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Human Behavior Analysis under Drop Test using MADYMO

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Abstract

This dissertation tried to analyze passenger behaviors after an accident with the possibilities of a variety of accidents open reflecting the phases of the times of increasing interests in safety of passengers as the use of means of transportation such as cars and airplanes is increasing. Because a lot of data on head-on collisions, broadside collisions and reverse side collisions have been gathered through lots of experiments and interpretations, I chose to study a relatively unfamiliar subject, dropping collision. For example, I tried to study passenger behaviors in seating position after a dropping collision in preparation for falling accidents due to recent frequently-occurring sinkholes, driver`s carelessness or mechanical problems. I used MADYMO, passenger behavior interpretation program, and experimented with 2 meters high Drop Test device which I made in person to increase the reliability of the results. On the basis of these, I compared the real experiments with interpretations.

Key Words MADYMO, Drop Test, Dummy Model, Shock Absorber, Collision analysis

1. Introduction

A number of researches are being conducted to know the extent of damage which passengers take due to the unexpected accidents of means of transportation such as cars and airplanes and to minimize the damage. [1-6]. In general, researches for passenger protection are divided into the method of examination and the method of analysis. With the method of examination, we can create a similar condition and environment of real accident and conduct experiments to produce direct results, and the accuracy of results is high. In spite of these advantages, its need for expensive equipment and high experiment costs restricts experiment numbers. This is why simulation interpretations using computer programs are often used instead of real experiments. With the study for passenger safety through interpretation, it is hard to reenact and model the real phenomenon but its great repeatability, less expenses and the chances that we can discern the complicated relations which we cannot easily know through experiments are its great advantages.

So, this study analyzed passenger behaviors toward a dropping collision using MADYMO (MAthematical DYnamical MOdel) which is a passenger behavior interpretation program developed by TNO (The Netherlands Organization for Applied Scientific Research) of Netherlands. MADYMO provides a variety of dummies and human body interpretation models, and allows us to conduct passenger safety

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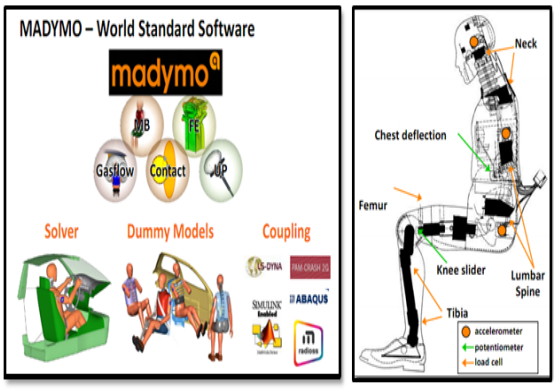


Fig. 1 MADYMO program

researches using these interpretation models in diverse collision conditions. Now, a lot of data on head-on collisions, broadside collisions and reverse side collisions have been gathered through active experiments, but researches about dropping collisions have been relatively less. These days, however, not only head-on collisions, broadside collisions and reverse side collisions but also dropping collisions have become one of the most important research parts owing to natural disaster such as sinkholes and man-made disaster such as carelessness of drivers and pilots or mechanical problems. Accordingly, this dissertation analyzed passenger behaviors in case of unexpected falling accidents and increased the reliability of the results by comparing the method of analysis using computer programs with the method of examination based on a direct Drop Test.

2. Drop Test

I personally conducted a 2 meters high Drop Test to increase the reliability of the interpretation results using MADYMO program. I prepared experiment equipment frame like Fig. 2, acceleration sensor and an ultrahigh-speed camera for this, and lastly installed DAQ system to gain data from acceleration sensor. Afterwards, I had a human-like dummy seated on a chair, fastened in a seatbelt, and at this point I applied 5 point seatbelt which supports total 5 directions including shoulders, waist and two crotches but not 3 point seatbelt, because a falling accident usually causes relatively great shocks. 5 point seatbelt is safer than 3 point seatbelt and holds the body tight when great shocks come upon the body so it prevents a passenger from being thrown out by falling shocks.

