TECHNICAL NOTES on Brick Construction

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Technical Notes 43G - Brick Passive Solar Heating Systems - Part 7 - Details and Construction [Mar./Apr. 1981] (Reissued Sept. 1986)

Abstract: Details and construction of brick masonry for passive solar energy system applications vary only slightly from conventional residential and commercial brick masonry construction. Typical construction details are provided for direct gain and thermal storage wall systems. These details, with slight modifications, are also applicable for attached sunspaces. Construction variations from conventional construction and considerations for compliance with the major model building codes are also discussed.

Key Words: attached sunspaces, **bricks**, **building code requirements**, **details**, direct gain systems, energy, masonry, **passive solar energy systems**, thermal storage wall systems.

INTRODUCTION

Brick masonry construction and recommended details for passive solar energy systems are similar to conventional residential and commercial brick masonry construction and details. The general concepts of direct gain systems, attached sunspaces and thermal storage wall systems are discussed in *Technical Notes* 43. Empirical sizing, rational approaches for determining the thickness of brick masonry as a storage medium, material properties and performance calculations are discussed in other *Technical Notes* in this series. In these passive solar applications, brick masonry may be used as a storage medium and structural component of the building. Brick masonry also offers the capability for esthetic designs, fire resistance and sound transmission reduction.

These recommended details are presented in an effort to show as many applications of brick masonry in passive solar heating systems as possible and are not offered as typical combinations of details. The details may be slightly varied and different combinations of the details may be used to satisfy the requirements of any specific passive solar heated building design.

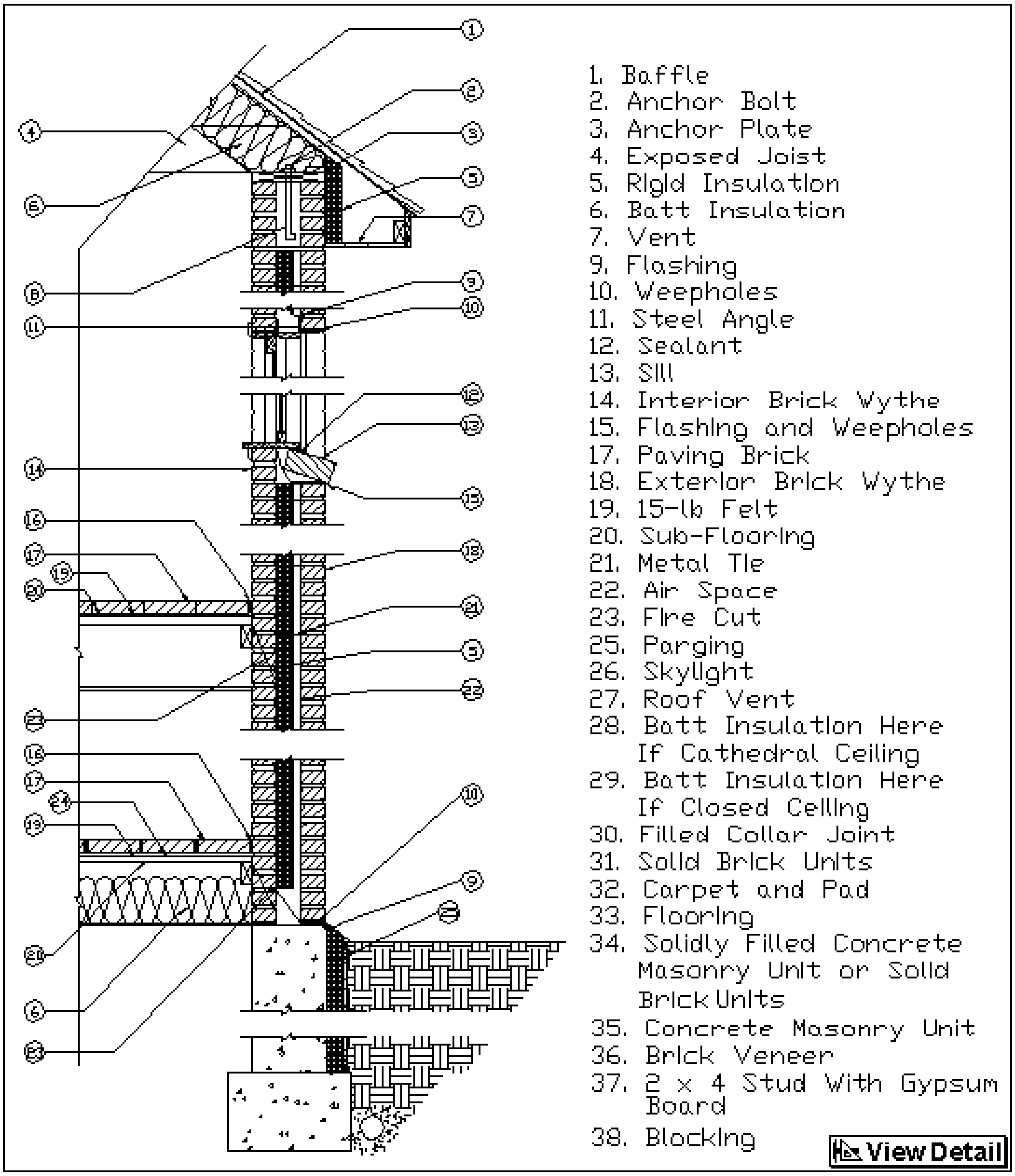
DIRECT GAIN

General

Details for brick masonry floors and walls used for thermal storage in direct gain systems are provided in Figs. 1 through 3. Each of these figures shows a typical connection detail for the ground floor, interim floors and roof.

