half coils
Material	Spring steel

B. Front Suspension

Front suspension is the independent suspension system. The main components of the independent suspension system include an upper control arm, lower control arm, spindle, brake calliper and brake rotor. Each of these main components are several additional components that attach to and have a important role in the behavior of suspension [3] are the sway bar to control arm attachment, the tie rod end, the spring, and the shock absorber.

Attachment of upper and lower control arm to the frame rail of pick up is accomplished through the use of bolts, which create revolute joints. The upper and lower control arms are attached respectively to the top and bottom of the spindle. Both of these connections are made through the use of ball joints, which are ball and socket joints.

The tie rod is attached to the steering mechanism and one end and portion of the spindle referred to as the steering arm on the other end. Steering of the vehicle occurs when tie rod end transfers from the motion from the steering mechanism to the spindle.

The tie rod end and spindle are attached using a ball joint. The spindle plays an important role in the front suspension. Not only it does connect the upper and lower spindle arms and follow for turning of the vehicle, but the components that allow the wheel to rotate as well as the braking components are attached to the spindle.

As the car maneuvers over terrain, such as bumps, the front suspension [4] allows the wheel and tire to move up and down with respect to the frame of the truck. The specific direction of this movement is controlled through the geometry and mounting points of the upper control arm, lower control arm, and tie rod.

The spring and shock absorber are attached to the lower control arm and frame of the truck. As the tire try to move upwards, the spring generates an opposite direction force to resist the motion. The motion is stamped by the shock absorber.

C. Existing Front Suspension System

Passenger car suspension system data from the existing vehicle model is created using UG.

ISSN: 2278 – 7798
International Journal of Science, Engineering and Technology Research (IJSETR)
Volume 2, Issue 5, May 2013

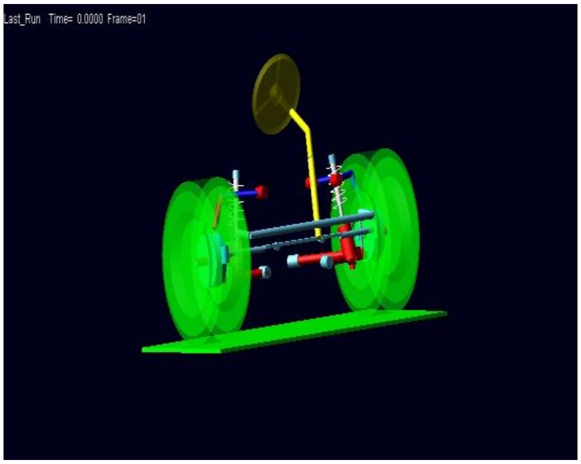
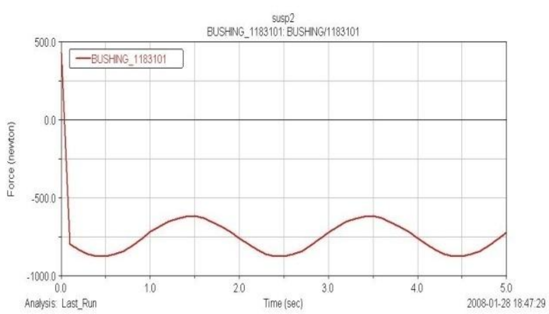


Fig. 1 Existing Model of the Front Suspension

D. Result of existing suspension model

Analysis of existing model is carried out to determine the forces acting on components of suspension system result given by graph.

