BUILDING DIGEST
CENTRAL BUILDING RESEARCH INSTITUTE, INDIA

DETERMINATION OF TROPICAL SUMMER INDEX IN OFFICE BUILDINGS

In this digest the curves, to determine tropical summer index under varying climatic conditions, orientation, glass area, indoor wind speed, shaded fenestration area and usage conditions are given. The central corridor type of office building as shown in Fig. 1 for Roorkee climate has been considered for the present study.

Tropical Summer Index

The tropical summer index is defined as the equivalent sensation under the conditions of given air and globe temperature, 50 per cent relative humidity and wind speed. The range of thermal sensations are given in Table 1.

It is implied that for comfortable conditions indoors during working hours the TSI value should not exceed 30°C, optimum value being 27.5°C.

The general features of building under consideration are :

Walls : 23 cm brick with plaster on both sides.

Roof : 10 cm R.C.C. slab, 9 cm lime concrete over it.

Floor : 2.5 cm cement concrete+7.5 cm brick blast.

Windows : all on longer wall, 3 mm glass, glass area varying from 5 per cent of floor area.

Door : 2.5 cm teak wood.

Intermediate floor : 15 cm R.C.C. with floor finish.

Since the diurnal variations of outside air temperature are large both steady and periodic heat flow through these building elements have been accounted in the computation of tropical summer index.

The following standard conditions are taken :

(i) the ventilation rate is 2 air changes/hour.

(ii) indoor wind speed is 0 3 m/sec.

(iii) the surface area of office furniture is 18 m^2

(iv) the floor area of 6—8 m^2 per person is taken.

(v) only natural lighting is considered.

(vi) the glass area is assumed to be 15 per cent of floor area and is provided on longer walls.

(vii) the climatic conditions prevailing in the hottest period at Roorkee (lat 30°, long 78°) is taken as representative hot dry climate.

To study the effect of various parameters namely climatic, design and usage nearly 150 cases have been considered and data on TSI has been obtained.

Effect of Various Parameters

The orientation of a building in proper direction mitigates the solar heat input into the building. The TSI curves obtained for four cardinal orientations are shown in Fig. 2 for varying glass area. The values of TSI at other indoor wind velocities can be modified with the help of Table 2.

The range of TSI that would result, when the position of the room in building alters i.e., an end room, internal room in a single storey or in double storey building are given in Table 3.

