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Dickens, H. B.

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WORKMANSHIP KEY FACTOR IN RAIN-TIGHT MASONRY

by

H. B. DICKENS

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FIGURES 1 AND 2: Place sufficient mortar on end of brick to fill joint completely.

Workmanship — key factor in rain-tight masonry

By H. B. DICKENS,
Head, Housing Section,
Division of Building Research,
National Research Council

Resistance of exposed walls to rain penetration is of basic importance to their overall performance. Many cases have occurred where the durability of a wall has been lowered, the insulation value has been affected, and the appearance has been spoiled by the penetration of wind driven rain. The best time to consider this problem is at the design stage.

Constructions which utilize the "open rain screen" principle (see Canadian Building Digest No. 40, Division of Building Research), offer the most effective means of controlling rain leakage and should be the designers first choice in seeking a solution to the problem. The principle involves the control of rain penetration by the provision of vented air spaces within the wall. It is the basis for the success of brick veneer and cavity masonry walls (and walls using wood shingles) which, when properly built, have performed well even under conditions of severe exposure to wind driven rain.

In contrast, solid masonry construction is much more vulnerable to rain leakage and in choosing this type of construction the designer must accept the possibility of through-wall penetration of rain and the probability of uncontrolled partial wetting with its attendent effects on the appearance and durability of the wall. Walls of solid masonry continue to receive wide use in at least one area of Canada and the object of this Note is to provide guidance in those items that determine their overall performance. Most of the suggested procedures are also applicable to any type of masonry where high quality construction is desired.

With low buildings some protection from wetting of the walls can be obtained by the provisions of wide roof overhangs but for high buildings and for severe exposure to wind driven rain the essential factor in achieving durable walls of solid masonry lies in the selection of materials and control of workmanship. Field and laboratory studies have shown that when leakage takes place in brick masonry it does so mainly at the junction of the brick and mortar and that a complete and permanent bond between brick and mortar is required to obtain resistance to rain penetration. The way in which brick and mortar are combined, therefore, is extremely important. Although this discussion deals primarily with brick, much of it also applies to other forms of masonry including block and stone.

Some Important Properties of Brick

Stated simply, the chief concern is to select bricks and mortar that are durable and, when applied under average job conditions, will be well bonded together. It is not difficult to name the properties important in brick: moisture absorption is one and a second is strength. These two properties are used in the standard specifications for brick as a measure of durability or resistance to frost action.

Suction requires special mention

There is one property, however, that requires special mention. It is not included in standard specifications and yet it has a marked effect on the bonding of brick to mortar. This is "suction" and may be defined as the rate at which a brick tends to draw or suck water out of the fresh mortar in which it is laid. If a brick with a high suction rate is used, it will tend to draw so much water from the mortar that the bond with succeeding brick will be greatly reduced. On the other hand, a dense brick, (one having a very low suction rate), will not form as good a bond as one having moderate suction.

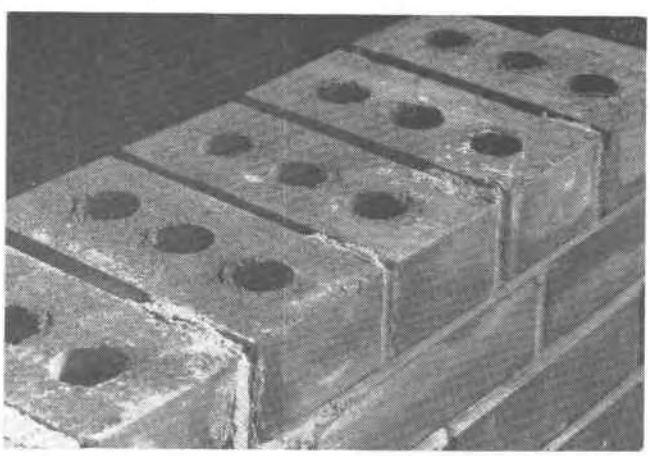
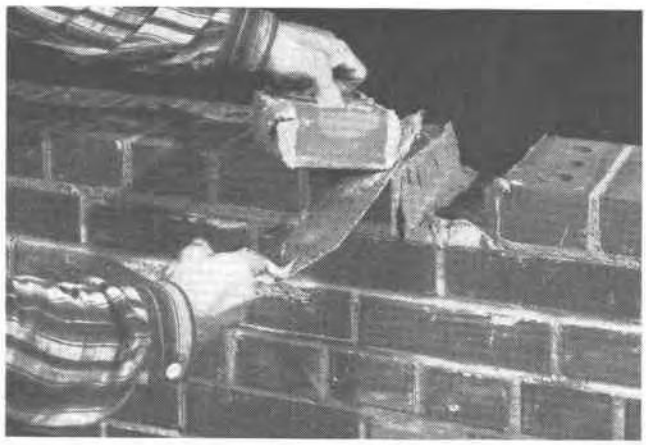


FIGURE 3: Cross joints not filled.



