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BUILDING NOTE

APPLICATION OF INSULATION AND

VAPOUR BARRIERS

by

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When we speak of insulation we are concerned with heat loss and the reduction of the rate of heat loss from a house. When we speak of vapour barriers we are concerned with the prevention of condensation of water vapour in the walls and attics of buildings and the protection of insulation. Ventilation of spaces over insulation is also associated with the prevention of condensation. This is, therefore, a rather complicated subject for discussion as a single topic.

INSULATION

The use of insulation has now become so general in new house construction that the general aspects of what insulation is, how it works, and what it does, will not be discussed in this article.

The use of substantial thicknesses of insulation has very real advantages for the home owner or tenant in heating economy and comfort. From the builder's viewpoint insulation is too often regarded as a nuisance. However, there are advantages for the builder through the use of insulation in terms of customer satisfaction resulting from low heating costs and comfort, as well as savings in heating equipment, if advantage is taken in the design of the system. With this must be coupled a note of caution. The advantages of insulation may not be achieved without careful selection of insulation and careful installation of it. It has been our experience in the "troubleshooting" that this Division has done that lack of information and good judgment as to a suitable insulation and lack of care in its installation has sometimes resulted in conditions in houses which were worse than if no insulation had been used. As a result of this we sometimes hear the argument that it is better not to use insulation. Surely this would be a backward step.

It is for these reasons that the following remarks on insulation are confined to a few comments about the selection of insulation and chiefly to comments on installation details which we consider to be worthy of care.

WHERE TO INSULATE

Bungalow. - The bungalow probably provides us with the fewest general installation problems. Fill-type insulation is a natural material for use over ceilings. Batt and blanket insulations may also be used successfully but where possible they should be applied from the top after a separate vapour barrier and the plaster base, or other interior finish, has been applied to the ceiling. The junction of the insulation on the ceiling with the top of the wall should be carefully made so that there is no thinning of the insulation at this point and so that the provision of ventilation at the eaves is not complicated. This means that insulation should not be placed in such a manner as to contact the roof sheathing. The use of platform-type construction is favourable from the insulation viewpoint since the insulation can be continued over the top of the wall plate and butted against the header at the ends of the ceiling joists.

The question is sometimes asked whether it is advisable to insulate between the floor joists. This is one case where it may be best to leave out the insulation. In most basements the temperature will be low enough so that the heat loss at this point will not be high. The problem is that it will be difficult to protect the insulation against condensation. However, if no insulation is to be used, it is wise to ensure that the sheathing paper and sheathing are well fastened against the sill plate to reduce air leakage to a minimum at this point.

Two-storey House. - The two-storey house has details almost identical with the bungalow but, in addition, there is the junction between storeys to consider. Insulation of the header between joists at mid-storey is similar to a bungalow. The answer is different in this case, however, and its use is recommended at this location. It is possible to carry the vapour barrier applied to the wall up between the joists to provide protection for the insulation. Insulation at this point, if well applied, will assist in the control of air movement between the joists under wind conditions. We have seen houses with dust markings between ceiling joists which suggest low temperatures between the joists resulting from air movement from the outside wall.

$1\frac{1}{2}$-storey House. - The $1\frac{1}{2}$-storey house provides a host of insulation problems and is probably the most difficult of standard constructions to insulate. The first recommendation is that one should not attempt to insulate between rafters from the eaves to the upper floor-ceiling line. If this is done a greater volume of space than is necessary is heated and it is difficult with this application to provide ventilation over the insulation. It is sometimes done in this way because people want more attic storage space. It is questionable whether the space needs to be heated even if it is to be used for storage. Wherever the insulation must be placed between the rafters, as in areas over sloping ceilings, there should always be an air-way left over the insulation. The need for this will be evident later when ventilation requirements are discussed.

The detail at the junction of the dwarf wall and the floor joists is also of some importance. Here wood blocking, which is generally placed under the plate of the dwarf wall, is a very useful feature. Insulation should be placed against it on the outside for its full depth and the vapour barrier on the ceiling below can be carried up between the joists and fastened to the blocking and the subfloor above.

Here again fill and batt or blanket insulation can be used in combination - fill insulation on the horizontal surfaces and batt or blanket insulations on the vertical and sloping surfaces.

The detail at the junction of the upper storey ceiling joists and the roof rafters may also be a problem. There will be a certain amount of interference with the batt or blanket between the rafters, and the ceiling joist which extends into the space between the rafters. I suggest that it would be best to make a turn to the horizontal between the ceiling joists without breaking the insulation at the angle. The end of the batt or blanket will then provide a stop for fill insulation if it is to be used. In many cases the space above the ceiling joists will be quite small and in these cases it will be simplest to continue the batt or blanket insulation across the ceiling.

