Façade study for a day lounge in a residential care home for dependent elderly and dementia patients.

Environmental Design Application

ART 032/132 DL

Erika Rees

Site Location

and Climate.

- The care home is located in Cardiff, Wales in the UK.
- Wales receives more rainfall and is cloudier than UK average.
- At latitude 51.5°N, the winter and spring sun paths are low in sky increasing possibility of glare.
- Cardiff airport (Rhoose) is prone to morning sea fogs, at all times of the year, but especially in the summer months. (Wheeler 1997)

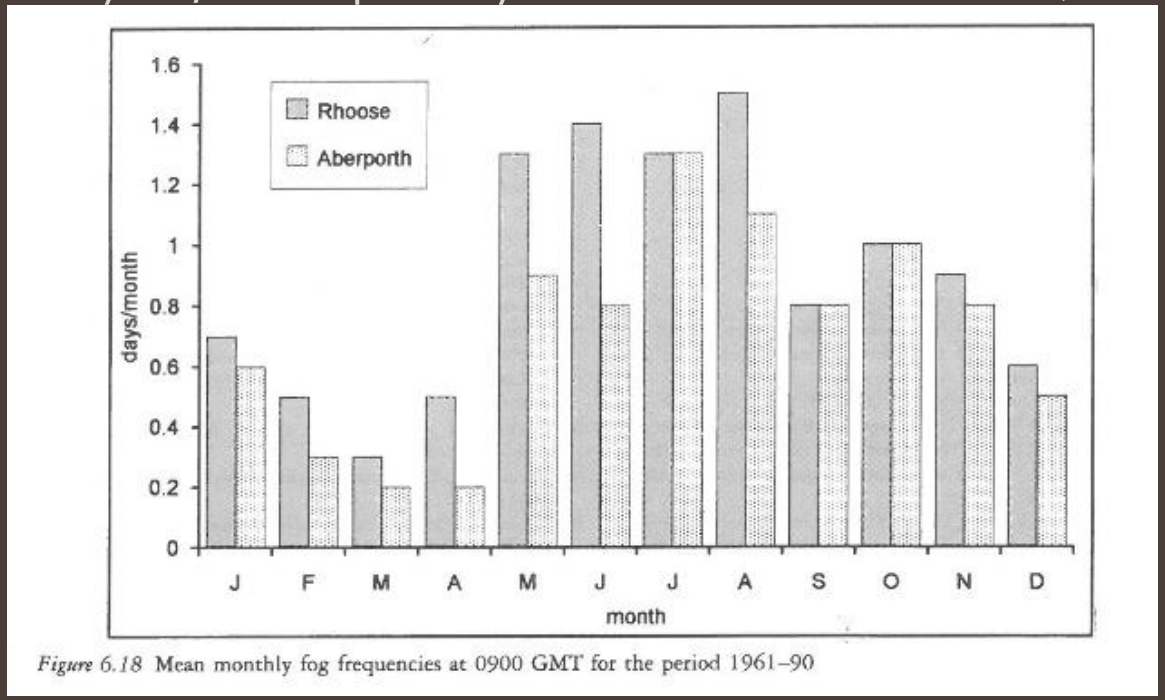
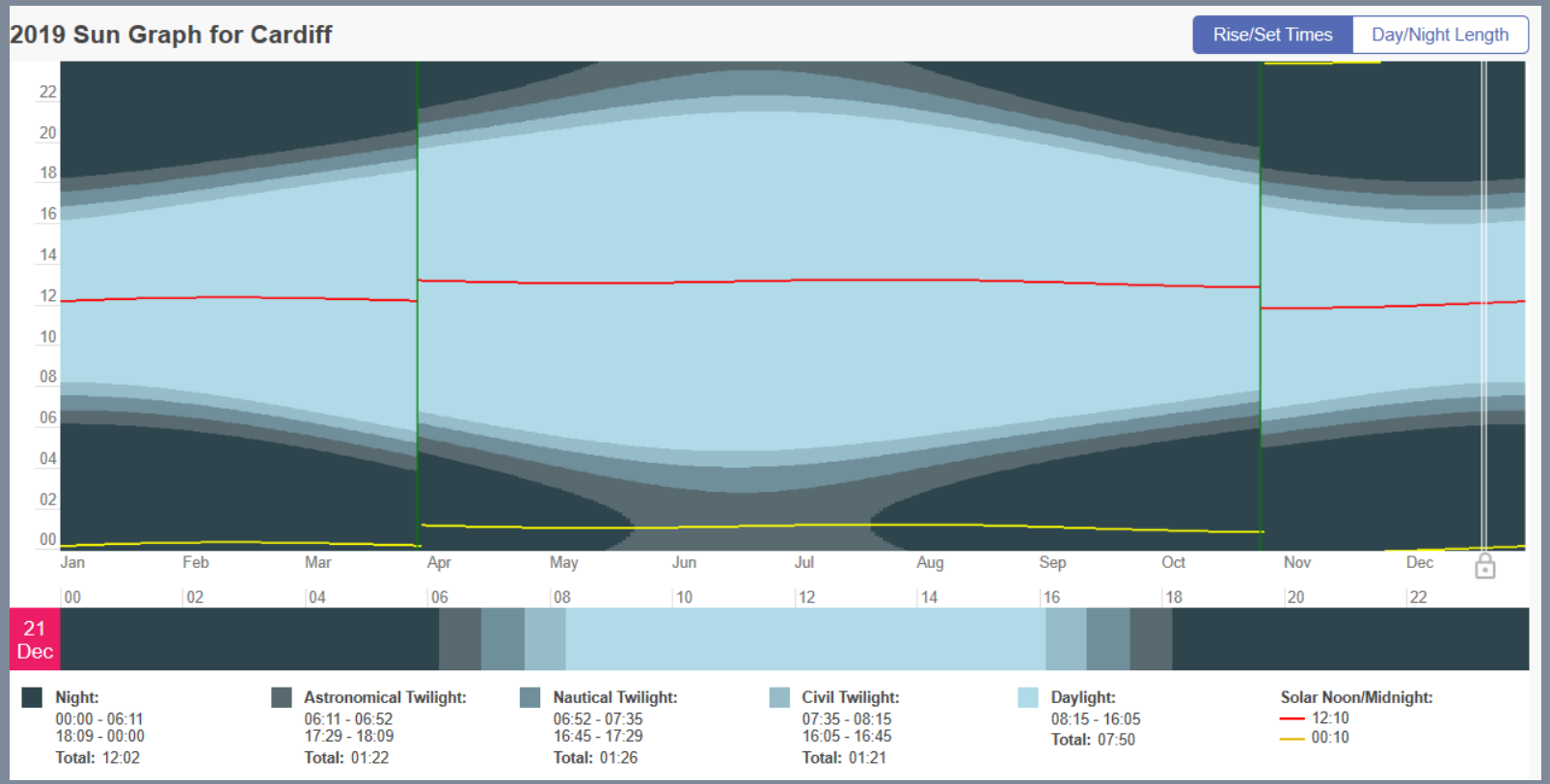


Figure 6.18 Mean monthly fog frequencies at 0900 GMT for the period 1961–90

(Wheeler 1997, p.155)



www. Timeanddate.com/sun/uk/cardiff

Daylight hours for Cardiff. (local time)

Winter solstice

08:15 – 16:05 GMT

Spring solstice

6:16 – 18:25 GMT

Summer solstice

4:55 – 21:33 BST

Care home locale

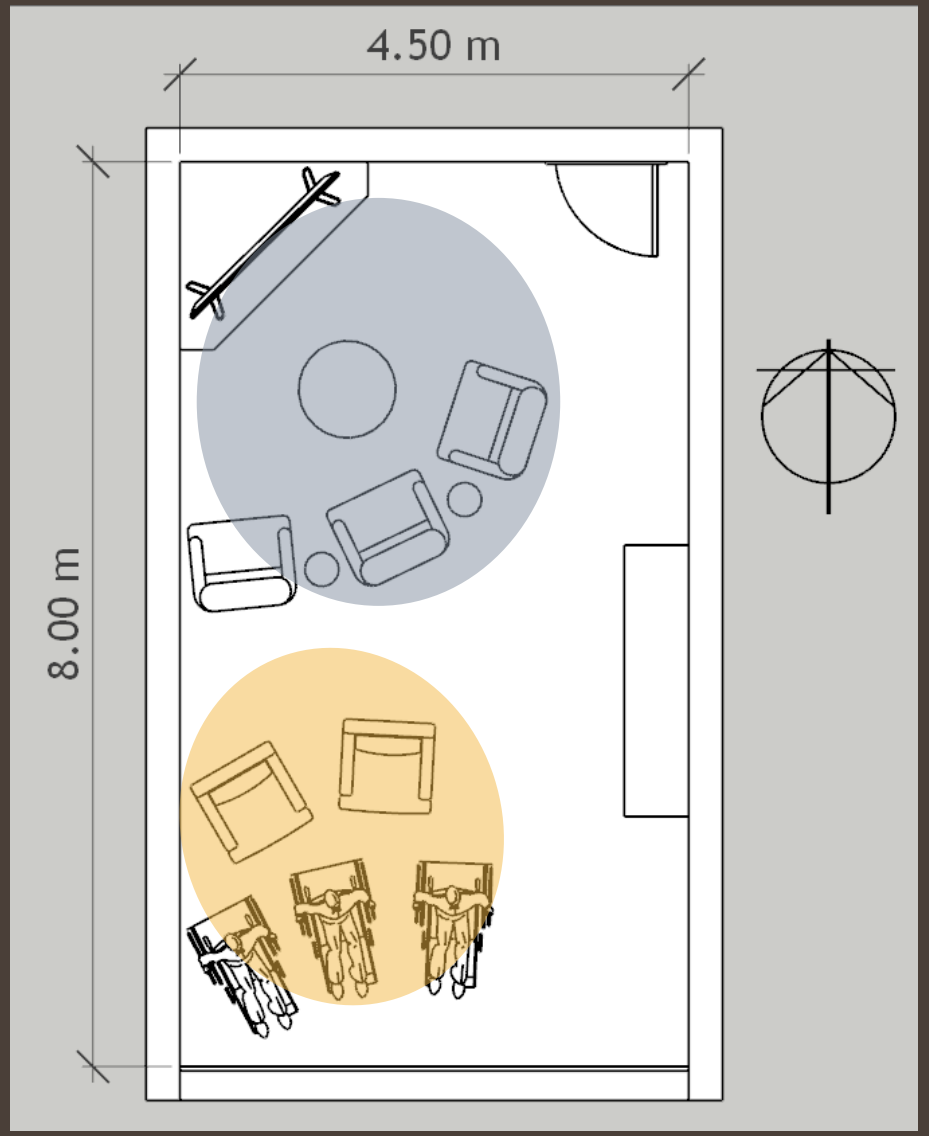
- Located in the outskirts of Cardiff city with own grounds and long rural views available.
- The day lounge is located on the ground floor with windows facing due south.
- Faces out into open garden space. No external obstructions have been factored into analysis.

