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Window to wall joints

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WINDOW TO WALL JOINTS

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Sealing failures, condensation, frame defects and poor dpc detailing are important reasons for water penetration around windows.

This paper briefly refers to some principles of weather protection, together with the related problem of accuracy, and makes recommendations for the design of window to wall joints.

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WINDOW TO WALL JOINTS

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INTRODUCTION

In a Symposium at BRE on weathertightness of buildings, criticism was directed to the edge joint between window and wall as a potential source of leakage. Just how universal or critical a problem this is, is impossible to estimate, but the experience of BRS, and of the Building Research Advisory Service suggests a fair amount of trouble from this source. Certainly no quantitative data is yet available. Potential sources of trouble are legion, and this paper can do no more than touch on a few.

However, indication from a number of sources [1] points to the need to keep aware of potential trouble. The paper draws on general experience going back over a number of years. It identifies likely sources of defects, and makes suggestions for their rectification. The comments are mainly confined to traditional forms of construction; that they may appear to be sometimes of an elementary nature does not automatically mean that they are always complied with. The illustrations are intended to demonstrate matters of principle rather than to be full working details.

Often the crucial problem in weathertightness seems to arise from repeated modifications to traditional details made for quite sound reasons in themselves, but leading to potential defects which were not foreseen. Such an example is the standard wood window in cavity brickwork. If the frame is protected by a rebate in the brickwork (as in a Georgian sash) then the comparatively small main sill will need a sub-sill to project the throating clear of the wall surface. If the sub-sill has to be omitted for economy, the window must be brought forward to the face of the wall, or even overlap it. A rebate is no longer possible and the problem becomes that of reconciling the rough brickwork with the smooth frame section in a butt joint situation. The usual answer is to specify 'mastic' which may fail after a few months. Anyway the porous brickwork of the reveal now provides a short-circuit for moisture.

Again, even assuming a 'mastic' joint is appropriate, it is not always possible to apply it easily on site. Figure 1 shows a window/wall joint from a BRS building. The original steel window had 'easy clean' hinges, which, when fixed against the reinforced concrete column, effectively prevented the operator from applying his gun to that area behind the hinge. On replacement, the previously hidden defect was revealed.

In both these cases the necessity to 'think the design through' in all its aspects, is clear.

SEALING COMPOUND FAILURE

The extent and direction of the movements to which a sealing compound will be subjected are not fully understood but relate to the materials used and the methods of construction. The joint should be accessible for application and repair, and either the frame or the wall should provide space of suitable size and shape with a firm backing against which the compound can be gunned. Well defined edges to this space assist the applicator in providing a neat finish and can show by inspection whether the full depth of sealing compound has been applied. Figures 2 and 3 show typical manufacturers' jointing details which patently do not satisfy the requirements outlined above. Seals may not be necessary for all joints and the performance requirements will vary for the situations in which they are used. However, as the majority of window frame sections are standard for a variety of situations it is of paramount importance that as much provision as possible should be made in the design of the frame rather than the cladding for the proper use of seals. Figures 4, 5 and 6 suggest how frame sections could be modified or redesigned to achieve this, although such modifications must take into account the limitations imposed by the materials used, the manufacturing process employed in making the section and the costs.

Figure 1 Failure to make good behind 'easy clean' hinge, which was later removed.

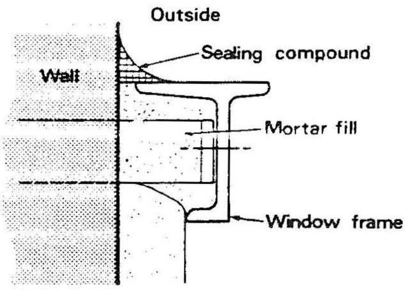

Figure 2

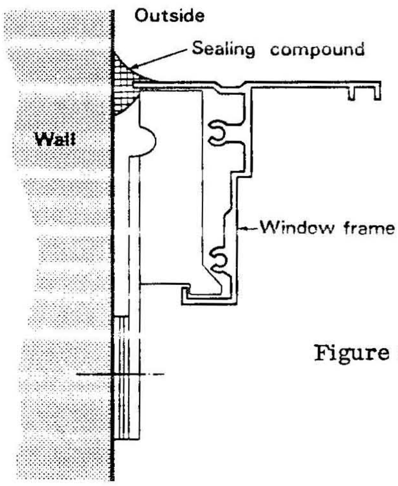

Figure 3

Figures 2 & 3 Typical manufacturers' details which do not make good provision for the application of sealing compounds

