Heliodons for architects' offices

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INTRODUCTION

Heliodons are commonly used for testing of the directional effect of sunlight on physical building models, aiming at reproducing the actual direction of sunlight impinging onto a building as governed by the variables to be adjusted. These variables are: [2, 3]

- the latitude variable, which defines the sun-paths in relation to the geographical location.
- the seasonal variation, which relates to the declination of the sun on a given day, and
- hourly change of the sun from East to West.

The heliodons developed so far could be broadly categorised into two categories:

- a fixed light source (single lamp or multiple lamps), [2,7,9,10], or a moving light source [1,2], with the building model rotated and/or tilted
- the building model is placed horizontally, and the light source moves [4, 5, 6]

While each heliodon is designed on different emphasis of its purpose of measuring certain variables, and for certain operation convenience, the category with horizontally placed models appear most easily understood to most people including students, professionals, building developers and ultimate building users. A heliodon of this category should be a basic equipment in an architectural office.

In designing a heliodon with horizontally placed building models, there exists a compromise among space available, convenience and speed of operation, ease of understanding of heliodon operation, the dimensions of the heliodon, the dimensions of building model to be tested, its applicability in testing building models of different latitudes, the accuracy of the results offered by the heliodon which primarily depends on the production of quasi-parallel light.

THE ACHIEVEMENTS OF RECENTLY REPORTED HELIODONS DEVELOPED FOR USE IN ARCHITECTS' OFFICE

Heliodons have been developed historically for use in laboratories. In the pursuit of a heliodon suitable for use in an architect's office, with improvement of lighting paralleity by producing quasi-parallel light [i.e. the parallelity aspects of sunlight] to be impinged onto physical building models for simulating various hours of the days and various days of the year, and for varying latitudes, [Fig 1] two table top heliodons have been developed. [12,14, Fig 2, Fig 3].

The one with time rings [14, Fig 2] also shows how the sun moves about the building, effected by the correct movement of the simulated quasi-parallel light. This heliodon, however limits the dimensions of the building models, and limits the models to maximum dimensions of 500 to 600mm cube. Furthermore the horizontally placed models have to be often shifted to catch the light, available at about 500 lux, coming out of , and perpendicular to, the face of the Fresnel lens which is of 220 mm x 220mm.

The one without time rings [12, Fig 3] looks simplest in construction in principle, but unstable mechanically in setting the hours of the days and days of the year. Also it does not explicitly show the movement of the sun around the building model. However the dimensions of the models can go up to 1m cube which is about the norm of most large models built by architects. [15] .For this heliodon, the horizontally placed models have also to be often shifted to catch the light, available at about 500 lux, coming out of, and perpendicular to, the face of the Fresnel lens which is of 220 mm x 220mm.

While horizontally placed models tested in the above two heliodons are normally working models which are loosely, but quickly put together, firmly built models at later design stages can be tested outdoor using direct sunlight as the light source [2, Fig 4] . This is the accurate method for testing building models. But this depends on the availability of sunlight, the altitude angle of sunlight as this correspondingly governs the amount of tilt the model has to be set to, and outdoor suitable environmental conditions such as wind speed and temperature for operators to work through the testing process.

If fact testing building models under the real sun is a long established method by mounting shade dials [8] or traditional sundials on the building model platform. This however involves a non-systematic process of trial and error of tilting the model platform for obtaining the desirable combinations of day and time. While in the light duty heliodon [2, Fig 4], the desirable combinations of day and time are obtained by systematically and conveniently operating the related components and the heliodon, thus effecting accurate and speed testing of the models.

THE PROPOSED BASIC TURNTABLE FRESNEL-LENS HELIODON FOR USE IN ARCHITECTS' OFFICE

Consolidating the advantages and overcoming the disadvantages and limitations of the above two table top heliodons, it is proposed to build a turntable Fresnel-lens heliodon [Fig 5] for use in architects' office for indoor testing of building models.