The Day Lounge Base Case

Surface Reflectances

- Wall 0.5
- Ceiling 0.8
- Floor 0.2
- External ground 0.2

Ceiling height 3m.



10:00 – 18:00 TV zone

08:00-10:00 Light therapy zone
10:00 – 18:00 Reading and craft zone

Brief

Users:

3-4 no. elderly patients, some with dementia.

1-2 no. staff.

Hours of use:

08:00 – 12:00

13:30– 18:00

year round.

Activities:

8:00 – 10:00

Morning Circadian stimulus treatment

10:00 –12:00; 13:00 - 18:00

Watching TV, reading.

Enrichment activities e.g. craft work, games.

Considerations in development of the design objectives

1. Decline of visual function of the elderly.

2. Regulation of the Circadian rhythm.

3. General well-being.

- Increased illuminance.
- Glare reduction.
- Avoid abrupt changes to light levels. (CIE2011)
- Good contrast between wall and floor planes.

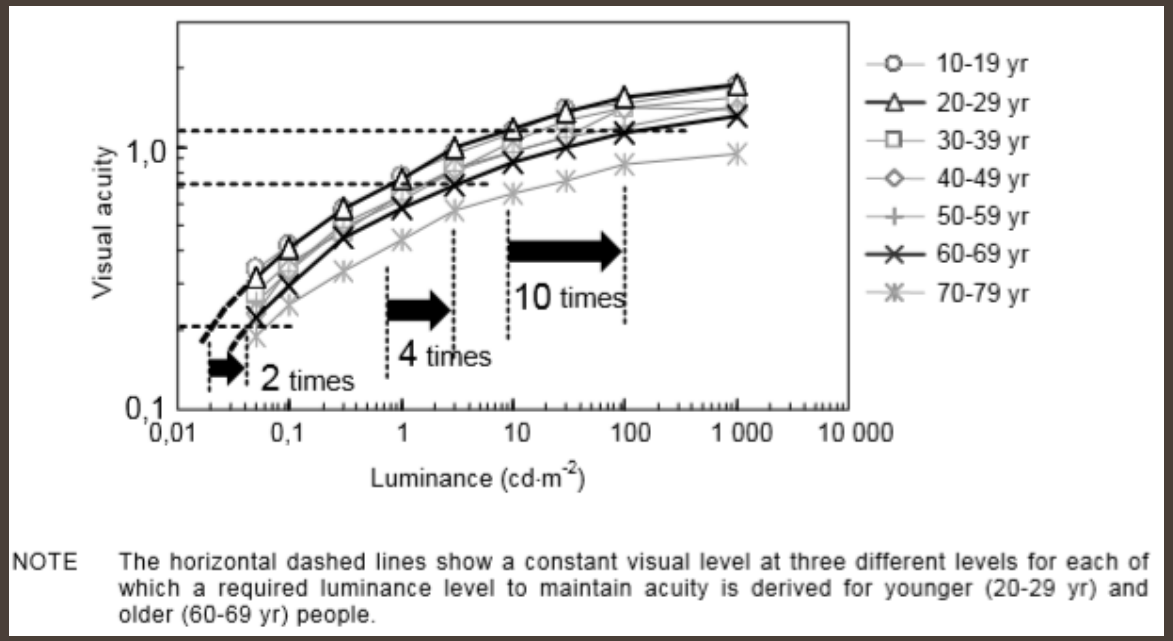


Fig.1 Visual acuity as a function of luminance level. (CIE 2011, p.)

- Due to the increase in light scattering in the ocular media of the eye, the effect of glare is exacerbated for older people and people with visual impairments. (CIE 2011, p.10)
- Elderly take longer to adapt to sudden changes in light level. (CIE 2011)

- Year round morning exposure to daylight spectural quality luminance.

- Recent and increasing research is highlighting role light has in regulating circadian rhythm.
- "Circadian disruption…is associated with depression, sleep disruption, agitated behaviour and cognitive decline." (Konis 2018)
- Potential as nonpharmacological treatment for dementia. (Konis 2018)
- The spectural quality of light is critical for circadian stimulus so artificial light providing equivalent photopic illuminance as daylight, may not provide same circadian stimulus. (Konis 2018)
- A study by Konis (2018) suggest that regular access to daylit spaces **in the morning**, specifically within 3m from windows, can significantly …aid in the maintenance of healthy circadian entrainment.

- Low cill height.
- Maintain views out during daylight hours.
- Limited sunlight penetration desirable.
- Create bright and homely environment.

- Views out can significant health and well-being benefits to building occupants. (SSL 2014)
- Views out can have a mitigating effect on perceived daylight glare. ((Tuaycharoen and Tregenza 2005) cited in SLL 2014)
- Some sunlight penetration can assist with perception of time of day.

Quantitative Guidance for development of design objectives

Visual Acuity Decline in Elderly.

- Increase recommended ambient illuminance levels by 50% in designing for the elderly. (Pocklington cited in CIE 2011)
- Minimum task lighting of 300 lux for elderly care homes. (Pocklington cited in CIE 2011)
- SSL recommend 200 lux average illuminance at table level of homes for the elderly. (SLL 2013)
- Recommended UGR equal to or less than 19 (CIE 2011)
- Minimum illuminance uniformity 0.60 for health care day rooms. (SLL 2018)
- Useful Daylight Illuminance (UDI) classification system sets a useful range between 100 lux (with supplementary lighting) and 3000 lux (glare). (Mardaljevic 2011)
- For rooms with an average Daylight factor > 5% won't usually need electric lighting in the day. (BSI 2018)

Quantitative Guidance for development of design objectives

Regulation of Circadian Rhythms.

- New area of research.
- No minimum requirements yet available for light exposure as a nonpharmacological treatment option. (Konis, 2018)
- The Lighting Research Centre recommends exposure to a circadian stimulus of 0.3 or greater (equivalent to 180 lux from daylight)**, at the eye**, for at least 1h in the **early part of the day**. (Konis, 2018)
- WELL building standard requires 250 EML (Equivalent Melanopic Lux) for break rooms (equivalent to 226 lux.) for accreditation. (Konis, 2018)
- A study by Dowling (2018) provided exposure to a minimum of 2500 lux for 1 hour a day for 10 weeks.
- In a study by Konis (2018), patients located within 3 m of a window from 08:00 to 10:00 daily displayed improvements.

Quantitative Guidance for development of design objectives

General Well being

- Lifetime Homes Standard require window cill levels below 800mm to allow a seated person views out. (Goodman 2011)
- SLL Guidance for views out from single aspect room 8m deep _ min 25% Wall to Window Ratio (WWR). (SLL 2018, p.35)
- 1 hour of sunlight on East, West, and South facades on 1st March recommended for residential buildings. (McMullan, 2012).
- Width of window 35% of length of wall for single aspect rooms. (SLL 2018)

Quantitative Design Objectives

Visual Acuity Decline in Elderly.

Uniformity ratio: 0.6 (SSL, 2018)
Average Daylight factor 5 %
e < 150 lux : Insufficient
150 < e >450 : supplementary lighting.
450 < e > 2500 : autonomous daylight
e > 2500 lux : glare
(adapted from Pocklington and Mardaljevic)

Regulation of Circadian Rhythms.

0800 -1000 local time minimum threshold within 3 m of window = 226 lux.

(adapted from WELL and Konis)

General Well being

Maximum cill height 800mm

Min 25% WWR

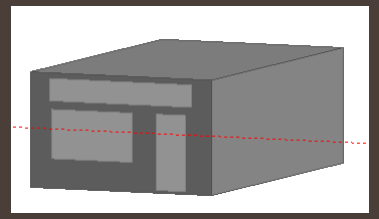
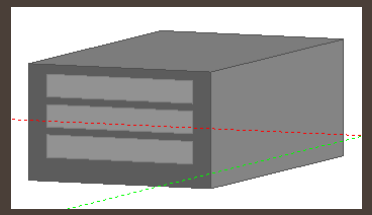
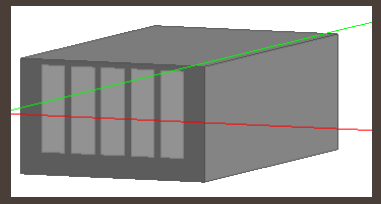
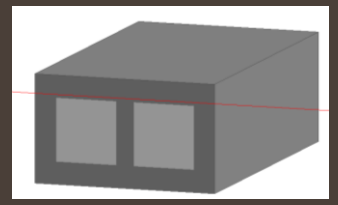
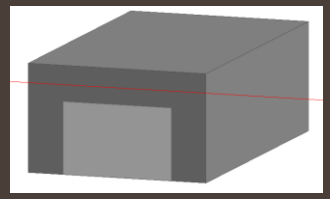
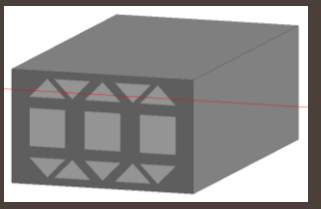
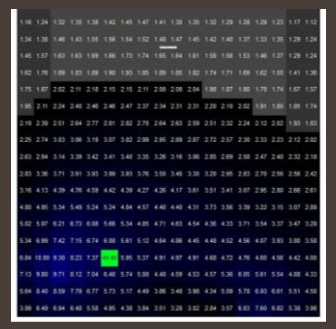
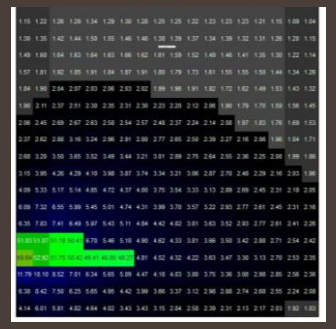
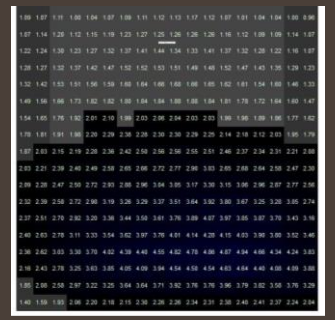
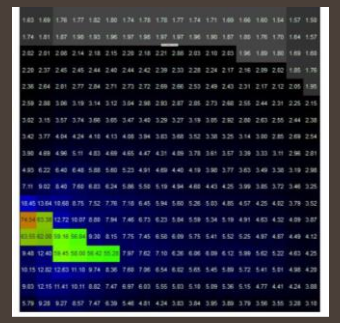
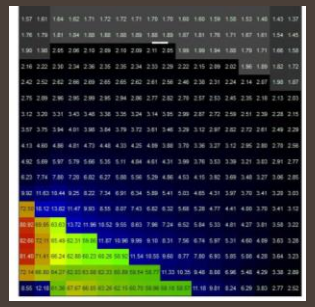
Allow min 1 hr sunlight penetration in March.

