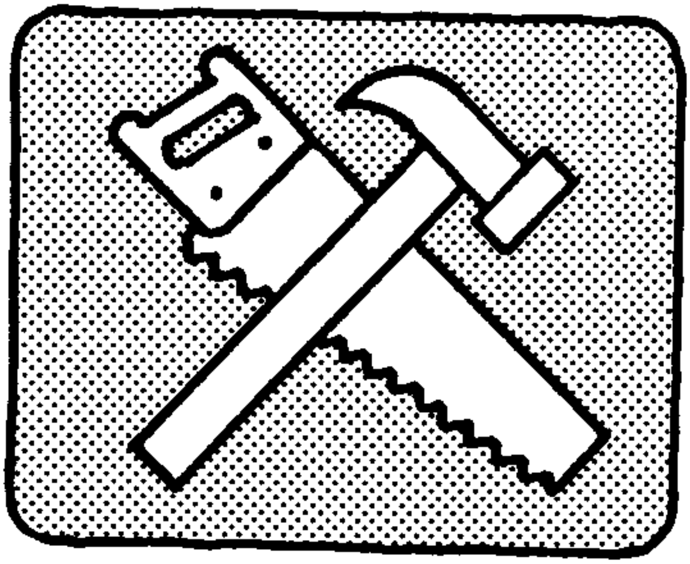
# CHAPTER 4 CONSTRUCTION DETAILS



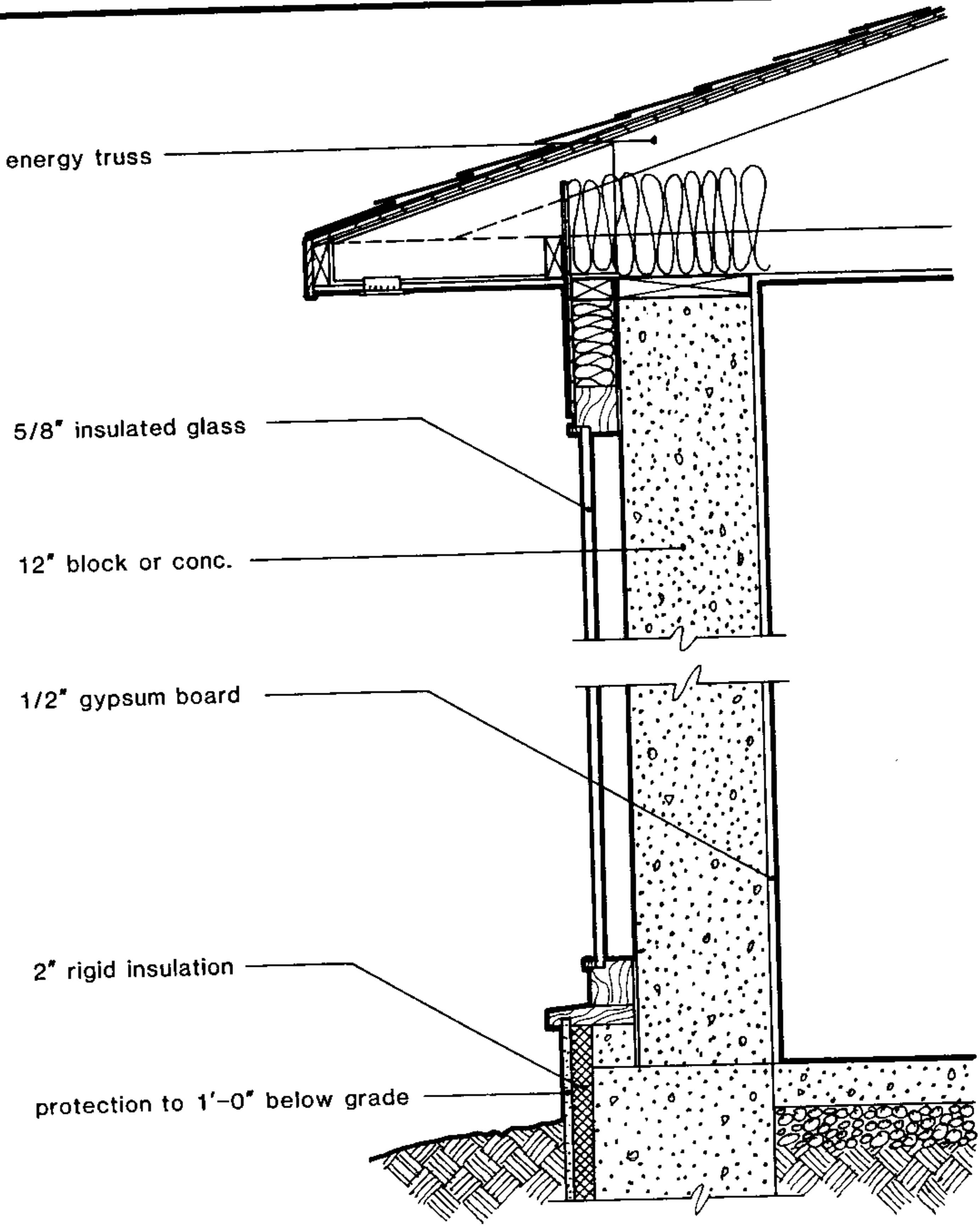
This chapter focuses on specific construction details for solar buildings. Included are recommendations for different passive solar systems, wall, roof and floor sections, and grade and subgrade wall details. By selecting the appropriate details, the desired solar and structural systems can be assembled.

