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EXTERIOR WALL CONSTRUCTION

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The various functions that a wall performs in service can be simply stated. These functions may then be recognized as considerations in the design of a wall construction or in the analysis of the adequacy of a specific construction.

Considerations in Wall Construction

The following considerations are those which may apply to a wall construction. They may be divided into two classes: general considerations and special considerations.

General Considerations:

1. strength;
2. control of heat flow;
3. control of water vapour flow;
4. inside finish;
5. outside finish.

Special Considerations:

6. resistance to fire;
7. resistance to sound transmission;
8. aesthetic value.

There is, in addition, the over-all consideration of cost which must be included in a complete analysis of a wall construction. The term cost here is intended to include not only the construction cost but also the cost of maintenance. Thus for comparative purposes the annual cost of a construction is the most reasonable basis for comparison.

All of these considerations can also be applied to roof constructions including ceilings. In this note, however, only walls will be discussed.

Detailed Considerations in Wall Performance

1. Strength

The first consideration is strength. The requirement for strength can be broken down into two parts:

a) Strength to support vertical loads.-

Vertical loads are those which result from the weight of the roof and those which may result from snow, wind, water, and occupancy loads within buildings;

b) Strength to support horizontal loads.-

Horizontal loads are those commonly associated with wind and, depending on the direction of the wind relative to the structure, may produce transverse loads in some walls and racking loads in others.

Strength is perhaps the most important consideration because in the development of building practice the essentials of shelter are commonly provided by a sheathed wood-frame construction or a load-bearing masonry wall with a sheathed roof structure.

The sheathed wood-frame construction and 8 inches of masonry have evolved as the elements which are the principal contributors to strength in house walls. For wood-frame construction 2 by 4 studs at 16 inch centres are still used. This size of member and spacing was not developed on a calculated or scientific basis but has evolved as a result of experience. More recently 2 by 4 studs at 24 inch centres are being used in single-storey houses and also larger members are used at even greater spacings, as in post-and-beam construction. These developments have been the result of the availability of special sheathing materials and also, in part, from a better understanding of the strength requirements for walls through experience and laboratory tests. In the case of solid masonry walls there has been little change. The use of hollow-concrete block and clay tile as a back-up for brick has been introduced. There has been the interesting development of the SCR Brick for 6-inch thick load-bearing walls. The acceptance of this thinner structural wall has been relatively simple because standard test methods have been developed along with a basis for evaluation; although it must be admitted that the basis for evaluation is largely that of comparison with walls that have been used with apparent success.

The big question that has to be answered from the point of view of strength is: "What is the minimum strength that a wall must have to do the job?" There is no ready answer to this question but it is worth asking because it has economic implications. In general the less material there is in a wall the less it will cost. Therefore, in designing walls for strength and economy the material that goes into a wall must be put to work in the best possible way.

For example, the suggestion is sometimes made that it is wise to have two layers of insulating sheathing on a wall, one on the inside and one on the outside, because not only will it be stronger but it will provide insulation and a plaster base too. But this approach can be questioned because the structural strength is likely to be overdone and the insulation requirement underdone. It is best to consider one requirement at a time and provide for that requirement in the most economical way.

Control of Heat Flow

The wood-frame wall and the masonry wall do not compare favourably when the matter of heat flow is considered. The standard wood-frame wall has a space for at least $3\frac{1}{2}$ inches of insulation and it has been shown that this thickness of insulation is economical for most regions of Canada. In order to provide this same thickness of insulation in a masonry wall it would be necessary to virtually build a wood-frame wall on the inside of a masonry wall. It is customary to use a lesser thickness of insulation on masonry walls placed between 2- by 2-inch furring strips. Thus about $1\frac{1}{2}$ inches of insulation is realized and in any strict comparison one should charge the masonry wall with the cost of providing the space for the insulation. This does not mean, however, that a masonry wall with $1\frac{1}{2}$ inches of good insulating on it is not a good wall but by comparison with the possibilities for providing maximum (and economical) resistance to heat flow in a wood-frame wall it does fall somewhat short.

If a substantial thickness of insulation is placed in a wood-frame wall the insulating value of any other materials that may go into the wall can be ignored and they can be selected without concern for this. For example it would not make an appreciable difference whether the sheathing material had any insulation value at all. Also for insulated masonry walls there need be little concern for the insulating value of the plaster or plaster base.

Insulation is perhaps in the best position of any materials in wall construction from the economic viewpoint since substantial thickness can be purchased and installed at low-cost, and up to a point the annual cost of the wall is reduced markedly over an uninsulated wall.

There is one aspect of heat flow or heat loss from a wall that has not been taken into account in the preceding comments. That aspect is the possibility of outside air being blown into walls and so displacing warmed air. It has been suggested that sheet materials applied to the outside of a wall will reduce heat loss by decreasing the movements of air in and out of wall spaces, and that narrow boards and a lapped layer of sheathing paper will allow relatively free movement of air in and out of walls. There is not much evidence to support either suggestion. Experiments conducted in Norway indicate that building papers with joints lapped tightly will provide a very large percentage of the total resistance to air flow in a wall construction.

