



STUDY ON THE OUTDOOR VISUAL INFORMATION INDICATING SYSTEM RAISED BY WIDE POWER FAILURE DUE TO THE NEXT NANKAI EARTHQUAKE

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SUMMARY

The 1995 Hyogoken-nanbu earthquake caused a power failure over a wide area and affected 2.7 million houses. Most of the outdoor power supply was cut off in addition to the indoor supply throughout the devastated area. Although, there was no panic in the darkness because, fortunately, dawn was coming in an hour, and there was no need to flee hastily from tidal waves.

It is expected that the next Nankai earthquake, surely anticipated in the future, will cause a power failure that could affect over 10 million people. It is also expected that tidal waves could reach many densely populated areas such as Osaka in two hours; therefore, quick evacuation must be executed onshore. Most regions, however, are not provided with outdoor lighting facilities including built-in emergency power supplies. Also, many outdoor signposts and guiding signs leading to places of refuge have no lights. For the purpose of urgently establishing an evacuation system, the author performed a perception experiment of the outdoor information indicating system with a board made of afterglow phosphorescent pigment that had no radioactive substance. Consequently, it was found that the non-power source system with no emergency power supply is useful for guiding people to safe places when outdoor power failure occurs at night. This indicating system can store light from sunshine during the day and can be used for many hours. Furthermore, it can be installed around outdoor lights, as it can store light from such artificial sources up until power failures occur. In conclusion, it is shown that this system is effective for evacuating people anytime, even during the night.

INTRODUCTION

The seismic investigation committee of the Japanese Government has announced officially that the occurrence probability of an earthquake in the Nankai area (around M8.4) within the next 30 years is 40% and the case of an earthquake in the Eastern Nankai area (M8.1), 50%. If these two big earthquakes occur simultaneously (M8.5), 20,000 casualties are estimated. In addition, since the present situation is that an earthquake in the Tokai area (damage assumption, 10,000 casualties) which is of a great ocean trench type earthquake may occur at any time, therefore, the government has promoted countermeasures such as promoting quake-proof building and so forth.

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In addition, in the metropolitan Tokyo area, damage assumption due to an inland earthquake (M7.2) was calculated, and serious damage similar to the case of the great earthquake in Hanshin and Awaji area (M7.3 1995) was predicted. In both cases, the maximum human damage was assumed, since fire disaster probability was high when earthquake occurrence time was weekday 6:00 p.m. in winter. However, the occurrence of a wide area electrical power failure due to a great earthquake and also its influence to human damage, have never been discussed. So the writers suggest immediate promotion of outdoor lighting equipment and a guidance display system that will function under a wide area electrical power failure for quick evacuation and the safety of evacuation routes and evacuation area.

The eastern Nankai and Nankai seismic countermeasure law estimates that the number of casualties by building collapse will decrease to one fifth (1/5) due to quake-proofing of wooden buildings. In addition, it is assumed that the number of casualties by a tidal waves (tsunami) may differ about 2 times due to dependence on the evacuation consciousness of the public. Therefore, there is an urgent need to enlighten evacuation consciousness for proper evacuation and prepare an evacuation plan. It is essential to secure lighting for evacuation at night.

In this research, in order to promote the outdoor information display system at the time of a wide area electrical power failure, at first, we reviewed the situation of electrical power failure that occurred at the time of the great earthquake in Hanshin and Awaji area (Kobe earthquake). Moreover, since it is urgent to promote this system, the visibility of the visual information display system (including guidance display board, direction guidance, etc.) which uses phosphorescent pigment is under investigation. This system will be a replacement for the standby power supply which requires huge amount of money.

