CHAPTER III

METHODOLOGY

This methodology has 3 systems: first system, designing house model and calculates OTTV and RTTV and modify OTTV and RTTV, the second, development of computer program to calculate OTTV, RTTV, and energy conservations, and the last, compare the results between house model and computer program.

House Model

1. The house model is designed for 4-6 people of occupants in this thesis and the specification of house model as follows:

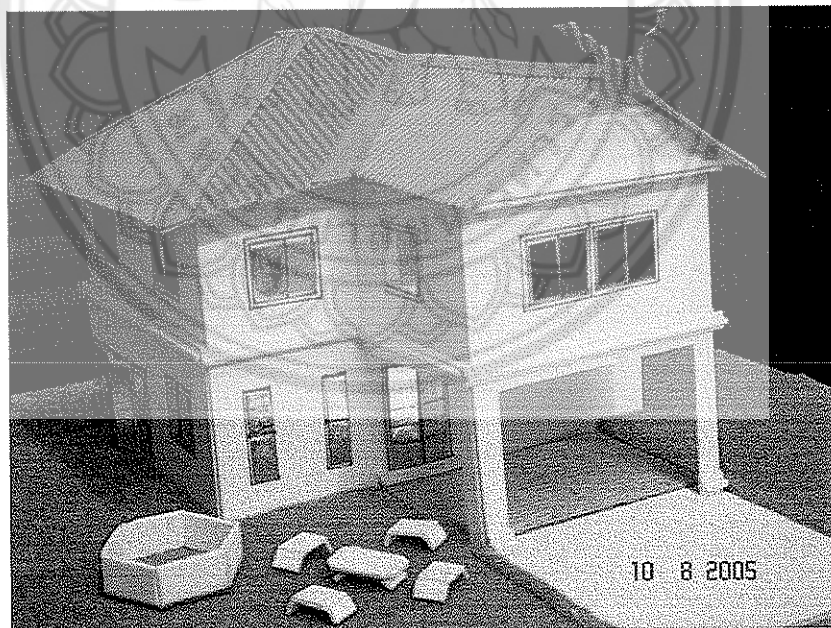   1.1 Using area is 171.24 m^2 and the house model has 2 floors.

Figure 5 Show the house model that is making for calculation energy saving in house.

1.2 The house has 3 bedrooms, 3 bathrooms, 1 living room, 1 parlor, 1kitchen and 1 car park.

1.3 The direction of parlor is in the north, living room in the southeast, bathrooms in the west, kitchen in the west, car park in the north, bedroom 1 in the north, bedroom 2 in the east and bedroom 3 in the southeast.
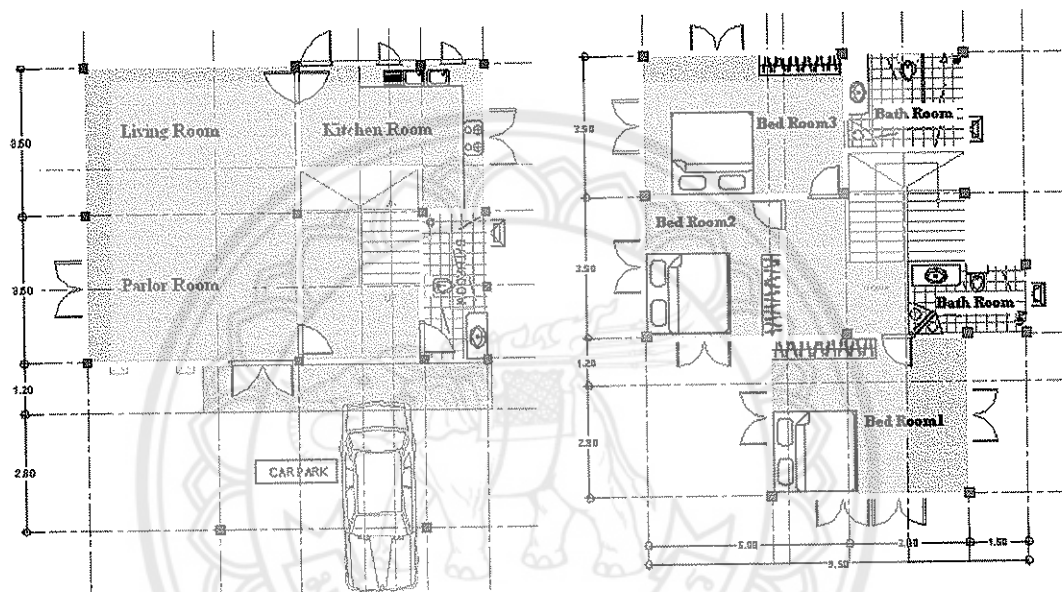
(a) Show the floor plan of house model.   (b) Show the second floor of the house model.

