7. Nowak, E.S., "Single Vehicle/Fixed Object Collision Study in Ontario Provincial Police District No. 2 For the Period January 1, 1976 to May 31, 1976". Prepared for Transport Canada. Report No. SVFO-FR-1-76, University of Western Ontario, Multi-Disciplinary Accident Research Team, London, Ontario, June, 1976.

8. Stewart, D.E., Sanderson, R.W., "The Measurement of Risk on Canada's Roads and Highways". Published in "Transport Risk Assessment", University of Waterloo Press, Waterloo, Ontario, 1984.

9. Glennon, J.C., Wilton, C.J., "Effectiveness of Roadside Safety Improvements - Vol.I - A Methodology for Determining the Safety Effectiveness of Improvements On All Classes of Highways". Report No. FHWA-RD-75-23, Federal Highway Administration, Washington, D.C., November,1974.

10. Calcote, L.R., "Development of a Cost-Effectiveness Model for Guardrail Selection - Vol. I - Technical Documentation". Report No. FHWA-RD-78-74, Federal Highway Administration, Washington, D.C., January, 1980.

11. National Cooperative Highway Research Program Report 239 "Multiple-Service-Level Highway Bridge Railing Selection Procedures". 1981.

12. Roer, P.O., Koike, H., Allen, C.,"Roadside Hazards - A Methodology and Technique for Determining Accident Potential". Prepared for Transport Canada. B.C. Research, Vancouver, B.C., July 1978.

CONCRETE MEDIAN BARRIERS CRASH TESTS AND ACCIDENT INVESTIGATIONS

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Abstract

Concrete median barriers have been tested in France since 1972. The first concrete barriers tested were precast. The results were disappointing, and we quickly moved toward the use of slipformed concrete barriers.

Over the past several years, the use of these devices has been increasing. The road standards specify concrete median barrier use on urban and suburban highways and at locations with restricted circulation conditions. At present, the Transportation Ministry provides for the expansion to all highways with limited speeds and on new four lane divided roads with narrow median widths.

The purpose of this paper is to describe the research carried out in France on these concrete barriers, to give crash tests results and to analyze their behavior in the field.

Introduction

The road construction effort in highway safety has been especially noticeable since 1965 in France. It became integrated into the development policy of the motorway network and led the Transportation Department to launch extensive studies concerning traffic barrier devices.

In this context INRETS, first developed metal beam barriers for roadside and median protection. Since 1972, following the American experiments, it conducted tests on concrete barriers for use on medians to contain both cars and trucks. (1), (2), (3).

The first concrete barriers tested were precast. The results were disappointing, and we quickly moved toward the use of slipformed concrete barriers.

