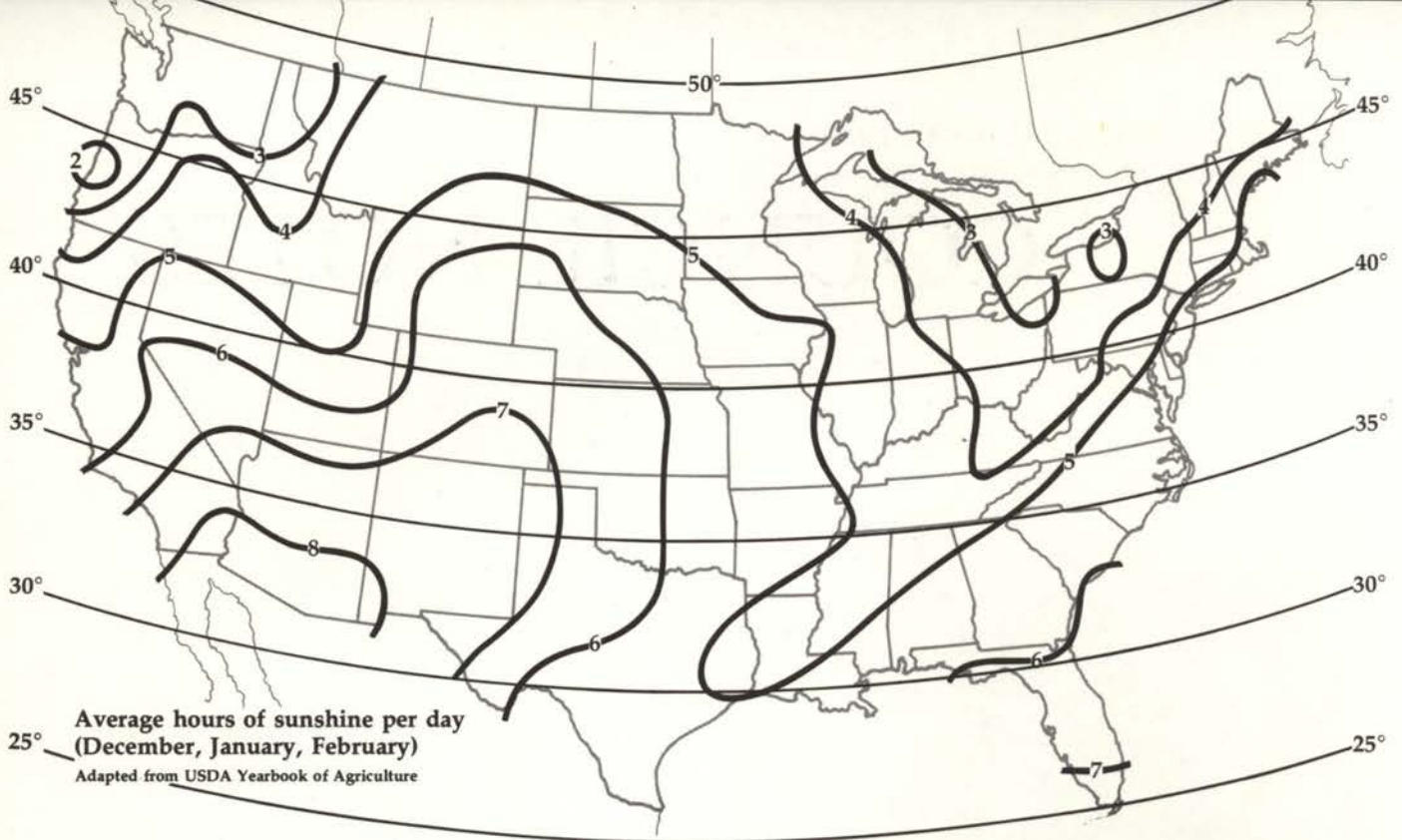


University of Illinois at Urbana-Champaign
Small Homes Council-Building Research Council

COUNCIL NOTES



C3.2 SOLAR ORIENTATION



The current energy crisis has again called attention to the energy-related benefits of solar orientation in house design. The Small Homes Council Circular C3.2, *Solar Orientation* (1946) is still viable, and it is reprinted on the following four pages. These principles contributed to the 1976 design of the *Illinois Lo-Cal House*, Council Notes C2.3.