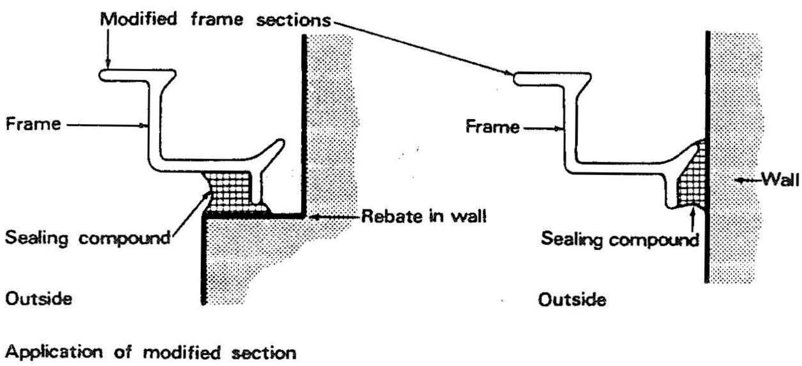

Figure 4 Suggested modification to standard steel window sections to provide recess for sealing compounds

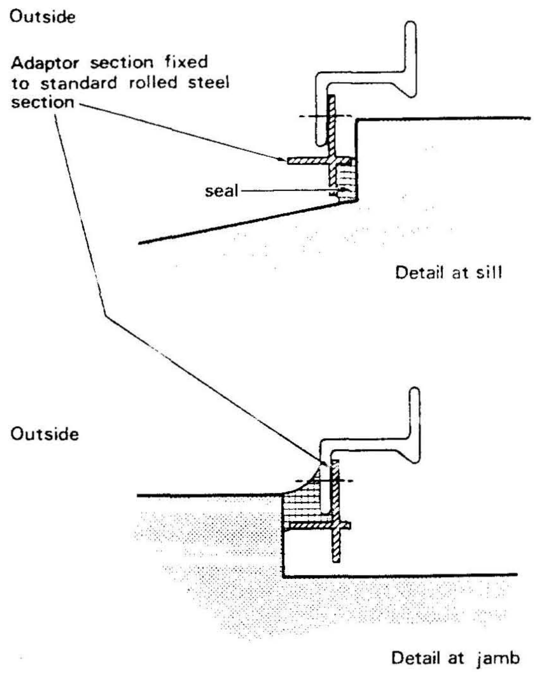

Figure 5 Suggested modification of standard steel frames to provide a recess for sealing compounds by use of an adaptor section

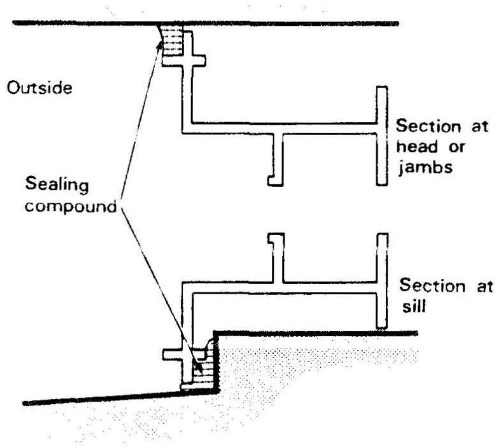

Figure 6 Suggested modification to aluminium frame sections to provide a recess for sealing compound

The problem of providing a good butt joint with sealing compounds is made difficult by the variability of joint width which occurs when frames are not cast or built in. In a recent BRS survey[2] deviations of ± 15 mm were found between in situ concrete columns and infilling windows. To cope with these variations of joint size it is sometimes suggested that the simplest solution would be to provide some form of overlap between the frame and the cladding, though of course a joint design should never be based solely on a single consideration such as dimensional variability[3,4]. This lap need not militate against the use of dimensionally co-ordinated components. Suggested dimensions for this lap have varied between 19 mm and 38 mm, but it is now possible to calculate the amount more accurately[5,6]. Unfortunately the details shown in Figures 2 and 3 are considered to be theoretically cheaper and this helps to perpetuate an unsatisfactory detail with consequent high maintenance costs.