Base Case Selection

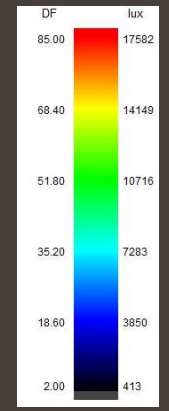
Design Objective 1. Maximise morning illuminance.

Group A options approx. 15% Window Wall Ratio
Group B options approx. 30% WWR
Group C options approx. 44% WWR ✓

Shortlist : Group C façade options

C-F1	C-F2	C-F3	C-F4	C-F5	C-F6
					
					

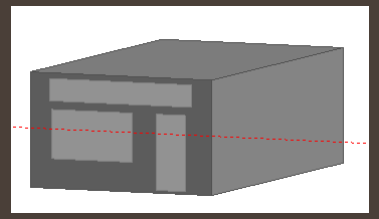
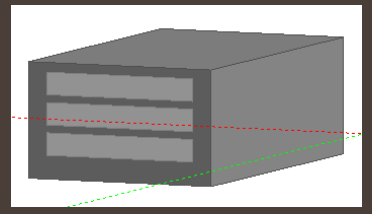
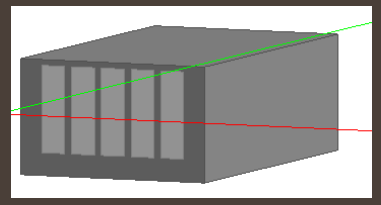
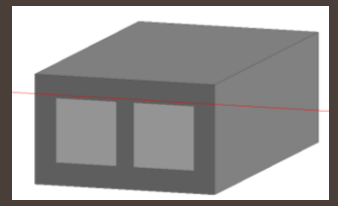
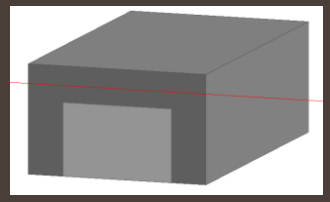
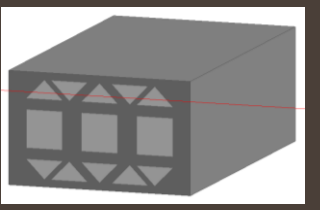
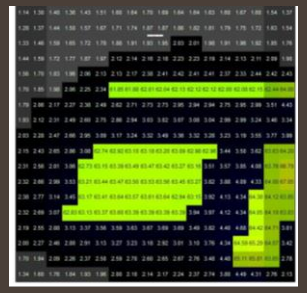
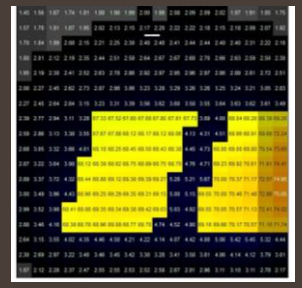
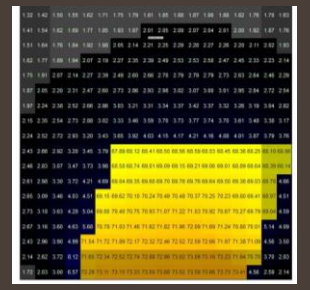
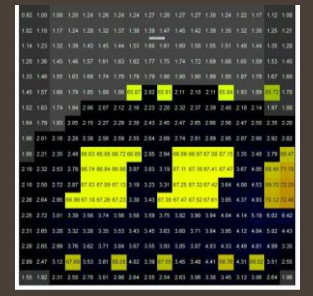
Spring Solstice
8 am illuminance maps



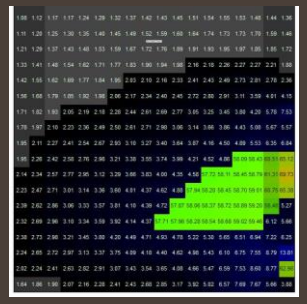
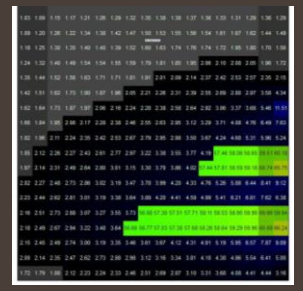
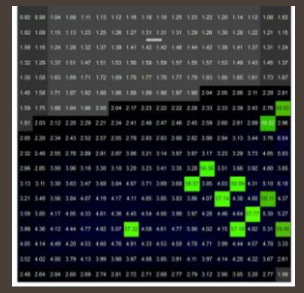
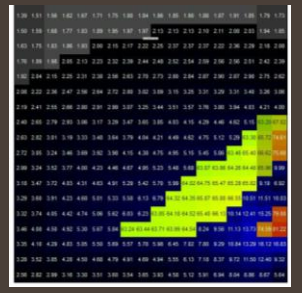
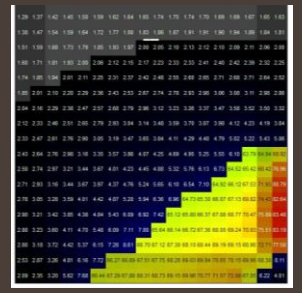
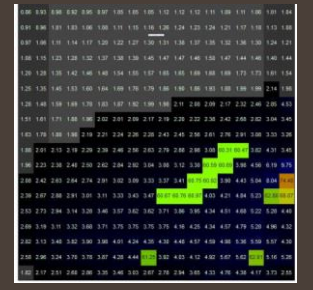
Score: 2 4 1 5 6 3
(6-high 1-low)

Observations: Vertical divisions reduce morning direct sunlight. The window vertical reveals act as vertical blinds.

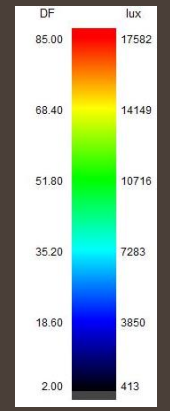
Design Objective: Minimise midday and afternoon glare.

	C-F1	C-F2	C-F3	C-F4	C-F5	C-F6
						
Spring Solstice 13:00						
Score:	4	6	4	2	1	3

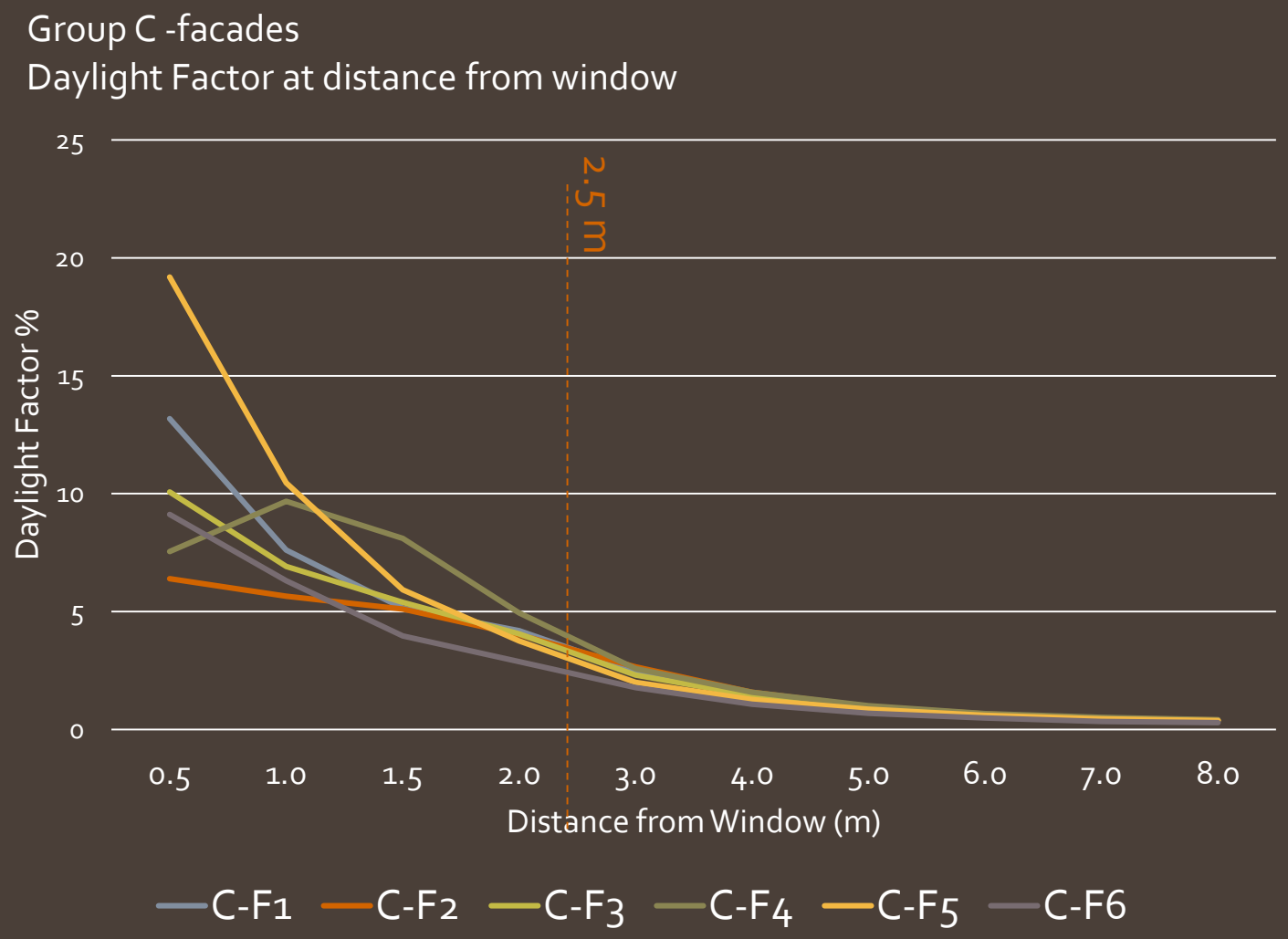
Observation: Horizontal divisions reduce midday direct sunshine. Higher window head increase sunlight penetration.

