A INNOVATIVE AND POWERFUL MOBILE ANTI-RAMMING SYSTEM

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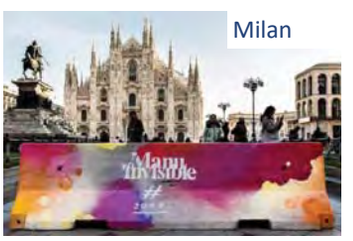
The present work is the result of the collaboration between University of Bergamo and Besenzoni S.p.A. A new startup (Besenzoni Defence & Protection S.r.l.) was founded.

THE PROBLEM: ramming attack, a "new" shape of terror attack

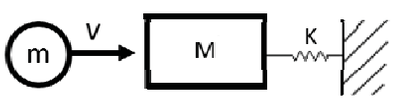
07/2016: Nice, Promenade (>80 killed people, ~300 injured)
12/2016: Berlin, Breitscheidplatz (11 killed people, >50 injured)
03/2017: London, Westminster (5 killed people, 50 injured)
04/2017: Stockholm (4 killed people)
06/2017: London, London Bridge (7 killed people)
08/2017: Barcelona, Las Ramblas (~15 killed people, 130 injured)
10/2017: New York, Manhattan (8 killed people, ~12 injured)

THE EXISTING SOLUTIONS



ARE THE EXISTING SOLUTIONS EFFECTIVE?
CAN WE IMPROVE THE PERFORMANCE WITH A INNOVATIVE, GOOD-LOOKING & MOBILE SOLUTION?

MATHEMATICAL MODEL

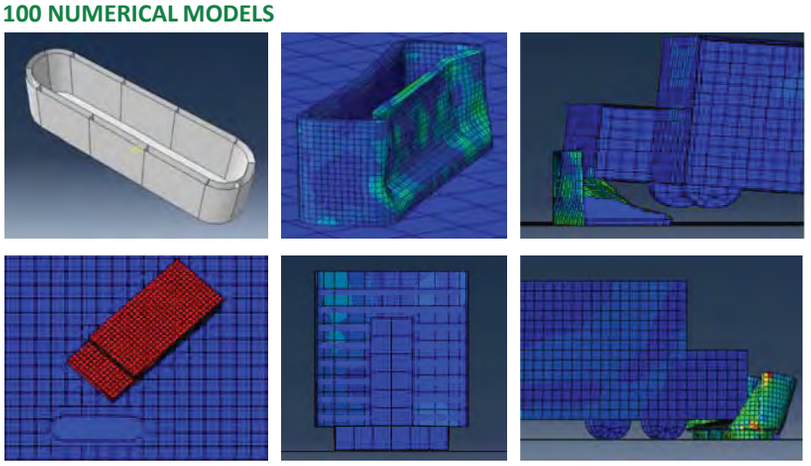


$$E_{total}(t_{initial}) = E_{total}(t_{final})$$

$$\frac{1}{2}mv^2 = \frac{1}{2}K\frac{1}{K^2}\frac{m^2v^2}{\Delta t^2} + \mu M_{eq} g \Delta x \longrightarrow \Delta x = \frac{1}{2\mu M_{eq} g} mv^2 \left(1 - \frac{1}{K}\frac{m}{\Delta t^2}\right) \longrightarrow \begin{matrix} \uparrow\uparrow \boldsymbol{\mu} \\ \downarrow\downarrow \boldsymbol{K} \end{matrix}$$

m = mass of the impacting vehicle; v = speed of the impacting vehicle; M = mass of the obstacle; K = stiffness of the obstacle; Δt = duration of the impact; μ = friction coefficient; M_{eq} = mass of the system after the impact (M for elastic impact, m+M for inelastic impact); g = gravity acceleration; Δx = displacement of the obstacle.

100 NUMERICAL MODELS

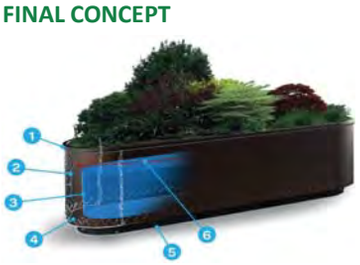


The obstacle is a **flowerpot** filled with water.

The following aspects were investigated:
- Different shapes (number of sheets, thickness of the sheets, distribution of the weight, production process)
- Different materials (for the flowerpot and the filler: steel, aluminum, concrete, lead)
- Different impact angles

➢ Explicit calculation
➢ SPH (Smooth Particle Hydrodynamics) methodology for water simulation

FINAL CONCEPT



M = 3600 kg (1550 kg water)
EASY TRANSPORTATION

1 Safety rubber border
2 Collapsible chassis
3 Shock absorption tank
4 Tyres puncturing device
5 High friction heavy base
6 Linking wires

EXPERIMENTAL CRASH TEST

RESULTS AND CERTIFICATIONS

m = 3500 kg v = 64 km/h

Obstacle		Displacement (m)
New jersey / cube	FEM	>30
Flowerpot	FEM & crash test	~4

✓ **PAS 68:2013** & **IWA 14-1:2013** standard certifications

AN EXAMPLE OF APPLICATION

ACKNOWLEDGMENTS Thanks to Ivan Adobati, Mattia Bonalumi, Pietro Servalli and Matteo Simone.

[1] PAS 68:2013 standard
[2] IWA 14-1:2013 standard
[3] AISICO certification, www.bdp-system.com/certification/certificazione-aisco/