Exterior Loadbearing Walls

Exterior loadbearing brick masonry walls may be constructed as insulated cavity walls to provide an interior brick masonry wythe for thermal storage and an exterior brick masonry wythe for durability, as shown in Fig. 1. The brick masonry should be continuous through all floor intersections so that the brick masonry bears on the foundation or foundation wall, provides adequate support and complies with building code fire safety requirements. Where wood joists frame into brick masonry wall construction, the wood joists should be fire cut.



Cavity Wall Construction

FIG. 1

The design should consider the local code requirements for minimum bearing. A thicker interior wythe may be required for bearing or special provisions incorporated into the detail so that both the exterior and interior wythes may be used for bearing. Bearing on both wythes should only be used when other alternatives are not practical, since there may be difficulty in properly constructing and detailing such a connection without interfering with the performance of the cavity wall. Additional information on the design, detailing, construction and insulating of cavity wall construction is provided in *Technical Notes* 21 Series.

Providing clerestories with the appropriate pitched roof in conjunction with a cathedral type ceiling and exposed beams or trusswork may allow even the North wall to be exposed to sunlight and used for thermal storage. This type of detailing may require consideration of exposed trusses in the roof/ceiling component. The trusses or other means of eliminating the thrust at the top of the cavity wall is necessary because the building codes do not allow lateral thrust on cavity wall construction. When considering the use of trusses or other members to relieve a cavity wall of this thrust, the spacing of the trusses or other members should be such that the interior of the wall is subjected to only minimal shading if it is to be used as thermal storage for direct gain.

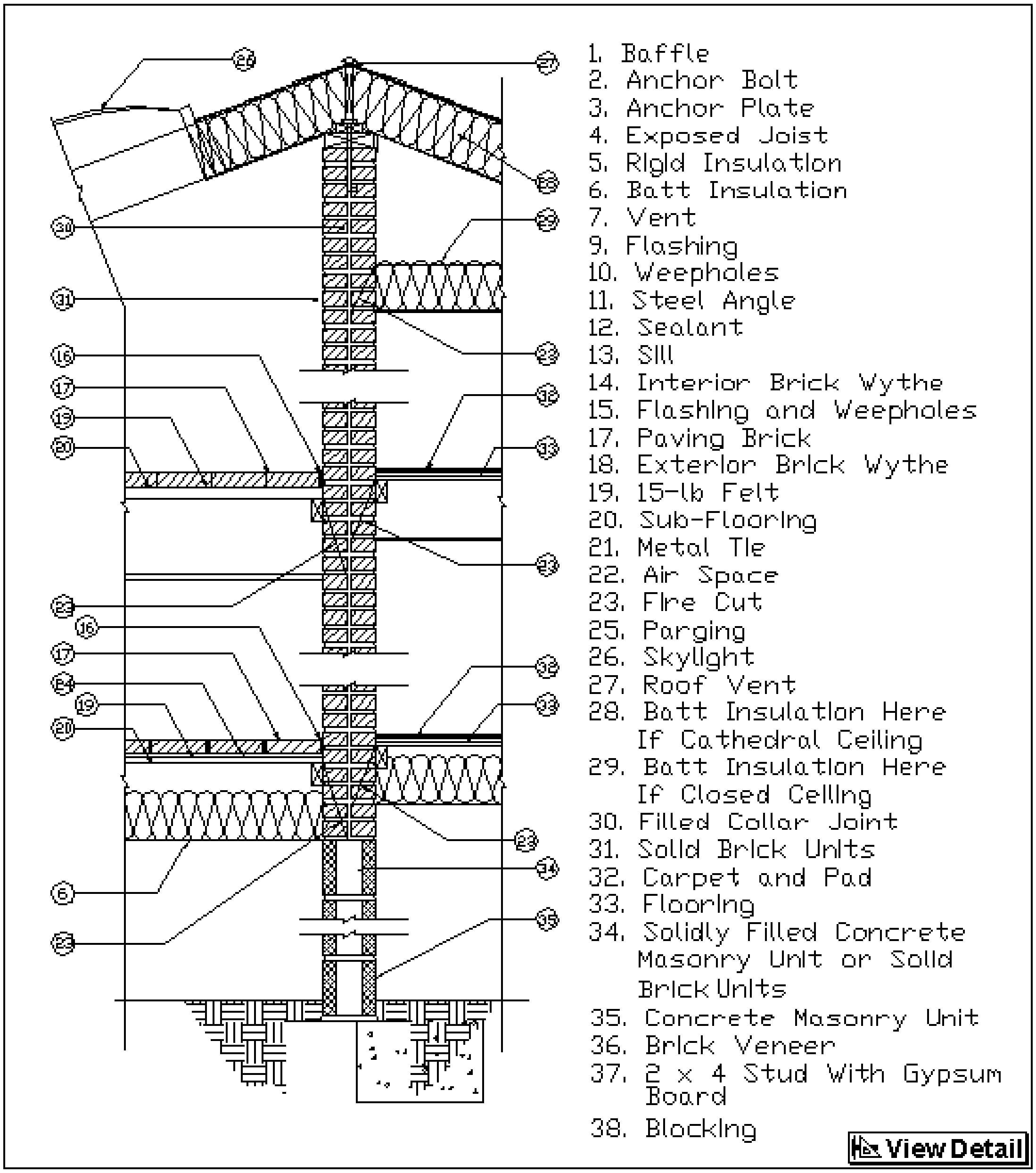
When considering the use of insulated cavity walls, the exterior wythe of brick masonry is thermally isolated from the rest of the wall system. Thus, the exterior wythe of the cavity wall is usually subjected to greater temperature fluctuations than the interior wythe used for thermal storage. For cavity wall construction, both the interior and exterior wythes may require expansion joints for thermal movement.