Spring Solstice 15:00						
Score:	3	4	6	2	1	5

Observation: Vertical divisions reduce afternoon glare.

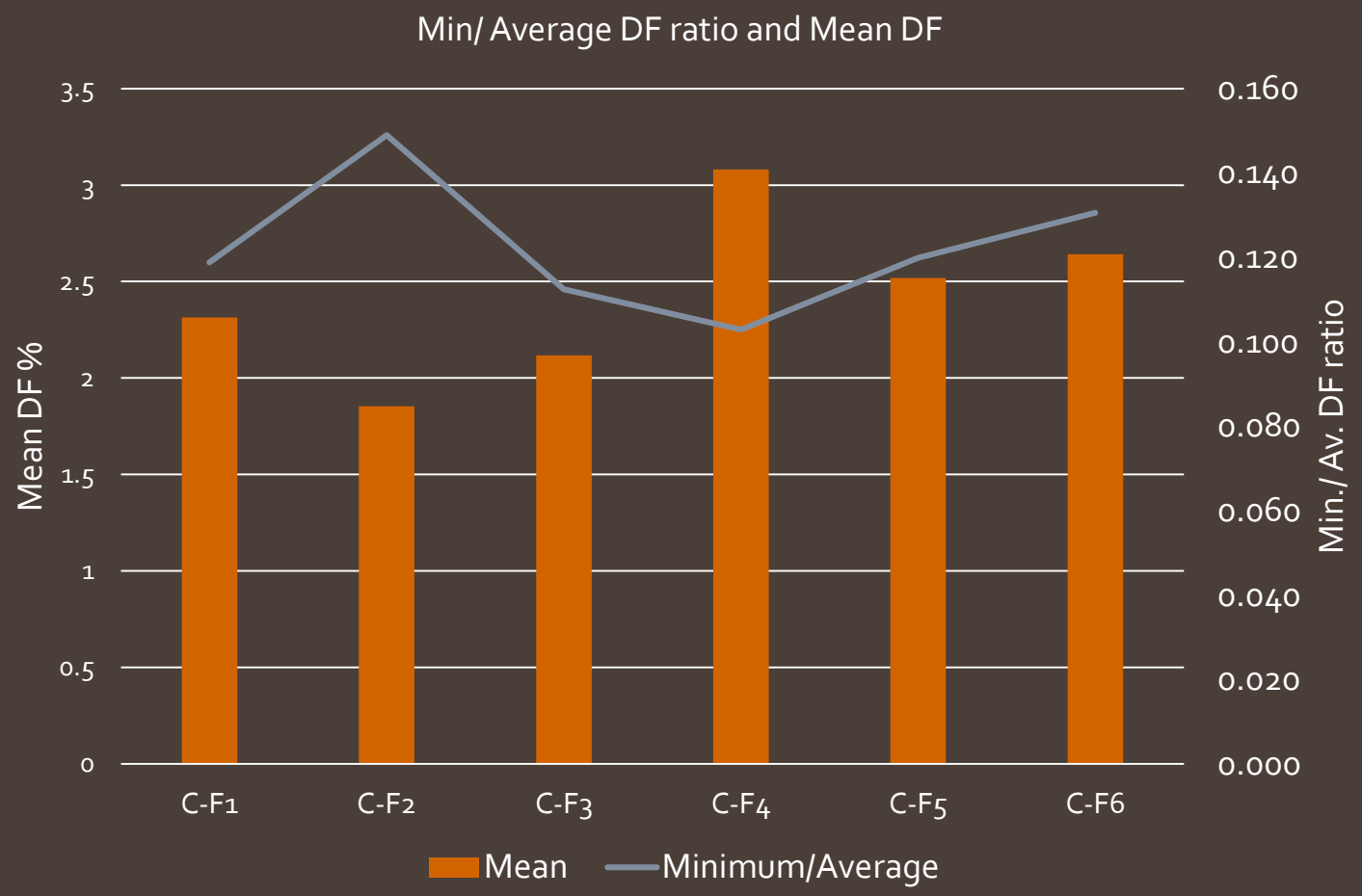


Design Objective: Good daylight penetration.



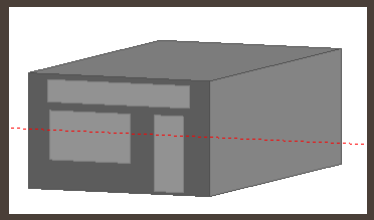
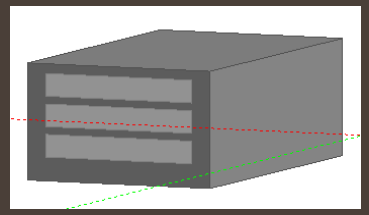
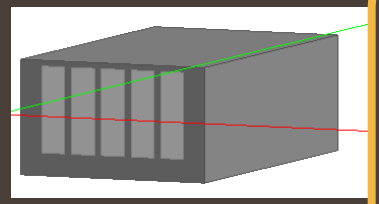
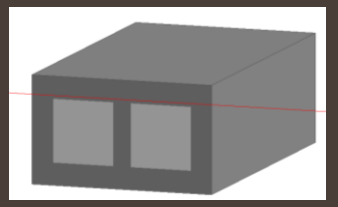
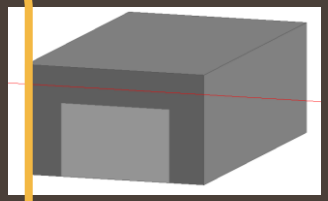
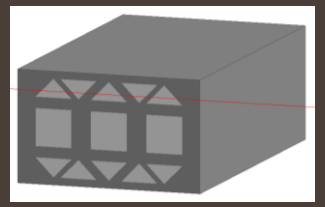
	DF% at 2.5m ranking
C-F1	4
CF2	4
C-F3	3
C-F4	6
C-F5	2
C-F6	1

Design Objective: Good general illumination and high uniformity



	Mean DF%	Uniformity Ratio
C-F1	4	3
CF2	4	6
C-F3	3	2
C-F4	6	1
C-F5	2	3
C-F6	1	5

Base Case Selection Results Table

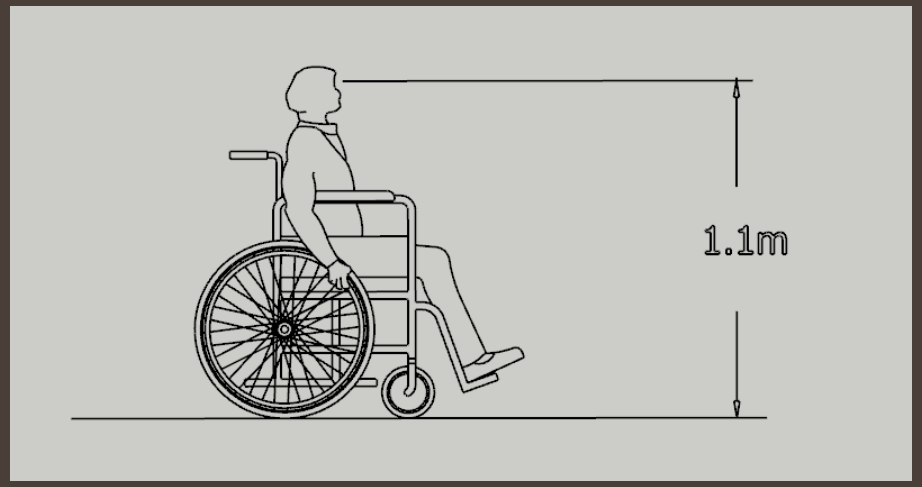







Priority Weighting		C-F1	C-F2	C-F3	C-F4	C-F5	C-F6
Higher morning Illumination	2	4(2)	8(4)	2(4)	10(5)	12(6)	6(3)
Lower midday glare	1	4	6	4	2	1	3
Lower afternoon glare	1	3	4	6	2	1	5
Greater DF at depth of 2.5m	1	4	4	3	6	2	1
Greater uniformity	1	3	6	2	1	3	5
Higher mean DF	2	6(3)	2(1)	4(2)	12(6)	8(4)	10(5)
TOTAL		**24**	**30**	**21**	**33**	**27**	**30**

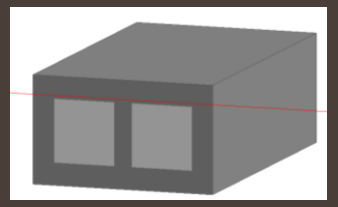
Selected Base Case (BC)

Study Parameters

- Working plane height set at 1.1m
- (Note: Design Builder does not provide vertical working plane).
- Daylight Factor Thresholds: Low 3% - High 10%
- Luminance Thresholds:
  - Morning Low 226 lux – high 2500 lux
  - Afternoon Low 450 lux – high 2500 lux
- CIE overcast skies for daylight simulations. No margins.
- CIE sunny clear day for illuminance simulations. No margins.
- Glazing: Double low e 6mm/13mm clear: Visible transmission 0.745
- Reflectances unchanged unless specified.