Fig. 2 Drop test

3. Modeling

Like Fig. 3, the interpretation sequence of MADYMO program was largely from interpretation model production to boundary condition setting and to giving contact conditions. At first, to produce a model, I did modeling within MADYMO program using Multi-Body and Finite Element. I produced a chair, Damper system and floor parts as Multi-Body using SURFACE.ELLIPSOID and I appointed Hybrid III 50th which is built in MADYMO program as a Dummy Model which I brought in and had it seated on the chair. At this point, Hybrid III 50th Dummy model was modeled on the basis of the standard of a healthy male adult with 180cms` height and 78kgs` weight. After I had a Dummy model seated, I did modeling of 5 point seatbelt like a Drop Test. The result is Fig. 4.

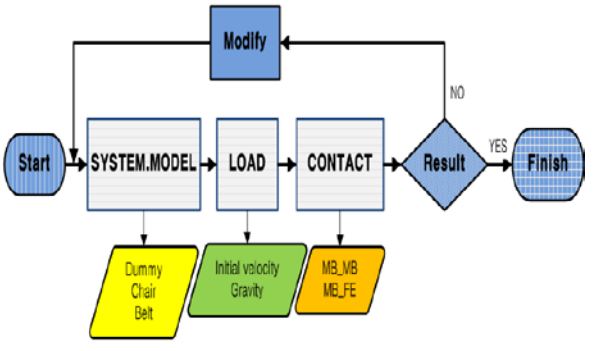


Fig. 3 Analysis process in FEM

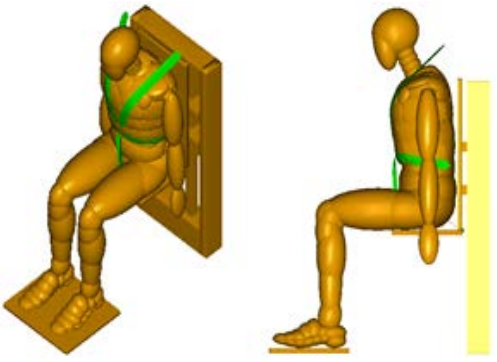
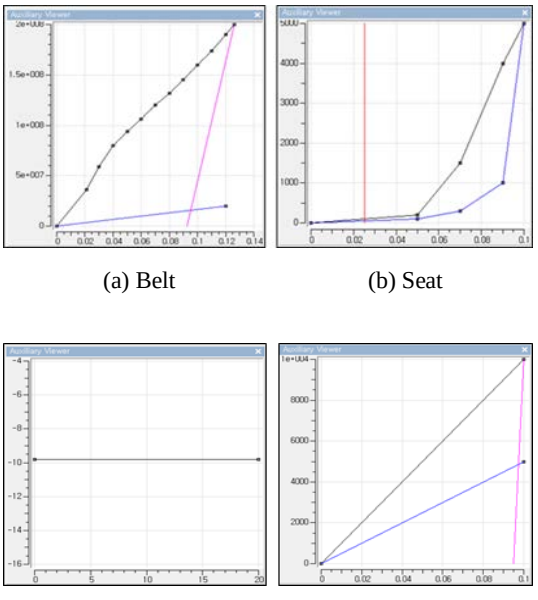


Fig. 4 Seating posture modeling in MADYMO

After completing the modeling, property value for each part should be applied. First, general property values were applied to chair seats, belts, and ground each referring to 'Frontal Crash' which is an example in MADYMO. The acceleration of gravity was set at 9.8m/s2 to provide the same environment as a Drop Test of motion of free fall.

The contact condition was Damper system and Dummy, ground and chairs were Multi-Body giving CONTACT.MB_MB one another, belts were Finite Element and CONTACT.MB_FE was applied at the contact parts between Dummy and belts.



