Research on the evaluation of the perimeter lighting layout to operate the surveillance system for the physical protection of nuclear facilities

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1. Introduction

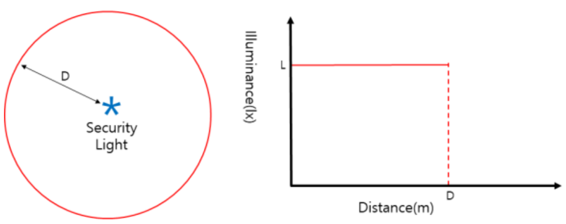
To protect against unauthorized removal of nuclear materials and sabotage of nuclear facilities, a physical protection system has been operated at domestic nuclear facilities under the 'Act on Physical Protection and Radiological emergency'. The Enforcement Decree of the Act specifies that sufficient lighting and visibility should be secured around the protected area, and thus, the nuclear facilities installed security lights at the perimeter of the protected area to secure the visibility of guards and the central alarm station.

The purpose of this study is to develop a mathematical model that can evaluate the layout of security lights of the protected area. Using the facility location problem [1,2,3], the mathematical model was developed to determine the optimal layout of security lights to minimize the shaded area that hinders surveillance. Small-sized results of the model calculation are presented at last.

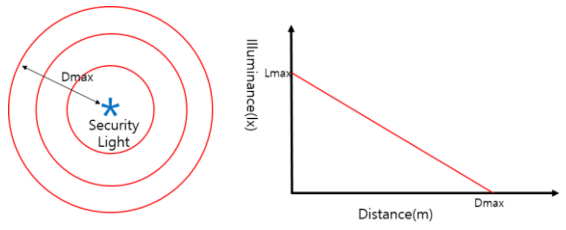
2. Methods and Results

This section describes the mathematical model for security lights. In the model, the coverage that represents the illuminance of individual security lights is defined, and the following characteristics of lights [4,5] are applied:

1) Points at the same distance from the light source have the same illuminance level
2) The farther away from the light source, the lower the illuminance
3) As there are more light sources around, the illuminance level at the point increases

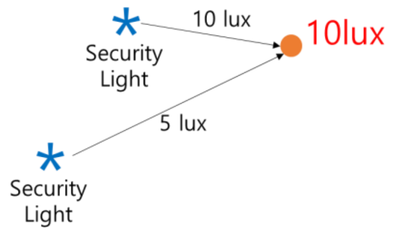


(a) In case of the binary coverage

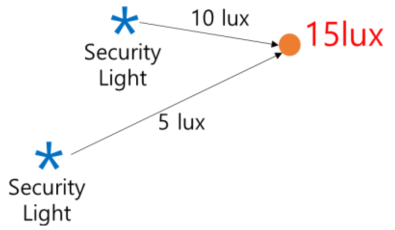


(b) In case of the gradual coverage

Fig. 1. Comparison of coverage definitions according to whether the characteristics 2) of lights is applied or not.



(a) In case of the binary coverage



(b) In case of the cooperative coverage

Fig. 2. Comparison of coverage definitions according to whether the characteristics 3) of lights is applied or not.

The mathematical model also represents constraints for limited deployable security lights and constraints for calculating whether the illumination level at each point satisfies the minimum threshold or not.

The optimal result of the lighting layout at the small-sized area is presented from the model, and the solution is calculated by ILOG CPLEX and JAVA.

3. Conclusions

This mathematical model to determine the layout of security lights can be used to evaluate the surveillance area when the deployment of security lights is given, or to calculate how many security lights are required at least to satisfy the minimum threshold of illuminance level for the whole perimeter.

In particular, the model is significant to evaluate the layout without examination of the actual deployment site. Also, since the layout can be evaluated before security lights are installed or changed in nuclear facilities, it can be used for the regulations such as the review of physical protection plans and inspection on physical protection systems.

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