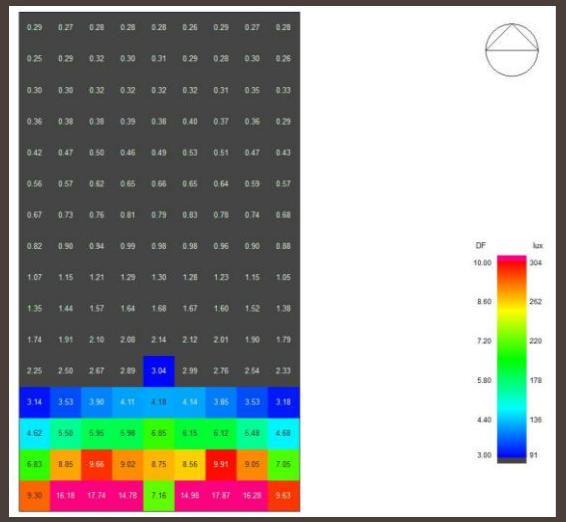


Base Case



	Average Daylight Factor (%)	Uniformity ratio (Min / Avg)
BC	2.702	0.093
Objectives	5.000	0.600

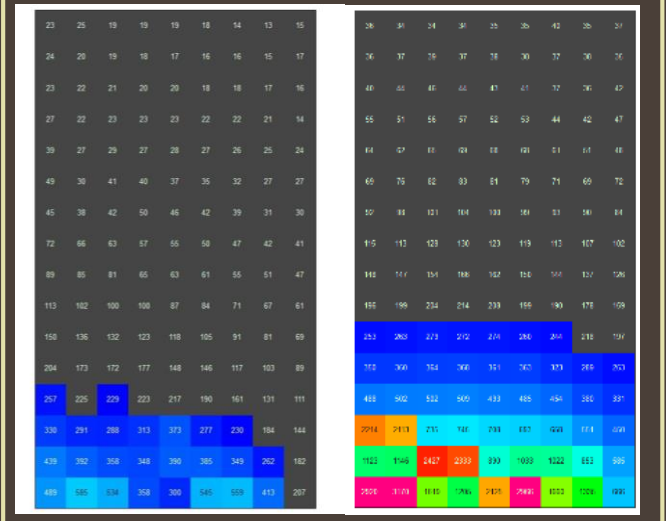
Daylight Factor Map



Low threshold =3%

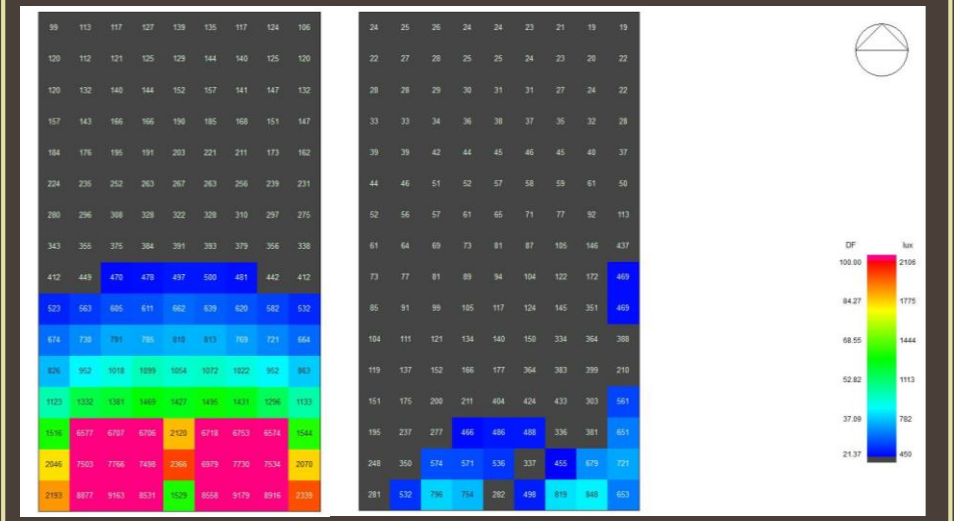
Illuminance Maps

Dec 21 0800 Mar 20 0800



Low threshold =226 lux
High Threshold = 2500 lux

Mar 20 1200 1500



Low threshold = 450 lux
High = 2500 lux

Base Case variation from design objective

Objectives Prioritisation

Variance

- Insufficient morning illuminance in winter
- Midday glare
- Some afternoon glare
- Poor daylight penetration
- Insufficient uniformity.

Design Objectives Priorities

1. Maintain views out.
2. Increase morning daylight and sunlight.
3. Increase daylight penetration into room.
4. Reduce afternoon glare. (Midday glare less problematic as room is unused over lunch hour.)
5. Improve uniformity ratio.

Road map of studies

Study 1

- Relocation of windows flush with internal surfaces.
- Objectives: Increase morning luminance and overall uniformity by increasing internal reflectance component.

Study 2

- Introduction of light shelves
- Objectives: Improve daylight penetration and uniformity by horizontal reflectance off light shelf or ground plane.

Study 3

- Introduce vertical plane external shaders/ reflectors.
- Objectives: Reflect in more morning East light. Block afternoon solar glare

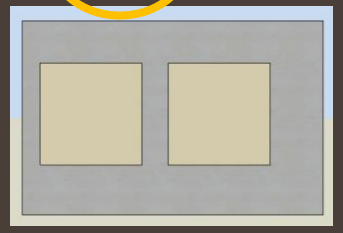
Study 1 _ Repositioning of window adjacent to internal surfaces.

Objective: Increase morning light penetration by internal reflection.

