

Detailed technical analysis of a severe bus rollover accident

The accident happened on 17. 04. 2005 in the morning hours (9⁴⁵) at the Grand St. Bernard Pass with a tourist coach (operator: a Swiss company MARTI) driving from Switzerland to Italy. The information about the accident was collected from the media listed below. The accident was a typical, severe rollover accident.

The vehicle is a high decker tourist coach; produced by IRISBUS, type "Iliade", being in service since July 2004 (new bus, 50 thousand km) The overall dimensions: length 10,6 m; height 3,6 m; width 2,5 m. Passenger capacity is 34, there were 24 passengers, one crew and 2 drivers on board in the moment of the accident. There was a drawing in one newspaper about the position of the persons on the board. 12 passengers and the crew were sitting on the right side, 12 passengers and the driver on the left side. The second driver could be on the right side, next to the crew. The seat spacing was 830 mm (very comfortable arrangement) every seat was equipped with safety belt, but no information whether the passengers used the belts or not. 6 side window pillars plus one windscreen pillar and one rear wall pillar on each side. Two service doors (one in the front, another one at the rear overhang) Kitchen and toilet on the two sides of the rear staircase. Hand-baggage rack on both sides above the seats. This type has been approved on the basis of ECE Regulation 66, but now information which approval test was used.

The road was a serpentine mountain road with a wet, but not a slippery surface. Fig.1. shows the map of the event. The total width of the road was 6 m (see Fig.2.) The bus drove upwards the hill and the accident happened after a left curve. From these two reasons the speed of the bus could not be too high. On the right side of the road there was a guide rail on the left rock wall.

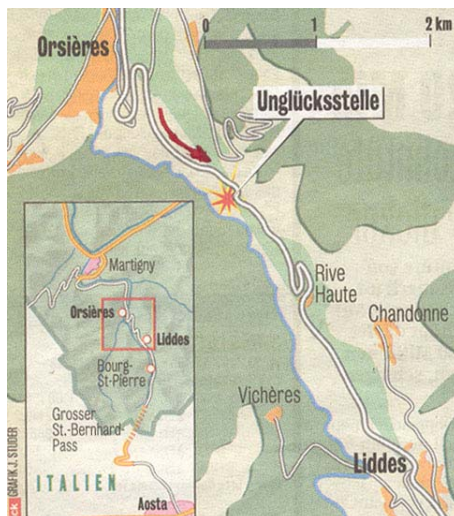


Fig.1. The map of the accident's scene



Fig.2. Narrow mountain road

The scene of the accident was reconstructed from the photos given by the newspapers. Fig.3. shows the cross section of the road and the path of the rollover process. The different estimations in the media were $H \approx 100-200$ m, $L \approx 50-60$ m and $h \approx 0,6-1,6$ m changing alongside the road where the bus was rolling down. Next to the road, at the beginning of the slight slope there were bushes, small young trees, but the whole slope was grassy ground covered by thin snow (see Fig.4.) Down, at the bottom of the precipice a small river flows in a forest. Fig.5. gives an impression about this place and the rocky wall of the precipice.

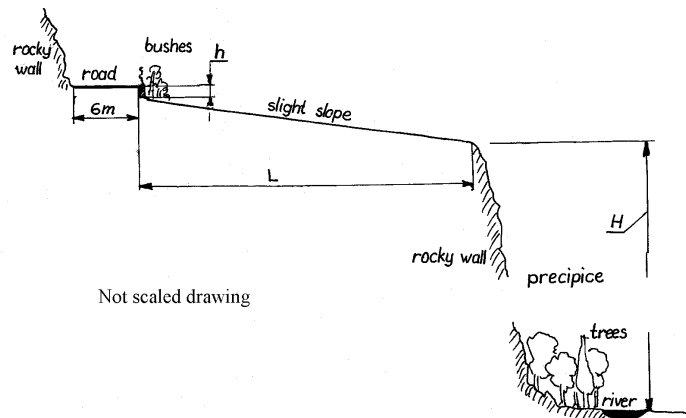


Fig.3. The path of the rollover process



Fig.4. View of the 50-60 m long slight slope



Fig.5. Down in the precipice (front wall view)

The rollover process started after the left curve where the road was already straight. The bus broke out the safety guide rail (its height and strength cannot hold back a bus) but the reason of that is not known and probably never will be known because both of the two drivers died. The bus rolled down to the slight slope and it had more rotations. It was a normal, regular lateral rollover as the path of this motion may be seen on Fig.4. The newspapers mentioned 6 or more rotations. If the superstructure of the bus did not collapse at the first impact, then – coming from the contour of the bus – the number of the rotations could be 4-5. If the superstructure collapsed, the number of the rotations could be 6-7. From Fig.4. – by a prudent estimation – 6 rotations may be rendered. After that the bus rolled into the precipice and its motion was not a regular lateral rotation anymore. This is proved by the seriously damaged front wall (Fig.5.) and rear wall (Fig.6.) Finally the bus stopped on its wheels, held this position by a tree.



