

dynamic testing of guardrails. This was done in 1958. We found that there had been no effective dynamic tests conducted or reported for more than 25 years, and that there was no really good research literature which would demonstrate what an effective guardrail installation is.

Accordingly, we began some dynamic tests, and we found very rapidly that our existing guardrail structures were not adequate. The posts were rotted, the guardrail section itself was found to have insufficient beaming strength. During the course of this, we consulted with the Highway Research Board Committee on Guardrails and Guideposts. We took advantage of the research which Mr. Beaton of California had conducted and we have reported progress to the committee throughout the course of this development, and have given to the committee all of the film footage of the tests which were conducted.

Mr. Lundstrom and Mr. Skeels made a report, a preliminary report, to the Highway Research Board in January of 1959, a paper entitled "Full-Scale Appraisals of Guardrail Installations by Car Impact Tests," and demonstrated certain conclusions. One, that good beaming strength is essential and that the 12-gage W-section steel rail mounted on posts spaced at 6 feet does provide adequate strength.

The end of the rail must be anchored securely. At that time we concluded that a mounting height of 18 inches at the center of the rail appeared to be satisfactory. Later research, I believe, suggested that 21 inches to the center is probably a better minimal value.

We found that 6 by 8 pressure-treated wood posts gave a very satisfactory performance. We found that the guardrail ends present a dangerous obstacle and we developed means to control that.

The second and more comprehensive report was made at the 40th annual meeting of the Highway Research Board in January 1961. This is entitled "Guardrail Installations—Appraisal by Proving Ground Car Impact and Laboratory Tests."

It was written by W. G. Cichowski, P. C. Skeels, and W. R. Hawkins. This shows the results of more than 60 tests at speeds from 30 to nearly 70 miles per hour and at angles of impact ranging from zero to 33 degrees. We had some additional conclusions, in addition to those that were presented before, that 1,000 pounds per inch spring brackets with 4-inch travel could be used as a mounting bracket to space the rail out from the post and reduce impact intensity at lower speeds.

We found, very importantly, that reinforcing washers are required on the beam mounting bolts to prevent the bolt head from pulling through; and that reinforcing sections are required under the beam-center mounting to the post. The ends must be ramped to avoid the end obstacle and they must be anchored.

Now, we found that the reduction in the spacing of the posts from the standard 12½ feet to 6¼ feet approximately doubled the beaming strength and that the use of the reinforcing washer increased the strength of the attachment to the post by three times.

So we have made results of this test available to many of the State highway departments in the 43 conferences we have attended, which I reported just a few minutes ago.

Now, we have a motion picture which summarizes this and I would like to show that now.