J-MLIT RESEARCH ONTO APEDESTRIAN LOWER EXTREMEITY PROTECTION
- Evaluation Tests for Pedestrian Legform Impactors –

Masao Notsu
Ministry of Land, Infrastructure and Transport of Japan (J-MLIT)
Toshiyuki Nishimoto
National Traffic Safety and Environment Laboratory (NTSEL)
Atsuhiro Konosu, Hirotoshi Ishikawa
Japan Automobile Research Institute (JARI)

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ABSTRACT

As for a Global Technical Regulation (GTR) legform impactor, which is discussed at the United Nations ECE/WP29/GRSP, a flexible pedestrian legform impactor (Flex-PLI) and a rigid legform impactor (TRL-LFI) is proposed. However, as for the Flex-PLI, evaluation test for its repeatability and reproducibility has not been confirmed. Besides, its advantage over the TRL-LFI must be demonstrated in full-scale vehicle tests.

In this research, several kinds of loading tests were conducted to the Flex-PLI, and its favorable repeatability and reproducibility was confirmed. Besides, vehicle tests were performed using the Flex-PLI and the TRL-LFI, and the Flex-PLI demonstrated its higher biofidelity and load measurability in full-scale vehicle tests.

INTRODUCTION

The Ministry of Land, Infrastructure and Transport of Japan (J-MLIT) has been studied for a domestic regulation aimed at moderating the injury severity of pedestrians in the event of a collision with a motor vehicle. As a result the Japanese Pedestrian Head Protection Regulation was issued in April 2004. This regulation requires vehicles to have a pedestrian head protective structure, and applicable to new-model vehicles which is put on a sale in September 2005 onwards.

To further advance the pedestrian protection performance of vehicles, J-MLIT is participating in the activity to develop the Global Technical Regulation (GTR) on the pedestrian head and lower extremity protection in view of adopting it into Japanese legislation. That is currently in the drafting stage at the United Nations ECE/WP29/GRSP. However, as for the GTR for the lower extremity protection, two different legform impactors - a rigid legform impactor (TRL-LFI) [1] and a flexible pedestrian legform impactor (Flex-PLI) [2] - have been proposed.
Figure 1 shows the overall design of TRL-LFI. Because of the TRL-LFI employs rigid units in the place of human bones, this legform impactor cannot reproduce the bending responses of human bones under impacts. The knee of TRL-LFI also differs from the human knee in consisting of metallic bending plates and shear springs instead of the ligament restraint structure of the human knee. The TRL-LFI is therefore considered to exhibit a low biofidelity in both structure and deformation characteristics [3][4].

Figure 2 shows the overall design of Flex-PLI. This legform impactor incorporates bendable units to simulate the human lower extremity bones bending, so that the biofidelity of Flex-PLI is considered as high [2]. In addition its knee structure was developed to equate the human ligament restraint structure and exhibits deformation characteristics equivalent with those of the human knee under impacts [2].

The measurement items of TRL-LFI are listed in Figure 3. This legform impactor has three measurement items around its knee, but no other items are present anywhere in the lower extremity structure.

On the other hand, as shown in Figure 4, the Flex-PLI has a total of 15 measurement items enabling load measurement in most of the lower extremity portions.

From the above comparisons, it can be stated that the Flex-PLI is more suitable for the formulation of an appropriate pedestrian lower extremity protection regulation because of its higher biofidelity and more detailed measurability in extensive portions of the lower extremity. However, to utilize Flex-PLI in actual regulation enforcement, its repeatability and reproducibility must be verified. Besides, its advantage over the TRL-LFI must be demonstrated in full-scale vehicle tests.

The present study was conducted sectional loading test and vehicle test using a Flex-PLI (ver. 2003) unit in order to verify its repeatability and reproducibility. Additionally, a vehicle test employing a Flex-PLI and a TRL-LFI was carried out to verify the advantage of Flex-PLI over TRL-LFI.

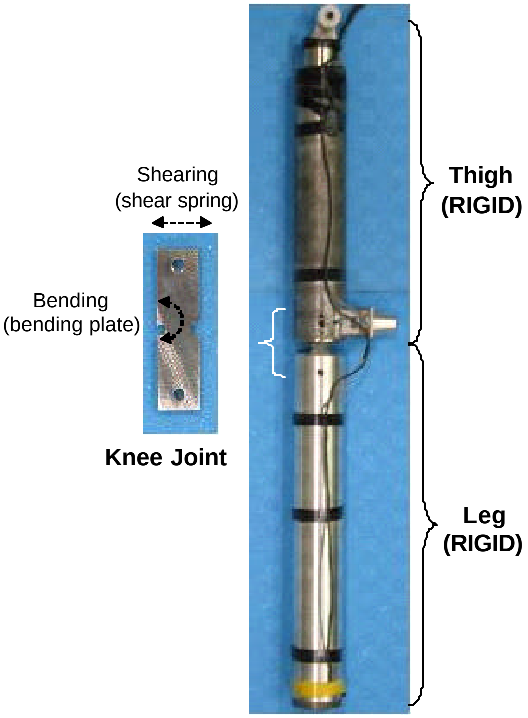


Figure 1. Overall design of TRL-LFI.

