STUDY OF SUNSHINE DURATION WITH CAMPBELL STOKES RECORDER

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Abstract: Sun plays a major Role in the Microclimate of a place and in the orientation of the building. Sunshine Duration is a climatological indicator measuring the duration that the ground surface is irradiated by direct solar radiation. The aim of the study is to find the Sunshine Duration (SD), Solar intensity, cloud cover & radiation in Chennai , TN at difference time Zones of the year .Campbell Stokes Sunshine Recorder is used in this Study as it provides the SD, Sun Path , Solar angle for different locations at different seasons. The data's obtained can be utilized in many architectural ways which help us in designing shading devices, room orientation and hence build a climate responsive structure. The study was carried out at Rajalakshmi School of Architecture, Chennai, Tamil Nadu where the orientation of the building & performance was also assessed. With these parameters, we shall maximize the utilization of solar radiation by using solar collectors & vegetation. Hence the study helps us to design more energy efficient, eco-friendly and aesthetically pleasing buildings in the future.

Keywords: Microclimate, Campbell stokes sunshine recorder, Time Lag, Decrement factor.

Introduction: Sunshine duration during a given period (e.g. within **one day**) is defined as the sum of the time for which the direct solar irradiance exceeds 120 W/m^2 . This value is equivalent to the level of solar irradiance shortly after sunrise or shortly before sunset in cloud-free conditions. It was determined by comparing the sunshine duration recorded using a Campbell-Stokes sunshine recorder with the actual direct solar irradiance.

Figure 1: Campbell Stokes Recorder

Campbell-Stokes sunshine recorders (Figure 1) and Jordan sunshine recorders have long been used as instruments to measure sunshine duration[1]. The Major advantage of The Recorder is its simplicity and ease of use. There are no moving parts and it thus requires very little maintenance and disadvantages include when the sun is low in the sky it may not have enough strength to properly burn

the card and thus can only measure the amount of bright sunshine as opposed to visible sunshine. Rain may cause the card to be torn when removing it and thus making it difficult to read.

$$R = R_0(1 - 0.75n^{3.4})$$

where:

R= solar radiation

n= cloud cover (0.0 - 1.0)

and

$$R_0 = 990 \sin \phi - 30$$

where:

$$\phi = \frac{\phi_{tp} + \phi_p}{2}$$

ϕ_{tp} = previous hour solar elevation angle

ϕ_p = current hour solar elevation angle

R_0 = clear sky insolation (W - m^2)

Equation 1: Measurement of Solar Radiation

Solar Radiation data can be derived using cloud cover & solar elevation angle. [1]The global solar radiation has two components namely direct and diffuse radiation. The global radiation is measured with the pyranometers, and the direct radiation with pyrheliometer. The algorithm for the solar radiation cloud cover adjustment calculator is (Equation 01.)

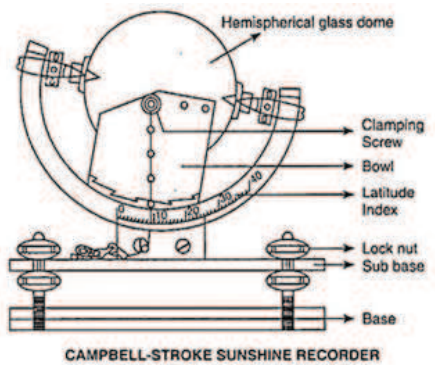
Solar energy has uses such as Greenhouse heating, power generation, industrial process heat systems, pumping of water, direct conversion of electricity (PV). Solar energy can be collected using solar collectors such as the back-pass solar collectors, concentrating solar collectors, Trombe wall and batch solar collectors such as water heating & glazed wall collectors. A solar collector comes four major forms such as the parabolic trough system, parabolic dish, power tower & stationary concentrating collectors [2]. The diversity of applications also include solar powered car races, evaporation and irrigation, calculation of water requirements for crops; monitoring plant growth and disease control and skin cancer research[3].

Aim & Objective: The aim of our study is to find, The Summer and Winter Sun Path, The Sunshine Duration, Intensity and cloud cover using the Campbell Sunshine Recorder for the duration from July 01,1013 to June30,2014.

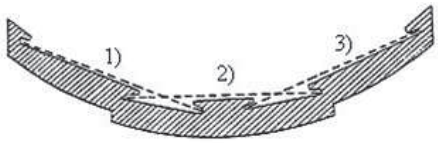
Materials and Methods:

Principles and Structure: A Campbell-Stokes sunshine recorder concentrates sunlight through a glass sphere onto a recording card placed at its focal point. The length of the burn trace left on the card represents the sunshine duration.

