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THERMAL PERFORMANCE OF RAIN-WETTED WALLS

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Pressure on sheltered sites is bringing more exposed locations into use for building. Consequently wind driven rain may be of increasing importance in determining the space heating requirements of national building stock.

Heat transfer across absorbent brick walls is increased by exposure to wind-driven rain. This is because the absorbed water lowers the thermal resistance of the brickwork, because evaporation cools the surface of the wall, and because during rainfall the wall surface is chilled directly. Conventional heat loss calculations make nominal allowance for the first of these mechanisms only.

Rough quantification based on the available observational data can be used to show that in exposed sites the increase in heat transfer due to reduced thermal resistance of rain wetted walls may be more than double the conventional allowance. The empirical evidence also suggests that, although no allowance is conventionally made for it, the increase in heat transfer because of evaporative cooling may also be significant. Direct chilling during rainfall is likely to be comparatively small in effect.

A mathematical model has been developed in order to study the performance of rain-wetted clay common brick walls as a function of geographical location, orientation and exposure. This model, coded in Fortran 77 is called WETWALL (Fig.1).

WETWALL results are consistent with the rough empirically-based quantification mentioned above.

Driven by hourly meteorological data (wind speed, rainfall, wet and dry bulb temperature, total and diffuse solar irradiation) recorded by the Meteorological Office at five widely-separated UK sites, WETWALL has been used to estimate cross wall heat transfers as a function of driving rain index. This has been done for cavity walls with and without insulation (conventional U-values 0.55 and 1.4 $Wm^{-2} K^{-1}$ respectively), and for solid walls (U 2.14 $Wm^{-2} K^{-1}$). Orientation-averaged results are presented graphically (figs 2 to 5) so that savings from surface treatment to render absorbent walls impervious, or from wind shelter at some distance from the building, can be evaluated simply for any UK site from the local omnidirectional driving rain index. The use of the graphical information is fully explained in the report presented to the PSA (see below).

It is found that surface treatment such as rendering will, if effective in preventing rain water absorption, produce savings ranging from almost nothing for brick built houses with cavity insulation in urban or sheltered locations in the east of the country to about 1500 kWh per year (in the region of 5 to 10% of the annual space heating requirement) for houses with 100 m^2 of uninsulated cavity brickwork in exposed locations in the west. Actual fuel savings will be increased beyond this range because of plant inefficiencies. 70% of the maximum saving is reached at a site specific driving rain index of 4 $m^2 s^{-1}$ which can be found anywhere in the UK outside the dry areas of eastern and central England, and will be frequent in the west where exposed sites will have much higher driving rain indices.

Savings from surface treatment of solid brick wall may as an upper limit reach five times the range quoted for cavity walls. However, the construction styles and more sheltered locations typical of older buildings are likely in practice to moderate this range.

The benefits of wind shelter vary with the protection factor achieved. Graphical information is presented (fig 6) which, for three wall types considered, allows estimation of the benefit of wind shelter with protection factor of 2 (halving of the windspeed), which is reasonable to assume in many practical situations. It is found that halving the windspeed (and hence the local driving rain index) has maximum benefit in energy saving at an antecedent local driving rain index of about 4 m^2s^{-1}. The corresponding savings for a house with 100 m^2 of absorbent external brickwork are estimated at about 240 kWh/year (walls cavity insulated), 740 kWh/year (cavity walls not insulated) and 3100 kWh/year (solid walls).

The area of external brickwork, 100 m^2, used here for illustration might apply to a detached house with 90 m^2 floor area. A centre terrace house of the same floor area could have about 40 m^2 of external brickwork and an end terrace or semi-detached house might have 70 m^2. For houses savings will scale approximately on wall area. For much larger buildings the savings will be relatively less because of the tendency of rain to deposit near edges.

This research is fully described in a report, Thermal Performance of Rain-Wetted Walls available from the Property Service Agency. I would like to thank Jeremy Dodd of the Property Services Agency, Eric Keeble and Tony Newman of the Building Research Establishment, John Prior of the Meteorological Office, Brian Day of Bristol University, Adrian Wyatt, Director of Energy Studies Unit and my colleagues, including support staff, at Exeter for their advice, comments and assistance in completing this investigation. I am grateful to Peter Richardson of Cornwall County Architects Department for introducing me to the problem in the first place.

