SUMMARY REPORT 146-4(S)

VEHICLE CRASH TEST AND EVALUATION OF MEDIAN BARRIERS FOR TEXAS HIGHWAYS

SUMMARY REPORT
of
Research Report Number 146-4
Study 2-8-68-146

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

September, 1972

TEXAS TRANSPORTATION INSTITUTE
Texas A&M University
College Station, Texas

Vehicle Crash Test and Evaluation of Median Barriers for Texas Highways

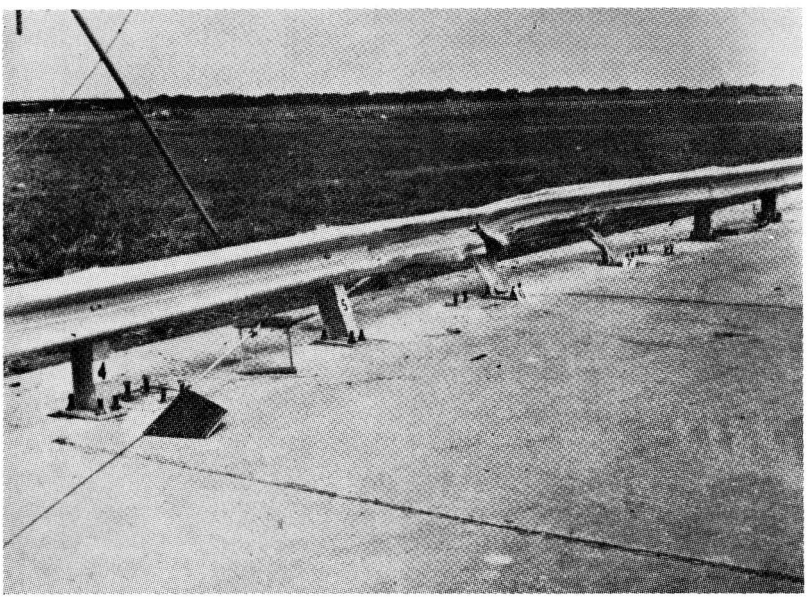
by

T. J. Hirsch, Edward R. Post, and Gordon G. Hayes

Full-scale tests were conducted to evaluate the performance of three median barriers of different configuration and lateral stiffness. The barriers selected by the Texas Highway Department were: (a) the Metal Beam Guard Fence (MBGF) which consists of two standard W-beam guardrails mounted back-to-back on breakaway steel posts, (b) the E-3 which consists of two elliptical steel rails mounted on strong steel posts, and (c) the concrete median barrier (CMB) with sloping faces.

All three barriers remained intact in restraining and redirecting a 4,000 lb. passenger vehicle under the severe impact conditions of about 60 mph and 25 degrees. However, some snagging occurred on a post of the E-3 barrier as a result of the vehicle mounting the lower rail member. Increasing the height of the lower rail member may be one solution for reducing the snagging.

The 150 ft. test section of the CMB barrier, which was not anchored to the roadway and contained continuous #5 longitudinal reinforcing steel, showed no tendency to overturn or slide



Damage to MBGF barrier after test.

during the 60 mph and 25 degree collision. The measured rotational displacement at the top of the barrier was 0.09 inches. A 1-in. layer of hot mix asphalt was placed 1-in. above the median and adjacent to the base of the barrier to help prevent sliding.