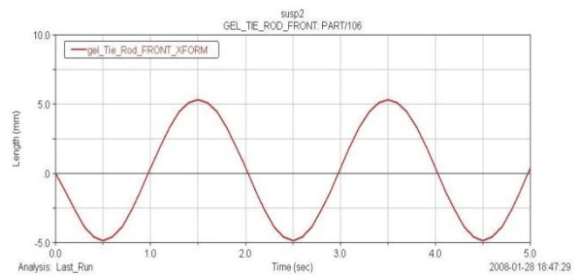
BUSHING FORCE



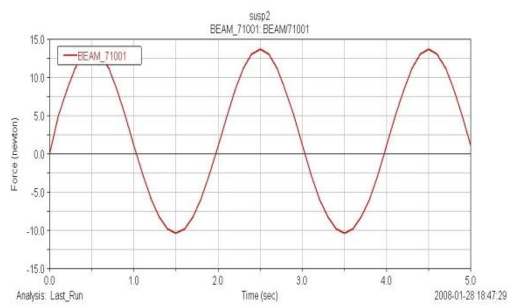
SPRING FORCE

TIE ROD FX

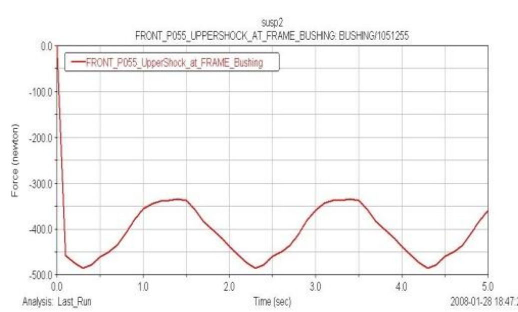
TIE ROD DIS



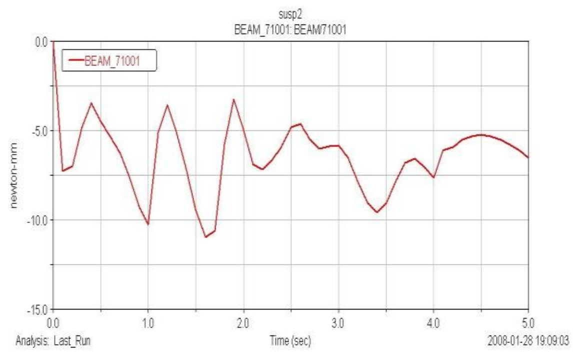
TIE ROD FY



UPPER SHOCK FORCE



TIE ROD TORQUE



III. DEVELOPMENT OF NEW MODEL SUSPENSION SYSTEM

Each of the suspension components was modeled to replace an existing, limited detail model. The given model is a short-long-arm front suspension model [5]. Currently there are revolute joints that connect each upper control arm (UCA) to the frame of the vehicle. We are going to replace the two joints with bushings wheel mass spring mass and CG investigate the differences for comparison the original suspension.

A. Analysis of suspension parameter data

TABLE III
SUSPENSION PARAMETER DATA EXISTING MODEL AND NEW MODELS

Suspension Data	**New Model 1**	**Existing Model**	**New Model 2**
Wheel Base	1927 mm	2175 mm	2560 mm
Spring Mass	0.88 kg	1 kg	1.18 kg
Centre of Gravity	2.64 mm	3 mm	3.54 mm
Wheel mass	3.52 kg	4 kg	4.72 kg

B. Suspension details

In addition to the proper mounting points and geometry of the components, other small details in the front suspension can make the difference between being able to let go of the steering wheel driving 60-mph down the road and needing to hold onto the steering wheel at all times. Steering system geometry (e.g. [6], [7]) and the mass of the suspension components are all very critical.

1) Mounting Points: Each of the main suspension components were modeled individually. Assembling the pieces with the proper geometry was essential to capture the dynamic performance of the suspension. The parts had to be placed in the right position with respect to each other as well as at the correct mounting locations.

