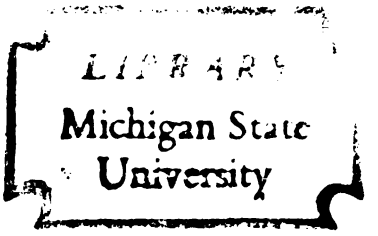
THESIS



This is to certify that the

thesis entitled

RESIDENTIAL THERMAL PERFORMANCE AND

THE MICHIGAN ENERGY CODE

presented by

Thomas W. Philp

has been accepted towards fulfillment
of the requirements for

M.S. degree in Building Construction

William B. Boyd

Major professor

Date May 15, 1980

O-7639

RESIDENTIAL THERMAL PERFORMANCE AND THE MICHIGAN ENERGY CODE

By

Thomas William Philp

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Building Construction Program

1980

ABSTRACT

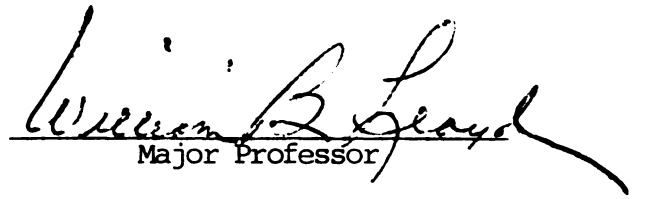
RESIDENTIAL THERMAL PERFORMANCE AND
THE MICHIGAN ENERGY CODE

By

Thomas William Philp

This program is an attempt to simplify the calculations required in determining the compliance of a one or two family dwelling with the Michigan Energy Code (or any energy code based on ASHRAE Standard 90-75).

Because of the large amount of effort required to translate building blueprints and specifications into machine-usable format and while the actual calculations consume only a small portion of this effort, a computer program will only be useful if these translating tasks are formalized into routines, simplified and appropriate forms are designed to simplify the architect/programmer interface. This entire problem could be approached using a digitizer and some sophisticated software, but this would be an expensive alternative, feasible only to a business or governmental body doing computer models on a large scale.

Approved 
Major Professor

Approved 
Department Chairman

ACKNOWLEDGEMENTS

Special thanks to Peter, Pat and Bill, Sal and Bus, Lori and Mush. Without their guidance and inspiration, this damn thing would have never been produced.

More thanks to Vicki, Sully, J. B. and P. B. for all their understanding.

TABLE OF CONTENTS

I. INTRODUCTION

This project consists of two major components. The first is a computer program which performs the calculations required in determining the compliance of a one or two family structure with the Michigan Energy Code, which is hereafter referred to as the Code. Secondly, a form or worksheet has been designed to simplify a builder's efforts in translating information from blueprints into machine-usable data.

II. PROGRAM EXPLANATION

The computer program component of this project is written in FORTRAN IV and is included as Appendix B. The objective of the program is to calculate the overall heat loss of the thermal envelope and determine if the structure complies with the Code. Discounting the preliminary information, this is the first data to appear on the computer printout.

This program also calculates and prints the total heat envelope thermal transmittance, the percent fenestration and maximum recommended fenestration. Thermal transmittance of all wall components, combined gross ceilings and floors over unheated spaces are all calculated and printed. The program also calculates and prints whether these assemblies and any slab floors are in compliance with the Code's requirements for those specific areas.

This program was written with no sacrifice of accuracy in regard to brevity. The long-hand method of determining a structure's compliance with the Code involves considerably less detail than that included in the program.

III. FORM EXPLANATION

The form component of this project serves to organize the builder's analysis of the heat loss characteristics of residential structures and is included as Appendix A. The numerical data necessary for heat loss calculations is initially scattered throughout the architectural drawings, and comprehensive heat loss calculations would be a formidable problem without an organized approach. A computer program has been written to do the actual calculations, but data must first be obtained from the building drawings and transferred into some computer-usable format. A form has been designed to expedite the blueprint/computer interface. The form is designed to be a self-explanatory worksheet with many graphic aids. The form also organizes the data in such a way that a keypunch operator can use the completed form as a guide to creating a deck of keypunched data cards which the computer can read.

IV. USER QUALIFICATIONS

The form was written for the person knowledgeable in residential construction terminology and the Code. It was not designed to be used by person's unfamiliar with residential construction. A thorough understanding of residential detailing and components is essential. The person using the form must also have access to and be familiar with tables containing design values of various building and insulating materials.

Values from these tables are associated with various components of a structure and specify their resistance to heat flow. These values are added for a composite section of a structure, for example a wall assembly, and then written in the form in the designated space.

The tables of design values may be found in the ASHRAE Handbook of Fundamentals, The Michigan Energy Code booklet and many other publications popularizing energy conservation.

V. NOTES ON THE WORKSHEET

The spaces for the owner's name, site address, contractor, contractor's phone number, and date, are included so that this information will appear on the computer printout. One minor problem that may arise here is the inadvertent use by the user of symbols that are not on the keypunch machine. If illegal characters are used in these spaces, the keypunch operator should substitute appropriate legal symbols. Recognized legal symbols are not listed here because of possible differences between machines.

Notice the "programming note" on the first page of the form. The numberic data entered in the "degree days" space must have a decimal point. The reason for this is that the computer will be manipulating this data, and the program is slightly simpler if the decimal point is entered here. R values and areas which are entered later in the form must also have decimal points.

Continuing through the form, the next portion deals with the roof component. Anyone using this form should recognize what is referred to as a cathedral type roof. This is a roof/ceiling assembly in which the finished interior surface exposed to a heated space is essentially the underside of the roof deck. If the building under consideration has any roof/ceiling area of the cathedral type, enter a "2" (two) in the space provided on data line 5 of the form and complete page two of the form. If the building does not have any cathedral roof

components, leave data line 5 blank. For proper operation of the program, the keypunch operator should enter a blank card into the data deck if data line 5 is blank. If this is inconvenient, a card with any single entry except "2" (two) can be entered.

On page two of the form, a diagram illustrates a typical cross-section of a cathedral roof. Using this as a guide, enter the R values of each element of the assembly into the spaces provided on the data line beneath the illustration. The five spaces for R values are labeled "roofing", "insulation", "wood plank", and "other". These labels are not important to the program, and R values can be entered into any of the spaces without regard to the label. Do not enter R values for the interior and exterior air surfaces, as the program contains this information. Each R value entered must have a decimal point.

If the assembly contains more elements than the five provided for in the form, add two or more R values together and enter the sum in one R value space on the form. Do not use more than one data line for any one cross-section.

Calculate the gross area of each type of cathedral roof in the structure under consideration. This must have units of square feet. A conversion table is provided for converting inches to decimal feet. Enter the gross area into the indicated space on the form. Be sure to include a decimal point.

If there is more than one type of cathedral roof/ceiling assembly in the structure under consideration, each type should be treated spearately with its own data line and area calculation. To inform the computer that more than one cathedral roof data line is being used,

the "status flag" was created. If there is more than one cathedral roof data line, enter a "6" (six) in the status flag position on each data line except the last one.

The status flag concept is used through the remainder of the form. Each different type of building envelope component will have a unique status flag.

Pages three through five of the form are self-explanatory to a person familiar with residential design and construction. The previous comments all apply here as well. Note that the cross-section through the framing and the cross-section through the cavity of the open-ceiling component are treated separately. This approach is followed throughout the form and results in high accuracy.

Pages eight and nine of the form deal with the windows and entry doors of the structure. Page eight contains an area to sketch the cross-section of each different window. The thermal transmittance (U) of each window assembly is calculated using methods familiar to a person skilled in residential design. These methods are not detailed here but may be found in many sources, for example, the ASHRAE Handbook of Fundamentals. This calculation is made for the path of maximum thermal transmittance through the window.

Estimate the percentage of the total window area that is sash for each window. If the percentage area of sash for any window is 20% or greater, an adjustment of the U value is made according to methods detailed in the ASHRAE Handbook of Fundamentals.

Enter the number of similar windows, the U value, and the dimensions of the window in the appropriate spaces in the form. All of

these entries must have a decimal point, and the dimensions must be in decimal feet.

If the U value of a window is known, the data may be entered directly into the form and the calculations omitted. The number of similar window units and their dimensions is still necessary, however.

Although the form does not explicitly state this, a similar procedure should be followed for each entry door in the heat envelope.

The remainder of the form should not present any appreciable difficulty to the user. There are a few additional guidelines that the keypunch operator should observe. These guidelines are included as page eighteen of the form. The program can handle an unlimited number of houses.

VI. RECOMMENDATIONS

Limitations of this program can be traced to flaws in the design of the Code. The scope of the Code does not permit inclusion of the overall heat gain and heat loss of a structure. The program could have easily been written to include these calculations despite involving complex microclimatic data and other complicated parameters.

Space and window orientation, thermal shutters and interior mass are all significant factors when energy requirements of a structure are analyzed. These factors are ignored by the Code but could be easily accomodated into the program.

