DEEMED TO SATISFY?
Do the building regulations for conservation of fuel and power encourage design innovations which make optimum use of energy or are they too prescriptive? VALTOS* and ABACUS† argue here that they are too dictatorial and demonstrate the point with a design exercise.

The regulations
The Building (First Amendment) Regulations 1978 for England and Wales contain regulation FF3 "Conservation of fuel and power".

A building or part of a building to which this part applies shall be so designed and constructed that the enclosing structure provides adequate resistance to the passage of heat the loss of which from the building or part would entail the consumption of fuel or power to enable temperature conditions normal for the proposed use of the building or part to be maintained.

Two approaches to complying with FF3 are set out in the deemed-to-satisfy provisions of FF4.

1 Walls, floors and roofs of a building must be designed and constructed to meet prescribed U-values and the total percentage areas of the openings provided for windows and rooflights in these walls and roofs must not exceed prescribed limits.

A wall, floor or roof may have a higher U-value provided the total rate of heat loss through all the walls, floors and roofs does not exceed that which would have resulted if the first approach had been adopted. Similarly the limits on openings for windows and rooflights may be exceeded provided that the total rate of heat loss through the glazed areas does not exceed that which would have resulted had the limits been observed, for example through the use of double or triple glazing.

Prescription and performance
It is important to draw a distinction between prescriptive and performance requirements. The deemed-to-satisfy provisions of FF4, by focusing on rate per square metre of fabric heat loss, prescribe allowable construction in large measure, thus precluding innovatory facade treatment such as solar walls, etc. More worryingly, it is entirely possible to satisfy the provisions with a design which, in terms of geometry, thermal mass, orientation, plant control, etc., may be profligate in energy consumption. Had the deemed-to-satisfy provision dealt directly with performance—maximum annual energy consumption based on occupancy and usage for example—the onus would have been on the designer to present a design solution, however innovatory, together with appropriate predictive evidence of its energy behaviour.

A test case
Take a hypothetical but entirely typical case: the prediction of annual energy requirement for a multi-storey rectangular hotel. The architect would be deemed to have satisfied the regulations by having solid walling of 0.6 U-value in conjunction with either 25 per cent single glazing or 51 per cent double glazing. The parameters are:

- Scale. The ground floor and single bedroom forms the basis of the exercise.
- Construction. Two wall constructions were considered. The first, 2a, is equivalent to a 0.6 U-value; the second, 2b, is equivalent to 0.35. The floor construction was taken as 150 mm concrete covered by screed and flooring. Glazed areas varied between 0 per cent and 80 per cent disposed unequally on north and south facades. It was assumed that 20 per cent footlights would be incorporated to match the maximum allowance.
- Site. The hotel is sited in the Thames Valley with the long axis on an east-west orientation.
- Occupancy. The floor considered comprises 28 bedrooms (each of 15 sq m) plus circulation and service spaces. Normal hotel bedroom occupancy patterns were assumed.
- Plant. A gas-fired hot water radiator system was assumed. The internal temperature was held at 20°C with the air changes varying over the day with a resulting average value of 0.66 in the single rooms and 1.0 on the ground floor generally.

A test of techniques
Some of the sophistication, or lack of it, of the regulations reflects the quality of the prediction tools designers have available. Three were tested.

Manual methods
Those typically used by M&E consultants based on the principles set out in the current CIBS (HIVE) guide.

RIBA/Textas calculator 'Degree day method'†
This method is based on traditional 'Degree day' routines. The calculator also offers an empirical method which takes more explicit account of solar gain but this is not appropriate in cases such as this where facade distribution is determined differently between opposite facades. To use the calculator, the designer enters the areas and U-values for the solid and glazed surfaces of the building envelope, an average internal and 'design' external temperature, the floor to ceiling height, the number of 'Degree days' for the site and two factors intended to make allowance for plant operation and useful internal heat gains.

ESP (Environmental systems performance) program‡
The ESP program is a dynamic model of the thermal behaviour of buildings which operates on hourly values of various climatological parameters (from Kew 1967 in this case). To use ESP the designer describes, as input data, the geometrical form of the building, the proposed construction, the mode of use and the prevailing plant-operating strategy. The program's predictions have been validated by the actual behaviour of real buildings.

Annual ESP simulations used a one-hour time increment and increasing percentages

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* VALTOS (a Glencoe-based architectural practice with offices in Richmond and Oxford) has a special interest in the energy performance of buildings.
† ABACUS is a research team in the Department of Architecture and Planning at the University of London studying developing countries and design, including the ESP programme described here.
‡ RIBA/Textas calculator 'Degree day method'.

1 Ground floor plan of test case hotel with no accommodation below.
2 Two types of wall construction used for the ESP simulation.
of single glazing. In all cases night-time curtain operation was included and for each glazing percentage the glazing was distributed 10 per cent on the north façade and the remainder on the south (except in the 80 per cent glazing case in which the distribution was 30 per cent and 50 per cent respectively). Corresponding RIBA/Texas calculator runs and manual calculations were performed by a graduate architectural student, a practising architect and a building scientist.

