REPORT ON PIE CHART USED FOR ATTRIBUTION OF MATERIAL FADING

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Introduction

The purpose of this report is to comment on the applicability of the Film Industry's accepted 'Fading Pie Chart' used both as a rule of thumb, but more often as 'Facts on Fading', in attributing fabric fading to different environmental factors. This 'Facts on Fading' guide suggests the following contributions to fabric fading:

- 40% caused by UV light
- 25% caused by visible light
- 25% caused by heat
- 10% caused by miscellaneous factors such as interior artificial lighting

There are other reports suggesting that the contribution of UV light to fading is closer to 60 to 65%. Visible light and heat accelerate the fading processes which is driven primarily by UV light. Visible radiation (sunlight) above 50 lux, the light level in movie theatres, contributes to fabric fading while for infrared radiation (heat) to have a detrimental effect the temperate needs to be above 20 degrees, but also depends on dye anchorage etc.

Applicability of the 'Fading Pie Chart' to New Zealand

Unfortunately the source of the Fading Pie Chart is unclear and nobody seems to know its origin. Without knowing the exact conditions under which the studies which lead to the pie chart were conducted, it is impossible to make any exact conclusions about its applicability to New Zealand conditions. The factors affecting fading of interior fabrics and furnishings will depend on a number of environmental variables including:

- The levels of UV and visible solar radiation, and the relative proportion of UV and visible solar radiation to the total radiation incident on the exterior of the building This in turn will depend on the position of the building in relation to the sun, the time of the day and the time in the year, the eaves overhang, reflective properties of the surrounding area etc.
- The transmitting properties of the windows which will depend on the type of glass, whether or not the window has any additional coatings, the reflective properties of the glass etc.
- The properties of the room and the orientation of the fabric/furnishings e.g. the insulation of the room (which will affect the heat budget), the size of the windows in relation to the size of the room etc.
- The specific properties of the fabric

Clearly, these factors can combine to give a very different 'Fading Pie Chart' to that used by the Film Industry. Without access to the research used to generate the Pie Chart, it is impossible to gauge just how different it might be for a given set of conditions. The only approach is to make some realistic assumptions about how the Pie Chart was generated, and then see how this might be relevant to New Zealand conditions.

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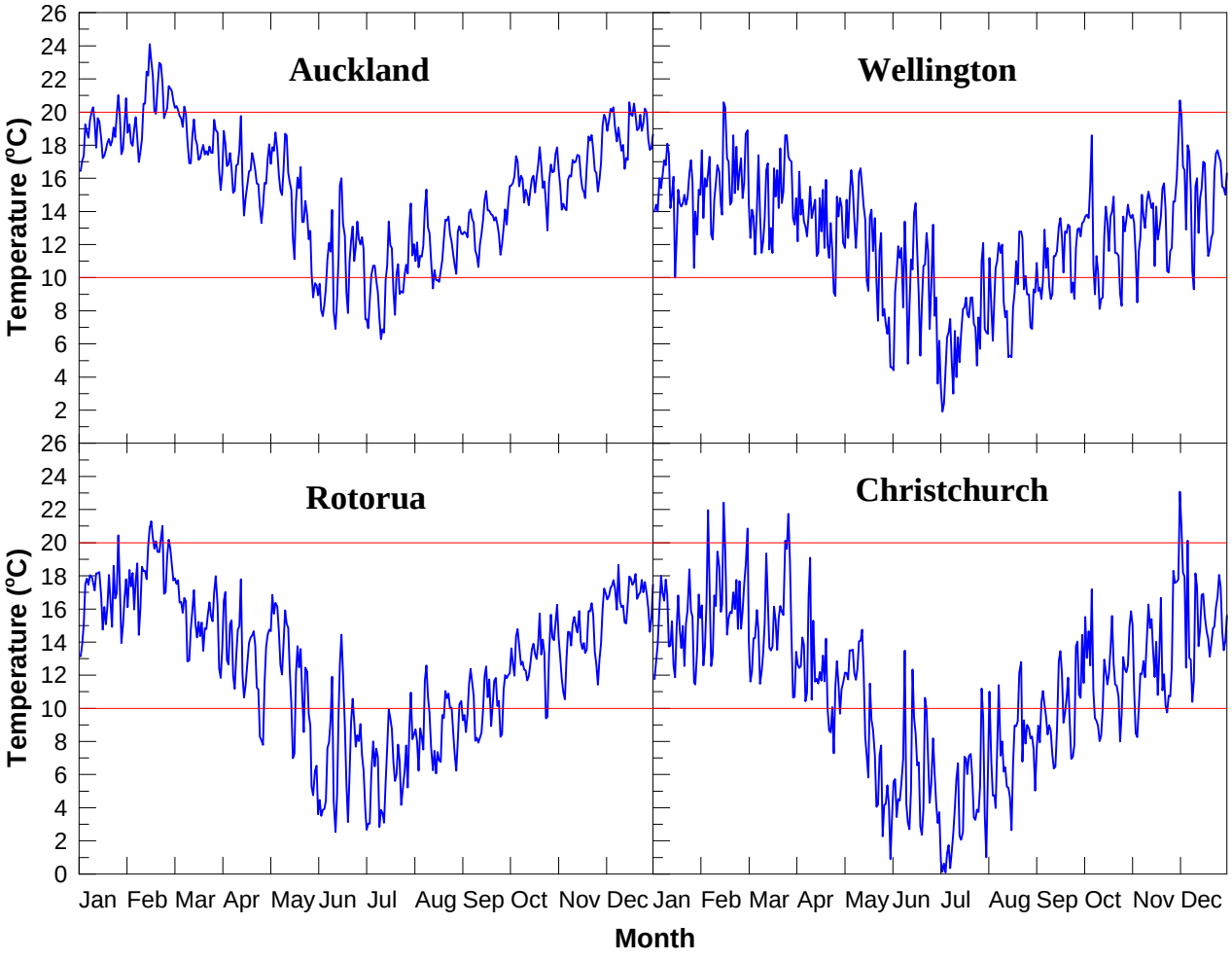
The UV radiation environment of New Zealand