Exterior Non-Loadbearing Walls

Cavity wall construction may also be used for exterior non-loadbearing walls. East or West-facing walls may be positioned in the structure so that they are exposed to morning or afternoon sunlight for direct gain storage. Typically, passive solar buildings require a large amount of additional interior mass which may be unexposed to direct sunlight. This mass provides supplementary thermal storage, resulting in a thermal flywheel for reduced interior temperature fluctuations. The interior wythe of the cavity wall may be considered when determining the amount of additional mass.

Interior Loadbearing Walls

Typical details for interior loadbearing brick masonry walls are shown in Fig. 2. These details are similar to conventional loadbearing construction. Wood floor joists bearing on the brick should be fire cut.



Interior Loadbearing

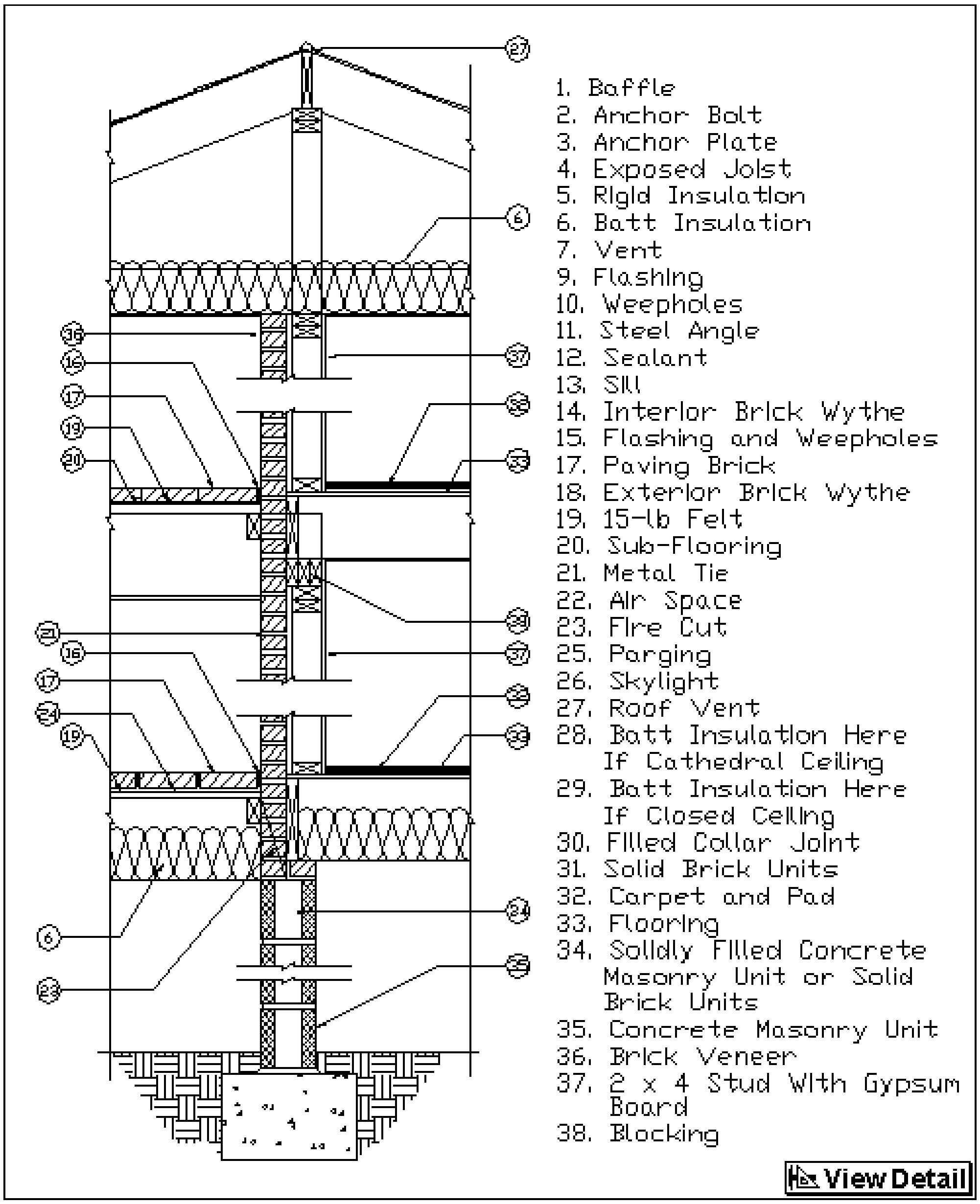
FIG. 2

A roof construction detail is provided, offering the option to use a skylight to expose the brick masonry loadbearing wall to sunlight. The interior brick masonry wall may be exposed to direct sunlight through South-facing windows and doors, or a clerestory may be used, depending on the distance from the South-facing wall.

The use of interior loadbearing brick masonry construction does not require any special consideration over and above conventional construction. The only exception is that provisions for thermal expansion may be required.

Interior Non-Loadbearing Walls

Interior non-loadbearing brick wall construction is quite similar to conventional brick veneer construction. The brick veneer should be constructed as shown in Fig. 3. The brick masonry should be continuous through all floor intersections so that all the brick masonry bears on the foundation or foundation wall and complies with building code fire safety requirements. Additional information on brick veneer construction is provided in *Technical Notes* 28 Series.



