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Design of new traffic lights: Traffic safety and maintenance ease

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ABSTRACT

When a LED array needs to be replaced or a traffic light needs repair, the traffic in one lane must be interrupted and lifts are needed to elevate the repairman, with all the danger that this involves, in addition to the economic cost and the traffic disruption caused. We have designed an illumination system for a traffic-light model in which the LED array is located at the base of the traffic light and from this emerges a bundle of optical fibers connected to the illumination plate of the traffic light. We seek to improve traffic safety and possibly achieve lower costs.

1. Introduction

In the broad sense, traffic safety is one of the fundamental aims of traffic regulation. Road-traffic safety refers to methods and measures for reducing the risk that a person using the road network might be killed or seriously injured [26]. Traffic safety is associated with the automobile and everywhere this is a common concern which is becoming more and more demanding.

The value of setting targets to improve road safety performance was acknowledged in the OECD's report *Safety on the Road: What's the Vision?* [26]. Some subsequent research suggests that countries with quantitative targets perform better than countries without targets [34].

One of the undeniable consequences of traffic is that car accidents occur, which represent a high cost for society and accentuate the mandatory intervention of public authorities in the maintenance of road-traffic safety. According to the World Health Organization, more than a million people are killed on the world's roads each year [33]. Road safety always implies a risk, but if the safety levels reached were optimum, accidents could be minimized and this risk would be more controlled and acceptable. A constant effort is required from society to reach the steadily more stringent safety levels. Prevention is by far the best option [9].

Traffic accidents are a highly complex worldwide problem that directly affects public health, economy, and citizens safety [33].

There are approximately 1.2 million human deaths per year due to traffic accidents and some 50 million that cause traumatisms. Consequently, traffic is the third cause of mortality in the world, after cardiovascular disease and cancer [33].

Therefore traffic signs and signals are fundamental together with the knowledge and correct use on the part of drivers and pedestrians.

According to a report in the General Traffic Administration of Spain, in the year 2008, a total of 634 persons died in urban areas of the nation, 5,411 were seriously injured, and 58,237 sustained minor injuries. In urban areas in the same year, 38% of the mortalities were caused by pedestrians being run over, 24% by lateral and frontal-lateral collisions, and 14% by running off the road. With respect to 2007, the fatalities from back-end and multiple collisions were significantly reduced (−40%). On the contrary, the fatalities from lateral and frontal-lateral collisions increased (2%) [33,9].

Firstly, all the guidelines that seek to regulate the social phenomenon of traffic must fulfil two fundamental aims: safety and fluidity. Regarding safety, the government should ensure better roads and better vehicles and thereby reduce accidents, but especially programmes are needed to instil in drivers, from youth, civically proper and respectful habits behind the wheel.

Secondly, fluid traffic requires roads and vehicles that permit sufficient speed, within the limits of safety and require the human spirit of collaboration and courtesy as well as solid knowledge of traffic regulations, the principles of signs that direct traffic. These two aims, instead of complementing each other, are rather incompatible and therefore any traffic rule should seek to strike a balance between the two so that any manoeuvre in traffic can be safe as well as fluid.

An essential aspect consists of improving the flow of vehicles through the cities [23,29,31]. Some authors have analyzed the flow

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of vehicles by the use of simulators [15,18,20]. In the literature we can find works about traffic simulation based on both, macroscopic [23] and microscopic [29,32] traffic views.

However, nowadays there is a growing trend towards microscopic modeling of traffic flow [18,29]. Other traffic models are based on cellular automata. In this type of model, vehicles are represented within cells, and rules determine how and whether vehicles move [35,7,22,28,24,1,14,25,11,6,30,8,4].

The three fundamental factors in traffic are: the person (the human factor), the vehicle, and the road. Thus, traffic is a multifactorial system in which these factors interact. The road and the vehicle are the material instruments at the service of the driver, who must make the best use of them and who will have the final decision to manoeuvre in order to ensure safe, fluid, and orderly traffic.

The vehicle is not only a means of transport, but also an instrument for work, leisure, and even a symbol of social status and way of life. It forms an essential part of the daily life of a vast number of people who depend economically and socially on the motor vehicle. In reality, the automobile, as a defining element of our civilization, has two facets: a positive one, which includes all the triumphs that motor vehicles represent, and the negative, especially traffic accidents, which represent a tragic tribute to the freedom and progress of the modern technological society.

