TS AlInGaP LED Amber Lamps for In-Roadway Pedestrian Crosswalk Strobe Lighting

Application Brief I-006

Introduction

A major concern to traffic management engineers is the safety of pedestrians in crosswalks. This concern becomes especially acute for pedestrian crosswalks at non-signalized intersections and at mid-block crossings. Pedestrian and vehicle accidents, many of which cause fatalities, occur both during daylight and nighttime hours. In the majority of cases, the motorist involved was not aware the crosswalk was occupied and did not see the pedestrian until it was too late to stop.

Various attempts to illuminate pedestrian crosswalks during the day and at night have not significantly reduced the pedestrian and vehicle accident rate during nighttime hours. Pedestrian activated pedestrian HAND - WALKING PERSON traffic signals have been installed at some crosswalks to help assure pedestrian safety. These signals do reduce the pedestrian and vehicle accident rate, but have the negative effect of interrupting vehicle traffic flow for a time period after the pedestrian(s) are clear of the crosswalk. A dependSanta Rosa experienced 12 pedestrian in-crosswalk fatalities during this same period, six during the year 1991. Because of this high accident and fatality rate, the City of Santa Rosa is experimenting with a new technology that uses in-roadway amber LED strobe lighting. It identifies occupied pedestrian crosswalks to oncoming motorists.

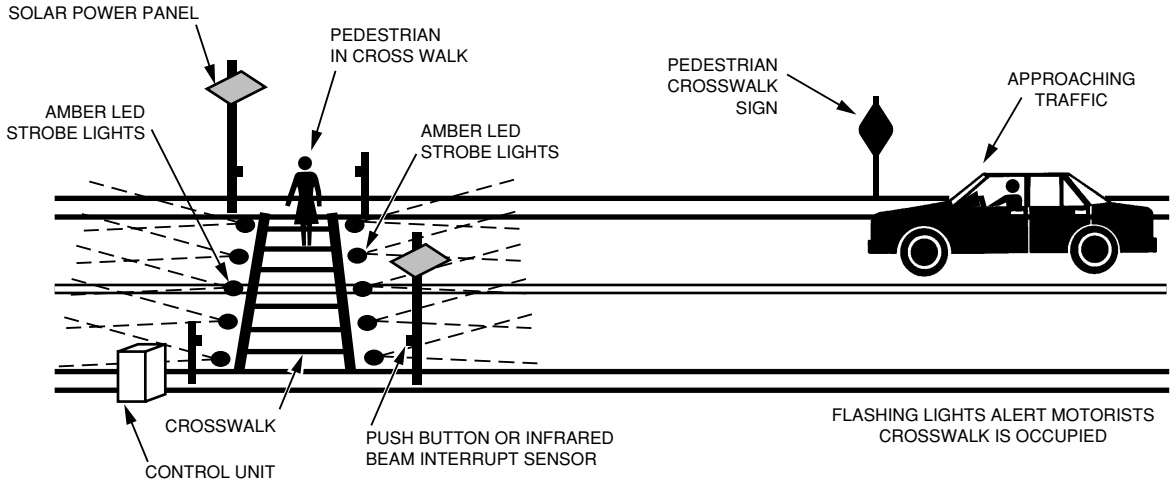

Figure 1. The Concept of In-Roadway LED Strobe Lighting for Pedestrian Crosswalks.

In-Roadway Amber LED Strobe Lights

Both sides of a pedestrian crosswalk are lined with amber LED strobe lights, placed in the roadway surface facing the oncoming traffic, as diagrammed in Figure 1. When a pedestrian enters the crosswalk, the LED strobe lights are activated. This occurs by either the pedestrian pushing a crosswalk button or by interruption of an infrared light beam across the entrance to the crosswalk. The flashing amber LED strobe lights alert oncoming motorists that they are approaching an occupied crosswalk and should immediately reduce the speed of their vehicles. The flash of the amber LED strobe lights is easily seen by the approaching motorists at a sufficient distance to permit vehicles to slow down and come to a safe stop. The down roadway viewing distance required for the amber LED strobe lighting is set to match the posted speed limit.

TS AlInGaP Amber LEDs Provide the Strobe Light Illumination

The light source selected for use in the in-roadway strobe lights is the HLMP-EL16, TS AlInGaP, 590 nm amber, 3700 mcd, 15°, T-1 3/4, nondiffused LED lamp. The following benefits that LEDs provide became the deciding factors to use a TS AlInGaP amber LED lamp over a xenon flash tube:

- Amber TS AlInGaP LEDs provide the best visibility for motorists at distances in bright sunlight and adverse weather conditions.
- The 590 nm amber color is the best for easy recognition by motorists who are red-green blind.
- TS AlInGaP LEDs are easily dimmable by pulse width modulation for nighttime viewing, eliminating the potential safety hazard of bright flashing lights.
- TS AlInGaP LEDs provide long term reliability and low maintenance, thus strobe lights do not require periodic changing.
- Low cost installation with containment of all electronics in one roadside cabinet.
- Easily designed LED drive circuitry eliminates EMI that can cause noise in vehicle radios.