Interior Non-Loadbearing

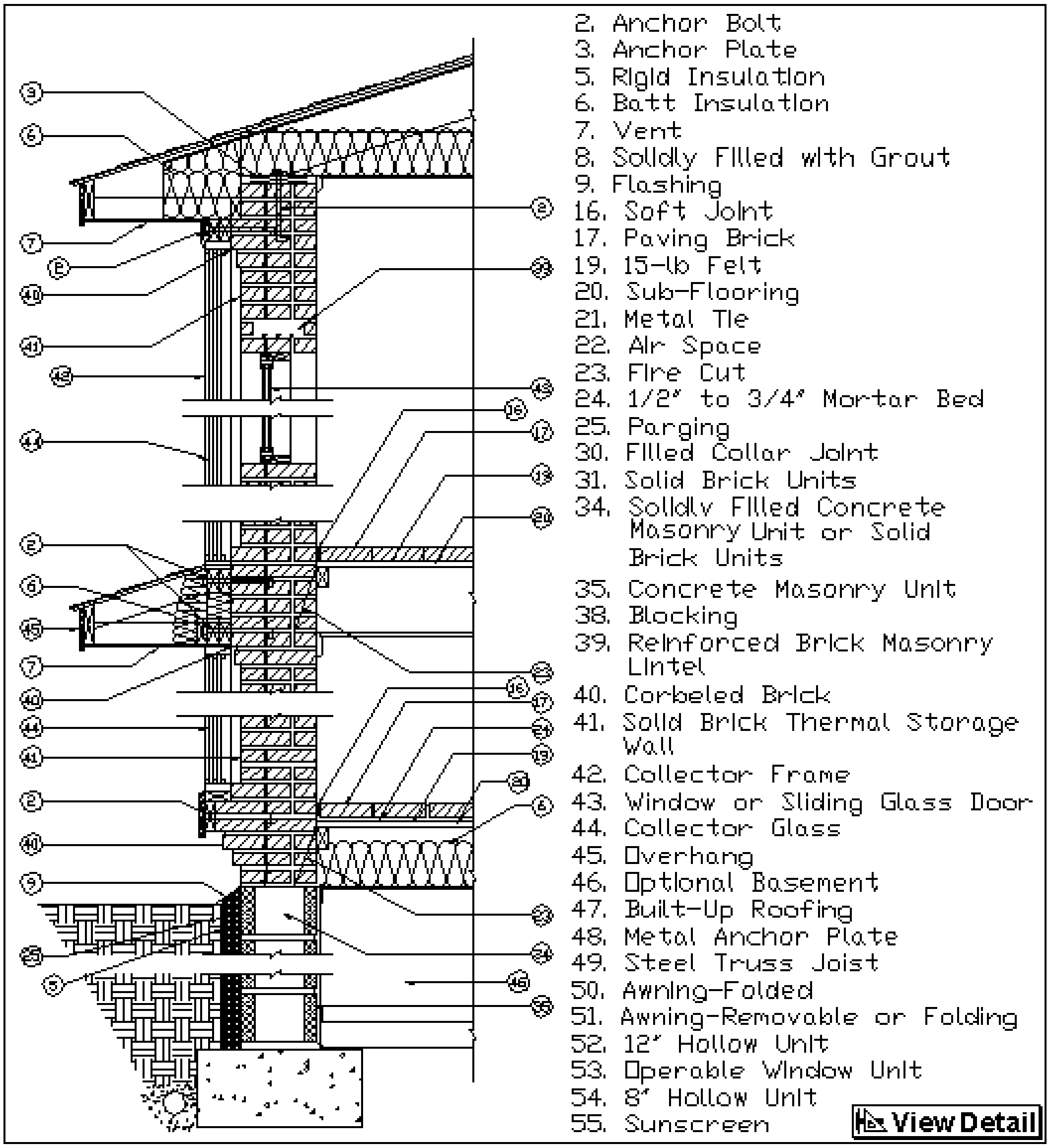
FIG. 3

The requirements in *Technical Notes* 28 Series apply to interior brick veneer construction, except that the requirements for the effect of weathering may be disregarded. The backup material; wood frame, metal stud, etc., should be constructed as in conventional construction.

If the interior brick veneer is constructed with wood frame or metal studs without sheathing between the backup and the brick veneer, the 1-in. airspace between the brick and the backup, as recommended in *Technical Notes* 28 Series, may be eliminated. If the brick veneer is constructed with a framing system that requires sheathing on the side to be veneered, it is recommended that a 1-in. airspace be maintained. This provides "finger room" to facilitate the laying of the brick. The use of the sheathing on the side of the backup material which is to be veneered may be required to provide the appropriate structural rigidity of the backup system. This sheathing may also be used to increase the fire resistance and sound transmission classification of the wall.