## SOLAR SYSTEMS

### TROMBE WALL

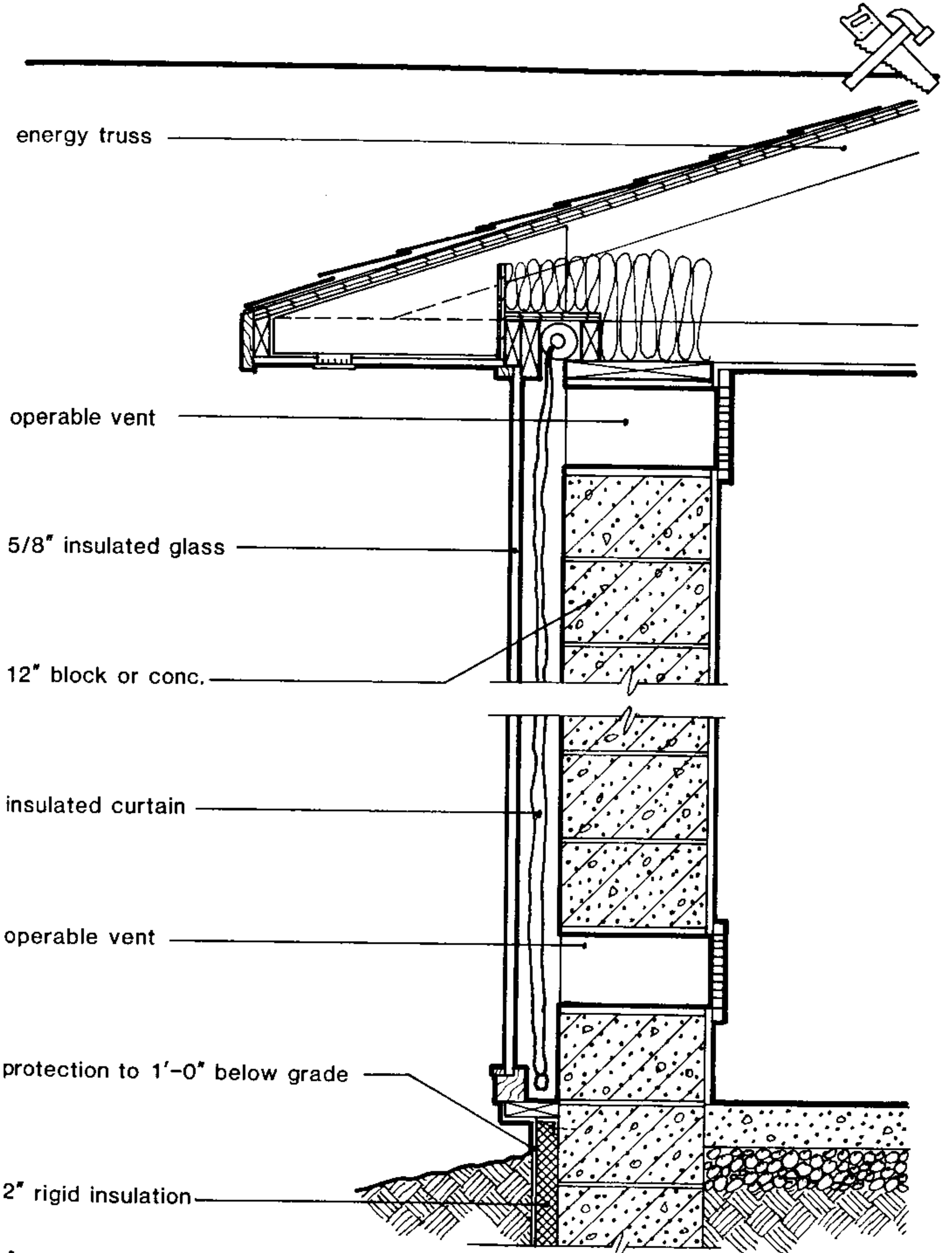
The ventless trombe wall (FIG 4-1) can be constructed from solid poured concrete, brick, stone, or concrete block with filled cores. The advantages in not venting this wall to the interior space are: 1) no insects or dirt will collect, and 2) little maintenance will be needed. Provisions for removing the glass to repaint the dark trombe wall surface should be made.

