

# Virtual Road Approach for Vehicle Durability Simulations

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## ABSTRACT

In current scenario, virtual validation is one of the important phase for any new product development process. The initial step for virtual validation for durability analysis of vehicle is to understand the loads which are transmitted to body from the roads. In current methodology standard 3g load cases are considered. These are worst load cases which show more number of high stress locations on vehicle. In actual vehicle running condition, dynamic loads are coming on vehicle structure. These dynamic loads can be obtained by measuring the loads coming on the vehicle through road load data acquisition system. The use of measured loads posed challenges due to the non-availability of representative mule in the initial phase of vehicle development.

To overcome these challenges, Mahindra & Mahindra developed a new approach which enabled the direct substitution of analytically synthesized loads for measured data. Analytically synthesized loads were derived by running the multibody full vehicle model on virtual road. Virtual roads are created in the software for different type of roads like pot hole, kerb strike, country roads, rough road, express highway roads and city roads. This virtual method of road load data acquisition helped to shorten the product development cycles and helped to increase the accuracy of stress prediction. Virtual road loads were validated with measured road loads for some events to increase the confidence. Paper highlights good correlation of dynamic loads derived from virtual road with the test loads and fatigue block cycle development based on proving ground target cycles.

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## INTRODUCTION

In current scenario Accelerated durability test at Mahindra & Mahindra is mapped to customer usage. In CAE all the DVP's are mapped to the ADT (Accelerated Durability Test). CAE uses conventional 321g load-cases (3g in vertical direction, 2g in longitudinal direction and 1g in lateral direction) to simulate the loads from ADT proving ground. 321g load cases capture almost all the failure locations in the vehicle structure but the major drawback is they capture significant amount of additional locations which doesn't fail in actual test. Fixing up these non-failure locations adds up lot of cost and mass. So in the current scenario it has become very important to capture only the failure locations and reduce non failure locations. The main reason for this deviation is the loads used in CAE to simulate the ADT test. CAE uses standard 321g load cases for evaluation of the vehicle structure. In field/test the loading will be different and we may see a different combination of vertical, longitudinal and lateral load. One method to measure the actual proving ground loads is using the wheel force transducers and the other method is using the strain gauges calibrated to measure

the spindle forces. The second method is called back load calculation. Both of these methods involve cost and time. These measurements have to be repeated for all new vehicle development programs. In addition to this having a full vehicle in the initial phase of the vehicle development program is difficult. To overcome these concern virtual roads were used at Mahindra & Mahindra. They overcome all the disadvantages mentioned above and importantly are vehicle independent. Once tracks data is measured they can be used for all new vehicle product development.

## ROAD PROFILE MEASUREMENT

Road profile measurement of test track is the basic step for modeling virtual road. Simple events profile measurements were done physically at Mahindra and Mahindra. For the road profile measurement of accelerated durability tracks like rough road and country road external agency help was taken. 2-Dimensional road profiles were measured in the longitudinal direction along the wheel path using Laser sensors for different roads and test tracks. These were available in the form of rdf (road definition file) which can be directly read in ADAMS.

Roughness index) were also extracted for all the tracks to understand damaging tracks. IRI is defined as the ratio of longitudinal slice of 2D road profiles showing elevations to the longitudinal distance travelled along the track. It is generally measured in meter per kilometer (m/km). [Figure 1](#) shows the IRI for portion of the test track. Typically the IRI is high for high damaging tracks/roads.