The Control of Water-Vapour Flow

The principal means of controlling water-vapour flow into walls is by the application of vapour barriers on the warm side of walls. This reduces the amount of water vapour that enters the walls. As an added precaution it is wise to consider the ease with which water vapour can leave the wall to the outside since vapour barriers are not perfect barriers.

The selection of a vapour barrier may not be important from an economic point of view since the applied cost of the best vapour barriers may be as low as 3 or 4 cents a quare foot. The difference in cost of membranes is small, so one might just as well have a good one to start with.

The use of foil-backed wallboard is one means of combining this function with the interior finish. Foil-backed lath is questionable as a vapour barrier because of the great length of crack that results.

We are often asked about the suitability of interior paints as vapour barriers. Here it can only be said that generally two or three coats of good oil, rubber base, or alkyd paints will provide substantial resistance to water vapour flow. I suggest that they should only be used as vapour barriers where it is not practical or economical to use a membrane barrier.

The damage in terms of paint failure, damaged insulation, and rotting of materials that can result from the omission of vapour barriers, or a poor installation, could certainly result in costs amounting to many times the cost of a membrane barrier.

Interior Finish

The function of the interior finish can be stated fairly simply as "the provision of a paintable, cleanable, and durable surface". The problems are all familiar - plaster cracking, and popping of nails and joint-filling problems in dry-wall construction. The selection of an interior finish is often a matter of personal choice and there appears to be few technical considerations that suggest any general advantage among materials used in the average house.

Exterior Finish

The functions of the exterior finish are several. It should shed rain and snow, and may in some walls provide resistance to the entry of wind. It should be durable under the conditions of exposure and should have dimensional stability over a similar range of conditions. It should not provide a barrier to the movement outward of water vapour that may move through or by-pass the vapour barrier. Finally the exterior finish should provide a pleasing appearance.

In wood-frame walls, including brick-veneer construction, the sheathing paper is the element of the exterior finish which is likely to provide the greatest resistance to water-vapour flow. The principal purpose of the sheathing paper is to keep liquid water and air out of the wall. Thus, a membrane should be selected that will shed water and at the same time pass water vapour. Sheathing papers are, in fact, represented by the common saturated building papers that are familiar to all. Unfortunately some manufacturers try to make their products too water resistant and, by so doing, make them too resistant to water vapour flow.

Stucco and brick veneer sidings are all fairly permeable to water vapour flow. Painted wood sidings do not meet this function very well because, as was previously mentioned, a paint film will provide a substantial resistance to water-vapour flow. Many have discovered this to their loss, as paint blistering is no stranger in the building scene. However, in most houses the situation is not serious since the siding is lapped so that the wall can breathe outward through the cracks between boards. The outward movement of water vapour is probably responsible for much of the paint failure that is reported.

The role of the exterior finish in keeping water and wind out of walls is perhaps the most important consideration in the over-all picture of wall performance. Water will cause materials to lose strength, change dimension, and may lead to a shortened life for the material because of rot or freezing action. The exclusion of wind has already been mentioned as a factor in connection with heat loss. Wind is certainly a factor which can contribute to wall leakage. Walls are much more susceptible to leakage during wind-driven rain than they are to rain without wind.

In our efforts to prevent wall leakage there has been a tendency toward the sealing of the exterior wall surfaces to try to produce a moisture-impermeable surface. The perfect sealing of a wall surface is almost impossible since fine cracks and joints that cannot be seen will allow the passage of water whether it is wind driven or not. It then becomes necessary to consider the best possible means of protection for the various elements of the wall. For example, by constructing the wall in two components, inner and outer, there will be a much better chance of improving over-all wall performance. The inner component can contain the structural, insulation and interior finish elements, and the outer component can serve simply as a weather screen in respect to rain penetration. This proposal will be recognized as typical of a cavity-wall construction or the standard brick-veneer construction. To provide the maximum protection against the entry of water into the wall the cavity behind the exterior finish should be freely drained and ventilated so that wind action may have a minimum effect on wall leakage. It may thus be possible to reduce the possibility of damage to walls due to water penetration to that which may occur as a result of the absorptive properties of the exterior cladding when a film of water exists on its surface. Dimensional stability with variation in moisture content and temperature and resistance to deterioration due to freeze thaw action would still be required of cladding materials as now, but the function of the cladding would not be so directly associated with the over-all performance of the whole wall.

Wood or stucco clad walls can be built on a similar basis by applying these materials on furring strips placed over the sheathing paper. Stucco finishes would require a backing which need only function during the application process. No great difficulty would occur with wood or other sheet sidings. Vertical furring strips provide natural ventilation channels and horizontal furring strips can be gapped or notched to allow drainage and ventilation.