Road Safety Devices Assessment for Sliding Motorcyclists Protection

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ABSTRACT

Statistics show that the impact with a roadside safety barrier of a motorcyclist sliding on the pavement after an accident is potentially more dangerous than the accident itself. In recent years, in effort to avoid the most serious consequences, the approach to barriers design changed and specific devices have been introduced to improve motorcyclists' safety. At LAST Crash Labs, the effectiveness of one of these devices was experimentally and numerically investigated. A good numerical-experimental correlation was obtained and, in view of that, it was concluded that the numerical approach is a rather reliable tool for the development of devices for motorcyclists' protection.

Keywords
Road safety barriers, Motorcyclists' protection, Anthropomorphic Test Devices

INTRODUCTION

Roadside safety barriers are designed to contain errant vehicles and to reduce the severity of collisions. Recent studies show that flexible barriers and w-beam systems are more effective in protecting the occupants of a car during an accident than the concrete barriers. Nevertheless, doubts raise about their effectiveness with regard to sliding motorcyclists' protection.

Statistics [1] show that the impact with a roadside barrier of a motorcyclist sliding on the pavement after an accident is potentially more dangerous than the accident itself. Flexible barriers and W-beam systems, in particular, may expose the motorcyclists to the risk of serious injury due to impacts with unprotected support posts. Attempts have been made to improve the design of safety barriers and avoid the most serious consequences of the impact of a motorcyclist with the barriers such as modifying the design of the posts or using different type of impact attenuator [1, 3].

At LAST Crash Labs the effectiveness of a device designed to improve sliding motorcyclists' safety was experimentally and numerically investigated. The device consists of a metal shield to be mounted as a part of existing W-beam barriers to increase the motorcyclists' safety.

In order to evaluate the effectiveness of the device, experimental tests and numerical simulations were carried out in parallel. Sliding motorcyclists' safety devices (SMSD) are not included in Road Safety European Requirements, *yet*. Indeed, the tests here described recall the tests prescribed by the Spanish Requirements UNE135900 [4] and the test procedures for the development motorcyclists' protection adopted at Laboratoire Inrets Equipements de la Route (LIER), France. The Head Injury Criterion (HIC) and the duration of the forces on the neck were used to verify that the safety device fulfils the requirements and then to validate numerical model reproducing the test.

The numerical model reproduced the impact scenarios in the experimental tests. In particular, a reliable numerical model of the Dummy Hybrid III 50th percentile (DH350) [4, 6] was used. A good numerical-experimental correlation was eventually obtained (for the tests considered) in terms of impact dynamics and quantities of interests – i.e. neck forces and accelerations. In view of that, it was concluded that the numerical approach is a rather reliable tool for the development of devices for motorcyclists' protection

A DEVICE FOR SLIDING MOTORCYCLISTS' SAFETY

In effort to increase the sliding motorcyclists' safety, the design of the existing road safety barriers must be improved. A new device (shown in Fig. 1) designed for new and already installed flexible barriers is here introduced.

The device is designed to avoid the impact of the sliding motorcyclist with the barrier posts and, at the same time, to contain the motorcyclist and prevent slides beyond/under the barrier. It is installed under the w-beam system and consists of a metallic laminate (a band) jointed to the barrier posts by means of deformable spacers design to reduce the loads on the motorcyclist.

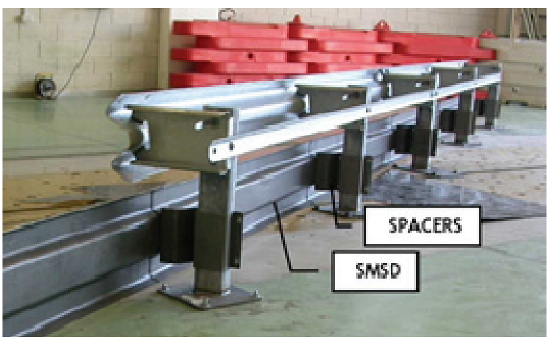


Figure 1. Sliding Motorcyclists' Safety Device (SMSD).

