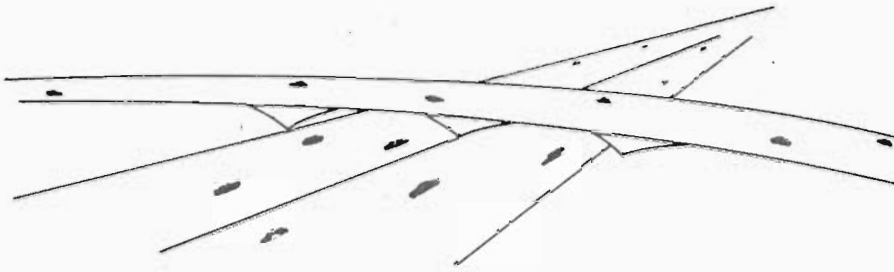

DEPARTMENTAL RESEARCH

Report Number SS 22.1

Z-PATTERN HIGH-MAST FREEWAY ILLUMINATION

STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION

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16. Abstract

The modification of existing freeways in Houston to accommodate busways necessitated the removal of existing lighting. Low-mast lighting would be costly and inadequate. This report describes the design of a high-mast lighting system for the Gulf Freeway and the consideration of such problems as variable ROW widths, curvilinear roadway geometrics and changing grade lines, and sections varying from at-grade main lanes flanked with frontage roads to sections with at-grade main lanes and frontage roads with elevated express lanes in between.

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Z-PATTERN HIGH-MAST FREEWAY ILLUMINATION

Special Study Report
No. SS 22.1

by

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Texas State Department of Highways and Public Transportation

January, 1980

This report is published in cooperation with the Federal Highway Administration. The contents of this report reflect the views of the author, who is responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Federal Highway Administration or the Texas State Department of Highways and Public Transportation. This report does not constitute a standard, specification or regulation.

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Houston has for years been growing at a tremendous rate. With the explosive growth of the city, the traffic problems have grown far in excess of the urban planners' predictions. In 1973, it became apparent that some existing freeways would have to be modified to include some form of mass transit facilities. Interstate Highway 45 (Gulf Freeway) from the Central Business District to I.H. 610 (South Loop Freeway) was selected as the first facility to be modified to include a busway in the central median. If this five mile long project is successful, other freeways may be similarly modified.

The freeway modifications to include the busway required the removal of the existing lighting system. It was apparent that a low mounting height lighting system would be very costly and would not provide adequate lighting. The usual freeway lighting system for Houston consists of 50' mounting height, twin arm steel lighting standards, mounted within the confines of a non-yielding high strength steel median rail and spaced at approximately 300 feet. The poles in the older systems were equipped with 1000 watt mercury vapor luminaires, with a modified I.E.S. Type III distribution. The newer systems have the more efficient 400 watt high pressure sodium luminaires.

The decision was made to design a high mast lighting system for the freeway. At that time, the standard usage of high mast lighting was for master multi-level interchanges and not for tangent main lane sections. The high mast designs produced either symmetric or asymmetric lighting patterns using mercury vapor or high pressure sodium units. The freeway modifications required keeping the freeway median clear of obstructions, thus requiring the placement of the lighting standards along the right of way lines. The project was laid out using symmetric and asymmetric high pressure sodium units at varying mounting heights. A study of the lighting layout showed that the system, as laid out, would produce numerous objectionable results such as poor uniformity, dark spots, excessive spill light, excessive back light and glare. Part of the problems mentioned resulted from variable right of way widths (350' to 450') and curvilinear roadway geometrics with changing grade lines. In addition, the roadway sections varied from the usual at grade main lanes, flanked with frontage roads to sections with at grade main lanes, and frontage roads with elevated express lanes between them, in other words, a dual-dual facility. The General Electric Company and the Holophane Company assisted in the original layouts and computer runs.