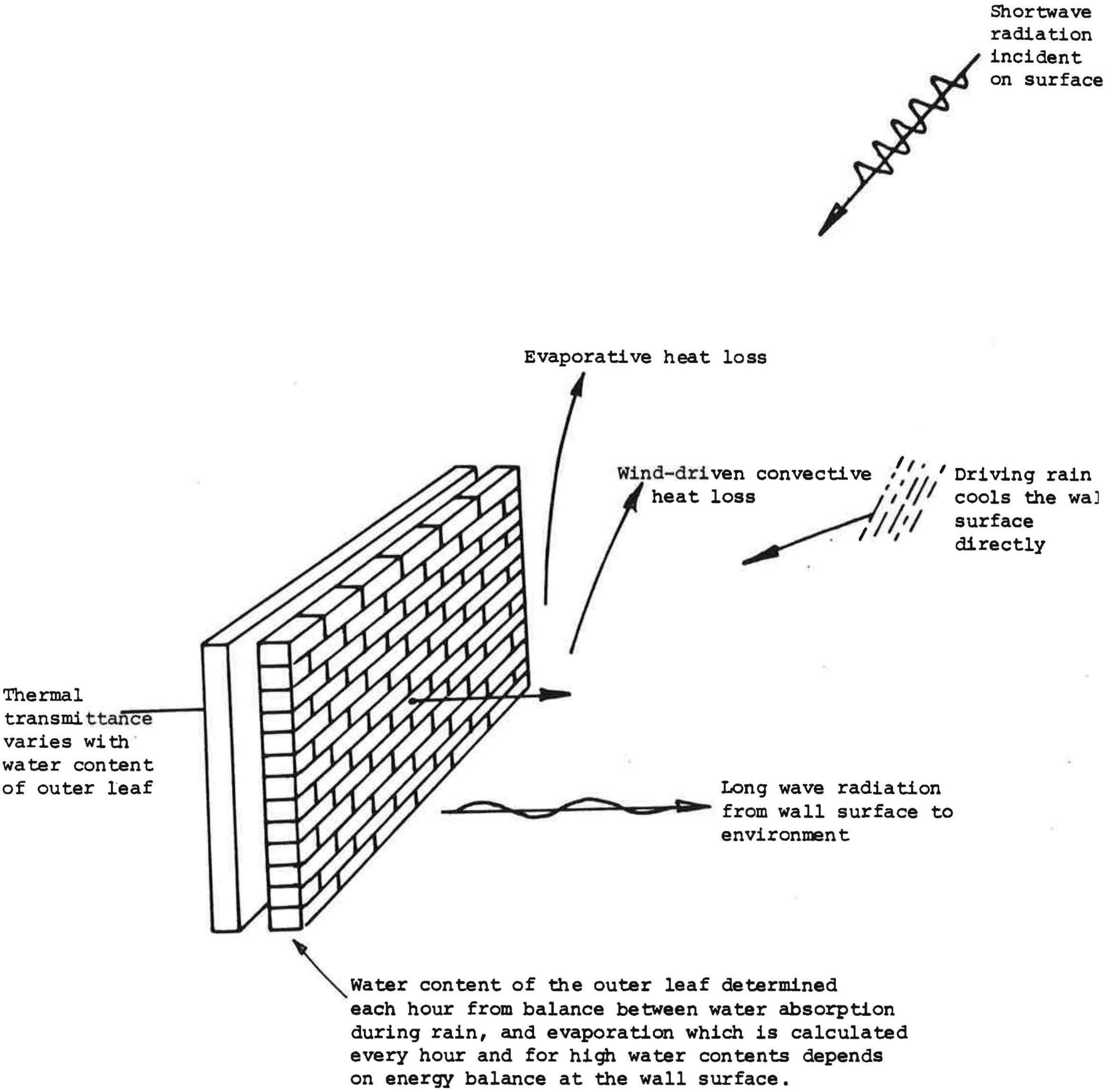

Figure 1 Qualitative visual appreciation of interactions considered in the WETWALL calculation of the impact of rain absorption and subsequent evaporation on cross-wall heat transfer. The WETWALL computer simulation allows for the first time realistic calculation of the reduction in space heating load due to surface treatment (such as render), or wind shelter to reduce the onslaught of wind-driven rain on the brick walls of buildings.

