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Impact Performance of Crash Barriers

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***Abstract*: Run-off road vehicle accidents are a major cause of loss and causality on roads, with an errant vehicle incident often leading to potentially serious injury or death for both the vehicle user and other road users. A road safety barrier is designed to safely control and redirect errant vehicles, absorbing the energy from the collision event and minimizing injury to vehicle occupants or other road users. This study aimed to show the impact performance of semi-rigid and flexible crash barriers in terms of energy absorption of barrier and ASI value. Finite Element Software Abaqus was used to develop models of three types of barriers, i.e. w-beam steel crash barrier, thrie beam steel crash barrier and cable barrier. The barriers were impacted upon by simplified vehicle model with impact velocity 60 kmph and at an impact angle of 20º to carry out the computer simulation using Abaqus. The simulation results of the models showed that the optimal result was registered by the cable barrier, which demonstrated higher crash energy absorption and a lower ASI value than the other barriers did.**

***Keywords*: Roadside safety, Crash barrier, Abaqus, Simulation, Impact Energy Absorption**

1. Introduction

One of the ways to improve road safety is the use of road restraint systems for occupant and road user safety [1]. A road safety barrier can be simply defined as an object the function of which is to redirect and safely control an errant vehicle during an impact, for the safety of the vehicle's occupants and all other road users and road workers. W-beam guardrails are one of the commonly used semi-rigid barriers along the roads of Nepal in the recent years. As most of the hill roads in Nepal are along the river routes and are characterized by steep vertical alignment and sharp curves, installation of steel beam barriers become necessary and suitable compared to other types of barriers because of the narrow width section or space restriction in most of the hilly roads. However, w-beam barrier which is mostly in use does not always meet the requirements of safety barrier in some cases, especially for heavy vehicles and may fail to serve the purpose as a barrier. Thrie beam barrier, which is a type of semi-rigid barrier, and cable barrier, a type of flexible barrier needs to be investigated for their performance so that the barriers can be considered for improvement of safety along the roads. The main objective of this research study is to predict the behavior of two types of steel beam barriers, w-beam and thrie beam barrier as well as cable barrier under impact condition in terms of impact energy absorption and ASI value.

2. Literature Review

A. *Efficacy of crash barriers*

In a study by Russo, the results showed that cable barriers were 96.9 percent effective in preventing penetration in the event of a cable barrier strike. The same study statistical analyses which accounted for regression-to the-mean effects showed that fatal and incapacitating injury crashes were reduced by 33 percent after cable barrier installation [2].

In a research undertaken by Zou et al., the safety performance of road barriers in Indiana in reducing the risk of injury was assessed, with hazardous events such as rolling over, striking three types of barriers (guardrails, concrete barrier walls, and cable barriers) with different barrier offsets to the edge of the travelled way, and striking various roadside objects being studied. A total of 2124 single-vehicle crashes (3257 occupants) that occurred between 2008 and 2012 on 517 pair-matched homogeneous barrier and non-barrier segments were analyzed. The study found that the odds of injury are reduced by 39% for median concrete barrier walls offset 15–18 ft from the travelled way, reduced by 65% for a guardrail face offset 5–55 ft, reduced by 85% for near-side median cable barriers (offset between 10 ft and 29 ft), and reduced by 78% with far-side median cable barriers (offset at least 30 ft) [3]. An evaluation of 293 miles of cable median barrier in Washington found fatal collision rates were reduced by half and an estimated 53 fatal collisions were prevented after the installation of cable median barrier (Olson, D., et al.) [4].

B. *Crash Performance of barriers using FEM*

The Finite Element Method has been previously used to construct models of road safety devices which can be used to simulate the performance of the devices in certain impact scenerios.

Ogmaia investigated if Abaqus/Explicit could be used as the finite element software for simulation of crashes. A full-scale test was conducted and the parapet installation and vehicle used was modeled. Same conditions as in the full-scale were used in the simulation. The results indicated that it is possible to simulate the full-scale crash using Abaqus/-Explicit provided a proper vehicle model and a detailed model of the test installation [5].