Fig.6. Down in the precipice (rear wall view)



Fig.7. Another picture about the slight slope

The casualties were very severe: 12 fatalities and 15 injuries, 4 of them were said in life danger, more serious injuries were reported. From the different reports the following information could be read out:

- In the first period of the rollover (rolling down on the slight slope) many passengers (14) were ejected. Some newspaper reported that only those passengers survived who were ejected. But on the photos (see Fig.4. and Fig.7.) 1 or 2 dead bodies may be recognized covered by shroud.
- 13 persons remained in the bus when it started to roll down into the precipice, that was reported
- Finally 5 dead passengers were found in the bus and one survival close to the bus, but being ejected.
- One report mentioned that among the ejected passengers 6 were dead.

Possible injury mechanism It will be never known how the accident really happened. The following is an estimation. If no one on the board used the safety belt, (there was no report about that) at the first impact, when the door side can trail hit the ground, the side windows (as well as the windscreen and the rear window) were broken and the large-scale distortion of the superstructure started (see Fig.8.)

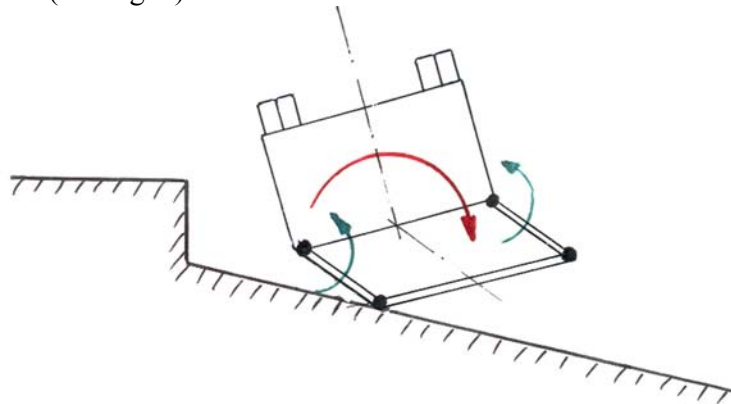


Fig.8. Deformation at the first impact

The bus was rolling down around the cantrail as axis of rotation and the superstructure (the window columns) was "rotated" around the waistrail as axis related to the rigid "lower part" of the bus. That means: the passengers and crew, sitting on the door side (14 persons as it was said above) could be ejected, because there was no roof anymore "above" them. The people sitting on the left side were closed and maybe pressed by the "down coming" roof. Their position became worse and worse with every rotation on the slight slope. 13 persons remained in the bus when it started to roll down into the precipice, most of them were probable dead. Falling down the bus could have different contacts with the rocky wall and not only on its superficies but may be on its front and rear walls and these different impacts could eject further bodies. One person survived this whole process, this is a miracle.

Was it a severe rollover accident? The answer is – at first glance – yes. But going a little bit deeper into the problem, the answer is not so obvious, and simple.

1. It was earlier said and proved that for high buses (overall height is more than 3,4 m) the existing approval test method is not appropriate. Because of the geometrically limited deformation, the weak superstructure cannot be separated from the strong one [2] so the approval itself does not guarantee the required strength of the superstructure. There is another theoretical possibility: the majority of the passengers used the seat belt. In this case it is easier to explain the collapse of the superstructure (higher energy input than it was simulated by the approval test) but it is more difficult to explain the high number of ejected persons.
2. Analysing the situation, four combinations may be considered: strong or weak superstructure rolling down on slight or steep slope.
3. On a slight slope the two possible situations are shown on Fig.9. If the superstructure collapses the bus becomes a "semi-cylindrical body" and continues the rotation. If the superstructure is strong enough and it does not have considerable distortion, the bus is slipping on a certain distance and stops.