Early Solar-Oriented Houses

Beginning in the 1930's, many houses were built using the principles of solar orientation. Since houses of that era were poorly insulated by today's standards, a solar house had high heat loss and needed large south windows to supply adequate solar heat. In some, the entire south wall was glass, which further increased heat loss and discomfort. During sunny hours, the large south windows provided ample solar heat, even overheating on many days. On cloudy days and at night, the heat loss was high through the large glass area as well as the walls and ceiling.

In many solar houses the type of heating system used was slow to respond to the wide variation in heat demand, and it was difficult to maintain comfort conditions.

Illinois Lo-Cal House

The Illinois Lo-Cal House corrects the deficiencies of the early solar houses as follows:

Super-Insulation. Super-insulation (triple glazing, R-40 ceiling, R-33 wall, and R-20 floor insulation) greatly reduces the heat needed from solar gain and from the heating system.

Optimum South Window Area. For each locality, the optimum window area is based upon the design heat loss of the house, average outdoor temperature, altitude, and the average number of hours of winter sunshine. In most climates, south-facing triple-glazed windows add more heat to the house from the sunlight they admit than the heat lost to the cold outdoor air through the glass.

South windows should be large enough to gain adequate solar energy during typical winter conditions, but not so large as to frequently overheat the house. Occasional overheating is an opportunity to "air out" the house. When larger than optimum, the south windows contribute little more usable solar gain for winter heating but significantly increase house cooling loads during the warmer months, even though the glass is properly shaded. For a super-insulated house, the optimum south glass area may be only 8% of the total floor area.

Heating System. The recommended heating systems respond quickly to sudden changes in heat demand. Panel heating systems, such as heated floor slabs or ceiling panels, are not used.

Winter Sunshine

The solar design of a house will vary with the climate and location. The map shows the average hours of sunshine per day during the months of December, January, and February. Much of the heavily populated northeast and midwest averages four to five hours per day, or a solar gain of about 800-1000Btu/sq. ft. per day on south glass.

SOLAR ORIENTATION

In Home Design

CIRCULAR SERIES

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Planning for the Lot

House in Cary, Illinois; George Fred Keck, Architect

ISSUED BY THE SMALL HOMES COUNCIL

UNIVERSITY OF ILLINOIS BULLETIN

VOLUME 42, NUMBER 25, FEBRUARY 6, 1945. Published weekly by the University of Illinois. Entered as second-class matter at the post office at Urbana, Illinois, under the Act of August 24, 1912. Office of Publication, 358 Administration Building, Urbana, Illinois. Acceptance for mailing at the special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized July 31, 1918.

Material in This Circular Prepared by W. H. SCHEICK, D. B. LINDSAY

For copies of this Circular (C3.2) or additional information address
Small Homes Council, Mumford House, University of Illinois, Urbana



CIRCULAR SERIES
SMALL HOMES COUNCIL

C3.2

AN INTRODUCTION TO SOLAR ORIENTATION

can be no more than a discussion of the physical principles underlying the subject. A few "solar houses" have been built, with apparently satisfactory results. The University of Illinois has not as yet investigated heating problems in houses of this type. Several points should be noted:

A. Solar orientation may be applied to any kind of architectural design, but is best achieved in non-traditional types which permit the use of large glass areas, or groups of windows.

B. "Glass areas" may be achieved, at varying costs, with ordinary windows, plate glass, or structural glass. Improvements in the manufacture of glass offer many possibilities of design.

C. A "solar house" is not a "glass house," but is one in which glass areas are carefully placed, and protected from summer sun and winter storms.

D. The professional advice of an architect is desirable in planning for solar orientation. An unskilled planner can make serious mistakes by using large glass areas in a manner which results in excessive heat loss, glare, or lack of privacy.

