Solar road studs:
an innovative solution to increase visibility and safety on South Africa's roads

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Illumination from raised solar road studs provides night-time visibility for up to 1 000 metres ahead

The solar cat's eye, made of tough polycarbonate material, has a low profile above the road surface and a 60-ton compression resistance

INTRODUCTION

Statistics reveal that South Africa has almost double the global average road death toll per capita, which is quite frightening considering our socioeconomic circumstances (Vanderschuren *et al* 2011). South Africa spends R52 billion on road crashes and fatalities annually; it is therefore clear that road safety investments are warranted (Tsedu 2009). Clear demarcation and visibility on our roads have proved to reduce accidents.

However, since the 1960s road lighting has remained largely unchanged, until the past decade, which has seen a rapid development in lighting, and technological advances made possible by the development of the LED (light-emitting diode). A LED is a semi-conductor that emits visible light when an electric current passes through it. LEDs are used in television and computer screens, and are now readily available as a light source, for example as light bulbs, down-lights, floodlights and for strip-lighting. LEDs are environmentally friendly and sustainable, as they are long-lasting (with a lifespan of 30 000 plus hours), efficient, cost-effective, cool, emit minimal ultra-violet light and are mercury free.

The potential of LEDs for use in the road environment is vast, examples of such applications being street lights, traffic lights, LED road studs, road signage and Intelligent Transport Systems (which use LEDs in message signs). LEDs have brought about a revolutionary wave of change to the way in which road lighting can be utilised. This article is about the use of LEDS in road studs and their potential to increase visibility and safety within the road environment.

LIGHT POLLUTION

Conventional roadway lighting causes considerable light pollution of between 35–50% of total light pollution of a city (Boyce *et al* 2009). Although street lighting provides increased visibility, it is a major contributor to light pollution, with up to 30% of roadway lighting not reaching the roadway. Current lighting options utilise vast amounts of electricity and are unnecessary (Luoma *et al* 2011). One method that is used to reduce electricity for street lighting is to switch off every alternate light. This is, however, more costly than the use of LEDs, as it results in a 17% increase in accidents and a 27% increase in roadside damage (Elvik *et al* 2009). Light from LEDs, on the other hand, can be directed to where light is required, thereby limiting unnecessary light pollution.

IMPROVING ROAD VISIBILITY

A 2002 study indicated that the main road factors contributing to road accidents were poor visibility (34%), sharp bends (17%) and slippery roads (17%) (Ojungu-Omara & Vanderschuren 2006).

According to *The Handbook of Road Technology*, "glare is formally defined as luminance greater than to which the eye is accustomed". Headlights, strong road lighting and high-pressure sodium lights cause a certain amount of glare which is distracting for drivers, dramatically affecting their visual perception (Elvik *et al* 2009). During the hours of darkness, a driver's visual environment and visual sensitivity are severely diminished, and these deteriorate further when glare is experienced, commonly from oncoming headlights (Elvik *et al* 2009). Drivers need the navigational guidance provided by the illumination of the roadway and its surroundings, such as pavements, centre-line and road edge delineation, to inform them of the current vehicle position and to navigate the road ahead (Elvik *et al* 2009).

Reflective road studs (cat's eyes) have been in use on South Africa's roads for more than 40 years to improve visibility at night. The problem with these conventional road studs, however, is that they only have a reflective portion and rely on car headlights for illumination. Reflective road studs do not allow the driver an effective reaction time, compared to solar road studs which illuminate the roadway for up to 1 000 m, thus improving the driver reaction time to potential hazards from three to thirty additional seconds when travelling at a speed of 100 km/h. Solar road studs would be helpful when glare is encountered as they would assist the driver in staying on the roadway by providing illuminated guidance in the event of glare from headlights, streetlights or other sources.

WHEN ARE SOLAR ROAD STUDS USEFUL?

At night

Statistics reveal a disproportionate number of accidents at night, compared to daylight hours, with multi-vehicle crashes twice as likely to occur, and pedestrian accidents four times more likely to result in a fatality (Lay 2009). At night a driver relies on light in order to navigate a roadway. In urban areas light is generally provided primarily in the form of street lighting, but in rural areas drivers rely solely on vehicle headlights to navigate the roadway ahead (Lay 2009). Reflective road studs are limited in their application as the reflective portion requires light to reach it in order to increase visibility, and studies done in America found that most driving is done with dipped headlights. The beam of a car's headlight when dipped is limited to 30–50 m (Elvik *et al* 2009) and up to 90 m with headlights on, and this is only made visible in the direction that the car is travelling.

According to Boyce *et al* (2009), "a bright road surface is obtained by directing beams of light up and down the road in such a way that sufficient light is reflected off the surface to reveal objects of uneven surfaces, whilst keeping glare at a minimum". Solar road studs effectively illuminate the road surface, providing greater vision and viewing distance at night. They do not require electricity and can feasibly replace overhead street lights.