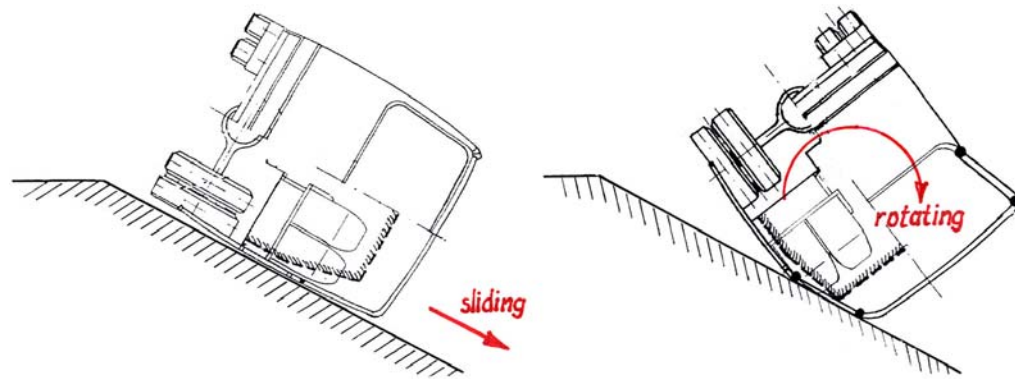


Fig.9. Slight slope situation



Fig.10. Weak superstructure on steeper slope

Fig.11. Strong superstructure on steeper slope

4. On a steeper slope the situation could be different but the result similar. In the mid of the '70-s 4 rollover tests were made on a standard 6:4 slope ($\approx 33,5^\circ$) in Hungary. Fig.10 shows the rollover process with a weak superstructure (type IKARUS 250 original design) The superstructure collapsed at the first impact and the bus – as a "semi-cylindrical body" rolled down and stopped at the end of the slope on its roof ($1\frac{1}{2}$ rotation) Fig.11. shows the same rollover test with the same bus type but having a reinforced superstructure. At the first impact the superstructure did not collapse, the bus continued the rotation (the cantrail served as the axis of the rotation) When the other side cantrail contacted the ground – again no considerable deformations – it became the new axis of the rotation and finally the bus stopped on its right side ($1\frac{1}{4}$ rotation)

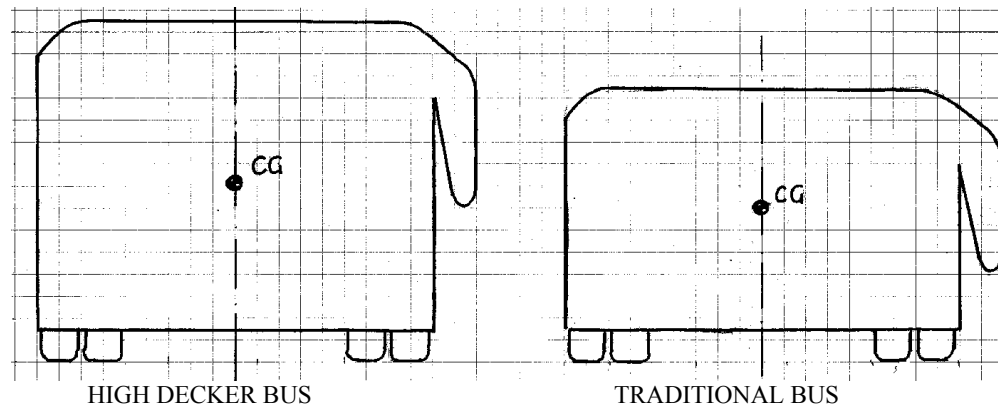


Fig.12. Shape of "semi-cylindrical bodies"

5. It is interesting to mention an essential difference between the traditional and HD buses in this respect. This difference is between the shape, contour of their "semi-cylindrical body" (rigid body) when their superstructure collapsed (see Fig.12.)

a) In the case of HD buses this contour is almost a square with a side ratio $\approx 2,5:2,3$ which makes easier the continues rotation.

b) In the case of traditional buses this is an oblong with a side ratio $\approx 2,5:1,6$ This makes more difficult the continues rotation

Considering all the above said facts and arguments, the answer on the question: "Was it a severe rollover accident?" – instead of the simple "yes" – could be more sophisticated. It may be assumed that if the superstructure could have had the required strength (not only the approval mark: see para.1. above) the bus would stop after the first impact and of course certain injuries could happen due to the inside motion and impact of the passengers, but the really severe rollover accident (6 rotations and falling down into a precipice) could have been avoided.

References

- [1] Matolcsy M. Rollover safety for all bus categories. Proc. of the 36th Meeting of Bus and Coach Experts, on CD. Organized by GTE, Budapest (2005 August) p.14
- [2] Matolcsy M. Standard accident as the basis of vehicle approval test. EAEC Conference, Bratislava (2001) Section B01 Safety, p.9.

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- 2. HIR TV Evening news, short report 19³⁰ (Hungarian)
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- 4. Népszabadság, daily newspaper (Hungarian) 18.04.2005
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