The arrangements shown in Figure 7 illustrate one example of how fitting problems can be reduced by lapping, and provision made at the same time for sealing around the frame and protecting the seal. The principles are applicable for many types of cladding and frame.

Failure of the seal due to movements other than anticipated moisture or thermal movements can be caused by warping and twisting of frames, deflection and creep of the structure surrounding the frame, and movements of the frame due to loose fixings. Many of these defects could be avoided by more informed design, selection, sizing and use of materials. Deflection and creep of the structure surrounding the frame should be anticipated and allowed for.

Failure is probably more likely in 'working' joints (joints designed to permit movements of cladding and frame) than in 'non-working' joints (components bolted together through a bed of sealing compound), suggesting that improved performance could be gained if site joints were made non-working, with working or movement joints incorporated in the frame or a 'third member' during manufacture, although the possibilities of applying this in practice may not be numerous. It is obviously preferable for joints wherever possible to be made in the factory where controlled conditions for the application of sealing compounds or gaskets exist.

CONDENSATION

Condensation on the glass and on the indoor surfaces of metal frames may wet surrounding wall surfaces especially below the window, and may well therefore be misinterpreted as rain penetration. Drainage channels ought to be provided to remove this condensation, and correct diagnosis is usually straightforward. However, although there is no direct evidence on its occurrence, the chances are that some of the dampness thought to be rain penetration could be attributable to condensation within the frame. All hollow metal frames could be subject to this and large sheet metal sub-frames are particularly prone. Experiments carried out at BRS[7] suggest that sufficient water to saturate areas of walls is produced when the inside of the unfilled frame is exposed to humid air under appropriate conditions. Complete sealing or filling of the frame with a vapour impermeable material reduces the condensation to a very small amount. Complete filling of the back of the frame is however sometimes difficult to achieve. If condensation cannot be prevented the cladding around the frame should be designed to drain condensation out of the building. Trapping the condensate in a position where it can do no damage and can subsequently be evaporated is a possible alternative solution, but one which should be used with caution.

DEFECTS IN THE FRAME

Defects which allow water from sash rebates or similar features to enter the building are found in both timber and metal frames. In timber, loose knots and shrinkage splits have been known to let water through the sill. A feature which has caused considerable trouble is the practice of allowing water check grooves on the jambs and mullions to pass through the sill on the sides of tenons or comb fingers, thus providing a path for water penetration into cladding below (Figure 8). Badly fitting or decayed tenons can give rise to similar troubles. This source of penetration usually goes unnoticed if the frame has been built into the outer leaf of a cavity wall, but in solid walling, or where the frame is set in the inner leaf and no dpc tray is provided under the sill, dampness often results.