THE GREAT EARTHQUAKE IN HANSHIN AND AWAJI AREA (THE 1995 HYOGOKEN-NANBU EARTHQUAKE) AND WIDE AREA, LENGTHY HOUR ELECTRICAL POWER FAILURE

In the case of the earthquake that occurred in the southern part of Hyogo prefecture in 1995 (the great Hanshin and Awaji earthquake disaster), electrical power failure affected about 2.6 million houses mainly around the Hanshin area (between Osaka and Kobe)[1]. However, since fatal damage did not occur in power supply equipment such as electric power supply facilities, electric feeder lines, transforming stations and so forth, as shown in the Fig.1, the number of power failures affecting houses decreased to 1 million after two hours, and then after six days all emergency power transmission was completed.

In the case of viewing the great earthquake in Hanshin and Awaji area from an angle of lighted environment,

- 1) Not only interior lighting but also outdoor lighting such as street lights and so forth went off due to the wide area electrical power failure. However, since the earthquake occurrence time was 5:46 a.m. and this was about 80 minutes before sunrise of the day in Kobe, daylight was obtained very soon.
- 2) Most of the earthquake victims suffered in general buildings where there was no disaster prevention lighting equipment. Therefore, they had to evacuate or perform rescue operation with flashlights that might have to be searched for through the rubble or turned over furniture, while having the fear of collapse of buildings and minor quakes in darkness.
- 3) Regarding public buildings, etc. equipped with evacuation lights and emergency lighting equipment, although their building frame and lighting equipment were damaged, almost nobody was found there except in hospitals and hotels.
- 4) There were only a few commuters outdoors and in transportation facilities.
- 5) Tidal waves (tsunami) did not occur.

Due to the above-mentioned fortunes, it can be said that the occurrence of evacuation panic under electrical power failure was averted.

Furthermore, one of the features was that a fair proportion of victims were forced to live in evacuation centers for a long time. Although lighting in emergency evacuation centers night and day could ease the fear of minor quakes at first, as time went on, psychological and physiological disorders such as irritation or sleeplessness and so forth were increased.

