Building Codes and Energy Simulation

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The Centre for Building Performance Research at Victoria University School of Architecture has recently concluded R&D for the Energy Efficiency Clause of the New Zealand Building Code. This report, contributed to the BEPAC Newsletter, discusses some of the issues that arose in the course of the work.

I would like to begin with definitions of the awfully dry terminology of the NZ Building Code (1 July 1993). If you bear with me on this, I hope you will find that building codes provide a unique test of the validity and practical application of simulation. In the Code a performance statement is supported by non-mandatory **Approved Documents** which may be used to demonstrate compliance. These may include an **Acceptable Solution** ('this answer is acceptable') and / or a **Verification Method** ('this "test" can be used to verify compliance'). The current **Clause H1: Energy Efficiency** has an Acceptable Solution for housing (a table of R-values dating back to 1977); and a Verification Method (a numerical Building Performance Index calculated using Annual Loss Factors (ALF[1])). For all other building types, there is only a Verification Method, which is a simple checklist of measures the designer "shall take (into) account."

In 1993, specification of ALF as a Verification Method placed New Zealand at the forefront of countries developing energy efficiency codes. Using it, a designer is able to account for direct solar heat gains as well as conductive heat losses. Unfortunately, the "index" of performance in the Code (units: $kWh.m^{-2}.DegDay^{-1}$) is normalised for climate coldness, so that it produced the same index of performance in climates with New Zealand latitudes as widely varying as Seville and Munich or Los Angeles and Portland (Oregon). Code compliant construction is therefore the same throughout the country.

The overall code is performance based. It defines only minimum standards, not "good design" and was introduced in response to industry dissatisfaction with the heavy costs of meeting the previous complex web of legislative requirements. Recent government moves to respond to international climate change agreements, and a desire to place the Energy Efficiency Clause of the NZBC in a performance formulation provided an opportunity to update the requirements for both residential and non-residential buildings.

A review of data on all buildings constructed since 1970 suggested a separation of building code provisions according to building size (under and over 300 square metres) and height (under and over 3 storeys). Following this review, the R&D followed a conventional international pattern[2]. Modelling of minimum design alternatives was conducted in the simulation programs SUNCODE-PC[3] and DOE 2.1E[4]. For the NZBC, the main differences from convention have been requirements to focus on: minimum acceptable levels of performance; net positive economic lifecycle benefits; and energy efficiency (improving benefits) rather than energy conservation (less energy use).

Two stand alone houses, of nominal floor area 100 m^2 and 200 m^2, were modelled using SUNCODE-PC, in four climates. For commercial office buildings, two buildings of nominal floor area 3,000 m^2 and 15,000 m^2 were modelled using DOE 2.1E in the same four climates. Sensitivity studies were carried out on the assumed internal loads, the window to wall ratio, the operating schedules and the HVAC system type. Additional studies were conducted on eight (8) other building uses: Supermarket; Retail Warehouse; School; Apartment Tower; Hotel Tower; Retail Tower; Motel Row; and Retail/Office Row.

An early personal goal of the R&D team was development of a single energy performance coefficient for all building types that could be used as the target in a Verification Method. However, it soon became apparent that there was a reluctance in government to incorporate into the legislation the full technical complexity of all potential combinations of location, occupancy types, hours of operation etc. These were to be left to the Acceptable Solution(s). Consequently, on release in 1995 of the draft revised Clause some lobbyists pointed out that contrary to the exact performance specifications in other Clauses of the Code the energy efficiency Clause had no specific numerical performance "index". The most recent draft includes a performance "index" for houses. Whilst similar to its climate normalised predecessor, it does differentiate between the performance of a house in a cold and a warm climate. All other quantified (numerical) requirements have been incorporated into Acceptable Solutions. Each Acceptable Solution, in turn, has been developed with three levels of tools - a Schedule Method (a table of R-values), a Calculation Method and a Modelling Method.

As each tool requires significant development, it was necessary to determine which building type(s) would be covered by each tool. This determination was made on the basis of an analysis of NZ construction over the past 24 years. This clarified the development priorities for design support tools. The greatest benefits were thought to come from providing tools which simplify the compliance process for the 13,200 small and low residential buildings constructed each year. Conversely, the complexity and individuality of the 58 large and tall buildings constructed each year make development of support tools costly and reduce the likelihood of any one code tool providing a major benefit.

The benefits of implementation in the small low residential buildings include: energy efficiency improvements in this sector affect some 60% of the total floor area constructed per year; and, skilled energy design analysts are unlikely to be involved

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so simple design tools are likely to be highly sought after. A survey of 80 designers, builders and enforcement officials[5] found New Zealand designers, builders and code officials have some interest in the creation of improved energy efficiency in their buildings. Most believe that energy efficiency in buildings is a worthy goal, but implementation is limited by their perceptions, owner disinterest or the belief that energy efficiency is associated with additional costs. There is a perceived client requirement for a minimum capital cost design rather than a minimum lifetime cost. Any tools for the majority of the design professions represented by this snapshot sample of the industry must be simple and cheap to apply.

This conclusion is supported also by the differences in practice amongst the designers surveyed: the existing advisory standard for commercial building energy efficiency (NZS4220:198?) had been used by over half the engineers for code compliance in the previous year. ALF, the more simple to use residential code compliance method was used the least; only (9%) of the respondents had used it in the past year.

It is presumed that the current lack of interest in verification methods will change as the required thermal performance levels become more stringent. New Zealand industry's acceptance of verification methods for structural compliance would tend to support this conclusion as would the California energy efficiency experience: "Currently [in California] it is estimated that 80% of houses use the computer methods, and only 5% use the prescriptive packages."[6]

The Calculation Method in the Acceptable Solution uses an area-weighted envelope thermal resistance formula similar to the ASHRAE OTTV[7] procedure. For the first time in New Zealand, glazing heat losses must be included in this calculation. The area weighted envelope thermal heat loss is calculated for both a Reference Building and for the Proposed Building, and the heat loss for the Proposed Building must be no worse than for the Reference Building.

The Modelling Method also requires that a Reference Building's energy performance may not be exceeded by the Proposed Building. The Modelling Method permits almost any "model" to be used. In the industry survey some computer "simulation" tools were used for calculating air conditioning requirements. There was no commonality in the tools used. Rather than test every computer thermal modelling program available throughout the world, the IEA's "Building Energy Simulation Test (BESTEST) and Diagnostic Method" is proposed as a means to evaluate the suitability of thermal simulation programs[8]. This test is based on single "room" test cell data. There are undoubtedly questions which could be asked about its suitability as a certification process for performance calculation tools which will primarily be used to model complex multi-storey buildings. The only measure of reassurance we have been able to draw is that the new Clause does not specify HVAC performance, it concentrates on building fabric and lighting.

With the exception of the engineers, most professional groups surveyed showed a preference for checklist type design support tools. Manual calculations were least favoured, with computer calculations coming in between in popularity. Engineers favoured computer calculation over the checklist. Architectural designers were equally divided in preference for checklists and computer tools. Taking CAD use as an indicator of high level computer use, 83% of the engineers use CAD and thus could be expected to be able to utilise complex computer based design support tools with most ease. However, although 89% of those surveyed did some kind of computing, the overall industry use of CAD is only 42.5%!

Respondents were asked at which stage of design they would like tools to be applicable. Preference was very clearly towards tools that could be used "early in the design process". Preference was also clearly expressed for tools that could inform the energy design process rather than just produce code compliance reports. Translating these preferences into useful tools for the future remains the challenge for all of us in building simulation.

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