FIGURES 4 AND 5: Place mortar on sides of closure brick and on brick in place.

A measure of suction is given by the Initial Rate of Absorption (I.R.A.) of the brick which may be defined as the number of grams of water absorbed by a brick when laid in water 1/8 inch deep for one minute. Experience indicates that the best results are obtained with bricks having an I.R.A. between 5 and 25 grams. When bricks are above this range it is necessary to control their suction on the job, in order to achieve good bond. This can be done by wetting the brick since suction decreases as moisture content of the brick increases. The bricks are hosed down after being stacked in such a way as to ensure uniform wetting.

Wetting should be done several hours prior to using the bricks so that their surface is dry when placed in the wall, otherwise their suction may be reduced too much and the bricks may then float or slide on the mortar. Whenever possible bricks within the 5- to 25- gram suction range should be selected so that wetting will not be necessary as it is difficult to control and may greatly increase the problem of efflorescence. The control of suction by wetting is particularly difficult during cold weather because it is then undesirable to erect a wall using materials that are relatively damp.

Precautions with Concrete and Sand Lime Brick

In the case of concrete or sand lime bricks, control of suction by wetting should be avoided because it will cause these materials to expand before laying, thus increasing the shrinkage which such units subsequently undergo. Fortunately the practice of incorporating waterproofing agents in these bricks at the time of manufacture, which is becoming more common in the industry, tends to maintain the suction characteristics of the units at a reasonably low level.

The problem of dimensional stability or the change of length of the brick with changes in its moisture content does introduce, however, some special considerations in the use of these units. Concrete and sand lime bricks generally exhibit a somewhat greater dimensional change when wetted or dried than do clay units. If built in the wall in a wet and green condition they will shrink and are apt to cause severe cracking. Shrinkage occurs most often during the initial drying period after the bricks are made. High-pressure steam curing will greatly reduce the amount of such shrinkage and is receiving increasing attention from Canadian manufacturers.

It is important that both concrete and sand lime units be reasonably dry when used. Ideally they should have a moisture content approaching the average they will experience in service. Unless it is known with certainty that these units have been delivered in a properly cured and dried condition, they should be stacked for as long as possible (preferably several weeks or months) under conditions of good air circulation and protected from rain. They should not be in direct contact with the ground or they will absorb moisture from the soil by capillarity. Additional precautions can be taken to control the effects of shrinkage in a wall by careful selection of mortar to be used.

On the basis of laboratory and field studies, the following mortar mixes are suggested for use with brickwork:

Type of Unit	Control of Suction	Mortar Mix (by volume)
Clay — High Suction (above 25 gm)	Wet	1:1:6 > 1:2:9
Medium Suction (5 to 25 gm)	Do not wet	1:½:4½ < 1:1:6 > 1:2:9
Low Suction (below 5 gm)	Do not wet	1:½:4½ < 1:1:6
Concrete	Do not wet	1:2:9
Sand Lime	Do not wet	1:2:9

Selection of mortar and performance

Mortar consists of a cementing agent, sand, and water. The cementing agent may be portland cement, lime, masonry cement or a mixture of these. The pro-

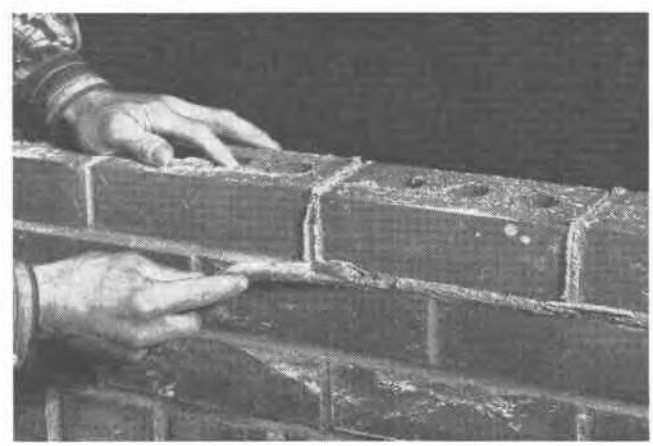


FIGURE 6: Concave tooling of joints.

portions in which the mortar ingredients are combined determine the properties of the mortar which, in turn, have a significant effect on the performance of a wall.

