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PREPRINTS—SESSION 2

Methods to improve the building envelope

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wall, which, according to the calculations, would lower the temperature level, and thus the influence of the moisture on the overlying floor construction.

Conclusion

Based on the measurements and calculations undertaken, it is almost certain that injection of insulation in crawl space basements is suitable in some form or other, like for instance:

a. Simple injection
b. Injection with external foundation wall insulation, possibly combined with drain pipes.
c. Like a. or b. with some kind of advance control of the boundary conditions as regards moisture.
d. Like a., b. and c. but with a fungicide mixed into the injected insulation.

When the project has been completed in 1 to 2 years, the empirical material is expected to be comprehensive enough for us to have found a method for the determination of the moisture and constructive boundary conditions which are clearly decisive of the choice of the method of insulation for a crawl space basement.

For the time being, we are of the opinion that closing the ventilation and measuring temperatures and moisture content in the soil below the crawl space basement after 1 to 3 months will result in the necessary boundary conditions for choosing the insulation procedure as insulation compared with this experiment will be an obvious improvement of the hygrothermal conditions in the floor construction.

The effect of insulation, mode of operation and air leakage on the energy demand of dwellings in the U.K.

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Summary

The paper describes the results of a computer study of the behaviour of two better insulated houses, one of rationalised traditional and one of timber frame construction. Their performance is compared with a contemporary house.

The conclusions of the study are that better insulation is an effective energy conservation measure, but the heavyweight characteristic of insulated structures results in intermittent heating being a less attractive means of reducing the heat demand. Air leakage, if not controlled, becomes an important component of the total heat loss and the consequences of its underestimation are explored.

Resumé

Cette etude décrit les resultats d'une etude par ordinateur sur le comportement de deux maisons avec une isolation meilleur, une a construction traditionelle rationalizee et l'autre a charpente en bois. Leur performance est compare avec une maison moderne.

On a conclu par l'etude qu'une isolation meilleur est une mesure effective en ce qui concerne les economies d'energie mais la nature lourde des constructions isolées a pour consequence que le chauffage intermittent est une methode moins satisfaisante pour reduire les besoins en chauffage. La fuite d'air, si elle n'est pas reglée, faite une partie importante des pertes du chaleur et les consequences de sa sous-evaluation sone etudiées.

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The most widespread and effective measure taken to conserve energy in dwellings has been the application of better insulation. What may not be appreciated in the first instance is that a better insulated dwelling may not behave as expected for a number of reasons. The factors considered most important are discussed in this paper.

The consequence of better insulation levels and therefore low fabric heat losses, is the emergence of the ventilation heat loss as an important factor which has to be explored.

Better insulation - background to research programme

The British Gas Corporation, as the dominant supplier of fuel for domestic heating, has an interest in the implication of future trends in building design and of the likely patterns of energy demand. An analysis of past trends and likely future developments in the provision of housing by traditional and non-traditional methods in the U.K. has shown that it is the rationalised traditional* and the timber-framed methods of construction which are likely to dominate the market. The study has also shown that because of changes in the structure of the population and other socio-economic factors, it is likely that the typical dwelling will have a floor area of around 80 m^2.

For this reason, the British Gas Corporation initiated a computer based study of the performance of these two types of better insulated semi-detached houses, one of rationalised traditional and the other of timber framed construction. In our view, the two types represent the practical limits of "heavyweight" and "lightweight" construction likely to appear in the mass housing market in the near future. The performance of these two better insulated houses was compared with a contemporary house, the insulation levels of which were based on current practice and conform to the requirements of the U.K. Building Regulations[1]. The size, plan and glazed areas of all three structures are identical and the total design heat loss as calculated according to the CIBS Guide[2], of the two better insulated houses are identical. Details of house construction, fabric and ventilation heat losses and of useful fortuitous heat gains are given in Table 1. The computer program which was used in the analysis of the thermal performance of the structures had been developed on the basis of the work of Rouvel[3].

* A method of construction based on traditional materials but employing standardised components and design details.

