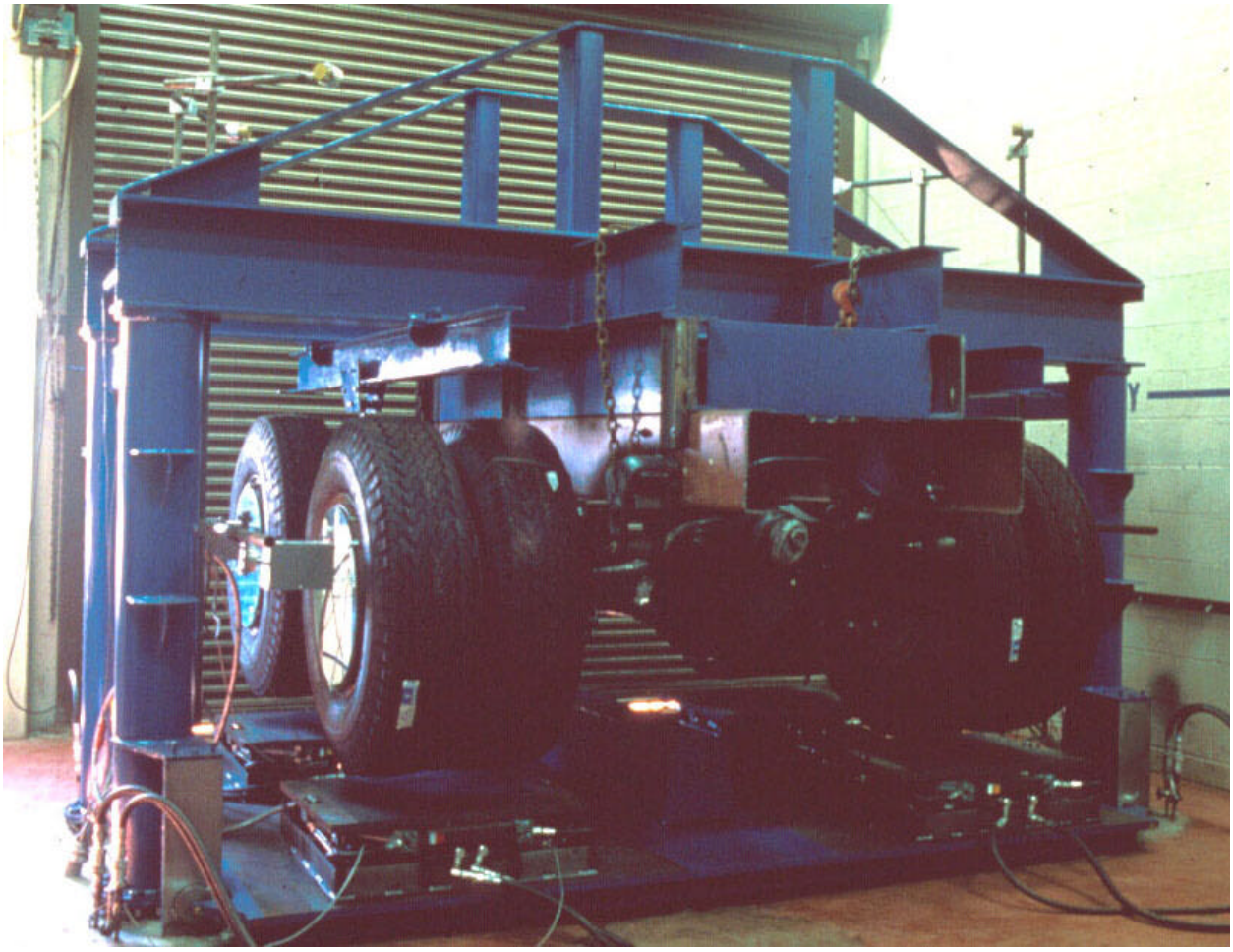
UMTRI HEAVY-VEHICLE SUSPENSION MEASUREMENT FACILITY



UMTRI's heavy-vehicle suspension measurement facility is a permanently installed laboratory device for measuring all of the compliance, kinematic, and coulomb friction properties of commercial vehicle suspensions germane to vehicle simulation. The system can be used to measure single or tandem axle, steering or non-steering, and front or rear suspensions. Suspensions can be tested installed on the actual vehicle or on a frame "buck."