EXPERIMENTAL TESTS

Impact scenarios

Since SMSDs are not included in Road Safety European Requirements, the tests carried out to investigate the effectiveness of the device followed both the Spanish Requirements UNE135900 [4] and the test procedures adopted at LIER, France.

In the UNE135900 [4], three different impact scenarios are described:

1. **Post centred (head impact).** The motorcyclist's head impacts with the barrier in correspondence of a post at 60 km/h and 30 deg incidence.

2. **Vain centred (head impact).** The motorcyclist's head impacts with the barrier between two posts at 60 km/h and 30 deg incidence.

3. **Vain centred (shoulder impact).** The motorcyclist's shoulder impacts with the barrier in correspondence of a post at 60 km/h and 30 deg incidence. Motorcyclist's body is parallel to the barrier all the impact duration.

A further impact scenario was also considered. Accordingly with the Spanish Requirements the motorcyclist lay down on the back – which is a rather uncommon position for a sliding motorcyclist. In view of that, tests are currently carried out with the motorcyclist in fetal position. Of these, only the first two impact scenarios described in the UNE135900 [4] are here considered. The other scenarios are still under investigations.

In order to evaluate the effectiveness of a SMSD, the UNE 135900 suggests to consider the Head Injury Criterion (HIC) and the Neck Injury Criterion (NIC) and, for these two criteria, indicates two safety levels: a minor level for small injuries and a major level for serious but not lethal injuries (Table 4, in [4]).

Test facilities

The SMSD was installed under a 3-m length H3 class flexible barrier. A DH350 wearing an Euro 3 helmet and the typical motorcyclists clothes and protections was used in the tests. The DH350 was equipped with accelerometers and a force transducers at the base of the head to evaluate HIC and NIC.

The DH350 lied on a board launched toward the barrier at the prescribed impact velocity. The board was stopped two meters before the impact point while the DH350 continued sliding and impacted the barrier.

A Teflon panel was placed between the board and the DH350 and in front of the barrier to reduce friction effects and keep the velocity constant until the impact with the barrier.

The tests were filmed using an high speed camera in effort to have a deeper insight in the dynamics of the event.

Tests results

First impact scenario (Fig. 4-A). The head of the DH350 impacted with the barrier in correspondence of a post at 60.2 km/h and 30 deg incidence. As a consequence of the impact the spacers crushed and absorbed the most part of the impact energy. The metallic band twisted up, but succeeded in containing the sliding dummy. The HIC and NIC were within the safety limit indicated by the UNE 135900.

Second impact scenario (Fig. 6-A). The head of the DH350 impacted with the barrier between two posts at 60.5 km/h and 30 deg incidence. The spacers crushed and the metallic band underwent severe plastic deformations, but succeeded in containing the sliding dummy. The HIC and NIC were within the safety limit indicated by the UNE 135900.

Figure 2. Test facilities.

NUMERICAL SIMULATIONS

Moving from the results obtained in the experimental tests, a finite element model was developed. The aim was to exploit the potentiality of the numerical approach to further develop the barrier system. Simulations were carried out using LSTC LS-Dyna 971 [7].

Numerical model

The numerical model (Fig. 3) reproduced the impact scenario described in the UNE135900 [4].

The overall numerical model consisted of three parts: the barrier, the DH350, and the ground. The FE model of the barrier consisted of 25,573 four-nodes elements. The piecewise linear plasticity material and the mechanical properties of the steel were used.

For both the DH350 and the Euro 3 helmet, numerical models validated against test data were used [4, 6]. The clothes and protections have a negligible influence on the HIC and NIC and therefore were not modeled.

The ground was modelled with a planar rigid wall. In effort to reproduce the actual test scenario, the friction between the DH350 and the ground was zero.

