DAYLIGHTING CALCULATIONS

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Methods for Calculation

- Lumen Method
- Daylight Factor Method
  - Overcast sky
  - Clear sky
- BRE Protractors
- Flux transfer Method
Lumen Method

- Provides simple way to predict interior daylight through skylights & windows.
- Similar to the zonal cavity method for electric lighting.
- Assumes an empty, rectangular room with simple fenestration & shading devices, including light shelves.
Lumen Method

Four basic steps:

- Exterior illuminances at window or skylight are determined from daylight availability materials.
- Net transmittance is determined.
- CU’s, or ratios of interior to exterior illuminance, are determined.
- Interior illuminance is calculated.
Lumen Method

- Available daylight
  - Overcast sky
Lumen Method

- Available daylight
  - Clear sky - summer
Lumen Method

- Available daylight
  - Clear sky – fall & spring
Lumen Method

- Available daylight
  - Clear sky – winter
Lumen Method

Basic equation

- \( E_i = E_x \times NT \times CU \) (8-27, IES Handbook)

Where:

- \( E_i \) = interior illuminance in lx
- \( E_x \) = exterior illuminance in lx
- \( NT \) = net transmittance
- \( CU \) = coefficient of utilization

Formula for toplighting differs
Figure 8-21. Standard conditions in a room for calculating sidelighting. H, W, and D represent room height, width, and depth, respectively.
Daylight Factor

- Low precision procedure for determining illuminance at any point in an interior space.
- Direct sunlight excluded.
- Uses sky with known luminance distribution.
Daylight Factor

- DF is ratio of illuminance at a point on a plane to the illuminance on a horizontal exterior plane produced by a hemisphere of the sky.

- Has three components that are summed:
  - Sky component (SC)
  - Externally reflected component (ERC)
  - Internally reflected component (IRC)
Daylight Factor

- Sky component (SC)
  - Due to daylight received directly at the point from the sky.

- Externally reflected component (ERC)
  - Due to daylight received directly at the point from external reflecting surfaces.

- Internally reflected component (IRC)
  - Due to daylight reaching the point after one or more interreflections from interior surfaces.
Daylight Factor

- Components

Figure 8-23. Daylight factor components. See Equation
Daylight Factor

- DF = SC + ERC + IRC
- Must determine each factor to determine DF.
Daylight Factor

Figure 8-24. Geometry for determining daylight factor in a simple environment. See text.
Daylight Factor

- Sky component

Figure 8-25. Sky Components of Daylight Factor, in Percent, for CIE Overcast Sky. *See Figure 8-24 for terms h, w, and q.
Daylight Factor

- Internal reflected component

![Figure 8-27. Multipliers for Minimum Internally Reflected Daylight Factor](chart.png)
Daylight Factor

- Externally reflected component
  - Generally small.
  - Usually roughly approximated.
  - See IES Handbook, ninth edition
Protractors

- Used to estimate the sky & internally reflected components of daylight factor.

- Used for:
  - Overcast skies
  - Clear skies without direct sun

- Use during the schematic phase to roughly estimate performance.
Protractors

Based on a conceptual model of interior illuminance being dependant on three variables:

- Luminance of the source
- Apparent angular size of the source
- Position of the source relative to the analysis point.
Protractors

- Most common methods:
  - BRS daylight factor protractors for overcast skies
  - Bryan clear sky protractors
- The protractors are used to determine the sky component (SC)
- Combined with other data to determine the total daylight factor (DF).
BRS Protractors

- Set includes ten protractors:
  -Five for the uniform sky
  -Five for the C.I.E. overcast sky

- For apertures that are vertical, $30^0$, $60^0$, horizontal, of without glazing.

- Two parts to each protractor:
  -For sections
  -For plans
BRS Protractors

- Sections & plans required to use protractors.
- Limitations for use:
  - Station point below sill height & at least 1’ from floor, walls, ceiling
  - Best scale is \( \frac{1}{4}” = 1’-0” \)
- Guidelines for use in Robbins; Moore; or Hopkinson, et al.
Appendix E: B.R.S. Protractors (Overcast Sky)

F.1. B.R.S. sky component protractor for vertical windows—overcast sky. (Reproduced from B.R.S. Daylight Protractors by permission of the Britannica Company Limited. Copyright.)

B.R.S. SKY COMPONENT PROTRACTOR FOR VERTICAL GLAZING
(C.I.E. OVERCAST SKY)
BRS Protractors
BRS Protractors

15-8. B.R.S. daylight factor protractor: (a) top half is primary protractor for use over section; (b) bottom half is auxiliary protractor for use over floor plan to determine the width correction factor. A complete set for various plotting slopes for both overcast and uniform sky conditions is available (see Longmore in References). (Reprinted from Hopkinson, 1963, courtesy of Her Majesty’s Stationary Office)

15-9. Use of the B.R.S. daylight protractor:
(a) sky component (SCO) (above the external obstruction) at reference point P for infinitely long window = 3.8% − 0.2% = 3.6%;
(b) correction for window length (for 19.5° average sky elevation) = 0.3 + 0.15 = 0.45. The sky component at P = 3.2% × 0.45 = 1.44%.
Bryan Clear Sky Protractors

- Developed by Bryan & Carlsberg (1982)
- Nine protractors based on BRS method
- For clear skies.
- Formatted differently than BRS but used in same manner.
- IRC determined by table.
- Cannot be used for horizontal apertures or slanted glazing.
- Can be used for vertical apertures, impact of overhangs, & vertical fins.
Resources