The availability of Solar illumination at Roorkee

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ABSTRACT. Measurements of the availability of solar illumination on an external horizontal surface at Roorkee are described. The measured values are compared with those calculated from the empirical formula proposed by Elvegard and Sjostedt for clear skies. It is found that the constants of this formula need modification to fit the observations at Roorkee. The illumination corresponding to a cal/sq. cm/min of total radiation incident on the horizontal surface from the sky and sun was also computed from the thermal data available for Roorkee. These computed values agree within 10 per cent of those reported in the literature.

1. Introduction

A knowledge of the availability of solar illumination is a prerequisite to daylighting design. Measurements of the daily and seasonal variations of this quantity are meagre in this country. Experiments were initiated in this institute to obtain data on the availability of daylight on a horizontal plane outdoors. This paper summarizes the results of observations for a period of one year from January to December 1962.

2. Experiment

Measurements were made using a Megatron integrating type photocell provided with colour and cosine corrector discs. The photocell was located on an elevated platform, well above surrounding objects and exposed to global solar illumination (sun and sky). The output of the photocell was fed to a Sunvic self-balancing potentiometric recorder through a suitable attenuating resistance network. The recorder was checked against a Leeds and Northrup K-3 potentiometer and the photocell against a standard lamp on the photometric bench. Finally the illumination levels as measured by the recorder were compared with those of a Weston standard foot candle meter from time to time.

Observations were made from 9 A.M. to 5 P.M. on all days except on holidays, rainy days and on days when the instruments were checked. It is proposed to extend these observations from sunrise to sunset as soon as facilities become available. A day was treated as partially cloudy when the recorder trace showed even the least amount of fluctuation at any time of the day.

3. Results

The sets of curves for the total solar illumination on a horizontal surface were arrived at by averaging the illumination on cloudless days every hour between 9 A.M. and 5 P.M. Since this illumination varies with solar altitude and azimuth it was thought reasonable to divide the month into two equal halves and then compute the average to arrive at the hourly variation of the total illumination on the horizontal. The results are represented in Figs. 1 (a) to 1 (c). Here the variation of the illumination on the horizontal are plotted against the time of the day. The results are for the data available for the year 1962.

Elvegard and Sjostedt (1940) suggest that the intensity of the total available daylight I, on the horizontal, from a clear sky can be computed from an empirical equation of the form —

$$I = K_1 \sqrt{\sin \theta} + K_2 \sin \theta . 10^{-0.1m} \quad \text{lumens / sq. ft} \quad (1)$$

where θ is the solar altitude, K_1 and K_2 are constants and m the air mass. The values of K_1 and K_2 are 1750 and 13200 respectively. Calculated and observed values of I show

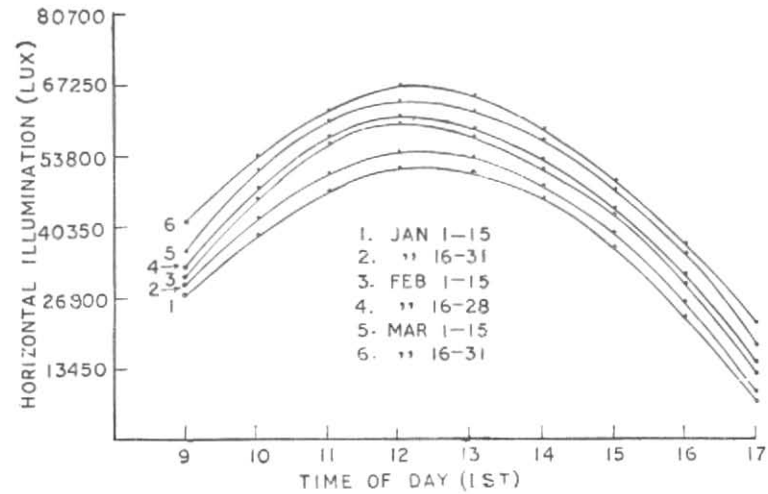

Fig. 1(a)