The facility is composed of an overhead static structure to which the vehicle chassis is rigidly fixed, a movable table which serves as the "ground" and whose vertical and roll motion exercises the suspension, and four "wheel pads," one for each wheel set of a tandem axle suspension, on which the tires of the suspension rest. Each wheel pad can act either as a frictionless surface, or apply controlled shear force and moment to the tires in the ground plane. Each pad contains a load cell system for measuring the forces and moments applied to the suspension. Potentiometric transducers measure the resulting motions of each wheel and axle. The facility uses up to 48 individual transducers. Signals are gathered by a digital data acquisition system whose software allows for flexible calculation and display in real time for test monitoring or later for data reduction.

Parameters which can be determined include vertical rate, coulomb friction, roll rates (total and auxiliary), roll-center height, roll steer, lateral compliance, and lateral force and aligning moment compliance steer. Load leveling and the interaxle load transfer due to braking can be determined for tandem suspensions. For steering axles, jounce steer, wrap-up (caster) rate and wrap-up steer may also be measured.

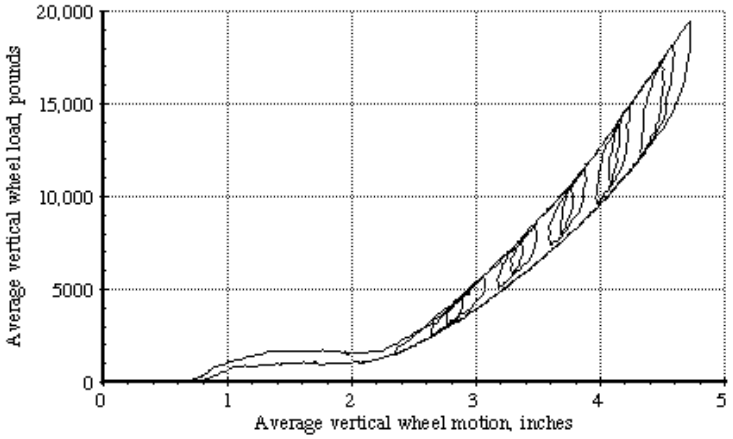
TEST DESCRIPTIONS

In all suspension measurement tests using the UMTRI heavy-vehicle suspension measurement facility,[1] the frame of the vehicle is held fixed and the suspension is exercised by moving the facility "table" vertically or in roll, or by applying tire shear forces (lateral or longitudinal) or moment (aligning) using the "wheel pads." The table is typically moved as a single unit with the simulated ground surface under all tires being of a common plane.

Force and moment measurements are made with load cell systems located in each of the wheel pads. Thus, in general and *except where noted, forces and moments reported in the data are absolute values measured at the tire/road interface*. Resulting motions of the suspension and wheels are measured with a variety of potentiometric devices. *Generally, these motion measurements are relative (not absolute) and are referenced to the fixed frame of the vehicle, not to the simulated ground plane*

The following paragraphs outline the procedures used in the five physical types of tests generally conducted with the facility.

- *Vertical motion*. The suspension is exercised by vertical motion of the table. Table motion is controlled by a feedback servo-system sensing the vertical and roll motions of the axle, so that the suspension motion is "pure" vertical motion with roll held constant. Force and moment control servo-systems are also used to maintain zero levels of tire shear forces and moment. (In some cases, limits of vertical stroke of the table may not allow for the full motion of the suspension in a single test. In these cases, tests are conducted in the "lower" and "upper" range.) For steering axle suspensions, the pitman arm of the steering system is held fixed so that steering gear lash will not contaminate the steer response data. Suspension spring rate and coulomb friction information is derived from this test. Spring performance data are reduced to forms appropriate for use in computer models. Reduced numerics include (1) linear spring rate and simple coulomb friction, (2) nonlinear spring table, and (3) envelope tables and β's for the UMTRI spring model. For steering axle suspensions, road-wheel steer as a function of vertical axle motion is also determined.