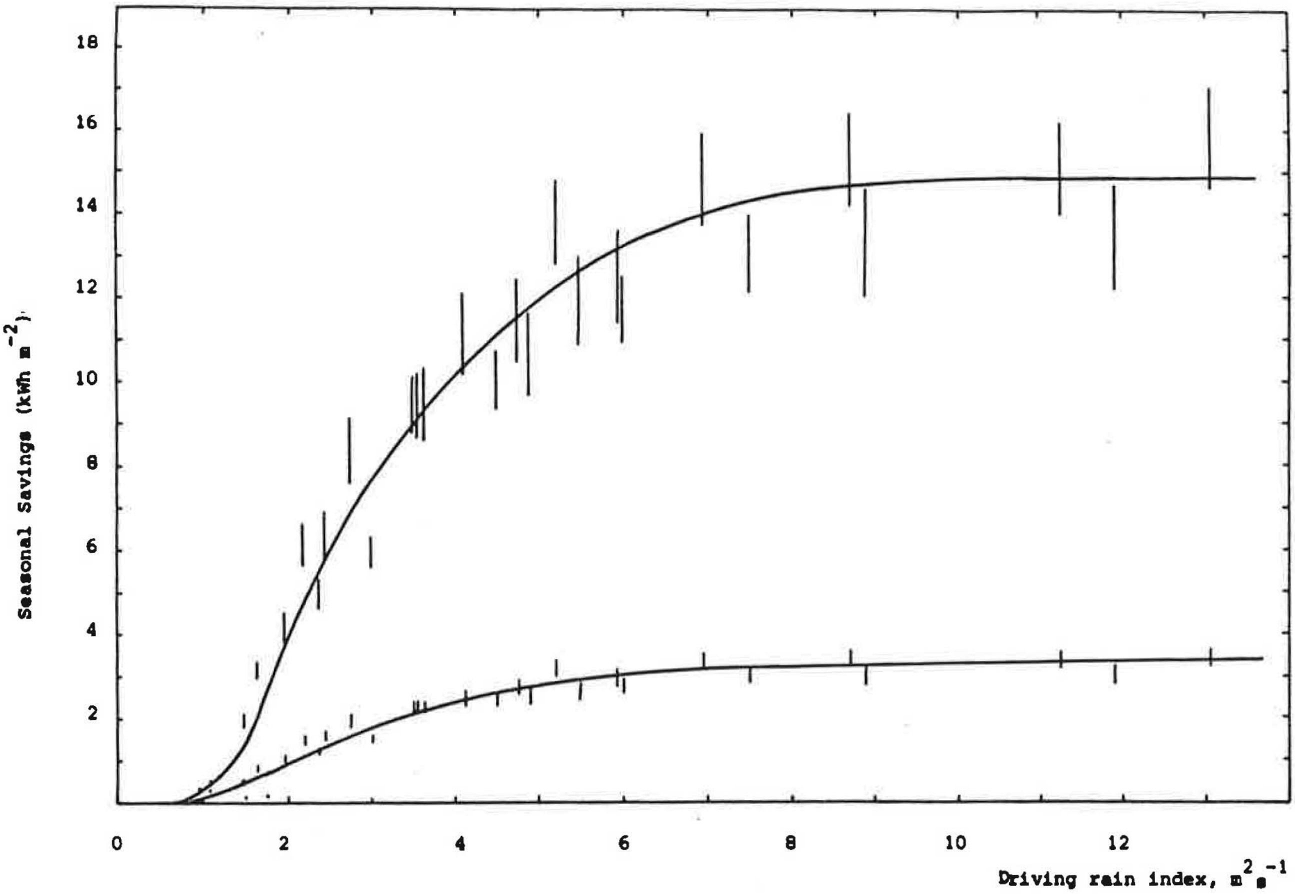

Fig 2 Seasonal savings from surface treating to render impervious insulated (lower curve) and uninsulated (upper curve) clay common cavity brick walls as a function of local driving rain index. Enclosure temperature 15.5°C yields lower end of error bar, 18°C yields upper. Data are orientation averaged.

