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An Examination on Retrofit LED Lighting using Cobra Structure

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Abstract

Background/Objectives: A new method was proposed to facilitate assembly of the lamp type light source without removing the existing registration device for replacing it with LED lighting.

Methods/Statistical analysis: An optical system that meets the type II medium was designed at a height of 6[m] that conforms to the Korea Industrial Standards(KS) illuminance criteria of the security lamp and to the Illuminating Engineering Society of North America(IESNA).The size of the LED lightings to be developed was designed so that they could fit into cobra lighting fixture. An E-base kit is developed so that the LED lighting could be assembled with the same E-base type as the lamp.

Findings: LED lightings have been developed to address the problem of replacing existing lighting. First, an optical system that meets the type II medium was designed at a height of 6[m] that conforms to the KS illuminance criteria of the security lamp and to the IESNA. Second, the lighting bulb used in existing lamps is mostly cobra lighting bulb. The size of the LED lightings to be developed was designed so that they could fit into cobra lighting fixture. In addition, the heat sink shape that solved the thermal problem when the LED lightings entered the lighting bulb was presented and the weight of the fully assembled LED lightings was aimed at less than 1[kg], and the weight of the heat sink was also satisfied when the design was designed to satisfy the weight of 0.668[kg]. Finally, the removal problem of the apparatus was solved by developing an E-base kit so that the LED lighting could be assembled with the same E-base type as the lamp, so that the lighting fixture used for the lamp can be used as it is.

Improvements/Applications: By prototyping optics, heat sink, and kit of designed security lamps, the performance reliability was obtained by comparing the results of the design simulation and measurement, and comparing the design and actual weight to ensure satisfaction with the target LED lighting of 1[kg] or less.

Keywords: *Retrofit LED Light, IESNA, Cobra Structure, Yellow pattern, E-Base Retrofit kit, Security lamp*

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I. Introduction

Security lampis installed for safety in areas that are dark at night and where crimes and accidents may occur. Installed on roads, mainly parks and houses where pedestrians pass. Although sodium lamp and metal halide lamp were used as light sources for existing

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security lamps, they are replacing by LEDs reduced energy consumption and long lifespan[1-3].However, when replacing LED lightings in existing lamps, there are problems with the replacement cost of removing existing lamps and the maintenance and repair cost of the removed equipment. Therefore, in this paper, LED lighting has been developed to solve problems that occur in the replacement of LED lighting. First, we designed the LED lighting optical system that satisfies type IImedium from a height of 6[m] that meets KS illuminance standards such as securitylamp and IESNA(Illuminating Engineering Society of North America)[4]. Second, we designed retrofit-type LED lighting that allows LED lighting to enter a cobra fixture, which is a fixture used in existing security lamp. Heat sink is designed shape under 1[kg] in weight to solve the heat problem when LED lighting enters the luminaire, and developed E-Base kit to assemble LED lighting with same E-Base type as existing lamp. We made prototypes of the designed optical system such as security lamp, heat sink, and kit, and compared the design simulation and measurement results to ensure the reliability of the design.

II. Materials and Methods

Retrofit kit design

Lighting used mainly for security lamp is often installed in a cobra structure.The cobra structure uses E-Base, applies power, and mainly uses E39/40. As a result, we designed a retrofit kit that can be followed by LED security lampwith E39/40 type cobra structure.The kit is made up of a total of four parts. There are two guide link parts that can be connected to the heat sink and two E-base kit parts that can be connected to the E-base. The E-base kit parts have hooks, so that the heat sink and retrofit kit can be firmly fixed and can be assembled in the direction.The retrofit kit was designed to be able to rotate 45° on both sides and to be assembled in multiple directions by rotating during assembly.The heat sink and E-base kit were designed to be bolted when a high-power product with a weight of 1[kg] or more was assembled with the retrofit kit. As a result, the retrofit kit is shared with multiple lights.The retrofit kit has a size of 60×55×65[mm] and weighs 50[g] including the connector when the prototype is made with 3D printing. The 3D print material was set to ABS in the design program.

