

GRAVE PROBLEM WITH THE STANDARD ROLLOVER TEST

(This paper is related to Reg.66. and presented by Hungary)

1. When the experts were working on Reg.66 (between 1975-1984) in Geneva, there was no big difference among the traditional buses and coaches covered by the scope of Reg.36, related to their main constructional features:

height: 3,0-3,1 m
width: 2,5 m
length: 10-12 m
floor height: 900-950 mm
CG's height: 950-1000 mm
curb mass: 9-10 tons

Therefore the standard rollover test (prescribed in Reg.66.) seemed to provide the same, or very similar test and loading conditions to all of the existing buses.

2. In the second half of '80-s a very significant differentiation was started in the bus construction and since the '90-s many new construction are running on the roads: midi buses, low-floor buses, high-decker tourist coaches, 15 m long vehicles (with 3 or 4 axles) etc.

height: 2,6-3,8 m
width: 2,4-2,55 m
length: 8-15 m
floor height: 350-1600 mm
CG's height: 600-1300 mm
curb mass: 8-15 tons

3. Using certain simplifications for the easier explanation:

- rectangular body shape in the cross section
- four plastic hinges deformation model
- similar passenger compartment height in all kind of buses.

This means - as Fig.1. shows - that the passenger compartment is shifted upwards with the increasing of floor height (and this results the increasing of the overall height of the vehicle)

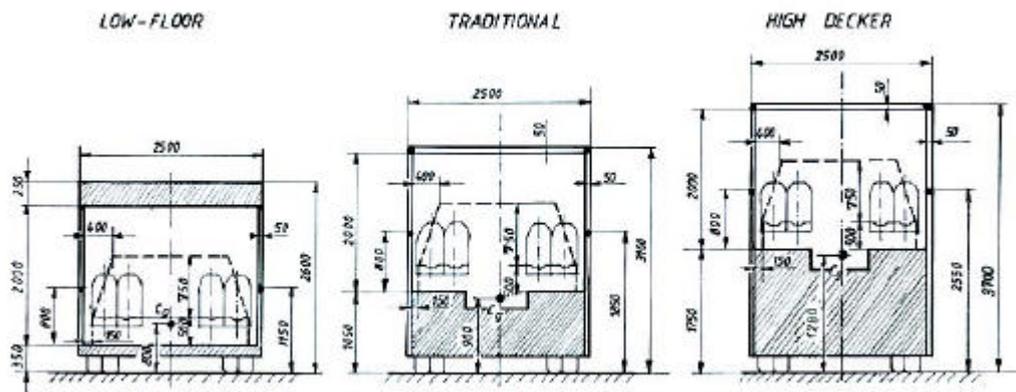


Fig.1.

4. Using the same standard rollover test for every kind of bus (the depth of the ditch is 800 mm) the geometry, the angle „ φ ” when the rail hit the ground will be different, see Fig.2.

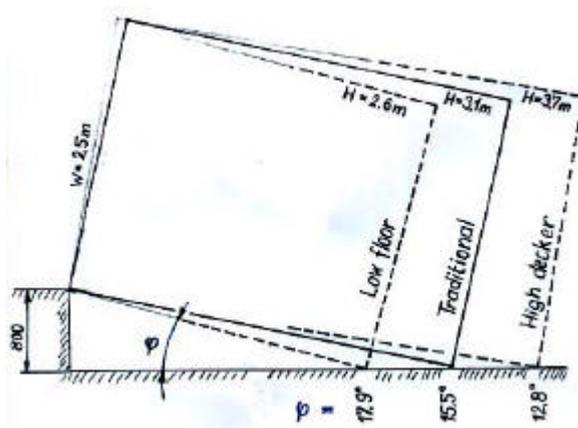


Fig.2.

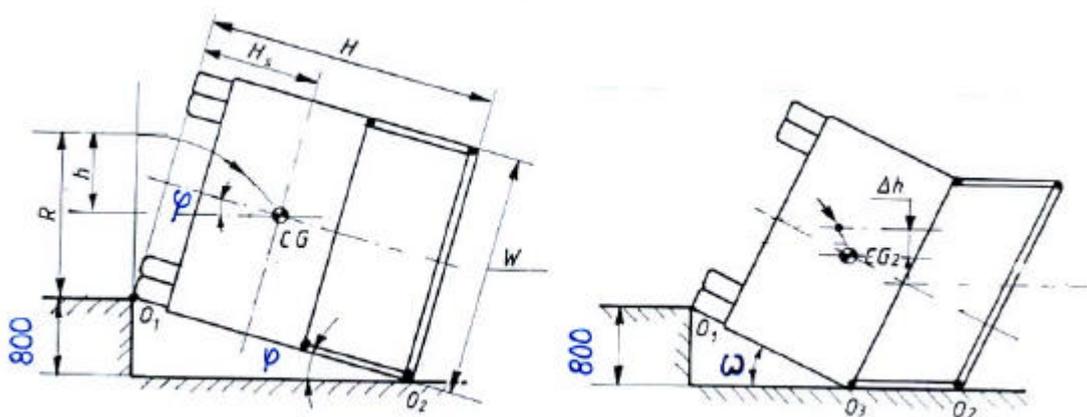


Fig.3.

5. Fig.3. shows a typical - four plastic hinges - deformation of the superstructure after the first collision with the ground (at the cantrail) till the second collision (with the waistrail) If the superstructure is not strong enough, this second collision will occur. The meaning of angle „ ω ” is shown on Fig.3. and it is clear that it depends on the geometry (depth) of the ditch and the geometry (height) of the bus. Table 1. shows the values of angle „ φ ” and „ ω ” of four bus types with rectangular cross section and also one type with real shape (IKARUS 250 is a traditional coach)

Table I.