One notable advantage of the use of LED strobe lights is the use of solar cell and battery power at roadway crosswalk locations where electrical power is not readily available. The efficiencies of the LED strobe lights permit operation off solar power during daytime hours as well as operation off battery power during nighttime hours. Should there not be sufficient sunlight during winter months, there is sufficient battery reserve to last for 30 to 60 days.

Construction of LED Light Module

Figure 2 shows a simplified cross sectional diagram of an LED strobe module. Durable Delrin construction of each test module housing withstands the weight of heavy vehicles in passing traffic. The window is of highly abrasion- and weather-resistant Hydex. Mounted on a small pc board on the inside are the TS AlInGaP amber LED lamps. Light from the LEDs passes through a lens assembly that focuses the light into an 8° beam. The modules have no active LED drive electronics.

Luminous Output

The luminous output from the amber LED strobe light units must be sufficient for a motorist to easily recognize the flashing LED strobe lights in bright sunlight condition along the full length of the motorist-viewing-distance-path. An array of 12 HLMP-EL16 TS AlInGaP LED lamps, at pulsed drive conditions, produces sufficient light output. Optical lensing placed in front of the LED lamp array focuses the LED emitted light into an 8° beam along the desired motorist-viewing-distance-path.
The ability of being able to dim the flashing amber LED strobe lights has shown to reduce the probability of being a hazardous visual distraction to motorists during nighttime hours. This decreases the possibility of a vehicle accident.

Control and LED Drive Electronics

A weather-proof cabinet contains the control and LED drive electronics by the roadside. The systems operate off 12 volt dc, supplied either from solar panels or by an ac-to-dc rectifier off the ac line. In this way, each bank of LED strobe light modules allows low voltage wiring in the roadbed. The control unit provides such functions as:

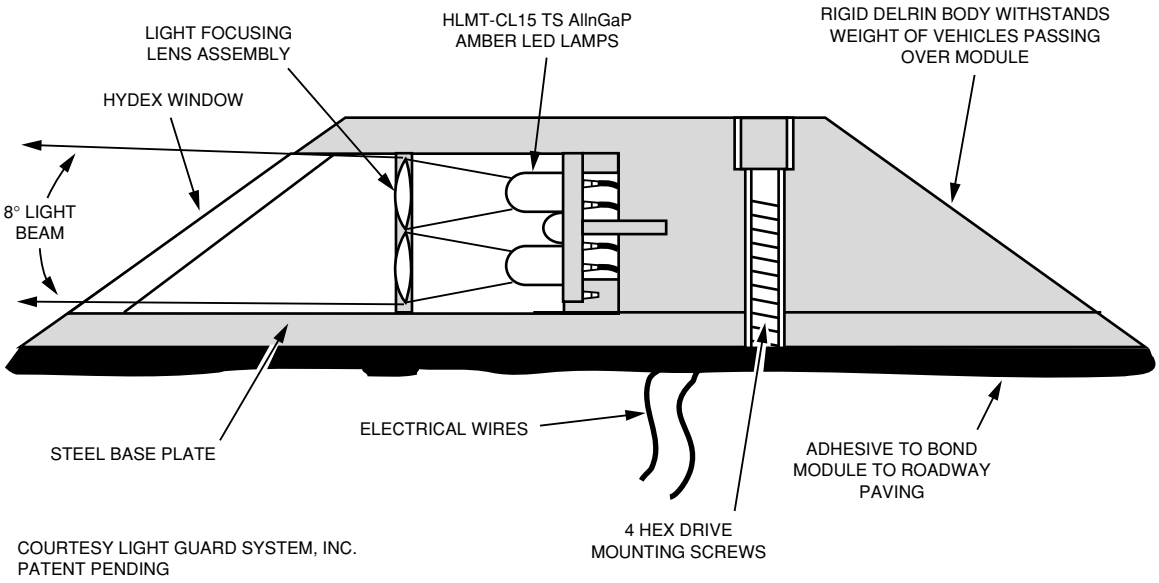

Figure 2. A Simplified Cross-Sectional Diagram of an LED Strobe Light Module.

- Pedestrian crossing data: Date, time, direction, total volume of pedestrian traffic.
- Adjustable pedestrian crossing time in 5 second intervals.
- Adjustment of LED flash rate.