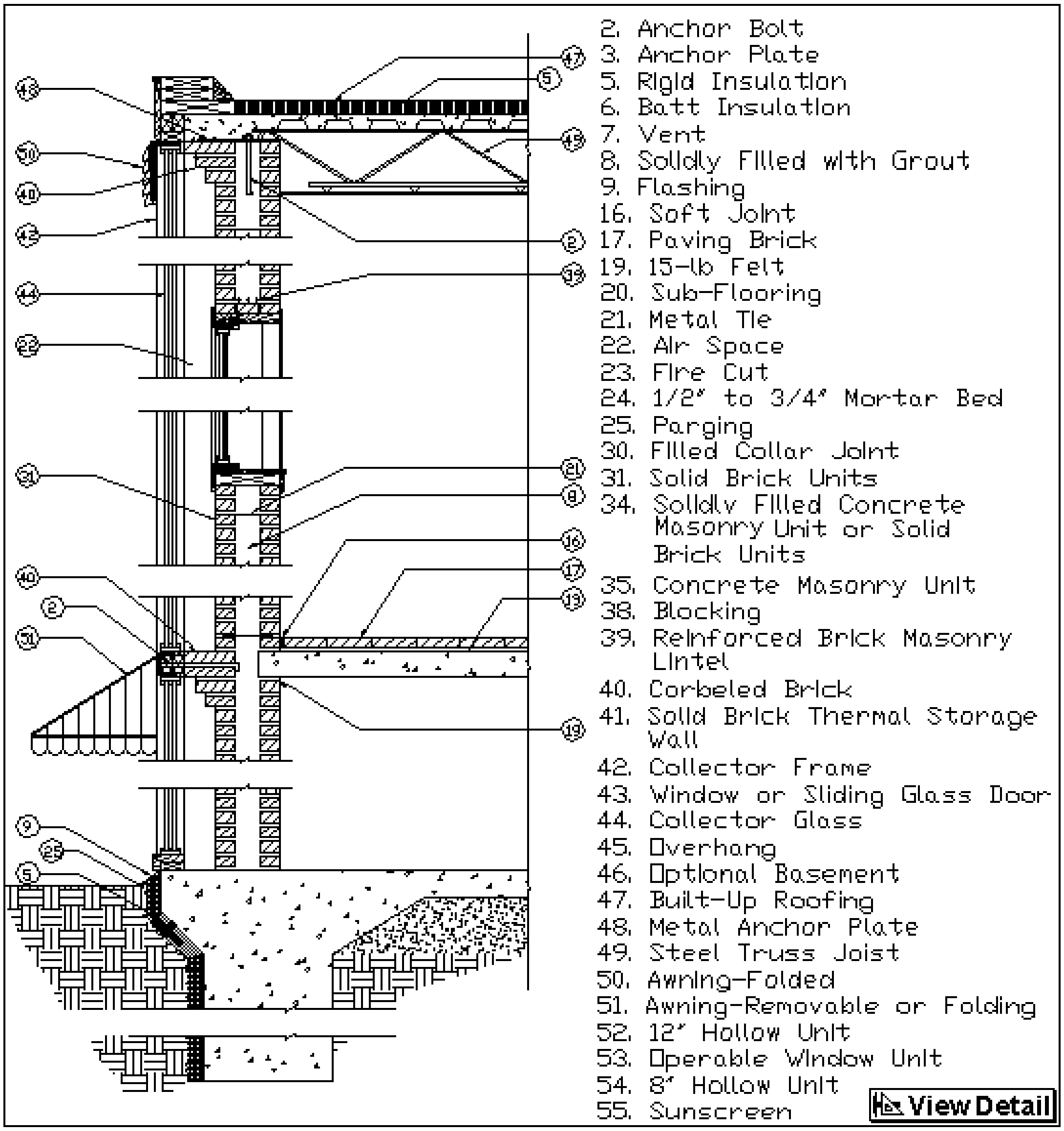
Interior Flooring

Typical details for brick flooring are provided in Figs. 1 through 6. The interim floor details show mortarless paving, and the ground floor details show brick masonry set in a mortar bed. These details are interchangeable. The interim floor detail shown in Fig. 3 is a typical detail for mortarless brick paving in a sand bed. The difference in thermal performance of mortarless paving as compared to paving units set in a mortar bed is insignificant. There may be a slight reduction in heat transfer from unit to unit, but this will typically have a negligible effect on overall thermal performance of the floor system being used as direct gain thermal storage. Paving units are used as the flooring in the thermal storage wall details, Figs. 4 through 6. These paving units in combination with glazing incorporated into the thermal storage wall for daylighting and visual contact with the exterior may be used to form a direct gain system. The brick flooring may also be used to achieve the additional interior mass required by many passive solar heated buildings.



