# STUDIES OF DAYLIGHT FACTOR: IMPROVING DAYLIGHT FACTOR BY THE USE OF NET CURTAINS

J L Anderson and M W Thompson

Centre for Environment and Computing in Architecture, University of East London,
Holbrook Road, London E15 3EA Tel: +44 (0)181 849 3683 Fax: +44 (0)181 849 3686
Email: anderson@postmaster.co.uk m.w.thompson@uel.ac.uk

## ABSTRACT

An examination of the effect of various types of net curtain on the daylight factor in a domestic room of 4.8m in depth. The types of fabric tested are all commonly in use in the United Kingdom to provide privacy to windows: polyester net, muslin cotton and patterned polyester lace. A comparison of daylight factor for the curtained room with the uncurtained room under the same external light conditions shows an improvement in comparative values as distance from the window increases. For some types of curtain and light condition, results indicate an increase in Daylight Factor of up to 80% to that of an uncurtained room 4 metres away from the window. These results compare most favourably with model studies of the effect of Light Shelves to increase Daylight Factor in deep plan spaces, but offer a low tech and inexpensive method, easily adaptable to many window types.

## KEYWORDS

Net Curtains, Diffusing Membranes, Daylight Factor, Deep Plan Space,

## INTRODUCTION

Net curtains are in common use in the United Kingdom, in building types as varied as the suburban semi, the country cottage and flats in high rise tower blocks. Their obvious purpose is to allow a view out, whilst limiting the view in; however their widespread use in locations and situations where the requirement for privacy appears unnecessary (for example, the upper storeys of tower blocks which are not overlooked) suggests that the net curtain has become a part of the British vernacular.

Architects and Environmentalists often comment that vernacular elements provide an environmental benefit, the reason for their development and widespread adoption, though this environmental benefit may no longer be the primary reason why the element is now incorporated into buildings. In looking at net curtains, we considered it would be informative to investigate the possible environmental benefits they may provide, particularly with regard to daylight factor.

## METHOD

The room chosen for the study is on the ground floor of a converted Victorian terraced house in North London, facing onto the street in a south-westerly direction. The window is a bay window and the ceiling height is 2.5m.

Measurements were taken using a Hagner Light Meter. Light readings were taken at a height of 1 m above ground level, along the centre line of the window at intervals of 0.5m or less to the back wall. Accuracy of position between readings was assured by suspending a plumb line of 1 m length below the light cell, and marking positions with charcoal on the floor. After each series of readings (curtained and uncurtained), an external light reading was taken, both immediately outside the window, and at a point nearby where the greatest amount of sky could be seen, although due to the dense urban landscape, this was not a "whole sky" reading. As the paper is looking at the comparison of curtained to uncurtained daylight factors, the comparison can be made of the light values themselves, as the readings were taken immediately after each other. Any variation in external light conditions during the readings should be minimal, and would be statistically minimised due to the large number of individual readings taken at different times.

## RESULTS

Data was taken on eight occasions, ranging from morning to afternoon, clear sky to overcast, over a period of days. The external conditions in each case are shown in Table 1.

TABLE 1
External Conditions for each set of readings taken

| Case Number | Light Condition | Time | External Light Reading | Light Reading Outside Window |
|---|---|---|---|---|
| 1 | Strong sun, high altitude cloud | 08.45 | 50000 | 8000 |
| 2 | Clear Sky | 09.00 | 28000 | 7500 |
| 3 | Clear Sky | 12.00 | 35000 | 7200 |
| 4 | Overcast | 10.00 | 8200 | 4300 |
| 5 | Overcast | 12.00 | 6500 | 2000 |
| 6 | Clear sky, some haze | 14.00 | Not Taken | Not Taken |
| 7 | Clear sky, some haze | 12.00 | Not Taken | Not Taken |
| 8 | Overcast | 10.00 | Not Taken | Not Taken |

