Temperature measurements at Carleton University library

Stephenson, D. G.

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TECHNICAL NOTE

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PREPARED BY D. G. Stephenson CHECKED BY APPROVED BY N. B. H.

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PREPARED FOR Carleton University

SUBJECT TEMPERATURE MEASUREMENTS AT CARLETON UNIVERSITY LIBRARY

The Carleton University Library becomes uncomfortably hot during the summer months. Measurements indicate that the inside surfaces of the opaque wall panels become very warm when the sun shines on the wall. As a result, a member of staff concerned with the planning of an extension to the library asked the Division whether changing the colour of the outside surface of the wall panels would significantly improve comfort conditions inside the library.

To answer this question it is necessary to know what conditions do obtain in the present library space and the relative importance of the several factors that affect the comfort level of the building. It was decided, therefore, that the Division of Building Research would measure, during July and August, 1961, both air temperature and the temperature of the surfaces that influence comfort conditions.

COMFORT CONDITIONS

An individual feels uncomfortable when his body experiences some difficulty in maintaining normal body temperatures. The four important parameters of surroundings affecting heat transfer from the body are:

(1) Air temperature
(2) Relative humidity
(3) Air velocity over the body
(4) Emissive power of the surfaces that can be "seen" by the body.

Comfort conditions can be improved by increasing air movement and reducing the other three factors when a space is too warm.

TEMPERATURE MEASUREMENTS

The library wall consists of 2 in. opaque plastic-faced panels made of paper honeycomb with a plastic surface, alternated with double-glazed windows between mullions which are about 26 in. centre to centre. A white plastic shading fin is attached to the outside of each mullion and projects about 10 in. from the wall surface. The windows have a vertical type of venitian blind on the inside. Two of the opaque plastic panels were reversed so that the surface outside was white instead of the standard black. One of these had standard white plastic shading fins projecting outwards from the mullions and the other reversed panel had shading fins covered by a black building paper. One standard wall panel (i. e. black side out) and window were also shaded by blackened fins so that it was possible to separate the effects of panel colour and fin colour. The arrangement is shown in Fig. 1.

Ribbon thermocouples were cemented onto the panel surface or sewn onto the blind at heights of 4 and 8 ft from the floor. Room air, ventilating air and ceiling temperatures were also measured. The values given in Table I are the maximum temperatures for a typical hot summer day (July 27, 1961).

TABLE I

SUMMARY OF MAXIMUM TEMPERATURES

FOR TYPICAL SUMMER DAY

Inside Air Temperature		92°F
Ceiling Temperature		89
Ventilating Air Temperature		88
Wall Surface Temperature, Location	A	105
"	C	94
"	D	95
"	F	101
Blind Temperature, Location	B	107
"	E	105

Peak values for the day occurred at about 5 pm; the difference of 11 F deg between the standard and reversed panel at that time was also the maximum for the day. In the morning when there was no direct sunlight on the wall there was no difference between the two arrangements, but by 1 pm the difference was 4 F deg and it increased steadily up to 10 F deg by 3 pm, remaining nearly constant at this value until 6 pm. In general, it seems that the difference builds up over a period of about 3 hours, is constant for 3 hours, and decreases to zero in another 3 hours. The times at which each phase of this sequence occurs depends on the orientation of the wall.

These results show that the temperature of the inside surface of the opaque wall panels can be reduced substantially over a period of several hours when the maximum temperatures occur, by reversing the panels. If all the panels were reversed the effect would be slightly greater than shown above since the inside air temperature would be closer to the temperature of the ventilating air. This reduction in wall surface temperature will give a significant improvement in the comfort conditions in the areas near the walls owing to the reduction of the emissive power of the wall surface.

The emissive power of the surface is proportional to the product of surface emissivity and the fourth power of the absolute temperature of the surface. Coating the inside surface of the wall with a material of low emissivity would also improve the thermal comfort conditions.