Bus type	H (m)	j (°)	w (°)
Midi	2,4	19,5	41,8
Low-floor	2,6	17,9	43,6
Traditional	3,1	14,9	25,6
High decker	3,7	12,8	18,3
Real IK 250	3,1	15,9	24,2

6. The acceptable, or permissible distortion of the superstructure is determined by the survival space. Fig.4. shows the meaning of angle „v” the inclination of the deformed window pillar when it just touches the contour of the survival space

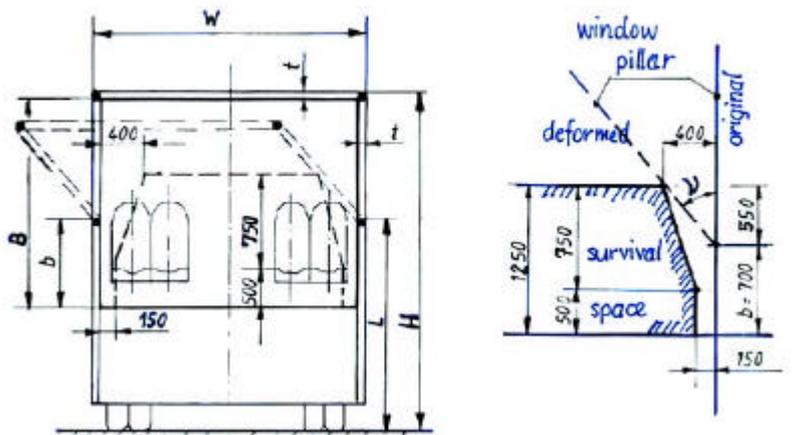


Fig.4.

7. The problem - the essential problem of this standard rollover test - occurs if

$$\omega < v$$

which means that the possible deformation of the superstructure - determined by the geometry of the rollover test and not by the strength of superstructure - is limited, the survival space could be unharmed in the case of a weak superstructure, too. This means, that the existing standard rollover test does not separate the weak superstructure from the strong one, if $\omega < v$. Using the realistic values shown on Fig.4. we can get

$$\text{tg } v = 400/550 = 0,727 \quad v = 36^\circ$$

Comparing this value to the values in Table 1. it can be seen that even in case of traditional buses this rollover test can be problematical.

8. It must be emphasised that the values of „ ω ” and „v” strongly depend on the real shape and geometry of the individual buses, so there is no general limit value, limit situation below which the existing rollover test is acceptable and above which it cannot be used. There are three zones, and the middle zone is a „dark range”. These zones may be characterised by the overall height (H) of the vehicle. The zones are the followings:

- in which the rollover test does not produce limited deformation, so it is usable ($H < 3$ m)
- in which both limited and unlimited deformation can occur depending on the individual figures, shape of the vehicle ($3 \leq H \leq 3,4$ m)
- in which the deformation is surely limited, so the rollover test is unusable ($H > 3,4$ m)

The values 3 and 3,4 m are not theoretically but only empirically based ones. The phenomenon of the limited deformation was proved on the Prague meeting of the ad-hoc expert group by the Czech presentation about a computer rollover simulation. (The goal of this simulation - as well as that of the presentation - was not the study of the limited deformation, it just came out)

9. To solve this problem, to avoid the geometrically limited deformation needs further detailed study. The possible directions of the solution, which should be a compromise:

- to maintain the existing simple standard rollover test
- to avoid the possible contact between the waistrail and the ground

- to decide what should be equal - the same for all kind of buses - in the case of the standard rollover test (e.g. potential energy, reference energy, drop of CG, impact force, depth of the ditch, etc.) Fig.5. gives some theoretical and practical solutions about this compromise:

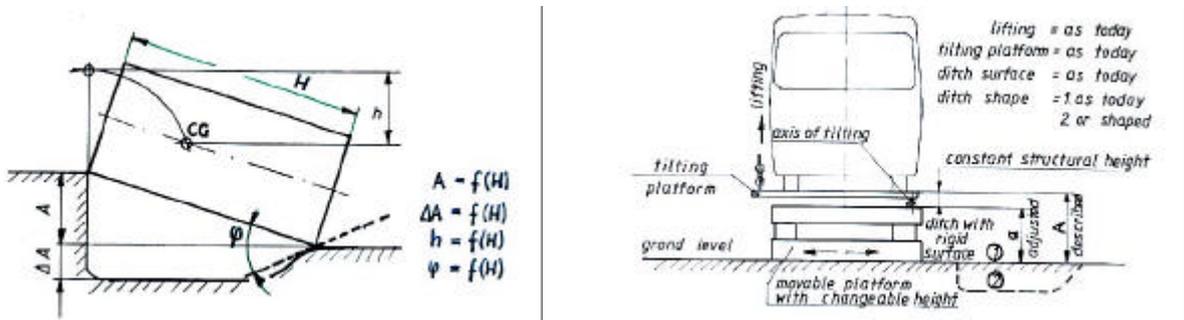


Fig.5.

Technically it seems to be easy to change the depth and/or the shape of the ditch, the impact angle at the cantrail, the drop of CG.

- The goal of this paper is to call the attention of GRSG on the very serious problem of the geometrically limited deformation which makes the approval test unreliable and to ask GRSG to authorise the ad-hoc expert group:
 - to study in details this technical problem
 - to find an acceptable solution which avoids the unreliability of the approval (standard rollover) test
 - to produce a fully agreed proposal to GRSG about the modified standard rollover test.