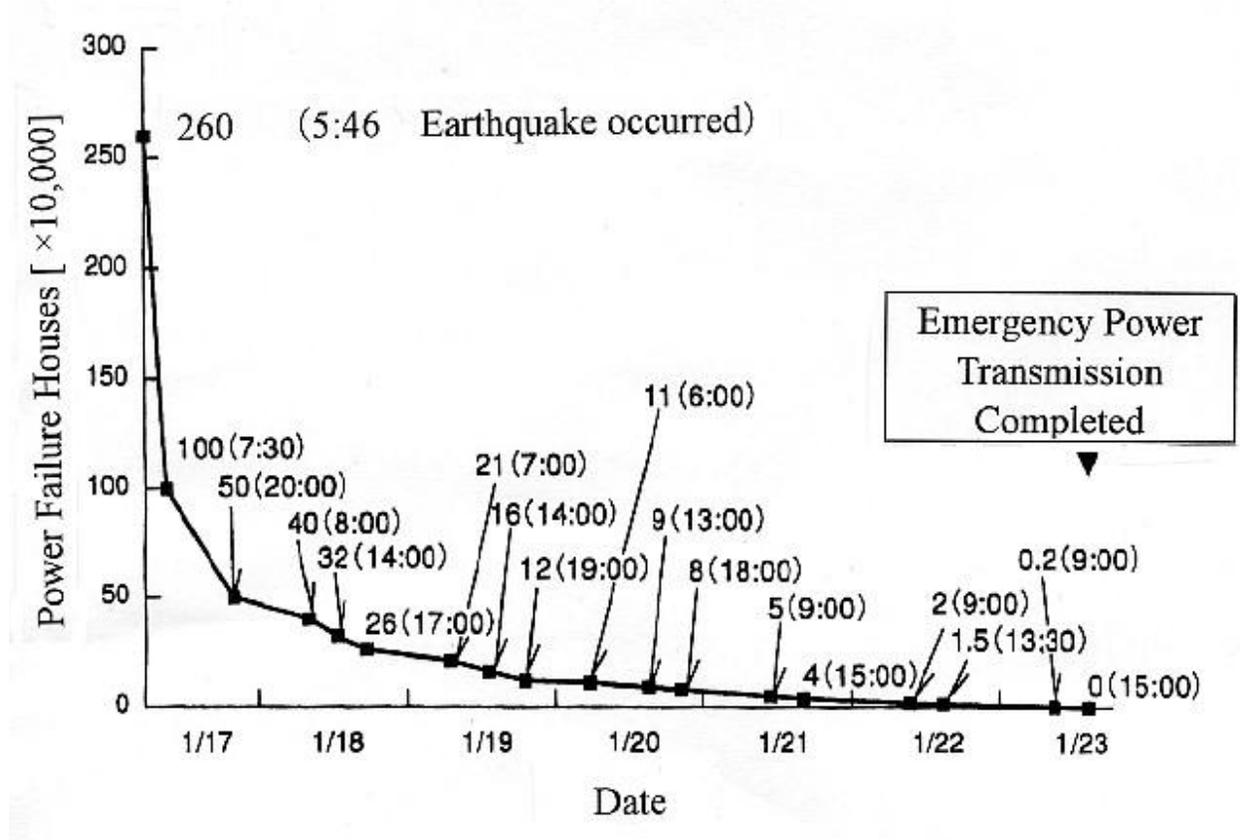


Fig.1 Temporal Transition of Houses with Power Failure at the time of the Earthquake in the Hanshin and Awaji area⁻¹⁾

NECESSITY OF OUTDOOR DISASTER PREVENTION LIGHTING

Outdoor Emergency Lighting

In the case of a great ocean trench type earthquake of high probability such as earthquakes in the Tokai area and the Eastern Nankai and Nankai areas, occurrence of human damage has been predicted because of the occurrence of a wide area lengthy hour electrical power failure and tidal waves (tsunami), that may reach heavily populated metropolitan regions within two hours. Especially in the coastal area near to the seismic center, it is estimated that more than 60% of the total death toll would be killed by a tidal waves (tsunami). In the case of an earthquake in the Eastern Nankai and Nankai areas, the number of houses affected by electrical power failure immediately after the earthquake is estimated about 10 million houses. This is calculated on the basis of actualities of the great earthquake in Hanshin and Awaji areas, by the use of a ratio of the number of houses affected by electrical power failure to the number of collapsed buildings due to quakes and liquefaction.

Regarding the disaster prevention lighting equipment (evacuation light, lighting equipment for emergencies) prescribed in the Fire Defense Law and the Building Standard Law, it is purposed to secure brightness in order that people can evacuate quickly and safely at the time of fire mainly from the buildings that the general public uses. On the other hand, the situation of a wide area lengthy hour electrical power failure occurring has not been assumed under the condition that patterns of daily evacuation routes have been changing greatly due to great earthquakes and so forth. Therefore, legislative preparations have not been made for outdoor disaster prevention lighting equipment such as street lights, etc. that have an emergency electric power source (including solar system) in order to secure and guide the evacuation route that leads to the emergency evacuation area. When a great earthquake occurs during the night, quick evacuation must be taken in order to escape from a tidal waves (tsunami) disaster. On that occasion, to secure light on an evacuation route and also in an evacuation area is one of the most important tasks in disaster prevention.

Local authorities in the Sanriku coast, the Pacific coast of Shikoku and so forth that have experienced huge tidal waves (tsunami) disasters in the past have tried to secure light for an evacuation route by setting up street lights with a solar power source or a wind power source.

The outdoor disaster prevention lighting is defined as "a light at the time of an emergency outdoors". Evacuation stages from the occurrence of a disaster are shown as time series. (Stage 1) about three hours immediately after the occurrence of a disaster, (Stage 2) about three days emergency evacuation, (Stage 3) on and after three days emergency evacuation, (Stage 4) restoration or reconstruction stage. In the case of the immediately after stage and the emergency evacuation stage, life preservation is given top priority, so lifesaving and temporary wide area emergency evacuation are done. Next, shift the main emphasis to safety confirmation, collecting information and medical activity. So the main required functions of the outdoor disaster prevention lighting are lighting for life preservation and to secure information display during the first and second stages.

