３．２．２　交通安全施設に関する研究

RESEARCH ON ACCIDENT REDUCTION BY INTERSECTION LIGHTING

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ABSTRACT

On roads in Japan, fatal accidents that take the lives of pedestrians tend to occur frequently at night. Every year, approximately 20% of all fatal accidents (about 1,500) occur at intersections at night, despite the low traffic volume at that time. The government has announced the goal of reducing the annual traffic accident fatalities to less than 5,000 per year by 2012, so fatal accidents that occur at intersections at night consists an extremely serious problem because they comprise such a high percentage of all fatal accidents.

The goal of this research is to clarify the conditions that intersection lighting must satisfy in order to reduce nighttime traffic accidents by appropriately installing intersection lighting. The research began with a survey of overseas standards for the brightness of lighting. This revealed that overseas, the brightness of intersection lighting is stipulated in terms of road surface illuminance, and is set in a range from 7.5 lx to 50 lx according to road traffic conditions at each installation location.

Based on the results of the survey, evaluation testing was done to obtain the minimum necessary illuminance and concept of luminaire layout to ensure safety when lighting is installed at intersections. The test hypothesized an intersection that is not influenced by road traffic conditions and roadside conditions to evaluate how visible pedestrians are to drivers and the impression of the lighting on drivers as they pass through the intersection. The results show that it is necessary to ensure average road surface illuminance of 10 lx or more at an intersection at night, and demonstrated that to obtain average road surface illuminance of about 10 lx, the layout stipulated by the commentary to the Road Lighting Facility Installation Standard (JRA, 1981) efficiently distributes illuminance and is the desirable layout.

Next, a field survey focused on intersections where many accidents occur was performed to identify causes of accidents related to road traffic conditions and roadside conditions. Then factors that impact effectiveness were analyzed by comparing the optical properties at locations where the accident reduction effects of lighting are high and locations where these effects are low. The results have shown that at locations with high nighttime accident rates, in addition to inadequate brightness at the intersection, road traffic conditions and roadside conditions cause problems, and at locations where nighttime accident reduction effects are high, vertical illuminance above the crosswalks is high. Next a study of the illuminance necessary to reduce accidents at intersections where many nighttime accidents occur was carried out focusing on the relationship between the occurrence of accidents and the illuminance at intersections. The results revealed that ensuring an average road surface illuminance of 30 lx and uniformity ratio of illuminance of 0.4 reduces accidents even more efficiently.

INTRODUCTION

According to traffic statistics from 2004 (ITARDA, 2005), 56.4% of all accidents caused by traffic accidents occurred at intersections. Of all accidents that occurred at intersections, 27.8% of accidents causing death or injury and 47.7% of fatal accidents occurred at night. Of fatal accidents occurring at night, many were pedestrian – vehicle accidents, and serious injury accidents involving pedestrians crossing streets occur frequently. That year, 1,539 fatal accidents occurred at intersections at night, accounting for about 21.7% of the total of 7,084 fatal accidents that occurred in Japan. The government has announced a goal of lowering the number of traffic accident fatalities to less than 5,000 per year by 2012, and considering the high percentage of all fatalities caused by nighttime fatal accidents at intersections, they are an extremely serious problem.

As an existing traffic safety countermeasure for nighttime intersections, the Road Lighting Facility Installation Standard (JRA, 1981) stipulates the layout of intersection lighting facilities, but this standard does not include standard values for brightness; only simple intersection examples are presented in The Road Lighting Facility Installation Standard Explanation (JRA, 1981) (below called the “standard explanation”) for the layout of luminaires. Considering the increasing complexity of intersection structures that has appeared in recent years as a result of the enlargement of intersection areas by road widening, the construction of grade separated intersections, and addition of right-turn lanes, in order to obtain appropriate accident reduction effects through future lighting facility installation, the standard brightness values and concept of luminaire layout must be clarified. The research obtained the conditions that intersection lighting must satisfy in response to this situation.

DOCUMENT SURVEY AND RESEARCH GUIDELINES

This research begins with a survey of overseas standards for the brightness of intersection lighting to study a method of confirming specific required lighting conditions. A report by the CIE (1995) stipulates the brightness that intersections require as illuminance, specifying the lowest average road surface illuminance to be maintained in an intersection within a range of 7.5 lx to 50 lx and uniformity ratio of illuminance of 0.4 according to the functions of the road and the complexity of the traffic (**Table 1**).

Table 1. Lighting Categories in Areas Where Orderly Traffic is Disrupted (CIE)

Lighting Category	Min. Maintained Illuminance	Uniformity Ratio of Illuminance
C0	50lx	0.4
C1	30lx	0.4
C2	20lx	0.4
C3	15lx	0.4
C4	10lx	0.4
C5	7.5lx	0.4

Lighting category judgment standard

①Road type ②Traffic volume ③Complexity of road structure

④Separation of road users from other forms of transportation

Based on the results, evaluation testing was done to obtain the minimum necessary illuminance and concept of illuminaire layout to ensure safety at an intersection that is not influenced by road traffic conditions and roadside conditions. The testing evaluated how visible pedestrians are to drivers in the intersection and the impression of the lighting on drivers as they pass through the intersection. Next, a field survey focused on intersections where many accidents occur was performed to identify causes of accidents related to road traffic conditions and roadside conditions, and at the same time, factors that impact effectiveness were analyzed by comparing the optical properties at locations were the accident reduction effects of lighting are high with that at locations where these effects are poor. Later an analysis focused on the relationship between the occurrence of accidents and illuminance at intersections was carried out, obtaining the requirements to reduce accidents at intersections where accidents occurred frequently.

ILLUMINANCE AND LUMINAIRE LAYOUT REQUIRED AT INTERSECTIONS NOT INFLUENCED BY ROAD TRAFFIC CONDITIONS AND ROADSIDE CONDITIONS

This obtained the minimum illuminance necessary to ensure safety at intersections not influenced by road traffic conditions and roadside conditions. It investigated the impacts on drivers of the locations of luminaires to clarify luminaire layout concepts. Then evaluation testing was performed focusing on the impression of both factors on the visibility of pedestrians to drivers and the impression on drivers as they pass through the intersection.

Setting lighting conditions

Based on the results of the survey of overseas standards, lighting conditions confirmed by the evaluation testing were set as shown in **Figure 1**. The illuminance values were set in four categories, 15 lx, 10 lx, 5 lx, and no lighting, according to the purposes of the study of the minimum necessary illuminance. The luminaire layout includes three layouts; the layout shown in the Standards Explanation (Layout A), corner layout (Layout B), and a layout combining the two former layouts (Layout C). By combining these luminance levels and these layouts, a total of 10 types of lighting conditions were set. Outside the intersection is a dark area with measured level of 0.2 lx where there is no lighting (below, the lighting conditions are indicated by the symbols shown in **Figure 1**).

Testing method

The testing was done at a full-size intersection of two roads with two lanes in each direction and a lane width of 3.25m to hypothesize the patterns shown in **Figure 2**. In the standing testing, drivers sighted pedestrians from inside their stopped car in 1 second, and in the driving testing, drivers sighted pedestrians while driving straight at 60km/h, and when turning left and right while turning at normal left and right turning speeds to evaluate their visibility. Drivers also evaluated the impression they obtained when passing through the intersection based on “danger to the pedestrian”, “driving ease”, “brightness of the intersection”, and “safety”. Each evaluation was done using the five-step evaluation shown in **Table 2** to score the testing results from 1 point to 5 points. The test subjects were 15 non-elderly people and 5 elderly people, and the pedestrians wore clothes in colors with low reflectance.