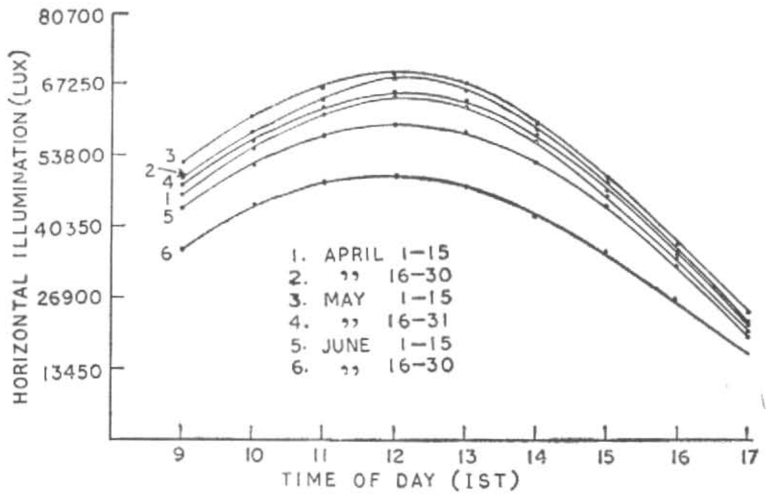

Fig. 1(b)

Figs. 1(a) and 1(b). Intensity of daylight on a horizontal surface at Roorkee

that the values of the constants K_1 and K_2 for tropical skies are 800 and 6100 respectively for solar altitudes between 30° and 60°.

Values of total solar illumination on the horizontal for a given solar altitude were also computed on clear days and shown in Fig. 2. It is found that there is a gradual decrease of this quantity from January to June and then it increases towards December. This is attributable to the increase of the dust content of the atmosphere in the tropics from January to June after which the rains set in and the atmosphere is dust free.

4. Illumination equivalent of radiation

The relation between illumination and total radiation on a horizontal surface was