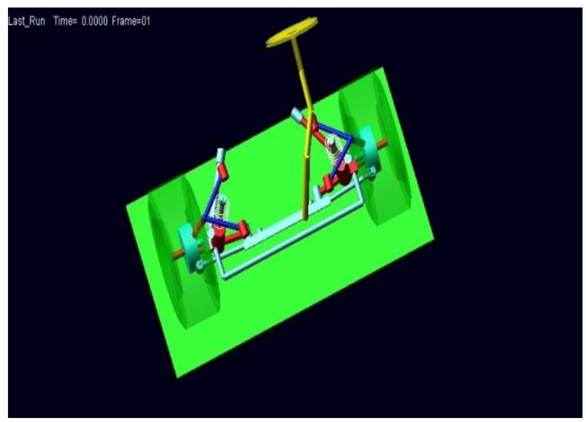


Fig. 2 Wheel Mounting

Measuring where each component mounts is not an easy task since there are many components that inhibit easy measurements. In order to obtain locations a rigid structure was created under the vehicle that essentially pointed to each mounting location. Measurement of the mounting points was then easily accomplished using a level and tape measure.

The modeled suspension components were then oriented to these positions. The mounting point locations provide good overall suspension geometry however each vehicle is fine tuned with more detailed measurements than just these mounting points.

2) Steering System: Ackerman steering was checked on the new front suspension model. If the geometry of the components, the mounting locations and the suspension alignment were correct. Ackerman steering would be present a line was drawn from the steering arm on the front spindle to

ISSN: 2278 – 7798
International Journal of Science, Engineering and Technology Research (IJSETR)
Volume 2, Issue 5, May 2013

the center of the rear axle and it passed very close to where point B would be located.

The steering linkage (e.g. [8] – [10]) lengths are equally as important. If the tie rod ends are too long the inside mounting point, where the pivot occurs as the suspension travels up and down, the tie angle will change as the suspension travels up and down. This is sometimes referred to as bump steer. With the proper geometry and mounting locations for the steering [11] and suspension systems the new model did not exhibit bump steer.

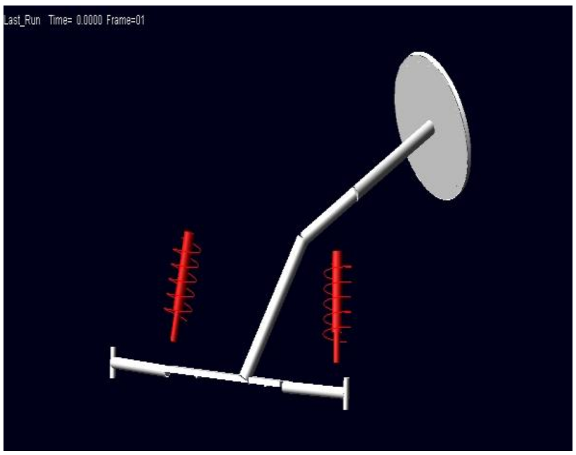


Fig. 3 Steering System

3) Component Masses: Maintaining proper mass in a new model with respect to the actual vehicle can be very important. Rotating and translating masses (e.g. [12] - [14]) can play an important role in the behavior of the test vehicle as it impacts a roadside device and gets redirected. When the vehicle suspension encounters an obstacle such as a curb, the component masses effect suspension movement. The components were first modeled using a standard mass for wheel spring all the suspension parts that were then modified on a component to component basis to get the proper mass. A component of masses for major front suspension components between the previous car models, new car model that since the brake calliper was not modeled and it was combined with the spindle since it bolts to the spindle.

C. Model description

- The given model is a geometric representation of a short-long arm (SLA) suspension subsystem.
- The steering rack and body ground are constrained
- A translational joint connects the steering rack to the body ground.
- A fixed joint connects the body and ground to ground.
- The lower arm and lower strut are constrained as shown next:
- A spherical joint connects the lower strut to the lower control arm.
- A revolute joint connects the lower arm to the body ground.
- The upper arm and upper strut are constrained as shown next:
- A revolute joint connects the upper arm to the body ground.