Figure 1 shows an exploded view of the retrofit kit parts and a cross-sectional view, and Figure 2 shows that bidirectional rotation is possible when assembled with a heat sink. Figure 3 shows the assembly diagram when the heatsink red and retrofit kit yellow are assembled.

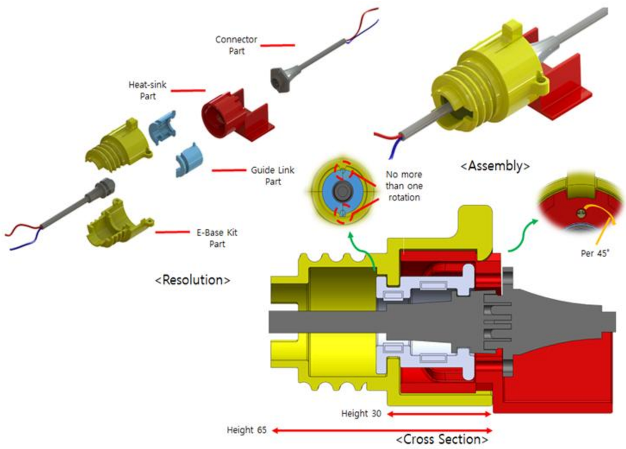

Figure 1. Retrofit kit part exploded view and sectioned view

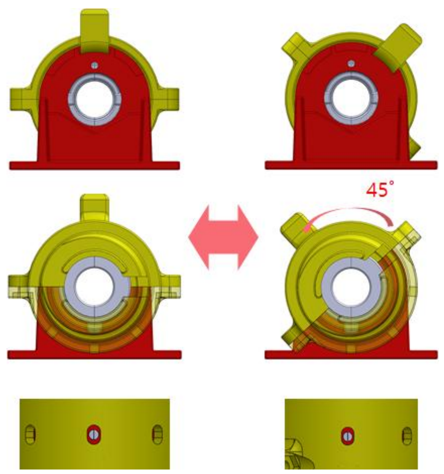

Figure 2. Retrofit kit bi-directional rotation cap ability

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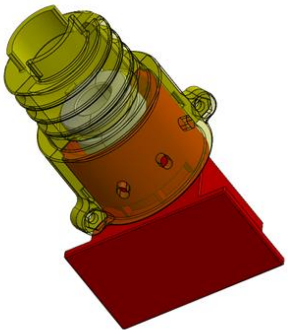

Figure 3. Assembly drawing of heat sink and retrofit kit

LED chip selection

MJT 5050 is used for LED chip for security lamp. MJT 5050 is configured with a size of 5×5[mm], and uses a total of 52 units to drive 0.96[W] per unit, with Ra set to 75 and color temperature selected to target 5000±230[K] did. Table 1 summarizes the information on MJT 5050 PKG provided by Seoul Semiconductor[5].

Table 1: MJT5050 specification

Parameter	Symbol	Value			Unit
		Min	Type	Max	
Luminous Flux	Φ_v	154	180	-	Lm
Correlated Color Temperature	CCT	3,700	5,000	7,000	K
CRI	Ra	70	-	-	-
Forward Voltage	V_F	60	63	68	V
Power Dissipation	P_d		1.26	-	W
Viewing Angle	$2\theta_{1/2}$		120	-	Deg.
Thermal resistance (J to S)	$R\theta_{j\text{-}s}$		6.0	-	K/W
ESD Sensitivity(HBM)	-	Class 3A JESD22-A 114-E			

Optical system design and simulation

Optical system design goals

Security lamp is installed and operated on roadsides and roadsides of less than 8[m] wide in residential areas (Climbing height 8[m] or less, lamp brightness 150[W] or less). Table 2 shows the illuminance standards for pedestrians defined by KS certification. LED security lamp must conform to the pedestrian lighting standards simulated based on the light distribution test measurement data. However, the illuminance calculation area corresponding to the installation height follows the applicable floor area. Applicable to three types of 4[m], 5[m], and 6[m], which are widely used as installation height for LED security lamp. Among the light distribution patterns presented by IESNA to meet the demand for light distribution such as overseas security lamp, it was selected as type II medium. IESNA light distribution patterns can be identified using the photometric cooper program[6].