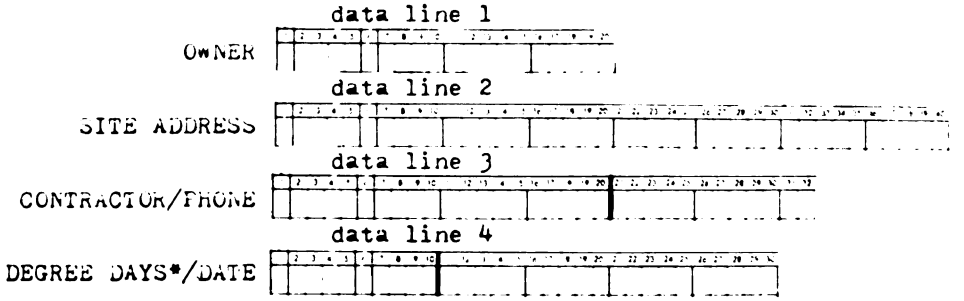
This program may become obsolete within several years. The Michigan Energy Code will eventually be replaced by a federal standard, Building Energy Performance Standards (BEPS), despite lobbying efforts by the National Association of Home Builders who seek to delay its implementation. These proposed federal standards will take the total energy consumption of a structure into consideration. After BEPS is implemented, I will probably become involved with devising a simplified worksheet and computer program that will assist builders in determining the compliance of their structures with BEPS.

APPENDICES

APPENDIX A

MICHIGAN ENERGY CODE

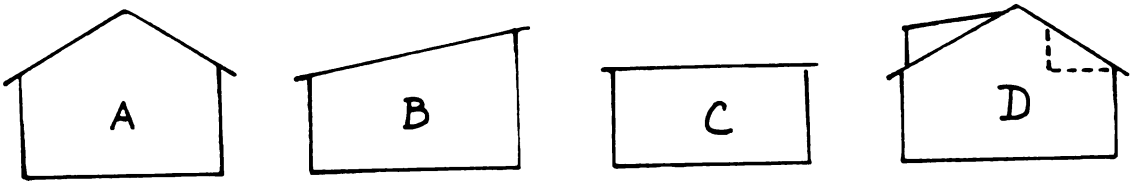
PRELIMINARY DATA



*Programming note: Degree Days is in floating point format. A decimal point must be included.

ROOF COMPONENT

Referring to the building blueprints, is any part of the structure a CATHEDRAL ROOF? YES NO (A roof/ceiling assembly in which the finished interior surface exposed to a heated space is essentially the underside of the roof deck. See sketches below.)



Note on sketch C: If there is an air gap of two inches or more between the bottom of the roof deck and the insulation, this is not a cathedral roof but an open-ceiling type.

Note on sketch D: Where a combination of roof/ceiling types exists, the cathedral area is treated separately from the open-ceiling.

If the answer circled above is YES, place a two (2) in the box below and complete the following section pertaining to cathedral roof.

If the answer above is NO, leave the box blank and skip the section on cathedral roof.*

*Programming note: Don't forget to insert a blank card in the data deck in this case.

CATHEDRAL ROOF [ ] data line 5

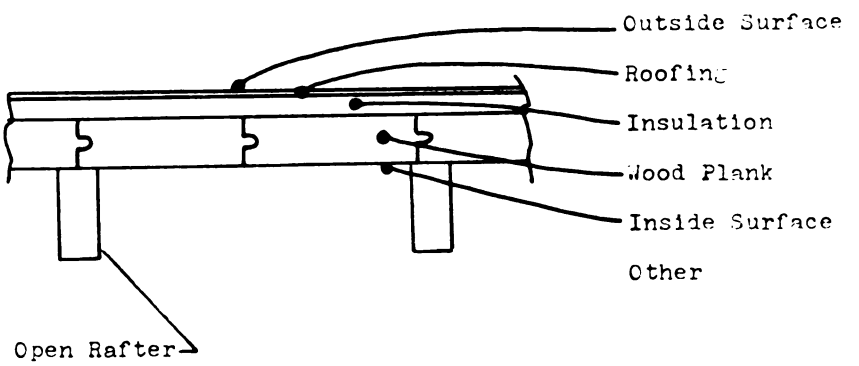
CATHEDRAL ROOF COMPONENT

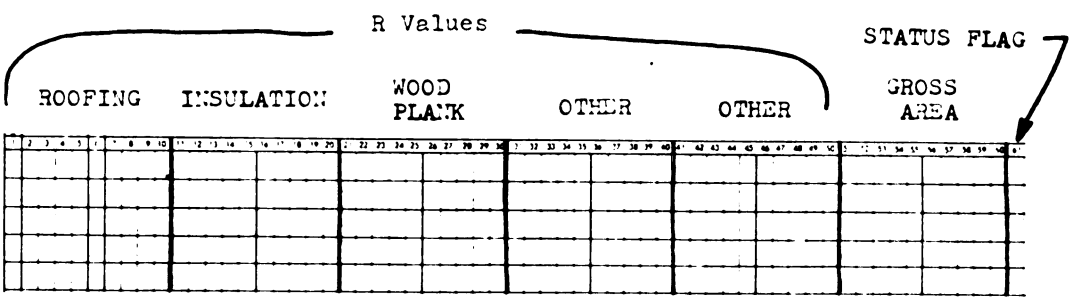
Referring to the cross-sectional diagram below, enter the R value of each element of the assembly into the positions indicated. Decimal points must be used in each entry.

Do not enter R values for inside and outside air surfaces. Framing does not have to be estimated for the cathedral roof.

Leave the spaces labeled "OTHER" blank if they are not needed.

If there are more than one area of cathedral roof in the structure, use a separate line for each area.





Calculate the GROSS AREA of each cathedral roof/ceiling area, and enter it (in square feet) in the same line with the R values for that area. The GROSS AREA is the inside surface area of cathedral roof/ceiling over heated space.

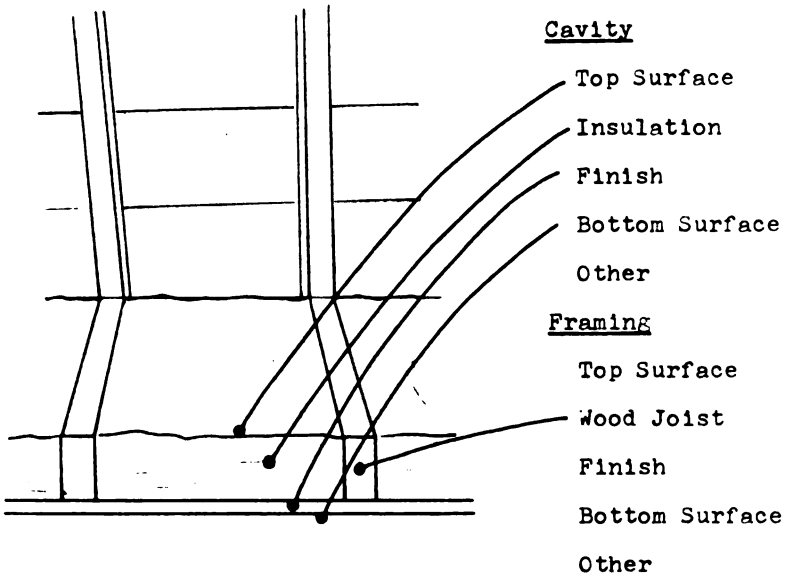
The last position in the data line is a status flag to indicate that another cathedral data line follows. If there are more than one data line, enter a 6 (six) in this position on each line except the last one.

OPEN-CEILING COMPONENT

Also includes roof/ceiling types with two inches or more air space between insulation and roof deck.

Care must be taken when analyzing structures with dormers, heated attics, and other complications to properly identify elements of the heat envelope as to cathedral roof, open-ceiling, wall, etc., because code thermal transmittance requirements are different for each.

Referring to the cross-sectional diagram below, enter the R value of each element of the assembly into the positions indicated. Decimal points must be used in each entry. Do not enter R values for inside and outside air surfaces.



Instructions for entering data:

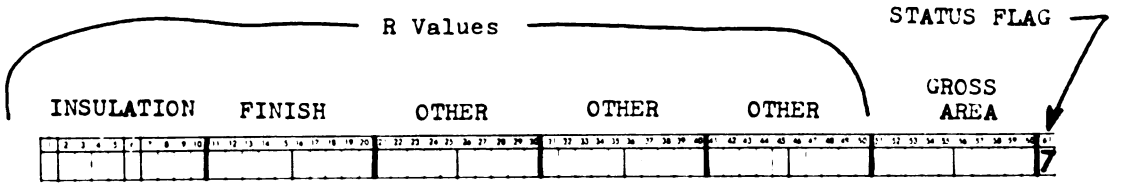
Enter R values of the CAVITY assembly components into the indicated spaces.

Compute GROSS AREA of this open-ceiling area (including framing), and enter it (in square feet, using decimal point) in the proper space. The GROSS AREA is the inside surface area of open-ceiling over heated space.

OPEN-CEILING COMPONENT (continued)

Programming note: A 7 (seven) is entered in the last space to indicate that a FRAMING data line will follow.