Because of the inability of the then known lighting systems to produce an acceptable lighting system, a development program was set up under the direction of the Texas Department of Highways and Public Transportation's Houston Urban Project Office.

Personnel of the department's Materials and Tests Division and the Highway Design Division were to assist in the development, testing and evaluation. The testing was to be done with the assistance of personnel of Texas Transportation Institute of Texas A & M University at T.T.I.'s Research Annex located in Bryan, Texas. The Annex facilities had been used before in several lighting research and development projects. The facilities included a 400' x 5000' concrete area and a 150' free standing pole equipped with a lowering ring designed to accept numerous types and sizes of lighting units. Funding for the development project was provided through Interagency Contract No. IAC (74-75)395 and work started in April, 1974.

Previous work had determined that an acceptable system to fit the many conditions and constraints could only be accomplished with directional floodlights using several beam widths and aiming angles. Study showed that if a "Z" pattern could be developed, the pattern would eliminate or diminish glare in the oncoming motorists' eyes (a goal that traffic engineers and lighting engineers have been trying to achieve since the inception of roadway lighting). Preliminary computer arrays by G.E. indicated that it might be possible to produce the desired pattern and light the freeway from R.O.W. to R.O.W. with eight 1000 watt H.P.S. floodlights mounted at 150'. G.E. furnished eight units for testing. Varying beam spreads could be obtained by using various reflectors and socket settings.

Tests were run at mounting heights of 100', 125' and 150' using many different beam widths, aiming angles, louvers and side shields. Finally, after 2-1/2 years of work, the desired system was developed. The system consists of six 1000 watt high pressure sodium floodlights. The narrow beam units on the left side (facing the roadway) form one leg of the "Z" by illuminating from the median to the far side of the system in the direction of travel. The narrow beam units on the right side illuminate from the right of way line to the median again in the direction of travel. The medium beam units fill in the body of the "Z" by illuminating from above the entire central width of the system. Louvers and shields control the spill light and back light. Careful study of a properly designed and installed system will show that at no time will a motorist be confronted with light shining against his line of sight (into his eyes). All light rays are either coming from above or going in the same direction as his line of sight. The units are mounted 125' above the roadway on free standing steel poles equipped with lowering rings for ground level unit maintenance. The poles, spaced at 700' maximum spacings and placed along the right of way line, can light a right of way width up to 500'. The system is designed for the poles to be placed along one side of the roadway to minimize the cost of conductors, conduit, etc., but due to the flexibility of the "Z" pattern, poles may be swapped from side to side as required by physical constraints.

Specifications state that the beam spreads of the fixtures on each pole may be varied to produce the required lighting pattern and produce an initial average footcandle level of 1.1 on the travelways with the pole spacing and mounting height shown on the layouts. The average to minimum ratio shall be no greater than 3 to 1 nor shall the average to maximum ratio exceed 3 to 1. Light intensities along the travelways shall not decrease at a rate less than 0.7 nor increase at a rate greater than 1.4 based on a 15 foot grid. Initial spill light shall not exceed 0.15 horizontal footcandles at any point 100' outside the right of way line on either side of the freeway facility. The specifications state that photometric requirements specified will be determined on the roadway after installation.

The specifications also require prior approval by the State of the floodlights for use on a project. The manufacturer, through the Contractor, must submit to the Department complete fixture aiming angles and aiming diagrams, aiming instructions and computer lighting arrays. In addition, the equipment to be furnished will provide roadway illumination that meets the specification requirements. Extrapolated, interpolated, or computer generated data is not considered as satisfactory data.