West

BC

A

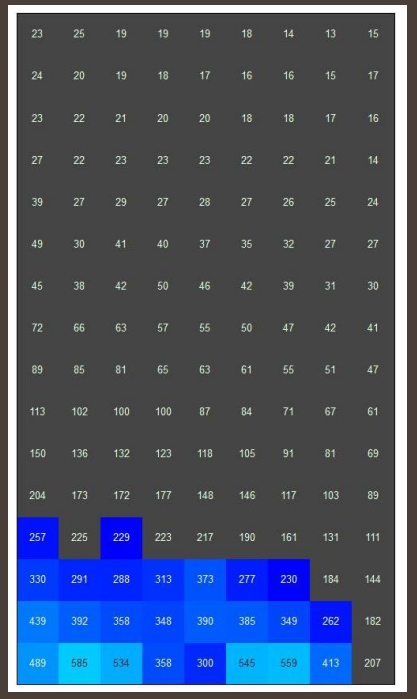


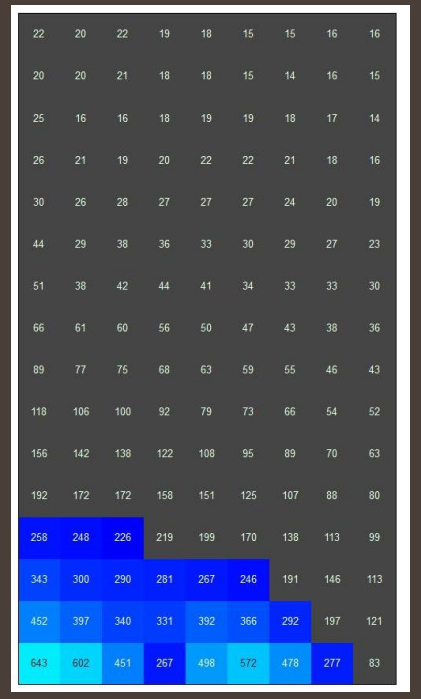
B

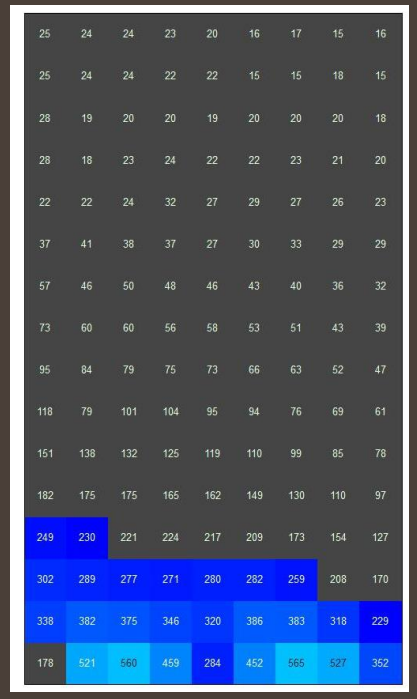
C

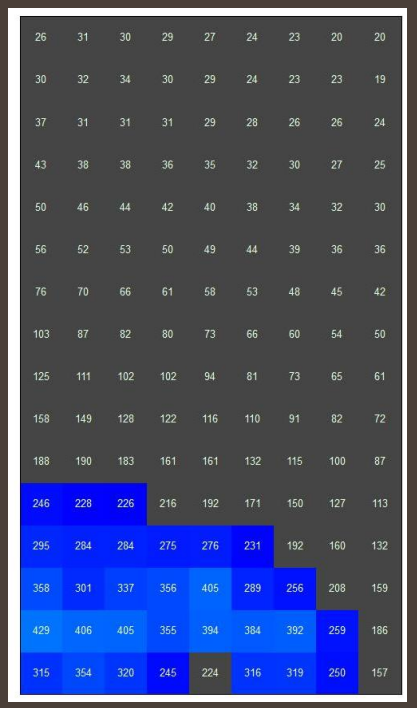
East

Illuminance Dec 21 08:00





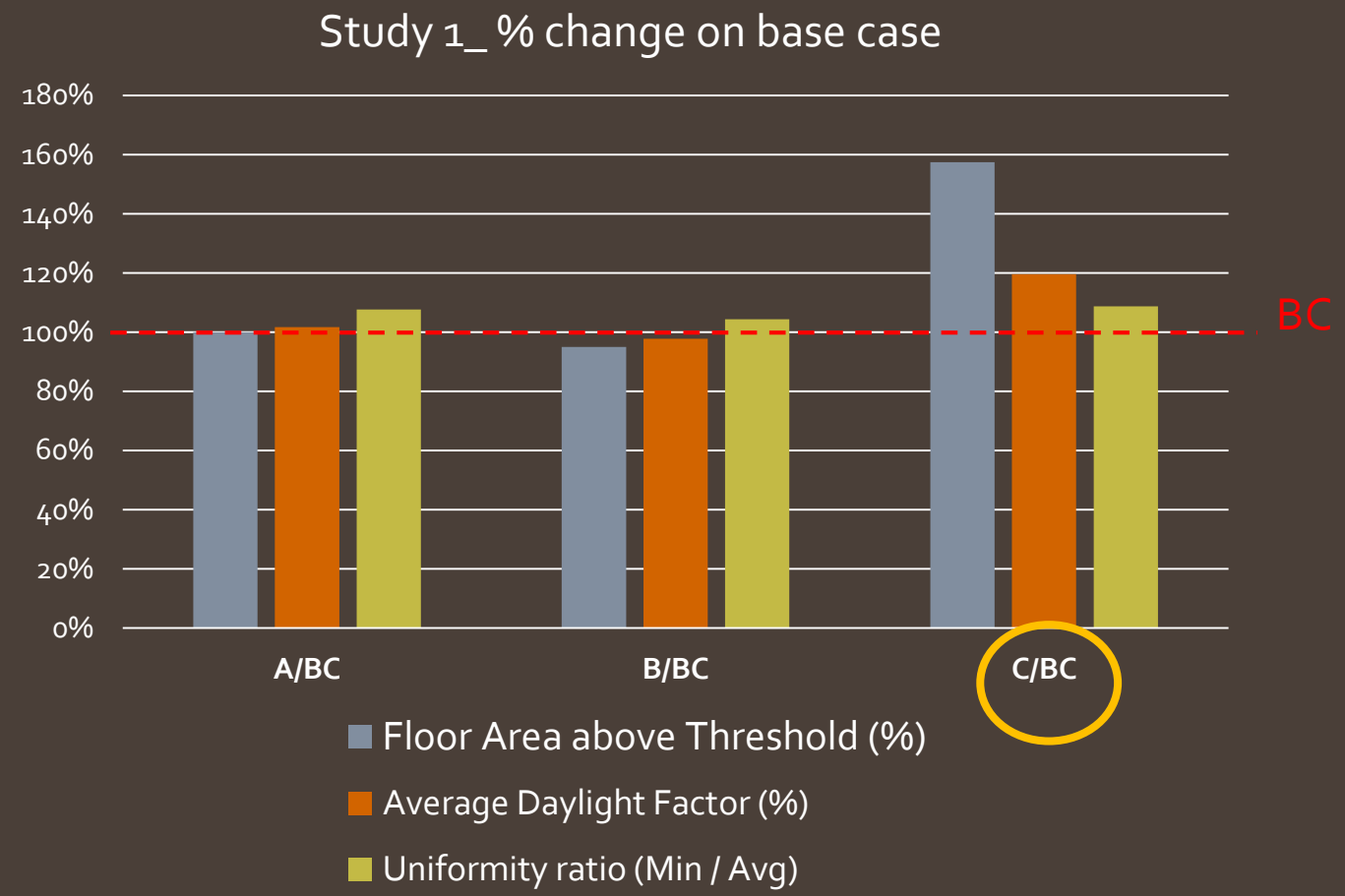




Study 1

Remarks:

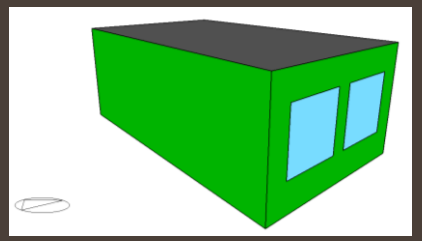
- Options A and C increased area of morning threshold illuminance.
- Option C increased area more but with more lower levels of illuminance.
- C performs best in distributing daylight and increasing average daylight factor.



Study 2 _ Introduction of Light Shelves

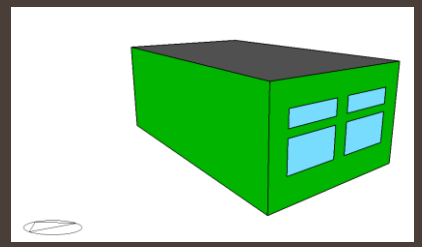
Objective: Improve daylight penetration and uniformity by horizontal reflectance off light shelf or ground plane.

BC



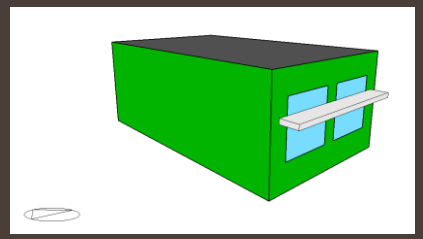
Base Case
Ground Reflectance
0.2

A



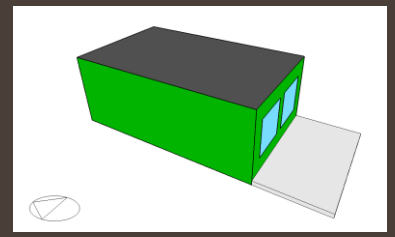
Internal Light Shelf
Cill reveal depth 0.6m
Reflectance 0.7

B

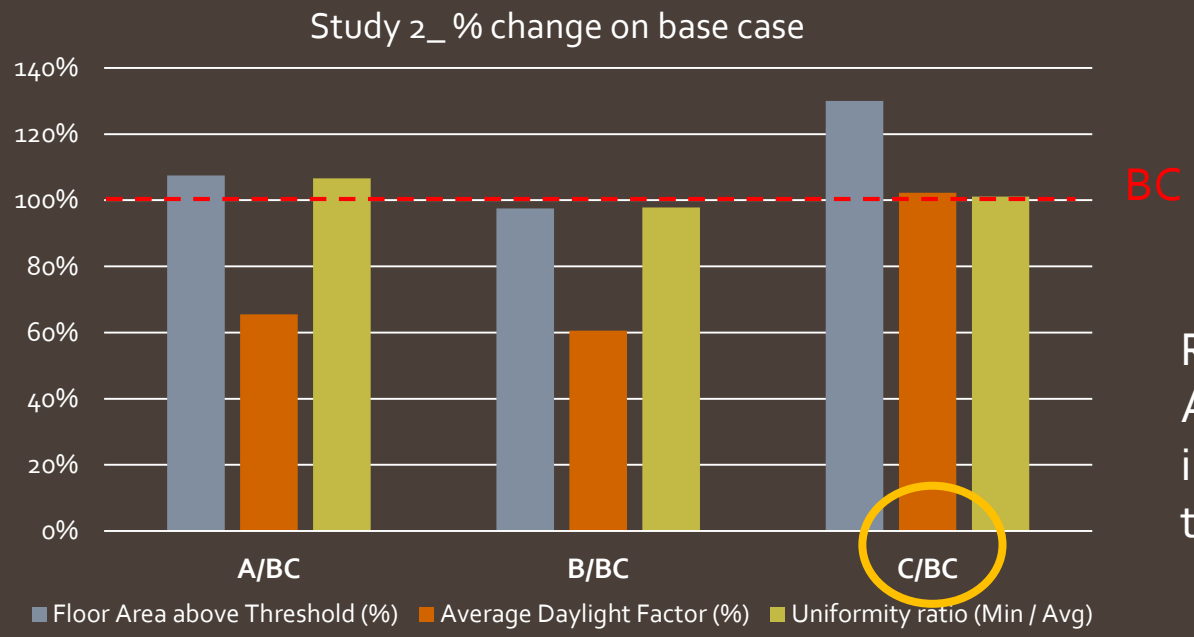


External Light Shelf
Shelf depth 0.6m
Reflectance 0.7

C



External patio
Patio depth 3m
Reflectance 0.6

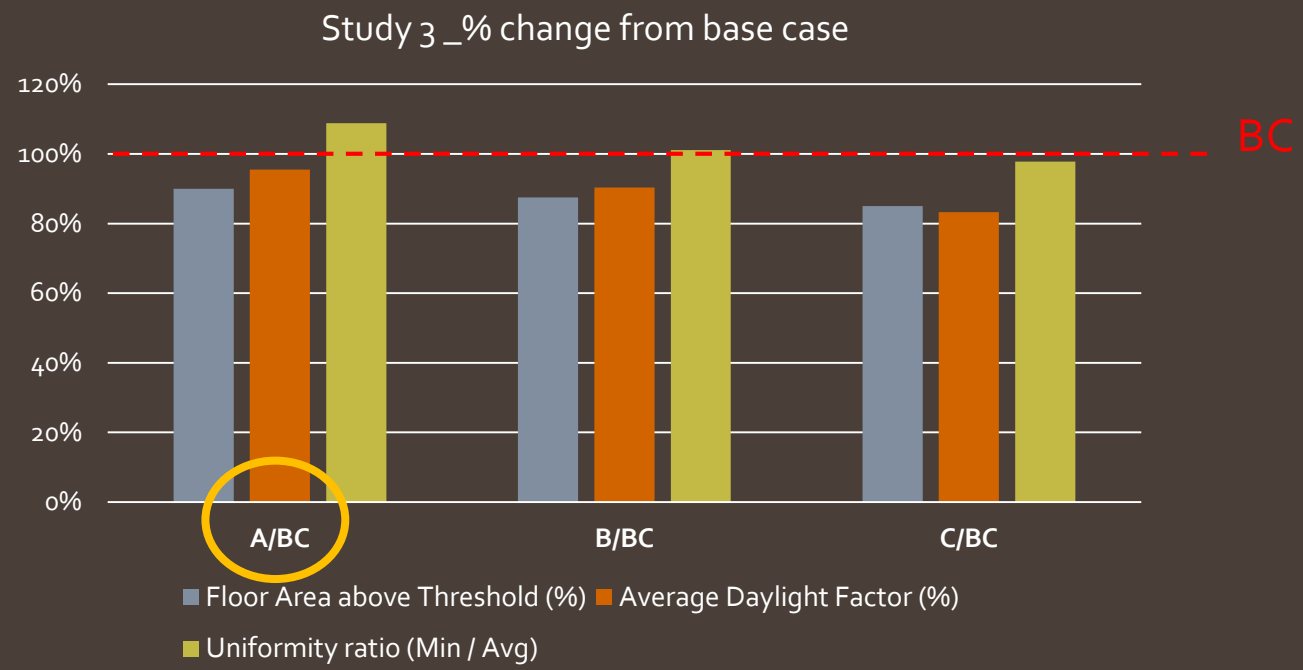


Remarks:
A and C improve daylight spread, but the introduction of light shelves do reduce the mean daylight factor.

Study 3 _ Introduce vertical plane reflectors/ shade

Objective: Direct morning light internally and shade afternoon glare.