Cavity data line



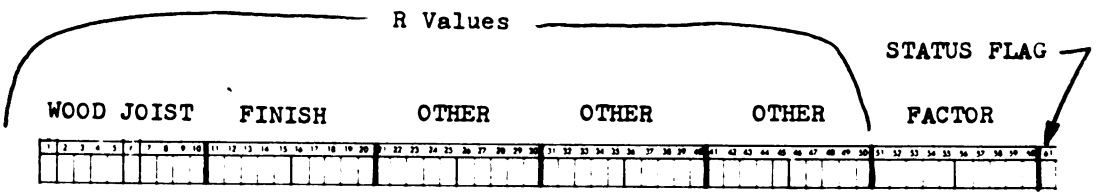
Enter R values of the FRAME assembly components into the indicated spaces.

To find the framing area factor, divide the center-to-center distance between joists (in inches) into 1.5 (one and one-half). Enter this number into the FACTOR position.

For example:

FACTOR	16" c/c	1.5 ÷ 16 = 0.09375
	24" c/c	1.5 ÷ 24 = 0.0625

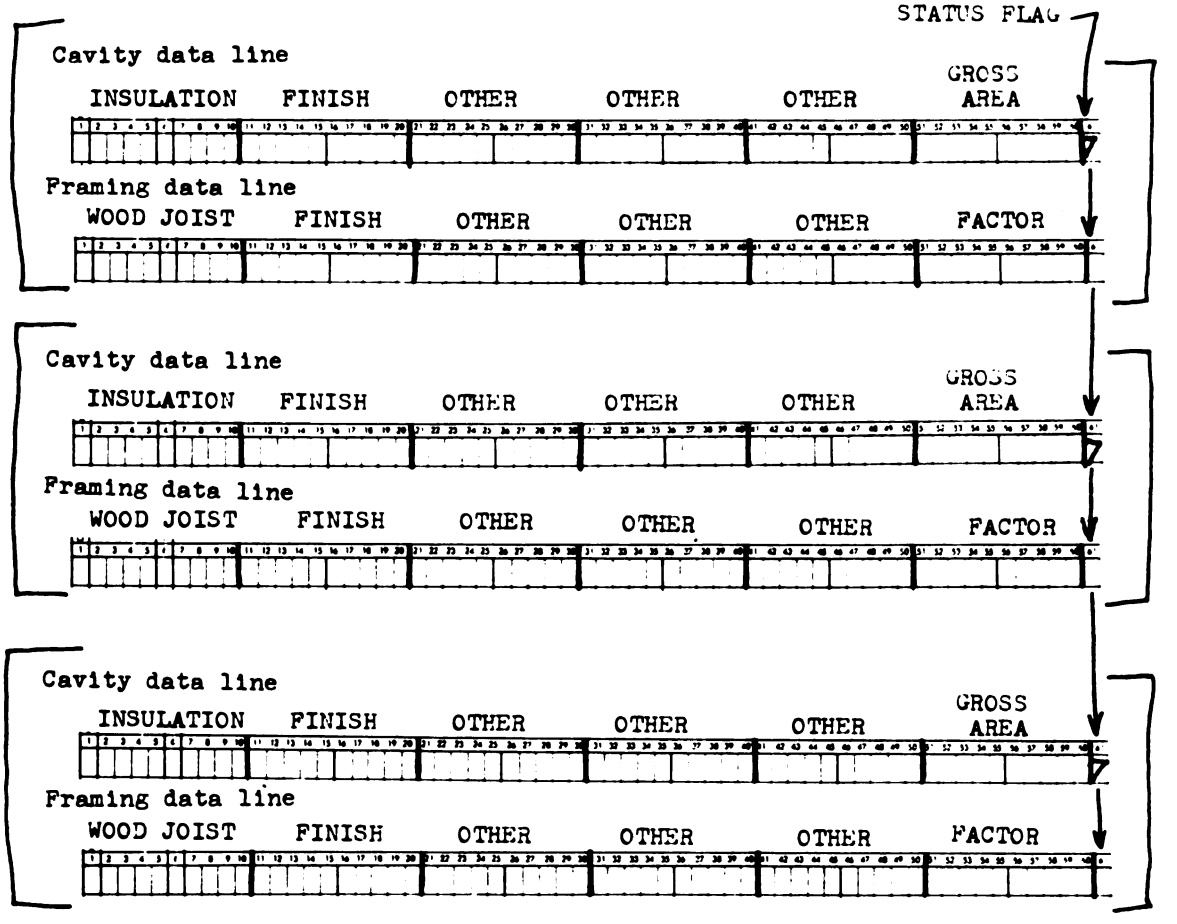
Framing data line



If there are more than one type of open-ceiling assembly in the structure, this procedure of entering one cavity data line followed by one framing data line should be followed for each area in turn. In the case of additional areas being needed, enter an 8 (eight) in the framing data line status flag of each area except the last, to indicate that more roof/ceiling data lines follow.

OPEN-CEILING COMPONENT (continued)

Additional open-ceiling data lines. (Skip this page if these are not needed.)



WALL COMPONENT

The wall component contains several assemblies that must each be treated separately. They include the RIM JOIST (of which there may be more than one if the building is multistory), WINDOWS, ENTRY DOOR, MASONRY WALL, WALL CAVITY, WALL FRAMING (including headers), and possibly others depending on the individual peculiarities of the structure. Each section applicable should be completed and the computer will calculate the composite wall component of the heat envelope.

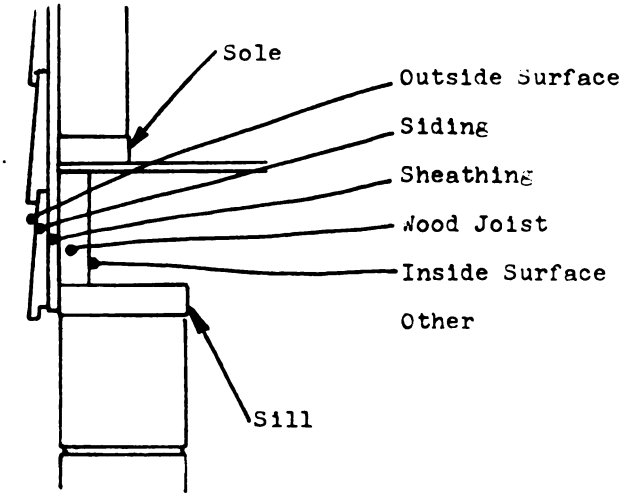
Walls that are included in the heat envelope are walls that enclose a heated area and are exposed to outside temperature. Unheated porches, garage, storage, unheated attic, etc., are considered outside temperature.

RIM JOIST ASSEMBLY

Include all rim joist areas that are exposed to outside temperature (per definition above). This would include rim joists on all floors.

Referring to diagram below, enter the R value of each element into the positions indicated (using a decimal point in each). Do not enter R values for inside and outside air surfaces.

If the rim joist is not the common box sill type illustrated below, enter R values of the elements in the indicated spaces following the same general pattern (at a cross-section of least R with greatest surface).

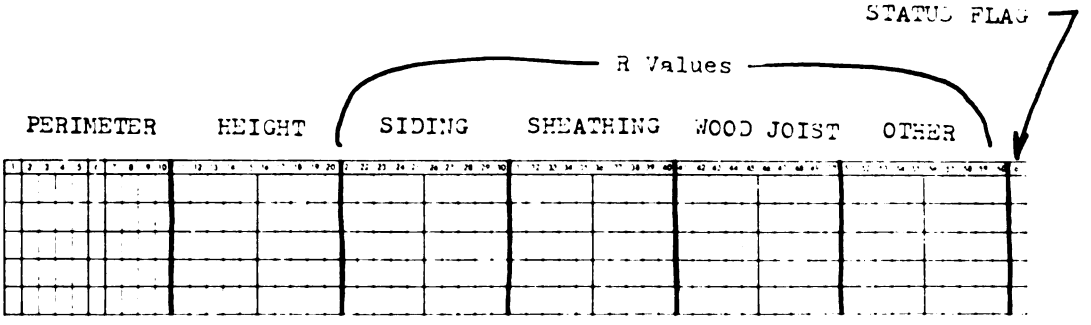


RIM JOIST ASSEMBLY (continued)

Calculate the PERIMETER of each rim joist type, and enter it (in feet using decimal point) in the indicated space.

Determine the HEIGHT of the assembly, from the bottom of the sill to the top of the floor. Convert this figure into feet (with decimal point) using the conversion table in the Appendix, and enter it in the indicated space.

If more rim joist data lines are to follow the first, enter a 1 (one) in the STATUS FLAG box of each line except the last.



WINDOW ASSEMBLY

There are typically many different types of window in a structure. Since a large percentage of a building's heat loss is through the windows, particular attention should be given to their analysis. Each different type and size of window must be analyzed individually. A worksheet for this purpose follows this page. Complete one worksheet for every window type and enter the resulting data in the data lines on page nine.

Table 6 from ASHRAE Handbook of Fundamentals is located in the Appendix.

Window Worksheet

Complete one worksheet for each different type and/or size window. All windows of the same type and size should appear on the same sheet.

Use the space below to sketch the window with dimensions.

Enter the total number of windows of this type and size in the UNITS position.

