Joint Transportation Research Program

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Workzone Lighting and Glare on Nighttime Construction and Maintenance Activities

Introduction

Roadway projects, including asphalt paving and milling, are often staged at night to reduce inconvenience to road users, give work crews less traffic to protect against and help crews meet tighter project deadlines. However, there are safety challenges with nighttime operations. Examples of such challenges include adequate lighting to ensure the safety of workers and motorists and appropriate lighting for work activities. In addition, it is harder to see and be seen at night.

This study describes the results of qualitative analysis of work zone incidents in maintenance projects recorded by INDOT between 2016 and 2020. The incidents include safety events that involved INDOT's employees, vehicles, and pieces of equipment and resulted in motor vehicle crashes, road-worker injuries, incidents, and near misses. Through on-site experiments, the report also discusses the determination and evaluation of disability glare on nighttime work zones and provides lighting-related guidelines to reduce disability glare and hence improve the safety of workers and motorists during nighttime highway construction and maintenance projects.

Roadway construction lighting systems.

Findings

This study analyzed work zone incidents during daytime and nighttime roadway operations on INDOT maintenance projects during a 2016–2020 time frame. Analysis of data from these projects indicated that most INDOT workers' injuries and motor vehicle crashes occurred during daytime hours. A lower percentage of crashes occurred during nighttime shifts that could have been in darkness depending on the time of year. During nighttime shifts, there were typically fewer vehicles on the roadways, compared to daytime traffic volumes and hence, lower exposures of workers to motorists. Most worker injuries resulted from worker strains and sprains, followed by workers getting struck by vehicles or equipment or falling, slipping, or tripping at the work zone. Most of the motor vehicle crashes were linked to privately owned vehicles (POV) striking INDOT vehicles or equipment. The next most common vehicle crashes were single INDOT vehicles or equipment involved in a damage incident without other vehicles or equipment being involved, and INDOT vehicles or equipment

striking other INDOT vehicles or equipment, building, fence, or other INDOT-owned structure. Most of these POV-struck INDOT crash types involved intrusion of POV drivers into the work zone, resulting to a greater extent in a rear-ended collision with a trailer-mounted attenuator (TMA).

The study provides practical recommendations to INDOT and roadway contractors in Indiana regarding optimal lighting arrangements. Findings from the on-site experiments indicated that an increase in mounting heights of both balloon lights and light towers (LED and metal-halide) resulted in significant reduction of veiling illuminance ratio values, which represent disability glare levels. Compared to "perpendicular" and "away" orientations, orienting the light towers in a "towards" direction (45 degrees) significantly increases the disability glare levels of the lighting arrangement. Increasing the tilt angles of luminaires of the LED light tower also resulted in an increase in veiling luminance ratio values. The observer's age factor "*k*" plays an important role in determining the veiling luminance. As the factor *k* increases, the veiling luminance (and hence, disability glare value) also increases.

Implementation

Selecting a proper mounting height for lighting systems that use metal-halide or LED light sources is vital to control or reduce glare in work zones. Owners and general contractors should raise the light towers to mounting heights greater than 18 ft. (5.5 m) and up to the full extension of the light mast (typically 30 ft. or 9.1 m) to minimize disability glare levels. Selecting proper mounting height for balloon lights can also help prevent higher disability glare levels, but most importantly, choosing the equipment's power output is critical.

Aiming light towers in the direction of the traffic movement should be avoided whenever possible. However, if this condition is not met, the light tower must be fully extended with the luminaires aimed at least 45 degrees from the horizontal.

LED light towers would be preferred over metal-halide light towers in the "towards" and "perpendicular" orientations due to the lower values of veiling luminance ratio values they generate in each orientation.

Luminaires of light towers should be aimed so that the angle formed by the nadir and the center of the luminaire's beam spread should not exceed 60 degrees. For metal-halide light towers, an angle of luminaires less or equal to 45 degrees is recommended to reduce higher disability glare levels. For LED light towers, all luminaires should be aimed at angles of 60 degrees or less below the horizontal to minimize glare.

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