1. WHAT IS SOLAR ORIENTATION IN HOME DESIGN?

"ORIENTATION" means the placement of the house on the site with respect to compass directions, so that its various rooms are correctly related to sun position, wind direction, views, or other desirable surroundings.

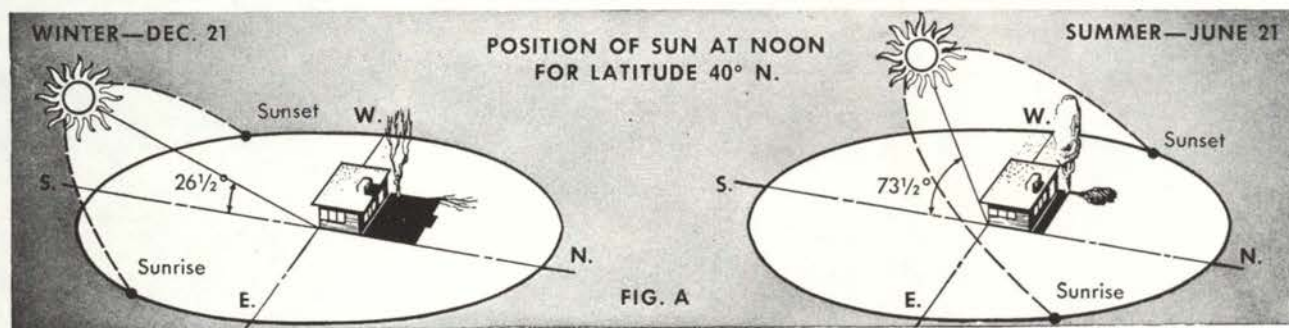
"SOLAR ORIENTATION" means facing as many rooms as possible to the south, in order to obtain the benefits of sunlight. This requires a knowledge of the angles of sunlight at different times of the day and at different seasons.

2. WHAT ARE THE BENEFITS OF SOLAR ORIENTATION?

A. Additional warmth — The radiant heat (infra-red rays) of the sun enters the house through the glass, supplementing mechanical heat during the daylight hours. (*Whether or not this sun heat results in a net gain for the house depends upon many factors of construction beyond the scope of this circular.*)

B. Daylight — Increased daylight is provided in living quarters. Southern exposure also provides better summer ventilation in most parts of the United States.

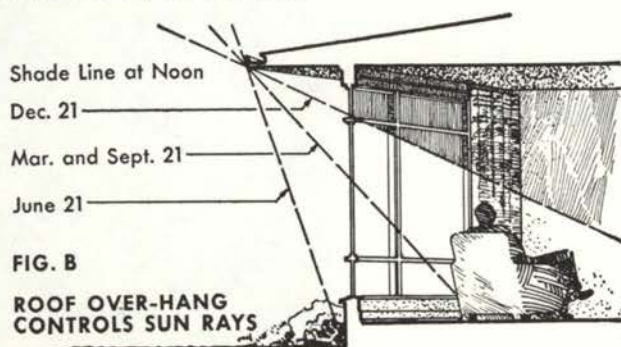
C. Enjoyment of living — For many persons extra winter sunlight and broader views of the outdoors are important advantages. Large window areas help to create a feeling of spaciousness.



3. SOLAR MECHANICS

Successful use of solar orientation depends upon knowledge of the changing position of the sun throughout the year. Everyone knows that the sun is much higher in the sky in summer than in winter; that it rises and sets north of the east-west line in summer, and south of the same line in winter.

This variation in the sun's position in our sky occurs because, as the earth follows its orbit, the tilt of the earth's axis places us in a changing relationship to the sun.



The position of the sun and the angle of sunlight can be determined accurately for any hour of the day at any time of year in any latitude. Fig. A shows the conditions which obtain on the longest and shortest days of the year. *Generally speaking*, it can be said that the angle of the sun above the horizon at noon is about 30° in winter and 60° in summer for latitudes near 40° N.