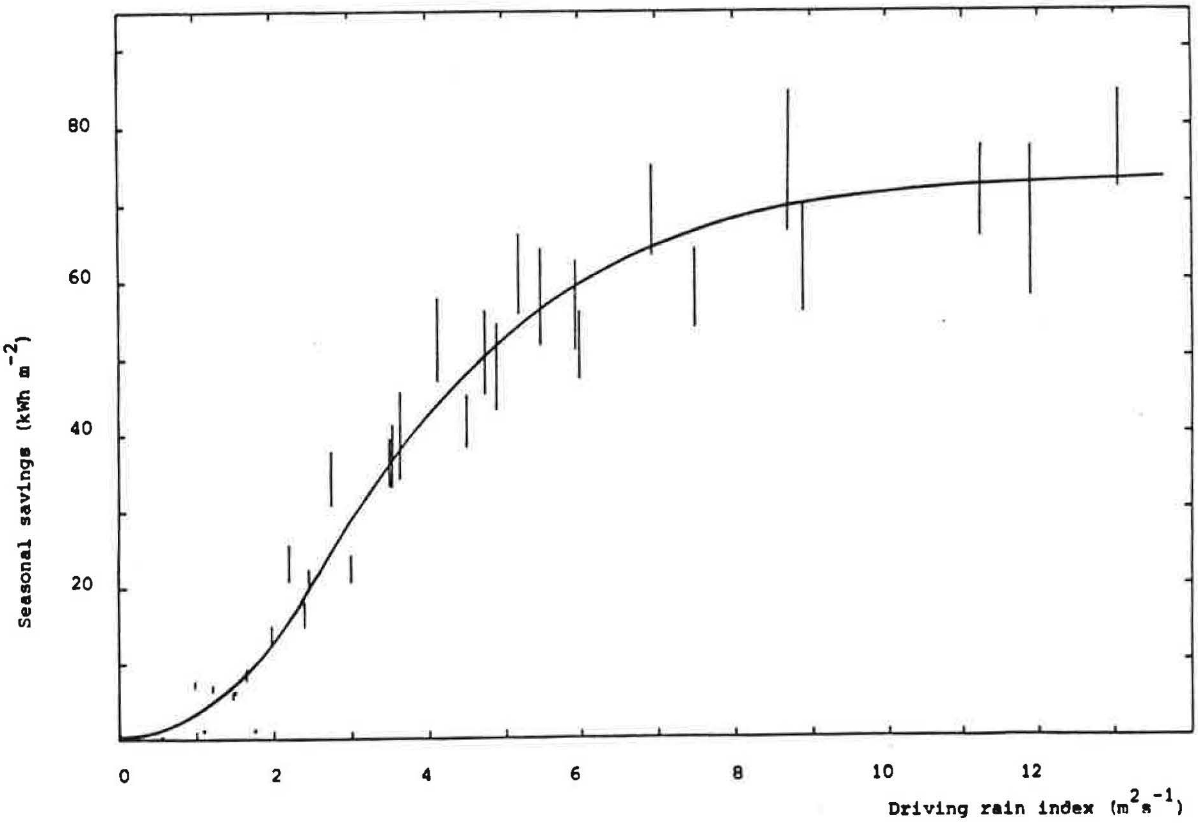

Fig 3 As fig 2 but for solid walls. Savings may in practice be reduced because of the constructional styles of older buildings.