Table 2: Illumination standards for pedestrian(KS)

Traffic of night pedestrian	Area	Illuminance[lx]
		Average surface illumination
Busy road	Residential area	5
	Commercial area	20
Low-traffic road	Residential area	3
	Commercial area	10

Optical system design

A single optical lens was designed using a free-form surface to create a type II medium light distribution curve in the design of a single optical system designed for security lamp. The optical design was designed using LightTools 8.4, and the lens material was set to

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PMMA(Poly Methyl Methacrylate)[7].In the initial design of the lens, we found the yellow pattern. The reason why yellow pattern is found is because of the difference in thickness of the yellow fluorescent coating coated on the blue light chip of the LED, which results in thickening of the out-line of the photometric pattern. To eliminate this yellow pattern, it is possible to reduce the yellow pattern by adjusting the ratio of the blue light chip to the yellow fluorescent material, but a separate measure is needed to reduce the yellow pattern optically because it does not apply to the LEDs being mass-produced.To control the yellow pattern using an optical system,the first is to control the yellow pattern by bending the light evenly by applying an internal TIR Lens. However, in this paper, an optometrist consisting of a free curve, not of axis symmetry, cannot be replaced by an internal first-half lens.

Therefore, a method of applying a cross-wave pattern to an optical system consisting of a free-form surface to scatter and control the yellow pattern scattered in the outline of the irradiation region was applied[8].As shown in Figure 4, the light distribution pattern was confirmed by applying the cross-wave pattern to the single lens. It is located in 0.65 MH at 0~1.75 MH of type II, it is located at 2.55 MH in the Medium range of 2.25 to 3.75 MH and satisfies the result of typeIImedium. Figure 5 shows the result of applying the light distribution data to the IES road type and confirming the result of the light distribution pattern.Result of the photometric curve, as shown in Figure 6, the light distribution curve expands the horizontal light distribution graph to 70˚, satisfying my typeIImedium.

In order to confirm the pattern that the light is irradiated to the floor at 6m, the highest height of the KS standard, the x-axis is designed to be 25,000[mm] and the y-axis is 15,000[mm].The results were derived by using an RGB chart that can confirm the color of the actual light irradiated on the irradiation surface.As shown in Fig. 7, the white pattern spreads horizontally on the irradiation surface and the yellow pattern is not seen.

In anticipation of a decrease in the performance of the optics due to the cross-wave pattern, a single lens was designed to satisfy the type II medium by changing the curvature of the interior primary and secondary faces of a single lens.