Conflicting predictions
ESP results for single glazing (the whole building U-value was 3-5) demonstrate a minimum energy requirement, 3 (point C/4), with 60 per cent glazing and computed as a 6-5 per cent energy saving on the no-glazing case (point C/1). The corresponding minimum points with the calculator runs and manual calculations occur in the no-glazing case (points B/1, B/2) and A/1(1).

In general the practitioner's calculator results were obtained by strict adherence to the values recommended in the user's manual tables, whereas the remaining calculator and manual results reflect an attempt to include an allowance for available, useful internal gain. Indeed both the calculator and manual method rely on the experience of the user to make such an allowance. In other words, these methodologies often take no explicit account of orientation, thermal mass, layout geometry, shading, variation in occupancy, casual gains, curtains and blinds or climatic variability (the manual methods shown in this and subsequent weeks' AJ 'Energy file' papers do include some of these factors).

Consequently, in the results no minimum energy point was obtained for positive percentage glazing values. On the other hand, the ESP model does make explicit allowance for the above factors by dynamically modelling longwave and shortwave radiation effects, surface shading and insulation, the operation of curtains, variable casual gains, the effects of ventilation and infiltration and the transient flow of energy through constructional elements.

Optimum glazing
When the energy savings are compared with the additional constructional investment, the 60 per cent single glazing/0-6 U-value solution (point C1/4) represents a cost-in-use advantage over the 25 per cent single glazing/0-6 U-value solution prescribed by the regulations (point A1). With 60 per cent single glazing and a U-value of 0-35 the savings are even greater. As energy costs escalate over the 60-year life of the building, the savings will become that much more significant.

Double glazing
Further ESP runs for double glazing resulted in a 17 per cent annual energy saving—at 60 per cent glazing and relative to the no-glazing case. Adoption of this scheme would result in a benefit in cost-in-use terms

3 Predicted energy consumption at differing glazing areas for the whole ground floor. The calculator and manual method tested neglect benefits of solar gain.

4 For a single room facing south the desired glazing area predicted by ESP suggests that energy consumption is largely independent of glazing area; any limit is pointless.
A single room

ESP simulations were performed for both heavyweight and lightweight internal constructions and as before night-time curtain operation was included. Calculator runs were performed as previously, 4. ESP results demonstrate that with single glazing the minimum energy requirement point corresponds to 35 per cent glazing (18 per cent energy saving against the no-glazing case) and that with double glazing the value ranges from 40 to 60 per cent glazing depending on the associated thermal capacity (yielding a 25 per cent to 35 per cent energy saving against the no-glazing case).

As previously, the steady-state results of the other methods show no minimum turning point for positive values of glazing area. For the constructions chosen, it is interesting to note that with double glazing in a lightweight structure, the dynamic analysis indicates an optimum percentage point less than the prescribed limit (51 per cent), whereas with similar glazing in a heavyweight structure the indicated optimum is more than the regulation allowance.

Limits of the regulations

While this was a limited and somewhat simple exercise, dealing primarily with glazing, it points to some important issues. Quite clearly, in the heavyweight construction case—and there is no reason to consider it atypical—the deemed-to-satisfy provisions limit the designer to a percentage glazing which is below optimum ‘conservation of fuel and power’. In other cases, the glazing allowed by the regulations may be significantly above the optimum. So slavish compliance with current deemed-to-satisfy, or indeed any other, prescribed values is unlikely to be in the best interests of energy conservation or cost-benefit.

Those designers concerned to pursue the goal of energy conservation beyond the constraints of deemed-to-satisfy provisions—and thereby save their client and the nation money—cannot rely exclusively on the techniques currently available on the RIBA/Texas calculator or on the commonly used manual alternatives.

Hopes for the future

Better techniques

A new generation of energy models—some already existing (e.g., ESP), more in the course of development—are enjoying a rapid take-up by architectural practices. These models deal explicitly with building geometry, orientation, thermal mass, shading, variable occupancy, climatic variability, plant operation and the host of other variables on which thermal behaviour is dependent. The benefit from this degree of precision lies not solely in prediction of energy consumption but in prediction of the quality of the internal environment.

5 Willis Faber and Dumas at Ipswich as it might be, deemed to satisfy?

6 The glazed skin has some energy advantages: in such a deep building 100 per cent double glazing may be possible within the regulations.

Progressively these models—some perhaps manually operated, some certainly computer-based, but all rigorously validated—will become easier to use and more readily accessible, even to the smaller practices, through existing or newly-formed consultancy agencies. Discussions are presently in hand on proposals to make such models available through a national network of regional centres.

Better regulations

Currently available and validated models clearly provide the necessary and sufficient evidence for bypassing the deemed-to-satisfy provisions by addressing the intention of FF3 directly. In the longer term there is the prospect of replacing the current prescriptive (and therefore restrictive) regulations with performance specifications—i.e. annual energy consumption ‘targets’. These targets would be established by controlled application of validated models to large populations of existing and hypothetical buildings.

Integrated approach

Ultimately there may be growing commitment to the concept of integrated appraisal models (in which very considerable work has already been invested), which allow energy considerations to be balanced against the entire range of cost and performance variables—including the issue of visual impact.

The choice open to practice, then, is clear: to take the soft option of mandatory constraint or to meet the challenge of the energy crisis head on.

References