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HIGH-MAST LIGHTING

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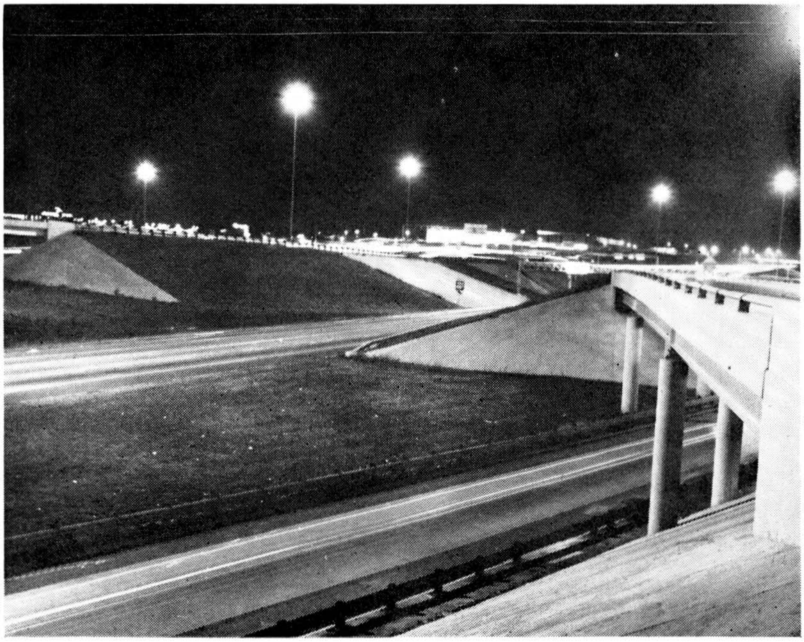

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High-Mast Lighting

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Introduction

High-mast lighting is a term coined to describe the application of the area lighting concept to highway interchanges and complex intersections. Although high-mast lighting is recognized as a "popular new concept," it is the application rather than the concept that is new. The concept dates back to the 1800's when tall masts were installed in several cities to illuminate large areas and thus provide a pleasant nighttime environment.

The first known application of high-mast lighting to highways was the Heerdter Triangle installation in Dusseldorf, Germany, in the late 1950's. It was followed by installations in other European countries, including Holland, France, Italy, and Great Britain.

Interest in high-mast lighting in this country was stimulated by the successful applications in Europe and the increasing difficulty of lighting some highway interchanges by conventional methods. The Texas Highway Department requested an investigation of high-mast lighting applications be made within Research Study 2-8-64-75, a roadway lighting research study already underway at TTI, and under the sponsorship of the Texas Highway Department in cooperation with the U. S. Department of Transportation, Federal Highway Administration.

The High-Mast Lighting Concept and Objectives

The principal task in applying high-mast lighting to highway interchanges is to synthesize the visual advantage provided the driver by daylight. This visual advantage consists of being able to see all things pertinent to the driver decision-making process well in advance so that he may assimilate the information, plan his maneuvers and execute them in an orderly fashion. Among other things, it requires that he be able to distinguish roadway geometry, obstructions, terrain and other roadways, each in its proper perspective.

In order that high-mast lighting may accomplish the principal task as described above, the system must provide:

1. Adequate illumination to reveal the roadway geometry;

2. Adequate illumination for visibility of objects within the roadway;

3. Adequate illumination on areas other than roadways for proper orientation, perspective, and speed and distance judgments;

4. Good uniformity of illumination and brightness, especially on roadways; and

5. Minimum discomfort and disability glare.

The objectives of the research on high-mast lighting were:

1. To determine the desirability of lighting interchanges with high-mast lighting;

2. To develop a system of light sources, supporting hardware, and design procedures for lighting interchanges with high-mast lighting;

3. To test the prototype system through application under actual operating conditions; and

4. To recommend guidelines for the design of high-mast lighting based on observations of test installations.

It should be recognized that this research was strongly oriented toward applications. Time, funding and specialized technical competence did not permit an exhaustive laboratory and theoretical investigation of all the underlying ramifications of lighting, visibility, physiological and psychological aspects of the problem. Rather, a subjective approach was taken most frequently in the evaluation, utilizing technical data on light distributions and glare effects. This seems justified when specialized technology has not yet been able to develop measurement techniques and apparatus to measure the relationships of illumination and visibility in a practical sense.

Research and Development of High-Mast Lighting

About the turn of the century, the city of Austin, Texas, traded a narrow-gage railroad for a number of 150-foot towers and installed them at several points throughout the city where artificial "moonlight" was desirable. Although the light sources have been changed with advancement in technology, most of the towers are still used effectively. The effectiveness of the Austin "moonlight" towers was an added incentive to this study, and preliminary studies in this research were made with the Austin towers. The six 400-watt mercury vapor lamps used in the towers at the time were replaced with six 1000-watt mercury lamps for test and observation. The results of this preliminary study are reported in Research Report 75-4.