TABLE 2
Light Readings (lux) for various types of net curtain and external condition (as described in Table 1)

| **Type of Net Curtain** | **Case Number** | **Distance from Inner Face of Window (m)** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **0.00** | **0.33** | **0.66** | **1.00** | **1.33** | **1.66** | **2.00** | **2.50** | **3.00** | **3.50** | **4.00** | **4.50** |
| No curtain | 1 | 4000 | 10000 | 4000 | 2800 | 1800 | 1500 | 1000 | | | | | |
| Polyester lace | 1 | 3000 | 3800 | 2800 | 2000 | 1200 | 1000 | 800 | | | | | |
| No curtain | 2 | 4600 | 16000 | 4100 | 3200 | 2300 | 1600 | 1300 | 1000 | 800 | 550 | 440 | 390 |
| Polyester lace | 2 | 4200 | 4900 | 4100 | 3200 | 2100 | 1600 | 1300 | 1000 | 700 | 680 | 580 | 480 |
| No Curtain | 3 | 16000 | 27000 | 26000 | 26000 | 25000 | 24000 | 2500 | 2000 | 1800 | 1400 | 1200 | 1000 |
| Polyester Lace | 3 | 16000 | 14000 | 13000 | 11000 | 11000 | 2600 | 2300 | 2200 | 1600 | 1200 | 1000 | 700 |
| No Curtain | 4 | 1600 | 1200 | 1000 | 620 | 450 | 300 | 190 | 100 | 80 | 62 | 53 | 43 |
| Polyester Lace | 4 | 300 | 240 | 200 | 150 | 120 | 86 | 63 | 50 | 44 | 42 | 38 | 34 |
| No curtain | 5 | 2400 | 2500 | 1800 | 1300 | 800 | 550 | 320 | 180 | 120 | 90 | 53 | 48 |
| Polyester Lace | 5 | 1800 | 1500 | 1200 | 750 | 550 | 420 | 300 | 180 | 150 | 120 | 95 | 82 |

| **Type of Net Curtain** | **Case Number** | **Distance from Inner Face of Window (m)** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **0.00** | **0.50** | **1.00** | **1.50** | **2.00** | **2.50** | **3.00** | **3.50** | **4.0** | **4.50** |
| No curtain | 6 | 3000 | 2200 | 1900 | 1500 | 1000 | 670 | 410 | 320 | 220 | 110 |
| Polyester Lace | 6 | 1400 | 1000 | 750 | 525 | 380 | 275 | 200 | 160 | 140 | 100 |
| Polyester Net | 6 | 1800 | 1500 | 1000 | 750 | 500 | 400 | 250 | 210 | 150 | 100 |
| No Curtain | 7 | 5000 | 3600 | 2700 | 1600 | 800 | 360 | 240 | 190 | 160 | 120 |
| Polyester Lace | 7 | 1100 | 750 | 600 | 340 | 210 | 160 | 140 | 120 | 110 | 90 |
| Polyester Net | 7 | 2500 | 2000 | 1400 | 800 | 500 | 320 | 210 | 170 | 140 | 115 |
| No Curtain | 8 | 1450 | 1300 | 650 | 325 | 200 | 120 | 77.5 | 55 | 47.5 | 39 |
| Polyester Lace | 8 | 550 | 450 | 220 | 150 | 100 | 75 | 60 | 50 | 50 | 40 |
| Muslin | 8 | 750 | 520 | 300 | 200 | 140 | 100 | 80 | 68 | 64 | 54 |

TABLE 3
Comparison of Curtained to Uncurtained Light values for varying Distances from the Window

| **Comparison** | **Case No** | **Distance from Window (m)** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **0.00** | **0.33** | **0.66** | **1.00** | **1.33** | **1.66** | **2.00** | **2.50** | **3.00** | **3.50** | **4.00** | **4.50** |
| Polyester Lace/ No curtain | 1 | 0.75 | 0.38 | 0.70 | 0.71 | 0.67 | 0.67 | 0.80 | | | | | |
| Polyester Lace/ No curtain | 2 | 0.91 | 0.31 | 1.00 | 1.00 | 0.91 | 1.00 | 1.00 | 1.00 | 0.88 | 1.24 | 1.32 | 1.23 |
| Polyester Lace/ No curtain | 3 | 1.00 | 0.52 | 0.50 | 0.42 | 0.44 | 0.11 | 0.92 | 1.10 | 0.89 | 0.86 | 0.83 | 0.70 |
| Polyester Lace/ No curtain | 4 | 0.19 | 0.20 | 0.20 | 0.24 | 0.27 | 0.29 | 0.33 | 0.50 | 0.55 | 0.68 | 0.72 | 0.79 |
| Polyester Lace/ No curtain | 5 | 0.75 | 0.60 | 0.67 | 0.58 | 0.69 | 0.76 | 0.94 | 1.00 | 1.25 | 1.33 | 1.79 | 1.71 |

