

Evaluating the Performance of Roadside Barrier Using Surrogate Devices

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Abstract: Evaluating the crash test is one of the most important stages of providing safety on roads. Nowadays, two kinds of equipments named surrogate devices are used to evaluate guardrails specifically, pendulum and bogie vehicle. This paper provides a review of usage these equipments and procedure to test guardrails. Advantages of each method are analyzed and also for each method, suitable application is recommended. The result of tests shows that, the bogie and pendulum tests are suitable surrogate devices to evaluate the performance of the guardrail.

Key Words: *Guardrail Performance, Pendulum Test, Bogie Vehicle*

1. INTRODUCTION

Recently, traffic accidents are main concern of societies (Pichai Taneerananon, 2005). Governments endeavor to reduce the accidents on roads by spending money for constructing many new highways and freeways but still, the traffic accidents rate is increased day by day (Nguyen Huu DUC, 2010). Managing and planning the programs to improve safety of the roads is very essential. These kinds of programs consist of classification of unsafe regions and to find the best solution to reduce these incidents (Diew, 2010). There are a lot of systems and several devices which are available for providing safety, to evaluate these kinds of methods the impact of them should be appraised. One of the useful methods is recording accidents to evaluate the safety of roads (MITANI, 2005).

there are several devices which have been used to control traffic and providing safety. Guardrails are the most significant component of the roads to provide safety. Different kinds of the guardrails have been used in roads, especially W-Beam guardrail. The performance of these components should be evaluated. A kind of method which has been used is experimental

method. We are focusing in this paper on a review of two kinds of devices, which were used to evaluate the performance of guardrail.

2. TESTING GUARDRAILS USING PENDULUM IMPACT TEST

Evaluating the structural adequacy of guardrails can be done by using pendulum (Douglas J. Gabauer, K. D, 2010). However other parameters of guardrails such as wheel snagging and risk of occupant cannot be evaluated by using pendulum. Brown in 1998 had done evaluation on FRP composite by using 820-kg pendulum. The pendulum which was used in this study consists of a concrete mass. The pendulum had a crushable nose inserted in front of the concrete body. This nose was made with a solid oak. FRP composite performance of rail specimen is subjected to absorb the energy with nose deformation. Seven oak spacers were located among mass and nose. The spacers were necessary to allow the optimal contact between the w-beam specimen and the pendulum nose. In this case a thin rubber was used in front of the pendulum nose to reduce the severity of the impact.

In another study which done by Nauman M. Sheikh in 2006 for evaluating performance of terminals, a heavy pendulum was used; in this experiment, a releasable cable anchor was used to create the anchorage of the terminal. This structure was designed to provide anchorage and able to release when vehicles impacted to end of the terminal .In the first step a heavy pendulum was used to evaluate the anchorage of terminal. Pendulum forces on the terminals at post with in transition. Finally, the anchorage of the system could sustain against the level of forces.

Brown in 1998 experimented the two similar tests, 97POO1 and 97POO2, were subjected into peak force and rail deflection. Acceleration histories with speed of 35-km/h for both the FPP composite tests were compared. The results of the tests were judged against the cable-anchored steel w-beam guardrail which was evaluated by 35-km/h pendulum tests. By using a 912-kg pendulum at the speed of 35 km/h the amount of dynamic response of w-beam rail FW composite was calculated. For both types of rails a couple of peak loads occurred coincidentally but the Maximum deflection was similar. Forces which are produced from pendulum had a velocity of 35 km/h couldn't make any failure into FRP rail element. A heavier, faster pendulum is needed to generate sufficient forces to fail the FRP composite rail.