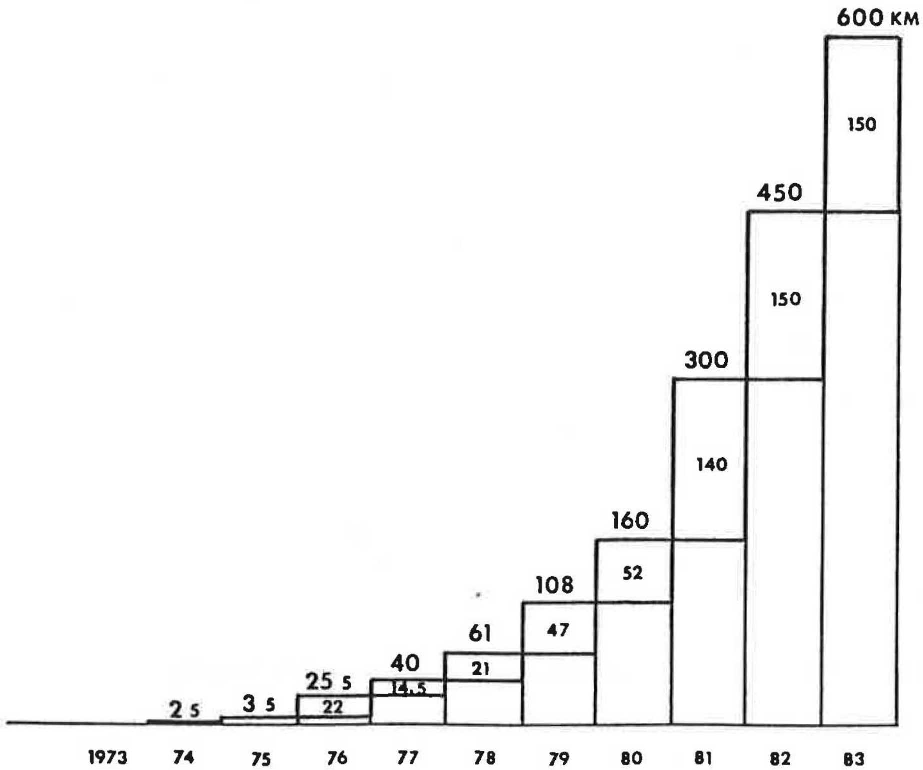

FIGURE 1 - Yearly Concrete Median Barrier Construction

Over the past several years, the use of these devices has been increasing. The road standards specify concrete median barrier use on urban and suburban highways and at locations with restricted circulation conditions. At present, the Transportation Ministry provides for the expansion to all highways with limited speeds and on new four lane divided roads with narrow median widths. (4), (5).

The purpose of this paper is to describe the research carried out in France on these concrete barriers called DBA (for medians) or GBA (for roadsides) and to analyze their behavior in the field in order to contribute to the standards for use.

Experimentation

The objective was to meet the first level of barrier protection for cars (standard highway construction) and the second level of barrier protection for trucks. Test conditions are shown in Table 1:

		Vehicle weight (kg)	Speed (km/h)	Angle (^{o})
Car protection	L1	1,250 (2753 lb)	80	30
		1,250 (2753 lb)	100	20
Truck protection	L2	12,500 (bus) (27530 lb)	70	20