The function of outdoor lighting equipment at the time of disaster

Local authorities have set up evacuation areas for the time of a disaster. In the nighttime, even for the local residents, higher visibility toward the evacuation area is required than the case of crime prevention level, when they evacuate with the weak such as the elderly, infants, casualties and so forth as to avoiding clutter on the streets and collapsed houses. Furthermore, in metropolitan regions, there are many temporary visitors and passengers as well as local residents. In order to guide those who are not familiar with local geography to the evacuation area without panic, a guide display system or a visible information system that is lit up or self emitting and shows evacuation areas (parks, open spaces, schools, etc.) is necessary.

Necessary illuminance to secure an outdoor evacuation route

The illuminance criteria that is necessary for outdoor evacuation have not been established. The Kansai branch of the Illuminating Engineering Institute of Japan (IEIJ) has performed an evacuation experiment on a simulation street where obstacles are laid out[2]. In this experiment, the following points are considered by the use of obstacle size, luminance ratio of obstacle and a road surface and road surface illuminance as parameters.

- _1) Consideration of distinctive minimum distance of an obstacle
- _2) Consideration of necessary walking time to avoid obstacles
- _3) Subjective evaluation of whether brightness is enough or not for safe walking

As the result, illuminance of 0.1-0.3 [lx] was required on the basis of visibility of obstacles and illuminance of 0.3 [lx] was required psychologically. In the case that illumination distribution is not even

like an actual street, it is considered that an average illuminance of 1-3 [lx] is an effective level for evacuation.

PROMOTION OF OUTDOOR DISASTER PREVENTION LIGHTING

On August 15th 2003 (Japan time), the maximum-scale wide area electrical power failure as never before, occurred in the northeastern part of America to Canada. It seems that 50 million people were affected. Darkness spread out after sunset and city's functions were paralyzed, but since the power failure occurred in a time of peace and the lesson from "September 11th terrorist attacks" was utilized properly, big panic was averted. On that occasion, it was reported that "It is unthinkable that the same thing might happen in Japan because technical capabilities and the management system are sufficient", "If an electric power plant stops, electrical power supply to environs will be shut off and supply-and-demand balance adjustment will be performed so that wide area electrical power failure will unlikely occur".

It seems that each electric power company perform simulations about priorities such as supply and shut off systems, power failure area and so forth in order to avert wide area electrical power failure and also creates a countermeasure manual. However, generally speaking, this type of information has not been revealed to the public. Regarding the region where more than the lower 6 level on the Japanese earthquake scale that causes human damage and building damage increases significantly is assumed or the 3 meter or higher huge tidal waves (huge tsunami) that causes human damage regardless of time of arrival or the tidal waves (tsunami) whose flooded depth onshore is 2 meters or higher is assumed, the eastern Nankai and Nankai anti-earthquake measures law stipulates the district where there is no coastal levee higher than these water level as a earthquake disaster prevention promoting district. Tokyo, Osaka, Kyoto, 18 prefectures and 497 local authorities fit this specified condition.

Against a tidal waves (tsunami), presently, quick evacuation is the most effective measure to be taken. Judging from the electrical power failure transition at the time of the great earthquake in Hanshin and Awaji areas, evacuation under wide area electrical power failure cannot be avoided when an earthquake occurs during the night. Including inland earthquake disasters, evacuation is indispensable due to building collapse and fire disaster, even though there is no tidal waves disaster (tsunami disaster). Furthermore, in the metropolitan region, there are many only day-time citizens and also people who are in a difficult position to get home. In order to guide those who are not familiar with local geography to the wide evacuation area safely, it is the most vital task to promote outdoor disaster prevention lighting that can secure light on an evacuation route, light on the guide display system and visibility.

However, regarding the idea of installing standby batteries for street lighting, in reality, it is impossible to do so financially. Therefore, self-help efforts of inhabitants are necessary. It can be said that installing the porch light or the gate lamp that has a built-in storage battery and creating evacuation routes by local inhabitants themselves are very effective measures.