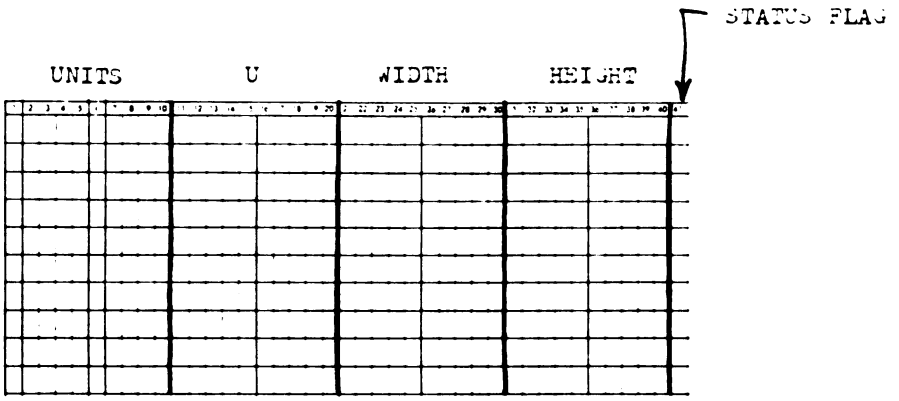
Enter the HEIGHT and the WIDTH of the window assembly, including the sash, into the spaces provided on the data line. These figures should first be converted into decimal feet (using conversion table in the Appendix).

Using Table 6 from the ASHRAE Handbook of Fundamentals to determine the thermal transmittance value (U) of the window. If the window has a wide sash in relation to the glass area, find the sash area and divide by the total window area. If the sash area is more than 20% of the total window area, see Part C of Table 6 for adjustment of the window's U value. Enter the adjusted U value in the indicated position in the data line.

WINDOW ASSEMBLY (continued)

Programming note: A decimal point must be used in all positions except STATUS FLAG.

A 2 (two) in the STATUS FLAG position indicates that another window data line follows.



ENTRY DOOR

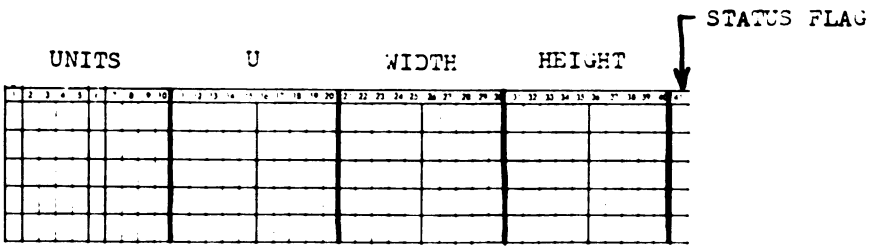
Find the U value of each entry door in the heat envelope from Table 5, ASHRAE Handbook of Fundamentals, located in the Appendix.

Enter the WIDTH and HEIGHT of the assembly in the indicated spaces.

Enter the number of identical assemblies in the UNITS position.

A 3 (three) in the STATUS FLAG position indicates that another entry door data line follows.

A decimal point must be used in all positions except STATUS FLAG.



MASONRY WALL

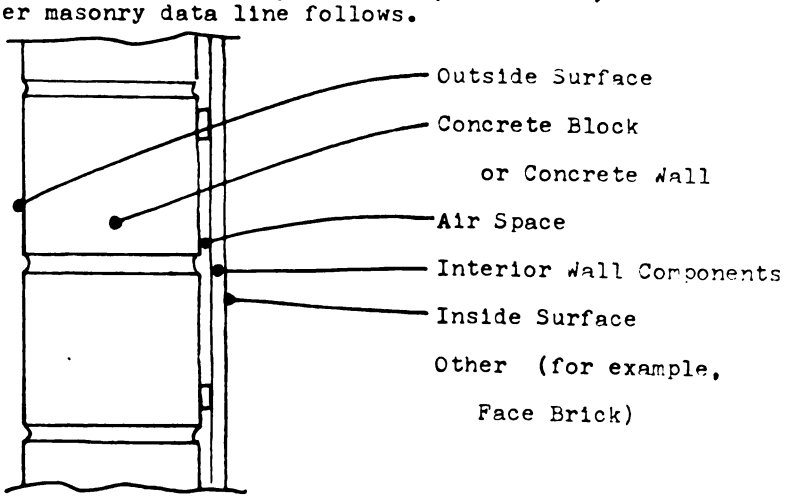
The masonry wall component includes any poured concrete or cinder block walls that enclose a heated space and are above grade. For instance, the above-grade portions of basement walls (where the basement is heated) would be considered in this section.

Do not include above-grade foundation walls that enclose an unheated crawl space. (These are not even part of the heat envelope.) Do not include framed walls with face brick. (These will be treated as ordinary wall.)

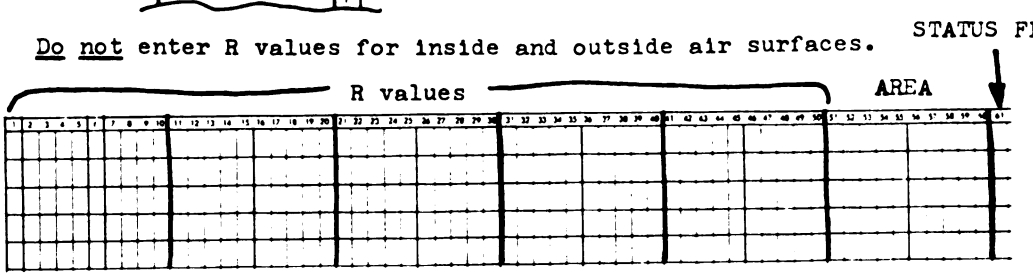
Using the diagram below as a guide, enter R values for the assembly components into the indicated spaces in the data line. Complete a separate data line for each different type of masonry wall. Use a decimal point in each entry.

Calculate the area of each masonry wall type <u>including</u> windows and doors. Enter this figure (in square feet using decimal point) in the **AREA** position.

If more than one masonry data line is needed, use the STATUS FLAG. Enter a 4 (four) in every line except the last, to indicate that another masonry data line follows.



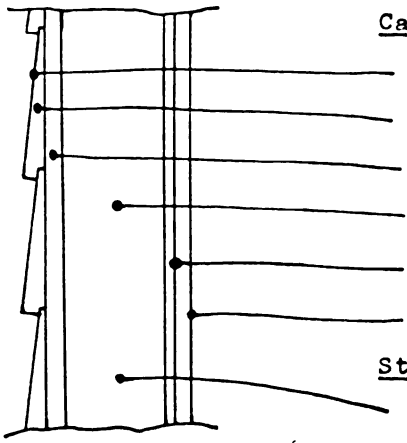
<u>Do not</u> enter R values for inside and outside air surfaces.



FRAMED WALL

Referring to the diagram below, enter R values for the assembly components into the indicated spaces on the CAVITY data line. Do not enter R values for inside and outside air surfaces.

Calculate the area of this framed wall area including windows, doors, and framing. Enter this figure (in square feet using decimal point) in the AREA position.



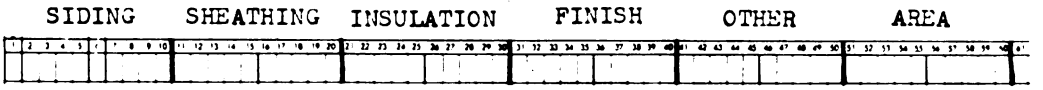
Cavity

- Outside Surface
- Exterior Siding
- Sheathing
- Insulation
- Interior Wall Components
- Interior Surface

Stud

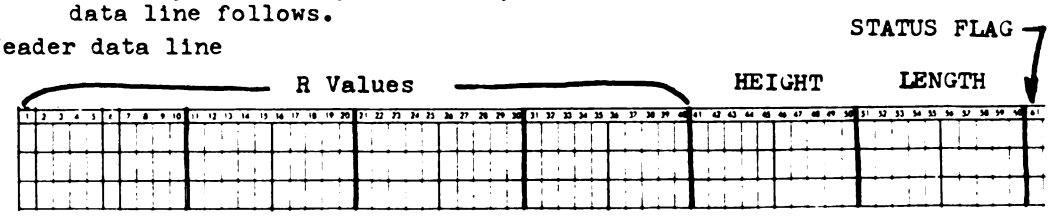
Same as cavity except; 3-1/2 in. Wood Stud in place of Insulation.

Cavity data line



If there are headers over the windows and doors, enter R values for header components into the indicated spaces on the HEADER data line. (If there are not enough spaces, add two or more R values together and enter the total.) Enter the height of the headers into the HEIGHT position (in decimal feet using conversion table in Appendix). Enter the total length of the headers into the LENGTH position (in decimal feet). Use the STATUS FLAG if there are more than one width of header per cavity type. Enter a 5 (five) in every line except the last, to indicate that another header data line follows.

Header data line



FRAMED WALL (continued)

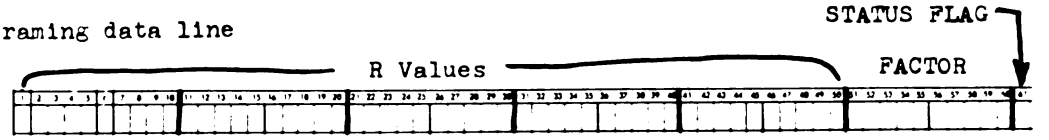
Enter R values of the FRAME assembly components into the indicated spaces.