Details of the Roadway Installation

The illustration in Figure 1 shows a mid-block crosswalk, across a four-lane roadway, that has a set of amber LED strobe lights along each side of a pedestrian crosswalk facing the oncoming traffic. The usual pattern is one LED strobe light located at the center of each traffic lane. One is located at the center of the roadway, and one near the parking lane. Placement on the roadway is designed to be outside the normal traffic tire travel wear pattern to reduce the wear abuse on the LED strobe light module housings. Any crosswalk pattern markings on the roadway surface are offset from the LED strobe light locations. The dark roadway surface acts as a contrasting background, enhancing the viewability of the amber LED strobe lights by motorists in bright sunlight conditions.

Figure 3 illustrates a conceptual two-lane, four-lane intersection. There are 14 LED strobe light modules along the two sides of each pedestrian crosswalk across the four lane roadway. There are 10 LED strobe modules along the two sides of the crosswalks across the two lane roadway. The outer-most LED strobe modules are placed in the parking lanes, angled inwards so as to be easily seen by motorists down the roadway.

Both sets of amber LED strobe lights flash simultaneously to signal motorists approaching from both directions that the crosswalk is occupied. They have a flash rate of once every 900 ms (300 ms ON and 600 ms OFF). The light beam angles are 8°, horizontal and vertical, to cover the down roadway motorist-viewing-distance-path. The anticipated cost of the in-roadway LED strobe lighting for a pedestrian crosswalk is about 1/5th the installation cost of conventional HAND - WALKING PERSON pedestrian signals. Costs can be as high as $100,000 for eight pedestrian signal heads at a large 4-way intersection.

Minimum Length of the Motorist-Viewing-Distance-Path

The minimum stopping distance on dry pavement, for the posted speed limit, determines the minimum physical length of the motorist-viewing-distance path. This minimum stopping distance includes a motorist decision distance, based on a one second reaction time, plus the necessary speed deceleration distance required to come to a complete stop as listed in Table 1.