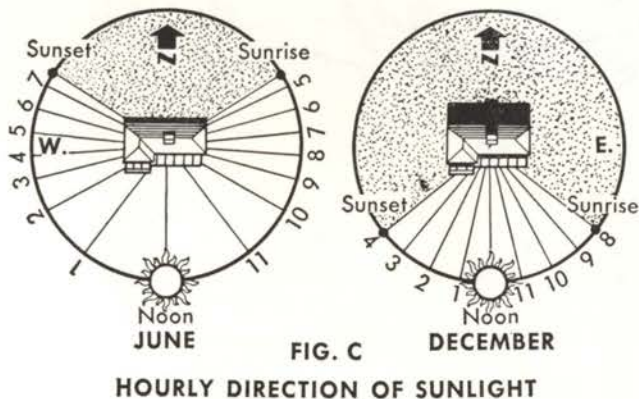
4. CONTROL OF SUNLIGHT

Additional warmth from the sun is desirable in winter, but objectionable in summer. Therefore, solar orientation must *control* the amount of sunlight falling upon glass areas.

Fortunately the laws of solar mechanics make this possible if major glass areas face *south*. An overhang, cornice or projecting eaves can be provided over south windows, casting a shadow on the glass in summer, but allowing the sun to enter in winter (Fig. B). The awning is a familiar form of summer sun control.

Control of sunlight in the spring and fall is relatively unimportant because the weather is more temperate.

5. CAN ORIENTATION CONTROL SUNLIGHT ON EAST OR WEST WINDOWS?



The answer is "no."*

In winter the sun rises late in the southeast and sets early in the southwest (Fig. C). Hence, very little sunlight enters east or west windows and they are useless for solar orientation.

In summer the sun rises early in the northeast and sets late in the northwest. A very large amount of sunlight falls upon east and west walls. It cannot be controlled by overhangs; when rising or setting, the sun is low, and its rays enter directly into east or west windows with much unwanted heat. This can be very uncomfortable on a late summer afternoon.

*Venetian blinds, or deciduous trees which will shade east or west windows, are reasonably successful.

6. IS THERE ENOUGH WINTER SUN TO JUSTIFY SOLAR ORIENTATION?

There is more sunshine during the winter months than most people realize. Government weather records over 39 years disclose that for the months of December, January, and February in Chicago, the number of sunshine hours is 53.6 per cent of the total number of hours possible.

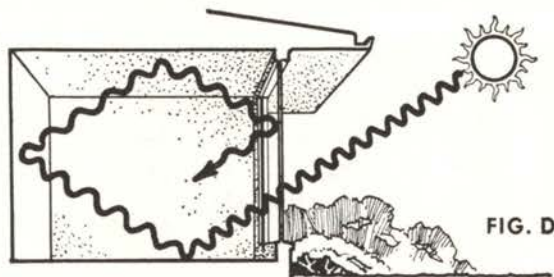
Solar heat is available in winter months even though the sun is not shining. Assuming the solar radiation on a clear day to be 100%, a hazy day will allow 60% to 80%, and a dull day 5% to 50%.

The earth is nearest the sun in December and January. There is also less water vapor in the air during the winter season. For these reasons, in the northern hemisphere about 16 per cent more radiant heat is received (on a surface perpendicular to the sun's rays) in winter than in summer.

7. HOW DOES SOLAR RADIATION WORK?

The sun's infra-red rays pass through the glass on a short wave length (Fig. D). The rays strike and warm the objects within the room and are then re-radiated on a longer wave length which will not pass out through the glass.

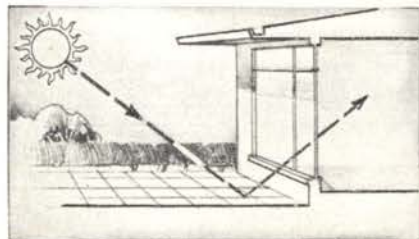
All large glass areas must be of *more than single pane in thickness*. If they are not, any gains in heat from sunlight will be offset by excessive loss of heat through the glass, particularly at night.



