Smart Transportation Alliance

Innovation in Road Equipment Systems: The case of lighting and signage poles

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1. Introduction

In 2014, a total of 25,700 fatalities were attributed to accidents on European roads[1]. Of these, 45% involved vulnerable road users such as pedestrians, cyclists and motorcyclists[2]. On average, one third of motor vehicle injuries are caused by off-road driving situations.

To **limit the severity of accidents when vehicles exit the roadway in run-off-road (ROR) situations, forgiving roadsides were created**. A set of European standards[3] has been published, which define the criteria to be fulfilled by roadsides to limit the adverse effects of human and physical factors in vehicle accidents.

Figure 1: A motorcyclist-friendly safety barrier manufactured by ArcelorMittal Ostrava is equipped with the lower guard strip that saves motorcyclists from severe injuries

The European safety standards require road equipment manufacturers to certify that their products comply with the standards (by applying the CE mark) before their road safety products can be placed on the European market. **This paper discusses the potential for even greater innovation in the area of on-road protection in forgiving roadways**.

Materials innovation should continue. Evaluating new products, processes and techniques to create more durable and environmentally friendly solutions are areas for infrastructure managers to look towards when taking decisions.

[1] European Commission. *How safe are your roads? Commission statistics show small improvement for 2014.* http://europa.eu/rapid/press-release_IP-15-4656_en.htm

[2] European Commission. Road safety in the European Union: Trends, statics, and main challenges. Marci 2015. http://ec.europa.eu/transport/road_safety/pdf/vademecum_2015.pdf

[3] European Transport Safety Council. *Forgiving Roadsides.* http://archive.etsc.eu/documents/bri_road5.pdf

2. Innovation for safety

While much has been researched and defined as to the length, endpoints and other aspects of forgiving roadways, there is a need to go further. The continued development of innovative road safety solutions is an urgent priority to reduce the number of deaths and injuries on European roads. These safety systems must be adapted to local traffic conditions both on highways and in urban areas.

The introduction of High Strength Steels has made steps to increasing innovation in road safety. These new grades of steel are enabling manufacturers to create high-performance road safety systems that save lives and reduce the risk of injury.

The **mechanical performance** of **High Strength Steel** grades is far better than that of commodity grades used in the past. For manufacturers, the micro-alloyed structure of High Strength Steels brings a positive impact on productivity. The performance of these grades is highly controlled, ensuring that every batch of steel will respond to manufacturing processes in the same way. This is especially beneficial when the production process includes profiling, stamping or welding.

The development of High Strength Steels provides additional advantages for road safety equipment such as **lighting and signage poles**.

One of the key requirements for lighting safety poles is an ability to sustain high wind loads, making these poles ideal candidates for the application of High Strength Steels. However, in an effort to strengthen the safety of the lighting poles through High Strength Steel there is a **potential threat of vehicle damage in the event of a crash**.

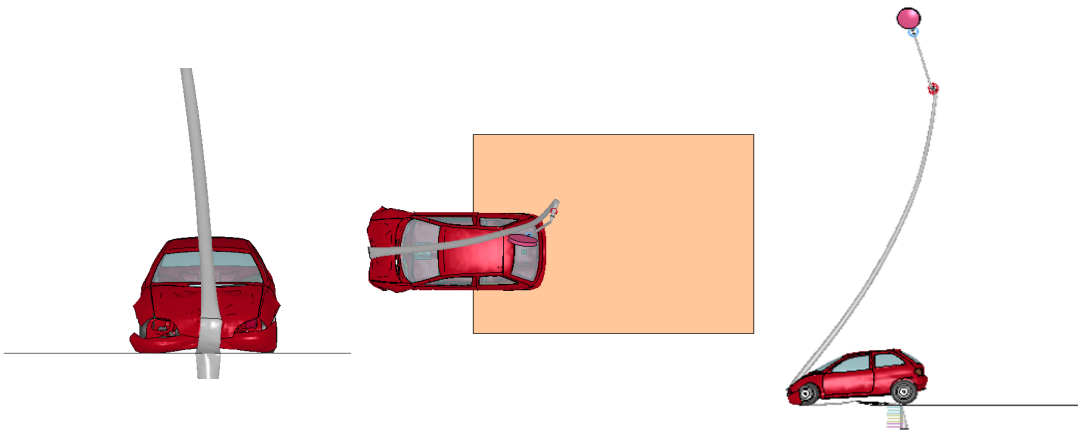

Figure 2: Example of an impact against a lighting pole

Erected support structures such as lighting poles can, under certain impact conditions, collapse and fall down, posing injury risks to road users and vehicle occupants. The severity of accidents for vehicle occupants is affected by the performance of these support structures

during impact. Based on safety considerations, support structures can be manufactured to behave in controlled manners to reduce the overall risk.