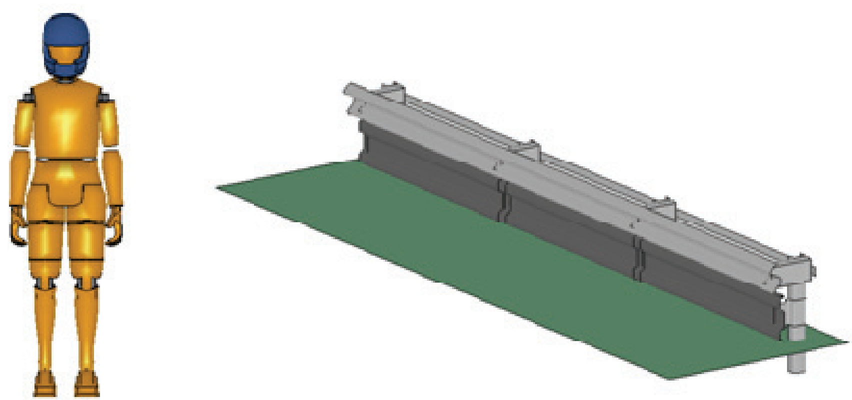


Figure 3. FE Model of both the DH350 (LHS) and barrier (RHS).

Numerical-experimental correlation

The results of the simulation and the data collected during the tests were eventually compared in terms of impact dynamic (crash behaviour of the DH350) and in terms of HIC and NIC and a close numerical-experimental correlation was obtained.

First impact scenario (Fig. 4). The behaviour of the DH350 was qualitatively similar to the one in the high speed movie of the test (Fig. 4-B) and the damages on the barrier similar to the ones observed after the test. Furthermore, a close numerical-experimental correlation was achieved in terms of neck axial force (Fig. 5-A) and head resultant acceleration (Fig. 5-B).

Second impact scenario (Fig. 6). The behaviour of the DH350 was qualitatively similar to the one in the high speed movie of the test (Fig. 6-B) and the damages on the barrier similar to the ones observed after the test. Furthermore, a close numerical-experimental correlation was achieved in terms of neck axial force (Fig. 7-A) and head resultant acceleration (Fig. 7-B).

CONCLUSIONS

Statistics show that the impact with a roadside safety barrier of a motorcyclist sliding on the pavement after an accident is potentially more dangerous than the accident itself. In effort to avoid the most serious consequences, in recent years, the approach to barriers design changed and specific devices have been introduced to improve motorcyclists' safety.

At LAST Crash Labs, the effectiveness a sliding motorcyclist' safety device (SMSD) for flexible barriers was experimentally and numerically investigated. The device consists of a metallic laminated installed under the w-system of a flexible barrier by means of spacer meant to absorb most of the impact energy and containing the sliding motorcyclist.

The tests carried out showed that the device fulfils UNE 135900 requirements on motorcyclists' safety. Furthermore, the data collected during the tests were used to evaluate the feasibility of the numerical approach as a means to develop SMSDs. Indeed, the results of simulations reproducing the impact scenario described in the UNE 135900 compared with the experimental data provided a good correlation in terms of accelerations and force on the neck of the motorcyclist.