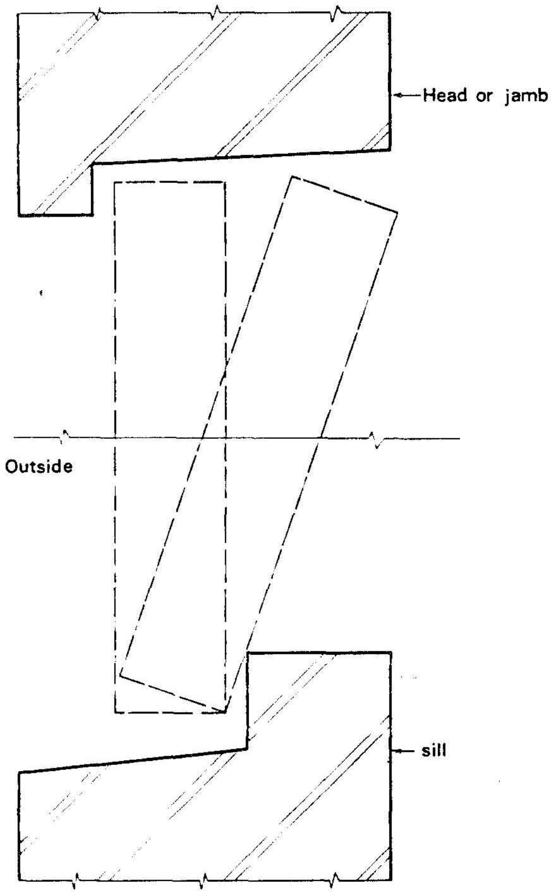

Figure 7 Timber window in concrete panel, suggested detail

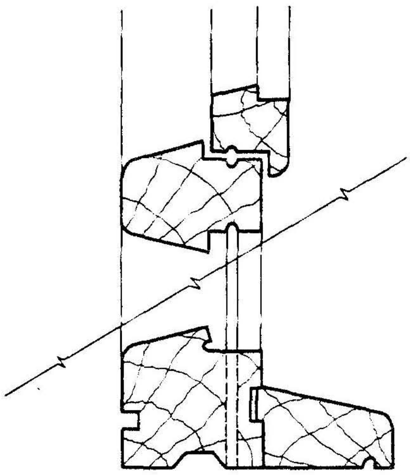

Figure 8 All or part of water check groove continues through sill on tenon

Some standard steel window sections, to make their application as universal as possible, have a variety of holes punched through the sash rebates both for fixings and the accommodation of fittings. When these holes are not filled in a made-up window they can become a source of water entry. Manufacturers' literature often shows the space at the back of the frame filled with a non-setting compound or 'waterproof mortar', the intention being to prevent the entry of water at these points. In practice, however, this can be difficult to achieve. Ideally these holes should be eliminated or a positive method of sealing fixing holes provided.

As with timber frames the corner joints in aluminium alloy windows are potential points of water penetration. All standard steel windows are welded at the corners and no trouble is experienced at this point. Aluminium frames employ a variety of methods of corner jointing. Flash butt welding is used to provide a rigid waterproof joint but this necessitates cleaning up and polishing operations. The welds also show through anodised finishes and this method of jointing precludes the use of pre-anodised or painted sections. Non-welded connections are, however, generally less satisfactory and may be disrupted in handling or fixing. Water penetration from this cause could, however, be prevented by designing the frame so that leakage through the corners was drained out of the building, eg by extending the sill member beyond the jambs and stooling the ends.

INCORRECT DETAILING OF DPC IN CAVITY WALLING

The two most likely causes of rain penetration around the frame in a cavity wall are bridging of the dpc between the inner and outer leaf and shrinkage of the frame away from the wall (Figures 9 and 10). In sheltered areas the vertical damp-proof course is commonly butted against the frame. This detail relies on the absorbency of the bricks in the outer leaf and will be unsuccessful in areas where the brickwork of the outer leaf is often saturated[8].

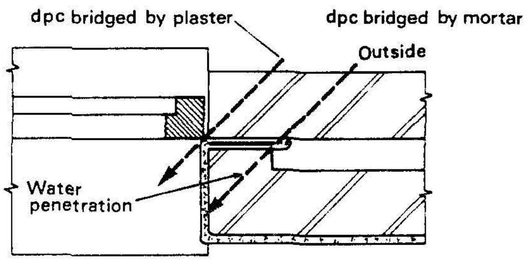

Figure 9

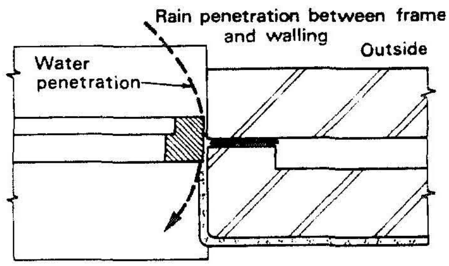

Figure 10

When standard timber frames are used in cavity brickwork with a half brick outer leaf, and no sub-sill is provided, the inside face of the frame is flush with the inside face of the outer brick skin, and bridging of the damp-proof membrane by the plaster can occur (Figure 9). Vertical dpm material of the same width as the brick is often used in this situation and this width is easily bridged on the cavity side by mortar droppings. Some authorities suggest that the vertical dpm and inner leaf of the cavity should lap the back of the frame. This detail is successful if neatly done and the damp-proof course kept in contact with the frame for its full height, but this may be difficult to achieve in practice. It also requires a wider frame section in many cases.