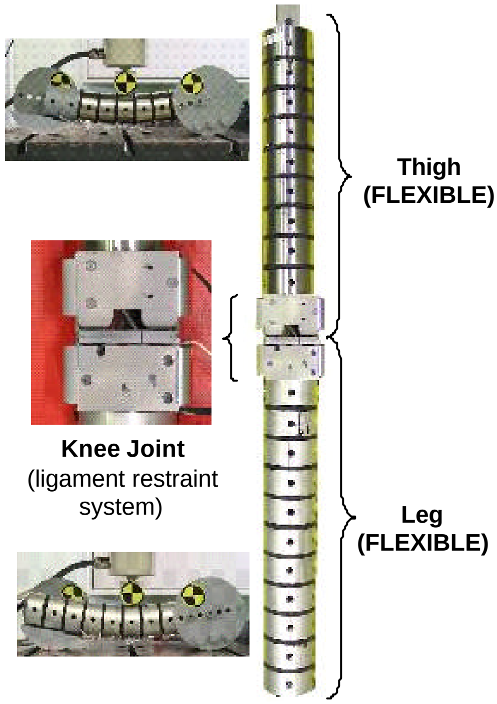


Figure 2. Overall design of Flex-PLI.

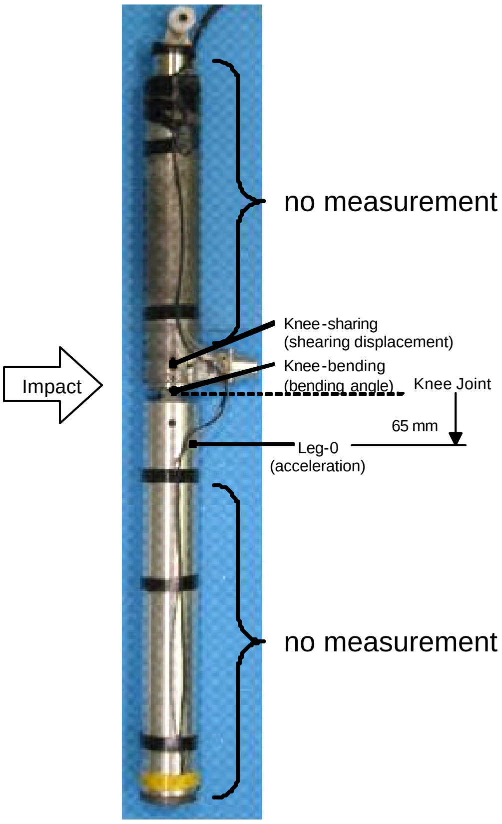


Figure 3. Measurement items of TRL-LFI.

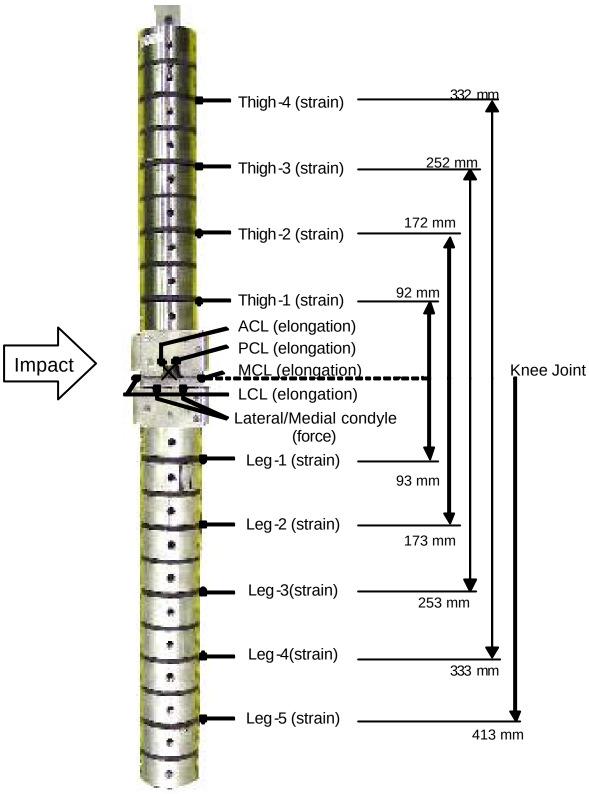


Figure 4. Measurement items of Flex-PLI.