Table 2. Grading Terms used for the Evaluation

Evaluation score.	1.	2.	3.	4.	5.
Visibility.	Invisible,	Barely visible,	Somewhat visible,	Clearly visible,	Extremely visible,
Danger to the pedestrian.	Dangerous,	Little dangerous,	Permissible,	Little safe,	Not dangerous,
Driving ease.	Difficult,	Little difficult,	Permissible,	Little easy,	Easy,
Brightness of the intersection.	Dark,	Little dark,	Permissible,	Little bright,	Bright,
Safety.	Dangerous,	Little dangerous,	Permissible,	Little safe,	Safe,

Results of optical measurements

Figure 3(a) shows the results of measurement of vertical illuminance at an elevation of 0.8m above the crosswalk at set illuminance of 15 lx. And “Outside” shown here is a case where a luminous flux from outside the intersection was measured, and “Inside” means a case where a luminous flux from the intersection was measured. As the results, the outside vertical illuminance was highest in layout A followed by layout C and lowest in layout B, and this gap is particularly large on the “side where a luminaire were laid out in layout A and layout C” that is on the left side of the figure. Turning to the inside vertical illuminance, differences based on layout are smaller than in the case of the outside vertical illuminance, but near the center of the crosswalk, the difference is larger than in the other part, with the difference largest in layout B followed by layout C and smallest in layout A.

Figure 3(b) shows the results of measurements of the illuminance distribution on the road surface of the intersection at set illuminance of 15 lx. The results reveal that in all layouts, the road surface illuminance near the crosswalk is higher than at other parts. And in layout A, the road surface illuminance is high along the vehicle lane, but in layout B and in layout C, it is high where pedestrians wait to cross the road and is lower than it is at and around the center of the intersection.

Evaluation testing results

Visibility of pedestrians

Figure 4 shows the average evaluation score and permissible rate (%) of the evaluation of the visibility of pedestrians at each of the set illuminance levels. And the permissible rate shown here is the percentage of test subjects who gave evaluations of “3. Somewhat visible” or higher.

1) Impact on evaluations by differences in illuminance

The higher the average road surface illuminance, the higher the evaluation, and at average road surface illuminance of 10 lx or higher, the average score was 3 or more regardless of luminaire layout. But the higher the illuminance, the smaller the percentage of improved scores, and at an average road surface illuminance of 10 lx and 15 lx, the results do not fluctuate very much.

2) Impact on evaluations by differences in luminaire layout

At set illuminance of 15 lx, the evaluation of layout C was higher than that of other layouts. In layout C, the visibility was higher because, even in a case where the set illuminance was high, the uniformity ratio of illuminance was higher than in other layouts and the road surface illuminance close to the crosswalk was higher than it was at other parts. At set illuminance of 10 lx and 5 lx, the evaluations of layout A are higher than those of other layouts. In the case of layout A, visibility was improved by the fact that a pedestrian can be seen as a silhouette, because the road surface illuminance was high from the crosswalk to the vehicle lane outside the intersection and the inside vertical illuminance above the crosswalk was low.

Impression as the drivers pass through the intersection

Figure 5 shows the evaluation scores and the permissible rate (%) obtained as evaluations of drivers’ impression as they passed through the intersection at each illuminance.

1) Impact on the evaluation by differences in illuminance

In the layout C case, the average score was highest at set illuminance of 15 lx, but in layout A and layout B, it was highest at the set illuminance 10 lx, and it fell at 15 lx.

2) Impacts on the evaluation by differences in luminaire layout

Like the evaluations of the visibility of pedestrians, at set illuminance of 15 lx, evaluations of layout C, and at set illuminance of 10 lx and 5 lx, evaluations of layout A were higher than those at other layouts. A reason for low evaluations cited is the abrupt change of brightness near the intersection, and it is presumed that the uniformity ratio of illuminance in the intersection has a great impact on the psychological state of drivers.

Study of conditions lighting must satisfy

The following are the results of a study of conditions that lighting must satisfy at intersections that are not influenced by road traffic conditions and roadside conditions.

1) Average road surface illuminance that is required

Even at an intersection that is not influenced by road traffic conditions and roadside conditions such as the intersection confirmed by this testing, the average road surface illuminance within the intersection should ensure 10 lx.

2) Concept of luminaire layout

If the average road surface illuminance inside an intersection is set at 10 lx, the layout shown in the standard explanation (layout A) should be used, because it is the most efficient. When the illuminance is set at a high level in a large intersection, the illuminance is often lower in the center of the intersection than around it, so the uniformity ratio of illuminance of the overall intersection should be increased by adding more lighting at the corners of the intersection as it is done in layout C.

REQUIRED ILLUMINANCE AND LUMINAIRE LAYOUT AT INTERSECTIONS WHERE ACCIDENTS OCCUR FREQUENTLY

This survey focused on intersections where many accidents occur was performed to identify causes of accidents related to road traffic conditions and roadside conditions, and at the same time, factors that impact effectiveness were analyzed by comparing the optical properties at locations were the accident reduction effects of lighting are high with that at locations where these effects are poor. Later, the relationship of the state of occurrence of accidents with intersection illuminance at 367 intersections designated as frequent accident locations was analyzed to obtain the intersection illuminance that efficiently reduces accidents.

Analysis of the causes of accidents according to the field survey

Because it was necessary to identify causes other than insufficient illuminance at the intersections that were surveyed, the survey was done at a total of 12 intersections: at six where the daytime - nighttime accident ratio (nighttime accident rate/daytime accident rate × 100%) is high even though adequate illuminance is ensured in the intersection (category X) and at six where the daytime - nighttime accident ratio is low even though the illuminance is relatively low (category Y). **Figure 6** shows the relationship between the daytime - nighttime accident ratio with the illuminance within the intersection at the intersections that were surveyed. The following are characteristics of accidents at each of the survey locations in category X (**table 3**). **Photo 1** shows the road traffic conditions and the roadside conditions that caused problems at these locations.

Table 3. Characteristics of Accidents at the Surveyed Locations

Survey Number	Characteristics of Accidents
X1	Many accidents involving cars entering and leaving a convenience store parking lot and cars traveling straight on the road.
X2	Many accidents involving cyclists crossing the road and cars traveling straight on the road.
	Many accidents occurring when cars are turning right.
X3	Many accidents involving cars turning right and pedestrians crossing the road
	Many rear-end collisions
X4	Soaring accident rate in recent years.
	Many rear-end collisions
	Many accidents involving two cars turning right
X5	Many rear-end collisions
X6	Many accidents involving two cars turning right

The survey clarified the state of road traffic during the nighttime at the surveyed locations and it included optical measurements of the vertical illuminance above the crosswalk and the road surface illuminance. **Figure 7** shows the vertical illuminance above crosswalks at various survey locations. Based on the results, in category Y, regardless of the low road surface illuminance, vertical illuminance above the cross walk is ensured, suggesting that a high level of vertical illuminance above crosswalks is an important element in obtaining the effects of improving lighting systems.