In cavity construction the dpm should form a complete break between the inner and outer leaf of the wall. This is sometimes achieved by nailing the dpm to the side of the frame, but this is difficult to handle on site as it involves bending and probably cracking the dpm and can make fixing of frame cramps difficult. A better solution is to provide a groove or rebate in the frame to ensure that bridging by the plaster is not possible, Figures 11 and 12. A similar detail can be achieved using a standard steel frame, Figure 13. Some American metal frames and some British steel sub-frames are provided with a long nib which can be used either in place of a vertical dpc or in conjunction with it, Figures 14 and 15.

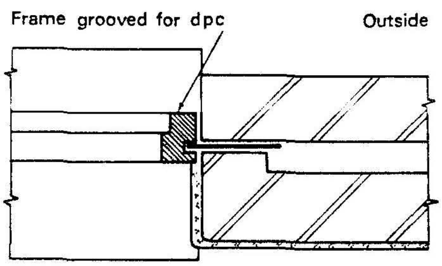

Figure 11

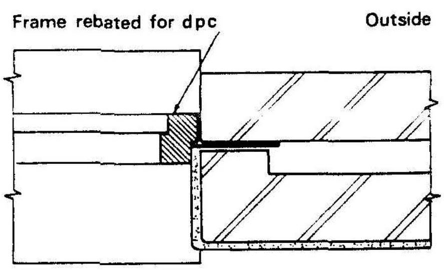

Figure 12

In Scotland the preferred practice in brick walls is to set the windows into the inner leaf and lap the frame with the outer leaf at the head and jambs, Figure 16. This practice increases the shelter provided by the walls and enables the dpm to lap the face of the frame. However, because of the small sections used in many standard timber frames a good lap is impossible to obtain without masking the face of the frame: this is not always visually acceptable, may prevent the opening light being fully opened, and also precludes the use of 'easy clean' hinges.

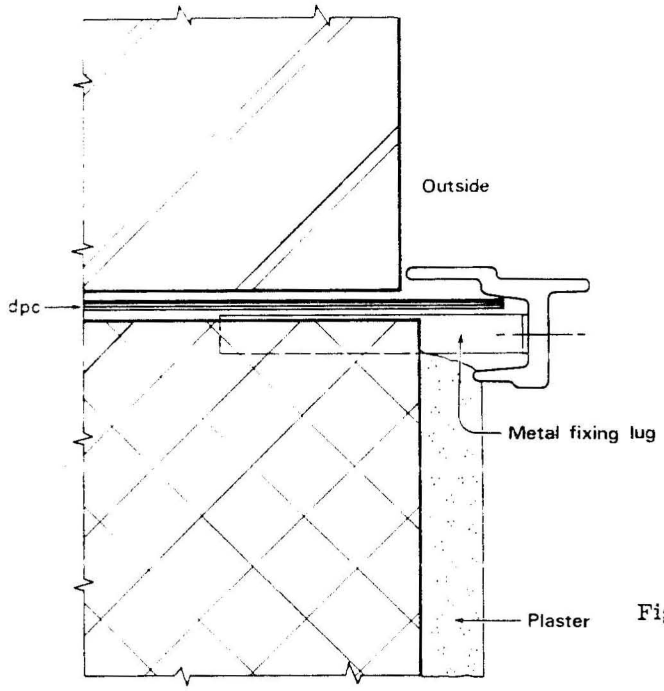

Figure 13 Horizontal section showing how vertical dpc can be tucked into standard metal frame