METHODOLOGY

Sectional Loading Test

The methodologies of the sectional loading tests are summarized in Figures 5 to 7. The thighs (Products Nos. 1, 3, 4), legs (Products Nos. 2, 4, 6), and knees (Products Nos. 2, 4, 5) of Flex-PLI for the tests were randomly selected.

Vehicle Test

The setup of the vehicle test is shown in Figure 8. This vehicle test was conducted to utilize the subsystem test method [1] which is propelling the legform impactor to the vehicle.

As shown in Figure 9, a sedan was used as the test vehicle. The impact point was located 200 mm to the left of the vehicle's center line as seen from the driver's seat. The test vehicle and the horizontal position of the impact point were selected randomly.

The legform impactor propulsion system, compressed gas type, is shown in Figure 10. In this vehicle test, Flex-PLI and TRL-LFI were each collided into the test vehicle at an initial impact speed of 11.1 m/s using the propulsion system.

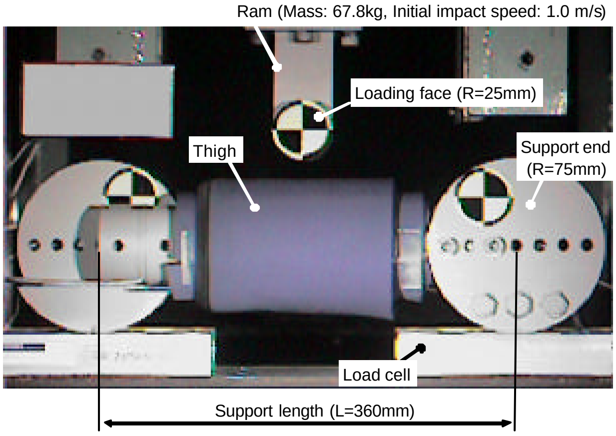


Figure 5. Sectional loading test set up for thigh (Flex-PLI).

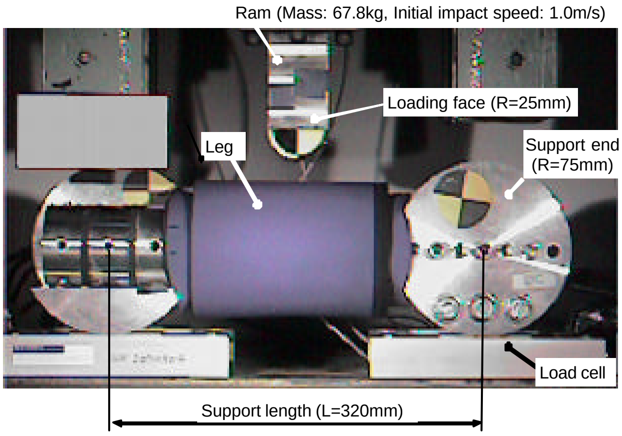


Figure 6. Sectional loading test set up for leg (Flex-PLI).

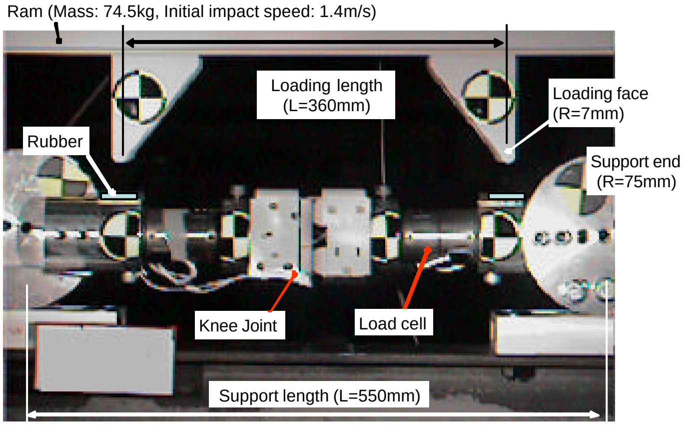


Figure 7. Sectional loading test set up for knee (Flex-PLI).

Figure 8. Vehicle test set-up. (subsystem test).

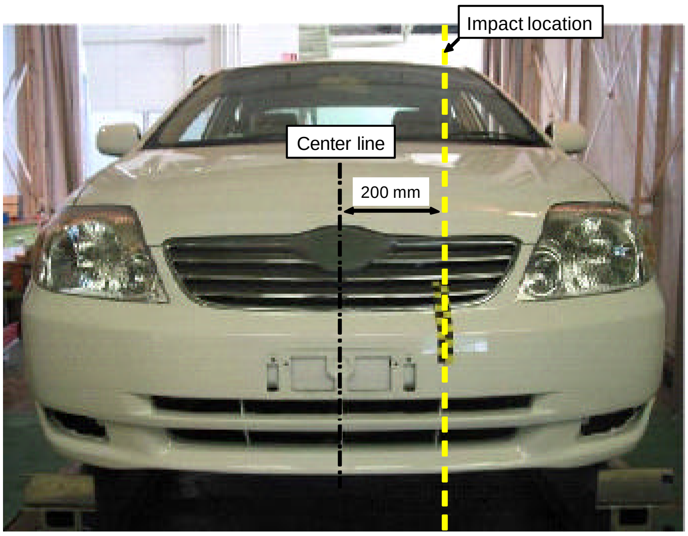


Figure 9. Test vehicle and impact location.