Traffic density, steadily growing, is the main cause of the high rate of accidents which is rising in direct proportion to the size of each city, although the most critical factor remains the human. Basically, traffic accidents can be fortuitous, due to human error, or caused by the traffic system, which is never perfect.

Vehicles as well as pedestrians should be guided and regulated for safe, fluid, orderly, and comfortable movement. Correct signposting has diminished accidents in the city. If we imagine for a moment a large city without traffic lights, a catastrophe would be inevitable. As technology advances and new studies in this field provide more data, traffic risks can be reduced, although human error can never be completely eliminated.

Public roads, used since antiquity, have become hostile for the individual due to the risks involved. These risks, as stated above, are due to the great density of current traffic and the velocity of the vehicles. Road safety depends on pedestrians as well as drivers, and therefore, it is vital to have correct signalling and sign posting as well as the proper use of these by the individual.

Traffic lights with LED technology comply with the European Guideline EN 12368 on traffic-regulation equipment [3,17]). This change has been important for different reasons: providing greater clarity, the traffic light is more easily distinguished at a greater distance; also, when a LED of an array ceases functioning, there is no need for an emergency repair, since, having multiple units, it can continue to illuminate; this represents a great advance in terms of preventing accidents and preserving citizen safety, both for pedestrians and for vehicles.

The group of LEDS is mounted on a panel and connected in such a way as to permit maintenance and greater safety in servicing the lights. Given that the colour is provided by the LED, the transparent diffuser, at the same time as protecting the diode panel, improves the optics, avoiding light emission upwards and downwards to the road surface.

However, when several units cease emitting light from a LED array, the repair requires the presence of several repair workers and the interruption of traffic, posing a certain risk for the worker as well as for the pedestrians and drivers. Similarly, for subsequent verifications, it is often necessary to use lifts, affecting traffic safety and fluidity.

Accelerated research, development and knowledge transfer is critical to the success of high-income countries seeking to move from current good practice and performance outcomes to the long-term "safe-system" goal of eliminating deaths and serious injuries on their roads. It is also critical to low and middle-income countries operating at far poorer levels of performance and aiming to move rapidly to current good practice outcomes and beyond, within far shorter timeframes than those previously experienced and suffered by high-income countries. Meeting these priorities will require knowledge transfer, which will play a pivotal role in the design and delivery of institutional reforms and interventions aimed at refocusing and scaling up country road safety programmes to more rapidly achieve higher levels of performance [2].

Taking into account all the above mentioned points our goal in the this work has been to design an illumination system for a traffic-light model in which the LED array is located at the foot of the light post and a bundle of optical fibers emerges and connects to the illumination panel of the traffic light. In this way, we seek to contribute to the improvement of traffic safety and possibly help to lower costs.

2. Material: Traffic lights

LED arrays comply with the European Guideline EN 12368 on traffic regulation [3] and the INTERNATIONAL STANDARD ISO 16508 CIE S 006.1/E First edition 1999-12-15 Corrected and reprinted 2000-11-15 (ISO 16508, 2010).

Here, we take a circular traffic-light model used for vehicles as these lights are the ones that require the most repairs and replacements of the LEDs. The model used is represented in the following figure. To measure the height of the traffic light, with its curved segment, we estimated the length of the arc, calculating 8.694 m. The measurements chosen for the calculations were 6000 mm of vertical column (H) and 4000 mm of horizontal extension (w), and a disk diameter of 200 mm (see Figs. 1 and 2).

The conditions of the emission angles were the same as in the INTERNATIONAL STANDARD ISO 165085 CIE S 006.1/E [17].

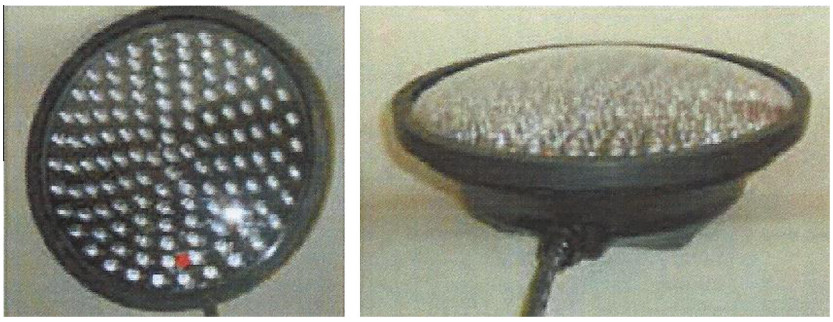

Fig. 1. Detail of the housing and the rubber joint of a traffic light of 200 mm in diameter.