The support is not considered a 'hazard' if it has been positively tested in accordance with the **EN 12767 standard**. This European standard defines a methodology for determining impact safety performance and defines the presentation categories for these impact test results.

The European standard considers **three categories of passive safety support structures**: i) *high energy absorbing (HE),* ii) *low energy absorbing (LE)* and iii) *non-energy absorbing (NE).*

Impact speed, v_i km/h	50	70	100
Energy absorption category	Exit speed, v_e km/h		
HE	$v_e = 0$	$0 \leq v_e \leq 5$	$0 \leq v_e \leq 50$
LE	$0 < v_e \leq 5$	$5 < v_e \leq 30$	$50 < v_e \leq 70$
NE	$5 < v_e \leq 50$	$30 < v_e \leq 70$	$70 < v_e \leq 100$

Table 1: European Standard EN 12767 methodology for determining impact safety performance

Energy absorbing support structures slow the vehicle considerably and thus reduce the risk of secondary accidents with structures, trees, pedestrians and other road users. Non-energy absorbing support structures permit the vehicle to continue its trajectory, with limited speed reduction, after impact with the support structure. Non-energy absorbing support structures may provide a lower primary injury risk than energy absorbing support structures.

In addition, EN 12767 defines four levels of occupant safety based on the values of the Acceleration Severity Index (ASI) and the Theoretical Head Impact Velocity (THIV) calculated for tests at different speeds. They are shown in Table 2.

Energy absorption categories	Occupant safety level	Speeds			
		Mandatory low speed impact test 35 km/h		Speed class impact tests 50 km/h, 70 km/h and 100 km/h	
		Maximum values		Maximum values	
		ASI	THIV km/h	ASI	THIV km/h
HE	1	1,0	27	1,4	44
HE	2	1,0	27	1,2	33
HE	3	1,0	27	1,0	27
LE	1	1,0	27	1,4	44
LE	2	1,0	27	1,2	33
LE	3	1,0	27	1,0	27
NE	1	1,0	27	1,2	33
NE	2	1,0	27	1,0	27
NE	3	0,6	11	0,6	11
NE	4	No requirement	No requirement	See 5.6	

Table 2: European Standard EN 12767: Occupant safety level determination methodology

All of the impact tests use a light vehicle, with gross static mass of 900kg, in order to verify that satisfactory attainment of the impact severity levels is compatible with the safety for the occupants of light vehicles.

During an accident, the pole must behave in a way that **minimises the possibility of serious harm to the vehicle's occupants**. This means specifically limiting potential for impact with an occupant's head (**THIV criteria**).

One of the best strategies, in terms of manufacturing technique, to make 'forgiving' poles or posts compliant with EN 12767, is the selection of the right material.

The steel mechanical properties have a major influence on performance, in particular for Energy Absorbing Systems. The choice of adapted steel, together with appropriate geometry, offers the potential to increase and optimise the safety performance of this kind of product.

High Strength Steels have demonstrated that they represent an optimised and competitive solution. In order to demonstrate the benefit of using high strength steel grades for lighting columns as compared with basic steel grades, a comparative study has been performed. Virtual testing has been used to reproduce the impact of a 900kg car against a lighting pole, with **impact speed of 100km/h at an impact angle of 20°.**