8. DO LARGE GLASS AREAS PRODUCE GLARE?

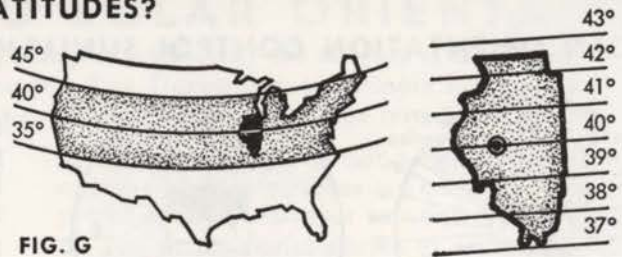
Glare is produced by contrasts of intense light and dark. It is likely to occur in a room with small glass areas because the bright surface of the window is in sharp contrast to the darker walls surrounding it (Fig. E). As the window area is increased, the level of illumination within the room is raised until contrasts are slight, and the effect of glare disappears (see photograph below). Exterior objects or surfaces such as white paving, which produce glare in the field of vision, should be avoided (Fig. F).

House in Chicago; William Deknatel, Architect



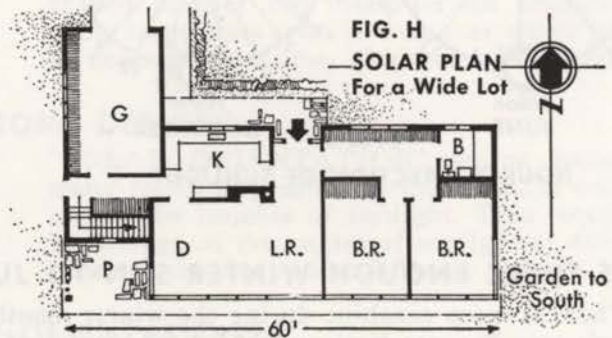
9. DO SUN ANGLES VARY IN DIFFERENT LATITUDES?

The angle of the sun's rays at any given hour or date varies with the latitude. It can be accurately determined for any locality. However, such computations are technical and too lengthy for discussion here. The diagrams in this circular are true for latitude 40° N. and nearly true over a band of about 5° on either side. Fig. G indicates that this band includes many of the most populous areas in this country.



10. HOW DOES SOLAR ORIENTATION AFFECT THE HOUSE PLAN?

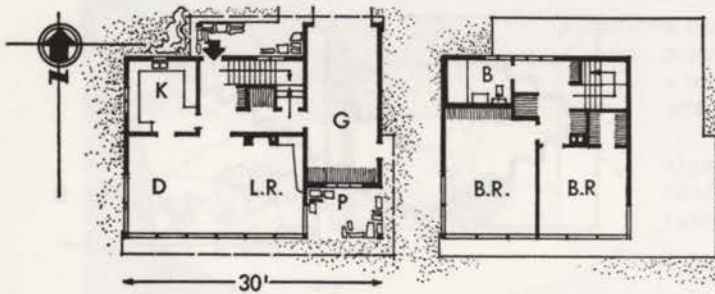
When planning the house for solar orientation, as much of the "living area" as is possible (living-dining rooms, bedrooms, etc.) should be given direct southern exposure (Fig. H). The northern side of the house forms a buffer against winter winds, and should contain service areas, halls, stairs, baths, garage, etc. Choice of exposure for the kitchen will vary with different homemakers.



11. WHAT IS THE EFFECT OF LOT SIZE AND DIRECTION?

Obviously, the completely "solar" plan can be achieved only on a wide lot (75' to 100'). New principles of community planning recognize this fact, and it is probable that many neighborhoods of the future will be subdivided into lots which can accommodate "solar" houses.

The basic principles, however, can be employed on any lot quite successfully. On a fifty-foot lot, for example, the living-dining area and at least one bedroom of a one-story house can face the sun. For narrow lots a two-story plan can achieve excellent solar orientation (Fig. I).