Following the favorable results of the Austin study, a portable antenna tower, capable of 100-foot mounting heights, and a prototype 100-foot steel shaft with hoisting mechanism, were erected at the Texas A&M Research Annex for detailed photometric studies. The studies resulted in the development of a prototype illumination system consisting of ten 1000-watt mercury vapor floodlights mounted at 100 feet. This prototype system was carried to a partially complete interchange in Fort Worth for field observation. It was the consensus of approximately 40 representatives of various governmental agencies that the high-mast lighting concept was very desirable and feasible.

A second field observation was conducted at a diamond interchange on IH 45 in Huntsville, Texas, using two 100-foot towers and the above described floodlight system. Again, the results were very favorable as judged by a large group of professional people representing several disciplines of the highway industry.

On the basis of the results of these field observations, a decision was made by the Texas Highway Department to install high-mast lighting in an interchange for detailed field study. Two such installations were planned, one at a small cloverleaf interchange on IH 30 near Texarkana, and one at a complex cloverleaf-directional combination on IH 10 in San Antonio.

Concurrent with the construction of the above installations, the 100-foot steel shaft was modified to provide a mounting height of 150 feet and improved hoisting capabilities for servicing. This new equipment provided field experience for future design work and permitted collection of photometric data for mounting heights up to 150 feet. On the basis of these latter data, one tower at the Texarkana installation was changed to a height of 150 feet. All other towers at both locations were 100 feet in height.

The installation of high-mast lighting at the IH 30 - US 59 interchange near Texarkana consisted of one 150-foot tower with ten 1000-watt floodlights and four 100-foot towers, each equipped with six 1000-watt floodlights to light one quadrant of the interchange. This design provided a measured average intensity of approximately 0.30 horizontal footcandles on roadway surfaces at an average-to-minimum ratio of 2.9 to 1.0.

A subjective-type diagnostic study conducted at the interchange resulted in the following findings:

1. With high-mast lighting, visibility and sight distance were increased, and the geometric features of the interchange were revealed in time to react in a rational manner;

2. Highway signs were easy to read, and decision points such as exit and entrance ramps were easily recognized with high-mast lighting;

3. Drivers were able to better judge the relative positions of their vehicles on the interchange with high-mast lighting, and could merge more easily into the traffic stream;

4. Higher levels of illumination in all areas and greater uniformity should be provided;

5. Lower aiming angles of individual floodlights should be used to reduce glare effects (45 degrees or lower); and

6. More strategic placement of masts should further reduce glare effects.

A relative cost comparison was made between high-mast lighting and conventional lighting for the Texarkana installation. This comparison indicated a considerable saving in the use of high-mast lighting as compared to conventional lighting designs.

The San Antonio installation consisted of twenty 100-foot high-mast units in combination with conventional 1000-watt luminaires dual-mounted in the median at 50-foot heights on the connecting roadways. One approach to the interchange had been lighted previously with 400-watt luminaires side-mounted at 30-foot heights.

A subjective-type diagnostic study of this installation resulted in the following findings:

1. High-mast lighting is definitely superior to other types of lighting for interchange areas;

2. Distances are easier to judge with high-mast lighting;

3. High-mast lighting provides a high level of driver comfort;

4. Uniformity of illumination is the most important quality of a lighting system, with glare and intensity level also important;

5. Glare was a minor problem at the installation, particularly in the directional interchange area. Spacing of masts should be reduced to permit lower aiming angles of individual floodlights, thus reducing glare effects;

6. The location of certain masts put the light source in the direct line of sight of the driver and caused some conflicts with overhead signs. Careful attention should be given to the location of masts to avoid conflict with overhead signs, and to reduce glare; and

7. Mounting heights should be increased to 150 feet to reduce glare and improve uniformity.

Comparison of Floodlights With IES Type V Luminaires

At approximately the time of the Texarkana and San Antonio construction, a system of high-mast lighting was being installed in the Auburn interchange near Seattle, Washington. The Auburn installation utilized a prototype IES Type V luminaire with metal halide lamps. Subsequent to their use in the Auburn interchange, samples of the Type V luminaire were obtained for test and evaluation at the Texas A&M Research Annex. Measurements of light distribution were made for combinations of 4, 6, and 8 units mounted at 150 feet and equipped with 1000-watt clear mercury and 1000-watt metal halide lamps.

The Type V luminaire has provisions for changing the light center spacing relative to the reflector. Changing the location of the light center changes the distribution of light from the luminaire. The angle from nadir of maximum candlepower can be varied from 55° to 63°.

The floodlight system is much less critical in spacing of masts because of the flexibility provided in the aiming capability of the floodlights. With the Type V system, once the location of the mast is established, the light distribution is fixed, except for the adjustment in light center spacing. This makes it more difficult to control the uniformity of illumination on the roadway.