Figure 6 Show the floor and second plan of the house model.

1.4 The brick masonry walls (brick with cement coat both sides of wall) have thickness 10 cm.

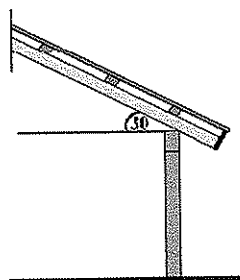1.5 The roof use asbestos cement tile that have pitched roofs 30°.

Figure 7 Show the slope of roof that refer from horizontal to vertical

1.6 Windows and doors use clear glass.

1.7 Ratio of areas between glasses and walls are more than 0.17

2. The materials for design energy saving houses in this thesis have the specification as follows:

2.1 This house is used brick masonry walls with cement coated and thickness 10 cm.
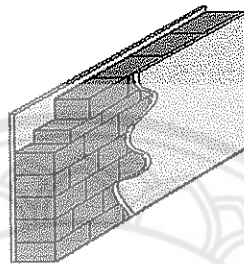

Figure 8 This is a brick masonry wall with cement coated.

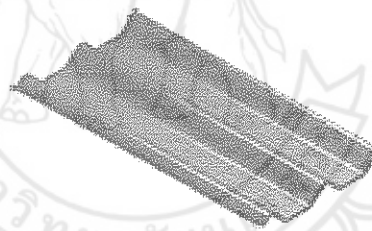2.2 The roof tiles are used asbestos cement tiles.

Figure 9 Show the roof tiles, asbestos cement tiles

2.3 The windows and the doors use clear glass.

2.4 The color of roof is medium brown paint and wall is white semi-gloss.

2.5 The directions of houses have 8 directions: north, northeast, northwest, south, southeast, southwest, east and west.

3. The result of mathematical model is based on OTTV and RTTV from standards stipulated by law in Thailand

Current OTTV and RTTV limit are

- For new building, OTTV $\leq$ 45 W/m^2

- For old building, OTTV $\leq$ 55 W/m^2

- For roof, RTTV $\leq$ 25 W/m^2

Development of Computer Program

Computer program in this thesis consist of 3 parts as follows:

1 Databases are primary data that used for calculation processes.

2 Input data in this part, user should be declaring parameters that are important for calculation processes.

3 Output data: user can select insulator and types of glass from output program to be under the standard stipulate law.

Databases

The databases concerning the energy conservation systems are classified in four groups. The first group is database for OTTV calculation, consists of six parameters as follows;

- Thermal transmittance (k) and density (ρ) of the building materials

- Air film resistance of wall (R)

- Air film resistance (R_a) of air space inside double wall

- Absorptivity for wall and roof surfaces

- Equivalent temperature difference for wall (TD_w), (°C)

- Correction factor for walls (CF)

The second group is database for RTTV calculation, consists of seven parameters as follows;

- Thermal transmittance (k) and density (ρ) of the building materials

- Surface air film resistance of roofs (R)

- Air film resistance (R_a) of air space inside the roof

- Air film resistance of the ceiling (R)

- Absorptive for wall and roof surfaces

- Equivalent temperature difference for roof (TD_r), (°C)

- Correction factor for roof (CF)

The third group is database for heat transfer, power saving and energy saving, consists of 3 parameters as follows;

- Hourly mean diffuse radiation on tilted surface, (W/m^2), the solar radiation value used in the computer program is the average radiation value of the Thailand

- Heat production rate in a human body

- Recommended air change rates

And the last group is database for the economic calculation in part of par back period.