The perfect mortar for brick-laying would have the following properties:

1—Easily workable; 2—Stiffen quickly enough; 3—Adequate strength; 4—Bond well to the bricks; 5—Durability.

Unfortunately all of these properties will not be found to the same degree in any one mortar mix. Another complication is the differences that exist in the properties of the bricks themselves. For each job, therefore, it is necessary to decide which properties are the most important and then to design a suitable mix.

This requires an understanding of the effect that each ingredient has upon the properties of the mortar. Portland cement increases the strength, rate of stiffening and frost resistance of the mortar. Lime decreases these properties but improves workability, plasticity and the ability to retain water against the suction of the brick.

Normally both materials are used in a mortar to obtain a desirable compromise of these properties. (See table on this page).

It may be necessary to adjust the proportions slightly to suit the particular conditions of a job. In making these adjustments the following points should be kept in mind:

1. Bricks with two much suction tend to dry out the mortar quickly unless a mortar with high water retentiveness is used. This suggests a high lime content.
2. A high lime content also gives plasticity to the mix which means increased workability — an important factor in assisting a bricklayer to achieve the good workmanship essential in obtaining a satisfactory job. Indeed the ability of a mortar to retain sufficient water to remain plastic and workable during bricklaying is of prime importance in the final quality of the bond. Such mortar can be spread more easily, and is less likely to dry out and stiffen before a good bond is obtained with the brick. Unlike concrete, mortar should in general contain as much water as possible at the time of laying, consistent with other requirements, in order to achieve a good bond.
3. With units such as concrete and sand lime which have a high drying shrinkage it is usual to specify a very weak mortar (again a high lime content) such as 1:2:9 (cement: lime: sand) in order to confine any cracking that does take place to the mortar joints where it is more easily repaired.
4. High strength mortar is not needed in conventional masonry walls — and mortar strength is not an indicator of bond. In fact the use of a relatively strong and dense mortar such as one rich in cement has often led to shrinkage cracks between the mortar and the brick through which rain can easily penetrate. The only justification for the use of a mortar with a higher cement content is to contribute to its frost resistance, but one should guard against risking too much on poor bond and shrinkage cracks in attempting to obtain better frost resistance by increasing the cement content.

Workmanship determines quality

In the final analysis it is workmanship that determines the quality of the wall. Good workmanship requires that all mortar joints in masonry be filled.

To ensure full bed joints the mortar should be spread thickly. If a furrow is used it should be kept shallow. There will then be enough excess of mortar in the bed joints to completely fill the furrow when the bricks are placed; otherwise a channel will be left in the mortar along which water can travel. Mortar for the bed joint should be spread out over only a few bricks at a time and the bricks placed before it has a chance to stiffen.

A method commonly recommended for filling head joints is to throw plenty of mortar on the end of the brick to be laid and then to push the brick into place so that the mortar oozes out at the top of the joint **(Figures 1 and 2).** Full cross joints are seldom secured on the average job, particularly in header courses **(Figure 3).** In header courses the mortar should be spread over the entire side of the header brick before placing. When placing closure bricks, either stretchers or headers, it is essential to spread mortar on the ends or the sides of both the bricks in place and the closure brick **(Figures 4 and 5).**

In laying hollow units such as concrete blocks, which do not present a solid face across the ends of the unit, special care should be exercised to secure full head joints on both the inside and the outside edges of the unit.

Type of Joint

All joints on the exterior face of masonry construction should be tooled to give a concave finish **(Figure 6).** There is much evidence to show that joints sealed in this manner are the most effective in preventing water from entering the wall. Tooling should be done with a round tool, slightly larger than the joint, with sufficient force to press the mortar tightly against the brick on both sides of the mortar joint. It should never be done before the mortar has begun to set. On the other hand it must be completed before the mortar hardens.

Conclusion

Constructions such as brick veneer and cavity masonry, which utilize the open rain screen principle, offer the most effective means of controlling rain leakage. Walls of solid masonry are more vulnerable to rain penetration and require care in the selection of materials and a high standard of workmanship if acceptable results are to be obtained.

The requirements for satisfactory materials can be met without great expense and the methods of building quality masonry walls are relatively simple. It is not so simple to get them built that way and until the importance of following the rules of good workmanship are recognized then research and even specifications will have little effect.