Illuminance that efficiently reduces accidents at Hazardous Spots

For Hazardous Spots, actual accident data and lighting conditions were abstracted, and based on these, the relationship of the illuminance inside the intersection with the accident reduction effects were analyzed. The nighttime - daytime accident ratio was used as an index to quantitatively represent accident reduction effects. The locations where these data were abstracted were 367 locations registered as Hazardous Spots in the Kanto Region, these were sampled for two three year periods—1996 to 1998 and from 1999 to 2001—with those where no accident had occurred during the daytime or nighttime omitted from the samples.

Figure 8 shows the relationship of the illuminance and the illuminance symmetry within the intersections with the daytime - nighttime accident ratio. A tendency for the daytime - nighttime accident ratio to fall as the illuminance rose was observed, and near 30 lx in particular, the inclination of the daytime - nighttime accident ratio increases. It is assumed that the effectiveness of lighting was clearly represented because, in addition to the effects of increasing illuminance, the uniformity ratio of illuminance approached 0.4 (CIE, 1995) that is among values recommended by the CIE to obtain a good lighting environment.

Study of conditions that lighting must satisfy

The conditions that lighting must satisfy at intersections where accidents occur frequently under the influence of road traffic conditions and roadside conditions were studied. The study obtained the following results.

1) Required average road surface illuminance

At intersections such as Hazardous Spots where accidents occur readily, average road surface illuminance of 30 lx and illuminance symmetry of about 0.4 should be ensured.

2) Concept of luminaire layout

At locations, where frequent car – pedestrian accidents occur, the layout of luminaires and luminous intensity distribution should be those that increase the vertical illuminance above the crosswalk.

CONCLUSION

This research has clarified concepts of illuminance and luminaire layout that are necessary at intersections not influenced by road traffic conditions and roadside conditions and at intersections where accidents occur frequently.

The National Institute for Land and Infrastructure Management (NILIM) has carried out many surveys and research projects concerning intersection lighting. In the future, the NILIM will study the appropriate provision of intersection lighting that provides safety and comfort to road users and the enactment of standards that can be fully applied by the newest lighting technologies.

REFERENCES

CIE(1995): Recommendations for lighting for motor and pedestrian traffic, Commission International de l'Eclairage.1995

ITARDA (2005): Traffic Statistics, Institute for Traffic Accident Research and Data Analysis.2005

JRA(1981); Road lighting system installation standards, Japan Road Asociation.1981

BIOGRAPHY OF PRESENTING AUTHORS

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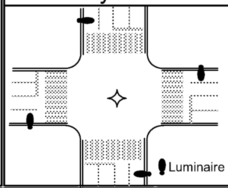
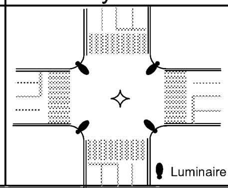
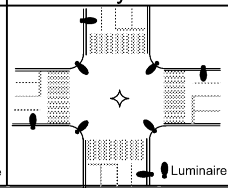
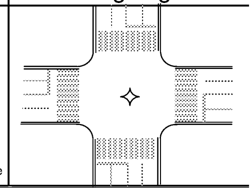
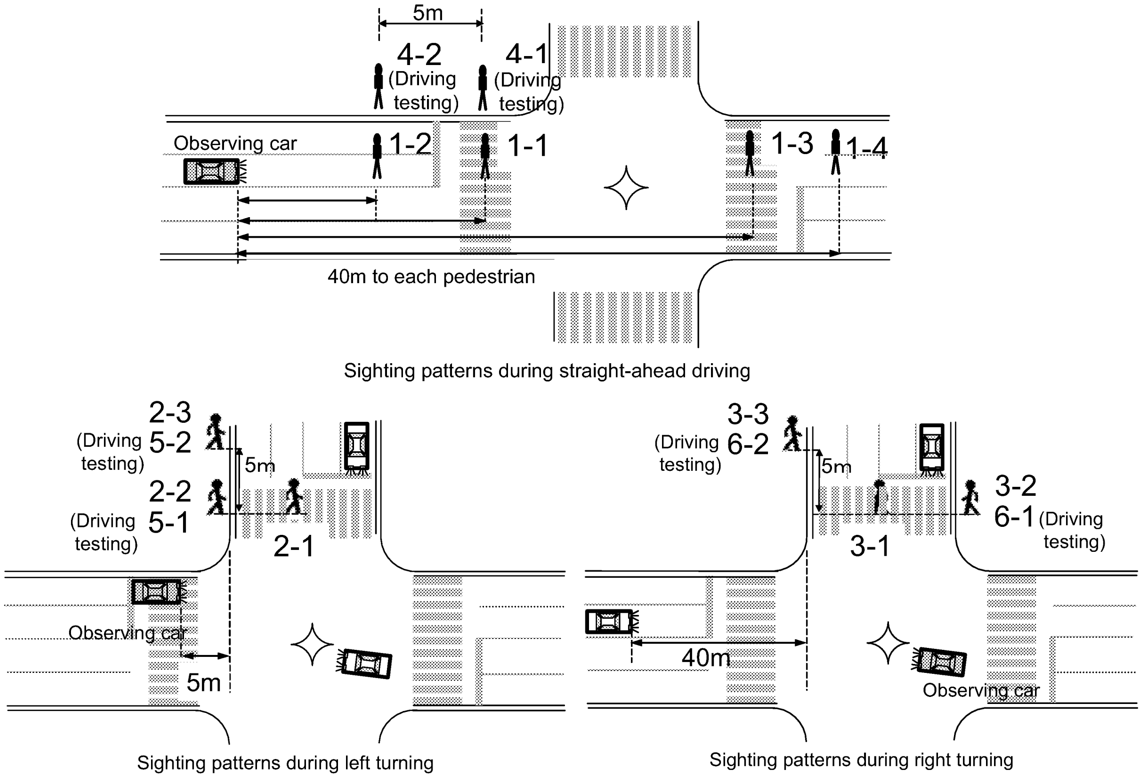
The Advanced Road Design and Safety Division conducts various research projects concerning traffic safety. Among these, the presenting authors are attend to research focused on traffic safety facilities, and have, in addition to road lighting, presented reports on research on safety fences and traffic signs and conducted studies to revise domestic standards.