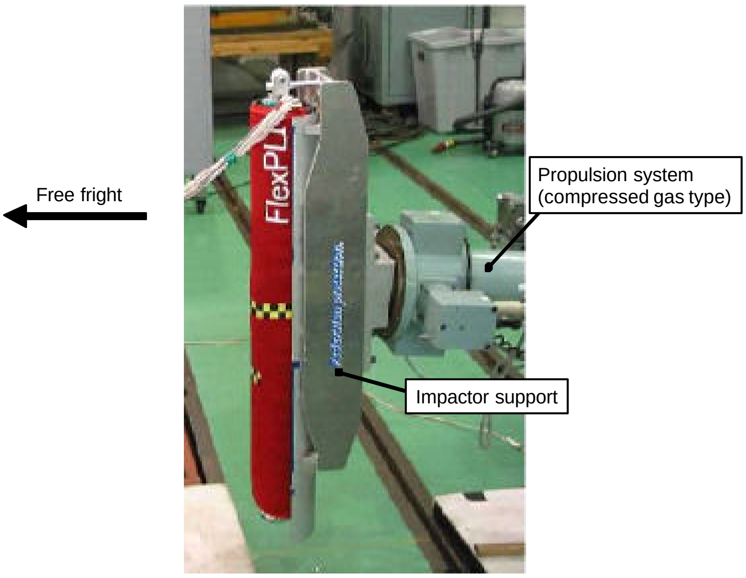


Figure 10. Legform impactor propulsion system.

RESUTLS

Sectional Loading Test

The deflection characteristics of the thigh and leg of Flex-PLI against repeated loading are reported in Figures 11 and 12. Both the responses of the thigh and leg remained highly constant throughout more than 20 times of loading.

Results on the reproducibility of the thigh, leg and knee of the Flex-PLI are described in Figure 13 to 15. Each of these Flex-PLI sections exhibited highly uniform load responses among the three discrete units tested.

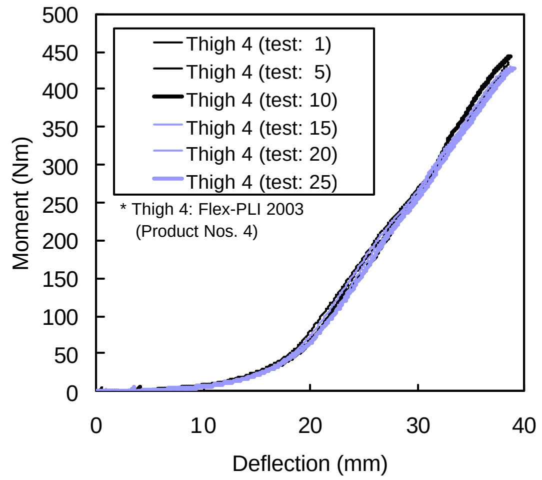


Figure 11. Repeatability test results for thigh (Flex-PLI).

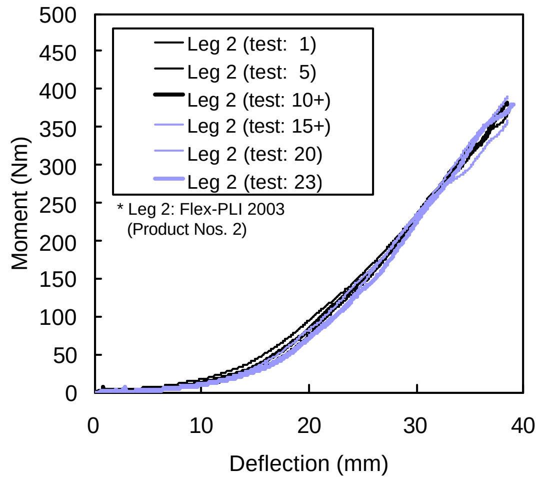


Figure 12. Repeatability test results for leg (Flex-PLI).

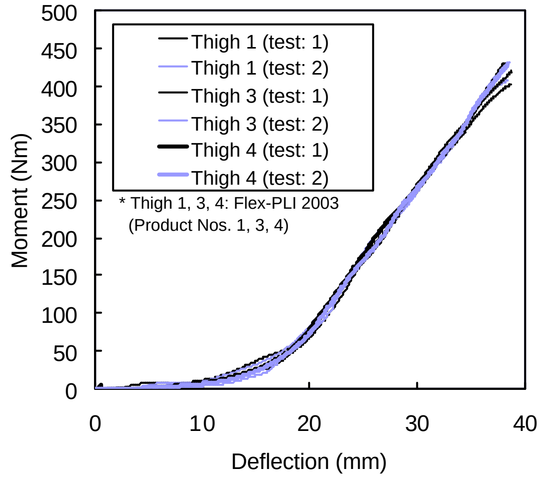


Figure 13. Reproducibility test results for thigh (Flex-PLI).

