SUMMARY REPORT 140-7(S)

COMPARISONS OF FULL-SCALE EMBANKMENT TESTS WITH COMPUTER SIMULATIONS

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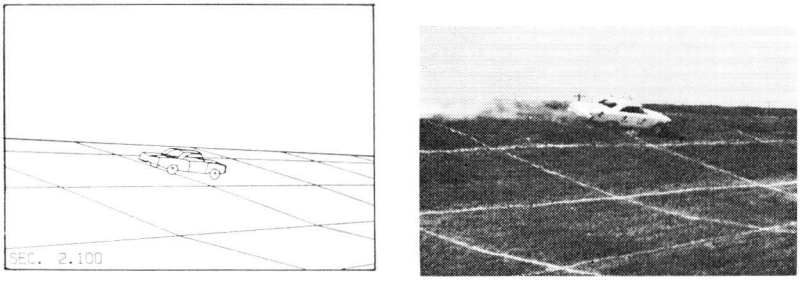

Comparison of Simulation with Full-Scale Embankment Test

Cooperative Research Program of the
Texas Transportation Institute and the Texas Highway Department
In cooperation with the
U. S. Department of Transportation, Federal Highway Administration

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Comparisons of Full-Scale Embankment Tests with Computer Simulations

by

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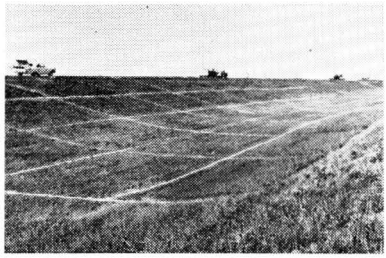
Criteria were presented in Research Report 140-4[1] identifying embankments which needed guardrail protection. A portion of the criteria was based on output from the Texas Transportation Institute's version of the HVOSM computer program.[2] Since HVOSM had not been validated for embankments with relatively steep side slopes and since implementation of the criteria would require changes in current Texas Highway Department design procedures, it was decided that a limited validation study should be conducted.

Six full-scale automobile tests were conducted on an embankment of Texas State Highway 21, an in-service roadway. The embankment, shown in Figure 1, had a side slope of approximately 3.5:1 and a flat bottom ditch approximately 20 feet below the roadway. The grassy slope, ditch bottom, and back slope were well compacted.

The test vehicle, a 1963 Ford, was instrumented with accelerometers. A radio control system was developed to accelerate the test vehicle to the desired speed and then to guide it off the roadway at the desired point and at the desired angle. Its subsequent response was recorded on high speed film and electronic instrumentation.



(a) View from top of backslope

(b) View from ditch bottom

Figure 1. Photos of Test Site.

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[1]Ross, Hayes E., and Post, E. R., "Criteria for Guardrail Need and Location on Embankments—Volume One, Development of Criteria," Research Report 140-4, Texas Transportation Institute, Texas A&M University, April 1972.

[2]HVOSM—Highway-Vehicle-Object-Simulation-Model. A computer program which simulates the dynamic behavior of an automobile. It was originally developed at Cornell Aeronautical Laboratory and later modified for specific studies at TTI.

A wide variety of encroachment conditions were obtained in the six tests. Encroachment speeds ranged from 45.1 mph to 63.6 mph, and encroachment angles ranged from 8.6 degrees to 20.4 degrees. In addition, suspension failures and, in one case, an attempt to steer back on the side slope created special test conditions. This range of test conditions is believed to encompass many of the conditions that occur in run-off-the-road accidents. It is significant that for these conditions both test and simulation results showed that a car could traverse the embankment with no tendency to roll over.

Each test was simulated by the HVOSM and the results were then compared with the measured test results. Three basic types of data were compared, namely, vertical accelerations, paths of the vehicles, and vehicle attitudes. Figure 2 shows the

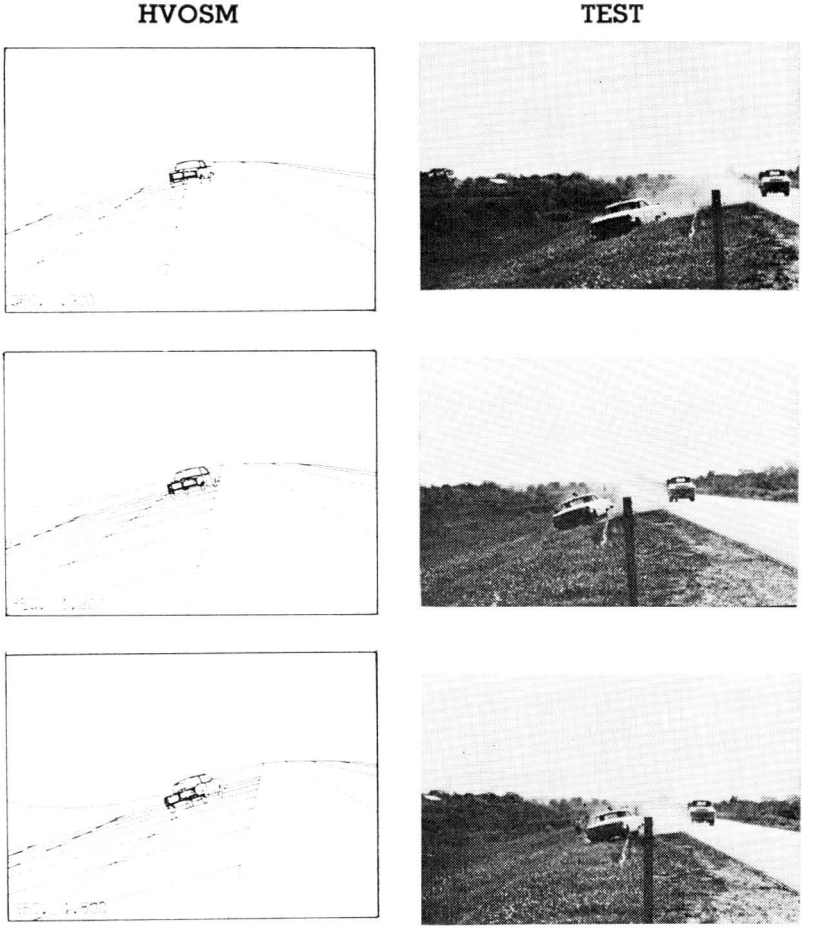

Figure 2. HVOSM and test results, Test No. 1.

attitude comparisons for Test No. 1 (encroachment angle of 9.7 degrees and encroachment speed of 55.7 mph) at T = 0.900 sec., T = 1.200 sec., and T = 1.500 sec. (vehicle left roadway at T = 0.0 sec.).

The following conclusions were drawn as a result of this study:

1. The Highway-Vehicle-Object-Simulation-Model can accurately predict the dynamic behavior of an automobile traversing an embankment, with the exception of those instances when mechanical failures occur in the vehicle (see conclusion 4).

2. As a consequence of conclusion 1, the criteria on guardrail need, presented in Research Report 140-4[1] has been substantiated.

3. An automobile and its occupants can traverse a 3.5:1 side slope with a flat bottom ditch 20 feet below the roadway with relative ease and tolerable accelerations for a wide variety of encroachment conditions.

4. HVOSM is incapable of predicting mechanical failures which may occur in an automobile and the subsequent effects of such failures. The suspension failures that occurred in two of the six tests were attributed in part to the condition of the test car's suspension system. The condition of the suspension system degenerated with each test.

5. Although vehicle control was lost due to mechanical failures in two of the six tests, the vehicle remained in a stable attitude and traversed the embankment without any serious problems.

The published version of the complete report of which this is a summary may be obtained by addressing your request as follows:

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