	Layout A			Layout B			Layout C			No lighting
Luminaire layout										
Set illuminance *	15Lx	10Lx	5Lx	15Lx	10Lx	5Lx	15Lx	10Lx	5Lx	No lighting
Lighting condition codes	A-15	A-10	A-5	B-15	B-10	B-5	C-15	C-10	C-5	No lighting
Remarks	Layout in the Standard Explanation			Corner layout			Layout combining layout A and layout B			Measured approx. 0.2 lx

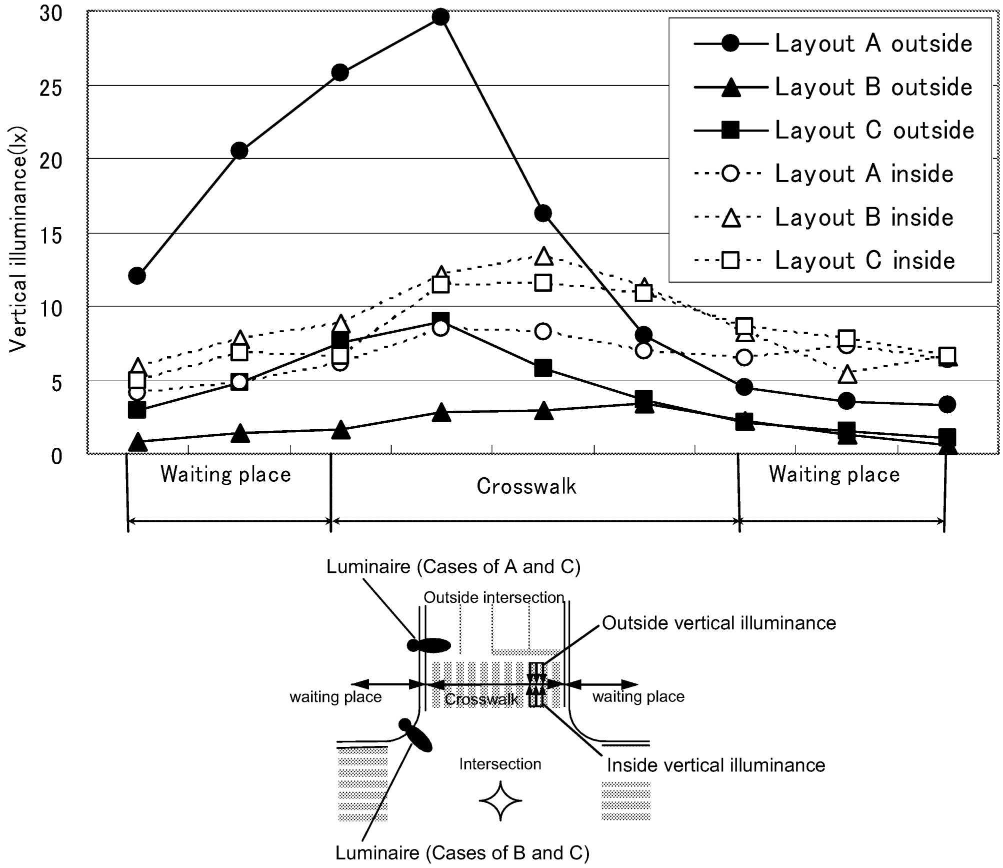
＊. Average road surface illuminance in the intersection

Figure 1. Lighting conditions confirmed by the testing

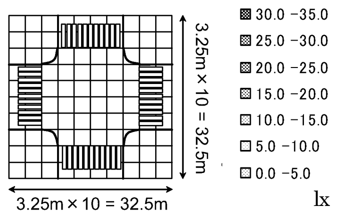
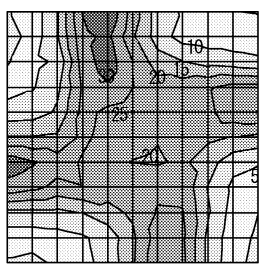
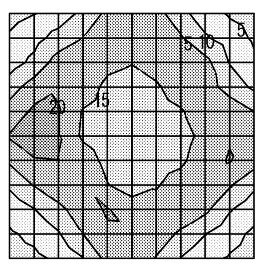
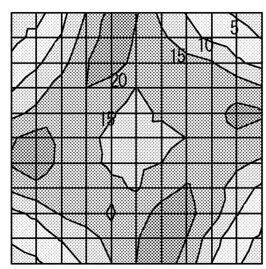


Observing car conditions		Pedestrian conditions		Sighting pattern
Standing testing	Presumed driving straight	Crosswalk directly ahead	In crosswalk	1-1
			Jaywalking	1-2
		Crosswalk across the intersection	In crosswalk	1-3
			Jaywalking	1-4
	Presumed turning left	Crosswalk to the left	In crosswalk	2-1
			Waiting to cross	2-2
			Jaywalking	2-3
	Presumed turning right	Crosswalk to the right	In crosswalk	3-1
			Waiting to cross	3-2
			Jaywalking	3-3
Driving testing	Straight (speed 60km/h)	Crosswalk directly ahead	Waiting to cross	4-1
			Waiting to jaywalk	4-2
	Left turn (gradual)	Crosswalk to the left	Waiting to cross	5-1
			Waiting to jaywalk	5-2
	Right turn (gradual)	Crosswalk to the right	Waiting to cross	6-1
			Waiting to jaywalk	6-2

Figure 2. Sighting Patterns



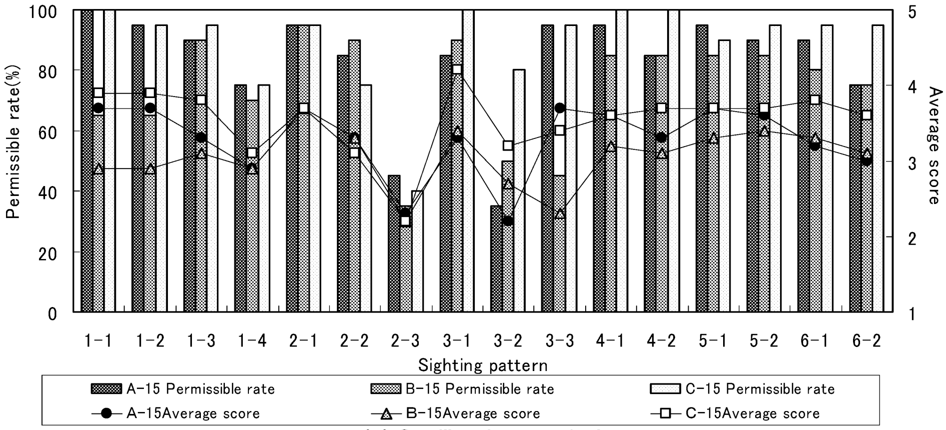
(a) Vertical Surface Illuminance at 0.8m Above the Crosswalk by Layout (Set Illuminance: 15 lx)

Luminaire layout	Layout A	Layout B	Layout C
Average road surface illuminance (Measured*)	18.2lx	14.4lx	15.1lx
Road surface illuminance symmetry	0.35	0.52	0.56
Road surface Illuminance distribution (Measurement range) 			

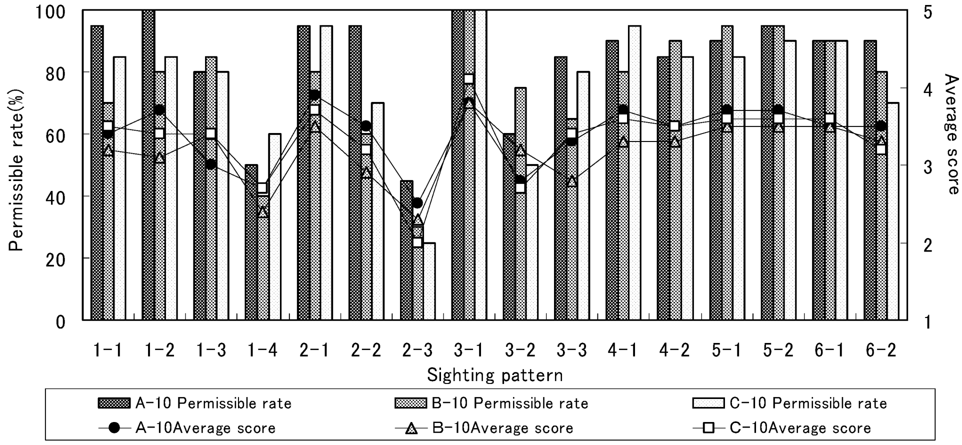
*. Because an ND filter was used to adjust the illuminance during the test, fine illuminance adjustment was impossible, so the average road surface illuminance does not necessary conform with the set illuminance.