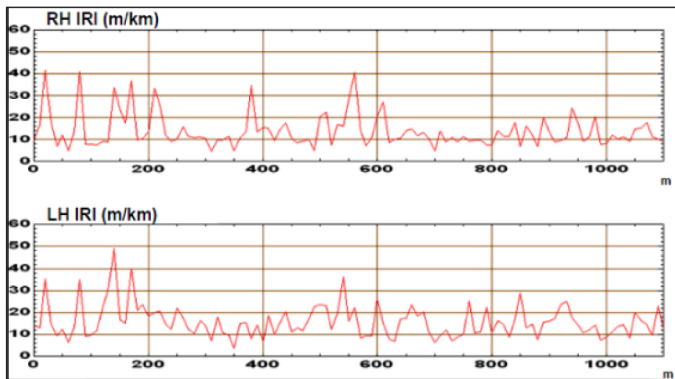


**Figure 1. IRI for VR-1 track**

## MBD MODELLING

A SUV was used for the virtual road exercise. Front suspension in the SUV was double wishbone type and rear was multi-link suspension. All the suspension parameters were measured individually at component level. A full vehicle MBD (multibody dynamics) model was prepared in ADAMS. All the parts of front and rear suspension were modeled using rigid bodies. The MBD model was updated with measured data for the spring stiffness, bump stopper stiffness and damper properties. The vehicle was considered in laden condition.

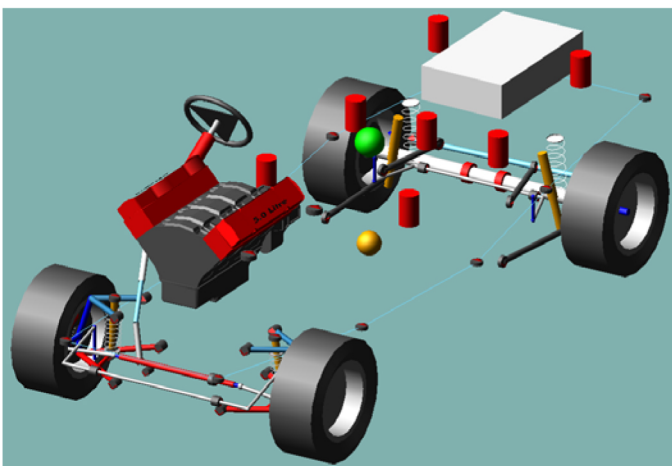


**Figure 2. MBD model of vehicle**

The mass and cg of the vehicle in laden condition was obtained from full vehicle FE model with all the vehicle parts modeled in it. The vertical forces obtained for front and rear

wheels for 1g static simulation were cross checked with the test vehicle FAW and RAW. UA tire was used to model tire which gives good results for durability analysis for dynamic load generation. The MBD model of vehicle is shown in the [Figure 2](#).

## VALIDATION OF MBD MODEL

The next important step was to check the correlation of MBD model with the test vehicle. Wheel force is transmitted to chassis frame through three major suspension elements. Three major elements of force transfer are spring, bump stop and damper. Good correlation of these three major elements was considered as major step of model validation. For validation of model simple events like Pot hole, curb strike and Long wave pitching were considered. SUV in laden condition was run on these three events and forces were measured.

The dimensions for these events were obtained from the available civil drawings and the dimensions were also verified by physical measurement on tracks. These events were modeled using 2D roads profiles in ADAMS software. [Figure 6](#) highlights the overall dimensions for curb strike and pothole event tracks. Long wave pitching track had following specifications:

- Amplitude = 7cm
- Wavelength = 7m
- Number of Waves = 9



**Figure 3. Kerb strike event**

Multibody model was run on these three different tracks at same speed for which measurements were done. Coil spring displacement, spring force, bump stopper force and damper force were extracted for these tracks. Above force component and displacement were compared with the measured force components and displacements for the respective events.

[Figure 4](#), [Figure 5](#), [Figure 6](#) and [Figure 7](#) highlights the correlation of coil spring displacement, coil spring force, damper force and bump stopper force for kerb strike event. This comparison was done for front and rear suspension. A good correlation between test and CAE values is observed for all the components.

[Figure 8](#), [Figure 9](#) and [Figure 10](#) highlights the correlation of coil spring displacement, coil spring force, damper force for long wave pitching event. This comparison was done for front and rear suspension. A good correlation between test and CAE values is observed for all the coil spring displacement, coil spring force and damper force. This