We assume that the Fading Pie Chart was generated in the USA for USA conditions. UV radiation levels in New Zealand are expected to be 30 to 40% higher than at the same latitudes in the USA [*McKenzie et al.*, 2001]. Visible light levels are expected to be only slightly higher. Therefore the fraction of UV to visible light in New Zealand is higher than would be expected in the USA. As a result, the contribution of UV radiation to the fading of fabrics and furnishings is expected to be much higher than in the USA and would increase the size of the 'UV light' component of the Fading Pie Chart – by exactly how much cannot be determined since we don't know the source of the original Fading Pie Chart.

The thermal environment of New Zealand

The Scottish Museums Council suggest that to minimize damage to interior textiles the interior temperature should be kept between 10°C and 20°C. This also has implications for the applicability of the Fading Pie Chart to New Zealand conditions. The figure below shows daily mean temperature for four sites around New Zealand for 2001 (blue lines). Also shown are the 10°C and 20°C limits suggested by the Scottish Museums Council (red lines). For most New Zealand locations the upper limit of 20°C is seldom exceeded while the lower limit of 10°C is frequently exceeded in winter. Therefore passive heating of homes, via visible and infra-red (heat) solar radiation through windows, can be important, primarily in winter, for keeping interior temperatures in the range which minimizes damage to furnishings and



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fabrics.

The Fading Pie Chart may have been derived for different ambient temperature conditions and therefore the relative contribution of 'Heat' to the other factors, may not be applicable to New Zealand conditions.

The cloud environment of New Zealand

Cloud cover generally reduces UV radiation at the Earth surface. The cloud cover conditions under which the standard 'Fading Pie Chart' was derived are unknown and this introduces additional uncertainty into the relative contribution of the various factors. For Auckland, Rotorua and Christchurch, the suppression of UV by clouds is about 33%. In Wellington, increased cloudiness makes this number closer to 38%. Suppression of UV by these amounts does not necessarily affect the relative contributions of the various factors to fabric fading – in fact, if cloud cover conditions over New Zealand are higher than the location for which the 'Fading Pie Chart' was derived, the relative contribution of UV may well increase further since clouds suppress visible radiation more effectively than UV radiation.

Summary

It is UV radiation that is primarily responsible for the cause of fabric fading (as a consequence of its high energy). In comparison to locations elsewhere, the high UV radiation of New Zealand makes UV even more important regarding fabric fading and reducing the transfer of UV radiation through windows will significantly extend the lifetime of fabrics. Visible radiation (sunlight) and infrared radiation (heat) accelerate the fading process, but for New Zealand conditions, are expected to be of secondary importance.

References

McKenzie, R.L.; Seckmeyer, G.; Bais, A.F.; Kerr, J.B.; Madronich, S. (2001). Satellite retrievals of erythemal UV dose compared with ground-based measurements at northern and southern midlatitudes. *Journal of Geophysical Research 106(D20)*: 24051-24062.

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