SPACES TO BE INSULATED

The question is often asked whether it is best to apply the insulation on the warm side of the wall between studs or on the cold side up against the outside sheathing. I do not think there is any direct answer to this question but I would like to mention some of the factors involved. First, we can suggest that if one is going to depend on the batt-back as a vapour barrier that it is best to apply the insulation on the warm side of the wall so that an effective vapour seal can be made over the studs. This method of application also may have an advantage in that the air space is on the outside of the insulation and if condensation does form in the wall it has a chance to run to the bottom and out of the wall space without wetting the insulation. The application of the insulation on the cold side places the insulation so that it may be wetted by condensation and it is necessary to apply a separate vapour barrier over the interior face of the studs to control condensation. The advantage of this application is that it will provide more uniform interior surface temperatures than the alternative installation. There will, therefore, be less tendency toward dust marking over framing members. This dust marking will be familiar to you all, especially in the older houses where plaster was used on wood lath without any insulation behind it. Dust tends to settle out on cool surfaces and thus it is an advantage to attempt to maintain wall surfaces at uniform temperatures.

Another method of installation is sometimes proposed, i.e. the installation of a blanket midway in the space between framing members. This method of application is often considered because it looks like an easy way to gain an additional air space and so increase the insulation value of the wall. But it should be noted that unless the blanket can be installed without gaps at top and bottom, the insulation can become ineffective because air movement will cause heat to bypass the insulation.

These remarks about insulation in spaces have assumed an ideal insulation which is of uniform thickness and fits the framing members snugly at each side. If the insulation does not fit the space and especially if it does not contact the framing members over most of its depth, the interior surface temperatures over the framing members will be low in relation to those over the central portion of the insulation in cold weather. This happens because the sides of the framing members are exposed to temperatures which are lower than they would be if no insulation was used. The insulation should fit snugly against the framing.

If the space is too wide for the insulation a gap will result and again variation in surface temperatures may create problems.

If the space is too narrow for the width of the insulation there may be a double air space and, in ceilings, cold air may move across from wall to wall under the insulation.

The foregoing discussion suggests two things: first, there is the selection of an insulation that is of a uniform thickness and at the same time one that can be easily cut to fit spaces of non-standard width: secondly, framing members must be at uniform spacings so that insulations made to fit such spacings can be applied in the desired manner. A survey made by this Division in 1951 covering 77 houses in 9 Canadian cities indicated that approximately one-third of the area of house walls, exclusive of window and door openings, had studs spaced so that the spaces formed were unsuitable for the use of batt or blanket insulations of standard width. This indicates the need for care by builders in placing framing members. The use of templates for marking the location of studs on plates, or the notching of plates to receive studs, might be a means of improving the situation.

In the foregoing a number of details have been described concerning the installation of insulation which we in the Division of Building Research, have found to be important in helping insulation do its job. We think that the recommendations made will help to do this. Most of them have been verified in terms of performance either by laboratory tests or by observations of actual houses.

VAPOUR BARRIERS

The application of insulation in buildings, as has been mentioned, may lead to the condensation of water vapour in walls and attics unless precautions are taken to prevent the flow of water vapour through the interior finishing materials of the building. This situation arises because the warm air of the house has a higher capacity for moisture than the colder air on the outside and since there is generally plenty of moisture available in the house from washing, bathing, clothes drying, cooking and sometimes intentional humidification, there is inevitably a difference in vapour pressure between inside and out. This vapour pressure difference will move moisture into the walls and attics which, in an insulated building, are much colder on the outside than they would be if no insulation were used. There is a danger therefore of water vapour condensing within the structure. If condensation is allowed to form it may result in paint peeling, wetting of the insulation, it may contribute to rotting of wooden framing members and it may ruin interior decorations, especially on ceilings. As one extreme it may be suggested, as has been mentioned before, that no insulation be used and that the humidity in buildings be maintained at a very low level. Again this is an undesirable situation and we therefore look to means of controlling the flow of water vapour through the walls and ceilings. It is therefore recommended practice to install a vapour barrier on the warm side of insulated walls and ceilings to reduce to a minimum the flow of water vapour through them. At the same time it can also be recommended that the outer parts of walls and roofs should be constructed in such a manner that they can pass such moisture as does get through out to the outside. This involves the use of vapour permeable materials on the outer parts of walls and the use of ventilation to carry off unwanted water vapour in attics. Vapour barriers are available in a number of different forms but they are not easy to describe in simple terms. Generally speaking, however, any unbroken film of wax, asphalt, metal foil, and certain types of plastic film will provide protection against the movement of water vapour. Paint films may also be effective in reducing water vapour flow. Here again it is not simple to describe an acceptable vapour barrier. Speaking generally, two or three coats of a good oil paint, rubber base paint, or aluminum paint are likely to provide a substantial resistance to water vapour flow. Materials of this type should only be placed on the warm side of insulations. If they are used on the exterior of buildings there is a possibility that moisture may be trapped within the structure and ultimately cause deterioration.