The responses of materials to dynamic loads are totally different from static loads (Paul N. Roschke, 1995). Due to this, dynamic test by using a heavy pendulum was performed into plastic post was embedded 0.91 cm in soil .The pendulum released and forced to the post with speed of 35.9 km/h. Six posts were experimented and all of them were found undamaged. The only damage which appeared was a slight abrasion in place of pendulum impact. Two kinds of tests consist of laboratory and full-scale were performed to determine the acceptance and evaluating performance of plastic posts in comparison to the conventional 0.15×0.20 m standard wooden post and w6×9 structural steel posts which were used into w-beam guardrail. Heavy pendulum was utilized to evaluate performance of this kind of guardrail. In this technique two types' dynamic in-situ tests perform into post, which could successfully resist the impact.

Collaboration of pendulum impact test with computer simulation is one of the useful tools to evaluate guardrail systems. Pendulum impact test data shows dynamic response to a guard rail

system and provides extreme control and well-documented reports .In addition, the pendulum was able to obtain the energy-absorbing characteristics of w-beam guardrail, soil-post interaction and end terminal (Lawrence C.Bank, 1998).

Two tests were prepared to evaluate the design of end-terminal energy absorption. This test validated the numerical model and considers the pendulum impact test with 2000 kg mass. Graphical model of simulation and pendulum impact is shown in figure 2.1. The result of pendulum impact test and finite elements approach shows the design of terminal by steel-backed timber to be practicable. But conducting two tests consist of 820-kg car and 2000-kg pickup, required to validate the final design of terminal. In this case pendulum cannot simulate the impact of real vehicle on terminal. (Dhafer Marzougui, 2009).



Figure 2.1: Sequential images from simulation and real test with pendulum

Nauman M. Sheikh in 2006 evaluated the W6x8, 44inches, 36 inches, and 32 inches posts embedded in soil a pendulum impact test were used. This pendulum had a mass of 1850-lb and speed of 22mph when impacted to the guardrail. For comparing data, two tests were performed for each post, the result of experiment shows that the posts were not deformed for all tests. But, slight bending happened in one of the tests at ground for 44-inch embedment.

For evaluating the connection of base plate to post two pendulum impact tests were done by Akram Abu-Odeh in 2003 along with the strong and weak axis of the post. A crushable nose was installed in front of the mass and the calculated speed was 35km/h. as a result of this experiment for impact along strong axis the post break at the base plate and for weak axis, the post did not release at the base pate. Gabler in 2009 studied current damage on guardrails; they introduced 26 damages and recommends pendulum testing to better understanding of these damages.

It can be concluded that, this kind of method is mostly used to evaluate the strength rail of the guardrails and considering new material such as composite. This method could be utilized just for evaluating the capability of guardrails structure, other parameters, which are important for evaluating guardrails such as wheel snagging; rolling vehicles and analyzing the risk of occupant, cannot be done by this procedure. Also providing the speed of vehicle which presented in NCHRP 350 is more difficult in pendulum because pendulum just impact to the guardrail in perpendicular direction.

3. TESTING GUARDRAILS USING BOGIE VEHICLE

Another useful surrogate device which could be used for both the high and low-speed tests is bogie vehicle. A kind of dynamic test was designed by Weijia.Wu in 2007 to force the applied longitudinal guardrail beam to the post in the lateral direction. JOHN D.REID, D. L in 1998 performed 10 bogie tests to evaluate the result of numerical model and all of them had the same design for deflector plate. Several parameters considered in tests which were included for the structure of deflector and also for the guide tube length. In this study design, the deflector plate was improved as a result of bogie test and simulation. Another study conducted (John D. Reid, J. R, 2002) in which, Bogie test was used to determine the bursting force to rail. Two kinds of thickness 3.2 and 4.8 mm were experimented by simulation and bogie test. These tests were in close proximity with each other.

For configuration and obtaining the force deflection of several post-to culvert attachments, bogie vehicle test was used. For all the seven tests, the speed and weight of bogie vehicle was 16.1 km/hr and 2,217 kg respectively. For the first and last 5 five tests, failure occurred between the post and base plate. On the other hand, for the seventh test there were no weld failure or bolt damage at the post and plate. The reason given was that the failure mechanism is more readily reproducible than the weld failure. (Karla A. Polivka, 2002).