Aziz et al. conducted a simulation study using CAE software, Abaqus to predict the mechanics behavior of the barrier under impact condition. The impact velocity of 100 kmph was assigned at the rigid impactor of 900 kg with an angle of 20º from the reference plane. The computed value from simulation was compared to the experimental test values and the results were found to be acceptable [6].

In a research by Neves, R.R. et al., flexible and rigid road restraint system subjected to a 900 kg car impact is studied in detail via a finite element simulation, with the model being validated against experimental results. According to test TB11 from EN 1317 standard, the impact simulation results show that the flexible guardrail is safer than any of the analyzed concrete barriers [7].

3. Methodology

A. Crash Barrier Models

The study uses Finite Element Method software ABAQUS v.6.14 to analyze the impact crash test. The simulation was done using the models that meet the standard specifications by referring several guidelines used in Department of Roads for steel beam crash barriers, W-beam barrier and Thrie beam barrier. Four continuous beams of 4.318m × 0.312m × 0.003m each were used for W-beam and thrie beam model to represent the longitudinal rail. The top of the guardrail is located 700 mm and 850 mm above the ground level for W-beam and Thrie beam respectively with 2m spacing between the posts along the rail. Fixed boundary conditions were imposed at the bottom of the posts. Tie interactions were created between beams, posts and spacers to represent bolt connections between the parts and were assumed to be connected throughout the simulation.

The wire rope safety barrier model used is in accordance with IRC 119:2015 complying to standards of EN 1317 as well as NCHRP Report 350 [10]. The 3-strand cable guardrail consists of three 19 mm round post-tensioned wire cables (7 wires per strand) having a tensile strength of 16.7 KN. The cables are connected to steel posts, which are placed at a spacing of 3m. The top edge of the post is at a height of 780 mm above the ground level while the top and the bottom cable being at a height of 670mm and 480mm respectively. The models of barriers are shown in Figure 1. The material properties for the steel used is as tabulated in Table 1.

B. Crash Simulation

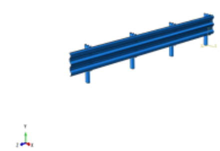
A simplified vehicle model of 10,000 kg mass was used as the impactor and an impact velocity of 60 kmph at an angle of 20º was assigned to the reference point of the vehicle. Simulation of the impactor on three different crash barriers was conducted. The assembled model representing impact scenario of w-beam barrier longitudinal rail and the vehicle is shown in Figure 2.

4. Results

A. Energy absorption of the barriers

The impact energy of different barriers was obtained from the simulation. The energy absorbed over time for w-beam, thrie beam and cable barriers was compared in graphical form as illustrated in Figure 3. The results from the simulation as shown in Figure 3 shows that the maximum energy absorbed for w-beam, thrie beam and cable barrier were found to be 559.63 KJ, 727.32 KJ and 1295.80 KJ respectively.


a) W-beam barrier model


b) Thrie beam barrier model


c) Cable barrier model

Fig. 1. Crash Barriers Models

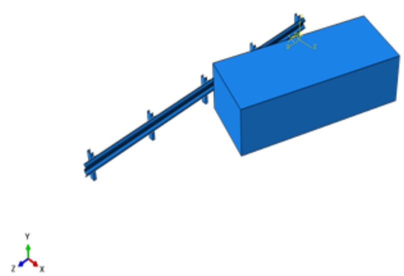


Fig. 2. Assembled model

Table 1
Material properties of steel

Material Properties	Value
Density, ρ (kg/m^3)	7850
Young's Modulus, *E* (Gpa)	200
Poisson's Ratio, υ	0.3
Yield Stress, σ_y (Mpa)	350

B. ASI value

According to the European standard EN 1317 [9], the acceleration severity index (ASI) is an index for assessing the injury criteria of the occupants. The ASI is used for characterizing the impact intensity, which is considered the most critical indicator of the impact rate on vehicle occupants. In general, a higher ASI index indicates a more severe collision and thus, a higher injury risk. The ASI values from the simulation for w-beam barrier, thrie beam barrier and cable barrier were observed as 0.30, 0.23 and 0.14 respectively which is in accordance with the EN standard (for impact severity level A, ASI≤1).