The Type V luminaire system provides the advantage of "redundancy" in light sources. A "burn-out" of one light source results in an over-all reduction in illumination rather than leaving a "hole" in the distribution. The floodlight system has a similar characteristic because of the overlapping of patterns from adjacent units, but is less effective because it lacks complete redundancy. Because of the complete redundancy, the Type V system permits greater flexibility in scheduling maintenance of the system.

The designer using the Type V luminaire cannot meet the uniformity requirements as recommended in this report without exceeding the average illumination significantly. On the other hand, a significant increase in the average illumination level will permit a relaxation in the uniformity ratio. In no case, however, should the uniformity ratio be greater than recommended by AASHO for conventional lighting.

Recommendations for Implementation

The research and development work at the Texas A&M Research Facilities and the full-scale experimental installations at Texarkana and San Antonio, as well as in other states, have provided a great amount of information on the application of the high-mast lighting concept in interchange areas. This section of the report presents tentative guidelines and recommendations for implementation, with the expectation that early design practice will dictate changes in these guidelines. Although many of the studies on which these recommendations are made were subjective in nature, these guidelines can be presented with the confidence that the underlying subjective evaluations were made by professional people with extensive experience in various highway-related disciplines.

Design values given in these guidelines should be treated as minimum values, and should be used only where "conditions are ideal." The values should be increased as extenuating circumstances prevail.

1. Average Light Intensity

Acceptable light distributions can be achieved using mounting heights of 100 to 150 feet. However, mounting heights of 150 feet provide a better distribution and aid in the control of glare. The high-mast installations in Texas and South Dakota (8) have provided average intensities of 0.25 to 0.35 horizontal footcandles. In general, the evaluations have shown that little additional illumination is needed. On the other hand, AASHO recommends a minimum average intensity of 0.6 horizontal footcandles (9) for continuous freeway or interchange lighting with a uniformity ratio as great as 4:1, average-to-minimum. By controlling the uniformity ratio more rigidly, it is felt that a lower average intensity can be utilized to achieve equivalent visibility conditions. Hence, the following recommendation is made:

Average Intensity: 0.5 hor. ft-c.

For areas other than roadway surfaces the average intensities should equal or exceed 0.10 hor. ft-c.

These values should be increased accordingly as any of the following extenuating circumstances prevail:

a. If a high average intensity is maintained on any connecting roadway. There is no positive rule, but the average intensity of illumination on roadways in the interchanges should be at least one-half and preferably two-thirds that on the connecting roadway.

b. If there is a relaxation in the uniformity requirements given below, the average intensity in the interchange is no better than the connecting roadway, then the average intensity in the interchange should at least equal that on the connecting roadway.

c. If there is (or expected to be) competitive lighting from adjacent development, the light levels in the interchange should be increased accordingly. Once again, there is no positive rule, but it should be recognized that lighting effects are relative, and a brightly lighted adjacent area will make a normally good lighting installation completely inadequate. On this basis, roadway lighting should be made competitive.

2. **Horizontal Illumination**

Maintain adequate horizontal illumination through limiting the spacing-to-mounting height ratios to 3:1 to 5:1.

3. **Uniformity of Illumination**

a. Average-to-minimum ratio—2 to 1

b. Maximum-to-minimum ratio—4 to 1

4. **Glare Control**

High-mast lighting should be given the same consideration as conventional luminaires in glare control. The control of candlepower distribution of semi-cutoff luminaires is described in the ASA Standard, "American Standard Practice for Roadway Lighting" (10).

5. **Placement of Masts**

The masts should be located as far as practicable from the travel lanes to reduce the fixed object hazard potential and to minimize the effect of glare. Also, there is an optimum location of the mast relative to the roadway so as to provide the most uniform light level on the roadway. In addition, careful consideration should be given to placement of the mast to assure that the light source is not directly in the line of sight of the driver.

6. **High-Mast Supports**

Both poles and towers have been used on high-mast lighting installations with apparent equal functional capability. Manufacturers now offer both as a "package deal," including lowering assemblies and other mounting hardware. The decision as to which type to use is a decision of local influence and should not be relegated to guidelines and practices.

7. **Mounting Assemblies**

There are three basic methods available for mounting high-mast light sources, described as follows:

a. Light sources fixed at top of mast; provisions are made for climbing the mast for service and maintenance.

b. Light sources fixed at top of mast; provisions are made for a motorized personnel carrier to transport serviceman to light sources for service and maintenance.

c. Light sources mounted on a lowering assembly with a motorized winch to facilitate lowering and raising of lighting assembly for service and maintenance. There are several versions of this latter method available. Some have locking mechanisms and power connections at the top while others provide continuous cable suspension for the lighting assembly and a continuous power supply line, connected at the base.

Once again, the selection of the method of mounting is largely dependent upon local influences and preferences.

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