For the pavement post guardrail the influence of mow strips had not been investigated (Nathaniel R. Seckinger A. A, 2005). For this case the posts were subjected to the impact by a bogie vehicle with weight of 839kg and speed of 35km/hr. pavement mow strip, guardrails was evaluated by both the simulation and real crash test and recommends suitable shape and diameter of post. Dynamic impact tests were numerically simulated and full-scale mow strip system models were assembled using the subcomponent models. With reference to nationally accepted criteria, crash tests of a strong post steel guardrail system and a wood post guardrail system encased in the selected mow strip configuration were considered to be successful. Recommendations for implementation are provided.

Three similar posts are subjected to the impact by a bogie test which had a mass of 1030 kg and speed of 18 km/hr (Weijia Wu, 2007), Based on the data of bogie vehicle and the quasi-static, dynamic resistance of bogie test was twice the quasi-static test. Graham et al, in 1967 developed a standard, at New York traffic barriers .they used both the real crash test and bogie vehicle to evaluate the performance of guardrails post in soils and rigid foundation. In another study Kuipers and Reid in 2003 studied the depth of embedment of steel post for median guardrails, A bogie vehicle used for the impact on the posts, the kind of post which was subjected to the force was W6x16 .The average forces which produced was about 29 KN and 29.6 KN for both the deflection was 381 and 597 mm respectively .For 940 mm embedment depth, the post was pulled out of the soil after impact. The maximum energy was absorbed during the rotation of the post in the soil; in this, the amount of energy absorbed was 24.9kj. For embedment, 1,016-mm the total energy absorption was calculated, 29.8 kJ and shows 16 % increase.

Two tests were performed by Jason A. Hascall in 2007 to find the minimum leave out in mow strip. The experiment on W152x13.4 steel by a diameter of 178-mm was done successfully. It was concluded, that the post rotation is one of the important factors to improve performance of system.

In another study dynamic test on post was performed by using 7.1kn impact of bogie vehicle with speed of 32km/h. for the first test and in the second test, for propelling bogie vehicle they used a pickup. The results of tests were used for determining the post diameter in the MGS (David E. Kretschmann, 2007). Ronald K. Faller in 2004 utilized bogie vehicle to evaluate the appropriate embedment depths for posts and also to draw the curve of force-deflection. The result shows 1.016mm embedment depth and was the best option for using in guardrails.

Midwest Roadside Safety Facility (MwRSF) performed bogie vehicle dynamic test on a kind of wood post known as CRT in a rigid foundation. The figure 3.1 shows the bogie and the wood post which is subjected to the impact. Three kind of test were performed at 0 degree impact angle, 90 degrees impact angle along the weak axis and along the diagonal axis. Because of putting CRT in the rigid foundation the amount of energy dissipated was calculated and is considerably less than the post subjected to the impact by pendulum in the soil. (Akram Y. Abu-Odeh, 2010).



Figure 3.1: the bogie vehicle which used in experiment

As a summary for this section the bogie vehicle seems to be a useful method to simulate dynamic force to the guardrails, most of the researcher as mentioned in this paper used this device for evaluating the characteristic of the post, embedded in the soil. And in comparison with pendulum, this method has two main advantages: firstly it is easy to provide desirable speed of vehicle via this procedure. Secondly bogie vehicle could impact to the guardrail with any angle.

4. CONCLUSION

Pendulum and bogie vehicle testing method, joined with computer simulation, have become one of the useful methods to test and evaluate the performance of roadside barriers, particularly to evaluate the strength of W-beam guardrail. The collection of testing data, presented in this paper, shows that bogie and pendulum testing methods are the most popular methods to simulate the real crash test. We have presented an overview of testing method under various conditions and represented the advantages of each method. Bogie vehicle appeared useful tools to evaluate characteristic of posts embedded in soil and pendulum impact was the helpful device to evaluate the strength the rail of W-Beam guardrail.

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