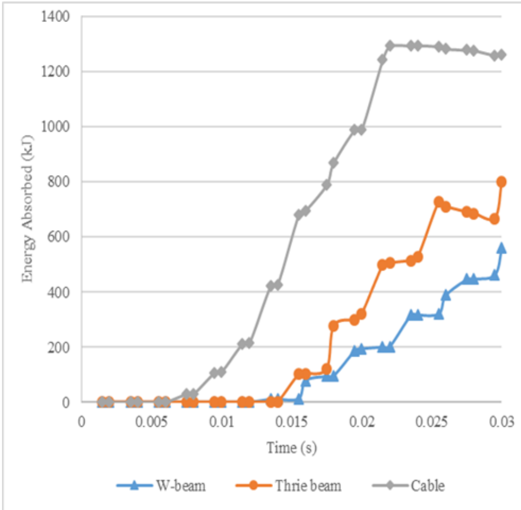


Fig. 3. Absorption Energy of different barriers

5. Conclusion and Recommendations

Based on the above results, clearly the thrie beam barrier and cable barrier absorb more impact energy than w-beam barrier. The best performance was demonstrated by the cable barrier with maximum impact energy absorption and lowest ASI value. Hence, thrie beam barriers and cable barriers can be preferred over w-beam barriers at locations having high accident rates to reduce the crash severity and occupant risk, where the traffic and road conditions allow. Furthermore, the roadside safety can be improved by opting to these barriers which is also evident from the previous studies on safety performance of barriers that indicate the reduction in the severity of crashes as well as overall crash rates. In order to mitigate and lower the frequency of road crashes, these unconventional safety barriers can play an important role which needs to be recognized by the concerned institutions The potential of using simulation method to explore the behavior of different road safety devices also needs to be assessed to make improvements on existing design of barriers and to design a new type of barrier for better safety.

References

[1] Butāns, Ž & Gross, K & Gridnevs, A & Karzubova, E. (2015). Road Safety Barriers, the Need and Influence on Road Traffic Accidents. *IOP Conference Series: Materials Science and Engineering*, pp. 96.
[2] Russo, Brendan James. (2015). Guidance on the application of cable median barrier: tradeoffs between crash frequency, crash severity, and agency costs. *Graduate Thesis and Dissertations*.
[3] Zou, Y., Tarko, A.P., Chen, E., Romero, M.A. (2014). Effectiveness of cable barriers, guardrails, and concrete barrier walls in reducing the risk of injury. Ac*cident Analysis and Prevention*, Volume 72, pp. 55-65.
[4] Olson, D., M. Sujka, and B. Manchas. (2013). Cable Median Barrier Program in Washington State. *Publication WA-RD 812.1, Washington State Department of Transportation*.
[5] Ogmaia, D., Tasel, S.E. (2015). Simulation of vehicle crash into bridge parapet using Abaqus/Explicit.
[6] Aziz, A., Aziz, M.R., Yamin, A.F.M. (2018). The simulation of highway W-beam barrier due to collision. *Proceedings of Mechanical Engineering Research Day*. pp. 218-219.
[7] Neves, R.R., Fransplass, H., Langseth, M. et al. (2018). Performance of some basic types of road barriers subjected to the collision of a light vehicle. *Journal of the Brazilian Society of Mechanical Sciences and Engineering, 40: 274.*
[8] Department of Roads. (2073). Standard Specifications for Road and Bridge Works.
[9] European Committee for Standardization. (1998). European Standard EN 1317-1. *EN 1317-2, Road Restraint Systems.*
[10] https://www.safetyfirstindia.com/products/wire-rope-barriers/