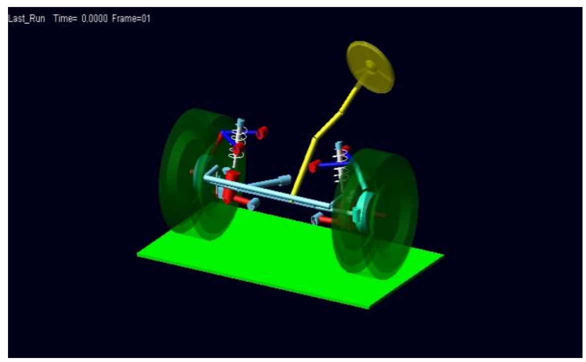


Fig. 4 New Front Suspension Model

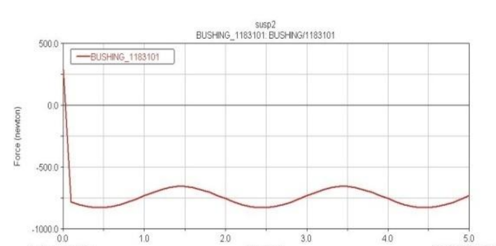
IV. ANALYSIS OF NEW MODEL SUSPENSION SYSTEM

Analysis of new model is carried out to determine the forces acting on components of suspension system result given by graph.