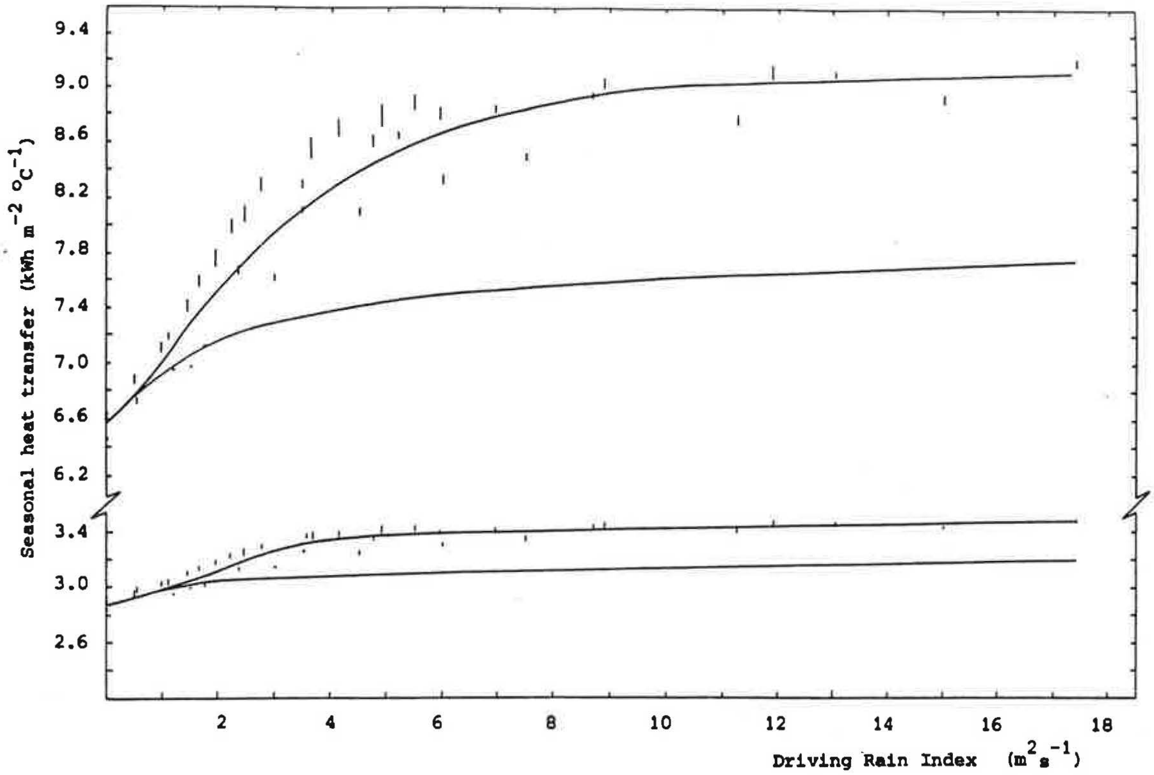

Fig 4 Orientation averaged seasonal heat transfer across insulated (lower curves) and uninsulated (upper curves) clay common cavity brick walls as a function of driving rain index. Calculated points are shown for absorbent walls only; the lower line in each pair is for surface treated walls. Seasonal heat transfers are expressed as kWh per m^2 of wall and °C of average inside - outside temperature difference (which should be about 10°C). These curves can be used to estimate the benefit of wind shelter.

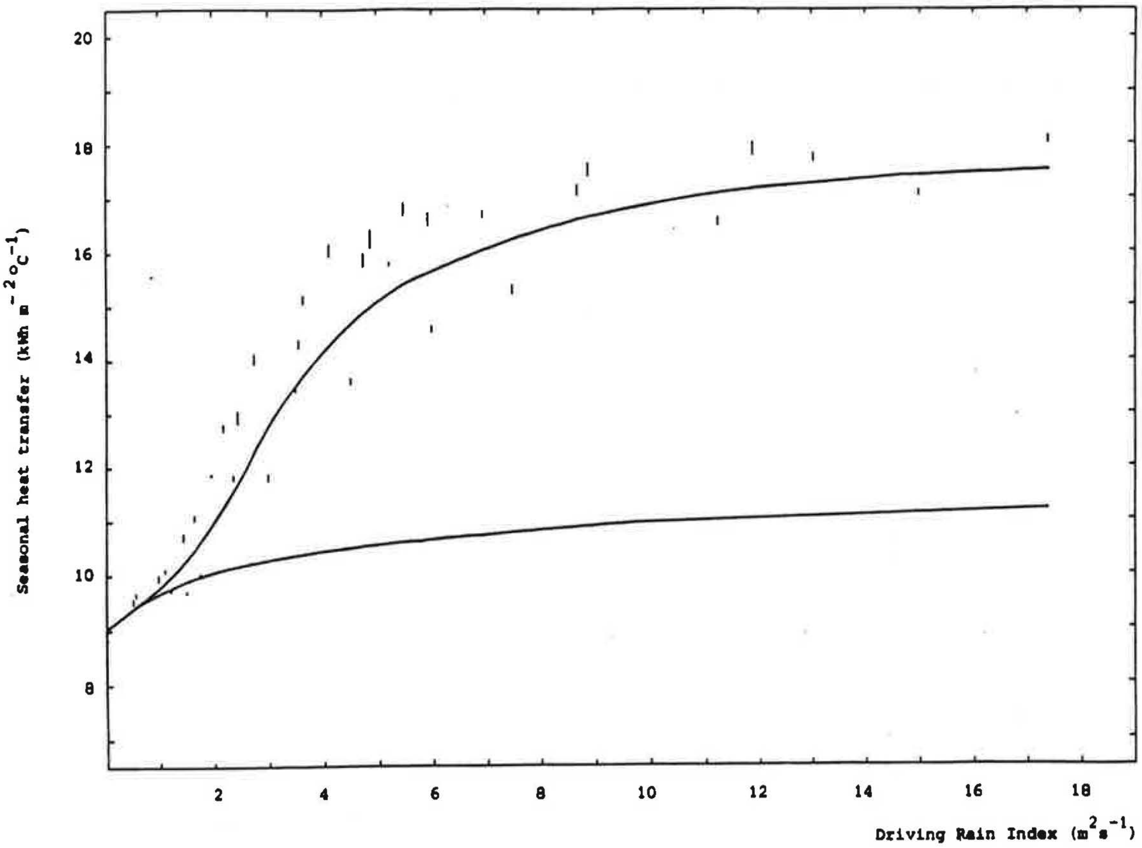

Fig 5 As Fig 4 but for solid walls. Savings may in practice be reduced because of the constructional styles of older buildings.