EXAMINATION OF AN OUTDOOR VISUAL INFORMATION SYSTEM AT THE TIME OF ELECTRICAL POWER FAILURE

Phosphorescent pigment

Regarding phosphorescent pigment used for the experiment, its main ingredient is Aluminate chloride (SrAl_2O_4 : Eu, Dy Strontium Aluminate), and it is superior in light stability and it is possible to use it outdoor in direct sunlight. In addition, there is no limit regarding its use and places, since it does not include radioactive materials, just like self-luminous pigments. We used the one whose peak wave length of light emission was green, 520 [nm]. This wave length can be sensed brightly in sensitive wave length bandwidth even in darkness. Its activation wave length band is wide as 200-450 [nm], but its peak wave length is 365 [nm] and its light is in the ultraviolet region. As intensity of the radiated light is stronger,

brightness also increases. If radiation is more than 500 [lx], afterglow can be obtained around the maximum value. If there is more than this brightness, it is OK to radiate more than around 180 [lx·h], indicating in the form of multiplying the brightness of activation illuminance by the irradiative time.

Overview of the experimental method

The experiment was performed in the laboratory where a light control (dimmer) of 0-2500 [lx] was available. After cutting the white vinyl sheet to which phosphorescent pigment was applied, into the size as 300x300 [mm], 150x150 [mm], 75x75 [mm], 38x38 [mm], 19x19 [mm], 9.5x9.5 [mm], 4.5x4.5 [mm] and attaching each piece to the black non-reflective board which stood against the wall and then exposing them by the necessary integrated luminance, brightness measurement on the emission face was performed in a completely dark condition. In addition, we wrote “Evacuation Area” on this A-4 size sheet with black letters and attached it to the black non-reflective board likewise. The character and its size are MS Gothic, 72P, 48P, 36P, 28P, 14P, 10P and 8P. An experimental subject evaluated recognition of light emission body and readability of characters at a distance of 2.5 [m].

Overview of the experimental result

1) Afterglow luminance in case of radiation of high activation illuminance

In the case of radiating the illuminance on the phosphorescent sheet is 2000 [lx], there was not much difference in brightness of its afterglow until the integrated luminance was 50 [lx·h]. The result is shown, in the case of 2500 [lx·h] in the Fig.2, and in the case of 50 [lx·h] in the Fig.3. The horizontal axis is afterglow time and the vertical axis is afterglow luminance. We changed the intensity of activation illuminance but in the case of more than 400 [lx], there was little difference.