To find the framing area factor, divide the center-to-center distance between joists (in inches) into 1.5 (one and one-half). Enter this number into the FACTOR position.

For example:

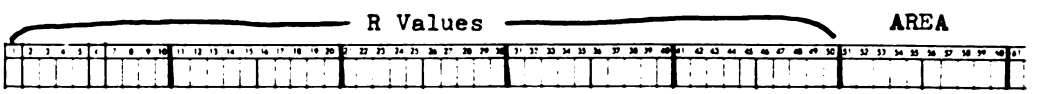
FACTOR	16" c/c	1.5 ÷ 16 = 0.09375
	24" c/c	1.5 ÷ 24 = 0.0625

Framing data line

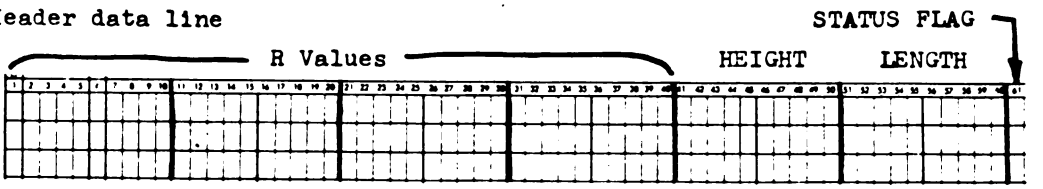


If more than one type of framed wall exists in the structure, enter a 9 (nine) in the STATUS FLAG position on the framing data line (except the final one) to indicate that another set of wall data lines will follow. Follow the preceeding procedure for each different type of framed wall. Additional data lines are provided for this purpose.

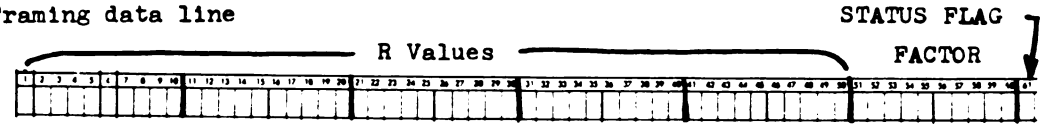
Cavity data line



Header data line

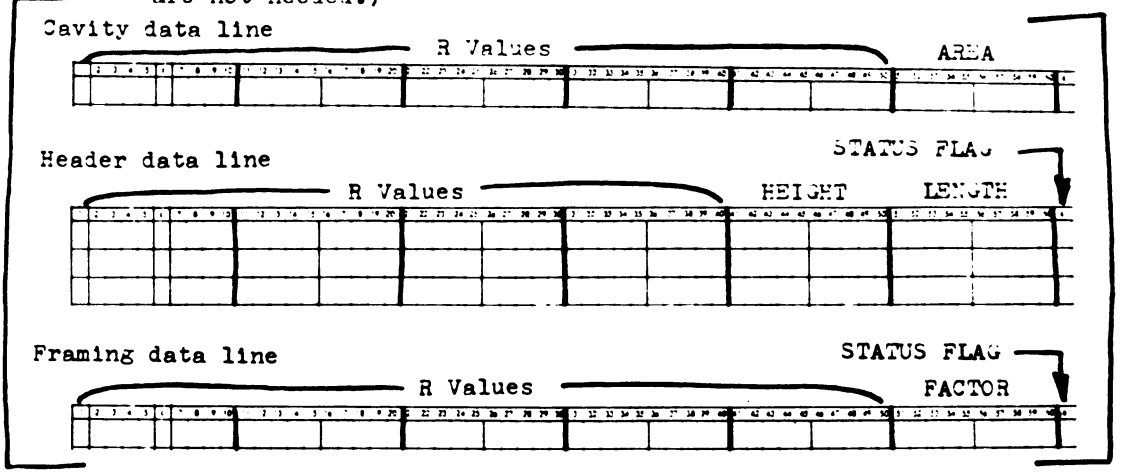


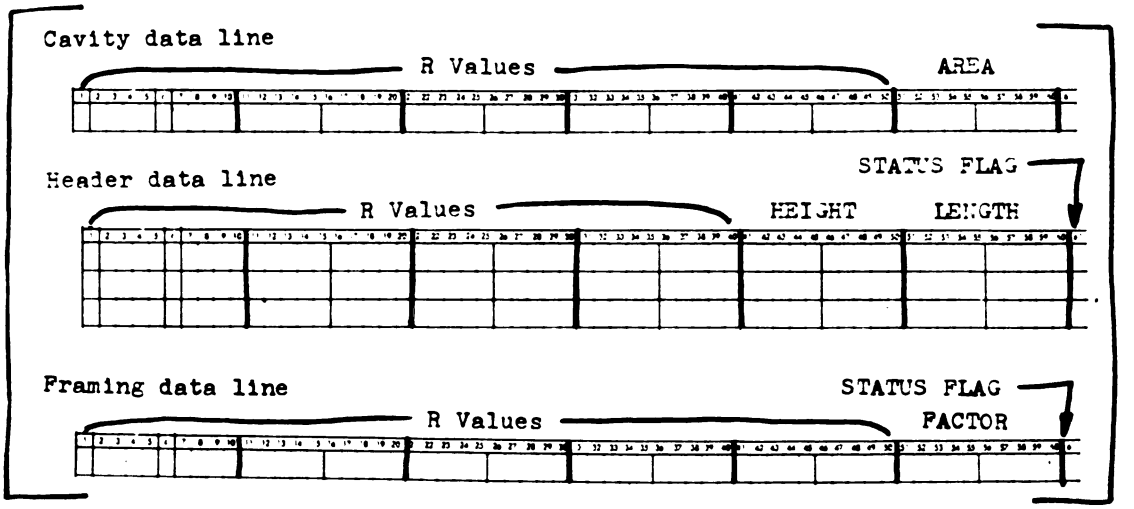
Framing data line



FRAMED WALL (continued)

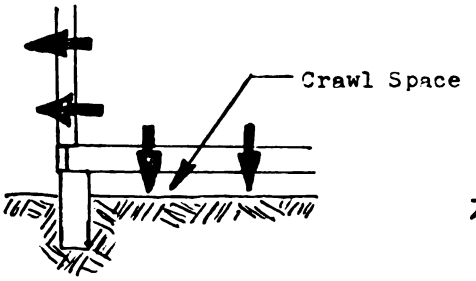
Additional wall component data lines. (Skip this page if these are not needed.)



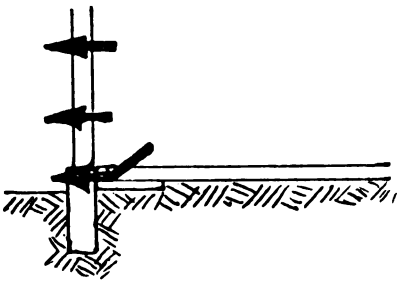


FLOOR COMPONENT

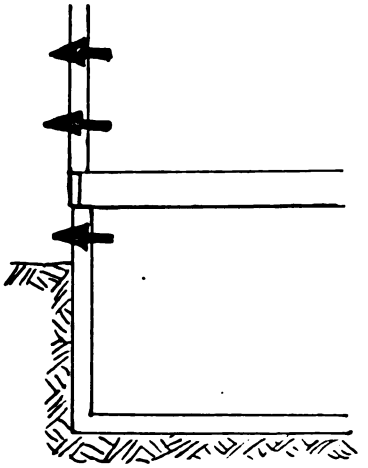
There are several types of floor assembly commonly encountered, and each is treated differently. To simplify the task, four basic floor types have been identified. They are: (1) the floor over unheated space, (2) the slab-on-grade (heated and unheated), (3) heated basement, (4) a combination of the above. These types are illustrated below.



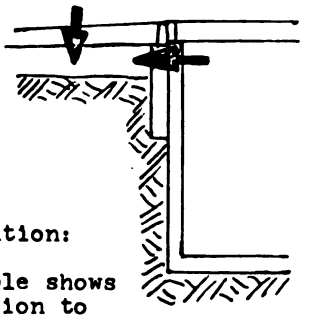
Floor Over Unheated Space



Slab



Basement



Combination:

example shows addition to existing structure

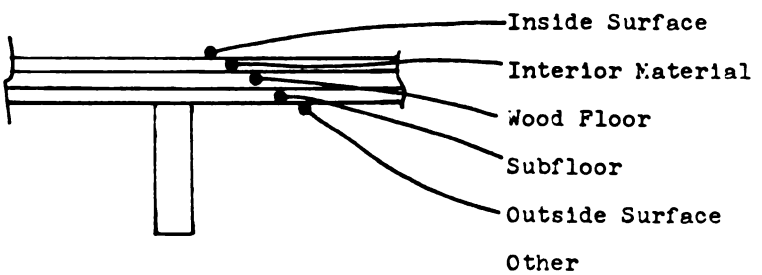
FLOOR COMPONENT (continued)

The HEATED BASEMENT is a special case of wall component (and the above-grade portion of the basement should be entered as wall component). If the entire structure is over a heated basement, no floor component exists. Thus, in a combination of floor types, care must be taken to properly identify each element.