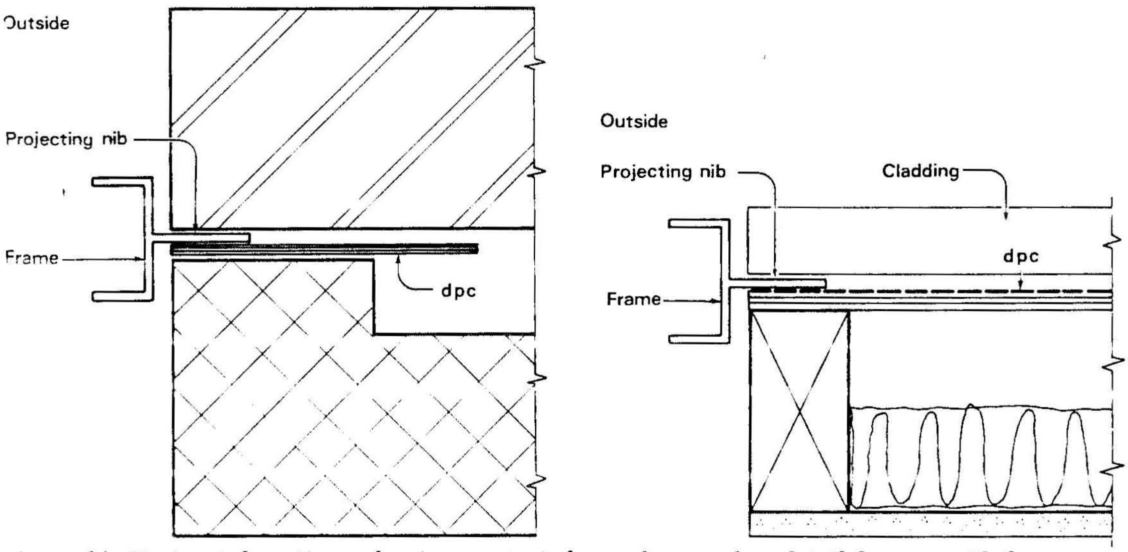

Figure 14 Horizontal sections showing suggested weatherproofing detail for use with frames which incorporate a projecting nib

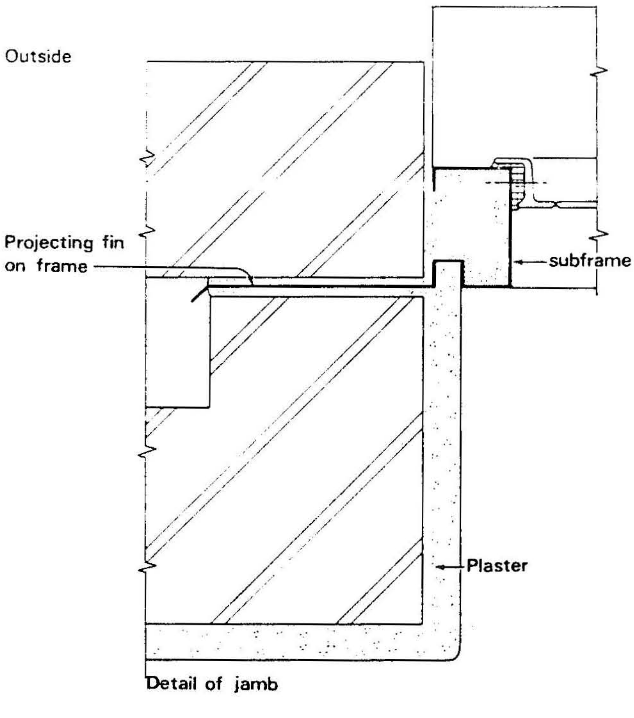

Figure 15 Horizontal section showing proprietry sub-frame with projecting nib built into cavity wall

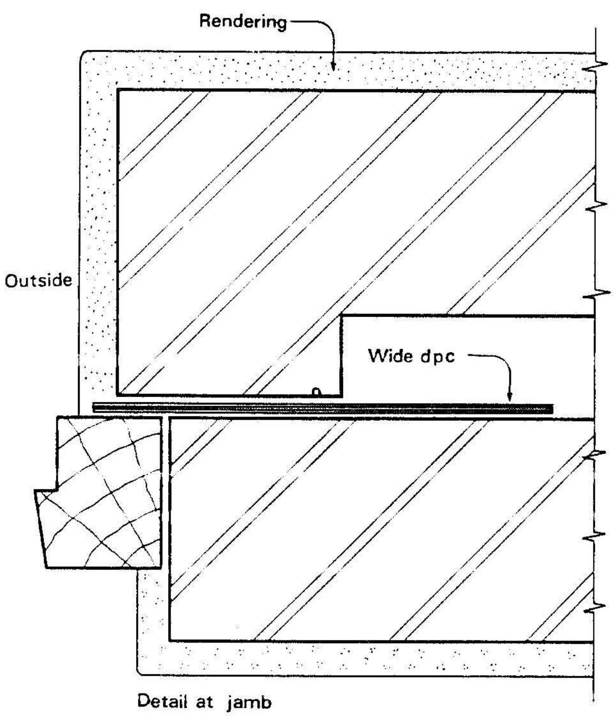

Figure 16 Horizontal section showing suggested method of weather-proofing in frames built into the inner leaf of a cavity wall

DIMENSIONAL VARIABILITY

When deviations are taken into account at the design stage few difficulties arise[4]. Situations which require a high degree of accuracy can either be avoided or provision made for overcoming them, eg by using laps, easily cut, or adjustable members in the frame assembly. Compared with the accuracy of the cladding or structure in which they are placed, windows are an accurate component, although occasionally lack of straightness of members and twist in the frame occurs.

