LIGHTING DESIGN FOR A FOOTBALL FIELD

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ABSTRACT
A good lighting design for a football field is important both for the players' performance and for the spectators to watch the game in pleasure. In this paper, lighting design for a football field which has a stand of 15000 seating capacity is considered. The required number and positions of floodlights are determined as a result of lighting design to satisfy minimum lighting level on the football field.

1. INTRODUCTION

A good lighting design should satisfy the requirements and comfort of each of three groups of people in a football match. These are players, spectators and officials. A good lighting design for a football field is of importance both for the players to play the match in pleasure and to display a good performance in the game and also for the spectators to watch the game in pleasure. Providing an appropriate illumination for one group should not introduce objectionable glare into the field of view of the other two groups. The areas where football match will be televised usually requires a higher level of illumination. This not only ensures good broadcast condition, but also improves vastly visibility for both spectators and participants.

The basic requirements for a good lighting design of night football lighting are: a) Adequate illumination to meet the demands of particular class of play and the maximum spectator viewing distance. b) Correct distribution and focusing of the floodlights to ensure the best utilization of light with maximum ease of sight for players, spectators, and officials. c) Uniform

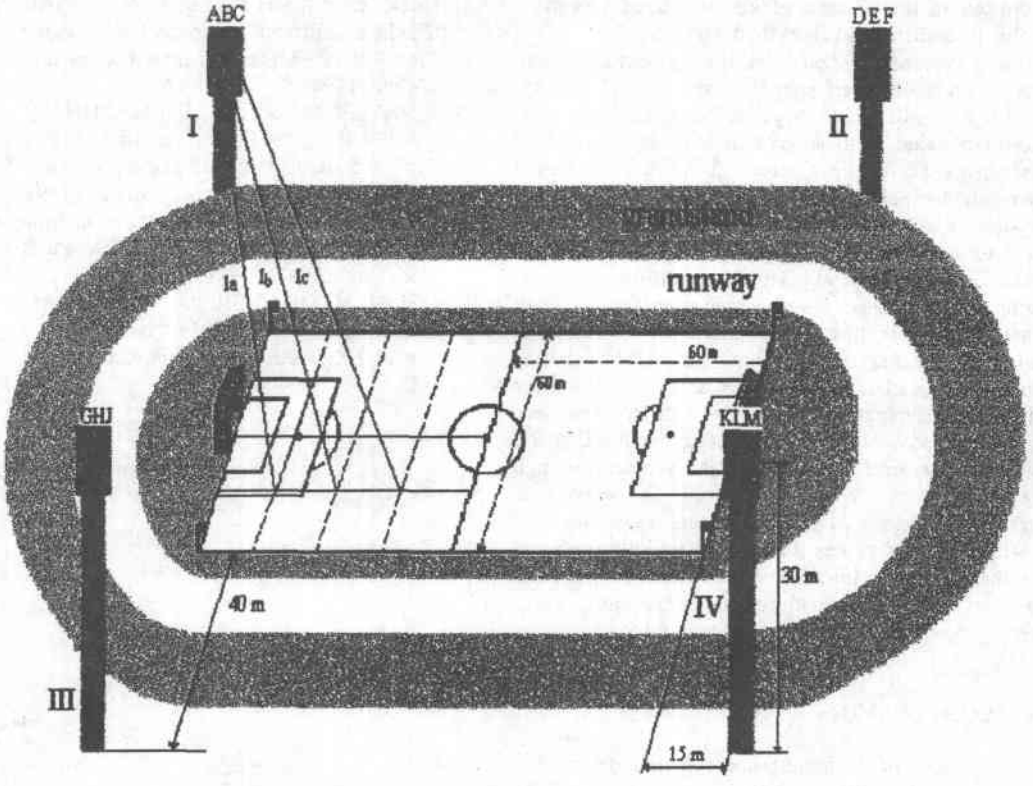

Figure 1.The lighting arrangement proposed for the football field.

distribution of light on the field.

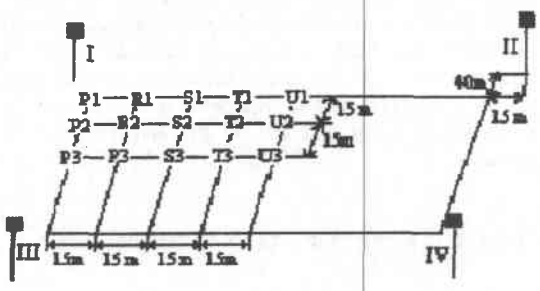

Figure 2. The points whose illumination levels are to be calculated.