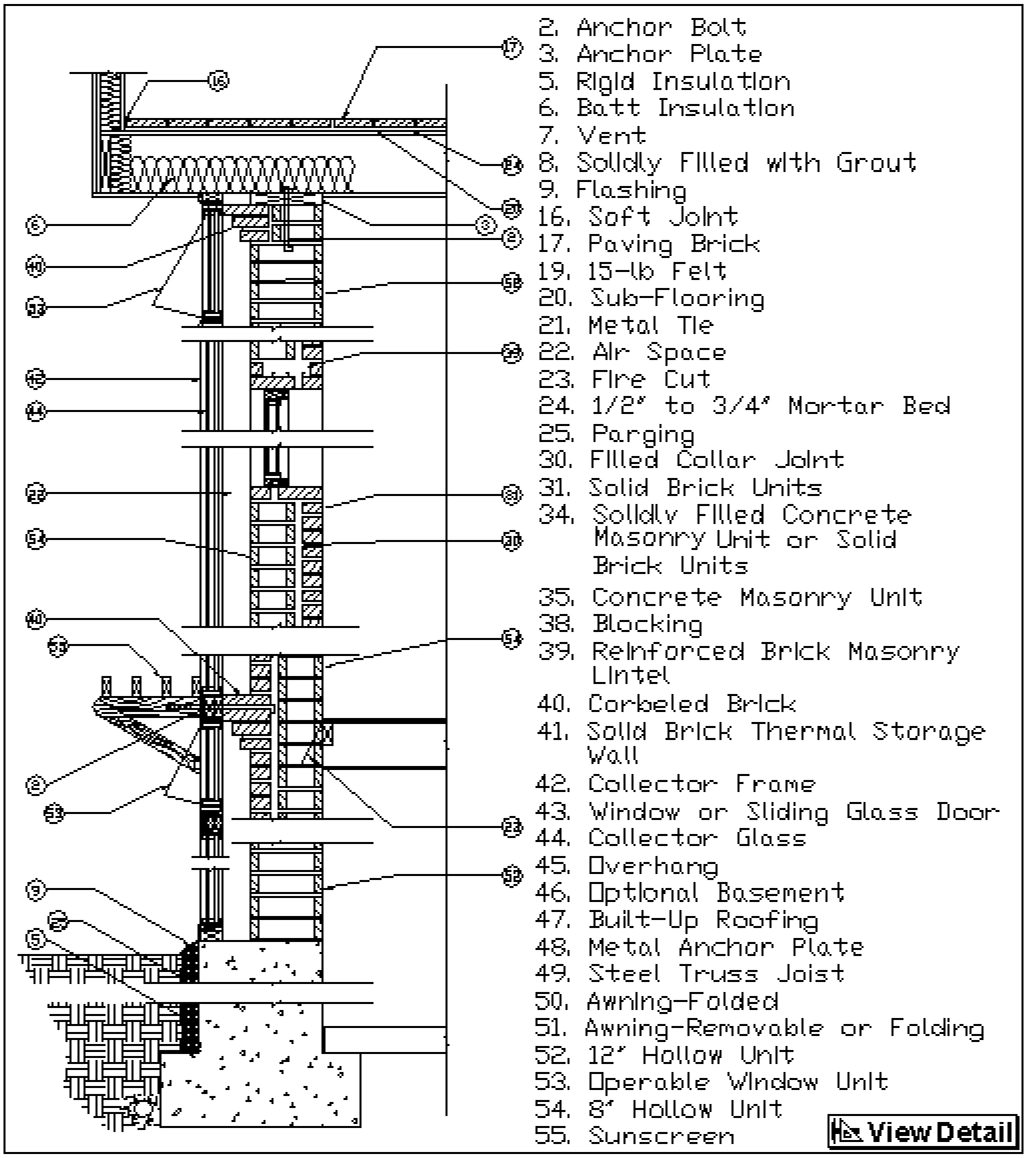
Solid Brick Thermal Storage Wall

FIG. 4



Grouted Hollow Thermal Storage Walls

FIG. 5



The Use of Hollow Brick in Thermal Storage Walls

FIG. 6

A soft joint should be installed around the perimeter of the brick paving, mortarless or set in a mortar bed, to provide relief of the stresses due to thermal movement, deflection and differential movement between the brick flooring and adjacent construction. Additional soft joints may be required for thermal expansion.

Supporting brick masonry paving on floor systems requires sufficient stiffness of the system to adequately support the additional weight in such a manner as to satisfy the minimum deflection requirements of the brick paving. For mortarless brick paving, the maximum deflection should be less than or equal to L/360. For brick paving set in a mortar bed, the maximum deflection should be less than or equal to L/600. For wood floor systems supporting brick flooring, the sizing and spacing of the floor joists should be adequate to support the additional weight, satisfy the floor joist structural requirements and the deflection requirements of the brick flooring.

The floor connection details shown in Figs. 2 and 3 should be such that the top surface of the brick flooring is level with other floor finishes. If this is not desirable, or possible, the appropriate riser distance between the surfaces of the different floor finishes should be provided to comply with the governing building code.

The use of brick paving is discussed in detail in *Technical Notes* 14B. The brick flooring may also be constructed by laying face brick in a rowlock position. Another option is to use reinforced brick masonry floors, as discussed in *Technical Notes* 14B.

THERMAL STORAGE WALLS

General

Figures 4 through 6 show the thermal storage wall being used as a structural component of the building, supporting various floor and roof systems. These combinations are not typical, but are offered to demonstrate the various alternatives available.

The thickness required for thermal storage walls is usually sufficient for the wall to be used as a loadbearing component of the building without any special considerations. However, it may be necessary to check the structural adequacy of the wall.

The thermal storage wall may be several wythes of solid brick, as shown in Fig. 4; solid through-the-wall units; a grouted cavity wall system, as shown in Fig. 5; or grouted hollow units or combinations of grouted hollow units and solid units, as shown in Fig. 6.

Details

Details for solid brick thermal storage walls are shown in Fig. 4. Corbeling the thermal storage wall to provide support for the exterior glazing is one way to eliminate the need for thick foundation walls. Brick masonry may be laid as projected headers to provide a durable support for attaching the glazing assembly to the wall. This eliminates the use of combustible materials exposed to high temperatures for extended periods of time. Projected headers may provide a durable non-combustible, horizontal separation between individual floors for multi-story vented thermal storage wall systems. This may be used to comply with the building code requirements regarding the fire-stopping of plenums. Vertical separation to provide a means of closing the sides of the thermal storage wall air space may also be achieved with projected headers.

Depending upon the structural loads imposed on the projected headers and to avoid exposing cores, corbeling may be required, as shown in Fig. 4. The air space between the glazing and the thermal storage wall should be of a thickness that satisfies the building code requirements for unreinforced corbeling. If these limitations cannot be met, an alternate means of support for the glazing will be required.

Additional glazing is provided in each detail to show that the thermal storage wall need not be a solid barrier eliminating any view of the exterior or daylighting. This glazing may be used as a direct gain collector with interior brick masonry floors and walls as the thermal storage.

The air space between exterior glazing and the thermal storage wall may be interrupted at various intervals and the thermal storage wall made discontinuous, as shown in Fig. 7. This may be used to incorporate direct gain and thermal storage walls into a combined system.

