CHAPTER VII

CONCLUSIONS

Through this study existing algorithms for constructing hourly weather data and calculating hourly heat gain and heat loss through building envelope were studied and applied to identify energy optimizing building shapes for 16 different orientations in a given location.

By studying climatic forces on the built environment and human comfort, critical weather elements were identified. In addition, using TMY (Typical Meteorological Year) methodology a set of 8760 hour weather data which might represent the long term climatic conditions in Oklahoma City area was prepared.

A computer model was prepared to calculate hourly building heat gain and heat loss amounts through opaque building materials and windows using the Heat Transfer Function method, which was introduced by ASHRAE, and conventional UAdT method, respectively.

Finally, through computer simulations with the given building data and hourly weather data, energy optimizing building shapes for 16 orientations in Oklahoma City area were identified.

The following conclusions were drawn as a result of the hourly heat gain and heat loss simulations.

1) Winter climatic conditions have more impact on building energy requirements than summer climatic conditions in the Oklahoma City area. Figure 7.1 shows the daily average heat gain and heat loss through the unit surface area of the walls of 16 orientations and the roof in summer and winter. In addition, the National Climatic Data Center[1] indicated that the average heating degree days in the Oklahoma City area was 3865 °F-days versus average cooling degree days of 2036 °F-days for the ten year period of 1976 through 1985.

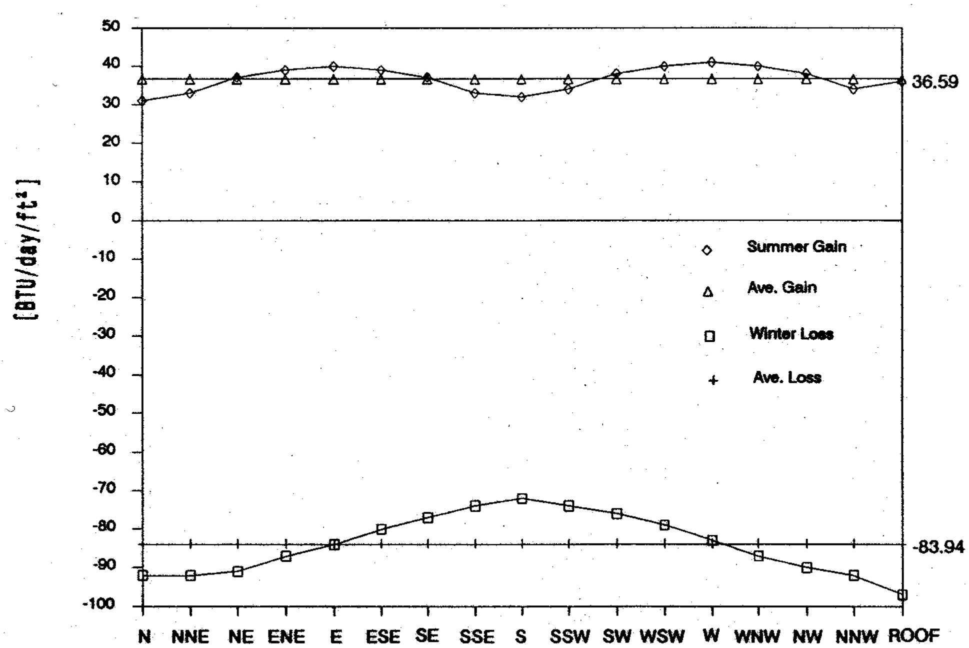

Fig. 7.1 Daily average heat gain and heat loss through unit surface area [BTU/day/ft²]

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[1] NOAA: "Local Climatological Data, Annual Summary with Comparative Data, Oklahoma City, Oklahoma, 1985"

2) In winter, provided that the same materials are used in all wall constructions, the north wall causes more heat loss than the walls of other orientations, because of no direct solar radiation on the north wall.

3) In summer, the west and east walls cause greater heat gain than other walls because of long exposure to the low sun rays in the morning and afternoon, which result in more intensive direct radiation on them.

This observation might suggest that more thermal insulation be given to the north, east and west walls, to minimize winter heat loss through north wall and summer heat gains through east and west walls.

4) Most of all, as shown in figure 7.2, the buildings oriented toward the south or south-east directions and having optimum shapes for those orientations result in the least amounts of heat gain in summer and heat loss in winter. These buildings yield nearly 30% less heat loss in winter and 70% less heat gain in summer than any buildings that have main window walls not facing the south or south-east directions.