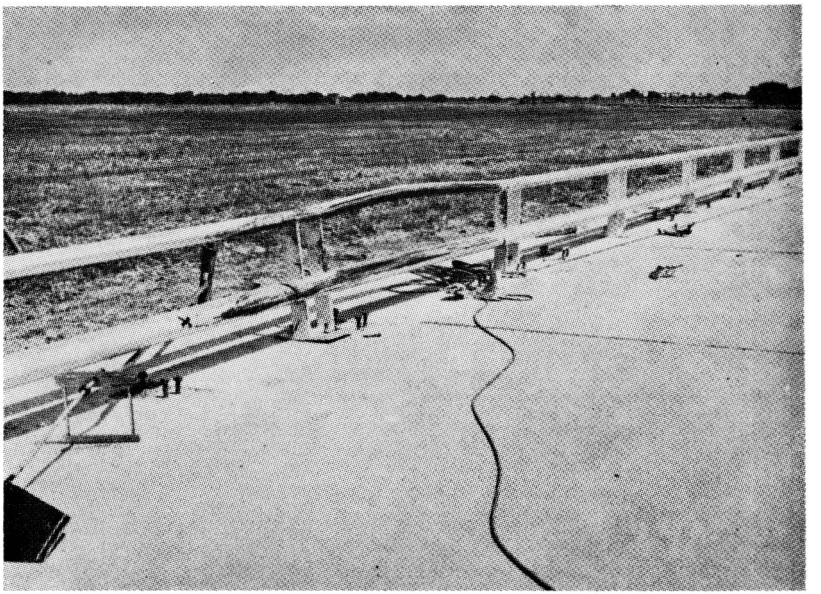
The breakaway fillet-weld post connections of the MBGF barrier were effective from a standpoint of providing greater flexibility and permitting the posts to displace laterally without significantly reducing the height of the rail member, and thereby, preventing vehicle ramping.

A 60 mph and 25 degree test showed that luminaire poles and fencing can be safely mounted on the top of the CMB barrier in narrow medians. On the other hand, a luminaire pole protected by flexible guardrail may be unsafe in narrow medians because the lateral displacements of the guardrail may allow the vehicle to contact and knock the luminaire pole onto the roadway.

The departure angles of the vehicles after redirection varied from a low of 6 degrees to a high of 20 degrees. The 20 degree departure angle occurred with the semi-rigid MBGF barrier due to the side ramping effect created by the barrier displacements. On wide shoulders and under high speed and large angle collisions, the large departure angles would most likely not create a hazardous condition for other nearby vehicles because most full-scale tests demonstrate that the colliding vehicle after redirection is pulled back toward the barrier due to the high friction drag forces of the severely damaged front wheel.

A comparative study of the three barriers demonstrated that barrier displacements were very effective in reducing the lateral vehicle decelerations, vehicle damage, and hence, injury severity. During a 60 mph and 25 degree barrier collision, it was predicted from measured lateral decelerations that the probability and severity of injury to unrestrained occupants in a standard size 4,000 lb. passenger vehicle would be: 72 percent and major for the rigid CMB barrier; 62 percent and major for the E-3 barrier undergoing a displacement of 0.7 feet; and, 46 percent and on the threshold of major for the MBGF barrier undergoing the largest displacement of 1.5 feet. An injury probability of 46 percent represents the apparent division between minor and major injuries. An average of nine individual assessments of vehicle damage rating using the National Safety Council (NSC) 7-point rating severity scale were: 5.75 for the CMB barrier; 6.1 for the E-3 barrier; and, 5.2 for the MBGF barrier.

Two additional tests were conducted on the CMB barrier at lower angles of impact of 7 and 15 degrees to evaluate its performance under representative inservice narrow median type collisions. It was predicted that the probability and severity of injuries to unrestrained occupants in a standard size 4,000 lb. passenger vehicle would be: between 19 to 22 percent and minor