| **Comparison** | **Case No** | **Distance from Window** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **0.00** | **0.50** | **1.00** | **1.50** | **2.00** | **2.50** | **3.00** | **3.50** | **4.00** | **4.50** |
| Polyester Lace/ No Curtain | 6 | 0.47 | 0.45 | 0.39 | 0.35 | 0.38 | 0.41 | 0.49 | 0.50 | 0.64 | 0.91 |
| Polyester Net/ No Curtain | 6 | 0.60 | 0.68 | 0.53 | 0.50 | 0.50 | 0.60 | 0.61 | 0.66 | 0.68 | 0.91 |
| Polyester Lace/ No Curtain | 7 | 0.22 | 0.21 | 0.22 | 0.21 | 0.26 | 0.44 | 0.58 | 0.63 | 0.69 | 0.75 |
| Polyester Net/ No Curtain | 7 | 0.50 | 0.56 | 0.52 | 0.50 | 0.63 | 0.89 | 0.88 | 0.89 | 0.88 | 0.96 |
| Polyester Lace/ No Curtain | 8 | 0.38 | 0.35 | 0.34 | 0.46 | 0.50 | 0.63 | 0.77 | 0.91 | 1.05 | 1.03 |
| Muslin/ No Curtain | 8 | 0.52 | 0.40 | 0.46 | 0.62 | 0.70 | 0.83 | 1.03 | 1.24 | 1.35 | 1.38 |

It was expected that the net curtains would significantly reduce the luminous flux within the room and this expectation was confirmed. However this reduction was not uniform with regard to the distance from the window, but lessened as the distance from the window increased, as shown in Figure 1 below. Indeed, on five of the occasions that readings were taken, the luminous flux was greater with curtains than without at a distance of over three metres from the window.

Although the general trend in this instance is upwards, the values for Case 3 drop after a peak at 2.5 metres from the window, and both Cases 2, 5 and 8 show the beginnings of a fall away. Further investigation in a larger room would be needed to gain a clear understanding of this effect. It must also be pointed out that even at the points when the light levels are greater with net curtains than without, the general light levels are still low.