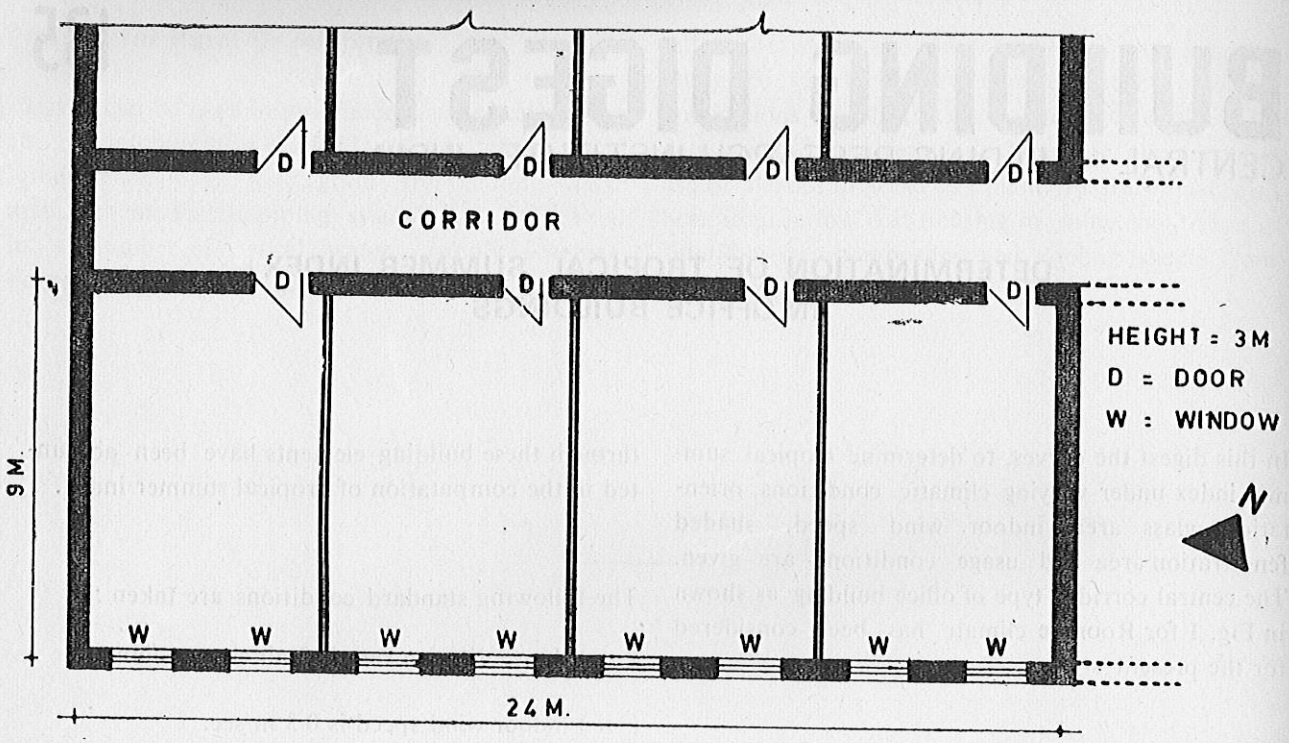

Fig. 1. Typical Plan of a Corridor Type Office Building.

Table—1

Thermal Sensation Ranges

Sl. No.	Thermal Sensation	TSI—Ranges °C	Remarks
1	Slightly cool	19°—25°	—
2	Comfortable	25°—30°	optimum at 27.5°C
3	Slightly warm	30°—34°	—

Table 2

Change in TSI due to Change in Internal Air Velocity

Indoor air velocity m/sec	0.0	0.3	0.5	0.75	1.00	2.00
Value to be added to TSI	+1.1	0.0	—0.34	—0.66	[illegible]4	—1.78