It is required that in the lighting design of a football field, almost all points on the field should be at the required illumination level in compliance with the related standards. Generally, the distance between the spectators and the play is the first point to be considered in determining the lighting requirements. Secondly, the seating capacity of the stands should be considered. The floodlights which are to be used for the lighting of a field should be adequately chosen . Floodlights with narrow beam spread result in spotty illumination. On the other hand, The floodlights with wide beam spread result in poor utilization and a low level of illumination, particularly in the centre of the field. So, they may produce glare in opposite stands close to the side lines.

In the lighting design presented here, as shown in Figure1, three groups of floodlights mounted at the top of four poles are used for the illumination of the football field. The illumination levels produced at different points on the field which are shown in Figure 2 are determined using personal computer utilizing MATLAB. Number of floodlights is increased until the required illumination levels at the specified points are satisfied. It is accepted that once the illumination levels at the specified points satisfy the required minimum level, the number of floodlights is said to be determined and their positions are accepted to be appropriate. Otherwise, the number of floodlights is increased and their positions may be changed.

2.CALCULATION OF ILLUMINATION LEVELS PROVIDED BY GROUP FLOODLIGHTS

In Figure 1, group floodlights A,F,G and M are mounted at the top of poles I, II, III and IV and each group has two individual floodlights. The distance between each of these group floodlights and the points to which they are focused are equal and given by,

$$l_a=l_f=l_g=l_m=\sqrt{30^2+85^2+30^2} = 95 \text{ m}$$

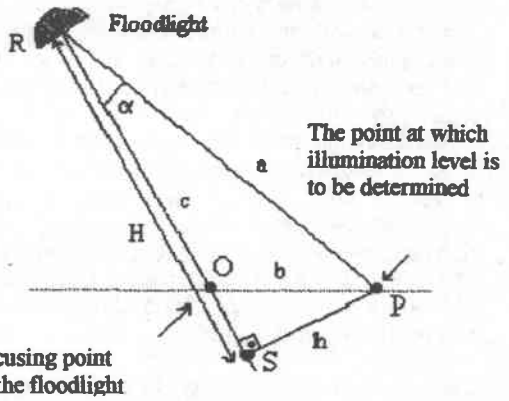

Figure 3. The required dimensions to determine the illumination of point P.

Group floodlights B, E, H and L which are at the top of the same poles contain four floodlights each and their

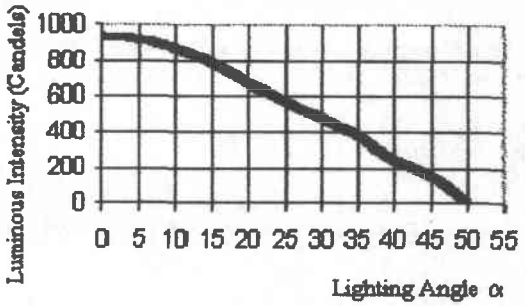

Figure 4. Luminuous distribution curve of a narrow spread, HQL type mercury vapour lamp of 1000 lumens.

distance to the focusing points on the field are the same and given by,

$$l_b=l_e=l_h=l_l=\sqrt{30^2+85^2+45^2} = 100.7\text{m}$$

Similarly, group floodlights C, D, J and K which are mounted at the top of the same poles contain fifteen floodlights each and their distance to the focusing points on the field are the same and given by,

$$l_c= l_d=l_j=l_k= \sqrt{30^2+85^2+60^2} = 108.3 \text{ m}$$

Each pole used has a height of 30 meters. Other dimensions related to the football field considered and the location of poles are shown in Figure 1. The angle α which is illustrated in Figure 3 is the angle between the focusing point of the floodlight of interest and the point on the field whose illumination level is to be determined.

As an example, illumination level of point U_1 on the football field , shown in Figure 2 will be determined

here. If the illumination level calculated is in compliance with the required standard levels, then calculations for the other points on the field are carried out. In order to find the illumination level at point U_1, it is essential to determine the total illumination level produced at this point due to all group floodlights. Figure 2 illustrates the points for which, lighting angle α and the distance H are calculated. In lighting design, narrow spread, HQL type mercury vapour floodlight lamps of 1000 W having luminous flux of 55000 lumens is considered. Figure 4 gives luminous distribution curve of such a lamp having a luminous flux of 1000 lumens.

Consider the floodlight with the lighting triangle POR, shown in Figure 3. Point O is the focusing point of the floodlight; point P is the location on the field at which illumination level is to be determined. The sides of a, b, c of the triangle can be determined from the dimensions given in Figures 1and 2. Surface area of the triangle in terms of its edges a, b, c is given by,

$$S = \sqrt{d*(d-a)\,(d-b)\,(d-c)} \qquad (1)$$

where d=(a+b+c)/2. The height of triangle POR with respect to base c and the distance H can be determined as,

$$h = \frac{2S}{c} \quad \text{and} \quad H = \sqrt{a^2 - h^2} \qquad (2)$$

Hence, lighting angle α may readily be found as,

$$\alpha = \cos^{-1}\frac{H}{a} \qquad (3)$$

This angle is to be determined for all points of interest shown in Figure 2. Later on, luminous intensity $I\alpha$ corresponding to angle α is found making use of the luminous distribution curve. Hence, illumination level E produced by the floodlights at the point of interest is determined by,

$$E = \frac{I_\alpha}{H^2}\cos^3\alpha \quad \text{(lux)} \qquad (4)$$

Table 1 gives lighting angle α corresponding to point U_1 and the illumination levels produced at this point due to each of these group floodlights.