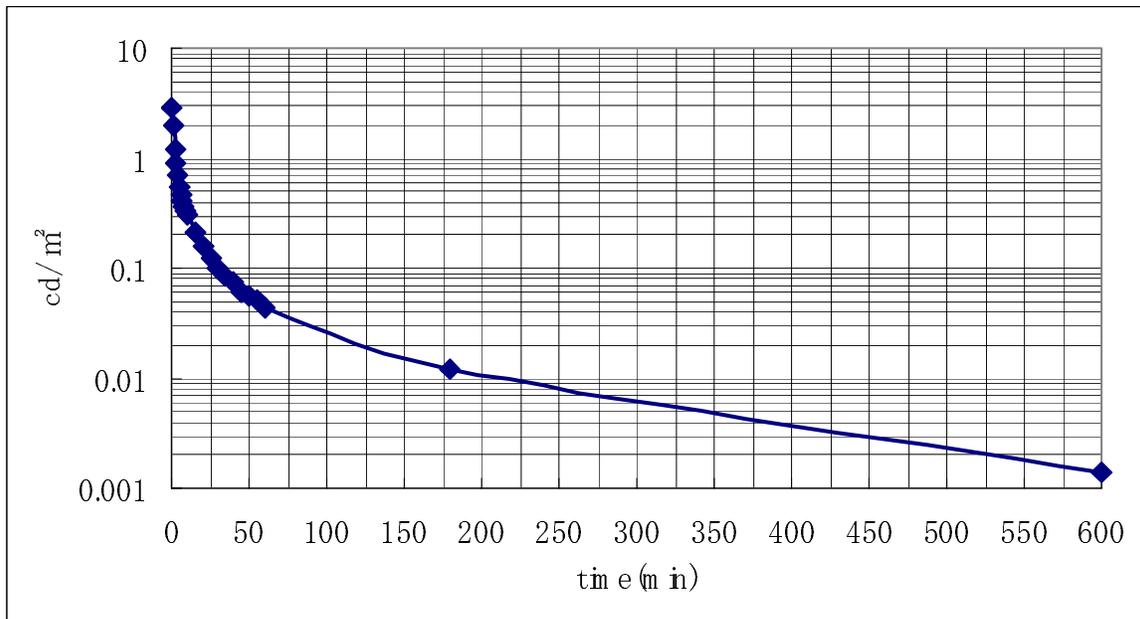


Fig.2 Variation per Hour of Afterglow luminance_ (2500lx·h)

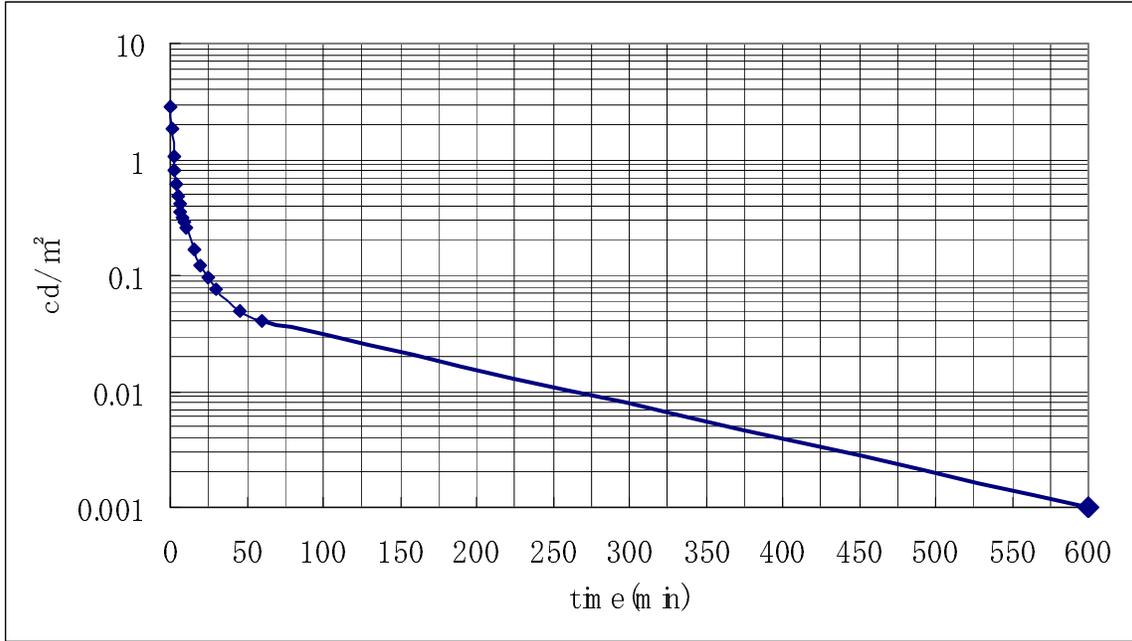


Fig.3 Variation per Hour of Afterglow luminance(50lx·h)

2) Afterglow luminance in case of radiation of low activation illuminance

Assuming the actual street lightening, phosphorescent was performed (build up light or energy) in brightness of 3 [lx]. As shown in the Fig.4, it was understood that in the case of 3 [lx] in a dashed line, initial afterglow luminance became a low value in comparison with the case of more than 400 [lx] in a solid line. As shown in the Fig.5, in the case that phosphorescent amount was 50 [lx·h], afterglow luminance after 1 minute became brighter in proportion to activation illuminance. In the case of 3 [lx], afterglow luminance was equivalent to the afterglow in the case of 25 minutes later after exposing more than 400 [lx]. Therefore, it can be said that it is necessary to pay close attention to an installation site.