The provision of laps in the cladding at the head and jambs can reduce the requirements for accuracy in the overall vertical and horizontal dimensions of the frame and opening but can increase the problems of dealing with twist, ie deviation in the vertical plane. The sealing requirement for the head is decreased because of the protection which this joint receives from the lap and any cladding overhang. Many fixed lights, and even a few opening lights, will also accept a small degree of twist and still function more or less satisfactorily.

WEATHER PROTECTION

Traditional practice and work at both Norwegian and British Building Research Stations has demonstrated that considerable protection can be obtained from the shape of the joint and its surrounding features. Unlike sealing compounds and gaskets this form of protection does not deteriorate with time. A BRE Digest[9] suggests ways in which seals can be protected by the geometry of the joint. Some of these principles are illustrated in Figure 17. It must be remembered that when open drained joints are used the material forming the exposed faces must be durable or accessible for maintenance.

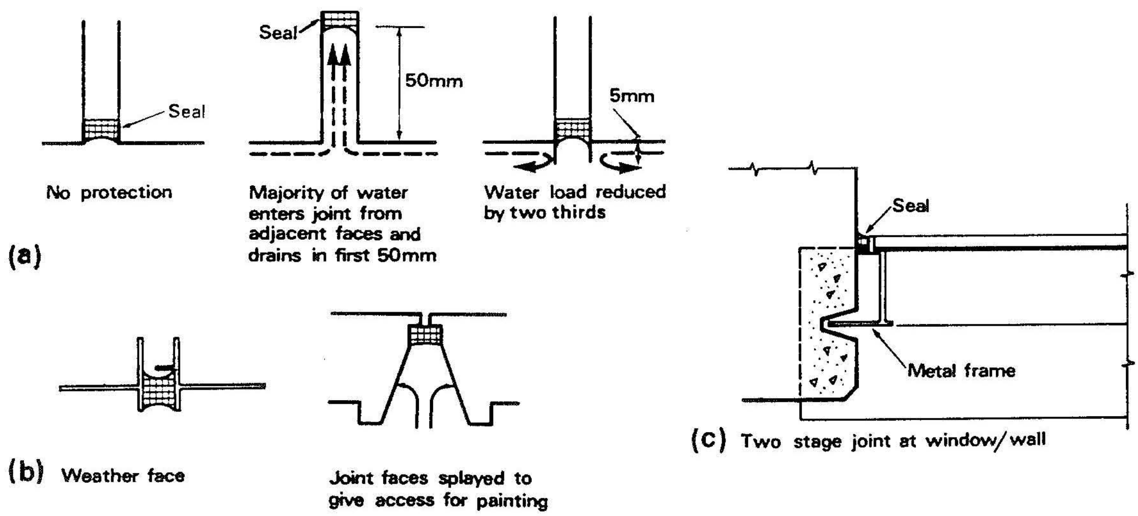

Figure 17(a) Protection by drainage and reduction of side flow. **(b)** Diagrammatic joint profiles using these principles of weather protection. **(c)** Horizontal section at jamb showing drained joint principles applied to a window to wall joint

WATERBARS

When considering the problem of obtaining a weathertight joint between a window and a concrete panel it was suggested that cast-in waterbars might offer a solution for limited circumstances. Almost no data exists on this application though of course the detail is used for door thresholds, so a number of tests were carried out. In all, 17 sets of waterbars composed of different materials were cast in concrete under controlled conditions and put out under natural exposure for a period of approximately $2\frac{1}{2}$ years, Figure 18, and then tested by ponding water on one side of the weather bar.

The results show that waterbars can give protection, though some distorted somewhat due to expansion and contraction. Obviously much depends on the quality of the concrete and of workmanship.