Average vertical rate of a four-spring suspension

- *Roll motion*. The suspension is exercised by roll motion of the table. Table motion is controlled by a force and moment feedback servo-system so that the total vertical load applied to the suspension is held constant at the desired value while roll moment on the suspension is varied over the range of interest via side-to-side load transfer. Force and moment control servo-systems are also used to maintain zero levels of tire shear force and moment. Force and moment control of table motion allows the motion of the suspension to be determined by the suspension geometry, rather than by facility geometry. This test is typically repeated at three conditions of vertical load. For steering axle suspensions, the pitman arm of the steering system is held fixed so that steering gear lash will not contaminate the roll-steer response data. Suspension roll rate, auxiliary roll stiffness, roll-center height, and roll steer are determined using the data from this test.

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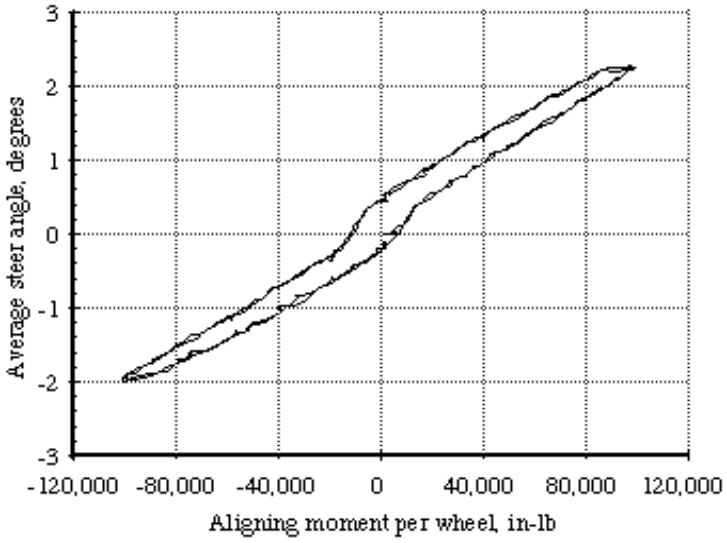
1 Winkler, C.B. and Hagan, M. "A Test Facility for the Measurement of Heavy Vehicle Suspension Parameters." SAE Paper No. 800906, August 1980.

- *Aligning moment*. The suspension is exercised by the application of aligning moments at each tire (or tire pair in the case of dual tires). Prior to the test, the suspension is excersized vertically to establish the desired vertical load (typically with zero roll moment). During the test, the table is controlled by feedback of the vertical position of the right and left axle spindles so that the *vertical and roll position of the axle is held fixed*. (As a result, vertical and roll motions, and especially their influence on steer, are not allowed to influence the test, but vertical load on the individual tires may change slightly during the test.) The force and moment control servo-systems of the wheel pads are used to vary the aligning moment at each tire while longitudinal and lateral forces are held fixed at zero. Aligning moment is equal at each wheel throughout the test. This test is typically conducted at one or more conditions of vertical load. For steering-axle suspensions, the steering wheel is held fixed throughout the test. The test is conducted with the engine running if the steering system includes power steering. The test measures aligning moment compliance steer. For steering axle suspensions, the data are reduced to equivalent steering system and tie-rod stiffnesses parameters: K_S and K_T respectively.



Aligning moment compliance steer of a steering axle

- *Longitudinal (brake) force.* The suspension is exercised by the application of longitudinal tire shear force at each tire (or tire pair in the case of dual tires). Setup and control of the table is as described for the aligning-moment test. The force and moment control servo-systems of the wheel pads are used to vary the longitudinal force at each tire, while lateral force and aligning moment are held fixed at zero. Longitudinal force loading is equal at each wheel throughout the test. This test is typically conducted at one or more conditions of vertical load. For steering-axle suspensions, the pitman arm of the steering system is held fixed so that steering gear lash will not contaminate the steer response data. Spring-wrapup rate and wrapup steer are determined for steering axle suspensions. Inter-axle load transfer is determined for tandem suspensions. This test is generally not conducted on single axle, non-steering suspensions.
- *Lateral (side) force.* The suspension is exercised by the application of lateral tire shear force at each tire (or tire pair in the case of dual tires). Prior to the test, the suspension is loaded vertically to the desired level (with zero roll moment). Setup and control of the table is as described for the aligning-moment test. The force and moment control servo-systems of the wheel pads are used to vary the lateral force at each tire while longitudinal force and aligning moment are held fixed at zero. Lateral force loading is equal at each wheel throughout the test. This test is typically conducted at one or more conditions of vertical load. The test data are reduced to produce measures of lateral compliance and lateral-force steer.