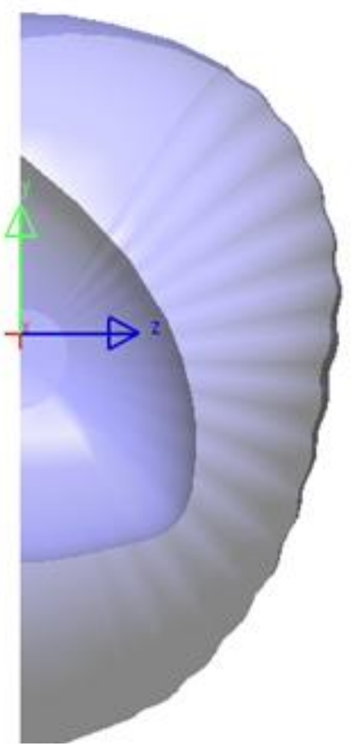

Figure 4. Single lens shape

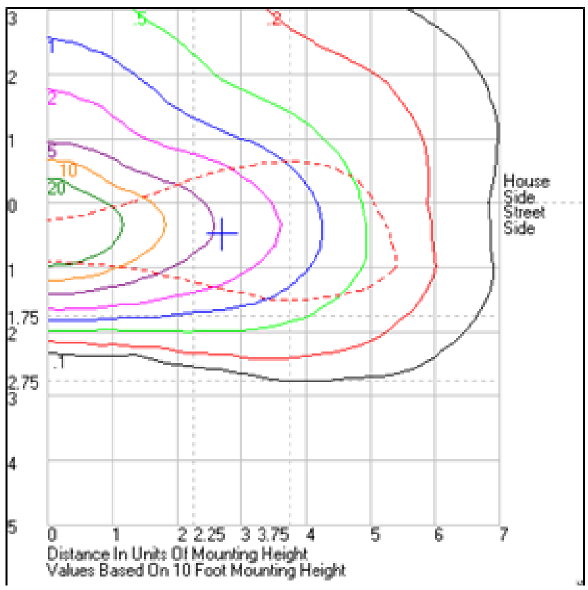

Figure 5. Plot display (Single lens shape)

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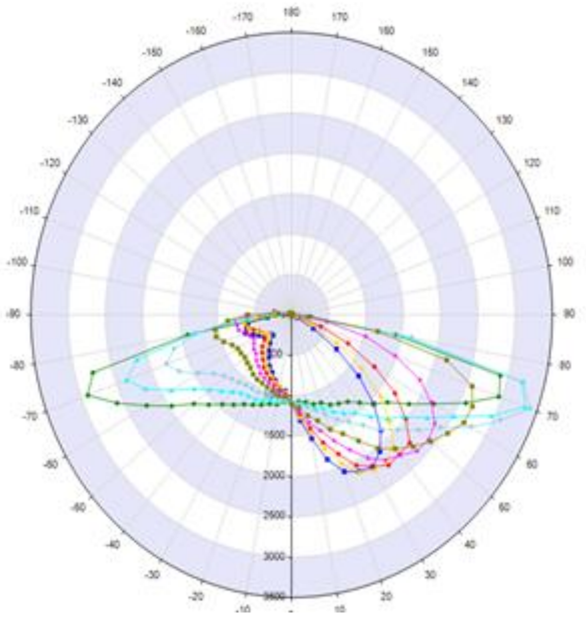

Figure 6. Single lens intensity chart

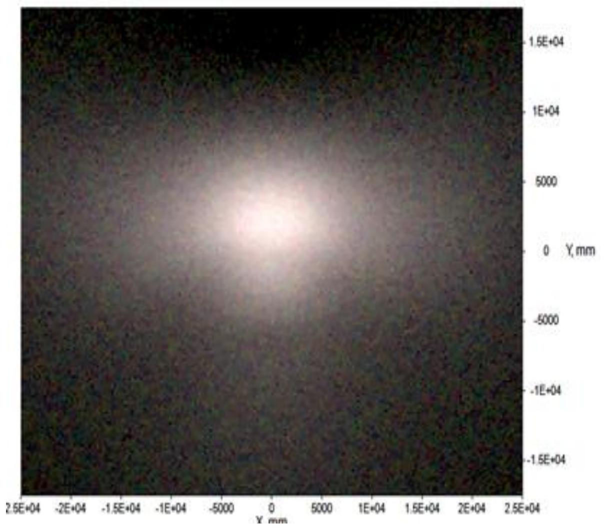

Figure 7. Single lens true color raster chart (X axis: Horizontal, Y axis: Vertical)

Optical simulation

Figure 8 is an overview of the light simulation. To find out the brightness and intensity of the light going out in each direction around the light source, the receiver was installed at points 4[m], 6[m] and 8[m], respectively, and the Far field was set up to measure the distribution of the light emitted and the angle of the light emitted. Using 5 LED PKGs, 50[W] of electricity consumption is implemented. 0.96[W] per LED PKG and the total luminous flux of the illumination is set at 6,750[lm](light efficiency 135[lm/W]).The receiver is set to 4[m], 6[m], and 8[m]. To check the photometric curves, the photometric angles shall be determined and verified by determining the point at which the maximum peak angle is 50%. The vertical and horizontal light angles shall be 50% of the maximum intensity.

First, the Yellow pattern has implemented controlled optometric features while satisfying type II medium based on single lens features. The implemented optics will have a single lens arranged at 6×9 and a total of 52 single lenses excluding two single lenses will be placed in the portion of the power wire. Later, through optical simulations, the light intensity RGB chart of the lighted area and the luminous curves were checked to ensure the same performance as a single lens. As a result of the verification, the horizontal axis photometric graph extended to 70° to satisfy type II medium, and the yellow pattern was controlled in the light intensity RGB chart.

