# Static and dynamic tests on reinforced rubbers used for road safety barriers

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**Kulcsszavak:** biztonsági korlát, ütés, erősített gumi, elnyelt energia, jelátalakító
**Keywords:** safety barrier, impact, reinforced rubber, absorbed energy, transducer

## Összefoglalás

A közlekedésben résztvevők számára az egyik legnagyobb kihívás a közúti szállításban a nagy biztonsági szint. Annak érdekében, hogy a biztonsági szint tartható, vagy fokozható legyen, a veszélyes útszakaszokon korlátokat helyeznek el, hogy megakadályozzák a járművek váratlan útelhagyását és biztosítsák azok optikai irányban tartását.

Ezek az útkorlátokat úgy kell tervezni, hogy a lehetséges maximális energiát nyeljék el és megtartsák az integritásukat a gépkocsi ütközését követően is. Éppen ezért, a biztonsági korlátok szerkezeti szilárdságát, és néhány e célra használt anyag mechanikai jellemzőjét vizsgálták. Ebben a publikációban néhány olyan új típusú biztonsági korlát statikus és dinamikus vizsgálatait ismertetik, amelyek a jövőben kerülnek betervezésre.

## Abstract

One of the major issues in road transport is to ensure a high safety level for the traffic participants. In order to maintain and improve the road safety, barriers are located on dangerous road regions, in order to protect the vehicles against the unexpected exits from the road platform and to ensure their optical guidance.

The safety barriers must be designed in such a way as to absorb as much energy as possible and to keep its integrity after an impact with a vehicle. For this, the strength structure of the safety barrier and the mechanical characteristics of some materials used in their construction should be analyzed.

Table 1. The average values of the force necessary to detach the rubber from the steel fibers, together with the corresponding values of the ultimate stress and strain are presented in Table 2.

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In this paper, the static and dynamic tests of some elements that may be utilized in the design of a new type of safety barrier are described.

## Mechanical characterization

A safety barrier covered with a rubber reinforced with steel fibers was tested. Since the mechanical characteristics and elastic constants of the rubber were not known, tensile tests on specimens with a 30 × 9.4 mm2 rectangular cross section were performed. Several tests were undertaken on an INSTRON 8801 servo-hydraulic machine in order to determine the Young's modulus and the force necessary to detach the rubber from the steel fibers.

The stress-strain curve for one of the tests is presented in **Hiba! A hivatkozási forrás nem található.**.

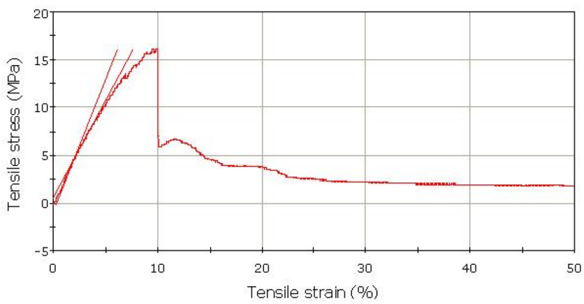


**Fig. 1.** Stress-strain curve for metallic insertion reinforced rubber

Since rubber is a hyper-elastic material, the tangent modulus Et was determined in different points on the stress-strain curve, and an average value was calculated for two different stress span. The obtained results are listed in

| Test nr. | Young's modulus [MPa] | | |
|---|---|---|---|
| | Automatic | For tensile stress 1 - 2 MPa | For tensile stress 6 - 10 MPa |
| 1 | 249.5 | 269.6 | 202.0 |
| 2 | 208.1 | 225.4 | 129.7 |

Table 1: Youngs' modulus for reinforced rubber

| Test nr. | $F_{max}$ [kN] | $\sigma_u$ [MPa] | $\varepsilon_u$ [%] |
|---|---|---|---|
| 1 | 4431.49 | 15.7 | 10.0 |

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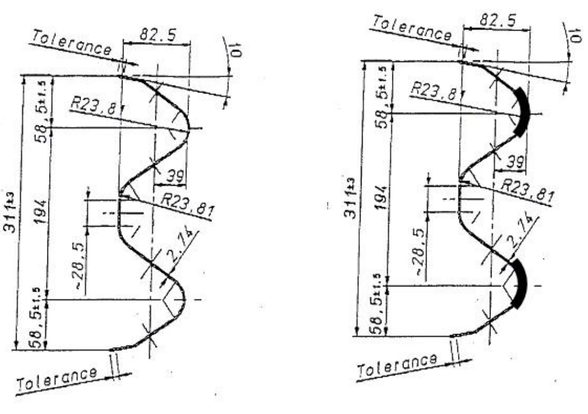
| | | | |
|---|---|---|---|
| 2 | 3978.1 | 11.4 | 8.5 |

Table 2: Ultimate force, stress and strain for reinforced rubber

## Static and dynamic tests

In order to characterize the dynamic behavior of the reinforced rubber used to cover the safety barriers, shock tests in bending were performed for a simply supported double-corrugated safety barrier without (Case 1) or with (Case 2) reinforced rubber (Hiba! A hivatkozási forrás nem található.). A special device and an adequate methodology were used.

The impact strength defines the capacity of a material to absorb energy during failure. The greater the tenacity of the material, the greater will be the absorbed energy [1], [2].




a) b)

**Fig. 2.** Cross section of a double corrugated safety barrier: a) Without rubber; b) With rubber

For studying the impact behavior of the safety barrier, some preliminary tests [3], [4] were performed in order to determine the static influence of the reinforced rubber on the bending behavior. A special device for supporting and loading was conceived and achieved for the static bending tests (Fig.3). The barrier was made of steel plates with 3 mm thickness, with a span of 1860 mm between the supports and loaded with a force of 245.25 N in the middle. For each case, the displacement was measured in the central section using an inductive transducer, whose signal was processed with a SPIDER 8 multichannel amplifier with data aquisition. The obtained results are listed in Hiba! A hivatkozási forrás nem található..

Further to the static tests, the displacement was also measured for a dynamic load. A weight of 23 kg was left to fall on the barrier in the central section from four different heights. The same devices were used to measure the dynamic displacement δd. The impact coefficient was calculated as:

$$\psi = \frac{\delta_d}{\delta_{st}} \qquad (1)$$

The automatic recording of the dynamic displacement for one of the tests in case 2 is shown in **Hiba! A hivatkozási forrás nem található.**. The displacements of the safety barrier for all the four falling heights together with the impact coefficient are listed in Hiba! A hivatkozási forrás nem található..

## Conclusions

Both from the static and dynamic tests, it can be observed that a slightly greater displacement occurred in the safety barrier covered with reinforced rubber. This can be an indicator of the possibility to absorb more from the kinetic energy of a vehicle that impacts the barrier. Since data referring to the impact energy are not enough to predict the impact effect, more tests involving the geometry of the barrier, the material and the speed of the impacting vehicle are needed.

## Acknowledgements

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