SIMULATIONS OF BUS-SEAT IMPACT TESTS ACCORDING TO ECE REGULATIONS

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ABSTRACT

This paper deals with bus passenger seat and seat anchorage strength according to the official ECE Regulation 80 and partly to the ECE R14.
The regulations are based on a standardized real accident situation. In spite of this, the requirements don't follow the new demands, e.g. the compulsory usage of seat belts.
AUTÓKUT Hungary has just started a new project to develop a new alternative method for testing bus seat and seat anchorage strength.

REGULATIONS FOR BUS SEATS

ECE Regulation 80: *Uniform provisions concerning the approval of seats of large passenger vehicles and of these vehicles with regard to the strength of the seats and their anchorage. (Date of entry into force: 1989.)*

This regulation applies to vehicles constructed for the carriage of more than sixteen passengers, with passenger seats having reference height of at least 1m intended to be installed facing forward.
The requirement: in the case of an impact with 30 [km/h] velocity, the seats shall retain the passengers in the predetermined zone. The heads of dummies shall not pass forwards more than 1.6 [m]. The braking acceleration shall be kept between 8÷12 [g]. Biomechanical acceptability criteria are also determined in accordance with human tolerance capability.
Interesting and confusing is that this approval mark can be obtained with quasi-static test too, although the correlation between the two types of tests is deeply doubtful, not mentioning the biomechanical criteria. (The static test simulate the chest and knee impact simultaneously with two load cylinders at each sitting position.)

ECE Regulation 14: *Uniform provisions concerning the approval of vehicles with regard to safety-belt anchorage. (Date of entry into force of Rev. 03. for coaches: 1992.)*

During the test of coach lapbelts the test load of 740 ± 20 [daN] shall be applied for at least 0.2 [s] duration to a traction device attached to the two lower anchorage. Additive longitudinal load of 6.6 times the weight of the complete seat shall be applied at center of gravity of the seat. (In configuration of 3-point belt the test load to be applied is 450 ± 20 [daN] for both belt sections.) The basic standard accident situation is an impact with 10 [g] deceleration. It is same as at the Regulation ECE R80.

TESTING TO ECE R80 AND ECE R14

AUTÓKUT carries out seat tests from the mid 70's, participating in different developing phases of the ECE R80. Test method's improvement has been performed gradually.
In our tests no compliance has been found in the results of static and dynamic tests.
According our previous full-scale bus impact tests the occupant protection in a 10g crash situation is acceptable and sufficient requirement. (Some studies of crashes lead more serious conclusions to demand 20g crash condition. [4])
Figure 1 shows the ECE R80 test of a Hungarian double coach seat.

Figure 1. Seat test on a double coach seat with rail-type anchorage according to ECE Regulation 80. The seat fulfills the requirements.

At the first seats of the buses and coaches the passengers shall tighten the installed belts as prescribed in other regulations and national traffic rules. In this case the flying passenger, in the second row, impacts to the seat-back of the first row preloaded with a belted passenger. This type of seat loading is not examined by the ECE R80.

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Figure 2. Crash situation of a coach front double seat with two belted dummies in the test condition of ECE R80. The seat previously passed the normal regulated test, but it doesn't withstand the increased loading and isn't able to keep the dummy in the required zone.

The mandatory usage of lapbelts claims the change of test conditions of ECE R80.

The second ECE Regulation for bus passenger seats is the ECE R14 concerning the belt and seat anchorage.

Carrying out this type of test for a few double coach seat , the result was astonishing. Although the double passenger seats previously got the type-approval related to ECE R80, some of them failed the test of Regulation 14. (Fig. 3.) The seat-leg got bigger bending moment and the absorbed energy was more in this investigation than during the ECE R80 test.