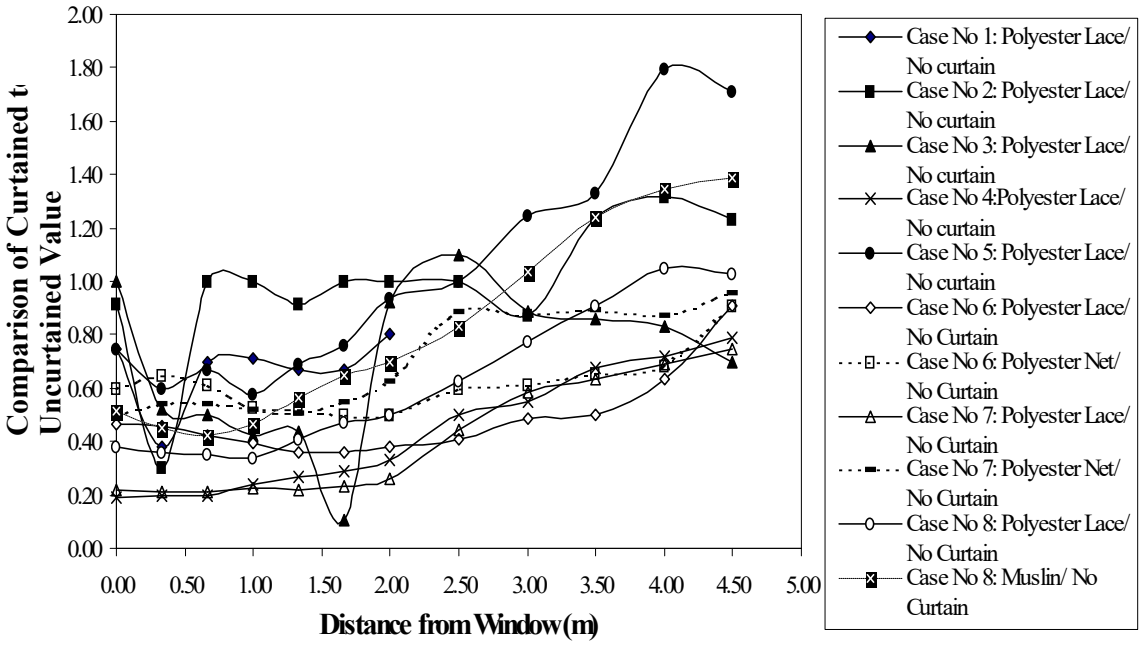


Figure 1 : Graph showing Comparison of Curtained to Uncurtained Light Values against Distance from Window for varying external conditions and net curtain types.

***Reasons for the Effect***

It is possible that these readings could be due to changing light effects outside (ie the sun coming out from behind a cloud whilst the net curtain readings were being taken) rather than the effect of the net curtain. However when the sky was clear, there was no cloud which could cause such lighting effects, and the overcast days were very cloudy.

It seems more likely however that the effect is caused by the net curtain. In this case, it is most likely to relate to the curtain acting as a light diffusing membrane. Thus the curtain would scatter or diffuse light into the room, allowing greater reflection of light from the ceiling and walls into the back of the space. Net curtains of different weaves, densities and materials would cause different diffusion patterns. The effect of these different patterns on the light paths could be investigated using vector illuminance.

***Glare***

The other advantage which can be seen in the clear sky readings in particular (Cases 1, 2, 3, 6 and 7) is the effect of the net curtain in reducing the peaks in the luminous flux due to sunlight. The use of net curtains significantly reduces these peaks, which on the working plane can cause disability glare due to reflections of the direct sunlight directly into the eye. Net curtains also reduce the brightness of the sky seen through the window which can be a cause of discomfort glare due to the contrast between the bright sky and the general illumination level within the room which is low in comparison.

***Comparison to Improvements in Daylight Factor Achieved Using Light Shelves***

M W Thompson and A Mucibabic's paper to the 1995 CIBSE Conference in Eastbourne, "Model Studies of Daylight Factor: Light Shelves, Curved Ceilings and External Obstructions" reached the conclusion that "The use of Light Shelves in situations where the overall ceiling height is 4.0m or less results in only marginal increase in Daylight Factor provided the shelf is wholly outside and in a low position in relation to the window. The maximum percentage change is of the order of 11%." Increases in Daylight Factor only occurred in this example at a distance of 6-7 metres from the window. In comparison, net curtains provided a maximum percentage change of the order of 80% at a distance of 4 metres from the window.

## CONCLUSION

Net Curtains can provide considerable increases in Daylight Factor of up to 80% at distances over 3 metres from the window. Given the widespread search for ways to improve natural lighting in deep plan spaces with, for example, light shelves, net curtains offer a cheap and simple alternative solution to such high-tech and construction-complex solutions. Net curtains also offer other benefits, reducing both discomfort and disability glare, providing privacy and increasing insulation values. Investigation into the effect of different weaves, materials and density of fabric may yield a curtain with a more dramatic effect on daylighting than the net curtain types used in these investigations. Etched or frosted glass, which have a diffusing effect on light, may also have a similar effect on daylighting.

## REFERENCES

M W Thompson and A Mucibabic. (1995). Model Studies of Daylight Factor: Light Shelves, Curved Ceilings and External Obstructions. *CIBSE Conference Proceedings.*