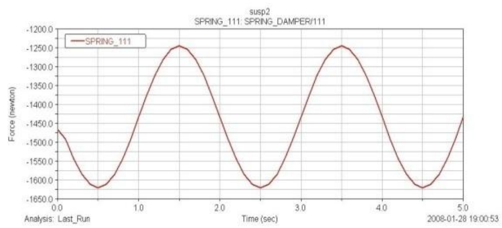
A. Result on new model 1

Forces acting on components of given by graph

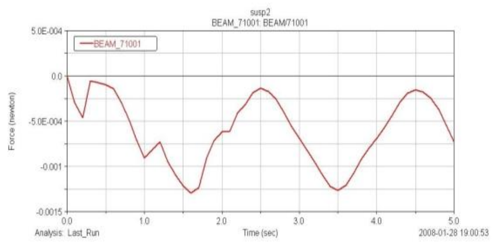
BUSHING FORCE



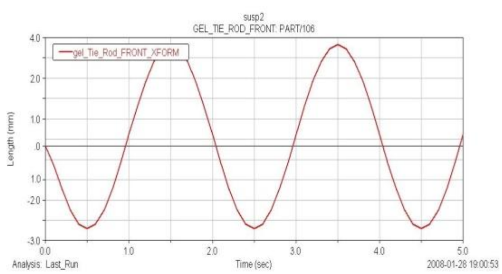
SPRING FORCE



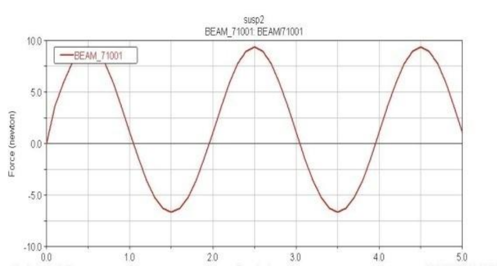
TIE ROD FX



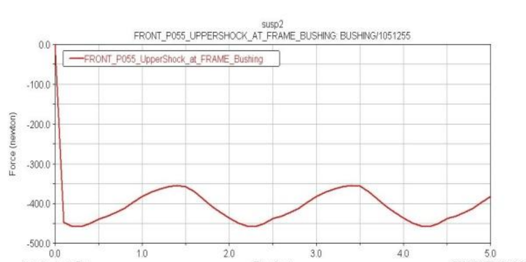
TIE ROD DIS



TIE ROD FY

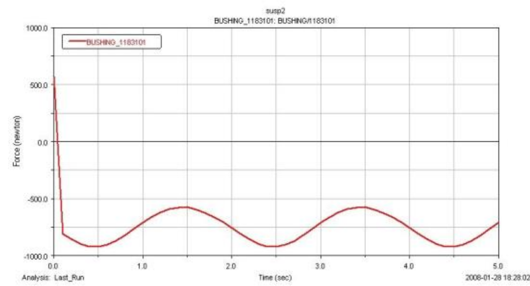


UPPER SHOCK FORCE

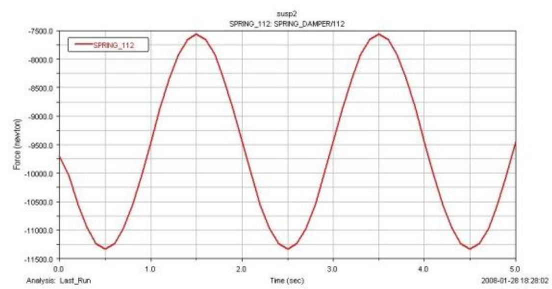


B. Result on new model 2

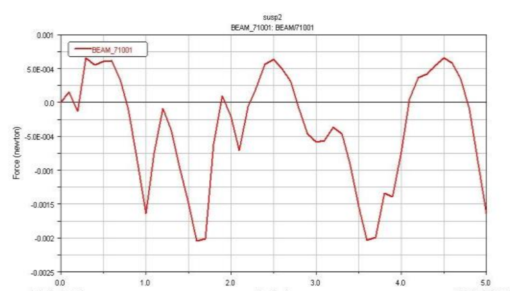
BUSHING FORCE



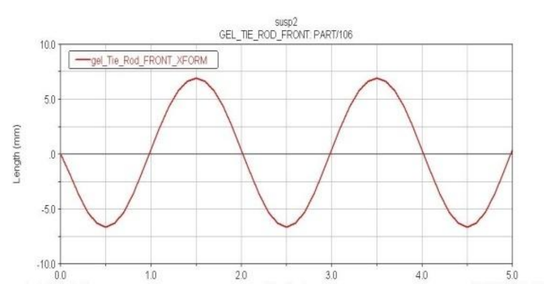
SPRING FORCE



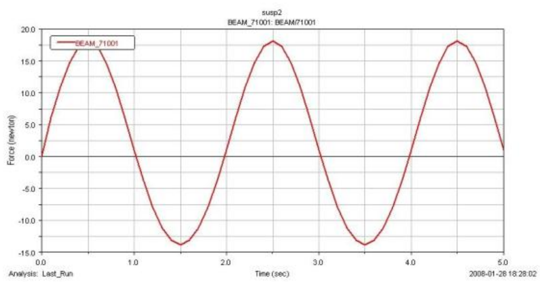
TIE ROD FX



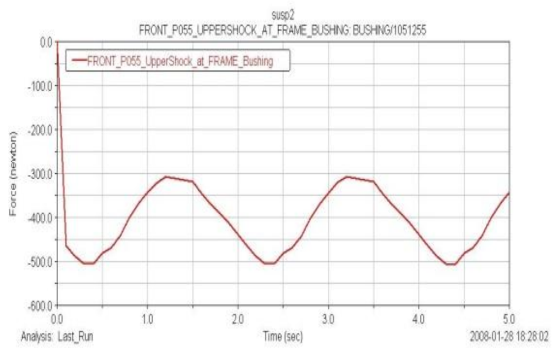
TIE ROD DIS



TIE ROD FY



UPPER SHOCK FORCE



C. Comparison of result suspension models

TABLE III
COMPARSION OF THREE SUSPENSION MODELS
ANALYSIS RESULT GIVEN

Suspension Component	**Force Acting Suspension Component Per Time**		
	New Model 1	**Existing Model**	**New Model 2**
Bushing	760 n/s	800 n/s	890 n/s
Upper Shock	440 n/s	460 n/s	485 n/s
Spring	1600 n/s	10500 n/s	11250 n/s
Tie rod FX	0.0001 n/s	0.0005 n/s	0.0075 n/s
Tie rod FY	7.5 n/s	12.5 n/s	17.5 n/s
Tie rod Distance	2.5 mm/s	5 mm/s	6.5 mm/s

V. CONCLUSION

Using ADAMS [15], a new front suspension and steering system was developed replaced the existing system on a car model used for roadside safety simulation. All of the critical components such mounting points, tracks width and mass were incorporated into the new modal along with the capability to make the most. The first new model with wheel base 1927mm has lower CG when compared to the other two models. Further the mass wheel and spring mass also reduced considerably. So the first new model is found to be a feasible solution for the passenger vehicle suspension. It is believed that these modifications significantly improve the performance of simulating impacts with roadside, where dynamic suspension movement and with guardrail system.