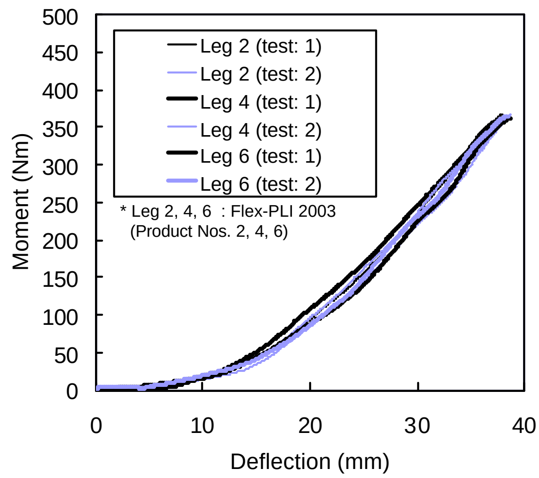


Figure 14. Reproducibility test results for leg (Flex-PLI).

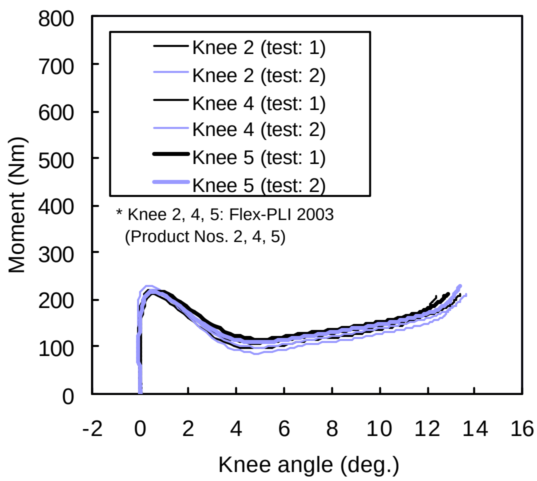


Figure 15. Reproducibility test results for knee (Flex-PLI).

Vehicle Test

The behaviors of Flex-PLI and TRL-LFI observed in the vehicle test are illustrated in Figure 16. The time-sequence photos clearly show that all the sections of Flex-PLI bend in a collision with a vehicle, while the TRL-LFI bends only at its knee under an impact.

The impact waveforms measured by Flex-PLI and TRL-LFI are given in Figures 17 and 18. The Flex-PLI allows measurement of load conditions in detail throughout the lower extremity, but the TRL-LFI measures load conditions only around the knee.

The results of the vehicle test on the repeatability of Flex-PLI are reported in Figure 19. The Flex-PLI exhibited an excellent stability of responses to repeated collisions with the test vehicle.