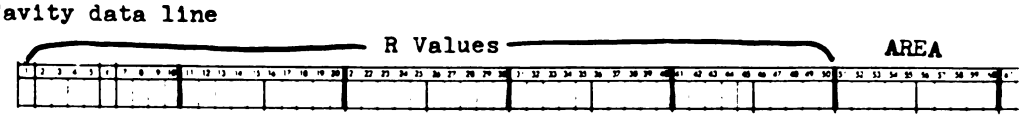
FLOOR OVER UNHEATED SPACE

Referring to the cross-sectional diagram, enter the R value of each element of the floor cavity into the positions indicated on the cavity data line. Do not enter R values for inside and outside air surfaces.

Calculate the area of this floor assembly (including framing) and enter this figure (in square feet using decimal point) into the AREA position on the floor cavity data line.



Cavity data line



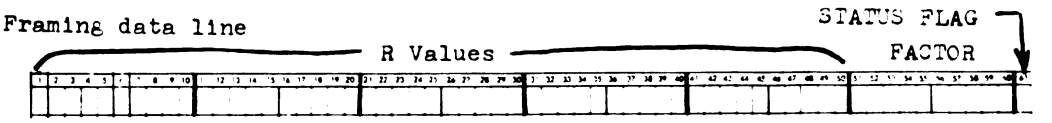
Enter R values of the floor framing components into the indicated spaces on the framing data line.

To find the framing area factor, divide the center-to-center distance between joists (in inches) into 1.5 (one and one-half). Enter the result into the FACTOR position.

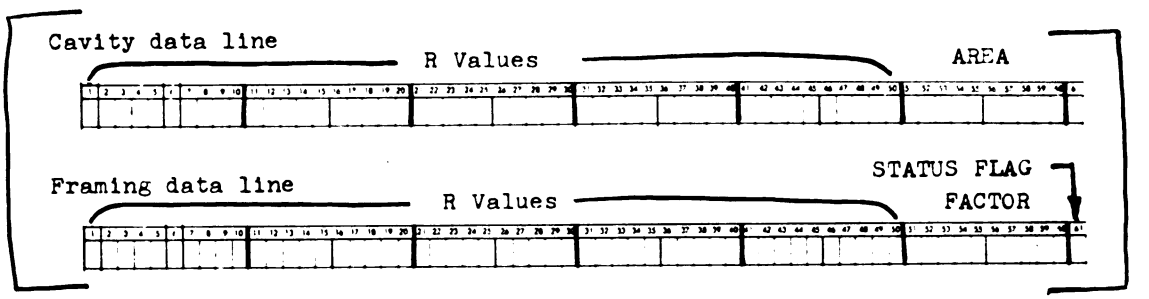
For example:

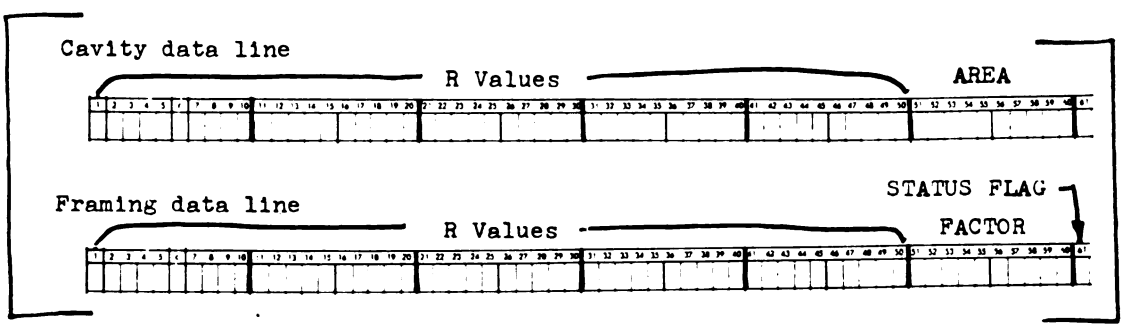
FACTOR	16" c/c	1.5 ÷ 16 = 0.09375
	24" c/c	1.5 ÷ 24 = 0.0625

FLOOR OVER UNHEATED SPACE (continued)



Follow this procedure for each different type of floor over unheated space. If more than one set of data lines are needed, enter a 7 (seven) in the STATUS FLAG position of each floor framing data line except the last, to indicate that another set of floor component data lines follows.





SLAB ON GRADE

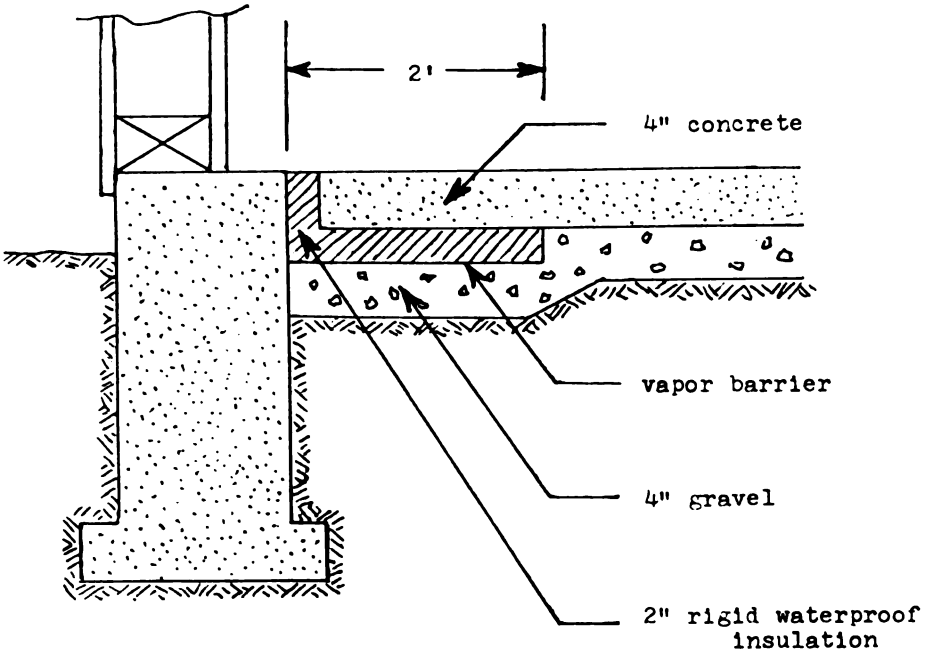
There are two main types of slab floors: heated and unheated. Referring to the building blueprints, determine whether the slab is heated or unheated. A heated slab is one in which the source of heat is located in the slab (radiant floor slab) or beneath the slab (perimeter, buried, underfloor heating ducts). If the slab is heated, enter a 1 (one) in the position labeled "H" on the slab data line. If the slab is <u>not</u> heated, enter a 0 (zero).

SLAB ON GRADE (continued)

The area of a slab floor does not have to be calculated.

Referring to the diagram below, notice that the insulation extends downward from the top of the slab and then horizontally beneath the slab. The insulation may also extend straight down. Enter the length of this insulation (total vertical and horizontal distance) in inches (rounded off to the nearest inch) in the position marked "L" in the slab data line. (If this distance cannot be determined, enter 24 (twenty-four).)

Enter the R value of this insulation in the R VALUE position.