3. THE ILLUMINATION PROVIDED BY ALL OF THE GROUP FLOODLIGHTS

Total illumination provided at point U_1 due to all of the group floodlights may be determined using Equation (5).

$$E_{U1} = \sum_{i=1}^{n}\frac{(I\alpha)_i}{H^2}\cos^3\alpha_i \qquad (5)$$

Where, n is the total number of group floodlights. Total illumination levels produced at different points on the football field are given on Table 2. It can be seen from the table that total illumination level at point U_1 is calculated to be E_{U1}=249 lux. Maximum illumination is found to be 372 lux and it occurs at point R_1.

Table 1. Lighting values related to the illumination of point U_1.

Grup	α	$I\alpha$	E (lx)
A	40,1	250	2,6
B	32,3	380	8,7
C	25,6	550	50,4
D	25,6	550	50,4
E	32,3	380	8,7
F	40,1	250	2,6
G	17,5	750	4,76
H	9,46	875	11,5
J	3	935	46,6
K	3	935	46,6
L	9,46	875	11,5
M	17,5	750	4,76
	E_{U1} =249 lux		

4. CONCLUSIONS

As can be seen from Table 2, minimum total illumination level provided by the group floodlights is 249 lux and it occurs at point U_1 in Figure 2. In other words, outer side of the mid-field is the region having the minimum illumination level. On the other hand, points R_1, R_2 and R_3 are those having higher illumination levels. Minimum illumination level required by VDE standards depends on the spectators capacity of a football field. Here, the illumination level of 250 lux is taken as reference which is proposed for a football field having an spectators capacity of 15000. So, the illumination levels calculated at the selected points as a result of lighting design of the football field considered are found to be satisfactory.

5. REFERENCES

[1] ÖZKAYA, M., "Yol Aydınlatması" İTÜ Publication No:1413, 1990.
[2] "Lider Aydınlatma" Catalogue of products , 1996
[3] J.E. TRAISTER, "Principles of Illumination", Howard W.Sams Co., Inc., 1974.

Table 2. Illumination levels produced by group floodlights at the selected points on the football field.

Group	EP1	EP2	EP3	ER1	ER2	ER3	ES1	ES2	ES3	ET1	ET2	ET3	EU1	EU2	EU3
A	29,4	22,7	16	20,81	19,24	15,05	10,75	12,23	11,38	4,82	6,87	7,52	2,6	3,54	4,53
B	54,6	40,05	27,23	48,18	42,6	29,72	30,66	30,75	25,59	16,05	20,07	19,22	8,7	12,06	13,34
C	171,2	120	79,55	182,9	142,5	106,4	135	122,2	96,7	84,66	66,91	79,94	50,35	60,89	59,1
D	8,7	12,17	15,74	12,96	18,23	21,66	19,5	26,46	33,5	31,12	40,26	43,56	50,35	60,89	59,1
E	0	2,05	2,46	0	3,09	3,87	4,68	4,3	5,68	5	7,40	8,72	8,7	12,06	13,34
F	0	0	0,5	0	0	1,18	0	0,97	1,6	0	2	2,56	2,6	3,54	4,53
G	8,45	11,52	15,98	8,6	11,46	15,05	7,8	9,5	11,38	6,32	7,1	7,52	4,76	4,95	4,53
H	13,58	18,9	27,23	15,74	21,5	29,72	15,8	20,38	25,59	14	16,76	19,22	11,5	12,85	13,34
J	36,77	52,27	78,28	51,93	69,23	99,75	54,26	72,58	96,7	52,2	66,14	79,94	46,62	54,29	59,1
K	19,31	18,2	15,74	24,37	24,19	21,66	31,35	32,13	33,5	38,75	42,37	42,7	46,62	54,29	59,1
L	3,67	3,34	2,46	5	4,68	3,82	6,85	6,6	5,68	8,97	9,33	8,86	11,5	12,85	13,34
M	1,15	1,06	0,5	1,6	1,3	1,18	2,33	2,1	1,59	3,3	3,2	2,56	4,76	4,95	4,53
Total	346,9	302,2	281,7	372	358	349	319	340,2	348,9	265,2	288,5	322,3	249	297,2	307,9