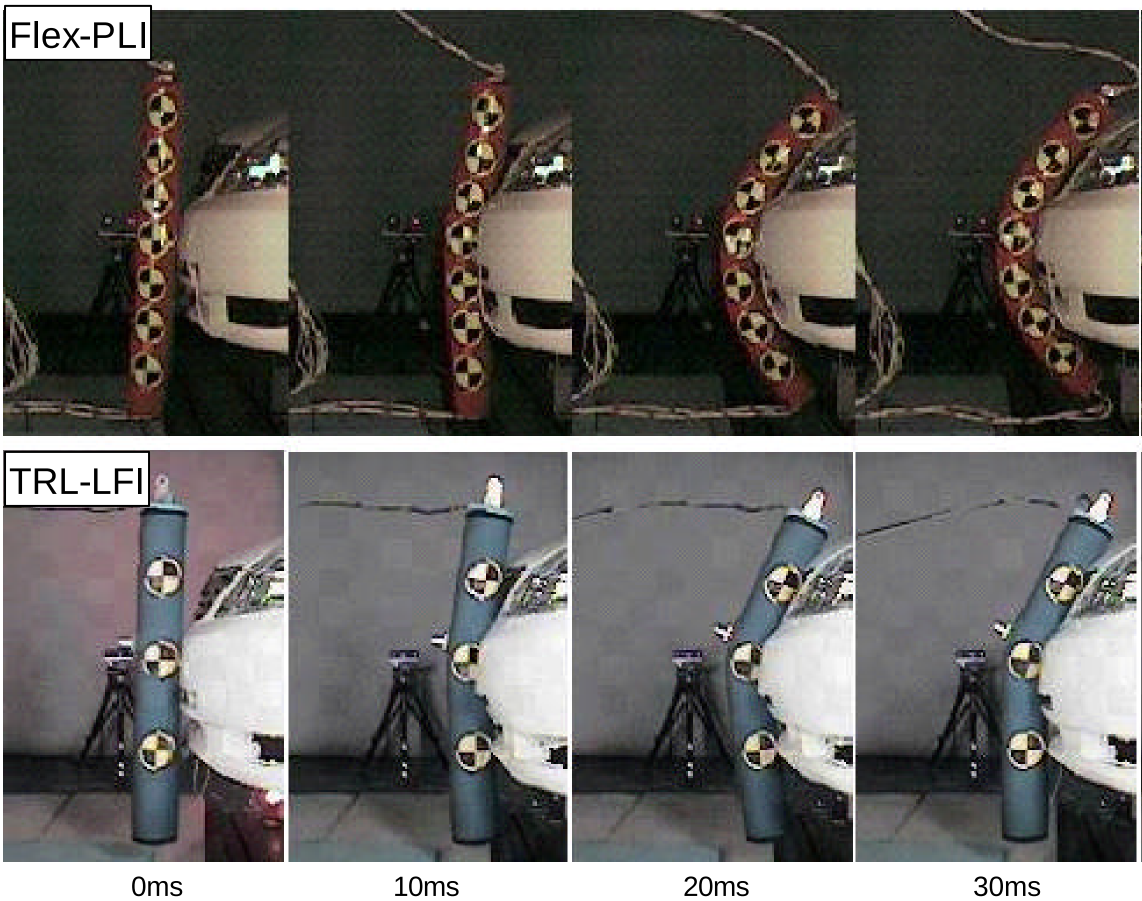


Figure 16. Vehicle test results (Kinematics).