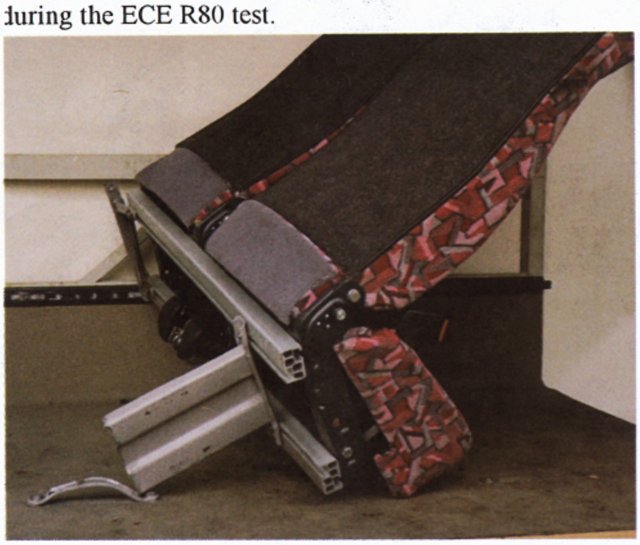


Figure 3. Double coach seat test according to ECE R14. The seat-leg couldn't withstand the loading.

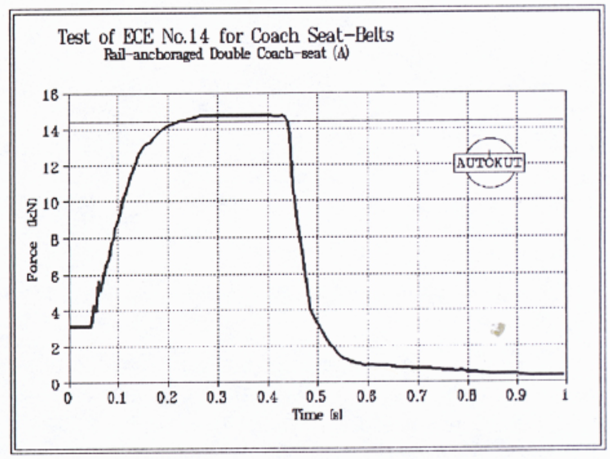


Figure 4. Force-time diagram of a successful double seat test according to ECE R14.

The conclusion is that the requirements of regulations of ECE R14 and ECE R80 are not independent, moreover the Regulation ECE R4, concerning the seat anchorage, is more rigorous.

Before carrying out the test by Regulation 80, it may be very reasonable for the coach and seat manufacturing companies to accomplish the seat belt anchorage controlling by test of ECE R14. It is faster and cheaper than the dynamic or static tests of ECE R80 and a good tool in the development process, specially for aftermarket seat manufacturers.

The critical notices according to the ECE R80 are the next:

- The Regulation allows two types of approval test, there is a dynamic one and a quasi-static one, but the results are different.
- The Regulation doesn't regard to the belted seats.
- Our previous investigations showed, that the seats having reference heights of 1÷1.3 [m], can cause fatal throat-hit which could be only controlled with added requirements for the biomechanical criteria concerning to the neck.

Some notices for ECE R14:

- The time rate of the force is not regulated. At our tests the applied forces had reached the regulated level in 0.15-0.2 [s]. Different run-up leads to different result.
- We have used preloadings of 150-200 [N] not required by the Regulation. By our explanation it is the preloading of the knee impact.

SIMPLE EXPERT SYSTEM FOR BUS SEAT IMPACT

The tests and the test equipment are expensive related to the above mentioned regulated bus seat test methods.
The goal is to develop a good tool which is easier and cheaper and examines the same accident conditions in compliance with the results.