Table 1 - Test Conditions

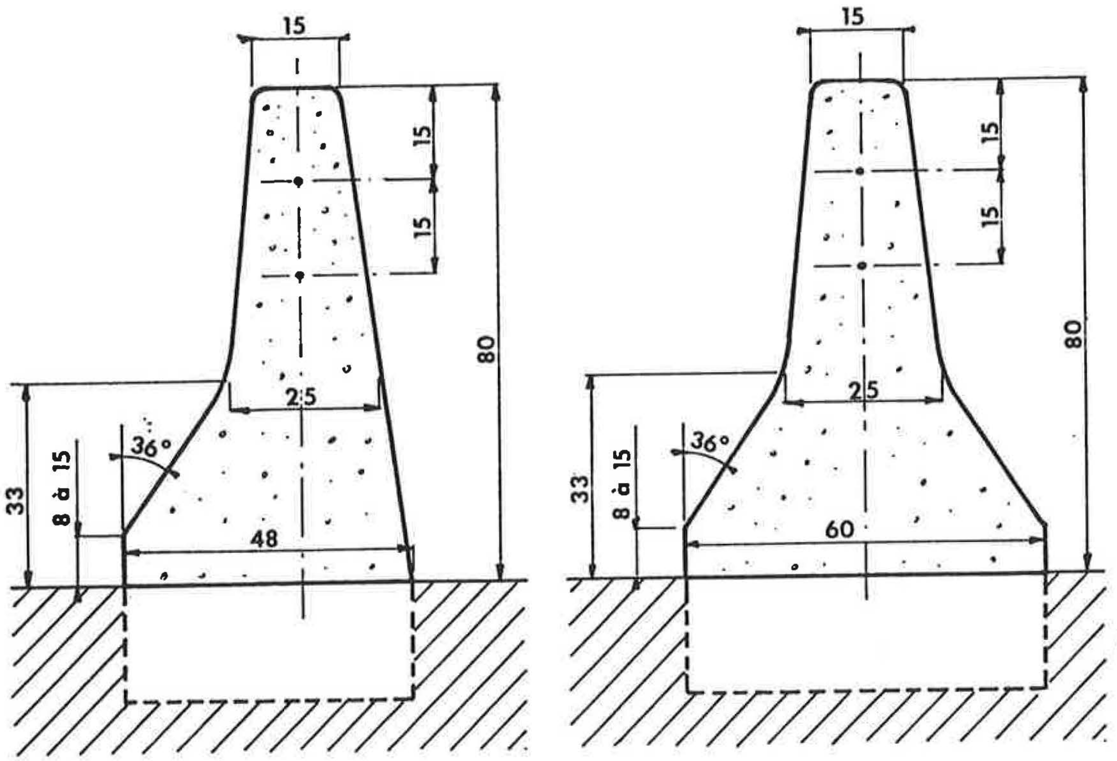

FIGURE 2 - GBA and DBA Designs

Light Vehicles Tests

Regarding passenger cars, three crash tests were carried out (Table 2). The results confirm the American ones: the speed and the exit angle were important, as well as the damage to the vehicle, but there were no roll-overs.

The concrete barrier was not damaged during the first two tests. On the other hand, during the third test the barrier, which was placed without any bond to the road was broken at 20 m.

The same crash tests carried out with standard guardrail resulted in less severe impact forces. Thus, in these cases the average of the ASI index on 5 tests was 0.5 compared with the values of more than 1 from the tests with concrete median barrier.

	Conditions				Results			
Test No.	Speed V(km/h)	Angle (°)	Weight M(kg)	Impact Indice I (3)	Exist Angle (°)	Stopping Distance (m)	ASI	ASI/I
319	84	31	1250	1.17	8	26	1.7	1.45
492(1)	72	30	1250	0.81	10	70	1.3	1.6
483(2)	108	19	1230	0.76	5	70	1.14	1.5

Table 2 - European Cars - Test Results - Concrete Median Barrier
Heavy Truck Tests

(1) DBA cast on compacted ground: break in barrier with 0.1 m deflection

(2) DBA cast without ground adhesive: break in barrier with 0.1 deflection

(3) Impact index: $I = \dfrac{M\ (V \sin\ \ )^2}{M_R\ (V_R \sin R)^2}$ where M_R = 1250 kg, V_R = 80 km/h

(4) ASI: Acceleration Severity Impact ASI: $\dfrac{GX}{GX_R}^2 + \dfrac{GY}{GY_R}^2 + \dfrac{GZ}{GZ_R}^2$

with GX_R = 12g, GY_R = 9g, GZ_R = 10g

One crash test with a truck and three crash tests with buses were conducted on standard concrete barrier designs. Two of the bus tests were on DBA and one bus test was on GBA. In all cases the vehicle was redirected, the vehicle deformation and the decelerations being satisfactory. There was no complete breaking off of the concrete barrier. We only noticed some light cracks which would require, at the most, concrete repair on a few meters of barrier.

		Conditions			Results	
Test No.		Speed V(km/h)	Angle (°)	Weight M(kg)	Exit Angle (°)	Stopping Distance (m)
Truck	320(1)	72	21	10,000	0	40
Bus	404(2)	70	20	12,000	7	80
	481(3)	70	20	12,000	0	80
	493(4)	65	20	12,000	0	150

Table 3 - Truck and Bus Test Results - Concrete Median Barrier

(1) Light damage on the DBA upper part (0.2 m high, 2.6 m long).
(2) No DBA damage
(3) Light fissure
(4) DBA cast on compacted ground: 0.08 m deflection, 4 breaks in 12m.

Construction

From the tests carried out at INRETS the concrete median barrier has been accepted as a standard truck barrier (level 2), that is to say, in general, for bridge construction.

The use of the standard barrier design has been limited to the restricted speed road network (suburban and urban highways) and to median widths narrower than 4 m for highways with a traffic volume more than 12,000 vehicles/day. Exceptions were allowed for some specific cases, and the Transportation Department is presently studying a relaxation of the barrier warrants.

Actually the construction of concrete barriers has been important owing to the maintenance advantages. At the moment about 1000 km have been built.

Evaluation in Use

A study of the A13 highway in a suburban area with high speed traffic and difficult sections (west Paris highway), where 17 km of median barrier had been constructed showed an improvement in safety when compared with the previous standard guardrail construction.

Only one continuous length of concrete median barrier of much importance has been constructed on more conventional highways. A barrier 14 km long was built on the access to the MORVAN plateau on the A6 highway. The construction of the barrier was completed in 1983. The decision was based mainly on the maintenance benefits. It is a relatively difficult section where the basic speed is 100 km/h. The main results of an accident study on this section of barrier are tabulated below.