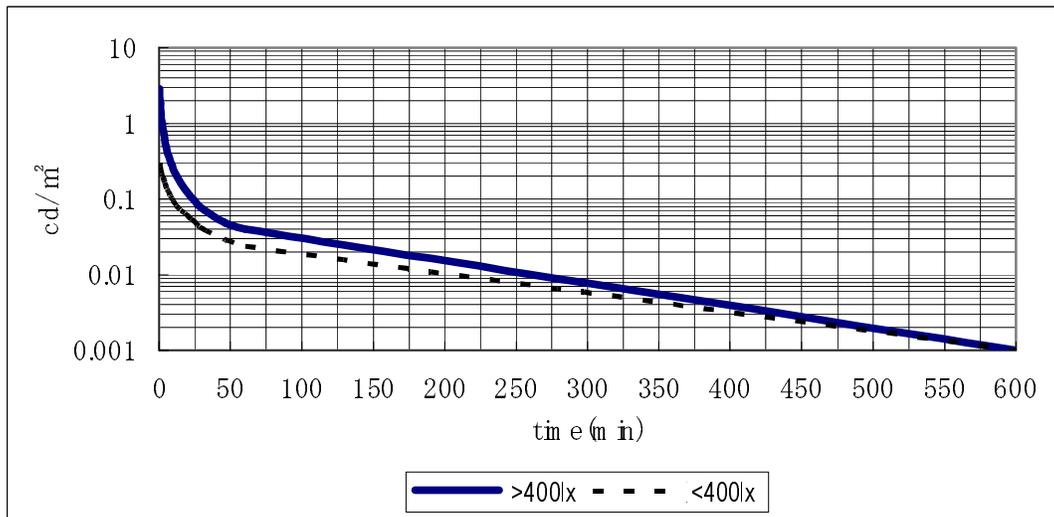


Fig.4 Relation of Brightness of Activation Illuminance and Afterglow luminance_ (50lx·h)