TWO STORY PLAN—Good Sunlight on Narrow Lot

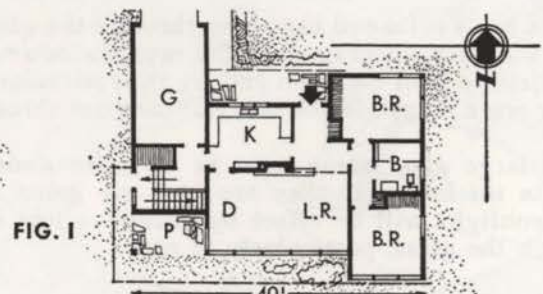


FIG. I

ONE STORY PLAN—On Normal Lot

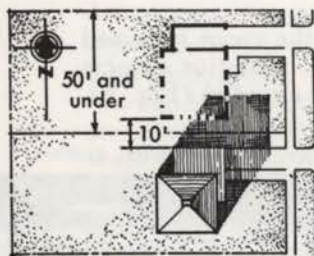
The importance of planning for maximum solar exposure must be weighed against other considerations which affect the house plan, and individual tastes must be satisfied. The diagrams at each side show situations common to most lots available in urban communities today, where houses usually are built on both sides of east-west and north-south streets.

It is apparent that large glass areas facing south on a narrow side yard would provide an unattractive or limited view, and might even be shaded by the adjoining house.

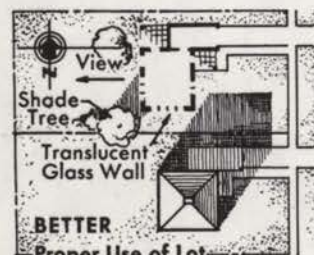
Large windows facing gardens to the east or west should be shaded from the rising or setting sun by trees, awnings, or blinds.

It is evident that a house which faces south toward the street would be a "goldfish bowl" if full-height clear glass were used on the front. A wise use of window sizes and sill heights will insure sunlight without this inconvenience.

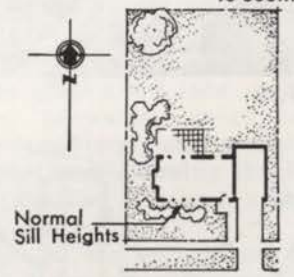
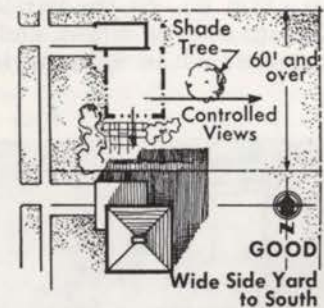
The only situation truly adaptable to the use of full-height clear glass is where the garden is south of the house. Here the occupant is assured of privacy; he can control the sunlight and develop the view of his garden.