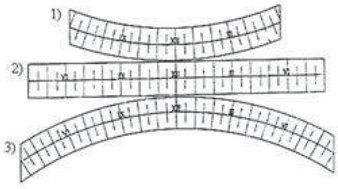
The device's structure is shown in Figure 02 (a). A homogeneous transparent glass sphere L is supported on an arc XY, and is focused so that an image of the sun is formed on recording paper placed in a metal bowl FF' attached to the arc. The glass sphere is concentric to this bowl, which has three partially overlapping grooves into which recording cards for use in the summer, winter or spring and autumn are set (Figure 02 (b)). Three different recording cards (Figure 02(c)) are used depending on the season. The focus shifts as the sun moves, and a burn trace is left on the recording card at the focal point. A burn trace at a particular point indicates the presence of sunshine at that time, and the recording card is scaled with hour marks so that the exact time of sunshine occurrence can be ascertained. Measuring the overall length of burn traces reveals the sunshine duration for that day. For exact measurement, the sunshine recorder must be accurately adjusted for planar leveling, meridional direction and latitude [1].



(a)



(b)

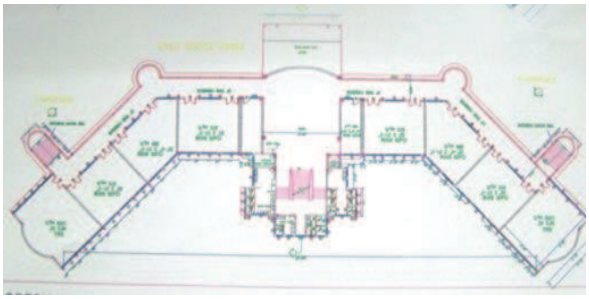


(c)

1. For Winter
2. For spring and autumn
3. For summer

Figure 2: Campbell-Stokes sunshine recorder
(a) Structure
(b) Cross section of bowl and grooves
(c) Recording cards

A typical 10 cm diameter glass sphere acts as a convergent lens to focus the sun rays on a time-graduated paper strip. If the irradiance is high enough, a hole will be burnt into the paper strip. Adding the total length of the burned parts gives the sunshine duration of the day[4]. The instrument must be worked physically and another paper strip mounted each morning before dawn. The angle of the recorder must be adjusted according to the time of the year for summer & winter sun to fall. The Experiment was carried out at different locations in Rajalakshmi School of architecture, Chennai to identify the intensities at different zones.(Figure 03.) .along with this climatic data has been calculated in ecotect software & solar radiation calculated from pv calculator.



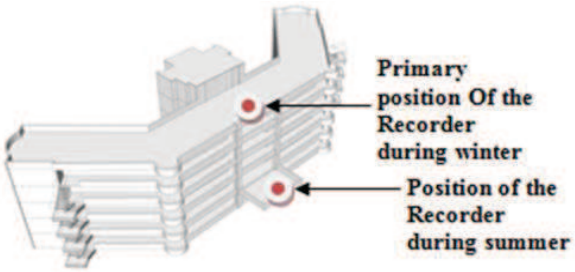
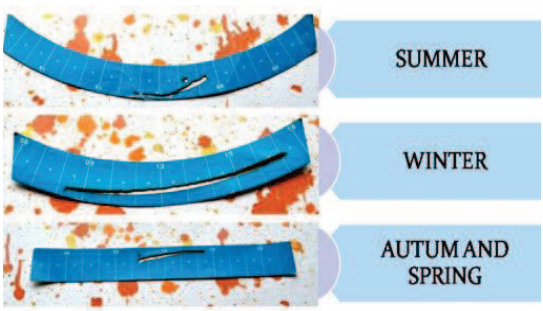
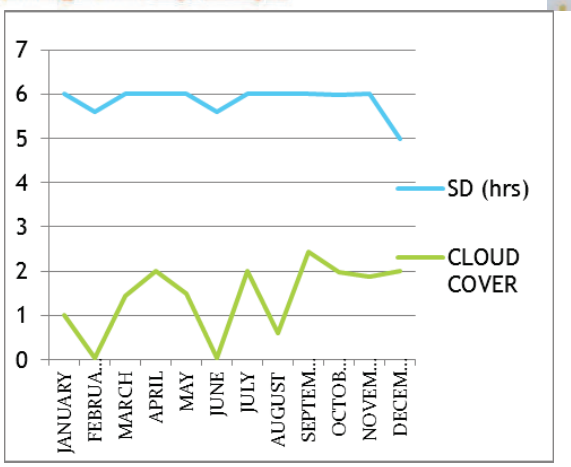


Figure 3: REC –RSA (Rajalakshmi School Of Architecture Block) Plan & Location where the Readings Were Taken

Results Discussion: The intensity of solar energy seems high as expected.