Figure 9 is a 3D optometric shape plot that satisfies type II medium and is controlled by yellow pattern by applying cross-wave pattern, and Figure 10 is a picture of a photometric curve graph that is verified by optical simulation results. Figure 11 shows the light intensity RGB chart investigated on the surface of the survey at a distance of 6[m]. When designing a single lens, it was found that the yellow pattern was also controlled in the overall optical system configuration through a cross-wave pattern.

Table 3 shows the uniformity and floor roughness according to the installation height 4[m], 5[m], and 6[m] by selecting the simulation target as a commercial area with low traffic according to KS security.Standard light of KS security light should have more than 0.15 uniformity and 10 or more average illuminance at all height.The manufactured security light system satisfies the KS standard at all heights.

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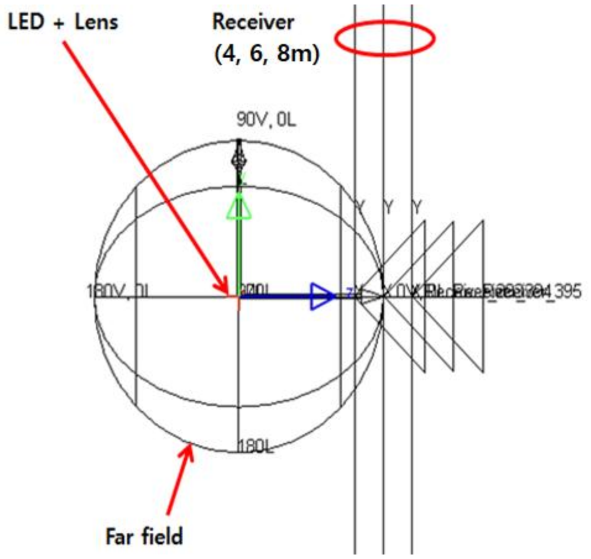