The key features of this heliodon [Fig 5], are:-

- It can test building models up to 1.2m high, about 2m long and about 1m wide.
- The face area of simulated quasi-parallel light coming from the Fresnel lens is 550 mm x 650 mm, available at about 50 lux, sourced by one 12V quartz-halogen 50W lamp placed at the focal point of the Fresnel lens. 50 lux is acceptable for taking photos with digital cameras.
    - The simulated quasi-parallel light can be set from 0 degree to 90 degree relative to the horizontal model platform, i.e. the altitude angle of simulated quasi-parallel light can range from 0 degree to 90 degree
- The simulated lighting assembly can be adjusted up and down to enable the simulated light to fall onto every part of the models in one, two or three adjustments.

- The horizontal turntable can be easily turned to set the solar azimuth angle relative to the orientation of the building at the desirable combinations of time and day and latitudes, with these combinations easily read off from available solar charts or related software.
- The horizontal turntable and its mounting chassis can slide on an aluminium track relative to the lighting source to enable the simulated light to fall onto every part of the models as the simulated solar altitude angle varies.
- A sundial is mounted onto the model base plate for affirming correct settings of desirable combinations of day and time
    - A solar movement demonstration device is mounted onto the model platform to show solar movement around the building model, corresponding to the solar altitude angle and solar azimuth angle simulated
- This proposed heliodon sits on a movable cart which can be transported to a corner of the office when it is not needed, thus minimizing its storage when it is not being used.
- The building models tested are placed horizontally.

THE PROPOSED COMPLEMENTARY RECOMMENDATION

For testing building models using actual sunlight as the light source as stated earlier, the light duty heliodon is recommended to be enhanced [15] by incorporating strong metal parts to enable it to hold heavier models.

Also the simulated quasi-parallel light of 50 lux coming out of the Fresnel lens of the above proposed basic turntable Fresnel-lens heliodon , or a spot light giving out much stronger light, can be used to test building models indoor with this enhanced metal heliodon, noting that however spot light gives out light which diverge somehow. This divergence will make tests results inaccurate.

CONCLUSION

The proposed basic turntable Fresnel-lens heliodon allows the building models to be kept horizontal. Therefore options of quickly and loosely fitted working models can be tested. This allows quick comparison of options of building models. With the device, mounted onto the model platform, showing solar movement around the building, the architects can communicate much better with the building owners and end users about the tests and solar design of buildings, thus facilitating solar and sustainable design in buildings.

Also this heliodon can be operated in office space of normal dimensions in an architect’s office. And the allowable dimensions of building models conform to those normally made by architects.

The above proposed basic turntable Fresnel-lens heliodon, together with the complementing enhanced portable heliodon, should bring about more popular use of heliodons in solar design of buildings.

NOMENCLATURE

AST	Apparent Solar Time, or true solar time.
d	the declination angle of the sun with respect to the centre of the earth, d=+23.44 deg at Summer Solstice and d=-23.44 deg at Winter Solstice. Different declination angles correspond to the different days of the year [Table 1].

L	geographical latitude of a place at Northern hemisphere
OQ,OM etc.	alphabets with a line underneath mean a line joining the points denoted by the alphabets.
t	hour angle, t = 0 deg for solar noon (i.e. AST 12:00 noon), for one hour, the hour angle elapsed is 15 deg., t is positive for AST p.m. and negative for AST a.m.
1,2…	component identification numbers of the invented heliodon, shown in the drawings of the heliodon and mentioned in the text

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Figure 1 – see separate drawing enclosed

Figure 2 – The Table Top Heliodon with time rings acting as the track for movement of assembly of simulated quasi-parallel light [from Ref. 14]
Heliodon set for the latitude of Hong Kong [22.5 degree North], noon apparent solar time, Equinox day [21 March or 23 September], with model placed on model platform – looking from the South-West side

Figure 2 is enclosed separately.

Figure 3 – The Table Top Heliodon [from Ref. 12]
Heliodon set for the latitude of Hong Kong [22.5 degree North], noon apparent solar time, Equinox day [21 March or 23 September], with model placed on table

Figure 3 is enclosed separately.

Figure 4 – The Light Duty Heliodon [from Ref. 2]

Building Model for Tokyo (33.75°N) simulated for 4 p.m. AST on 6 June, using direct sunlight in Hong Kong (22.37°N) at 2:35 pm local standard time on 28 Dec 1995. Note that the horizontal plane for placing the model is slanting up towards North in the setting of the equipment, and the reverse side of the plane is used for the other hemisphere.

Figure 4 is enclosed separately.