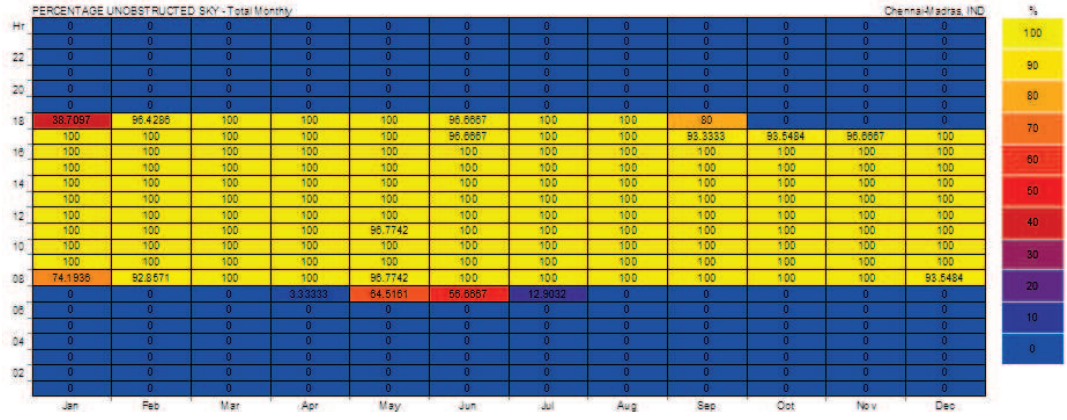




Month	SD (Hrs)	Cloud Cover
January	5.00	1.00
February	5.56	0.04
March	4.55	1.45
April	4.00	2.00
May	4.50	1.50
June	5.55	0.05
July	4.00	2.00
August	5.40	0.60
September	3.56	2.44
October	4.01	1.98
November	4.12	1.88
December	3.00	2.00

Figure 4: Results Of the Recordings Taken From July 01,1013 to June30,2014 at REC,Chennai

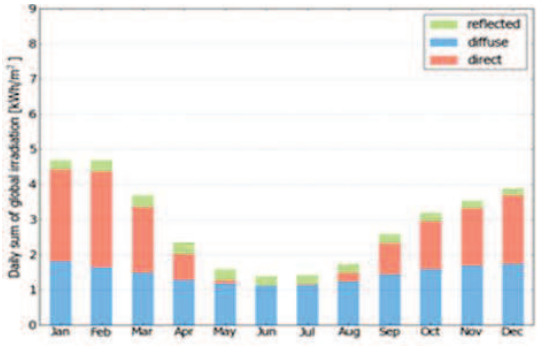
(a)



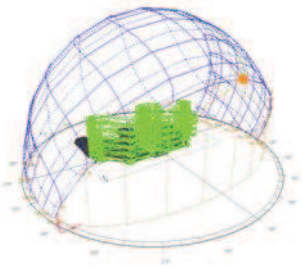
(b)

Solar radiation and air temperature — Manage/explain columns

Month	Gi_m	Sh_{loss}	Gi_d	Di_d	Ri_d	T_{24}
Jan	145.1	0.6	4.68	1.80	0.26	23.9
Feb	131.2	0.5	4.68	1.64	0.31	25.4
Mar	114.6	0.6	3.69	1.48	0.34	28.0
Apr	70.5	1.1	2.35	1.27	0.34	30.8
May	48.9	1.9	1.58	1.16	0.31	33.0
Jun	41.7	2.3	1.39	1.11	0.28	31.9
Jul	43.6	2.4	1.41	1.14	0.25	30.5
Aug	53.9	1.9	1.73	1.24	0.25	29.8
Sep	77.3	1.2	2.58	1.44	0.27	29.3
Oct	98.9	0.9	3.19	1.59	0.24	27.5
Nov	105.7	0.8	3.53	1.68	0.22	25.5
Dec	120.6	0.7	3.89	1.74	0.21	24.2
Year	1052.0	1.0	2.88	1.44	0.27	28.3



(c)



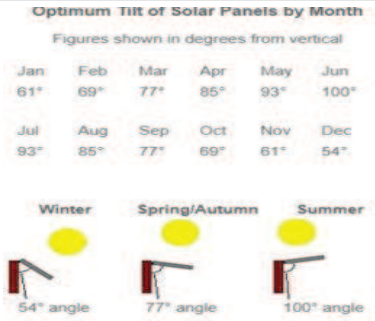


Figure 5:
(a)Results Obtained by Ecotect Software Analysis Using Climatic Data.
(b)Solar Radiation calculated from pv calculator.
(c)Ecotect SunPath and solar angle for each month

Conclusion: Sunshine Duration has been estimated by both methods – using instrument and by digital study. The Study shows sunshine hours, intensity & cloud cover for different seasons/time of the year. The study shows that can see that the orientation has been correct allowing the winter sun inside the building and block the sun during summer time. One change that can be done is that using if cavity walls in the eastern side. Additionally Solar Collectors and solar Roof tiles can also be used.

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