5) As indicated in the table 6.8 and figure 6.6, the optimum width-to-length ratios for a building that has its main window wall oriented toward the south are between 1:1 and 1.3:1, which are elongated along east and west axis as illustrated in figure 7.3.

6) Table 7.1 shows the optimum building shapes in terms of the building width-to-length ratio for each of 16 orientations

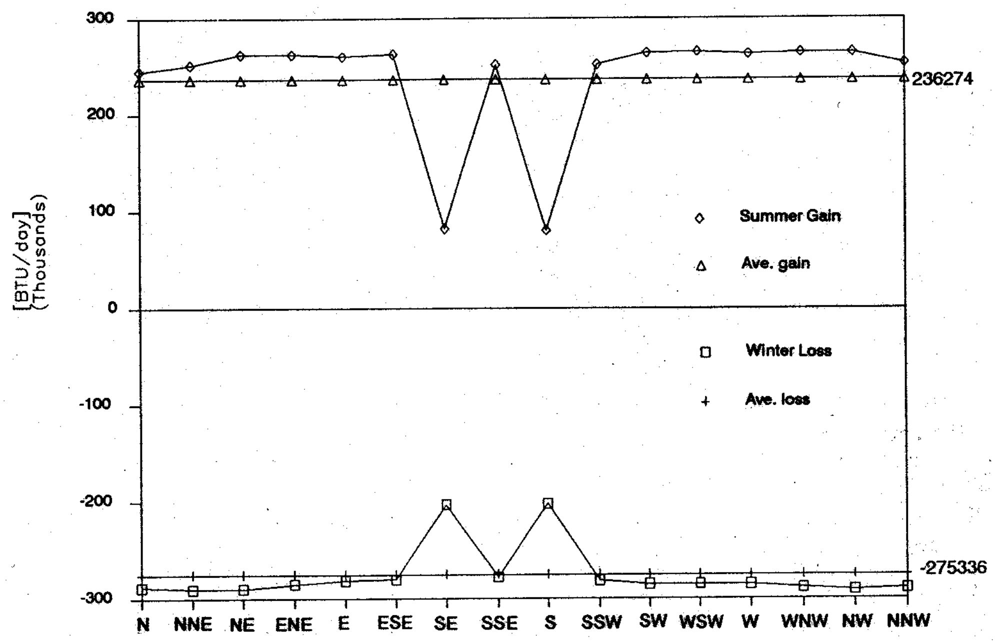

Fig. 7.2 Daily total heat gain and heat loss through walls and roof [BTU/day]

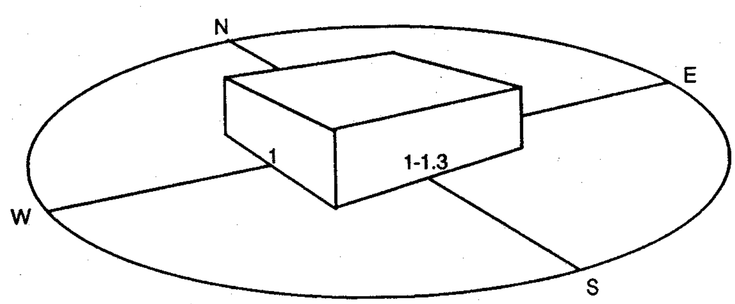

Fig. 7.3 Optimum building shape for a building orientated to 0° south

Table 7.1 Optimum width-to-length ratio for each of 16 orientations

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
Winter	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1
Summer	1.3:1	1.2:1	1:1	1:1.2	1:1.3	1:1.2	1:1	1.2:1	1.3:1	1.2:1	1:1	1:1.2	1:1.3	1:1.2	1:1	1.2:1
Optimum W-to-L Ratio	1:1 to 1.3:1	1:1	1:1	1:1	1:1 to 1:1.3	1:1	1:1	1:1	1:1 to 1.3:1	1:1	1:1	1:1	1:1 to 1:1.3	1:1	1:1	1:1

7) Finally it is concluded that the elongation along the east and west axis results in optimum heat gain and heat loss in both seasons for the buildings oriented toward the south, north, east and west, while a square form results in optimum heat gain and heat loss for the buildings toward other orientations.

It should be noted that the assumptions for the computer model were limited to facilitate this study. Further development of the computer model to consider different roof shapes, multi-room buildings, and heat gain and heat loss due to wind effects would represent considerable enhancement and enable the architect to make decisions on a basic building shape in the design process. In addition, it would be possible to create a set of design guidelines to optimize heat gain and heat loss in historic preservation districts in which new construction is subject to strict architectural criteria that may include building orientation, building proportion and materials.