(a) Belt (b) Seat

(c) Gravity (d) Ground

Fig. 5 Material property and Load

4. Result

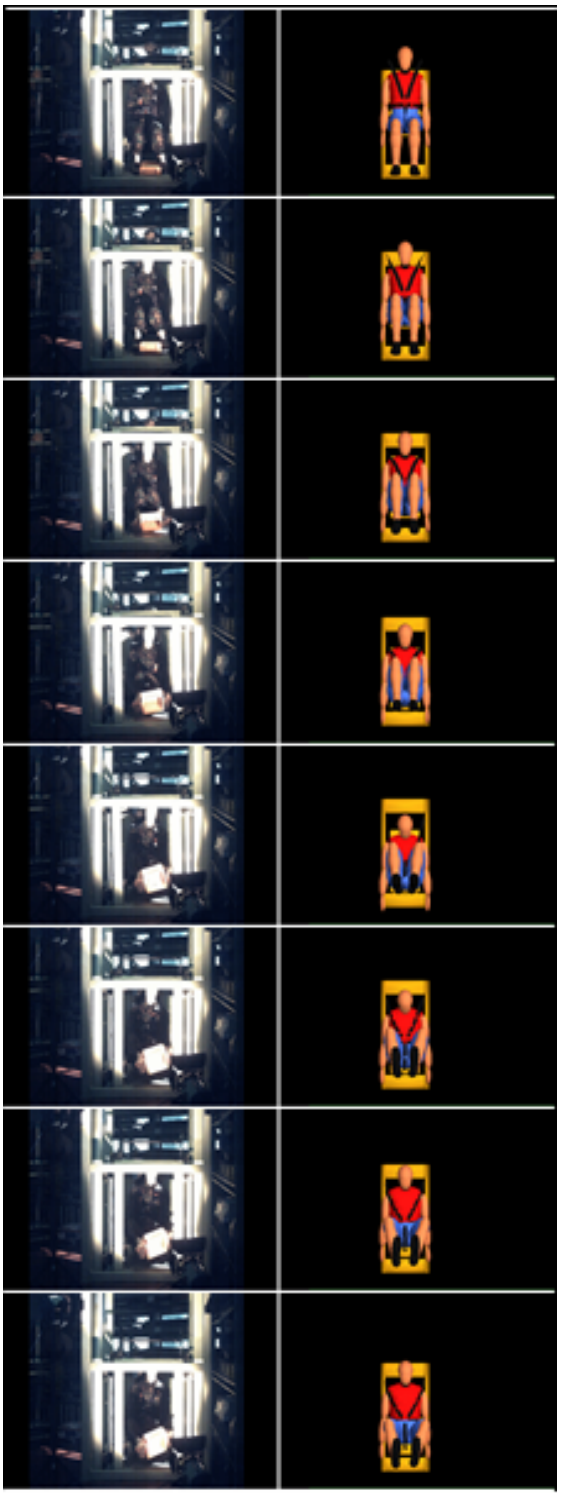


Fig. 6 Drop test and Analysis results

Based on the modeling results, I carried out interpretations using MADYMO which is a passenger behavior interpretation program. As a result of the interpretation, I could draw a Simulation which was right after a dropping collision. By comparing the results of passenger behavior of a Drop Test carried out before which were taken by an ultrahigh-speed camera with Simulation results using MADYMO program like Fig. 6, I could confirm that passenger behaviors right after a collision were similar to those of a real experiment.

5. Conclusions

I increased the reliability of the results through comparison between real Drop Test and MADYMO which is a passenger behavior interpretation program, and I could check the passenger behaviors on a dropping collision.

Industries are still carrying out the method of examination using Dummy with disadvantages such as huge costs and expensive experiment equipment, etc. If we set up and use wisely analysis techniques using competer programs, I expect the studies of analysis method with advantages such as less costs compared to the method of examination, great repeatability, and producing complicated relations which are hard to find through experiments to be lively.

Acknowledgement

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