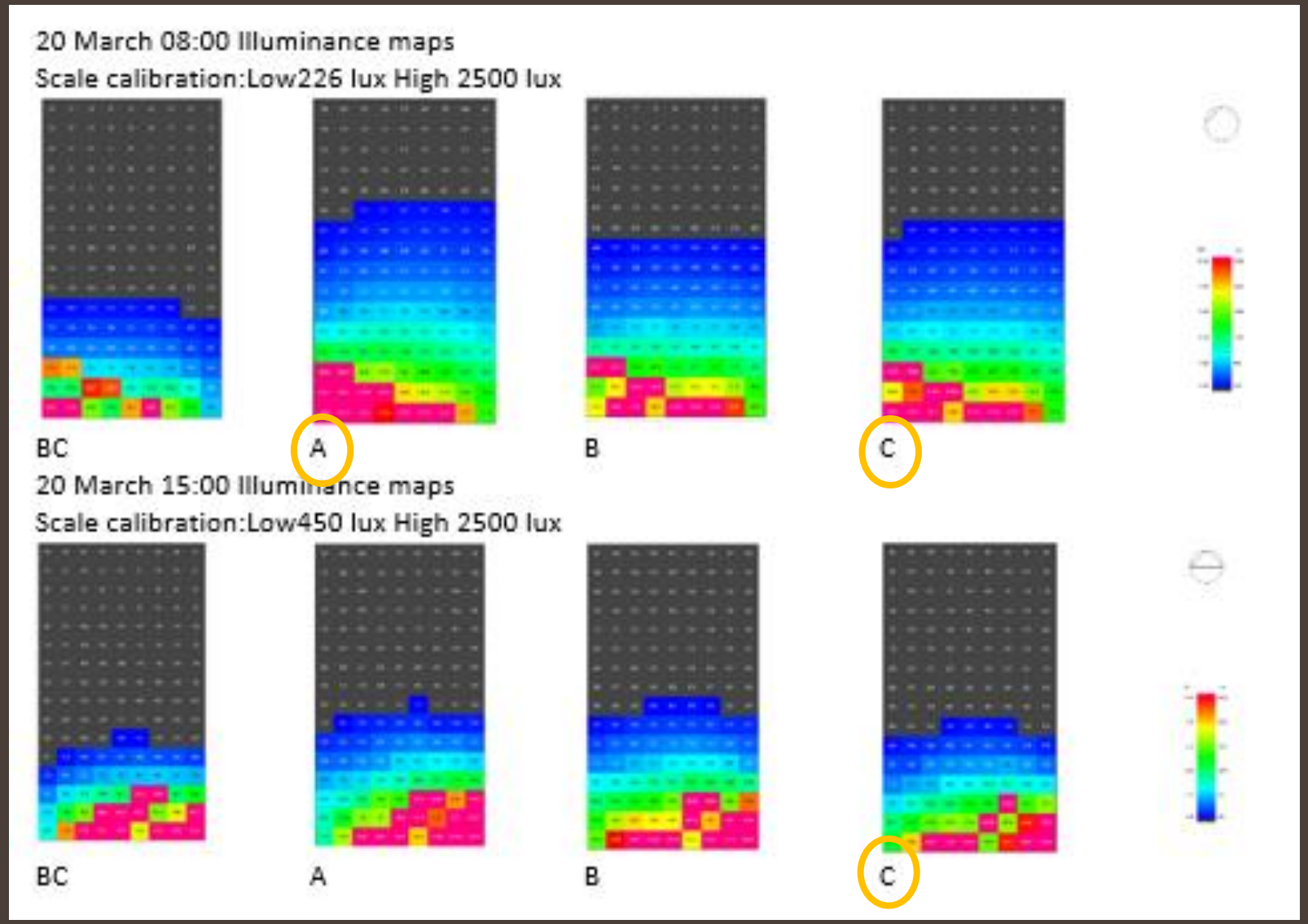
BC	A	B	C
			
Base Case	1.8m garden wall Reflectance 0.6	90 ° vertical fins 0.6m wide Reflectance 0.7	30° vertical fins 0.6m wide Reflectance 0.7



Remarks:
All fin options reduce average daylight factor, although option A does increase the uniformity ratio.

Study 3
Morning and Afternoon Illuminance

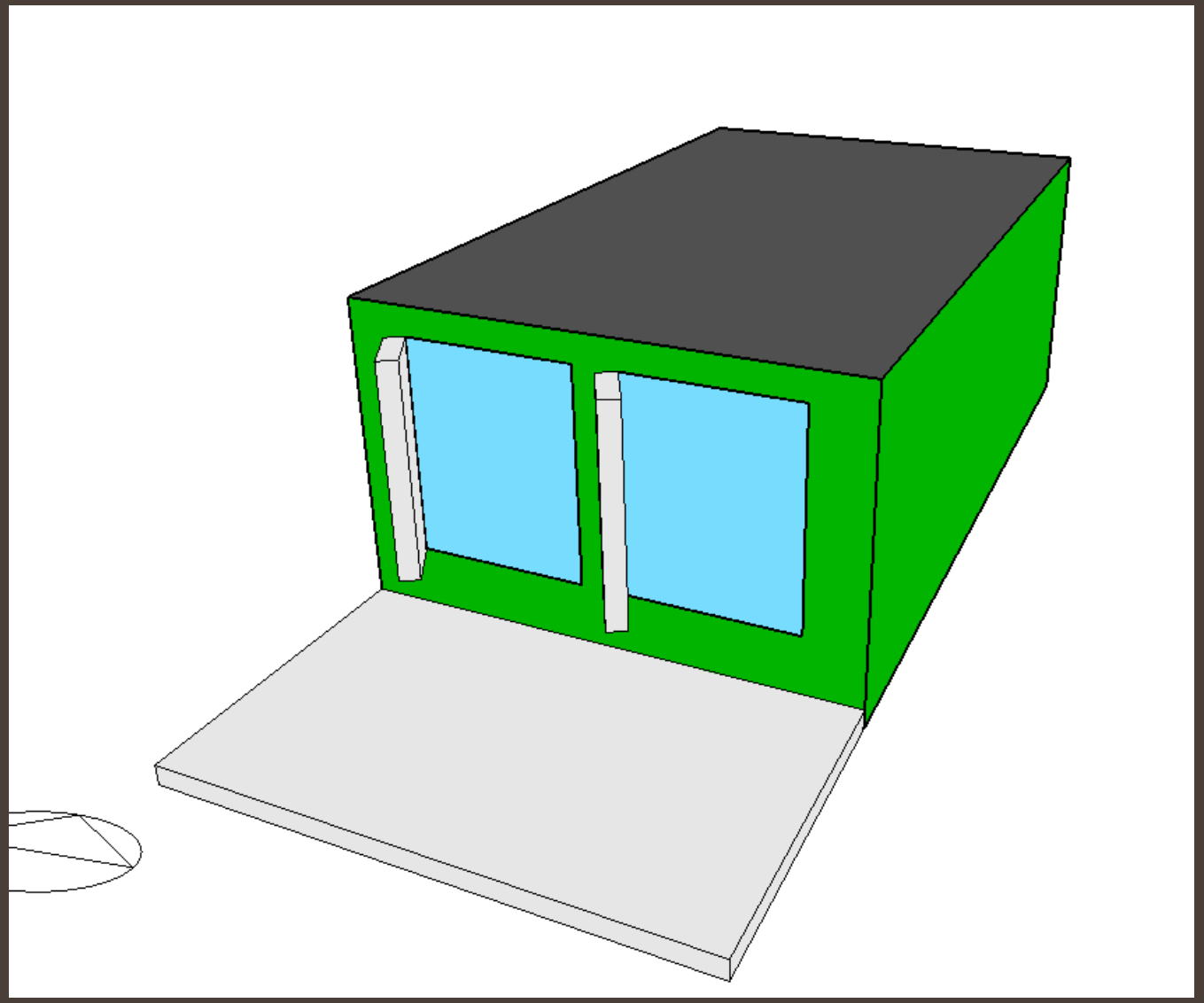
- All cases succeed in increasing morning sunlight penetration, A by the greatest. A has most morning glare.
- A slightly increases afternoon glare. B and C slightly reduce afternoon glare, C by the greatest.



Final Façade

Study 1 _ opt C
Study 2 _ opt C
Study 3 _ opt B

Additionally,
Cill level dropped to 800 to maintain views.

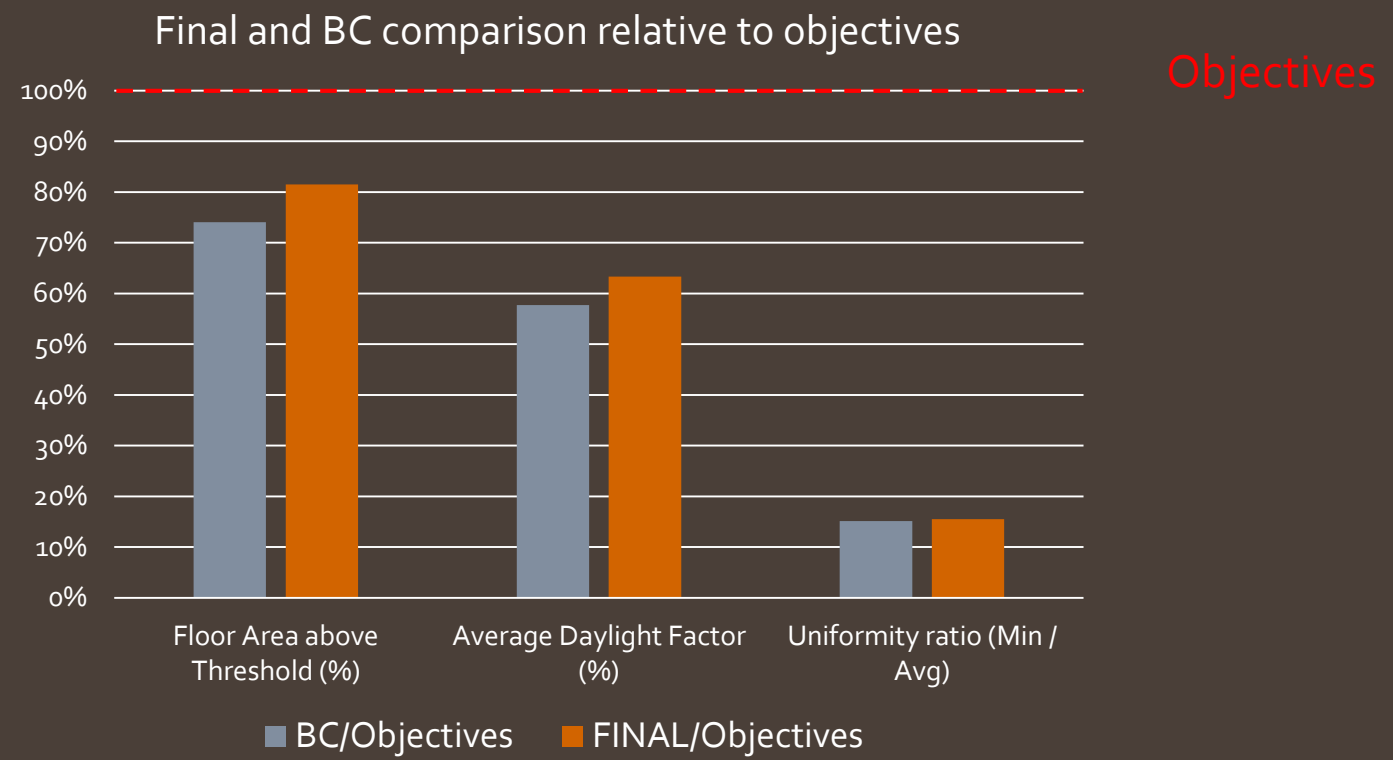


Final, Base Case and Objectives comparison

Remarks:

- Final proposal does improve on the base case in the 3 measures.
- Uniformity improvement is only slight.
- Final proposal is still far short of achieving the objective measures.
- A deep plan single aspect room would be expected to have daylighting supplemented by artificial lighting.