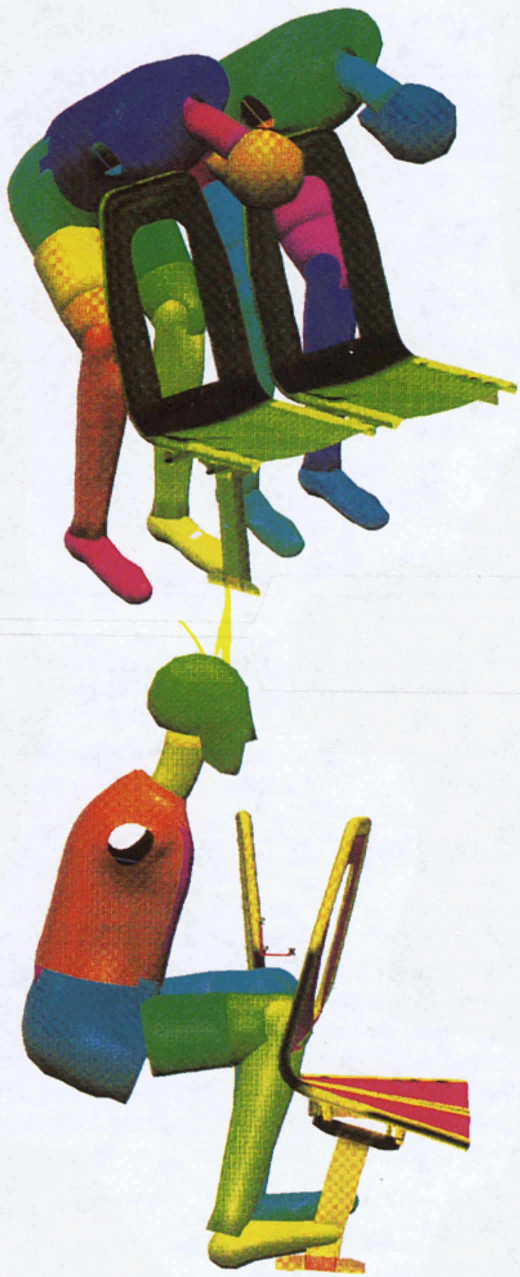


Figure 5. Complete simulation of dummy - bus seat impact by PAM-CRASH using an Ansys model of the seat. (Cooperative work with Tarok Ltd., Hungary.)

This kind of computational method is available, but it has big disadvantages: expensive and neglects the manufacturing technology.

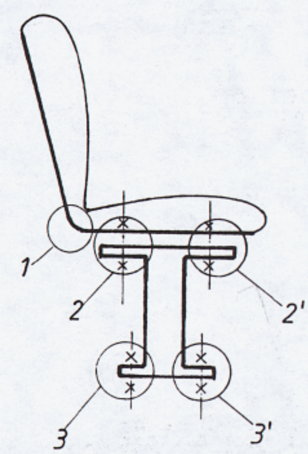
Simulation Principle

What are the main features of an acceptable inexpensive simulation method?

- It simulates the real accident situation.
- Secondly it is based on simplified laboratory tests.
- Finally it considers the manufacturing technology (e.g. welding joints)

Seat Model

All the used bus seats according to previous detailed investigations can be modeled as a unit of rigid elements and plastic hinges.



1 seat back curve

2
anchorage of seatleg and seat-frame
2'

3
seatleg anchorage
3'

fixing environment o
4 coach side-wall and seat-frame

Figure 6. General layout and plastic hinges of a bus seat

To set up a good seat model there are no more necessary than the exact masses, geometry of seat parts and the characteristics of plastic hinges.

Laboratory Tests

The moment-angle functions of the plastic hinges, shown on the drawing of Figure 6, can be measured in simple laboratory conditions.
The most important thing for getting the best approach is to measure the seat parts made with real manufacturing technology, not with any other (experimental) technology.