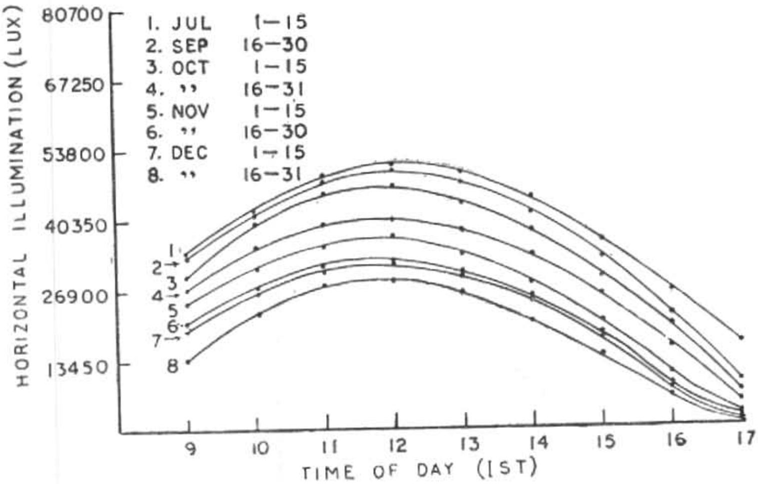

Fig. 1(c). Intensity of daylight on a horizontal surface at Roorkee

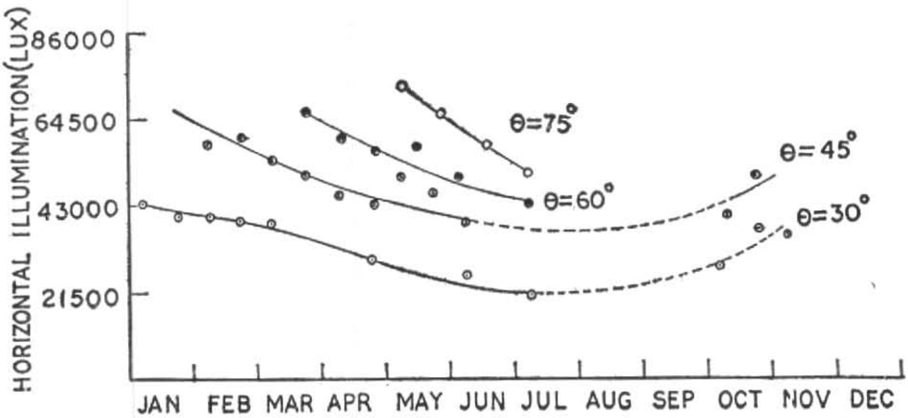

Fig. 2. Variation of the intensity of global illumination on a horizontal plane for several solar altitudes

studied for those days for which radiation data were available. The results are presented in Table 1. The illumination equivalent of 1 cal/sq. cm/min taken hourly are also given. These values are slightly less than those reported in the literature (*Illum. Res. Tech. Pap.* — see ref.), but are of the same order of magnitude as those obtained by Kimball (1921, 1923) and Dogniaux (1960).

5. Conclusions

1. The total daylight intensity on a horizontal surface varies from a maximum of 67·8 kilolux in mid May to 28·0 kilolux in mid December; fluctuations of the order of 10 per cent are possible from these values which are averages only.

2. The variation of the total incident daylight on a horizontal plane gradually decreases from January to July and increases from July to December. This is attributable to the variation in the dust content of the atmosphere.

3. A comparison of the values of the total incident radiant flux with the luminous flux indicated a conversion factor of 57·5 kilolux for every cal/sq. cm/min of the total radiation incident on the horizontal surface from the sun and sky.

TABLE 1

Relation between total illumination and global solar radiation incident on unit area of a horizontal surface between 10-30 A.M. and 4-30 P.M. (IST) on clear days

Date of observations	I	H	I/H	I	H	I/H	I	H	I/H
	10-30 to 11-30			11-30 to 12-30			12-30 to 1-30		
1 1-62	47·75	·885	54·20	50·10	·925	55·30	50·50	·885	56·90
11-1-62	44·45	·805	55·25	49·80	·885	56·30	51·10	·845	60·60
22-1-62	47·15	·803	58·60	51·10	·885	57·70	49·10	·845	58·10
22-2-62	59·20	1·005	59·00	64·55	1·085	59·50	62·40	1·005	45·75
23-2-62	51·75	·925	55·95	57·15	1·045	54·75	56·50	1·045	54·15
26-2-62	55·50	1·045	52·75	61·85	1·127	54·90	61·85	1·127	54·90
1-3-62	57·15	1·045	54·75	60·55	1·085	55·85	66·00	1·085	60·80
23-3-62	66·00	1·167	56·50	67·95	1·247	54·50	66·00	1·207	54·70
31-3-62	61·20	1·207	50·75	64·55	1·247	51·85	63·90	1·247	51·35
Mean I/H			55·30			55·60			55·25
	1-30 to 2-30			2-30 to 3-30			3-30 to 4-30		
1 1-62	46·35	·763	60·80	38·95	·603	64·55	26·25	·241	107·60
11-1-62	47·20	·723	65·10	37·00	·523	70·60	22·92	·281	81·25
22-1-62	43·05	·930	46·25	35·60	·603	59·20	22·92	·281	81·25
22-2 62	54·90	·965	57·00	44·45	·763	58·10	29·60	·523	56·50
23-2-62	45·10	·925	54·70	44·45	·805	55·25	28·95	·523	55·30
26-2-62	55·25	1·045	52·75	43·70	·885	49·40	30·22	·603	50·25
1-3-62	55·25	·965	57·25	48·45	·805	60·10	38·30	·523	73·35
23-3-62	59·85	1·085	55·25	48·45	·918	52·75	—	—	—
31-3-62	57·15	1·085	52·75	45·10	·763	59·00	32·25	·563	59·20
Mean I/H			55·75			58·75			70·70

I=Average illumination in kilolux H=Average global radiation in cal/sq. cm/min I/H=Kilolux/cal/sq. cm/min

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