Input Data

There are four main groups of input data: primary information, opaque and transparent wall, opaque roof and pay back period.

The first group is primary information input parameters as follows

- Number of occupants in your house for calculation the heat flow rate in a human body.

- Size of room or house in term of meter for check your room areas and calculate air condition size.

- The temperature outdoor and temperature indoor.

- Time in hours to use air per day for use in part of economic.

- Days for use air in one year for calculation in part of economic.

The second group is opaque and transparent wall that are data for calculation OTTV

- Side of walls that are absorbed radiation (1-4).

- Estimate position of room.

- Direction of wall and/or glass, which allow user to select one from eight codes. (North, Northeast, East, Southeast, South, Southwest, West, Northwest)

- Section code of wall. There are three choices for this item i.e. opaque wall only, transparent wall only and opaque with transparent wall.

- Types of wall and/or glass materials, which allow user to select one from 12 or user can input the data from another material.

- Area of wall and/or glass in term of square meter (m^2).

- Shading for windows, (Overhang or Fin).

- Color for wall, there are 50 choices for this items.
- Slope of wall in degree from 70° to 90°.

The third group is input data for RTTV calculation. There are consists of ten parameters as follows

- Types of roof slope, user can select one from two types; sloping roof and flat roof.
- Types of roof are the character of roof i.e. gable roof, hip roof, shed roof and salt box roof.
- Numbers of roof-pieces are put on the room.
- Direction of roof, which allow user to select one from eight codes.
- Area of roof in term of square meter (m^2).
- Slope of roof in degree from 0° to 60°.
- Types of materials roof.
- Color of materials.
- Lay out of ceiling
- Area of ceiling in term of square meter (m^2)
- Absorbtivity of material is high or low
- Air layers of roof between materials roof and ceiling in case of cathedral ceiling.

And the last group is Economical Data input: consists of many parameters as follows

- Pieces of wall that are absorbed radiation.
- Pieces of wall that are not absorbed radiation
- Temperature in house, (C°).
- How many types of internal wall?
- Types of internal material wall.
- Area of internal wall in term of square meter, (m^2).
- Cost of Insulation, (Bath/ m^2) and cost of electricity, (Baht/Unit).

Output Data

The data output from the computer program as follows:

OTTV/RTTV: shows the OTTV/RTTV system in each side before modify materials.

Type of insulation: shows the insulation that can reduce the load

Improve OTTV/RTTV: shows the OTTV/RTTV system in each side after install insulation.

Energy conservation data:

a) Heat Load: shows the heat that through from material building after install insulation

b) Power Saving: shows the electric energy saved by insulation

c) Energy Saving: shows the data of energy saving from this side

d) % of Energy Saving: shows the percents of energy saving

Economic: size of air condition, cost of energy saving, investment cost, and payback period.