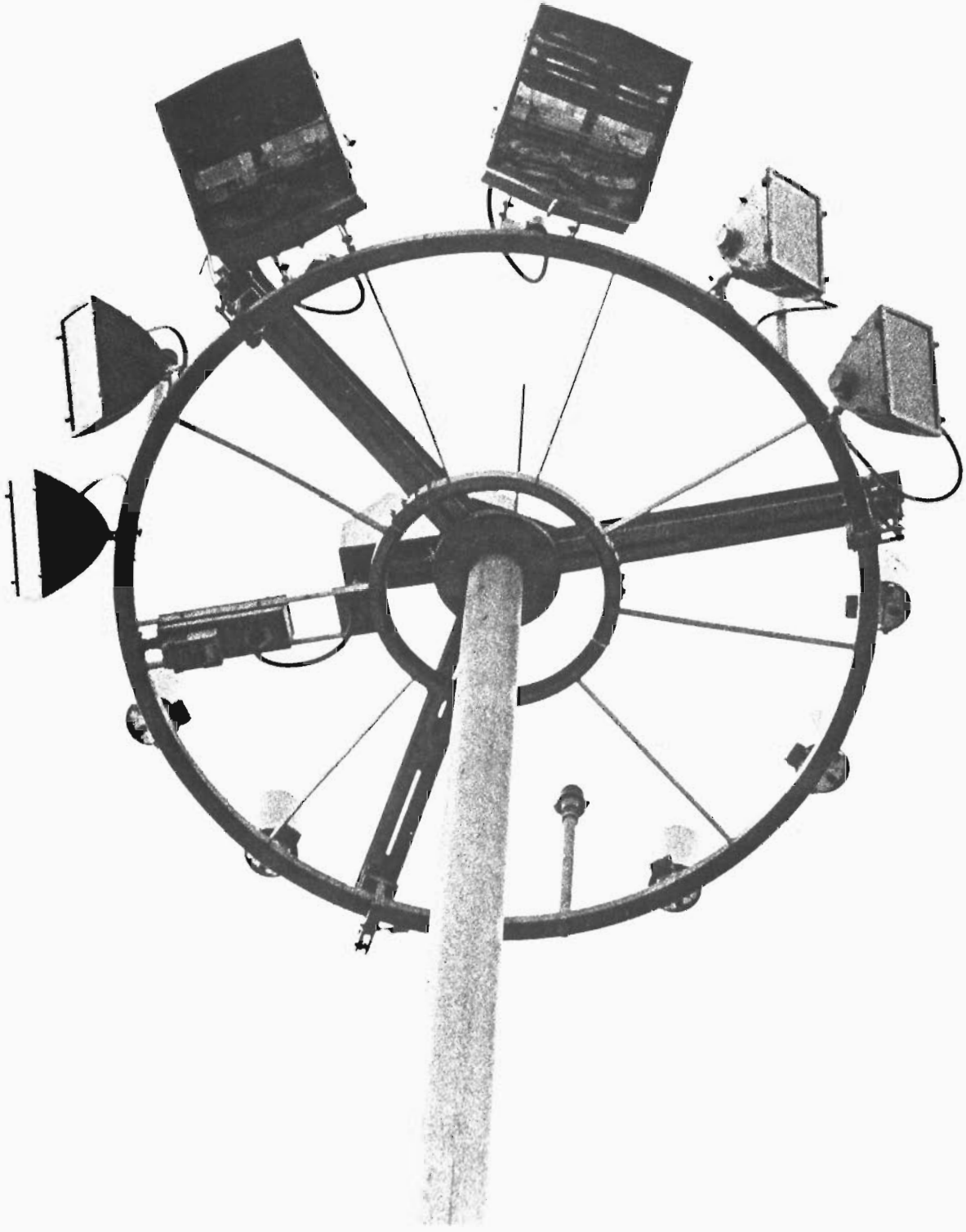
At present, four manufacturers have submitted, to the Department, fixtures for testing and prequalification. All four companies have, with several tests each, passed the requirements. They are General Electric, Crouse-Hinds, McGraw-Edison and Wide Lite. G.E., through subsequent testing, has been able to produce the required lighting with five 1000 watt HPS on each pole.