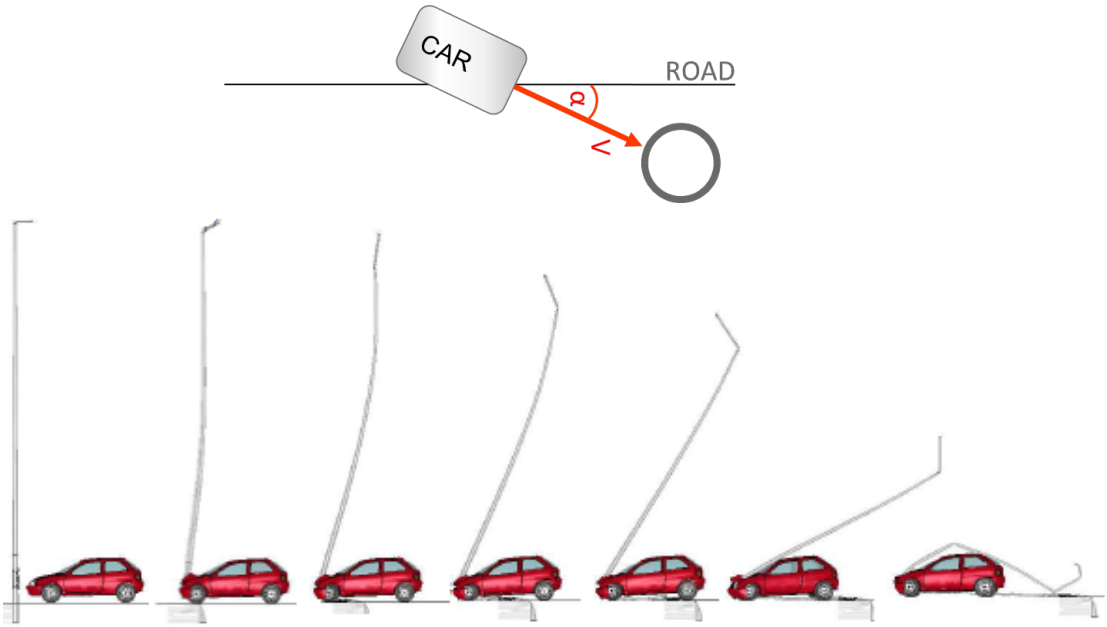

Figure 3: Sequence of an impact against a lighting pole

The graphs below show the results of this comparison in terms of ASI, THIV and exit speed