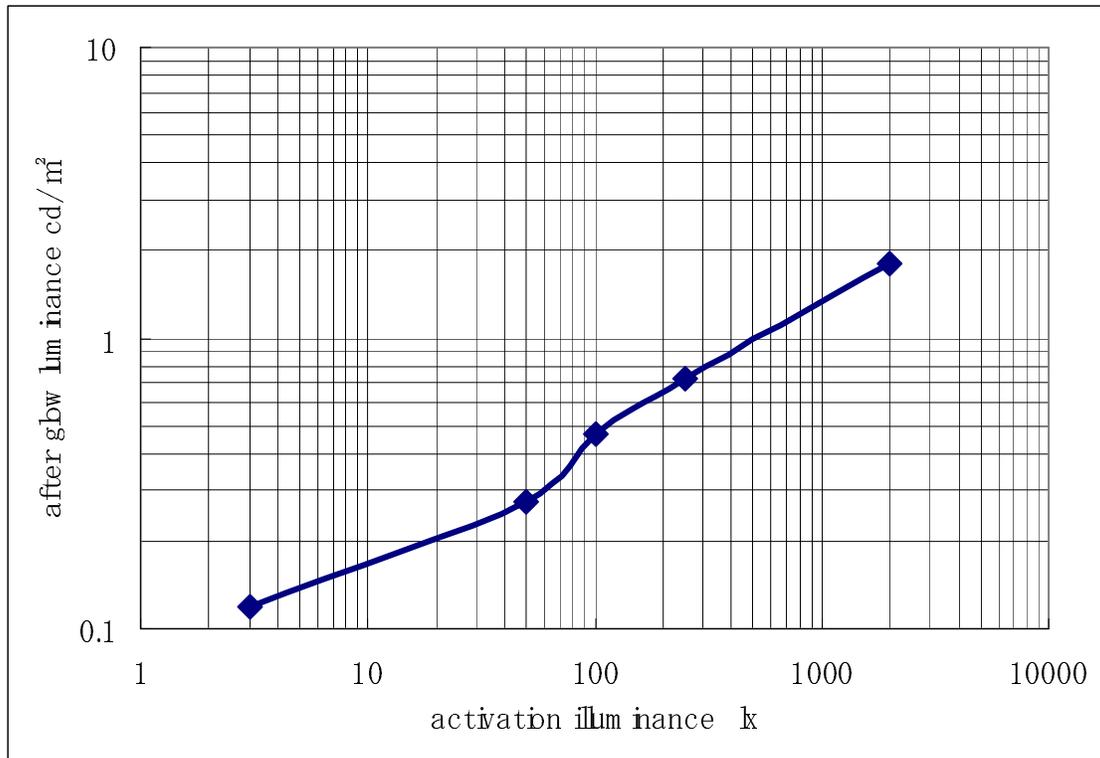


Fig.5 Relation of Intensity of Activation Illuminance and Afterglow luminance after 1 minute_ (50lx·h)

3) Visibility of phosphorescent sheet

The visibility evaluation test was done by ten female college students (their average age was 20 years old) who had normal color vision. In the case that corrected eyesight level (visual acuity) was more than 1.0, even if afterglow luminance was 0.01 [cd/m^2], the existence of all sized phosphorescent sheets were recognized. At a distance of 2.5 [m], in the case of less than around 0.04 [cd/m^2], characters of all point size were not readable. Characters were equivalent as follows. The size of the Chinese character of 72 points is 22x22 [mm] and in the case of the numeric character, 14x19 [mm] and the alphabetic character, 19x19 [mm]. However, even if afterglow luminance was 0.01 [cd/m^2], at a distance of 30cm, all characters up to 8 points were readable. The visual acuity 1.0 is defined as it is possible to recognize 1.5 [mm] gap of the Landolt ring under 500 [lx] brightness at a distance of 5 [m]. When darkness increases from 2 [cd/m^2] in which visual acuity 1.0 can be secured to 0.001 [cd/m^2], it is known that visual acuity will fall to around 0.1. Therefore, in the case of using phosphorescent sheets for the visual information system, it is considered that it is possible to prevent false recognition by displaying only the limited information such as an arrow showing a direction, a name of an evacuation area and a distance from the current position to the evacuation area.

CONCLUSION

- 1) Wide area electrical power failure occurred at the time of the great earthquake in Hanshin and Awaji area. However, evacuation panic in darkness did not occur.
- 2) Therefore, this disaster did not become a turning point to consider of securing outdoor emergency light. In addition, the promotion has not been done.

- 3) It is assumed that 10 million houses will be affected by an electrical power failure at the time of earthquake in the Nankai area. Therefore, it is predicted that if an earthquake occurs during the night, quake refugees will rush to an evacuation route where there is no lighting, in order to escape from a seismic sea wave (tsunami).
- 4) An outdoor information display system which uses phosphorescent pigment is able to secure visibility in darkness for a long time so it will contribute to safe emergency evacuation.
- 5) In preparation for escaping from a seismic sea wave (tsunami), it is necessary to set up a directional sign to show an evacuation area as quick as possible in coastal areas and river areas where there is no levee. If an outdoor information display system is installed on the existing roadway lighting pillars and street lightening pillars, its system performance effectiveness will increase because the system can perform phosphorescent (build up light or energy) until the next electrical power failure. In addition, a translucent display panel with built-in lighting is used for a guide map and so forth, and also if phosphorescent pigment is included in a translucent board, afterglow can be obtained for a long time.

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2. Tanabe,Y.et.al."Relation between the Disaster and Lighting Equipment",Report of the 1995 Great Hanshin-Awaji Earthquake Disaster of the Kansai branch of Illuminating Engineering Institute of Japan ,1997;149-155.