ACKNOWLEDGMENT

Mr.S.Pathmasharma would like to thank Dr.G.Ramesh, Principal, Dr.G.Chandramohan, Director-Academics, Faculty members of Department of Mechanical Engineering and the Management, Sri Krishna College of Technology, Coimbatore for their motivation and constant encouragement throughout this research work.

REFERENCES

[1] Reid, J.D., Marzougui, D.E., An Improved Car Model for Roadside Safety Simulation, Part I- Structural Modeling, Transportations Research Record 1797, TRB, National Research Council, Washington , D.C., November 2002.

[2] Tiso, P., Plaxico, C., Ray, M., M Marzougui, D., An Improved Car Model for Roadside Safety Simulation, Part II- Structural Modeling, Transportations Research Record 1797, TRB, National Research Council, Washington , D.C., November 2002.

[3] Paulsen, T.J., Improvements to the Suspension and Modularization of the car Finite Element Model, Thesis, University of Nebraska- Lincoln, April 2003.

[4] Boesch, D., Front Suspension and Tire Modeling- For Use in Culvert Grate Impact Sinulation, Thesis, University of Nebraska – Lincoln, April 2004.

[5] ROSS, H.E. Jr., Sicking, D. L., Zimmer, R.A., and Michie, J. D, Recommended Procedures for the Safety Performance Evaluation of Highway Features, Report 350, National Cooperative Highway Research Program, Transportation Research Board, Washington, D.C., 1993.

[6] TISO, P., "An Improved Suspension Model for the Reduced Model of the Chevrolet C2500 Pickup Truck," Master's Thesis, Worcester Polytechnic Institute, Worcester, MA, 2001.

[7] ZAOUK, A., Bedewi N.E., Kan C.D., and Marzougui D., "Validation of a Non-Linear Finite Element Vehicle Model Using Multiple Impact Data," Proceedings of the 1996 ASME

International Mechanical Engineering Congress and Exposition, Atlanta, GA, November 1996, pp. 91-106.

[8] ZAOUK, A., Bedewi N.E., Kan C.D., and Marzougui D., "Development and Evaluation of a C-1500 Pickup Truck Model for Roadside Hardware Impact Simulation," Proceedings of the FHWA Vehicle Crash Analysis Crash Confeerence, Mclean, VA, July 1996, pp. 1-31.

[9] ZAOUK, A., Bedewi N.E., Kan C.D., and Schinke H., "Evaluatiom of a Multi-Purpose Pickup Truck Model Using Full Scale Crash Data with Application to Highway Barrier, Impacts," Proceedings of the 29th International Symposium on Automotive Technology and Automation, Florence, Italy, June 1996, pp. 39-46.

[10] PLAXICO C., Ray M., Keeney T., "Modeling the tire rotation and steering in the C2500 pickup truck," Quarterly Report, FHWA Center of Excellence in LSDYNA Modeling, The University of Iowa, 7 July 1998.

[11] DIXON J.C., "The shock absorber handbook", SAE International, 1999.

[12] Communications with Dr. Jerry Wekezer and Rafal Wuttrich, Florida State University, Department of Civil and Environmental Engineering, 2001.

[13] GARRET, Riley, "Light Vehicle Inertial Parameter Database," National Highway Traffic Safety Administration, Washington, D.C., 1998.

[14] RAY, M.H. et al, C.A., "Recommended Guidelines for Curbs and Curb-Barrier Combinations," Project 22-17, Interim Report, National Cooperative Highway Research Program, Transportation Research Board, Washington, D.C., 2001.

[15] Adams Manual and Software Package