(b) Intersection Road Surface Illuminance Distribution by Layout (Set Illuminance 15 lx)

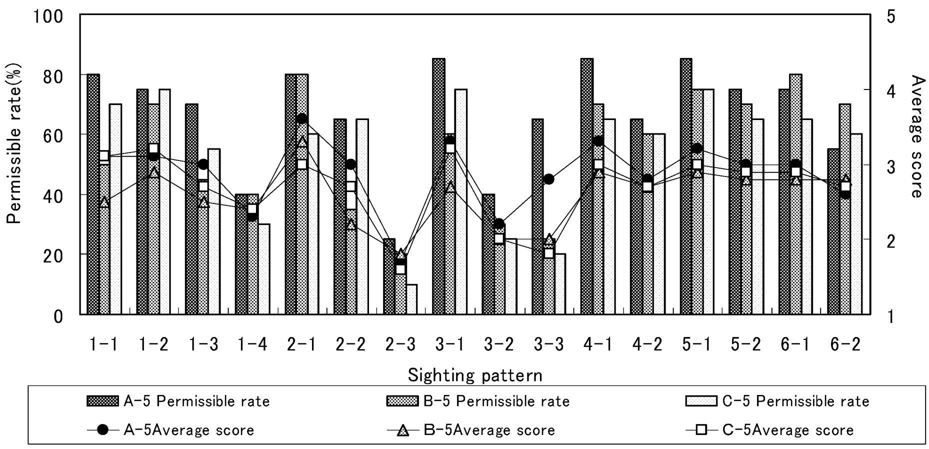
Figure 3. Results of optical measurements



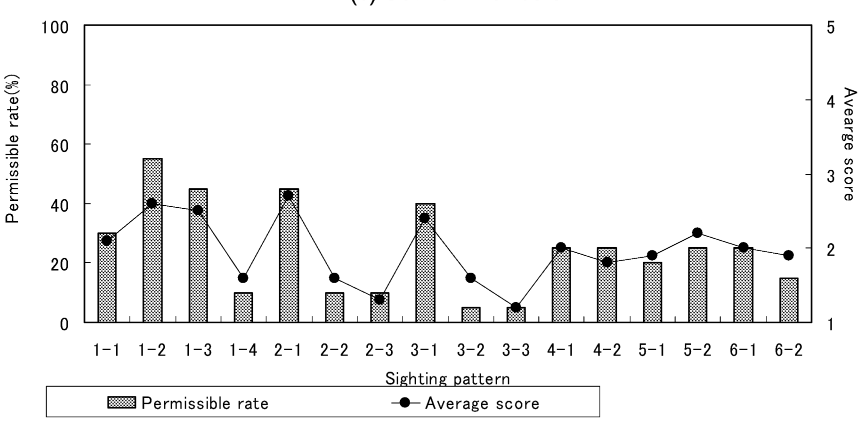
(a) Set illuminance 15 lx



(b) Set illuminance 10 lx

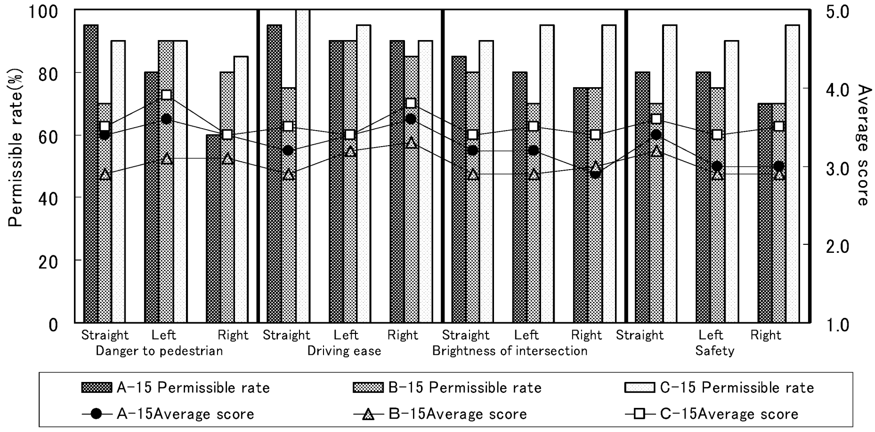


(c) Set illuminance 5 lx

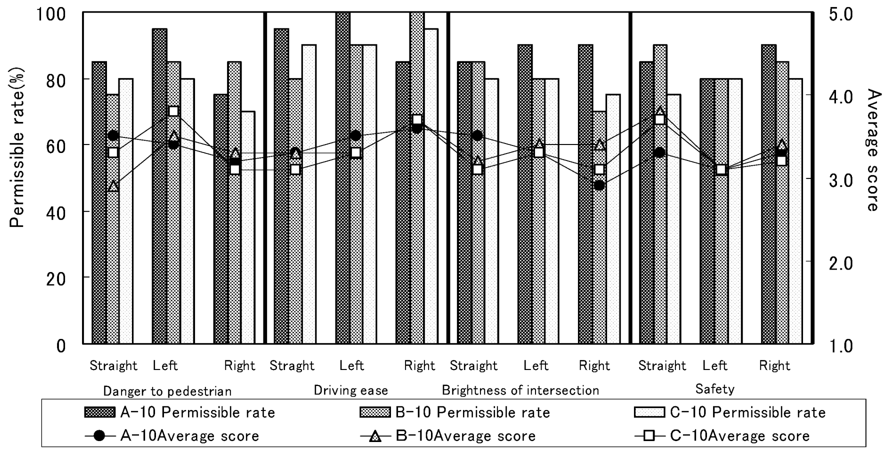


(d) No lighting

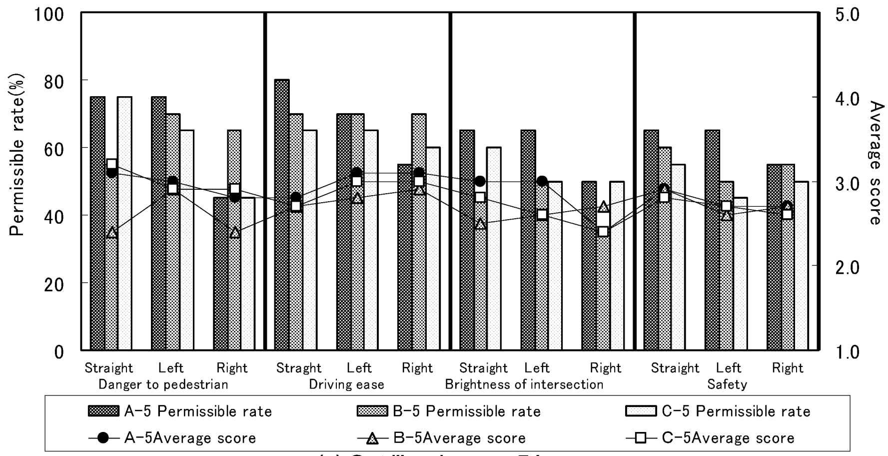
Figure 4. "Visibility" Evaluation Results by Set Illuminance (Permissible rate, Average Score)