	Average Daylight Factor (%)	Uniformity ratio (Min / Avg)	Floor Area above Threshold (%)
BC	2.702	0.093	27.778
Objectives	5.000	0.600	37.500
Final	3.168	0.093	30.556

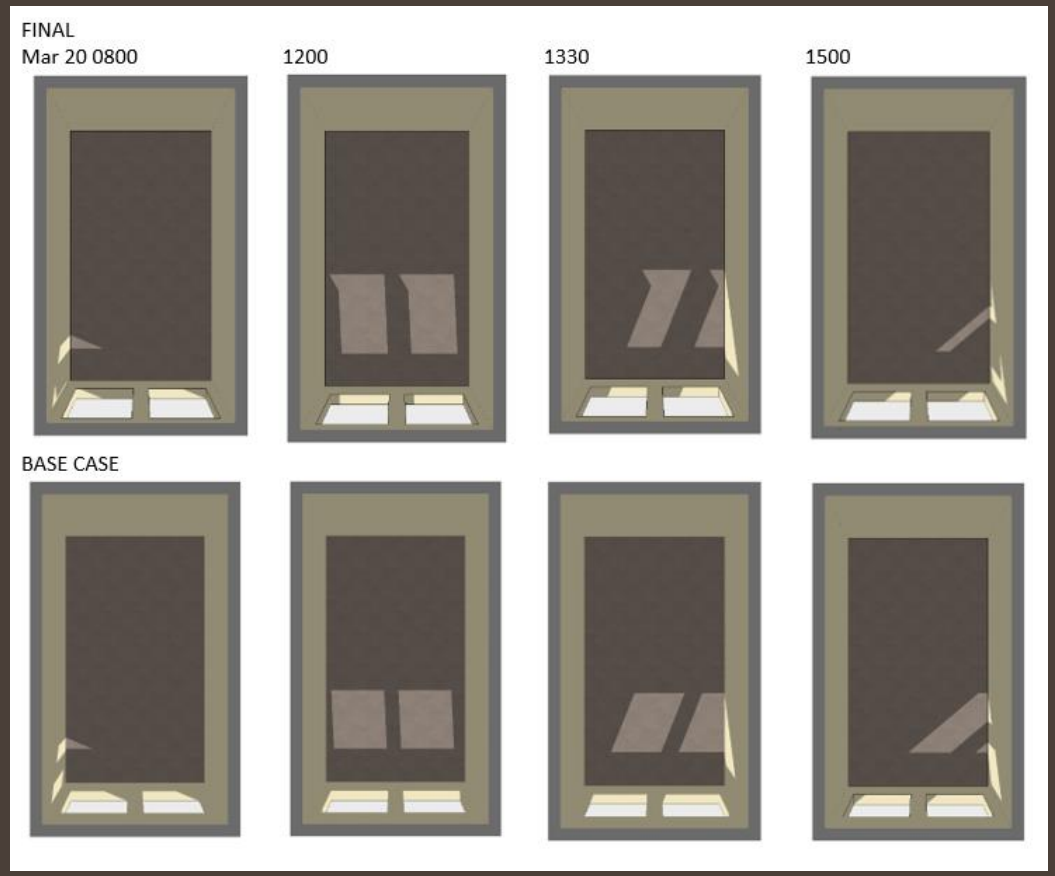


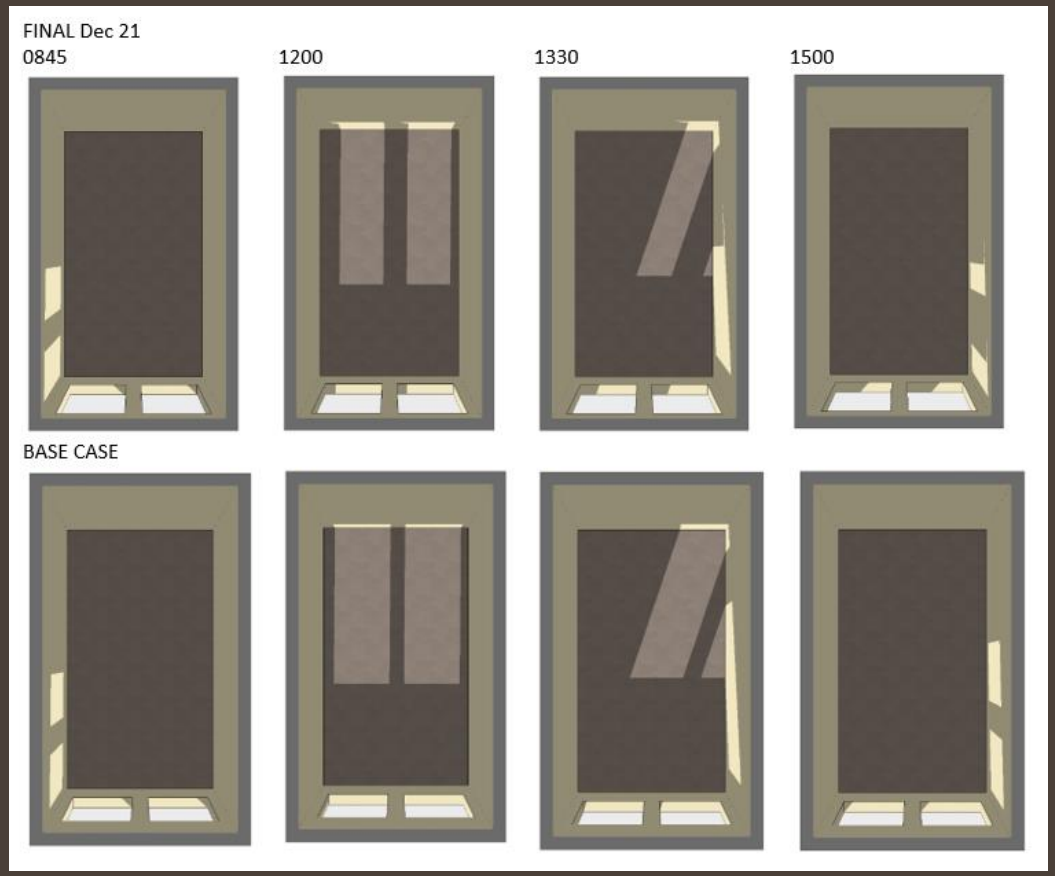
FINAL AND BASE CASE COMPARISON

Sunlight studies

Spring Solstice FINAL

BASE CASE





Remarks:

- Increased sunlight penetration into depth of room.
- Some blocking of afternoon glare.
- Midday glare still problematic, extending into TV zone in spring but can possibly be managed with internal blinds.

Further investigations

- Increasing height of vertical fins to block spring summer higher altitude afternoon sunlight.
- Increasing reflectance of lounge floor, but mindful of the need to retain clear contrast between vertical and horizontal planes. (CIE 2017)
- Selection of internal transparent blinds to mitigate midday and mid afternoon glare. Consideration of blind control mechanism; staff operated manual or automated to sensor or schedule.
- Supplementing with artificial lighting to both achieve luminance levels desired and to create homely feel.
- Optimisation of solar gain and heat loss through glazing.
- Optimisation of energy use for electrical lighting and for heating/ cooling to balance heat loss/ gain through glazing.
- Detailed investigation of glazing specification.

References

British Standards, 2008. *BS 8206-2:2008 Lighting for buildings. Code of practice for daylighting,* London: BSI.

CIE, 2011. *CIE 196: 2011 Guide to increasing accessibility in light and lighting,* Vienna: CIE.

CIE, 2017. *CIE 227: 2017 Lighting for older people and people with visual impairment in buildings,* Vienna: CIE.

Dowling, G. e. a., 2005. Effect of morning bright light treatment for rest - activity disruption in institutionalized patients with severe Alzheimer's disease.. *Int Psychogeriatr 17(2): 221–236. ,* 17(2), pp. 221 -236.

Goodman, C., 2011. *Lifetime Homes Standard,* Watford: IHS BRE press.

Konis, K., 2018. Field evaluation of the circadian stimulus potential of daylit and non-daylit spaces in dementia care facilities. *Building and Environment,* Volume 135, pp. 112 - 124.

Mardaljevic, J., 2017. *climate-based-daylight-modelling.* [Online]
Available at: http://climate-based-daylighting.com/doku.php?id=academic:climate-based-daylight-modelling
[Accessed 15 11 2019].

McMullan, R., 2017. *Environmental Science in Building.* 8 ed. s.l.:Red Globe Press.

SLL, 2013. *Lighting Guide 9 Lighting for communal residential buildings,* London: CIBSE.

SSL, 2012. *SLL Code for Lighting,* London: CIBSE.

SSL, 2014. *Lighting Guide 10 Daylighting A guide for Designers,* London: CIBSE.

Wheeler, E. a. M. J., 1997. *Regional Climates of the British Isles.* s.l.:Routledge.