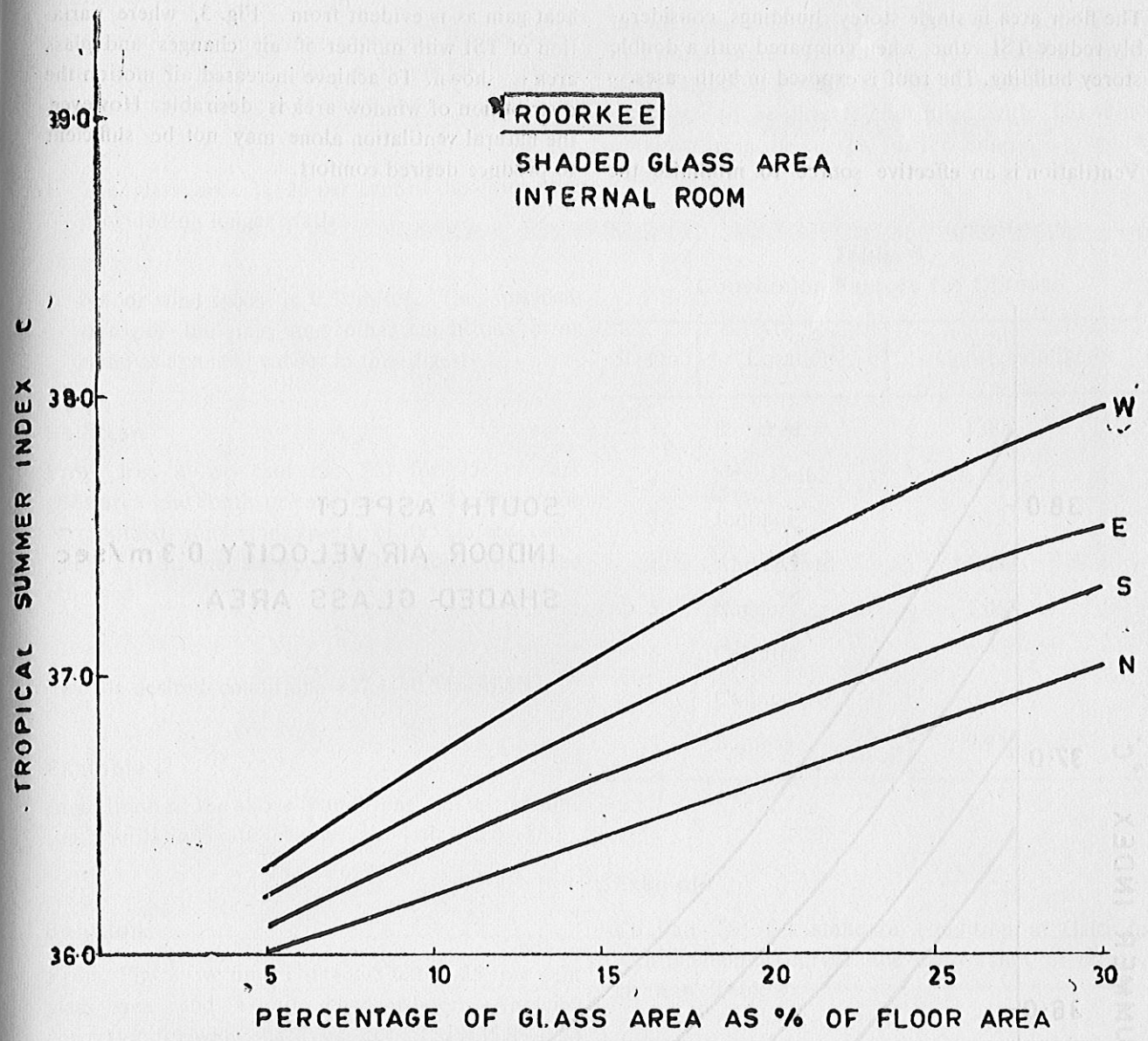

Fig. 2. Variation of TSI with Orientation and Glass Area as Percentage of Floor Area.

Table 3

The Range of TSI in Different Situations

Sl. No.	Orientation	Single Storey		Double storey
		Inner room	End room	Inner room
1	South	31.7—37.2	31.4—37.5	33.6—39.1
2	West	32.2—38.6	31.7—39.0	33.9—40.2
3	North	31.5—36.5	31.6—36.8	33.1—38.3
4	East	32.5—37.7	32.6—37.5	34.2—39.4

The floor area in single storey buildings considerably reduce TSI value, when compared with a double storey building. The roof is exposed in both cases.

Ventilation is an effective source to minimise the heat gain as is evident from Fig. 3, where variation of TSI with number of air changes and glass area is shown. To achieve increased air motion the distribution of window area is desirable. However, the natural ventilation alone may not be sufficient to produce desired comfort.

