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AVERAGE TRANSMITTANCE FACTORS FOR MULTIPLE GLAZED WINDOW SYSTEMS

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ABSTRACT

Multiple glazing is the most common "static" method of improving the insulating properties of windows. For simplified calculations of solar heat gain a single value for transmittance is chosen, usually the normal transmittance. Whenever such a method is applied, the normal transmittance should be replaced by an averaged value which takes into account the daily and seasonal variations of weather and the angle of incidence.

1. INTRODUCTION

Most buildings contain windows that are either single or double glazed. Solar transmission is relatively high but thermal losses may be substantial. In order to reduce these losses, increasing use is being made of windows incorporating three or more glass or plastic layers. Surfaces for which a substantial fraction of solar energy is received at large angles of incidence will exhibit low net energy transmittance due to reflection and absorption losses. When reductions in solar gain are compared to improvement in thermal resistance, the additional glazings may be counterproductive for some climates and orientations.

Detailed calculation procedures using measured hour-by-hour weather data are the most exact means of determining the energy balance of a window as an integrated building element. The complexity and cost of these methods make them unsuitable for quick comparisons. Most evaluations of the potential contributions of glazed building surfaces in passive solar design will continue to be done with a hand calculator and pencil and paper. In simplest terms, solar heat gain, SHG, involves the product of some solar radiation intensity available at the outside surface of the window, I, and a factor, T, for the fraction of incident radiation which is transmitted through the window. Through I, SHG depends on (1) latitude, (2) orientation, and (3) local weather (relative amounts of diffuse and direct solar radiation). T is usually a materials property only, representative of the type of window.

Solar transmittance as a function of angle of incidence $T(\theta)$ is available in the literature for a number of common glazing types.[1] More advanced window systems, including plastic layers and thin film coatings for thermal radiation control, have also been treated.[2] A single number must be settled on for rough estimation of passive solar heat gain, and the transmittance at normal incidence T_n is usually chosen.

The rational for using T_n as a nominal value comes from the assumption that the variation of $T(\theta)$ is very slight between $\theta = 0$ and $\theta = 45$ degrees for single and double pane windows. However, the angle of incidence is frequently higher than 45 degrees, and the direct solar intensity may still be appreciable at these high angles. In addition, figure 1 shows that the constancy of $T(\theta)$ for angles up to 45° breaks down as T_n gets smaller due to additional panes or surface coatings for improved thermal insulation. The average solar transmission will be lower than T_n, even for the case of single glazing.

The value of the concept of time averaged transmittance was pointed out by Berman and Claridge.[3] It was noted that monthly averaged transmittance does not depend on location, (latitude and local conditions of cloudiness) which simplifies and reduces the amount of information needed for general application.

2. METHOD OF CALCULATION

For the twenty-first day of each month, the hourly diffuse (including ground reflected) and direct solar energy flux are calculated as outlined by Kusuda and Ishii[4]. The solar optical properties as a function of angle for various glazing types are determined by classical methods[2]. The monthly average transmission coefficient is then defined as the ratio of the total solar gain over the day to the total available solar energy.

Climate is reflected in the values of the Liu-Jordan coefficients $\bar{K}_t$ and $\bar{K}_d$. For a "clear day", we have taken $\bar{K}_t$ = .8 and $\bar{K}_d$ = .125, and for a cloudy day $\bar{K}_t$ = .3 and $\bar{K}_d$ = .2. These values remain constant throughout the year in order to reveal the effects of variations in the earths orientation relative to the sun, and do not necessarily model any real weather pattern.