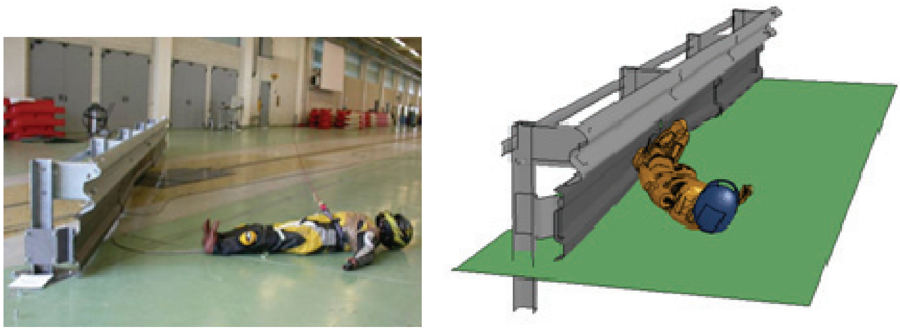
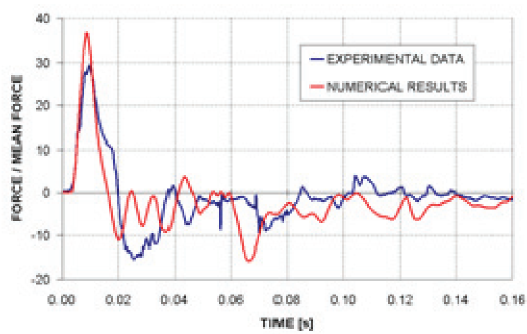


Figure 4. Scenario #1: test (RHS) and numerical simulation (LHS).



A

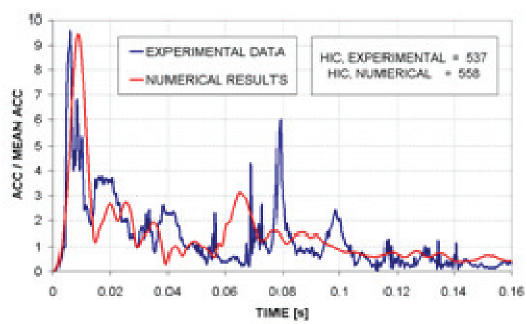


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Figure5. Scenario #1: (A) Neck force and (B) Head acceleration.

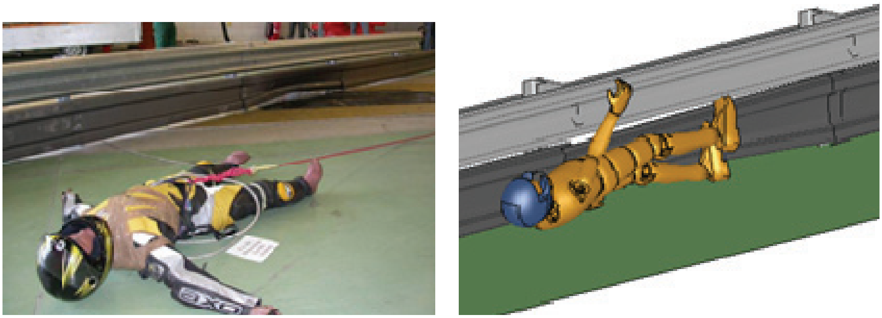
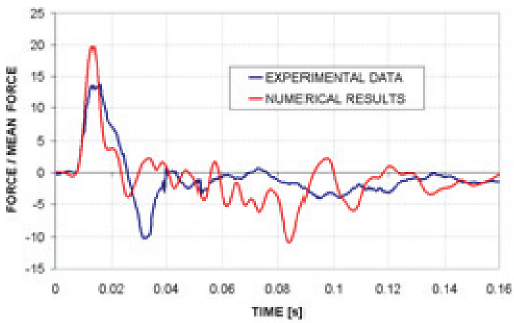


Figure 6. Scenario #2: test (RHS) and numerical simulation (LHS).



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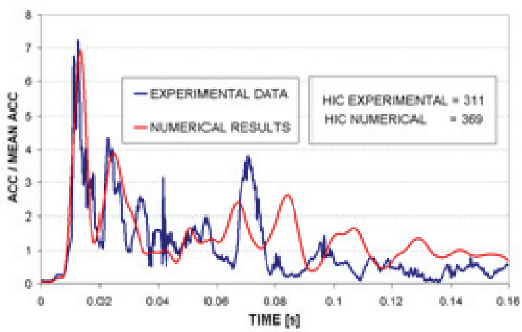

B

Fig. 7. Scenario #2: (A) Neck force and (B) Head acceleration.

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