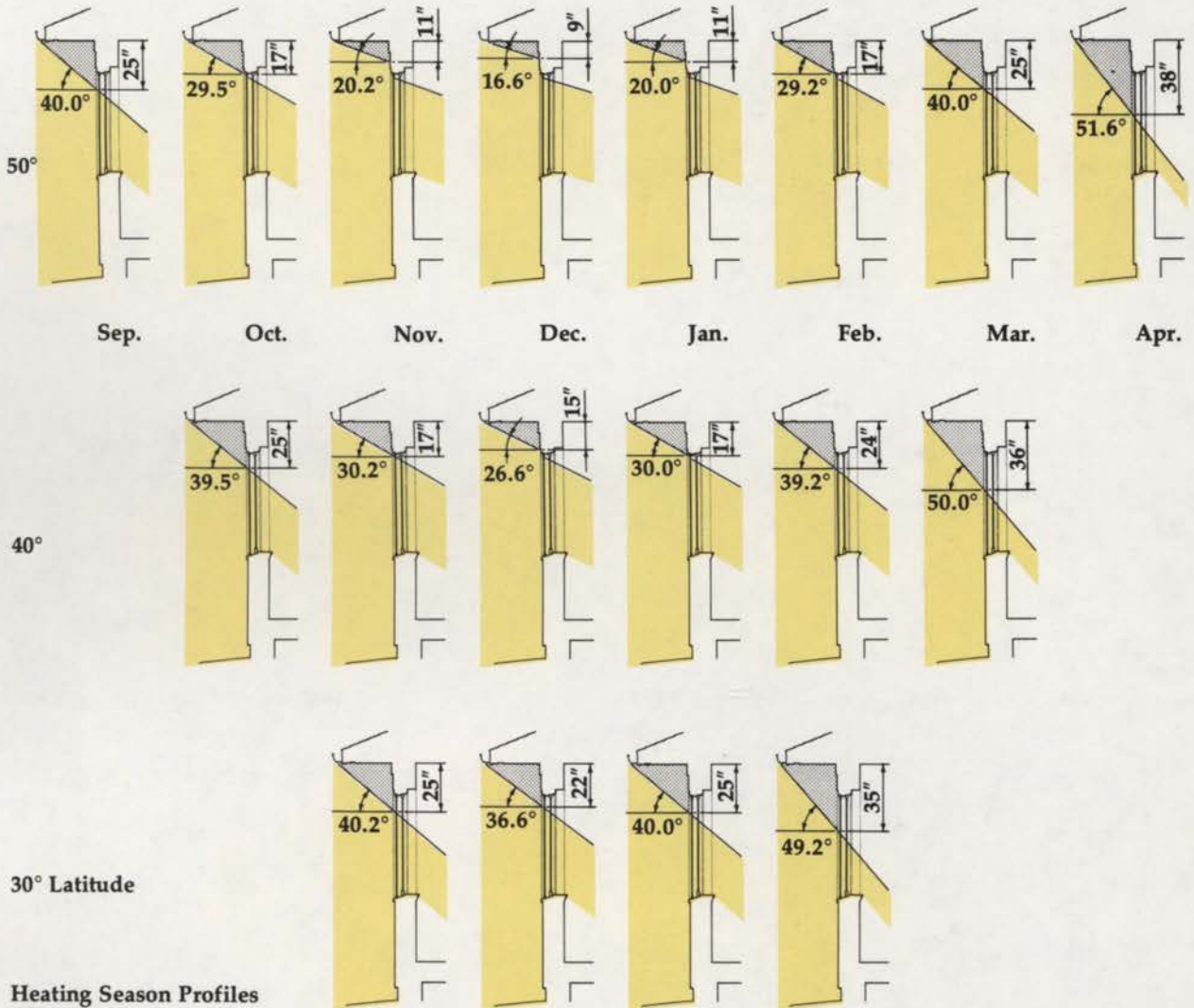
BAD
Narrow Side Yard to South



BETTER
Proper Use of Lot Facing East or West



Normal Sill Heights
Street to South



Heating Season Profiles

Climate Variation

At any given latitude, the length and severity of the heating or cooling season varies. For example, heating degree-day totals are usually higher in mountain areas and lower near large bodies of water. Even nearby cities may show a marked difference in degree-day totals.

Roof Overhang for South Windows

Ideally, the roof overhang over the south windows allows sunlight to enter the entire window during most of the heating season and shades the entire window during the cooling season. In a region with 5000 degree-days, the windows should be totally exposed during November, December, January, and February.

With a horizontal extension of 30", including gutter, located 16" above the top of the window, the 30/16 overhang usually provides the desired sun exposure for common windows.

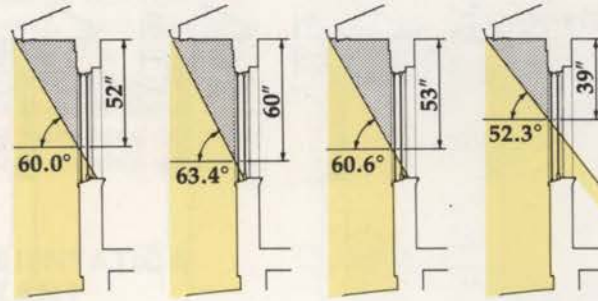
The south wall profiles for latitudes of 50°, 40°, and 30° are shown for the 21st day of each month of the normal heating and cooling seasons for that latitude. Interpolations can be made for solar angles on other days. Note that the window height shown is 50" from sill to head. Full-height windows or sliding glass doors will permit more solar radiation to enter than is shown by these profiles.