TABLE 1 DETAILS OF HOUSE CONSTRUCTION

	CONTEMPORARY	BETTER INSULATED	
		RATIONALISED TRADITIONAL	TIMBER FRAMED
Ground Floor	Carpet, concrete slab	+25 mm insulation & 20 mm wood floor	
First Floor	Suspended floor	Suspended floor	
Ceilings	Plasterboard on joists, 50mm insulation	Plasterboard on joists 100 mm insulation	
Roof	Clay tiles, felt	Clay tiles, felt	
Internal Walls	Lightweight block, plastered both sides	Lightweight block, plastered both sides	Plasterboard 50 mm air gap, Plasterboard
External Walls	Brick, 50 mm cavity, lightweight block, plasterboard	+ 50 mm cavity insulation	Timber frame, external brick veneer, 66 mm insulation, plasterboard
Glazing	single	double	double
Fabric heat loss Qf (kW)	4.4	2.2	2.2
Ventilation heat loss Q_v (kW)	1.5	1.2	1.2
Total design heat loss Q (kW)	5.9	3.4	3.4
Total diurnal useful heat gains (MJ/day).	63	63	63

The current U.K. practice of sizing space heating systems, as recommended in the CIBS Guide (1), is to calculate the heat loss based on an external design temperature of $-1^{o}C$ and then to add an extra 20% to the total. The additional 20% is basically in recognition of the fact that the external design temperature should be several degrees lower. The accepted sizing procedure therefore implicitly assumes continuous heating in cold weather.

However, a study[4] of the way central heating systems are used in the U.K. has shown that even in cold weather conditions the majority of householders (70%) operate their systems intermittently. (The reasons are - it is thought that intermittent operation results in a substantial reduction in fuel costs, house is occupied in the morning and evening only, heating system is grossly oversized thus permitting intermittent operation, lower comfort standards are accepted etc.). Although, strictly speaking, heating systems are sized to operate continuously at design conditions, it is just as important to examine the performance of structures at design conditions when heated intermittently as there is a high probability that in practice they may be heated in this manner.

Effects of better insulation

A structure will be subjected over the heating season to a wide range of climatic conditions, cloud cover being one important variable. In cloudy conditions the heat requirement, for continuous heating, will not vary significantly over a 24 hour period and its magnitude will depend on the level of insulation. The more complex phenomena associated with thermal storage in multi-layer walls affect the energy demand only to a limited degree. The difference in the thermal performance of structures is more accentuated on clear sunny days. For this reason, it will be the energy requirements and temperature variations of structures on clear days that will be used to illustrate the main point in the following discussion, although the original research investigated the performance of structures under a whole range of climatic conditions.

The energy requirement and the internal temperatures of practical intermittently heated better insulated houses on a clear day having a mean external temperature of $-1^{\circ}C$ are shown in Fig. 1. The limits of a band, within which the majority of better insulated houses would lie, are given by the performance of the "heavyweight", H, (rationalised traditional) and "lightweight", L, (timber-framed) houses. Also shown in Fig. 1 are the values for the contemporary house, C. For comparison, the energy requirements of continuously heated structures are shown in Fig. 2.

From Fig. 1 and Fig. 2 it can be seen that the diurnal energy requirement on a clear design day has been more than halved by a reduction of the design heat loss from 5.9 kW to 3.4 kW, i.e. 177 MJ instead of 394 MJ for continuous heating, and 149 MJ instead of 326 MJ when heating is intermittent. The reduction in heat requirement is not proportional to the reduction in design heat loss because of the way the structure can make use of incidental heat gains. The results of the study tend to show that there is little

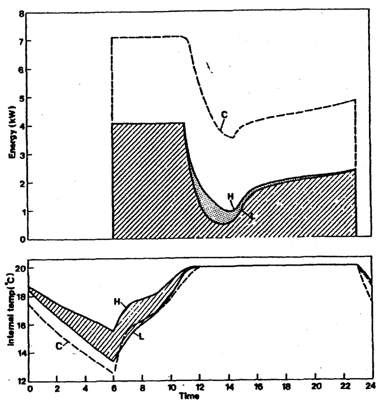

Figure 1. Energy consumption and internal temperatures on a clear design day (T_{mean} - $1^{\circ}C$), intermittent heating, plant size = 1.2 x design heat loss. H - rationalised traditional insulated house; L - timber-framed insulated house; C - contemporary house.

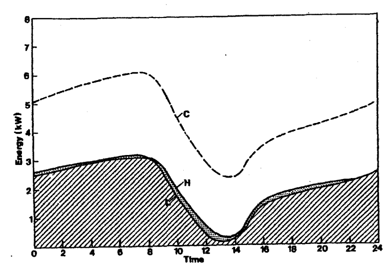

Figure 2. Energy consumption on a clear design day ($T_{mean} = -1^{\circ}C$), continuous heating, plant size = 1.2 x design heat loss.