The "Z" pattern system has been completed on the first main lanes tangent section of IH 45, Gulf Freeway. The system has also been constructed as part of the overall lighting system for the US 59 (Eastex Freeway) and IH 610 (North Loop Freeway) Interchange. The "Z" pattern was used in the approach sections of the interchange. The "Z" pattern is now under contract in two more main lane contracts and two master interchange projects.

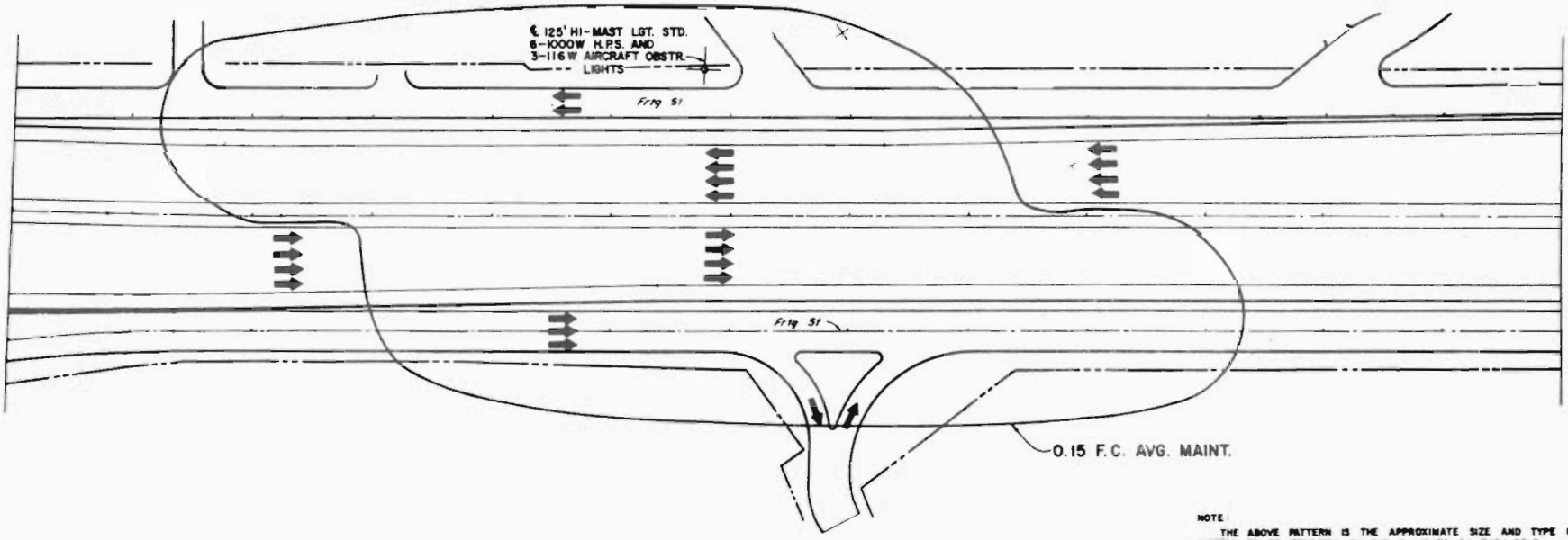
The "Z" pattern system has given us another tool to use in lighting our increasingly complex freeways. As more of our freeways are modified to include mass transit facilities, this new type of lighting may well become our most widely used system.

Two Side-Mounted "Z" - Pattern Lighting Standards
In North Approach of IH 610 and US 59 Interchange, Houston, Texas

"Z" - Pattern Standard Mounted Along
IH 45 Right-of-Way in Houston, Texas



View Looking Up At Floodlight
Mounting For "Z" - Pattern System



NOTE

THE ABOVE PATTERN IS THE APPROXIMATE SIZE AND TYPE OF PATTERN TO BE PRODUCED BY THE 6 LIGHTS ON EACH POLE. REVERSE II PATTERN IS REQUIRED TO MINIMIZE GLARE TO THE ONCOMING MOTORIST.