Slab data line

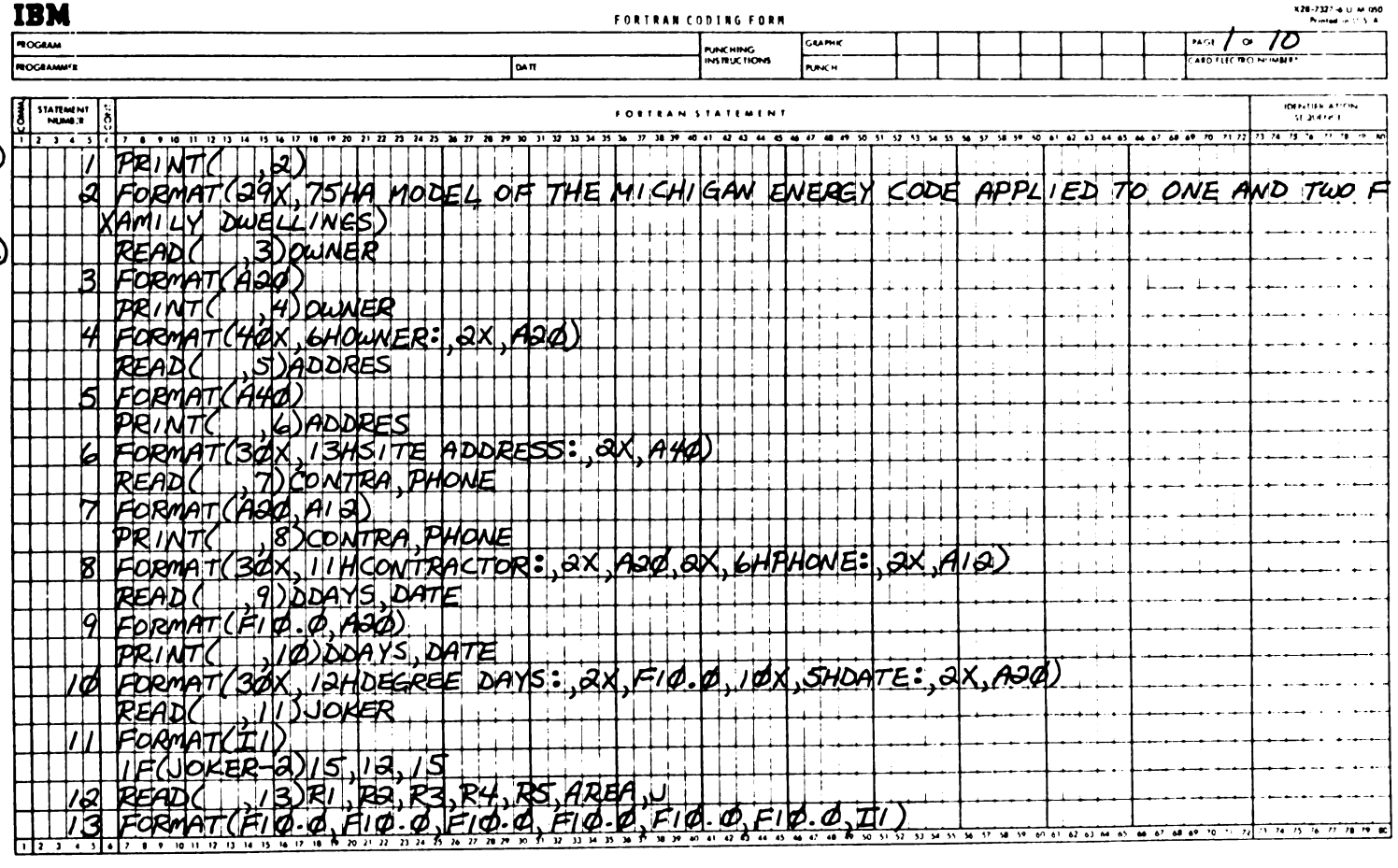
H L R Value

ADDITIONAL PROGRAMMING NOTES

Pages one and two	If there is no cathedral roof component, a blank card is inserted in data line 5, but do not insert a blank card in the cathedral data line, instead proceed directly to the open-ceiling data line.
Page four	If there is no open-ceiling component (for example, if the entire roof/ceiling assembly is cathedral type), insert two blank cards in the deck at the position normally occupied by the open-ceiling data lines.
Page seven	If there is no rim joist assembly, insert a blank card in the data deck.
Page nine	If there are no windows, insert a blank card in the data deck.
Page nine	If there are no entry doors, insert a blank card in the data deck.
Page ten	If there is no masonry wall component, insert a blank card in the data deck.
Pages eleven and twelve	If there is no framed wall component, insert three blank cards in the data deck.
Page fifteen	If there is no floor over unheated space (for example, if the entire floor is slab), insert a blank card in the data deck here.
Page seventeen	If there is no slab floor, insert a blank card in the data deck.

If data for another house is to follow, insert a data card with "999" (nine hundred ninety-nine) in the first three spaces.

APPENDIX B



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FORTRAN CODING FORM

PROGRAM | PUNCHING INSTRUCTIONS | GRAPHIC | PAGE 1 OF 10

PROGRAMMER | DATE | PUNCH | CARD ELECTRO NUMBER

C COMMENT | STATEMENT NUMBER | CONTINUATION | FORTRAN STATEMENT | IDENTIFICATION SEQUENCE

```
      1  PRINT(   ,2)
      2  FORMAT(29X,75HA MODEL OF THE MICHIGAN ENERGY CODE APPLIED TO ONE AND TWO F
     XAMILY DWELLINGS)
        READ(   ,3)OWNER
      3  FORMAT(A20)
        PRINT(   ,4)OWNER
      4  FORMAT(40X,6HOWNER:,2X,A20)
        READ(   ,5)ADDRES
      5  FORMAT(A40)
        PRINT(   ,6)ADDRES
      6  FORMAT(30X,13HSITE ADDRESS:,2X,A40)
        READ(   ,7)CONTRA,PHONE
      7  FORMAT(A20,A12)
        PRINT(   ,8)CONTRA,PHONE
      8  FORMAT(30X,11HCONTRACTOR:,2X,A20,2X,6HPHONE:,2X,A12)
        READ(   ,9)DDAYS,DATE
      9  FORMAT(F10.0,A20)
        PRINT(   ,10)DDAYS,DATE
     10  FORMAT(30X,12HDEGREE DAYS:,2X,F10.0,10X,5HDATE:,2X,A20)
        READ(   ,11)JOKER
     11  FORMAT(I1)
        IF(JOKER-2)15,12,15
     12  READ(   ,13)R1,R2,R3,R4,R5,AREA,U
     13  FORMAT(F10.0,F10.0,F10.0,F10.0,F10.0,F10.0,I1)
```

① ②

NOTES:

① INSERT PRINTER DEVICE CODE INTO PROPER POSITION FOR ALL PRINT STATEMENTS.

② INSERT CARD READER CODE FOR ALL READ STATEMENTS.

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FORTRAN CODING FORM

PROGRAM

PROGRAMMER

DATE

PUNCHING INSTRUCTIONS

GRAPHIC

PUNCH

PAGE 2 OF 10

```
      A=0.0
      Z=0.0
      U=1.0/(0.17+R1+R2+R3+R4+R5+0.68)
      A=A+AREA
      Z=U*AREA+Z
      IF(J-6)14,18,14
   14 UCATH=Z/A
      A2=0.0
      Z3=0.0
   15 READ(   ,13)R1,R2,R3,R4,R5,AREA,J
      U=1.0/(0.17+R1+R3+R3+R4+R5+0.68)
      READ(   ,13)R1,R2,R3,R4,R5,FACTOR,J
      AREA2=AREA*FACTOR
      U2=1.0/(0.17+R1+R2+R3+R4+R5+0.68)
      A2=A2+AREA
      Z2=U*(AREA-AREA2)+U2*AREA2+Z2
      IF(J-8)16,15,16
   16 UROOF=Z2/A2
      URIM=0.0
      ARIM=0.0
   17 READ(   ,13)RIMPER,RIMHT,R1,R2,R3,R4,J
      RIA=RIMPER*RIMHT
      U=1.0/(0.17+R1+R2+R3+R4+0.68)
      ARIM=ARIM+RIA
```

C STATEMENT NUMBER | CONT. | FORTRAN STATEMENT | IDENTIFICATION SEQUENCE

```
      URIM=URIM+U*RJA
      IF(J-1)18,17,18
   18 URIMJ=URIM/ARIM
      UWIN=0.0
      AWIN=0.0
   19 READ(   ,20)UNITS,U,Y,Z,V
   20 FORMAT(F10.0,F10.0,F10.0,F10.0,I1)
      A=UNITS*Y*Z
      AWIN=A+AWIN
      UWIN=U*A+UWIN
      IF(J-2)21,20,21
   21 UWIND=UWIN/AWIN
      UDOOR=0.0
      ADOOR=0.0
   22 READ(   ,20)UNITS,U,Y,Z,J
      A=UNITS*Y*Z
      ADOOR=A+ADOOR
      UDOOR=U*A+UDOOR
      IF(J-3)23,22,23
   23 UDOORE=UDOOR/ADOOR
      AR=0.0
      ZR=0.0
   24 READ(   ,13)R1,R2,R3,R4,R5,AREA,V
      U=1.0/(0.117*R1+R2+R3+R4+R5+0.68)
```

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FORTRAN CODING FORM

PROGRAM | PUNCHING INSTRUCTIONS | GRAPHIC | PAGE 4 OF 10

PROGRAMMER | DATE | PUNCH | CARD ELECTRONIC IDENTIFICATION

```
      A2=AREA+A2
      Z2=U*AREA+Z2
      IF(J-4)25,24,25
   25 UMAS=Z2/A2
      UZZ0=0.0
      AZZ0=0.0
   26 READ(   ,13)R1,R2,R3,R4,R5,AREA,J
      U=1.0/(0.17+R1+R2+R3+R4+R5+0.68)
      U2=0.0
      A2=0.0
   27 READ(   ,13)R1,R2,R3,R4,Y,Z,J
      U3=1.0/(0.17+R1+R2+R3+R4+0.68)
      A2=Y*Z+A2
      IF(J-5)28,27,28
   28 READ(   ,13)R1,R2,R3,R4,R5,FACTOR,J
      U3=1.0/(0.17+R1+R2+R3+R4+R5+0.68)
      UZZ0=(AREA-A2)*FACTOR*U3+U2*A2+(AREA-(AREA-A2)*FACTOR-A2)*U+UZZ0
      AZZ0=AREA+AZZ0
      IF(J-9)29,26,29
   29 UWALL=UZZ0/AZZ0
      UF3=0.0
      AF3=0.0
   30 READ(   ,13)R1,R2,R3,R4,R5,AREA,J
      IF(AREA)31,33,31
```