Operable or stationary shading devices may be attached to the structural framing of the glazing assemblies. The glazing assemblies should be sufficiently anchored to the brick masonry to accommodate these additional loads.

a Solar Savings Fraction as determined by using Method I of *Technical Notes* 43B

Vents

If the thermal storage wall is to be vented, each opening through the thermal storage wall should be approximately 64 sq in. The length of the opening should be about 4 times the height of the opening. The vents should occur as sets, one at the top of the wall directly over one at the bottom of the wall, to facilitate air flow. The number of sets of vents may be approximated by using Equation 1.

$$n_v' = F_v\ [(l_w \times hw) / (l_v \times h_v)] \quad (1)$$

where: n_v' = approximate number of sets of vents.

F_v = vent area factor from Table 1.

l_w = length of the vented thermal storage wall, in ft.

h_w = height of the vented thermal storage wall, in ft.

l_v = length of the vent opening, in inches, approximately 4 X h_v

h_v = height of the vent opening, in inches.

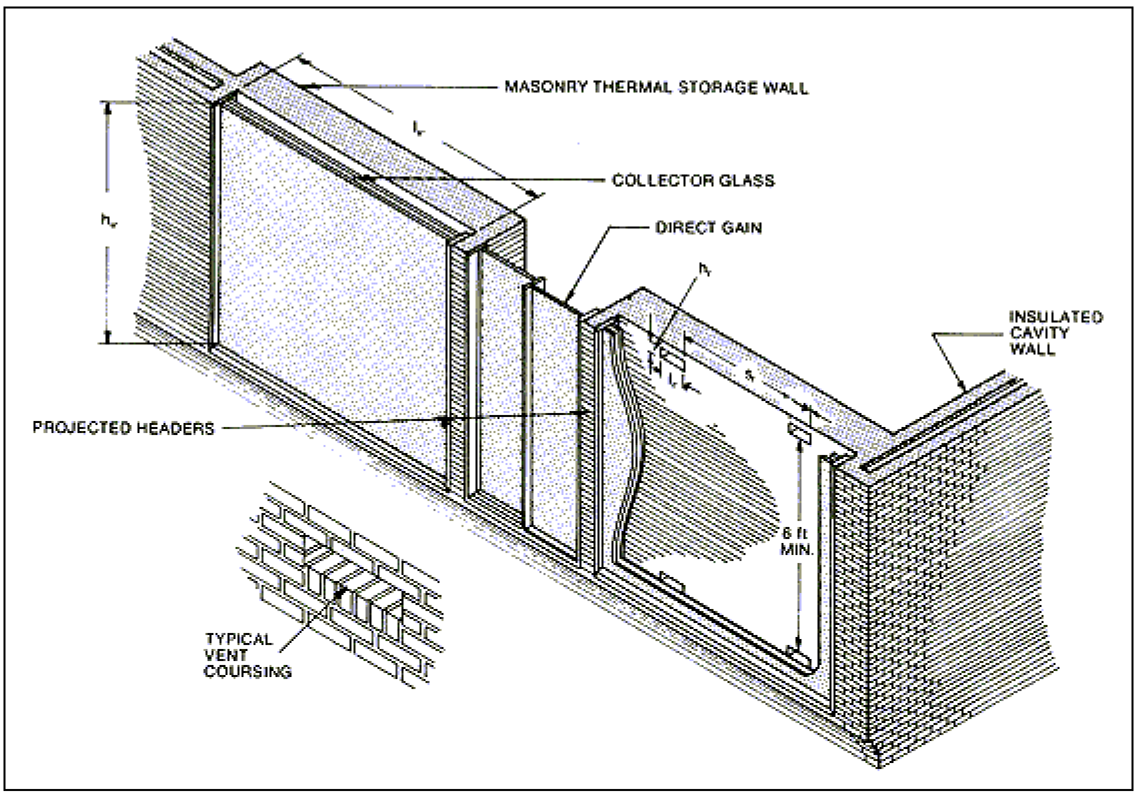
The actual number of sets of vents to be installed, n_v, should be a whole number. Performance tends to decrease as the percentage of vent area to wall area increases. The next lower whole number to n_v' should typically be used as the actual number of vents to be installed, if n_v' is less than n_v plus 0.70. If the value of n_v' is greater than or equal to n_v plus 0.70, the next larger whole number would typically be used as the number of sets of vents to be installed.

Both the vertical and horizontal spacing of vents will also affect performance. Top vents should be located as close to the ceiling as possible and the bottom vents as close to the floor as possible. The vertical distance between top and bottom vents should be at least 6 ft for full story height vented thermal storage walls.

The horizontal spacing of vents, s_v, may be determined by using Equation 2.

$$s_v = l_w / n_v \quad (2)$$

Example. A 25-ft long vented thermal storage wall system 8 ft high is expected to supply about 35% of a building's heating load, SSF = 0.35. Vent openings are formed by omitting one and one-half courses of standard modular brick vertically and two standard modular brick horizontally as shown in Fig. 7. Thus, the opening has a height of about 4 in. and a length of about 16 in. The dimensions of the vent opening satisfy the criteria of the length being approximately 4 times the height and the area being approximately 64 sq in. If other size brick are used, the courses and number of brick omitted to meet the area and height-to-length requirements of the vent opening will vary.



Locating Vents

FIG. 7

Using Equation 1, and F_v = 1.58 from Table 1 for a solar savings fraction of 0.35, the approximate number of vents would be:

$n_v' = 1.58\ (25 \times 8) / (16 \times 4)$

$n_v' = 4.94$

Thus, n_v is 5 sets of vents to be installed.

The horizontal spacing of vents may be approximated by using Equation 2.

$s_v = 25/5 = 5$ ft

The result is that the 25 ft long vented thermal storage wall should have 5 sets of top and bottom vents, each having an opening of approximately 64 sq in., spaced horizontally at 5 ft o.c.