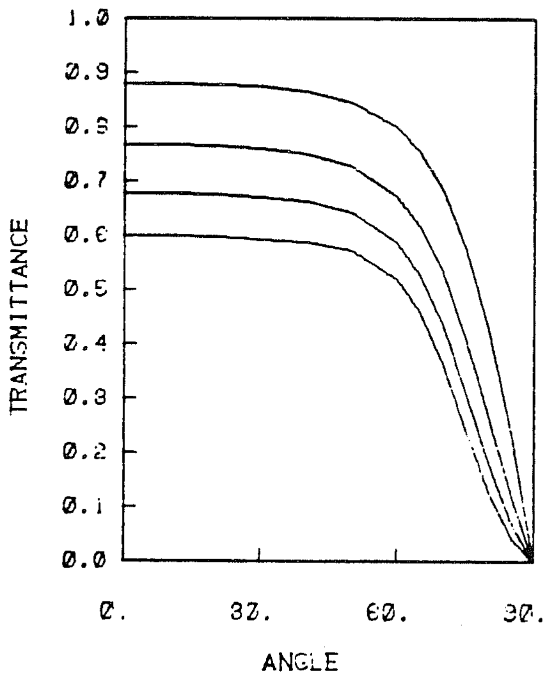

Fig. 1. Transmittance as a function of angle of incidence for 1, 2, 3, and 4 pane glass windows.

3. RESULTS

Monthly average transmittance values over a yearly cycle are presented in figures 2 through 5 for several orientations at 40° N latitude. Each figure shows single and quadruple glazing for clear and cloudy weather as a means of examining extremes of weather and window type.

Figs. 2-5. Transmittance as a function of month for several orientations at 40° N latitude. The upper two curves in each graph are for single and the lower two for quad glazing. Heavy lines are for cloudy days and light lines for clear days. For single glazing, T_n = .88 and T_h = .80, and for quadruple glazing, T_n = .60 and T_h = .52. (T_h = hemispherical transmittance)

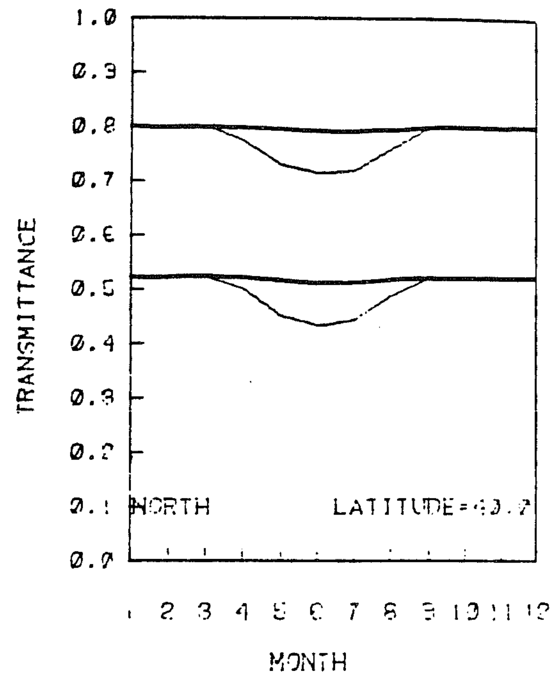

Fig. 2.

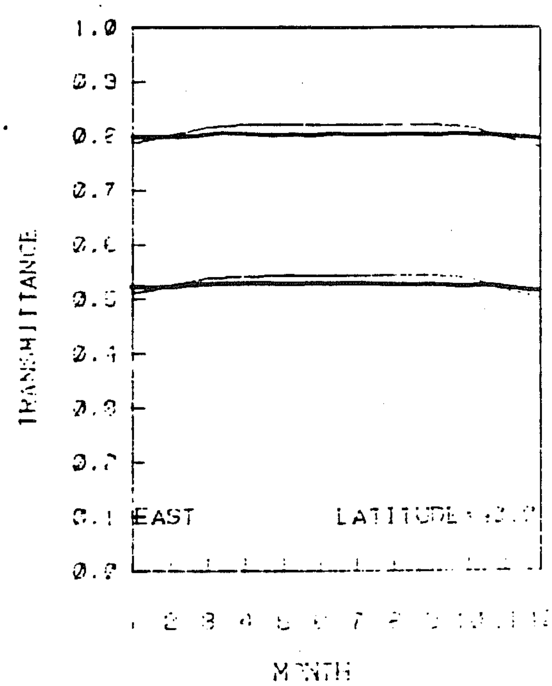

Fig. 3.