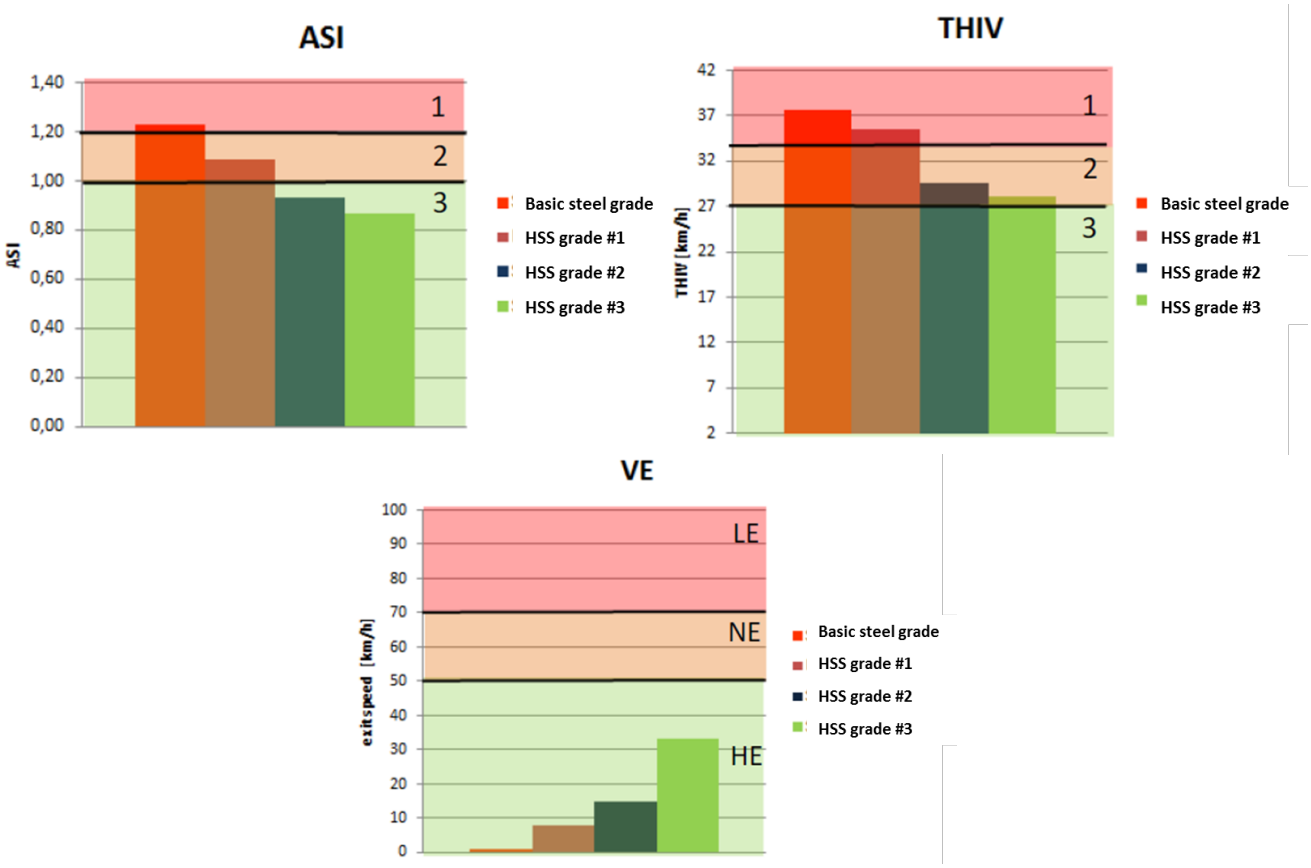

Figure 4: Compared performances of steel grades in relation to safety criteria

As confirmed by the outcomes of this study, the use of higher steel grade reduces the severity indices and can reach higher energy absorption categories. The energy absorption can be 50% more for higher steel grades as compared with common steel grades.

Based on this information and tests, **High Strength Steels increase the cost-effectiveness of designed solutions providing greater economic competitiveness** when compared to other materials.

In fact, High Strength Steels have tightly controlled mechanical properties that enable better energy absorption in the event of a crash and guarantee high performance of the product, ensuring reliable safety levels while significantly reducing a structure's weight.

Figure 5: A new innovative designed lighting pole without welding, coated with Magnelis® for better durability, absorbs the energy of a crash and saves lives. www.zippole.com

Moreover, traffic conditions are rapidly changing on European road networks. Heavy trucks weighing up to 44 tonnes have been introduced and in some areas, 60 tonne vehicles are authorised to use the conventional roadways. Sport Utility Vehicles (SUVs) have also grown in popularity over the last decade for personal use, however their accident behaviour differs in a substantial way from that of a conventional passenger vehicle.

Until recently, European standards have not included necessary provisions for these types of vehicles but some progress at the European committee level seems to be forthcoming. Solutions based on **High Strength Steels will probably be the indisputable answer to these new legislative requirements**, combining very high containment level and energy absorption capacity with a low severity index and limited deflection.

3. Ensuring durability

In addition to meeting safety requirements, transport infrastructure network owners are looking for more durable solutions to significantly decrease overall life-cycle cost from initial implementation. The steel industry has developed a **new generation of metallic coatings based on zinc-aluminium-magnesium alloys**. These coatings significantly enhance the durability of steel road safety equipment, and since 2015 have gained legal support through their introduction in the European Standard EN 10346 for metallic coated steels.

The coatings offer significantly enhanced durability compared to other commercial options. The thickness of the coating can also be significantly thinner than earlier corrosion-protection solutions like post-galvanisation processing.

Several European road administrations have already approved the use of zinc-aluminium-magnesium coating for road safety equipment and some others are on track for approval.

4. What's new? Sustainability!

Now and in the future, it is fundamental to consider sustainability in road infrastructure project management. In Europe, **standards** have been published and applied in different countries **to assess the environmental impact of construction products**. The most advanced is EN 15804, which defines the methodology required to produce an **Environmental Product Declaration (EPD)** for construction solutions.

For steel products, EPDs are a strong asset as they consider the benefits of recycling at end-of-life as part of the product's environmental performance (Module D of EN 15804).

An EPD dedicated to safety barriers that utilises High Strength Steels and new coating solutions will be published in the next months.

In the near future, owners of EU infrastructure networks will have a complete, standardised methodology to assess the environmental impact of their projects. This will enable them to evaluate different solutions for road equipment from a sustainability perspective.

The combination of safety improvements and the sustainability approach are giving rise to a real revival in road infrastructure engineering, which will enable further innovations.

The innovations above described are aligned with the Smart Transportation Alliance's vision, and allow for a greater focus on Smart Transportation Infrastructures that work with their surrounding environment. This will further reduce the overall impact on our ever more fragile ecosystems while providing efficient transport for people and businesses across the world.