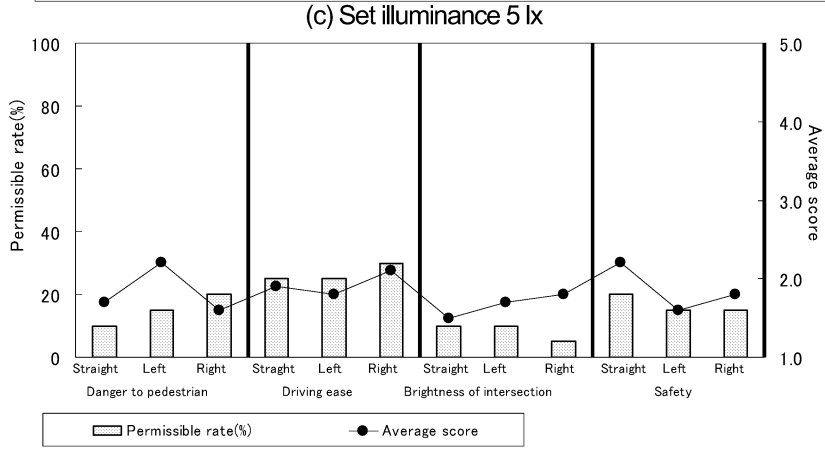
(a) Set illuminance 15 lx



(b) Set illuminance 10 lx



(c) Set illuminance 5 lx



(d) No lighting

Figure 5. "Impression when Passing Through the Intersection" Evaluation Results by Set Illuminance (Permissible Rate, Average Score)

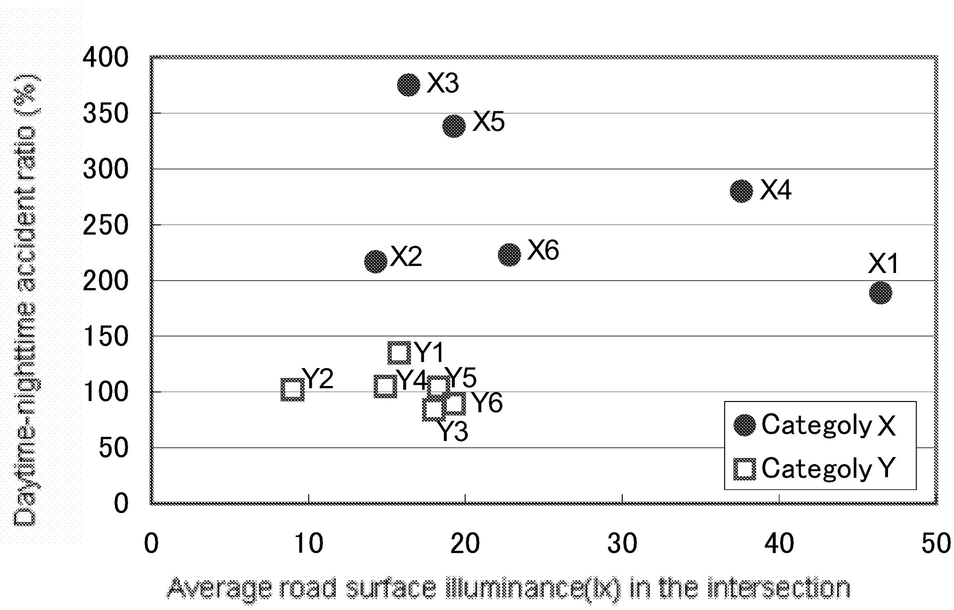
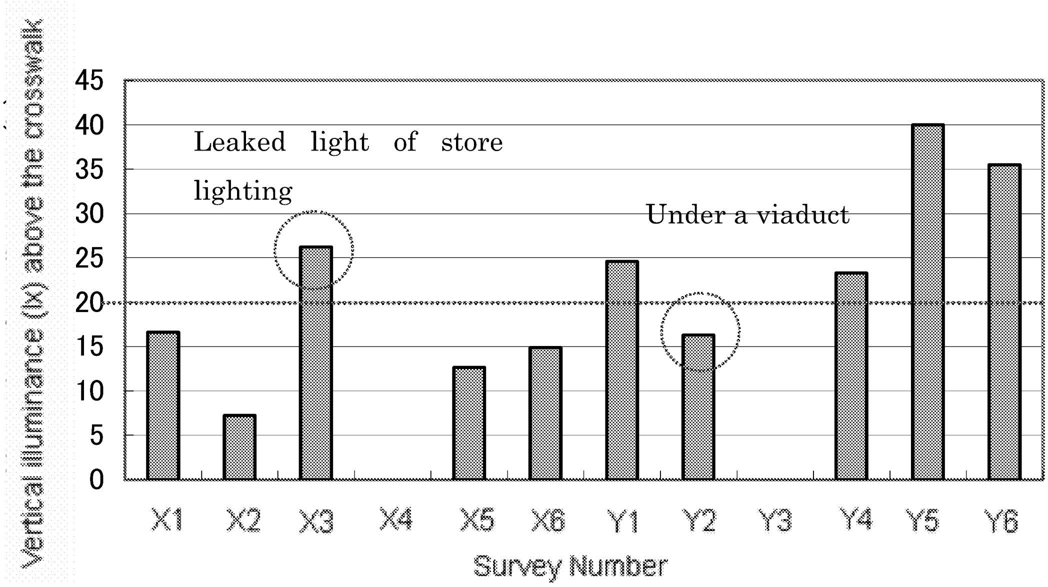


Figure 6. Daytime - Nighttime Accident Ratio at Locations Surveyed



(X4, Y3: Can't measure)