In order to prevent the trapping of moisture in walls, limits have been placed on the resistance to water vapour flow of sheathing papers which are generally applied under exterior finishes as a second line of defence against the entry of wind, rain, and snow. These papers are also difficult to describe in a general way but most of the common papers consist of asphalt or tar; saturated krafts or felts are in this class. Another type which has a water-resistant surface application may also be suitable.

It will be evident that the use of paint on the exterior of buildings may result in the creation of a vapour-resistant coating. While this is true it suggests that in painting exterior wood finishes there should be no attempt to seal the surface completely. Prepainting of wood siding is to be recommended from the wood protection point of view and no attempt should be made to fill all junctions between lapped materials with paint.

APPLICATION OF VAPOUR BARRIERS

Since the function of a vapour barrier is to reduce the flow of water vapour, every effort should be made to develop the available resistance in the material. Care should be taken that the material is not punctured or broken in application and all joints between sheets of the vapour barrier should be well lapped. Interior finishes or separate batten strips should be nailed to the framing members so that a tight joint between sheets of the vapour barrier can be achieved. Breaks required at electrical outlets should be carefully made so that a minimum opening is made. Where the batt or blanket backing is to provide the only vapour barrier, extra care should be taken to see that the backing is lapped over all framing members, including the top and bottom plates or headers in the case of ceilings. The use of a separate vapour barrier in addition to that provided with batt or blanket insulations is to be recommended, especially in areas with extreme temperatures.

VENTILATION

Ventilation is now recognized as a means of providing additional protection against condensation, especially in attics. So far we have no experience on which to base recommendations concerning the ventilation of walls. Ventilation is recommended since it permits the removal of water vapour that may bypass the vapour barrier through joints, tears, or around openings such as access doors to attic spaces. The ventilation of a simple gable roof may best be achieved by a combination of openings at the eave line and at the peak of the gable ends. The cottage-type roof may be handled in a similar way except that it is necessary to install roof jacks at the peak of the roof or in some cases special openings are provided at the peaks at the extension of the ridge line. The attic spaces in 1½-storey houses are often the most difficult to deal with. Here it is necessary to have eave openings combined with openings at the peak of the gable ends and there should be an airway over the insulation placed between rafters over sloping ceilings in order that positive ventilation will be achieved. In each case combined eave and peak openings have been suggested here because this permits ventilation under practically all conditions because of the difference in elevation between the upper and lower openings. Ventilation openings at the ridge line may provide adequate ventilation where a good vapour barrier application has been achieved on the ceiling but such openings may only function properly when the wind is blowing. Ample ventilation has an additional advantage in relation to summertime conditions since it will tend to reduce the temperature of the under side of the roof and, to some extent, will improve comfort conditions in houses in summer.

Flat roofs present special problems in regard to ventilation, particularly since the roofing material provides a very high resistance to water vapour flow. It is therefore necessary to ventilate each space above insulation between the roof joists. Where a good vapour barrier application is provided on the warm side of the roof, ventilation at each eave line may be sufficient. More positive ventilation will be achieved by providing a duct connecting all joist spaces on top of the roof upon which may be placed a ventilator which could be mechanically driven. In this way air can enter at the eaves and can be removed at a higher elevation.

The shed roof may be ventilated in a similar manner as the flat roof except that, because of the difference in elevation of the eave lines, there will be no need to provide mechanical ventilation.

In summary, ventilation is to be recommended in conjunction with vapour barriers to prevent the condensation of water vapour in attic spaces. It is essential where there is no vapour barrier applied on the warm side of the ceiling, as in the case when an existing house is insulated. Openings for ventilation should be sized in accordance with the ceiling area involved. At least $\frac{1}{4}$ square inch of ventilation opening is suggested for each square foot of ceiling area at inlet and at outlet. Fine screening used to prevent the entry of birds and insects will reduce the effectiveness of such openings by as much as 50 per cent and the indicated areas should be increased accordingly. All ventilating openings should be protected, where necessary, to prevent the entry of wind and snow. Simple louvres which will keep out rain may not be sufficient in all cases to prevent wind-driven snow from entering and being deposited on the top of insulated ceilings. Hoods may be required. Windows and their relation to heat loss should also be considered in the over-all consideration of heat losses and moisture control.