The entire process to find the appropriate OTTV system is show in Figure 10. And the entire process to find the appropriate RTTV system is show in Figure 11. The starting point is the data input from user.
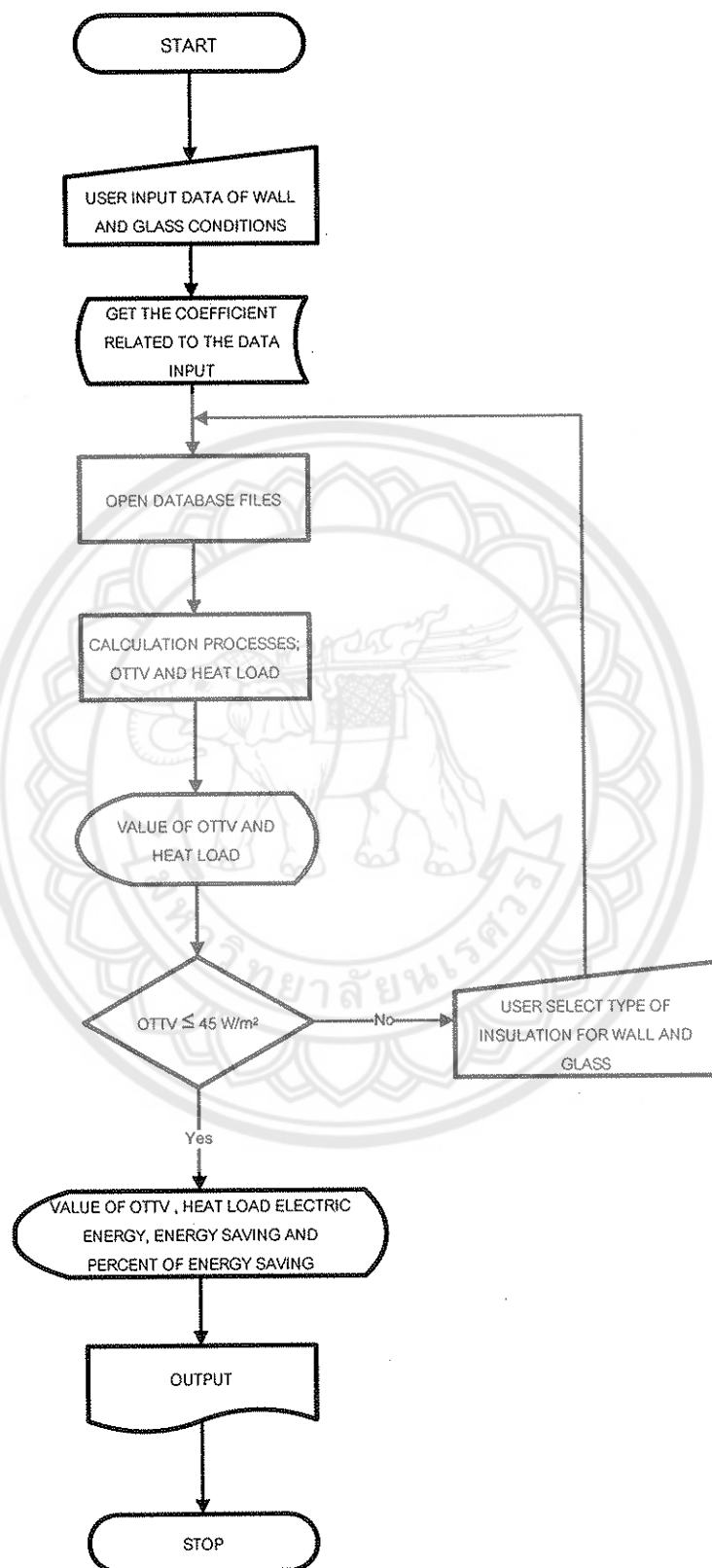
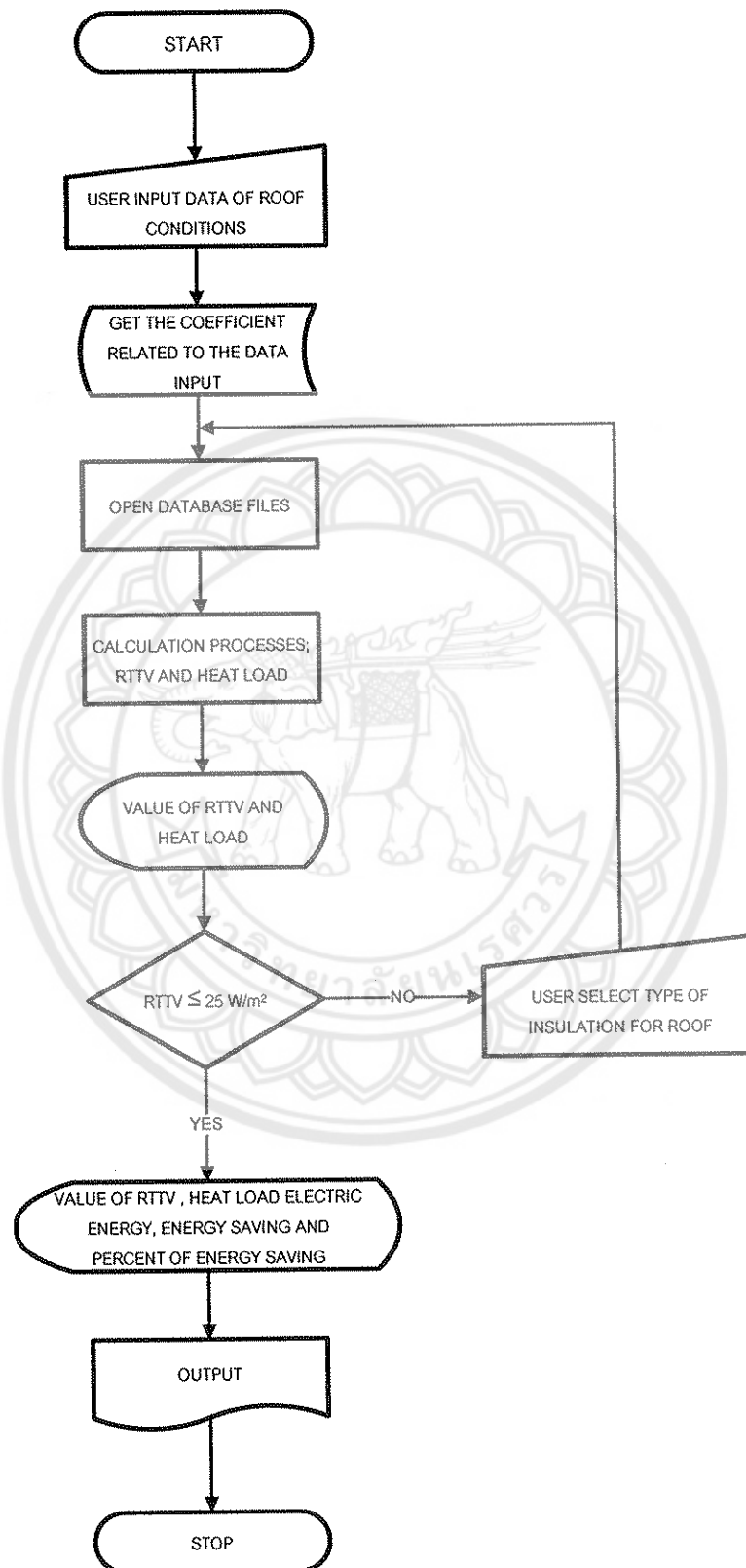Figure 10 Flow Chart for Program Computer Calculation in OTTV Processes