South Wall Profile – Heating Season

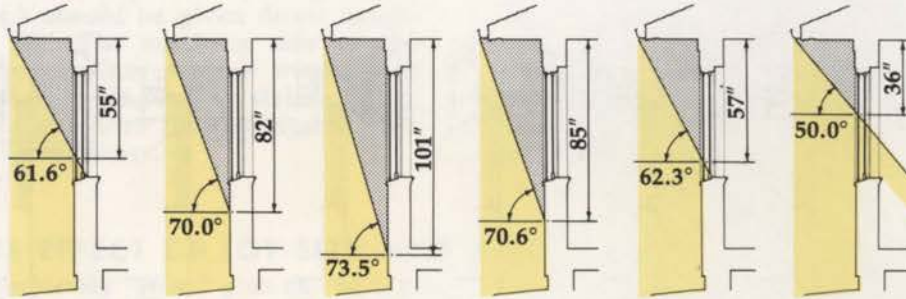
In general, the heating season is longer at 50° latitude than for areas further south. For example, in late summer (September 21) and early spring (April 21), when some heating demand may exist at 50° latitude, the window is more than half exposed to solar radiation. From September 21 to March 21, the window is exposed to the sun over 80 to 100% of its area. The 30/16 roof overhang provides about four more months of sun effect at 50° latitude than for 30° latitude.

Cooling Season Profiles

50° Latitude

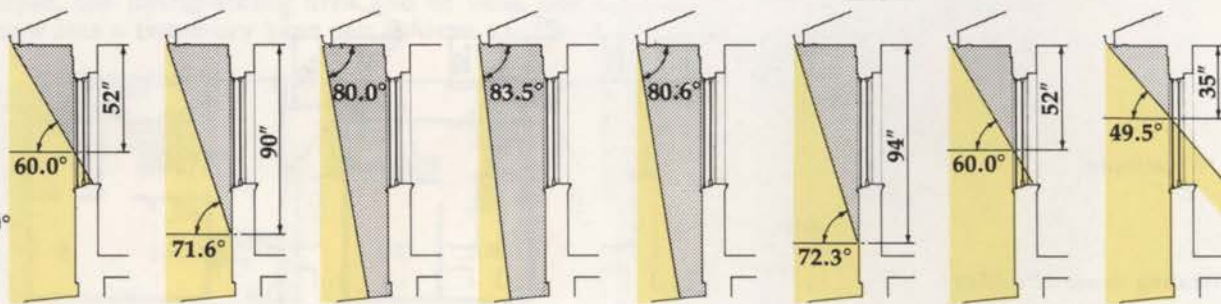


40°



Mar. Apr. May Jun. Jul. Aug. Sep. Oct.

30°



South Wall Profile – Cooling Season

The cooling season at 50° latitude is generally shorter than for more southerly regions.

For 40° latitude, the window is almost totally shaded from April 21 to August 21, and on September 21 the window is about 50% shaded. Solar radiation can enter the room through the lower part of the window after August 21. In years when cool weather arrives early, the solar energy entering the windows may be welcome. However, if the cooling season is prolonged, some means to exclude the sun might be considered. If more sun shading is desired for this time of the year, shade screens on the outside or venetian blinds on the inside can be used. Deciduous trees provide the best sun control and should be planted as soon as possible.

Standardized Overhang

The wall profiles are drawn to scale so that slight modifications of overhang, or window or glass

heights, can be made by altering the dimensions on the drawings.

A study of the weather conditions and the sun angles at various locations between 30° and 50° latitude indicates that a standard 30/16 overhang will provide good sun control on south windows for this range of latitudes. With the bottom of the roof overhang at the same level as the ceiling, the gutter is about 16" above the window. This construction allows more winter sunlight into the house and permits thick ceiling insulation to extend over the outside wall. When glass doors or tall windows are used, it may be desirable to increase the overhang to provide more shade.

COUNCIL NOTES Volume 2 Number 2 Fall, 1977

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Material in this publication by:

Seichi Konzo and Wayne L. Shick, SHC-BRC

Illustrations: Joan R. Zagorski and John B. Sadowski Editor: Henry R. Spies
Published quarterly by the Small Homes Council-Building Research Council, University of Illinois at Urbana-Champaign, One East Saint Mary's Road, Champaign, Illinois 61820. 25c per copy.