Figure 7. Vertical Illuminance Above the Crosswalk for Each Survey Location

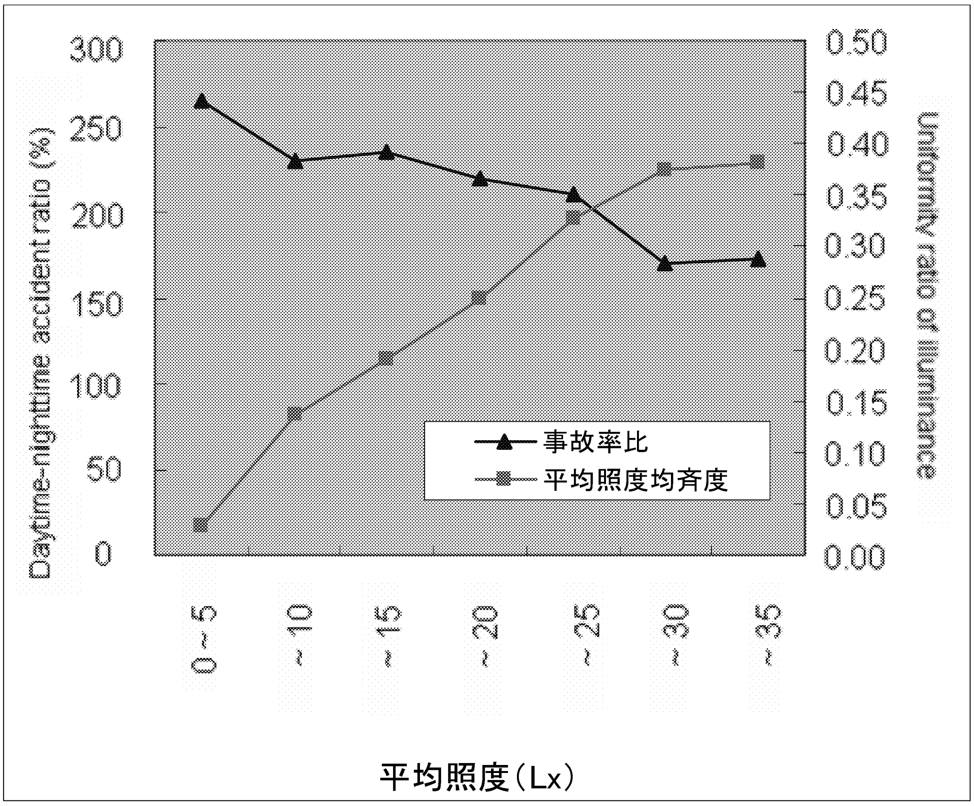


Figure 8. Relationships of the Average Road Surface Illuminance and the Uniformity ratio of Illuminance with the Daytime - Nighttime Accident Ratio in the Intersection

(a) Reduction of visibility where store lighting becomes light noise (X3, X6)

(b) Crosswalk visibility obscured by a structure (X3) (c) Traffic flow confused by a driveway to a shop (X1)

(d) Intersection on a crest so the headlights of the oncoming cars are blinding (X6)

(e) No crosswalk, forcing pedestrians to cross dangerously (X4)

Photo 1. Problems Caused by Road Traffic Conditions and Roadside Conditions at the Surveyed Locations

43. 道路照明基準の性能規定化に向けた検討

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1．はじめに

現在、道路法に基づく道路に道路照明を設置する場合、適切な視環境を確保し維持・管理するために「道路照明施設設置基準」が整備されているが、一部内容が仕様規定となっている。「規制改革推進３か年計画（平成１５年３月２８日閣議決定）」では、技術革新に対して柔軟に対応できるよう、このような仕様規定化されている基準については原則として全て性能規定化する旨の方針が決定されており、道路照明施設設置基準においても新技術や新手法への柔軟な対応を可能としコストの縮減や品質の向上を図る上で性能規定化の導入が望まれる。

2．検討内容

検討に当たり、性能規定化とは「要求する性能とそれを照査する方法を明らかにする形式で基準類を規定するもの」と定義した。本稿では、国内外の道路照明に関する規格や基準類を調査し、国際整合を検討するとともに、既往研究を調査し、安全性、視認性、快適性を踏まえた性能規定化を図るために必要となる道路照明の要求性能について検討を行った。

なお、道路照明の種類として、現行の道路照明施設設置基準に記載されている連続照明、交差点照明、横断歩道照明と道路のバリアフリー化を考慮して歩行者用照明を検討の対象とした。

検討結果を以下に示す。

2．１ 連続照明

道路照明施設設置基準と JIS(JIS Z 9111) [1]、CIE 勧告[2]、イギリス[3]、アメリカ[4] の規格・基準類を対象とした照明要件の比較検討では、各国の道路事情の違いにより道路分類や照明要件の種類は異なるものの、推奨とする照明特性（基準値）において大きな差は見られなかった。調査・検討の結果から、連続照明の要求性能について整理したものを表－１に示す。

表-1 連続照明に求められる要求性能

平均路面輝度　Lr (cd/m^2)	1.0　0.7　0.5 （特に重要な道路、またはその他特別な状況にある道路においては、輝度を$2cd/m^2$まで増大することができる）
総合均斉度　U_0	0.4
車線軸均斉度　U1	0.7　0.5
しきい値増加率　TI	10　15
誘導性	灯具を不適切に配置すると道路の線形、分合流に関して運転者に錯覚を生じさせる恐れがある。道路の線形が変化したり、他の道路と交差しているような場所においては、灯具の配置が道路の線形を良く示しているかどうかによって誘導性の良否がきまるので、道路照明施設の誘導性の良否を透明図などによって十分検討し、誤誘導を生じるような配置を行わないようにすることが望ましい。特に曲線部において誘導性を正しく維持するためには千鳥配列を避け、灯具の間隔を縮小することが必要である。

2．２ 交差点照明

国総研で実施した交差点照明の照明要件に関する研究[5]によると交差点内の平均照度１０Lx を確保することによりドライバーから見た歩行者の視認性が確保されると報告している。また、土木研究所が実施した交差点照明の事前事後の研究[6]および国総研が実施した事故多発交差点のデータ解析による研究[7]では、交差点内の照度が３０Lx 以上で交差点での事故削減効果があると報告している。CIE 勧告では、複雑分合流点の照明要件として照明区分を６段階に分け必要照度を 7.5～50Lx の範囲で規定し、均斉度は、すべての区分において 0.4（下限値として規定）を採用している。これらから、交差点照明の要求性能について整理したものを表－２に示す。

表-2 交差点照明に求められる要求性能

条件		交差点内平均照度(lx)	交差点内照度均斉度（連続照明区間）
道路分類	周囲環境		
主要幹線道路	店舗施設等による外部光がある	30	(0.4)
	影響を受ける光が殆どなく暗い	15	
幹線・補助幹線道路	店舗施設等による外部光がある	20	
	影響を受ける光が殆どなく暗い	15	

※灯具配置は配置例を原則とする

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2．3 横断歩道照明

横断歩道照明には、人物（歩行者等）をシルエットで視認する方法と逆シルエット（直接照射方式）で視認する方法がある。シルエットで視認する場合には、50m手前の運転者が人物の下半身 0.5mを視認するための背景として後方35m以上の路面が明るくなっていることと、照明配置が適切であることが照明の必要要件であり、既往研究[5)]や現行の設置基準から、必要とされる明るさは1.0cd/m²(15Lx)程度が推奨値として考えられる。逆シルエットで視認する場合には、照射する対象（歩行者等）の明るさが視認性の良し悪しを決めるため、鉛直面照度が照明要件となり、既往研究[8)]などから必要照度は20Lxを推奨値とすることが望ましいと考える。

2．4 歩行者用照明

歩行者用照明では、水平面照度、照度均斉度、鉛直面照度を照明要件として取り扱っている文献が多く、水平面照度については歩道等の周辺の明るさと歩行者等の交通量に応じて 20Lx～5Lx の間で規定している基準が多い。道路の移動円滑化整備ガイドライン[9)]では、高齢者や身体障害者等が安全・安心に移動の円滑な通行ができる明るさの下限値として 10Lx 以上を確保することが望ましいとしている。また、路面にムラがあると障害物が視認しづらくなることから、均斉度は 0.2 以上を確保するものとしている。国総研での視認性評価実験[10)]の結果によると、すれ違う通行者の顔の視認性および車両運転者から見た歩道通行者の見えやすさを考慮すると水平面照度を 5Lx 以上確保する必要があるとしている。また、路面の水平面照度 5Lx 以上および照度均斉度 0.2 以上を確保すれば人の顔が確認できるため、鉛直面照度については規定しないものとしている。これらから、歩行者用照明の要求性能として整理したものを表－3に示す。