Results also indicate that the blinds, when closed, reach approximately the same temperature as the wall surface. Since the windows comprise 50 per cent of the total wall area the temperature of the blinds has about the same effect on comfort conditions as the temperature of the wall panels. The blinds are heated by the solar radiation that they absorb so that it is desirable to reflect back through the window as much of the sunlight as possible. Accordingly, the fabric blind tapes on one window were replaced by strips of heavy paper with aluminum foil on both sides. This window was shaded on the outside by standard white plastic fins. On a clear hot day in August the standard blind reached a maximum temperature of 105°F when the room air temperature was 90°F; the maximum temperature of the foil blind was 93°F. This indicates that the foil blind substantially reduces the solar heat gain through the windows and that it will consequently improve comfort conditions in the building. A blind with a white surface facing the glass would also be superior to the present blinds, although inferior to the double-sided foil which was tested.

When maximum room air temperatures occur, ceiling temperature is lower, so that there can be no heat transfer from the ceiling to the room air at that time. Heat transfer through the roof, therefore, has a very minor effect on comfort conditions when the library is most uncomfortable. Thus any measures that reduce roof heat gain will have very little effect on comfort conditions.

A supplementary series of temperature measurements made to check the uniformity of the air temperature in the library indicate that it is nearly uniform throughout. Air mixing seems adequate but more air movement in the central region would probably improve comfort conditions (no air velocity measurements were made).

CONCLUSION

1. Temperature measurements made during the summer months indicate that the proposal for reversing the opaque wall panels is sound. Changing the colour of the shading fins, however, would have very little effect on comfort conditions within the building.

2. Blinds with a high reflectivity for solar radiation would significantly improve summer comfort conditions.

3. Heat transfer through the roof has very little effect on comfort conditions during the afternoon, so that any ameliorative measure intended to reduce this heat gain will have a very minor effect on comfort.

4. The air temperature throughout the library space is substantially constant.

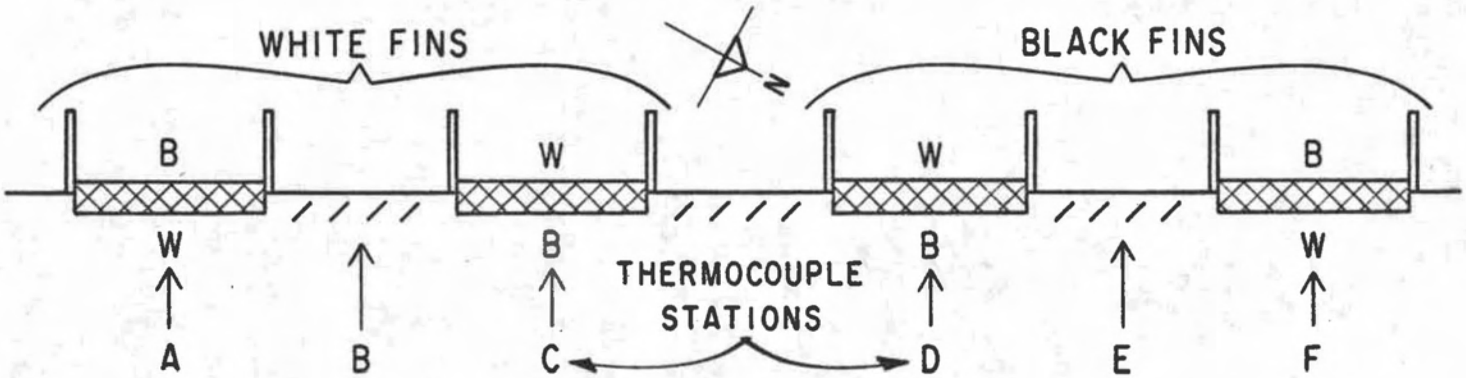

FIGURE 1 ARRANGEMENT OF FINS AND COLOUR OF PANELS

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