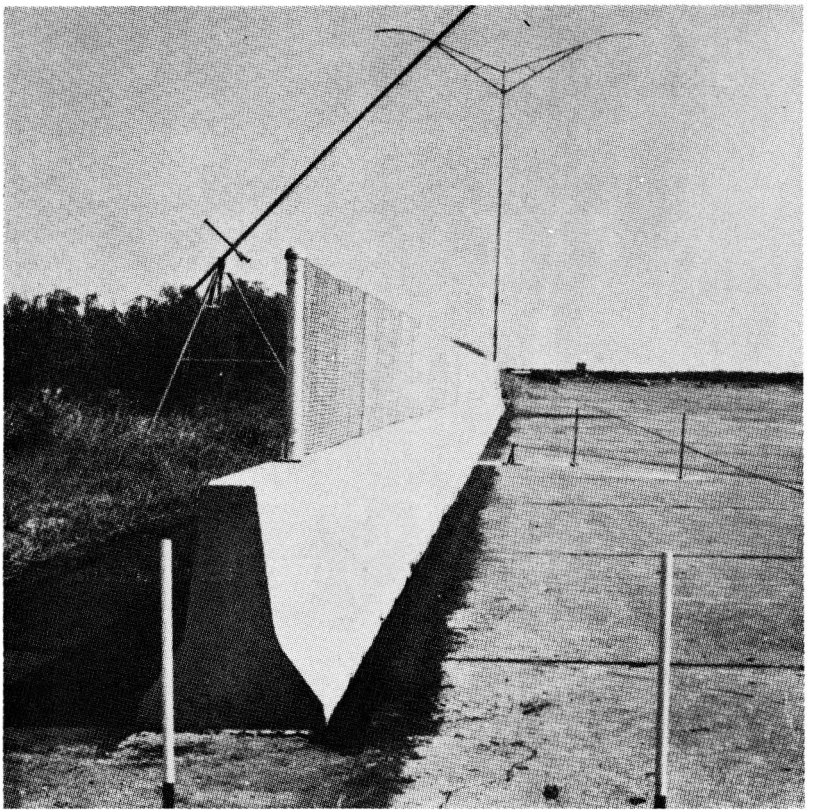
E3 barrier before and after test.

for a 60 mph and 7 degree collision; and, between 43 to 47 percent and on the threshold of major for a 60 mph and 15 degree collision. The averages of nine individual NSC vehicle damage scale ratings were 2.1 and 5.5 for the 7 and 15 degree collisions, respectively.

The 60 mph and 7 degree CMB barrier test and the tests of other investigators on concrete medians with sloping faces definitely show that minor sheet metal vehicle damage occurs under low impact speeds and/or angles.

As well known from field experience, this study showed that maintenance increases as barrier flexibility increases. Maintenance of the CMB barrier would be nil and would require at most an occasional light sandblasting job. Maintenance of the relatively rigid E-3 barrier would require the replacement of one upper 10 ft. rail, straightening of one post, and a paint touchup for an estimated cost of $290. Maintenance of the semi-rigid MBGF barrier would require the replacement of 25 ft. of the barrier including three breakaway posts for an estimated cost of $440.

Based upon information provided by the Texas Highway Department, the initial construction costs of the three barriers on a linear foot basis are: $13.40 for the CMB barrier; $19.20 for the E-3 barrier; and, $11.75 for the MBGF barrier.



Concrete median barrier before test.

One could conclude from the results presented that the MBGF barrier is the most economical concerning initial construction costs, and that the barrier is the safest concerning probability and injury severity to unrestrained occupants during a 4,000 lb. automobile 60 mph/25 deg. impact. However, the MBGF barrier would cost the most to maintain and its use in narrow medians is not desirable due to the possibility of the vehicle displacing the barrier a sufficient distance and knocking the luminaire pole onto the roadway. It appears that the MBGF barrier would probably be satisfactory for use on rural type roadways with wide shoulders, wide medians and relatively high speed but low traffic volume.

One could further conclude from the results presented that the CMB barrier is the most economical when both initial construction costs and estimated maintenance costs are considered. The CMB barrier with luminaire poles would be very desirable

for use on urban type roadways with narrow medians and carrying high speed and high traffic volume. In addition, low maintenance reduces the amount of exposure time, and hence, increases safety to maintenance personnel.

It is important that one keep in mind that all three median barriers investigated in this study have performed adequately while in service on our highways. Also, other factors in addition to those presented here should be considered when selecting a barrier. For example, information is available which indicates that approximately 75% of the vehicle collisions will occur at angles of 15 deg. or less. At lower impact angles, the safety and maintenance aspects of all three median barriers would improve. A graph is presented from which a highway engineer can examine the probability and severity of injury associated with rigid type traffic barriers under various combinations of impact speed, impact angle, and passenger vehicle weight.

The safety aspects of the E-3 could be improved by increasing the height of the lower rail member to prevent vehicle snagging on the support posts.

The published version of this report may be obtained by addressing your request as follows:

Phillip L. Wilson, Engineer-Director
Planning and Research Division, D-10R
P. O. Box 5051—VFW Building
(Phone 512 475-7346)