Figure 11 Flow Chart for Program Computer Calculation in RTTV Processes

Steps of Computer Program for Energy Conservation Houses

Step 1: User Input Primary Information of Room

      1 Number of occupants

      2 Room size (wide, length, high), (m)

      3 Temperature outside of room

      4 Temperature inside design

      5 Time that use air condition (0-23 hr), (hr/day)

      6 Number of day that use air condition (days/year)

Step 2: User Input Data of Room for Calculate OTTV or RTTV

      1 Estimate position room

      2 Direction of wall, (N, S, E, W, NE, NW, SE, SW)

      3 There are 3 section codes of wall: opaque wall only, transparent wall only and opaque with transparent wall

      4 There are 12 types of wall for user to select

          4.1 Brick wall (80 mm)

          4.2 Brick with cement coating wall (100 mm)

          4.3 Double brick with cement coating wall (200 mm)

          4.4 Concrete block with cement coating wall (90 mm)

          4.5 Brick and concrete block with cement coating wall (200 mm)

          4.6 Concrete wall (100 mm)

          4.7 Metal sheet (8 mm)

          4.8 Hardwoods (20 mm)

          4.9 Wood with gypsum board (130 mm)

          4.10 Brick with cement coating wall and gypsum board (130 mm)

          4.11 Double brick with cement coating wall and gypsum board (230 mm)

          4.12 Gypsum board (9 mm)

This program can support the value of another material that not present in this program and if user has another wall, user can input data for your wall such as type of wall, R-value and mass of material

5 Area of wall, (m^2)

6 There are 2 types of glass for user to choose

    6.1 Clear glass (8 mm)

    6.2 Tinted glass (8 mm)

And this program can support the other materials, if user has another glass, user can input data for your glass such as type of glass, R-value and mass of material (kg/m^2)

7 Area of clear glass, (m^2)

8 Color of wall

9 Shading device information

10 Estimate position and types of roof

11 Area of roof, (m^2)

12 Types of tile have 11 types:

    12.1 Asbestos cement roof tile

    12.2 Concrete roof tile

    12.3 Corrugated roof tile

    12.4 Clay roof tile

    12.5 Metal roof sheet

    12.6 Aluminum roof sheet

    12.7 Asphalt roofing

    12.8 Asphalt roofing on gypsum

    12.9 Concrete slab (15 cm)

    12.10 Wood roof tile

    12.11 Transparent roof tile (polycarbonates)

13 Direction of roof, (N, S, E, W, NE, NW, SE, SW)

14 Angle of roof, $(^{\circ})$ from the horizontal axis

15 Color of roof

16 Layout of ceiling

17 Area of ceiling, (m^2)

Step 3: Calculation Process: This process calculation about OTTV and RTTV

Step 4: Value from Calculation Process: Show value from step 2

Step 5: User Input Type of Insulation

> 1   From this step user can select type of insulator that has 31 choices and other that user can input properties of insulator for wall and roof and input cost of insulation.

> 2   User will choose type of glass for windows and doors that have 5 choices; solar reflective glass, low-E glass, laminated glass, heat stop glass and user can input properties of other glasses.

Step 6: Calculation Process of OTTV and RTTV.

> This step will calculate as follow: OTTV and RTTV base on standard of law in energy conservation

Step 7: This step will decide if value OTTV and RTTV in the last process not less than OTTV and RTTV in the fist step of calculation process, user will try again for select new insulator.

Step 8: This step will show value of calculation process from step 6

Step 9: User Input Data of energy

> 1   Input cost of electricity

> 2   Input cost of insulation

> 3   Temperature inside the house.

> 4   Area of wall between rooms inside (partition)

> 5   There 12 types of opaque wall between rooms inside (partition) I

>> 5.1   Brick wall (80 mm)

>> 5.2   Brick with cement coating wall (100 mm)

>> 5.3   Double brick with cement coating wall (200 mm)

>> 5.4   Concrete block with cement coating wall (90 mm)

>> 5.5   Brick and concrete block with cement coating wall (200 mm)

>> 5.6   Concrete wall (100 mm)

>> 5.7   Metal sheet (8 mm)

5.8 Hardwoods (20 mm)

5.9 Wood with gypsum board (130 mm)

5.10 Brick with cement coating wall and gypsum board (130 mm)

5.11 Double brick with cement coating wall and gypsum board

(230 mm)

5.12 Gypsum board (9 mm)

6 There are 2 types of transparent wall between rooms inside (partition) I

6.1 Clear glass (8 mm)

6.2 Tinted glass (8 mm)

Step 10: Calculation Process of energy consumption saving and cost

This step will calculate as follow:

1 Energy consumption saving

2 Investment cost

3 Cost of energy saving

4 Pay back period

Step 11: Value from Calculation Process: Show value from step 7