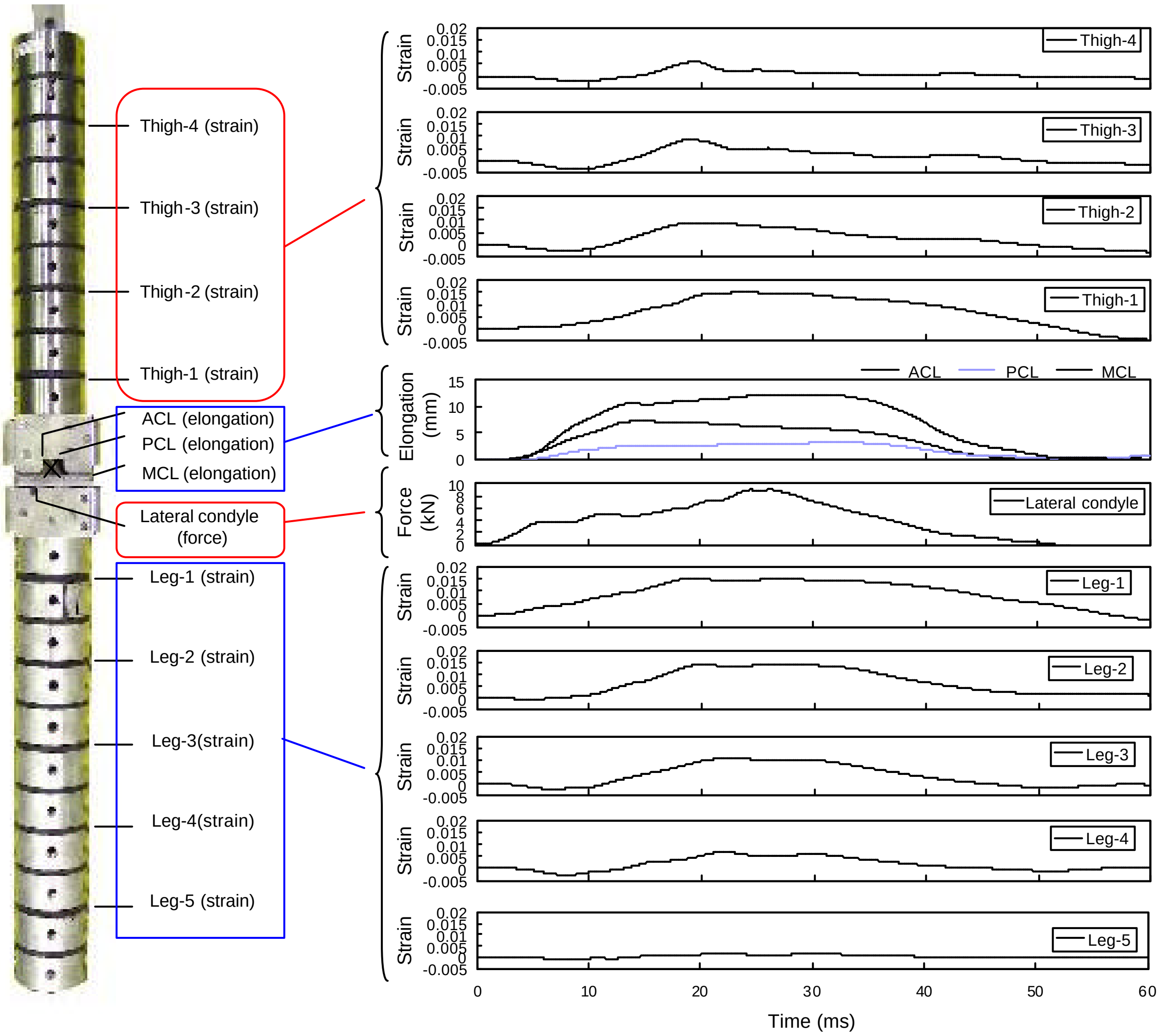


Figure 17. Vehicle test results (Flex-PLI waveforms).

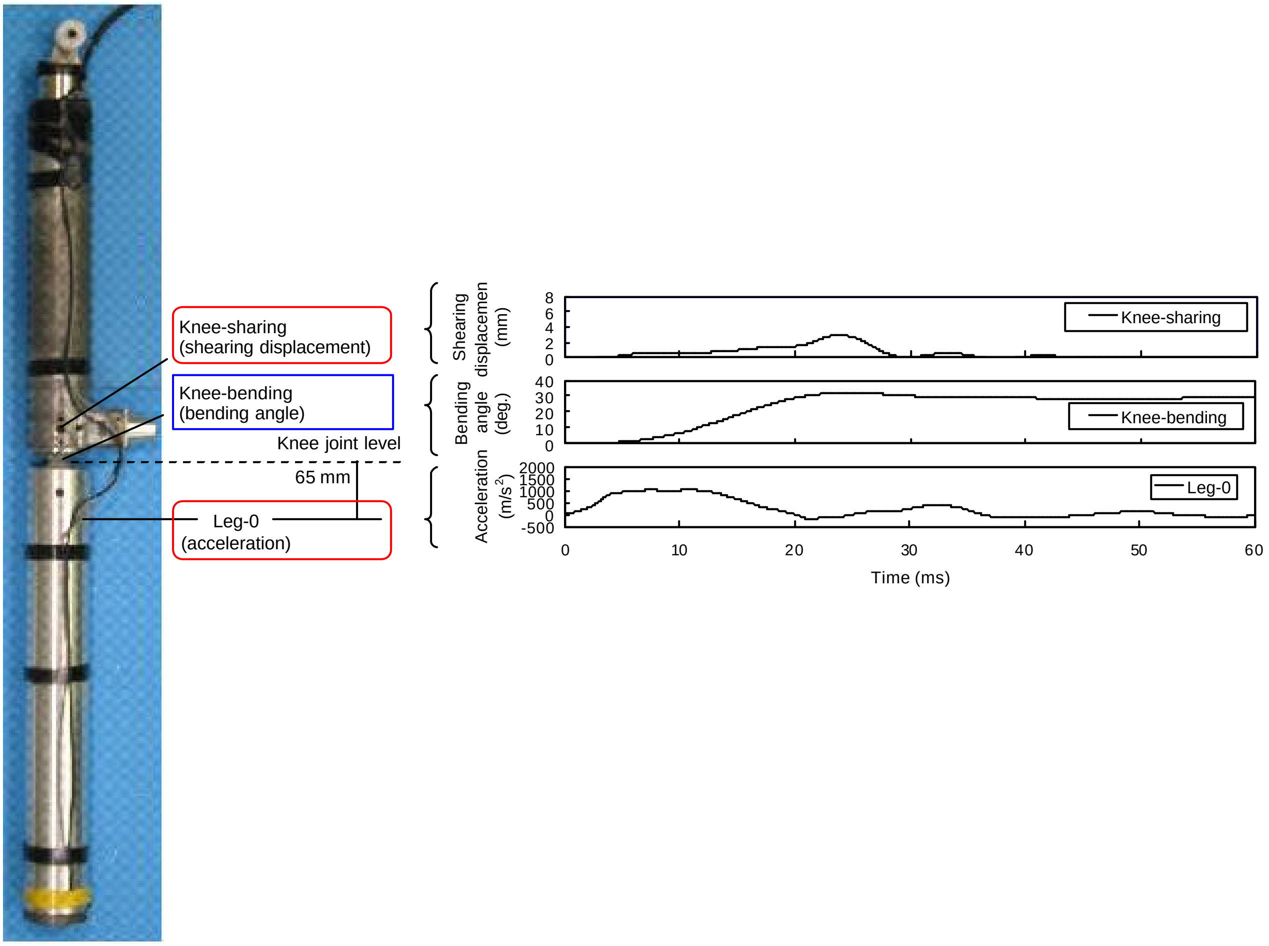
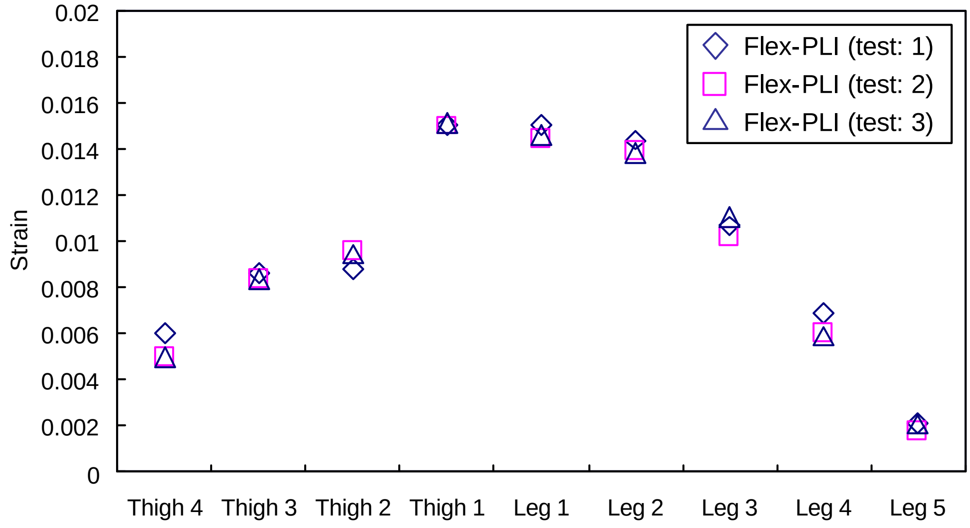
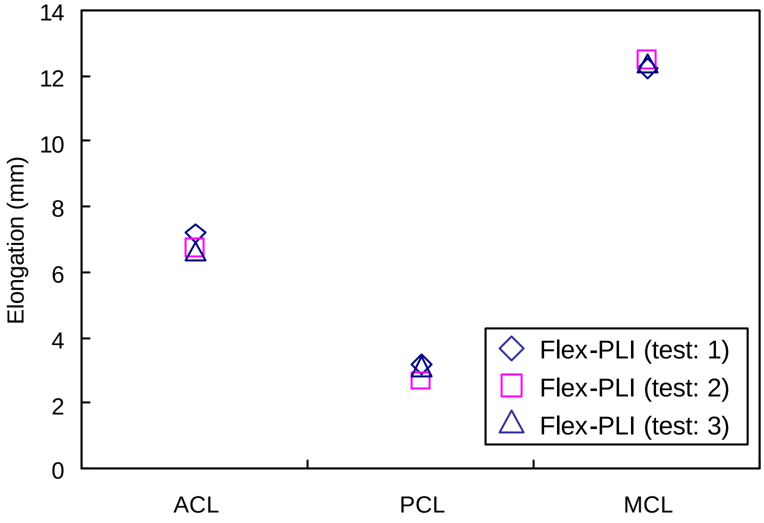


