Chapter 4

4.1 Validity of Assumptions made

Before we can judge the success of the Monte Carlo Method, we first need to look at the assumptions made. Some of them can be justified in the end by the comparing the results of the full simulations with the results of the Monte Carlo method, some, however, may not be justified in this manner. They will have to be re-evaluated at this time.

1) The use of Quick will not invalidate the results.

Since the method needs a deterministic method, one had to be chosen. Because of the extensive verification done on Quick, we can accept the method. (Van Heerden, E., 199?)

Conclusion

2) Five years of data is enough for the statistics to be accurate.

There is no way of knowing this for sure, and the only way to test it would be at least it against a larger period of weather. If we had such a period, we would have used that from the start. We should therefore state our answer in the form: "During the years 1994-1999, the building would have performed in the following manner..." This is a case of doing the best with what is available, and is enough to test the method.

3) The calculation of diffuse radiation is accurate enough.

The lack of measured diffuse radiation data is a difficulty for all simulation techniques, and the best method available for finding the diffuse radiation was used. The global radiation is the most important, and therefore the effect of diffuse radiation should be minimal.

4) The method will be valid for different homes and cases from that used for the simulations.

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3) The calculation of diffuse radiation is accurate enough.

The lack of measured diffuse radiation data is a difficulty for all simulation techniques, and the best method available for finding the diffuse radiation was used. The global radiation is far more important, and therefore the effect of diffuse radiation should be minimal.

4) The method will be valid for different houses and cases from that used for the simulations.

Because the method makes no assumptions about the building itself or variables other than climatic variables, it should be valid for all buildings and variables other than climatic variables.

5) No unacceptable errors were introduced by assuming that the temperature and radiation can be considered independent.

The most important question we have to ask ourselves is how large an error did we introduce by assuming that temperature and radiation can be taken as independent variables. If all the data is considered, there is a mean error of 0°C and a standard deviation of 1 degree. This result is better than expected, and within the range of errors we can expect from any thermal simulation.

When the data is split up into different categories, the assumption of independent variables again did not introduce any large errors. We can therefore conclude that assuming that temperature and radiation are independent variables did not introduce unreasonable errors, and we can safely continue with the method.

4.2 Success of the Monte Carlo method

The Monte Carlo method produced good results for the case studies. If the results from the method are compared with the results of the full simulations, we see that if all the data is considered, the mean error is -0.68°C, with a standard deviation of 1.37°C. When the different categories are considered, again the result is acceptable. The main aim of this study was to develop such a Monte Carlo method to calculate the inside temperature statistics of the building heat transfer problem.

It was shown that the method developed successfully approximated the inside temperature statistics for a five-year period by using only 72 (18 days per period of constant weather, with four such periods for this location) days, instead of the 1826 for a full five years. This means by using only 4% of the total data, a good approximation of the output statistics could be found. If a longer period of weather is used as input, there would still be only 18 days needed per period of constant weather.

The method is very practical and easy to understand, and can be used together with any deterministic method. It is open to include more variables, by simply setting up the statistical distribution of the input variable, choosing the nine days to simulate, and convoluting the end distributions.

4.3 Possible improvements

From what was discussed the first improvement suggested is to change the shape of the PDF's created by the Monte Carlo method. At the moment they are simple triangles. If one considers that the area's are normalized, i.e. made equal to one, then the occurrence values of the input distributions used does not make that much of a difference.

To explain: the values of the input occurrence values used were that at the first non-negative occurrence value, the most occurring value and the last non-negative value. The first and the last values are obviously small compared to the middle value. Then a simple triangle is constructed, and the area normalized. From this we can take the base length, the difference between the first and last non-negative value, as a known quantity.

Then the height of the triangle can be found from the formula for the area of a triangle: area = 1/2 x height x base, or in terms of the height: height = (area x 2) / base. With area = 1, the only variable remaining is where the highest part of the triangle lies.

Furthermore, the real distributions are not very triangular in shape. It is therefore suggested that the complete shape of the input PDF is used to build a PDF from the three data points found by the Monte Carlo method. In figure 4.2-1 a typical temperature output PDF for the convolution process is show, together with the triangular PDF created for the same case by the Monte Carlo method.

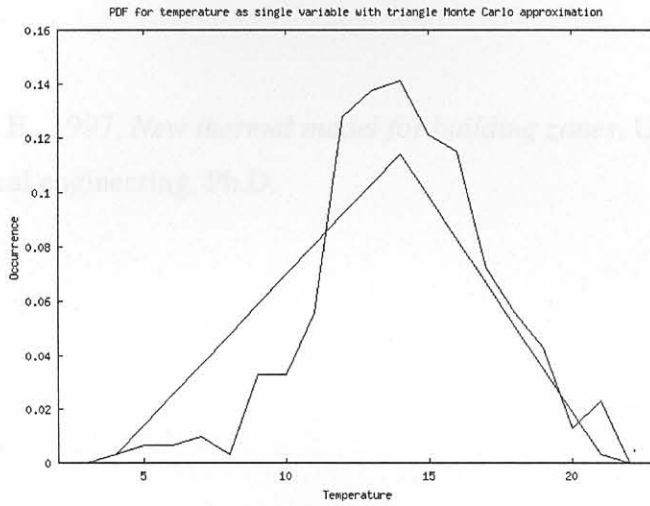PDF for temperature as single variable with triangle Monte Carlo approximation

Figure 4.2-1

The next area open for improvement is the diffuse radiation used at the moment. Measured data is most definitely the desired option. If that cannot be found then a method will have to be found that can include parameters such as overcast days, where the diffuse radiation will differ considerably from that found by a clearness index method. With a clearness index method the diffuse radiation is considered in a fixed relation to the global radiation for a certain month.

The last improvement is the time-span for the raw weather data used. For this exercise only five years worth of data was used. The more data is used, the more accurate the input distributions will be. Also there may be unknown weather cycles spanning more than five years.

References:

VAN HEERDEN, E., 1997, *New thermal model for building zones*, University of Pretoria, Mechanical engineering, Ph.D.