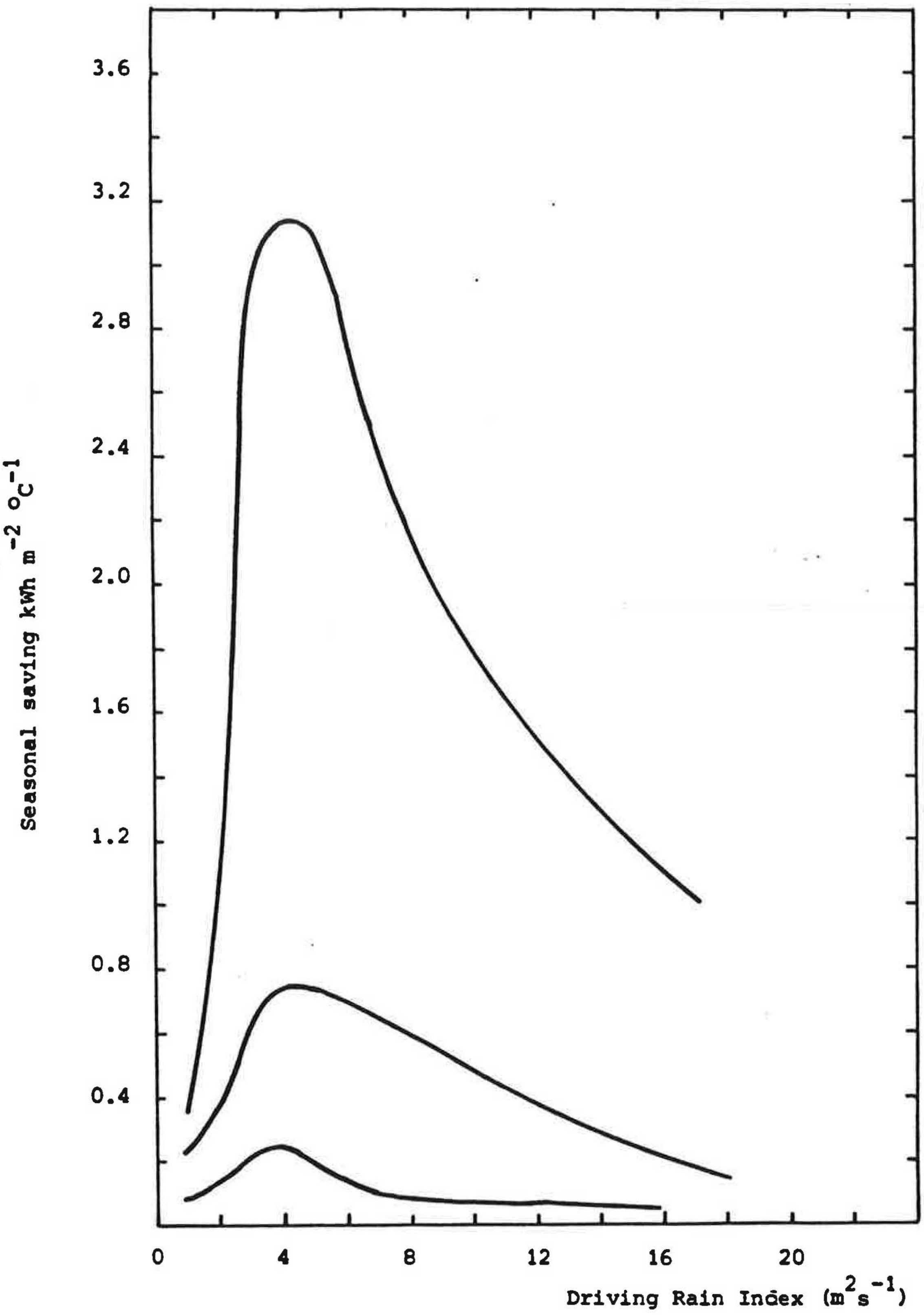

Fig 6 Benefits of wind shelter providing a protection factor of 2 against driving rain. Top curve is for solid walls, middle and bottom curves are respectively for uninsulated and insulated cavity brick walls. Walls are all absorbent and results are orientation averaged.