ATTACHED SUNSPACES

The typical details for direct gain thermal storage and thermal storage walls may be used for attached sunspaces with only modifications to the glazing details. Depending on the type of attached sunspace, the thermal storage components may be direct gain floors and walls or direct gain floors and vented or unvented thermal storage walls.

CONSTRUCTION

Solid brick masonry used as a thermal storage medium, as in all brick masonry construction, requires that all head, bed and collar joints be solidly filled with mortar. Solid brick are units which are cored less than 25 percent of the gross cross-sectional area parallel to the bedding plane. In typical running bond or stack bond construction, the brick should be shoved into full bed joints. This results in sufficiently filled cores so that there is little or no effect on the overall thermal performance of the wall. When soldier courses or projected headers are being considered, uncored units may be preferred.

Hollow brick are brick units in which the coring is less than 40 percent and greater than 25 percent of the gross cross-sectional area in the bedding plane. Hollow brick masonry used for thermal storage requires all head and collar joints and bedding surfaces to be solidly filled with mortar and all cores fully grouted. Projected headers and corbels may best be achieved by combining solid brick masonry with hollow brick masonry construction.

Grouted hollow walls are discussed in *Technical Notes* 17, 17C and 17D. When considering the use of grouted hollow walls, constructed of two wythes of brick separated by a fully grouted space, the only control over thickness will be requirements for adequate thermal storage. Thus, grouted hollow brick masonry walls may be advantageous when the thickness desired is not easily achieved by using modular sizes of brick. As in all brick masonry construction, the brick wythes should have all head and bed joints solidly filled with mortar.

MISCELLANEOUS CONSIDERATIONS

Thermal Expansion

For most applications of brick masonry as interior direct gain thermal storage, the temperatures within the brick masonry will probably range from 72 to 96ƒF. Thus, thermal expansion will not normally be a problem except where long interior walls or floors are used. Interior brick masonry used for direct gain thermal storage occurring in lengths longer than 100 ft or exposed to a higher maximum temperature should be analyzed for thermal expansion. The thermal expansion of brick masonry is discussed in *Technical Notes* 18A.

Thermal storage walls may be subjected to larger temperature fluctuations than direct gain thermal storage components. Usually, the difference between the maximum temperature and minimum temperature at the center of the thermal storage wall is small and no provision for thermal expansion is necessary. Generally, thermal expansion need only be considered for long or high thermal storage walls or for walls exposed to extreme temperature fluctuations.

The maximum mean temperature of brick thermal storage walls may be determined by using the temperature fluctuation equation in *Technical Notes* 43. The minimum mean temperature may be determined by using the steady-state temperature gradient through the wall as discussed in *Technical Notes* 7C.

Flashing

Flashing brick masonry thermal storage components is usually not required because the brick masonry is on the interior of the building. Cavity walls will require flashing as discussed and shown in *Technical Notes* 21B. Flashing may be required for thermal storage wall systems, depending on the type of glazing assembly and how it is mounted in front of the thermal storage wall.

Reinforced Brick Masonry

Reinforced brick masonry, as discussed in *Technical Notes* 17 Series, may be required depending on the structural design loads. For thermal storage walls, this is easily accomplished by using reinforced grouted hollow brick or reinforced hollow wall construction. Reinforced brick masonry may be designed so that the wall will be able to sustain lateral thrust.

Typically in reinforced brick masonry construction, the reinforcement is both horizontal and vertical, placed as near to the center of the wall as practical. This, in combination with the minimum required spacing to sufficiently reinforce a brick masonry wall does not result in any significant decrease in the wall's thermal performance due to thermal bridges.

Lintels and Sills

The thermal storage wall details provide several options for constructing lintels and sills. Additional information on lintels is provided in *Technical Notes* 17H and 31B. Information regarding the construction of brick masonry arches is provided in *Technical Notes* 31 Series. Brick masonry sill details are provided in *Technical Notes* 36 Series, however, most sills for thermal storage walls do not require a sloped top surface or a drip since they are not exposed to exterior weather.

Fireplaces

Interior fireplaces may be used to obtain additional mass to decrease the interior temperature fluctuations. Brick masonry fireplaces may be incorporated in the thermal storage component in any of these passive solar heating systems. A fireplace may be used for direct gain storage or may be constructed in a thermal storage wall. The design and construction of fireplaces is discussed in *Technical Notes* 19 Series.

Glazing

It is desirable that the glazing component of these passive solar energy systems be operable to facilitate cleaning, exhausting excess heat, providing a means of egress or a combination of these. The glazing may be sliding glass doors, awning type windows, hinged glass doors or other options. Hinged doors installed vertically or horizontally may greatly facilitate the cleaning of vented or unvented thermal storage wall collectors.

Depending upon building classification, building codes may require a 3-ft vertical separation between openings located vertically one above the other. This is not typically a requirement for residential buildings, or any building under 3 stories in height.

METRIC CONVERSION

Because of the possible confusion inherent in showing dual unit systems in the calculations, the metric (SI) units are not given in this *Technical Notes.* Table 13 in *Technical Notes* 4 provides metric (SI) conversion factors friar the more commonly used units.

SUMMARY

This *Technical Notes* provides information on the construction and detailing of brick masonry thermal storage components for passive solar energy systems. The information, recommendations and details contained in this *Technical Notes* are based on the available data and experience of the Association's technical staff. They should be recognized as suggestions and recommendations for the consideration of the designers and owners of buildings when using brick in passive solar energy applications.

All of the possible variations cannot be covered in a single *Technical Notes.* However, it is believed that the information is presented in a form such that specific details are interchangeable. The final decision for details to be used is not within the purview of the Brick Industry Association, and must rest with the project designer, owner or both.

REFERENCES

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