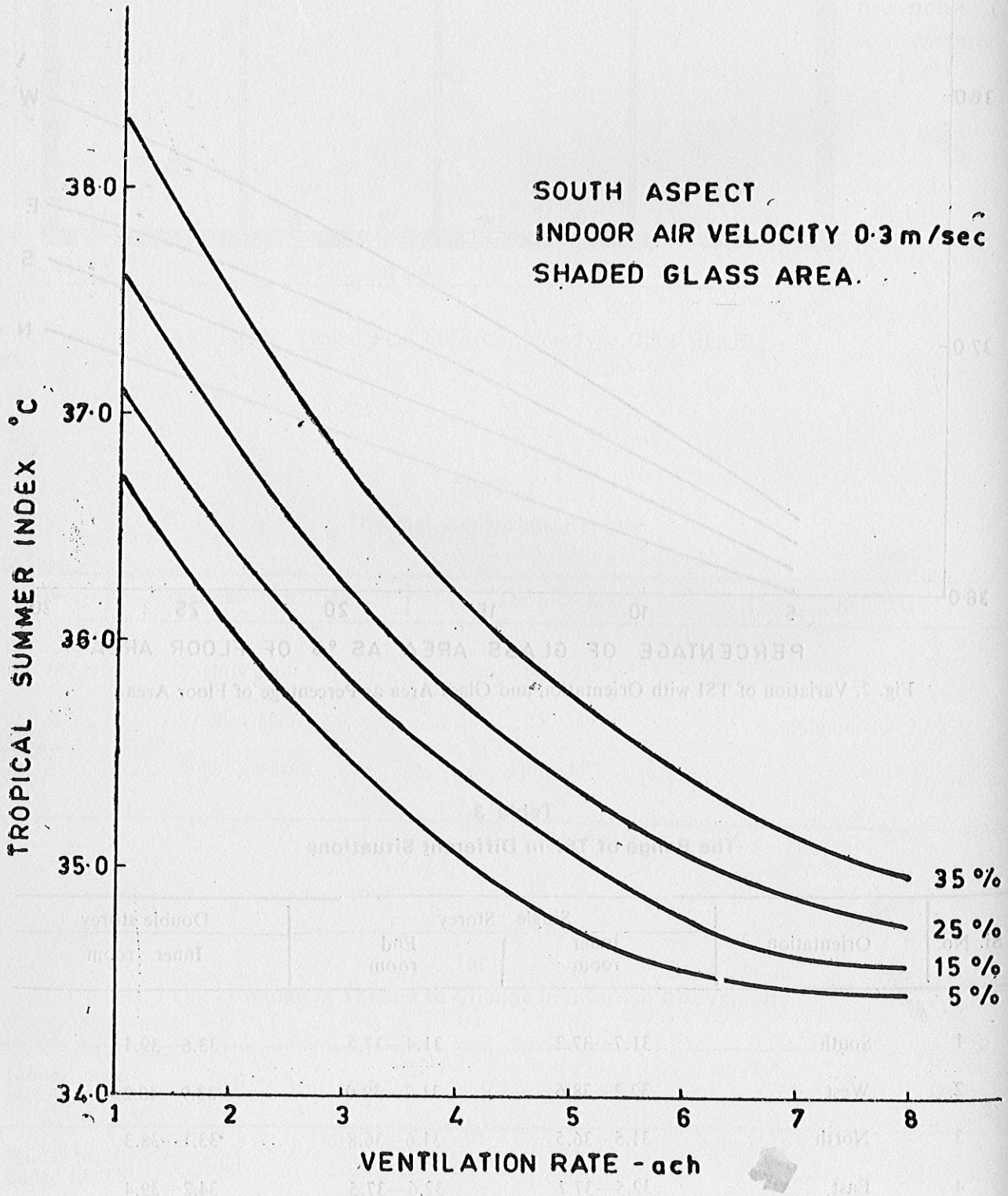

Fig. 3. Variation of TSI with Ventilation Rate and Glass Area.

Example 1

To find TSI for an inner room in a single storey building with the following conditions at Roorkee. The building is facing South direction.

1. The glass area is 25 per cent of the floor area provided on longer walls.

2. Indoor wind speed is 0.5 m/sec. The specifications of buildings and other conditions being same as assumed earlier in this digest.

Solution

From Fig. 2 we find the TSI for 25 per cent glass area and South orientation=37.1°C. This value is modified for wind speed of 0.5 m/sec using Table 2. So we subtract 0.34 from the value obtained.

TSI for desired conditions=37.1—0.34≃35.8°C.

Example 2

In addition to the above conditions let us assume the ventilation rate changes to 4 air changes/hr.

Solution

From Fig. 3 we find TSI=35.8°C for 25 per cent glass area and 4 air changes/hour. Applying correction for wind speed we get TSI=35.8—0.34 ≃35 5C°.

Example 3

In addition to the conditions in example 2 if it is an end roof of the building, find TSI.

Solution

Using Table 3 we get TSI=35.5+0.3=35.8°C.

From the above study it may be concluded that only natural means are not sufficient to bring down the TSI value within acceptable comfortable limits. The artificial means like fan, cooler and air conditioner may be employed to achieve the comfortable conditions. However, even without artificial means the TSI can be brought down to a minimum level by proper selection of parameters.

The data on TSI for fourteen major cities representing all types of climatic i.e., hot dry, hot humid, and warm humid was obtained for standard conditions mentioned earlier. The conversion factors which are to be directly multiplied with TSI value obtained from the curves, for few cities are given in Table 4.

Table 4
Conversion Factors for Climate

Sl. No.	Location	Conversion factor
1.	Roorkee	1.000
2.	New Delhi	1.066
3.	Jodhpur	1.122
4.	Ahmedabad	1.042
5.	Nagpur	1.062
6.	Calcutta	0.940
7.	Coimbatore	0.968
8.	Bombay	0.930

Example

To find TSI for standard condition at Calcutta with the help of curves and conversion of factors given in Table 4.

Solution

The TSI value for South orientation at Roorkee =36.65°C.

TSI value for same conditions at Calcutta =36.65×0.940
=34.45≃34.5°C.

Conclusions

The following conclusions can be drawn from the data obtained on TSI for various conditions:

(i) The building orientation has a significant influence on TSI. A building with longer wall having glass area facing South/North has lower TSI than the one facing East/West.

(ii) Building having greater glass area as percentage of floor area should be oriented towards the direction of minimum heat gain.

(iii) In corridor type offices four air changes per hour may be provided from thermal considerations.

(iv) In general the effect of various design parameters on TSI is same as that on indoor air temperature. The curves given in this digest shall be helpful in determination of TSI for various situations of climate, design and usage. However to obtain comfortable conditions natural means of reduction may not be sufficient and artificial means may be employed.

There is a demand for short notes summarising available information on selected building topics for the use of Engineers and Architects in India. To meet the need, this Institute is bringing out a series of Building Digests from time to time and the present one is the 135th in the series. Readers are requested to send to the Institute their experience of adopting the suggestions given in this Digest.

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