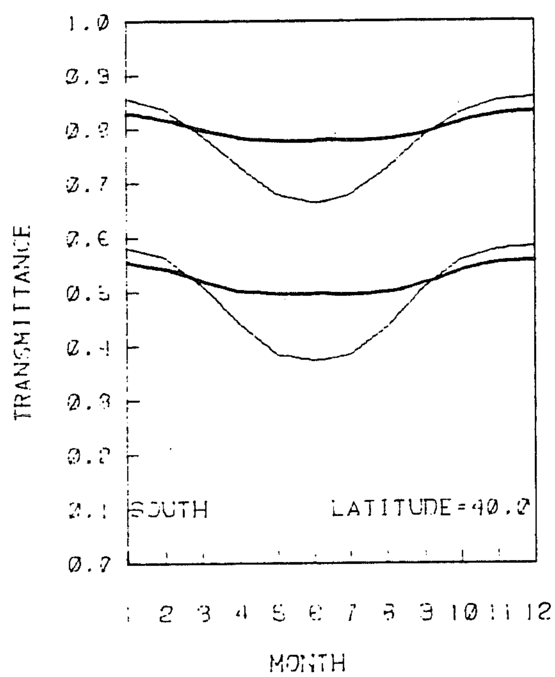

Fig. 4.

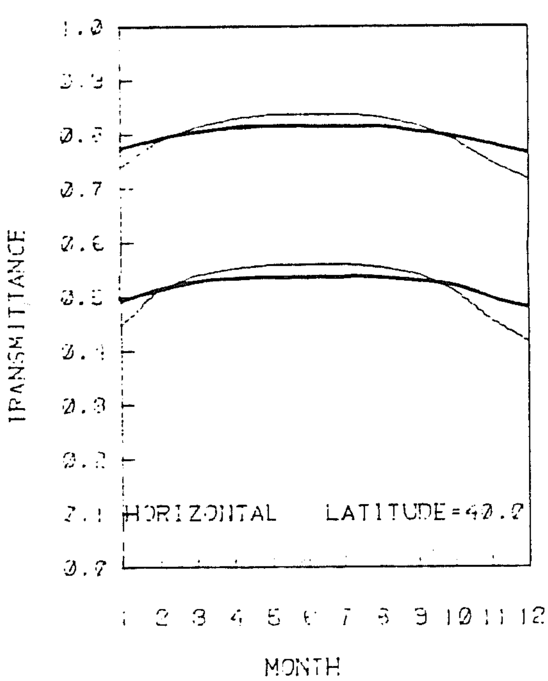

Fig. 5.

The following trends are observed from figures 2 through 5.

1. Variations in average transmittance with window type always show signficant differences.

2. Cloudy weather always results in less variation in any parameter, since transmittance approaches the hemispherical average.

3. Variations with latitude, cloudiness and orientation are small for east, north and west orientations, growing larger towards the south and horizontal.

4. CONCLUSION

In order to accurately evaluate the passive solar performance of a given window, seasonal average transmittances should be used; there is no single value for the transmittance which takes into account variations in latitude, orientation, time of year or local climate. In the heating season, for orientations other than south the transmittance at normal incidence is an overestimate of window performance, and a more accurate measure is the hemispherical average transmittance. For east, north and west orientations the hemispherical average is quite good; for south and horizontal windows neither normal nor hemispherical average transmittance is accurate, and a seasonal averaged transmittance should be used.

In subsequent work, a table of suggested seasonal transmittance values, by orientation, will be provided for a wide range of glass and plastic glazing systems, with and without selective optical coatings. These are not intended to replace annual load calculation methods but rather to provide a quick assessment as to the relative performance of a variety of improved glazing systems for all window orientations. To properly calculate the net energy transmittance of glazing systems for comparison with conductive losses, the absorbtance in multilayer glazings or coatings is accounted for. The incremental reduction in conductive/convective losses can then be compared to any resultant loss in transmitted energy due to the addition of optical coatings and/or glazing layers. Based on reference to these tabulated values, if the glazing system alternative looks better than the base case, any of several available annual load calculation techniques may be used to predict annual building thermal performance.

5. ACKNOWLEDGEMENT

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6. REFERENCES

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