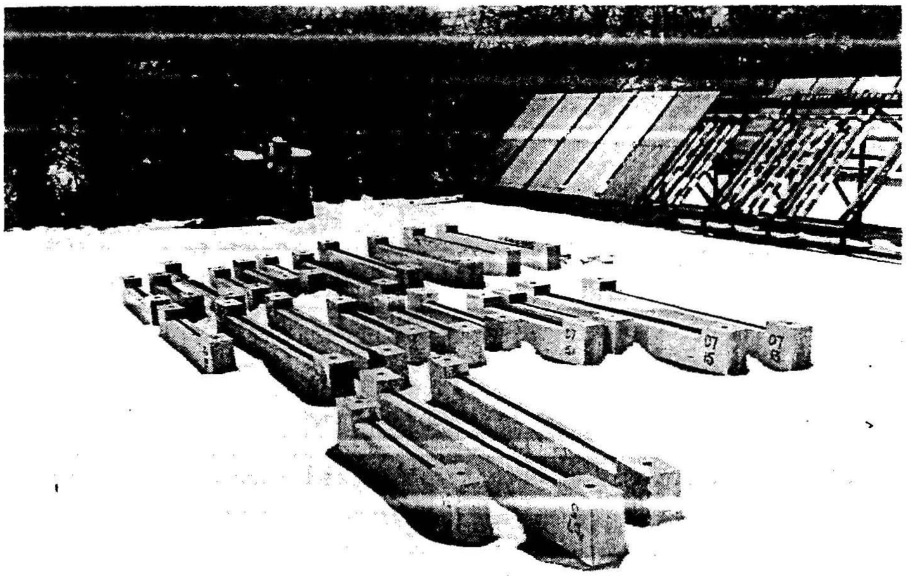

Figure 18 Waterbar specimens under exposure at Garston

COMMERCIAL CONSIDERATIONS

In discussion, many window and sealing compound manufacturers agreed that some of the details in common use are unsatisfactory and they would like to see them changed. However, they are in a highly competitive market so the need to tender competitively for jobs can over-ride their wish to see the best technical solution adopted. For this reason they considered that little technical improvement, if it involved extra cost, was likely to stem from the industry. A number of manufacturers mentioned that the requirements for architectural effect, eg flush exteriors to facades, often conflicted with good technical detailing especially when their standard products were used. It is said to be manufacturers' experience that clients or professional advisors were not generally prepared to incur the extra cost of modification to provide technically good solutions for these situations.

RECOMMENDATIONS FOR THE DESIGN OF WINDOW-TO-CLADDING JOINTS

1 Designs which maximise the use of protective features and minimise reliance on seals should be preferred. Straight butt joints are an obvious risk.

2 When frames are intended for jointing with a sealing compound, proper provision should be made for it in the edge profile of the frame rather than the cladding.

3 Where weatherproof joints are formed by seals, provision should be made in the design for their easy application, inspection and repair.

4 It should be assumed that some breakdown of the seal is probable during the life of a building and provision should therefore be made for this contingency, either by arranging for water to be drained outwards, or for any penetration to be localised so that the point of entry can be identified and the defect remedied.

5 In the design of a window-to-cladding joint, its clearance range should be identified and reconciled with deviations achievable in the construction[10].

6 Deviations in the structure due to deflection and creep should be predicted and allowed for.

7 Frame sections and fixings should be designed to accommodate movement and distortion of the frame, so that buckling is prevented.

8 In cavity walling an uninterrupted damp-proof barrier should be provided at the window jambs between the inner and outer skins of the wall and the frame profile, of adequate width so that bridging of the damp-proof membrane by plaster or mortar droppings cannot take place. Some of the recently developed plastics extrusions achieve this. The sill should project water well clear of the wall surface.

9 In detailing around the frame provision should be made for dealing with leakage of water through the frame and joints, ie by means of trays.

10 Provision should normally be made to deal with condensation, on whatever surface it occurs.

11 When a decision is taken on the value-for-money of comparative details, due consideration should be given to long term performance, ie cost in use not merely initial cost. Present methods of measurement are misleading in this respect.

12 It is not enough to specify details which work only if perfectly made. Details should be designed so as to reduce, as far as possible, the likelihood of defects arising from poor workmanship.

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