表-3 歩行者用照明に求められる要求性能

周辺環境	水平面照度(lx)	照度均斉度(最小/平均)
商業地域	10	≧0.2
住居地域 工業地域	5	

3．まとめ

今回の検討では、諸外国等の道路照明に関する規格・基準類を調査し、性能規定化を図る上で必要となる道路照明の要求性能についてとりまとめた。

連続照明の検討では、現行基準と国内外の規格・基準類を調査し、平均路面輝度、総合均斉度、車線軸均斉度、しきい値増加率、誘導性を照明要件としたが、誘導性についての要件を明確に示すことができなかった。交差点照明や横断歩道照明の検討では、視認性や安全性に関する既往研究から平均路面輝度や鉛直面照度を照明要件として抽出したが、これらについては灯具の配置についても重要な要件とされるため基準としての規定の方法に留意する必要がある。歩行者用照明の検討では、道路の移動円滑化整備ガイドラインや既往研究などから水平面照度と照度均斉度を照明要件とした。

最後に、道路照明基準の性能規定化を考える上で照明要件とその照査方法は対で考えなければならない。その為、今回とりまとめた要求性能に対する設計段階や現地での照査方法についても明らかにする必要がある。

＜参考文献＞

1)（財）日本規格協会；道路照明基準 JIS Z 9111-1988 2) Commission Internationale de l' Eclairage(CIE)；NO-115,1995 3)イギリス；BS5489-Part2,Part10 4)アメリカ；ANSI/IES RP-8-1983 5)国土技術政策総合研究所；交差点照明の必要照度と照明位置に関する実験解析業務 6) 大谷寛・安藤和彦・鹿野島秀行；道路照明による効果的な夜間交通事故削減対策の検討，照明学会第33回全国大会講演論文集，2000 7) 国土技術政策総合研究所；交差点照明の照明要件に関する実験解析業務 8)建設省土木研究所；土木研究所資料第 3668 号 高機能道路照明に関する検討，p105，1999 9)（財）国土技術研究センター；道路の移動円滑化整備ガイドライン 10) 国土技術政策総合研究所；国総研資料第157号 歩行者用照明の必要照度とその区分に関する研究，p56，2004

51. 道路照明技術の現状調査

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1．はじめに

近年夜間の重大事故が多発しており、昼間に比べて交通量が少ないにも関わらず、夜間死亡事故は死亡事故全体の約 52.3%(年間約 3,700 件)を占めている [1)]。国総研ではこれまでに道路照明施設による夜間事故削減に向けた研究をおこなっており、道路照明施設が夜間ドライバーからの歩行者の視認性及びドライバーの運転のしやすさ等の観点から交通安全対策として非常に有効であることを把握している [2)]。ところで、近年様々な新しい照明技術が開発され、夜間の交通安全対策として有効的なものや、景観への配慮やコスト削減といったニーズに対しても対応できる技術が開発されている。

そこで本研究では、近年の道路照明施設の技術開発状況を調査した。

2．調査概要

調査では連続照明、交差点照明について施設の概要、照明方式、特徴等を調べた。表-1 に調査を行った施設の概要及び目的、表-2 に No.8 多目的柱による交差点照明の調査結果を示す。連続照明ではポールの高さを従来のものより高くすることで灯具間隔を広くしたもの(No.1)や、反対に低くすることで維持管理の作業性の向上を図ったもの(No.2)がみられた。また車両後方遮光照明(No.4)や光チューブ照明(No.5)といった技術を用い、それぞれの特性を活かして安全性向上を図ったものも見られた。橋梁部の連続照明では照明を高欄や遮光板に設置し橋梁下の河川や住宅地への光害を抑制したもの(No.7)がみられた。交差点照明では多目的柱を用いて信号や標識と併設し美観性の向上や交差点付帯設備全体の初期コストの軽減を図ったもの(No.8)がみられた。また、配光を工夫した専用器具により交差点全体の均斉度を高めドライバーからの視認性を向上させたもの(No.9)もみられた。照明施設全般では近年普及している直線ポール(No.10)の他にも、無極電放電ランプ(No.11)やツイン発光型ランプ(No.12)等を採用する例が見られ、両者とも寿命が長く維持管理コストの削減を図ったものである。

表-1 調査を行った施設の概要及び目的

No.	照明区分	施設概要	目的
1	連続照明	高ポールによる広ピッチ照明	初期コスト削減
2	連続照明	低ポール照明	安全性向上(視線誘導)、維持管理の作業性向上
3	連続照明	平行する高架橋下部への照明設置	初期コスト削減(ポール不要)
4	連続照明	車両後方遮光照明	安全性向上(鉛直面照度高)、光害抑制
5	連続照明	光チューブ照明	安全性向上(均斉度高、視線誘導)、光害抑制
6	連続照明(長大橋)	制震装置を内蔵したポール	振動による金属疲労低減
7	連続照明(橋梁)	高欄、遮光板に設置した蛍光灯による照明	光害抑制
8	交差点照明	多目的柱(信号、標識等とポールを併用)	美観性、初期コスト削減
9	交差点照明	交差点専用器具(配光に工夫)	安全性の向上(均斉度高)
10	道路照明全般	直線ポール	美観性、初期コスト削減
11	道路照明全般	無極放電ランプによる照明(長寿命)	維持管理コスト削減、安全性向上(演色性良)
12	道路照明全般	ツイン発光管型ランプによる照明(長寿命)	維持管理コスト削減
13	道路照明全般	昇降式道路照明設備	維持管理の作業性向上
14	道路照明全般	漏光対策(フード型ルーバ)	漏光対策

表-2 調査結果の一例

No.8	
施設概要	多目的柱による交差点照明
設置場所	伊丹駅周辺地区
照明方式	設置高さ:H=10m 灯具配置:隅切り部配置 光源:水銀ランプ(HF400w)
特徴	多目的柱(信号や標識と柱を併用)を使用 ツイン発光管型ランプを使用
写真、図等	  ツイン発光管型ランプ　多目的柱

3．まとめ

本調査では、新しい技術を用いた道路照明施設について調査を行った。その結果、直線ポール、車両後方遮光照明、ツイン発光管型ランプなど道路照明機器全体で開発が進められ、従来のものよりコスト、安全性、光害といった問題に対して広く対応できるようになってきたことがわかった。今後は、新たなニーズに柔軟に対応でき、今回調査したように新しい技術の開発状況を把握し、交通安全対策として有効な技術を積極的に活用できるような基準の性能規定化に向けた検討が必要である。

【参考文献】1)交通統計、(財)交通事故総合分析センター、2005.4　2)交差点照明の照明要件に関する研究、日本道路会議講演論文集、(社)日本道路協会、蓑島治 岡邦彦 池原圭一、2005.11

Survey on Road Lighting Technology,　Osamu MINOSHIMA, Kunihiko OKA, Keiichi IKEHARA