Figure 8. Simulation conditions

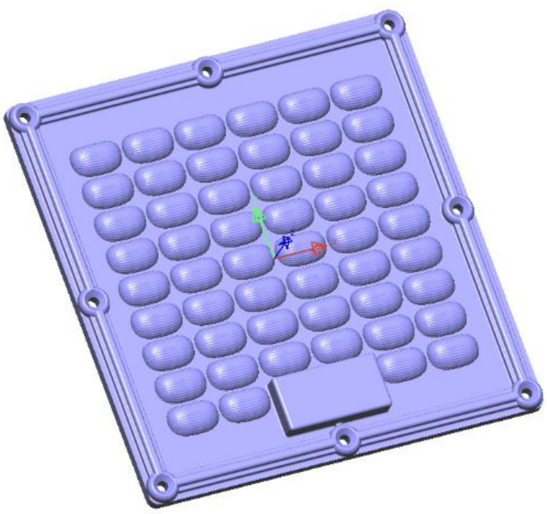

Figure 9. 3D optical system shape

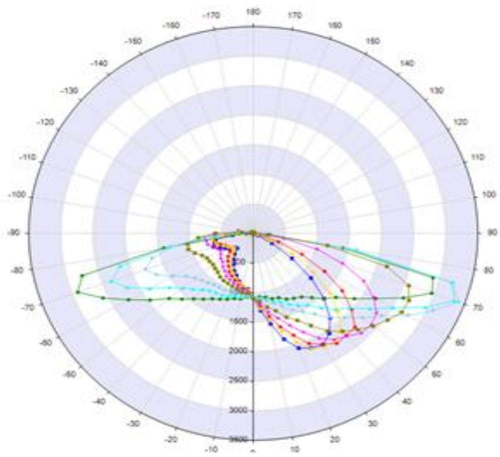

Figure 10. 3D optical system shape intensity chart

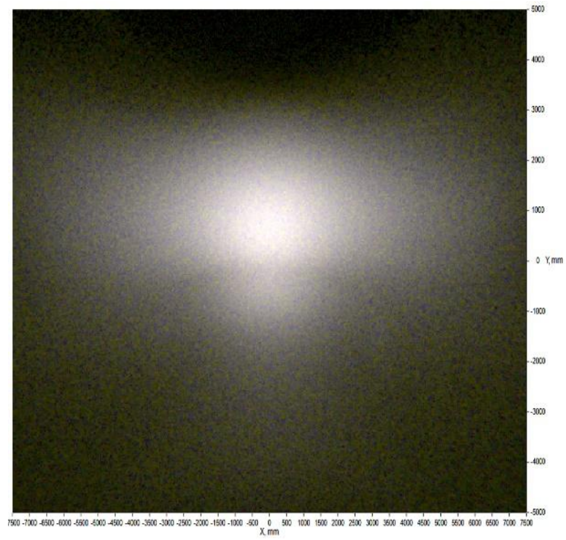

Figure 11. 3D optical system shape true color raster chart
(X axis: Horizontal, Y axis: Vertical)

Table 3: Simulation result according to KS standard

Installation height	4[m]	5[m]	6[m]
Irradiation surface area	8 × 4[m]	12 × 6[m]	16 × 8[m]
KS standard uniformity condition	0.15	0.15	0.15
Average illumination	56	31	20
Uniformity	0.307	0.240	0.206

Design and simulation of heat sink

The heat sink is designed by natural convection method by increasing the surface area according to LED PCB.It consists of two parts and is designed to be assembled by putting the driver in a heat sink, and then closing it with a cover. The heat dissipation performance of the heat sink cover is important because the heat generated from the driver is combined with the heat from the PCB substrate with LEDs, which is higher than the heat from each driver and PCB within the driver. Therefore, since the design of covers that can release heat efficiently is important, the design of the covers is changed to compare the heat dissipation performance after the optimal heat sink is designed. Table 4 is a table that summarizes the design figures of the heat sink. The total size is 134.5×164.5×53.5[mm], weighs 0.668[kg], and is Al 6061-O of material, Figure 12 is a diagram of the design of the heat sink 3D.

Table 4: Heatsink applied to security lamp dimension

Part	Specification
Manufacturing of heat sink	Machining
Width(W)	134.5[mm]
Length(L)	164.5[mm]
High(H)	53.5[mm]
Thickness of base	3[mm]
No. of fin	12
High of fin	53.5[mm]
Thickness of fin	3[mm]
Corner radius of heat sink	15[mm]
Heat sink weight	0.668[kg]

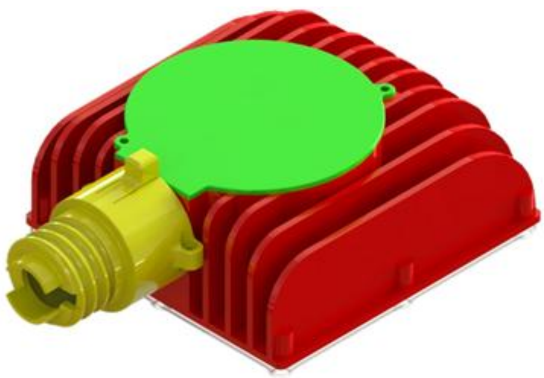

Figure 12. Security lamp Heat sink 3D modeling

After the design was completed, a heat simulationwas carried out. Three conditions were set up for the heat simulation[9,10]. The first external air flow is a three-dimensional steady state, laminar flow. Second, except for the density of the working fluid (air) the material properties are constant. Finally, the air is an ideal gas.

All contact resistance except thermal grease are ignored, and the thermal resistance of the LED is 0.35[W/m] and K and the boundary condition is set at 50[W] for LED power. The surface of the heat sink is set to black body wall and the outside temperature is set to 20℃. The analysis was verified 120 times after two hours of heat transfer in the Transient state.The heat simulation of the heat sink confirmed that the maximum temperature of the LED T_C was 62.67℃. Figure13 is a plot of the results of the primary heat dissipation simulation and is presented with the temperature figures for each color. Figure13 is a picture of the results of the secondary heat dissipation simulation and is represented with the temperature figures by color.