In wet road conditions

Light is reflected off a wet road due to a water film, but reflections are further increased on an uneven road surface, creating a mirror-like effect which decreases visibility (Lay 2009). Certain street lighting creates glare, such as that produced from high-pressure sodium (HPS)

The hardwired LED stud is a 24-hour operational road stud for use at pedestrian crossings, speed bumps and intersections

A pedestrian crossing fitted with hardwired hybrid LED road studs lights. These patches form a T-shape if lighting levels are sub-optimum, and with a further drop in lighting levels the illuminated areas form a contrast between illuminated strips and darker shadows (Lay 2009). If the roadway is wet the illuminated strip transforms into a hazardous strip of mirrored light, which makes the detection of reflective road studs, traffic markings and objects in the roadway virtually impossible (Lay 2009). Solar road studs offer a solution by increasing visibility on roadways – they are actively illuminated, remaining brightly visible, even during wet conditions (Lay 2009). Car headlights illuminate objects directly along the roadway, while solar road studs provide the same function, but are self-illuminated and improve visibility for up to ten times the distance of the road ahead (Boyce *et al* 2009).

In fog and mist

Fog and mist cause a scattering of light particles, making light penetration harder. Solar road studs will illuminate the road for a minimum of double the visibility distance that car headlights provide in these conditions (Boys *et al* 1997). In severe fog conditions the increased visibility will therefore provide a minimum of double the time for a vehicle to react to potential road hazards. Solar road studs are effective in fog conditions as they are placed on the roadway and their (LED) light penetrates fog better (Boys *et al* 1997).

At pedestrian crossings

Well marked pedestrian crossings alert the driver to potential hazards, thereby ensuring driver and pedestrian safety (Zwahlen *et al* 1997). Solar road studs and LED hardwired studs are ideal for this purpose.

SOLAR ROAD STUD CASE STUDIES

In 2003 a two-year pilot project was carried out in KwaZulu-Natal (KZN), north of Durban along the R66, in which 7 800 solar road studs were installed along a 34 km stretch of road. Seven months prior to the installation 103 accidents had occurred, 88 of which were serious and resulted in 27 fatalities, and 15 less serious accidents (Reed 2006). The 103 accidents in question cost the South African government an estimated R27 million, while the solar road studs cost R5 million! According to the KZN transport department, night-time road accidents were reduced by 70% within 12 months of the installation of the solar road studs.

In Britain a six-mile unlit section of the M25 was fitted with 4 500 solar road studs as an alternative cost-effective solution to street lighting in providing improved driver visibility. UK research showed that when solar road studs are used, drivers are significantly less likely to cross solid centre-lines or move out of lanes on a dual carriageway, and they brake earlier and more consistently (Reed 2006). In addition to improved driver guidance, its application reduces carbon emissions and operating costs. This study indicates that solar road studs can provide the same functionality and level of illumination required for accident prevention as street lights, but at substantially lower cost.

Planned hybrid LED hardwired road stud test in Cape Town

Safety at pedestrian crossings needs attention, as 45% of road accidents in South Africa involve pedestrians (Tsedu 2009). Earth Power has recently developed a hybrid LED hardwired road stud to illuminate pedestrian crossings and improve road safety in general; the LED light is operational for both day and night to ensure safe crossing and increased visibility for pedestrians. When hardwired LED road studs are placed on either side of pedestrian crossings, results indicate that there is a reduction in the average speed of approaching vehicles and an increase in the number of motorists who stop at the crossing (Bullough *et al* 2009).

Hybrid hardwired LED studs are useful as they require minimal electricity and can be powered by mounted solar panels in remote locations if there is no available power source. The studs operate continually 24 hours per day, programmed by a controller that automatically dims the LEDs at night to reduce glare and provide effective illumination. Earth Power is currently consulting with a senior traffic engineer at the City of Cape Town to finalise a suitable trial site within the City to test the hardwired LED road studs.

CONCLUSIONS AND RECOMMENDATIONS

Road lighting is a crucial part of road design, and designers need to ensure the roadway is adequately lit to provide illumination of the road ahead and increased reaction time (Lay 2009). Solar road studs offer numerous benefits, as mentioned in this article.

Solar road studs should be of a high quality, have a high compression resistance and wide temperature range, and should be correctly suited to their application, be it on the road edge, curves, intersections, pedestrian crossings or centre-line markings.

The road sector should aspire to apply automatic integration of safety measures, as is standard in aircraft safety. Hence, road studs should be incorporated into designs as an additional safety measure. Installing and upgrading roads with the use of LED lighting and solar road studs or hardwired studs will make a vital contribution to the reduction in road accidents and the unacceptable burden they impose on society.

NOTE

The list of references is available from the editor. ◻

SOLAR ROAD STUD BENEFITS SUMMARISED

(Boyce *et al* 2009)

- Maintenance-free and fully self-contained
- Reliable and robust design
- Proven reduction of night-time accidents by over 70%
- Improved driver visibility – 10 times better than traditional reflective road studs
- Visible for up to 1 000 metres
- Visible in adverse weather
- Highlights sharp bends and road hazards well in advance
- Allows substantially more time to react and anticipate road conditions
- Eliminates the need for street lights, thereby reducing costs
- Environmentally friendly
- Reduces light pollution
- Reduces wildlife road kill

Solar road studs have a lifespan of three to ten years, depending on battery type, quality of materials, the installation location, and the number of LEDs.

Source:
http://www.saice.org.za/downloads/monthly_publications/2012/2012-Civil-Engineering-August/#/0