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FORTRAN CODING FORM

X28-7327-4 U/M 360

PROGRAM | PUNCHING INSTRUCTIONS | GRAPHIC | PAGE 5 OF 10

PROGRAMMER | DATE | PUNCH | CARD ELECTRO NUMBER

STATEMENT NUMBER	CONTINUATION	FORTRAN STATEMENT	IDENTIFICATION SEQUENCE
31		U1=1.0/(C0.17+R1+R2+R3+R4+R5+0.68)	
		READ(,13)R1,R2,R3,R4,R5,FACTOR,J	
		U3=1.0/(0.17+R1+R2+R3+R4+R5+0.68)	
		A2=AREA*FACTOR	
		UF3=U1*(AREA-A2)+U2*A2+UF3	
		AF3=AREA+AF3	
		IF(J-7)32,30,30	
30		UFLOOR=UF3/AF3	
		GO TO 34	
33		UFLOOR=0.0	
34		READ(,35)K,L,R9	
35		FORMAT(I1,I2,F10.0)	
		IF(R9)36,37,36	
36		IF(K-1)37,38,37	
37		RSLAB=(DDAYS/10000.0)*0.75+2.5	
		GO TO 39	
38		RSLAB=(DDAYS/10000.0)*0.68+0.74	
39		PRINT(,40)	
40		FORMAT(40X,17HENERGY CODE LIMIT)	
		PRINT(,41)	
41		FORMAT(30X,48HCOMBINED GROSS WALL THERMAL TRANSMITTANCE VALUE:)	
		IF(DDAYS-10000.0)42,43,43	
42		ZN=10000.0-DDAYS	
		ZM=DDAYS-6000.0	

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X28-7327-4 U/M 050
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PROGRAM | PUNCHING INSTRUCTIONS | GRAPHIC | PAGE 10 OF 10

PROGRAMMER | DATE | PUNCH | CARD ELECTRO NUMBER

C (COMMENT)	STATEMENT NUMBER	CONTINUATION	FORTRAN STATEMENT	IDENTIFICATION SEQUENCE
			UCODEW=(ZN*0.30+ZM*0.16)/(ZM+ZN)	
			GO TO 44	
	43		UCODEW=0.16	
	44		PRINT(,45)UCODEW	
	45		FORMAT(35X,F10.0,2X,53HBTU PER HOUR, PER SQUARE FOOT, PER DEGREE FAHRENHE/	
			XT)	
			PRINT(,46)	
	46		FORMAT(40X,28HACTUAL STRUCTURE PERFORMANCE)	
			PRINT(,41)	
			UWALLY=(URIM*ARIM+UWIN*AWIN+UDOOR*ADOOR+Z+UZZO)/(ARIM+AWIN+ADOOR+A+AZZO)	
			PRINT(,45)UWALLY	
			PERWIN=((AWIN/(AZZO+A+AWIN+ADOOR))*100.0	
			RECMAX=((UCODEW-UWALLY)/(UWIN-UWALLY))*100.0	
			PRINT(,47)PERWIN	
	47		FORMAT(35X,21HPERCENT FENESTRATION:,5X,F10.0)	
			PRINT(,48)RECMAX	
	48		FORMAT(35X,29HMAX RECOMMENDED FENESTRATION:,5X,F10.0)	
			IF(UWALLY-UCODEW)49,49,51	
	49		PRINT(,50)	
	50		FORMAT(40X,31HWALL COMPONENT CONFORMS TO CODE)	
			GO TO 53	
	51		PRINT(,52)	
	52		FORMAT(40X,31HWALL TRANSMITTANCE EXCEEDS CODE)	
	53		PRINT(,40)	

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FORTRAN CODING FORM

X28-7327-4 U/M 050
Printed in U.S.A.

PROGRAM | PUNCHING INSTRUCTIONS | GRAPHIC | PAGE 7 OF 10

PROGRAMMER | DATE | PUNCH | CARD ELECTRO NUMBER

C	STATEMENT NUMBER	CONT	FORTRAN STATEMENT	IDENTIFICATION SEQUENCE
			PRINT(,54)	
	54		FORMAT(30X,56HCOMBINED GROSS ROOF/CEILING THERMAL TRANSMITTANCE VALUE:)	
			IF(QDAYS-8000.0)55,55,56	
	55		UCODER=0.05	
			GO TO 57	
	56		UCODER=0.04	
	57		PRINT(,45)UCODER	
			PRINT(,46)	
			PRINT(,41)	
			PRINT(,45)UROOF	
			IF(UROOF-UCODER)59,59,60	
	58		PRINT(,59)	
	59		FORMAT(40X,39HROOF/CEILING COMPONENT CONFORMS TO CODE)	
			GO TO 62	
	60		PRINT(,61)	
	61		FORMAT(40X,39HROOF/CEILING TRANSMITTANCE EXCEEDS CODE)	
	62		IF(JOKER-1)63,65,63	
	63		PRINT(,64)	
	64		FORMAT(30X,27HNO CATHEDRAL ROOF COMPONENT)	
			GO TO 71	
	65		PRINT(,40)	
			PRINT(,66)	
	66		FORMAT(30X,61HCOMBINED GROSS CATHEDRAL CEILING THERMAL TRANSMITTANCE VALUE	
		X	:)	

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FORTRAN CODING FORM

X28-7327-4 U/M 060
Printed in U.S.A.

PROGRAM | PUNCHING INSTRUCTIONS | GRAPHIC | PAGE 8 OF 10

PROGRAMMER | DATE | PUNCH | CARD ELECTRO NUMBER

C	STATEMENT NUMBER	C	FORTRAN STATEMENT	IDENTIFICATION SEQUENCE
			XCATHX=0.08	
			PRINT(,45)XCATHX	
			PRINT(,46)	
			PRINT(,66)	
			PRINT(,45)UCATH	
			IF(UCATH-XCATHX)67,67,69	
	67		PRINT(,68)	
	68		FORMAT(40X,31HCATHEDRAL ROOF CONFORMS TO CODE)	
			GO TO 71	
	69		PRINT(,70)	
	70		FORMAT(40X,36HCATHEDRAL TRANSMITTANCE EXCEEDS CODE)	
	71		IF(UFLOOR)74,72,74	
	72		PRINT(,73)	
	73		FORMAT(30X,28HNO FLOOR OVER UNHEATED SPACE)	
			GO TO 80	
	74		PRINT(,40)	
			PRINT(,75)	
	75		FORMAT(30X,49HCOMBINED GROSS FLOOR THERMAL TRANSMITTANCE VALUE:)	
			UCODEF=0.08	
			PRINT(,45)UCODEF	
			PRINT(,46)	
			PRINT(,75)	
			PRINT(,45)UFLOOR	
			IF(UFLOOR-UCODEF)76,76,78	

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FORTRAN CODING FORM

X28-7327-6 U/M 050
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PROGRAM | PUNCHING INSTRUCTIONS | GRAPHIC | PAGE 9 OF 10

PROGRAMMER | DATE | PUNCH | CARD ELECTRO NUMBER*

C	STATEMENT NUMBER	CONT.	FORTRAN STATEMENT	IDENTIFICATION SEQUENCE
	76		PRINT(,77)	
	77		FORMAT(40X,32HFLOOR COMPONENT CONFORMS TO CODE)	
			GO TO 80	
	78		PRINT(,79)	
	79		FORMAT(40X,32HFLOOR TRANSMITTANCE EXCEEDS CODE)	
	80		IF(R9)83,81,83	
	81		PRINT(,82)	
	82		FORMAT(30X,23HNO SLAB FLOOR COMPONENT)	
			GO TO 94	
	83		PRINT(,40)	
			IF(K-1)89,84,89	
	84		IF(R9-RSLAB)85,87,87	
	85		PRINT(,86)	
	86		FORMAT(30X,49HHEATED SLAB FLOOR DOES NOT MEET CODE REQUIREMENTS)	
			GO TO 94	
	87		PRINT(,88)	
	88		FORMAT(30X,41HHEATED SLAB FLOOR MEETS CODE REQUIREMENTS)	
			GO TO 94	
	89		IF(R9-RSLAB)90,92,92	
	90		PRINT(,91)	
	91		FORMAT(30X,51HUNHEATED SLAB FLOOR DOES NOT MEET CODE REQUIREMENTS)	
			GO TO 94	
*	92		PRINT(,93)	
	93		FORMAT(30X,43HUNHEATED SLAB FLOOR MEETS CODE REQUIREMENTS)	

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FORTRAN CODING FORM

X28-7327-6 U M 050
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PROGRAM		PUNCHING INSTRUCTIONS	GRAPHIC									PAGE 10 of 10
PROGRAMMER	DATE		PUNCH									CARD ELECTRO NUMBER

C COMMENT	STATEMENT NUMBER	CONTINUATION	FORTRAN STATEMENT	IDENTIFICATION SEQUENCE
	94		READ(,95)MORE	
	95		FORMAT(I3)	
			IF(MORE-999)97,96,97	
	96		GO TO 1	
	97		PRINT(,98)	
	98		FORMAT(50X,7HEND RUN)	
			STOP	
			END	

REFERENCES

REFERENCES

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