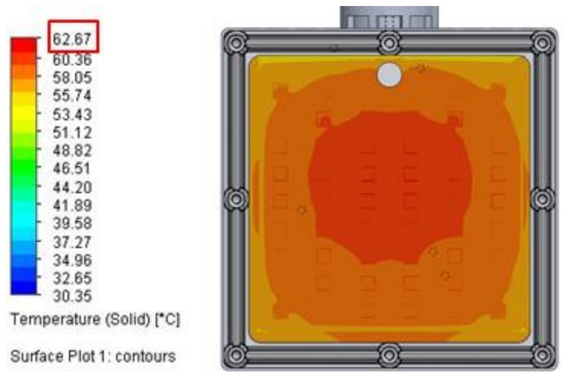

Figure 13. Flow simulation result : total temperature

III. Results and Discussion

Optical system prototype evaluation

A prototype optical system was made based on the previous simulation data, and the lens was measured with a Goniophotometer[11]. As a result of measurement, the horizontal light distribution graph of the light distribution curve was extended to 70˚, satisfying my type II medium, and confirming the reliability of the optical simulation. Table6 is a graph that summarizes the performance results of the prototype. Figure 14 is a photograph of the prototype optical system that satisfies type II medium. Figure 15 is a photograph of the light distribution curve.

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Table 6: Measurement result of Mock-up lens

Part	Performance evaluation
Input voltage[V]	220.4
Input current[A]	0.208
Input power[W]	44.0
Power factor	0.96
Total luminous flux[lm]	5,961
Illumination efficiency[lm/W]	135.4

Figure 14.Mock-up lens

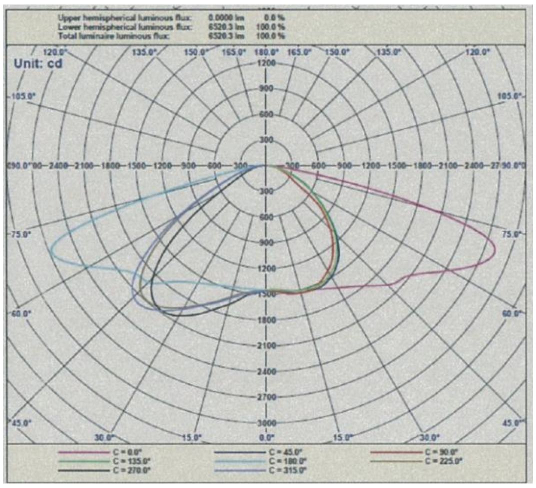

Figure 15. Intensity chart of mock-up lens

Evaluation of heat sink prototype

Therefore, as a result of heat dissipation simulation of the primary heat sink, the maximum temperature of the LED T_C was confirmed at 62.67℃, and then a heat sink prototype was manufactured and a heat dissipation test was performed. The measurement points were LED T_C point, power supply unit solding (-), heat sink base, and heat sink cover. As a result of measurement, thermal equilibrium was reached 90 minutes after the start of the experiment, T_C temperature was measured at 62.6℃, solding (-) at 59℃, base at 50.1℃, cover at 54.5℃, LED T_C and cover at 8.1℃the difference of less than was shown and the reliability of the heat radiation simulation was secured.LED T_C and cover showed the difference of less than 8.1℃, ensuring the reliability of heat dissipation simulation.

Figure16 shows the measurement points of the heat dissipation test, and Table 7 is a graph summarizing the measurement results. Assuming that 50[W] was applied as the target input power of the prototype, the room temperature was set to 20.05℃ and a heat dissipation simulation was performed. The average input power of the heat dissipation test result was 43.34[W], and the room temperature recorded 27.2℃.