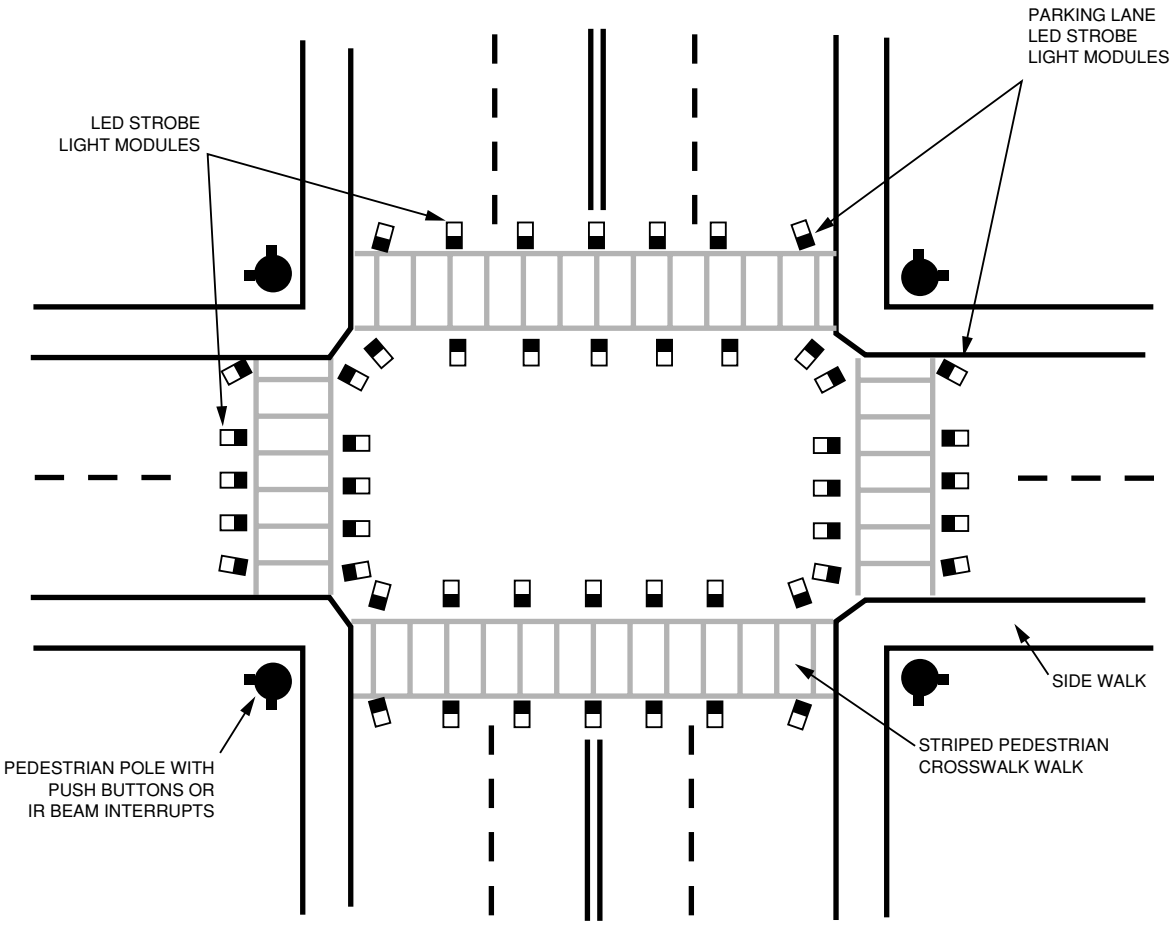

Figure 3. A Conceptual Two-Lane, Four-Lane Intersection LED Strobe Light Installation.

As an example, as determined from Table 1, the minimum motorist-viewing-distance-path on dry pavement for a roadway with a 35 mph speed limit is 161 feet. This distance would allow a motorist to visually recognize the flashing lights, slow down, and, if necessary, bring his/her vehicle to a complete, safe stop before traveling into the crosswalk area.

Development and Field Testing at Santa Rosa, California

In-roadway amber LED strobe lighting to identify occupied pedestrian crosswalks to oncoming motorists is under development by Light Guard Systems of Windsor, California, and is being field tested by the City of Santa Rosa, California. The field testing program, (6 to 12 months study during calendar years 1994 and 1995) is strictly to determine if in-roadway pedestrian strobe

Table 1. Minimum Vehicle Stopping Distance on Dry Pavement

Posted Speed Limit	1 Second Reaction Time	Braking Distance	Total Stopping Distance
25 mph	37 feet	53 feet	90 feet
30 mph	44 feet	81 feet	125 feet
35 mph	51 feet	110 feet	161 feet
40 mph	59 feet	143 feet	202 feet
45 mph	66 feet	184 feet	250 feet
50 mph	73 feet	227 feet	300 feet
55 mph	81 feet	271 feet	352 feet
60 mph	88 feet	323 feet	411 feet

lighting will significantly reduce vehicle and pedestrian accidents in crosswalks, by providing ample warning to motorists.

The reader must understand that in-roadway amber LED strobe lighting of pedestrian crosswalks is in the preliminary stages of development and testing. It has not been proven effective in reducing accidents or approved for use by agencies such as the California Traffic Control Devices Committee (CTCDC) and the Federal Highway Administration. (FHWA).

The City of Santa Rosa has identified three pedestrian crosswalks for installation of in-roadway amber LED strobe lighting and field testing. All three locations are at non-signaled intersections, selected on the basis of a high pedestrian and vehicle use. Two locations are at elementary school crosswalks, one location at the Proctor Terrace School on Bryden Lane and the other at the Matanzas School on Yulupa Avenue. The other location is the crosswalk at Howarth Memorial City Park on Summerfield Road, a busy four-lane roadway where a number of fatal vehicle/pedestrian accidents have occurred. Installation at the two elementary school crosswalks was completed in 1994. Installation at the Summerfield Road location was completed in April of 1995.

Preliminary results from the two elementary school locations have been very positive. Motorists polled agree that indeed the in-roadway amber LED strobe lighting does catch their attention and they do then slow down, looking for a pedestrian in the crosswalk in front of them.

Motorists have also indicated the excellent viewability of the in-roadway flashing amber LED strobe lights in foul weather conditions (e.g., during a heavy rain or in fog). The lights provide ample warning when the crosswalk is occupied. School children at the two elementary school crossings have observed motorists no longer "zoom" by their school, but slow down significantly when the in-roadway amber LED strobe lights are flashing.

Motorists familiar with the two school crosswalks that have the amber LED strobe lighting installed indicate they do tend to drive slower when approaching the crosswalk. They anticipate the flashing lights coming on as a pedestrian (school child) steps onto the crosswalk in front of them.

The City of Santa Rosa, Caltrans, and FHWA will be evaluating the results of this field testing program. Should the results be positive, the CTCDC could approve the installation of amber LED strobe lighting at all pedestrian crosswalks in the State of California. Based on this, FHWA could make LED strobe lighting for pedestrian crosswalks a standard throughout the United States. It would also necessitate the need for written standards to be adopted, and published in the *Manual on Uniform Traffic Control Devices.*

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