		Total Accidents	On-road Impacts	Roadside Impacts	Median Barrier	Traffic
1981-82 Standard Construction	N	156	50	58	48	
	%		32.1	37.1	30.8	1
07/1983-06/1985 Concrete barrier DBA	N	208	58	78	74	
	%		27.9	36.5	35.6	1.1
Change	%	+33	+16	+31	+54	+10

Table 4 - Guardrail and Concrete Barrier Evaluation

As shown in Table 4, the number of accidents has increased. This increase came mainly from the median barrier impacts. No final analysis is proposed to date; a study on visibility factors is being conducted now to help explain the accident data.

Table 5 allows us to analyze the severity of these accidents. The number of impacts into standard guardrail was relatively low, and there were no injuries between 1981-82. On the same section equipped with concrete barrier we list six injury accidents for an equivalent period. Furthermore, the cases of redirection were more numerous (77% instead of 56%) and more severe (in these cases 50% of the vehicles rebounded up to the embankment). Of course the concrete median barrier prevented all cross median accidents.

		Vehicle stopped		Vehicle redirected by barrier			
		Stopped against barrier	Vehicle penetrated barrier	On the road	With vehicle impact	On the road-side	Total
Metal beam standard barrier	Total	20	1	17	2	8	48
	Injury						0
Concrete metal barrier	Total	17	0	25	6	26	74
	Injury	0	0	0	2	4	6

Table 5 - Median Barrier Impacts - Analysis

	Stopped against barrier	Penetrated barrier	Redirected by barrier
Standard barrier %	42	2	56 (1)
Concrete median barrier %	23	0	77 (2)

Table 6 - Median Barrier Impact Frequency

(1) With 32% of vehicles rebounding up to the embankment

(2) With 51% of vehicles rebounding up to the embankment

We noticed that the injury accidents only occurred when the vehicle was redirected by the barrier.

Conclusion

We see, therefore, that the concrete median barrier is relatively standardized in France, this change having been made for reasons of cost and maintenance.

As regards the safety of the standard concrete barrier, the obvious benefit was the important reduction in cross median accidents. On the other hand the damage to passenger cars established during crash tests has been proved in real accidents, particularly on roads with high speed traffic.

So we believe that concrete barriers can be placed on all the highways with limited speeds. But in the other cases, according to the characteristics of the road and the traffic, the assessment may be different. Therefore, it does not seem possible to foresee a systematic safety gain with regard to standard barriers.

Acknowledgments

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1. Hirsch, T.J., Marquis, E.L., Nixon, J.F., Hustace, D., "Crash Test and Evaluation of a Precast Concrete Median Barrier". TRB Record 594, Washington, D.C., Transportation Research Board 1976.
2. Bronstad, M.E., Kimball, Jr., C.E., "Concrete Safety Shape Research". TRB Record 594, Washington, D.C., Transportation Research Board 1976.
3. "Guide for Selecting, Locating and Designing Traffic Barriers", American Association of State Highway and Transportation Officials, 1977.
4. Lasserre, J.F., "Les separateurs beton". Revue Generale des Routes et Aerodromes no. 554 (Juin 1979).
5. Adam, S., "Les separateurs en beton et les lits d'arret". Revue Generale des Routes et Aerodromes no. 598 (Juin 1983).

MOTORCYCLE IMPACTS WITH GUARDRAILS

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Abstract

Although we note few motorcycle accidents with guardrail impacts, one frequent concern of motorcyclists is the exaggeration of risk due to the presence of guardrail.

A study has been done in order to specify the real hazard of these accidents in different areas: rural highways and urban highways. The most important problem remains on the urban highways: the accidents with guardrail impacts represent one third of motorcycle injury accidents and lead to the third of the fatalities. The most common crash happens in curves, often with the motorcyclist falling down and knocking his head into the guardrails posts.

A guardrail with two beams was designed and tested in order to avoid the posts motorcyclists impacts. Tests were performed with a dummy ejected from a sled. The deceleration levels registered on different parts of the dummy were acceptable. Tests with cars were conducted to confirm this model.