Figure 18. Vehicle test results (TRL-LFI waveforms).



a). Thigh and leg strains



b). Knee ligament elongations

Figure 19. Vehicle test results
(Repeatability test, maximum values).

DISCUSSION

In the present study a sectional loading tests were first conducted on the thigh, leg and knee sections of the Flex-PLI. The results confirmed that all the lower extremity sections of Flex-PLI have favorable repeatability and reproducibility characteristics.

The next, a vehicle test was performed to compare the Flex-PLI and the TRL-LFI in collisions with a vehicle. The results indicated: 1) the Flex- PLI responds with a higher biofidelity in a collision as compared to the TRL-LFI, 2) the Flex-PLI enables measurement in greater detail than does the TRL-LFI, and 3) the Flex-PLI demonstrates an excellent repeatability in vehicle tests.

It is therefore hoped that laboratories in many countries will conduct verification tests on Flex-PLI so that a GTR for pedestrian lower extremity protection can be formulated assuming the use of Flex-PLI legform impactor.

CONCLUSIONS

- In the sectional test of the present study, it was confirmed that the thigh, leg and knee of Flex-PLI all exhibit a favorable repeatability and reproducibility.
- In the vehicle test comparing the behavior of Flex-PLI and TRL-LFI, it was verified that the Flex-PLI has a higher biofidelity and enables measurement in greater detail.
- In the vehicle test on Flex-PLI, an excellent stability of responses to repeated loading was confirmed.
- It is hoped that laboratories in many countries will conduct verification tests on Flex-PLI so that a GTR pedestrian lower extremity protection can be formulated assuming the use of Flex-PLI legform impactor.

REFERNECES

[1] EEVC Working Group 17 Report: Improved test methods to evaluate pedestrian protection afforded by passenger cars (1998) European Enhanced Vehicle Safety Committee.
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