In order to confirm the reliability of the thermal simulation and heat dissipation test, the power consumption and room temperature were reset and the simulation was performed. As a result of performing a heat dissipation simulation by resetting only room temperature in the existing heat dissipation test, the maximum temperature of the LED T_C recorded 67.61℃, and a temperature difference of 5.01℃ occurred from the result of the heat dissipation test. Based on this result, we conducted a heat dissipation simulation by maintaining the room temperature at 27℃ and changing the power consumption to 43.34[W]. As a result, the maximum temperature of LET

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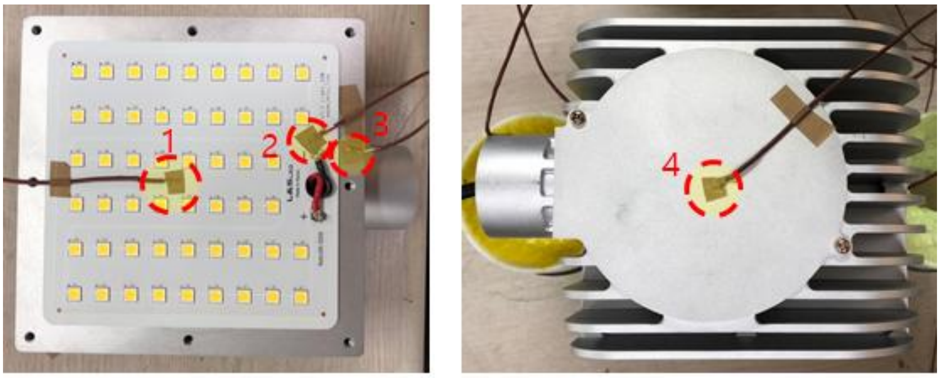
T_C was 61.97℃and a temperature difference of 0.63℃ occurred.

As a result, the error rate of heat dissipation simulation and heat dissipation test was measured at 1.01%, ensuring the reliability of simulation and test.



[The point of measurement of heat sink (Front)]

[The point of measurement of heat sink (Back)]

Figure 16. Measurement point of the heat radiation test

Table 7: Results of heat radiation test measurement

Part	**Temperature maximum(℃)**
LED T_C (Center)	62.6℃
Soldering (-)	59℃
Heat sink base	50.1℃
Heat sink cover	64.5℃
Indoor temperature	27.2℃
Humidity	19%
Power consumption	43.34[W]

Table 8: Comparison of the results of a thermal test and a heat radiation simulation

Part	**Thermal heat**	**Heat radiation simulation**		
		Existing	**Indoor temperature change**	**Indoor temperature and power consumption change**
Indoor temperature	27.2℃	20.05℃	27℃	27℃
Power consumption	43.34[W]	50[W]	50[W]	43.34[W]
Input data	-	40[W]	40[W]	34.672[W]
temperature maximum	62.6℃	62.67℃	67.61℃	61.97℃

IV. Conclusion

In this paper, the study on LED security lamp illumination applied with the retrofit system was carried out to draw the following conclusion.In LED lighting, to obtain an optical system that meets the type II medium specified by IESNA(North American Lighting Association), LED PKG selected MJT5050 and analyzed it by optical simulation after the

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design of the optical system, the results of type II medium were obtained.In the illumination using the LED light source that patterns yellow phosphor on the blue chip light, a yellow pattern is generated via the optical system. Cool white results were obtained by controlling the yellow pattern, which was not solved by the LED PKG itself, with the optical system.

The heat sink was designed and the prototype was manufactured. The heat simulation results showed that the LED T_C temperature had a heat dissipation performance of 62.6℃, and the prototype heat dissipation test result showed that the LED T_C temperature had a heat dissipation performance of 61.97℃. As a result of this analysis, the reliability of the heat dissipation performance was confirmed through a heat dissipation simulation and an actual heat dissipation test with a temperature difference of 0.63℃and an error rate of 1.01%.

Make an LED lighting product and retrofit kit and check that the power is turned on when connected to the E39/40 socket when assembled into a cobra structure which is an existing structure. Analyzed using the design program, the result of lighting with optimal size and weight less than 1[kg] was obtained.The optical design, heat sink design, and kit design in this paper confirmed the possibility of LED lighting that can be easily replaced with conventional lighting to reduce replacement costs and lighting disposal costs. The optical technology and retrofit kit used in this study can be used for other LED lighting.

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