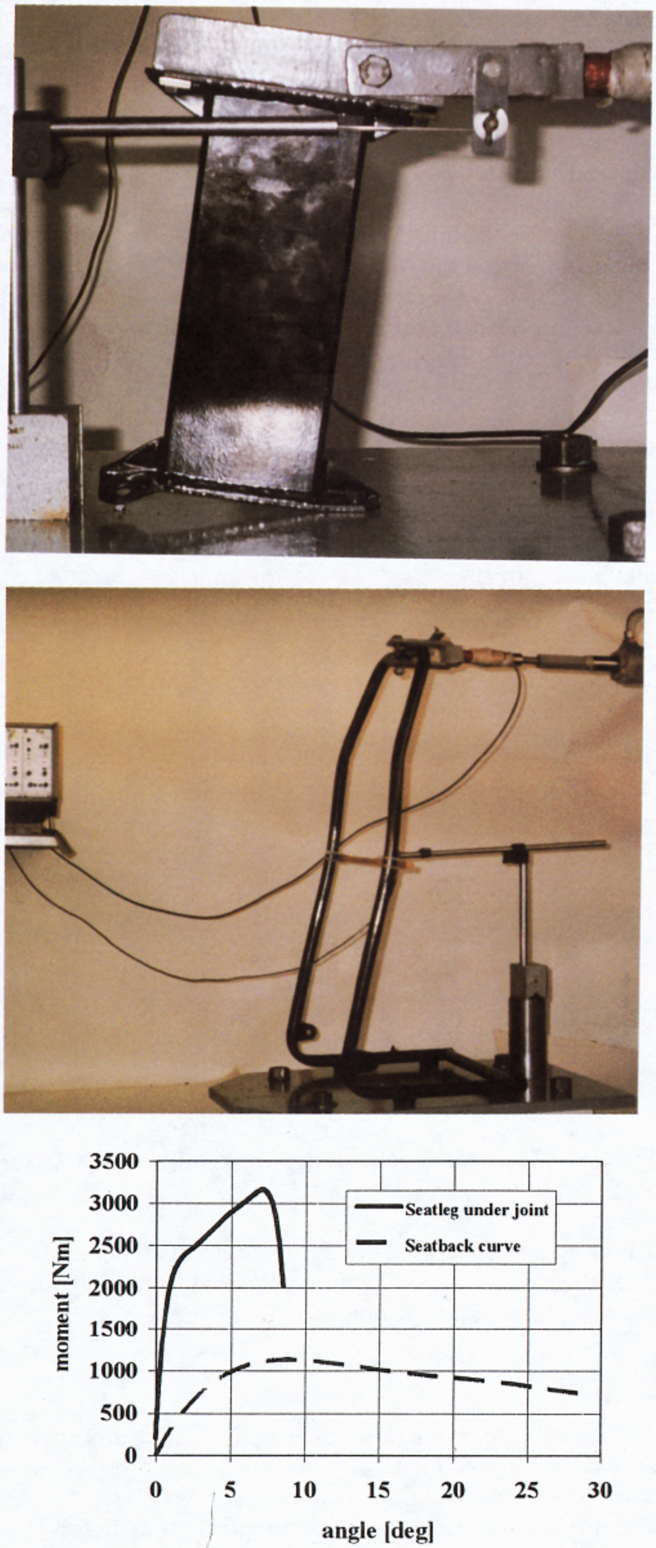


Figure 7. Laboratory bending test of a seatleg and seatback with the measured functions.

Computational Background

The results of laboratory dynamic tests can be built up to any sophisticated and expensive FEM software (Pam-Crash, Dyna,...), but the multi-body systems with suitable dummy module give easier, faster and cheaper approach. Not necessary to use the expensive M-B programs as Madymo or Adams, we have chosen the Alaska (Germany) software and just started the studying of ATB (USA) program's possibilities.

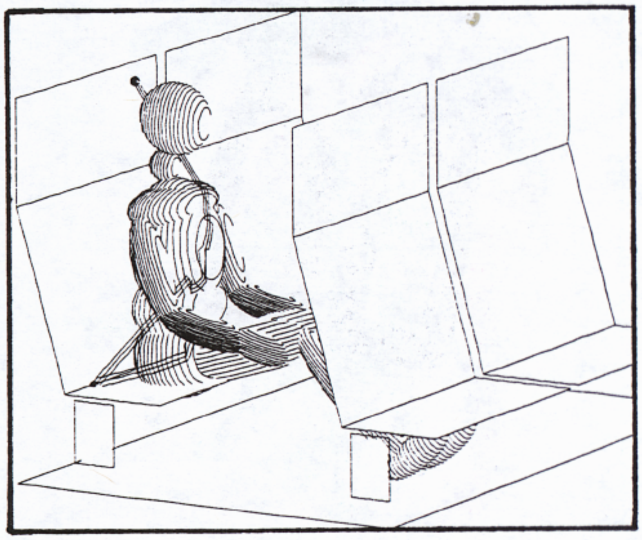


Figure 8. General arrangement for simulation of ECE R14 with multi-body software.

Using this method we can check all the parameters required for bus seats in ECE Regulations

CONCLUSIONS

The regulations related to the coach passenger seats should be integrated. It is not allowable that different test methods come to significantly different results. The compulsory usage of safety belts is reasonable and it claims changes on ECE R80. The described simulation method can be applied as alternative test method in compliance with dynamic test methods, even it gives a good tool for the designer on the design and development of strength of passenger seat-frame.

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