The vented trombe wall (FIG 4-2) begins transferring heated air directly to the living space as soon as the sun rises. The operable vent should have either manual or automatic controls to stop the flow of hot air to the space as well as to prevent warm house air from flowing back through the collection area and losing heat to the cold night glass. This detail includes a movable insulation system to reduce nighttime losses from the wall surface. Access to the movable insulation system through the attic space, operable vents, or by removing glazing is recommended.



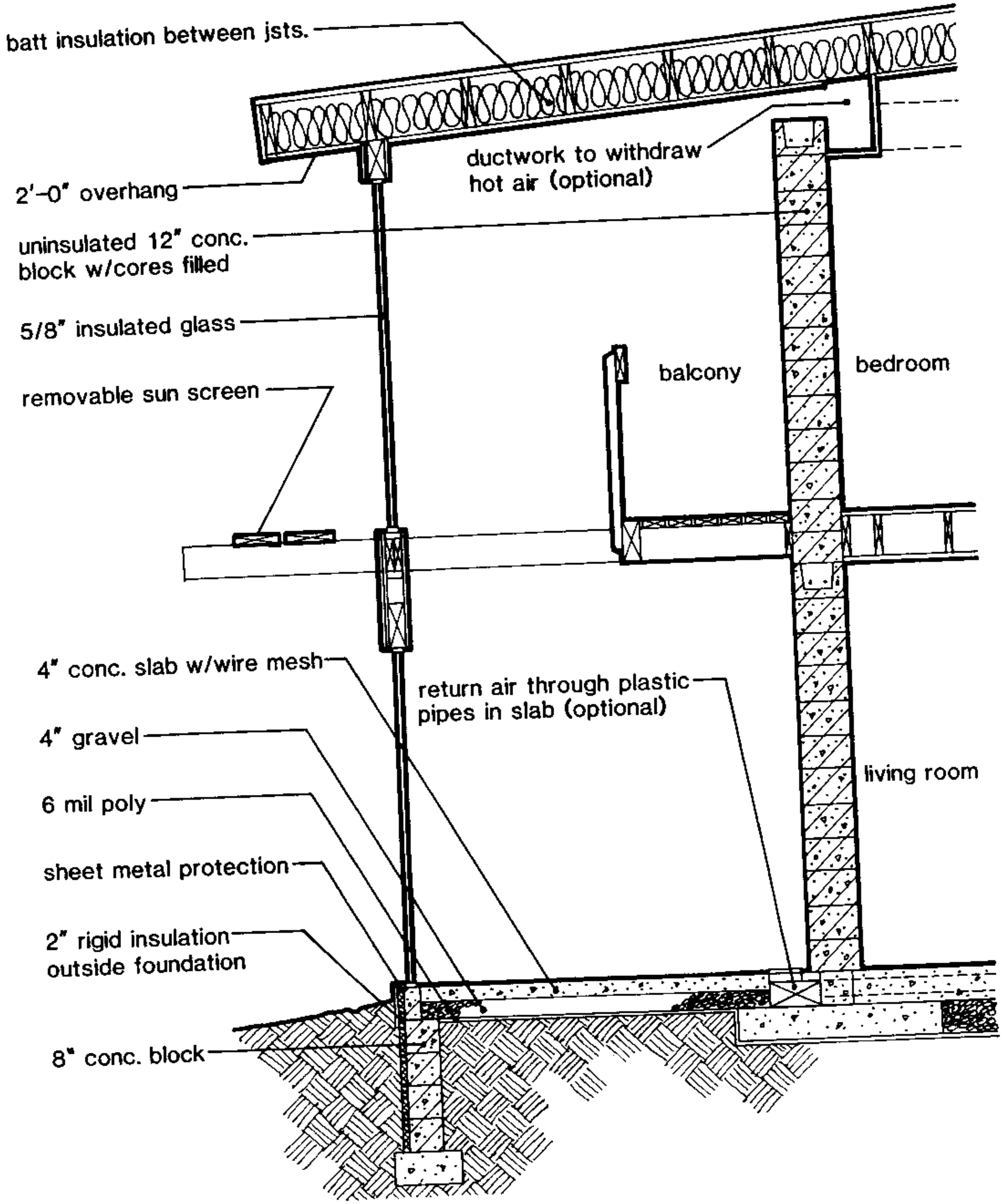

# 4-1 VENTLESS TROMBE WALL

scale: 1" = 1'-0"




# 4-2 VENTED TROMBE WALL

scale 1"= 1'-0"




## 4-3 GREENHOUSE

scale 3/8" = 1'-0"

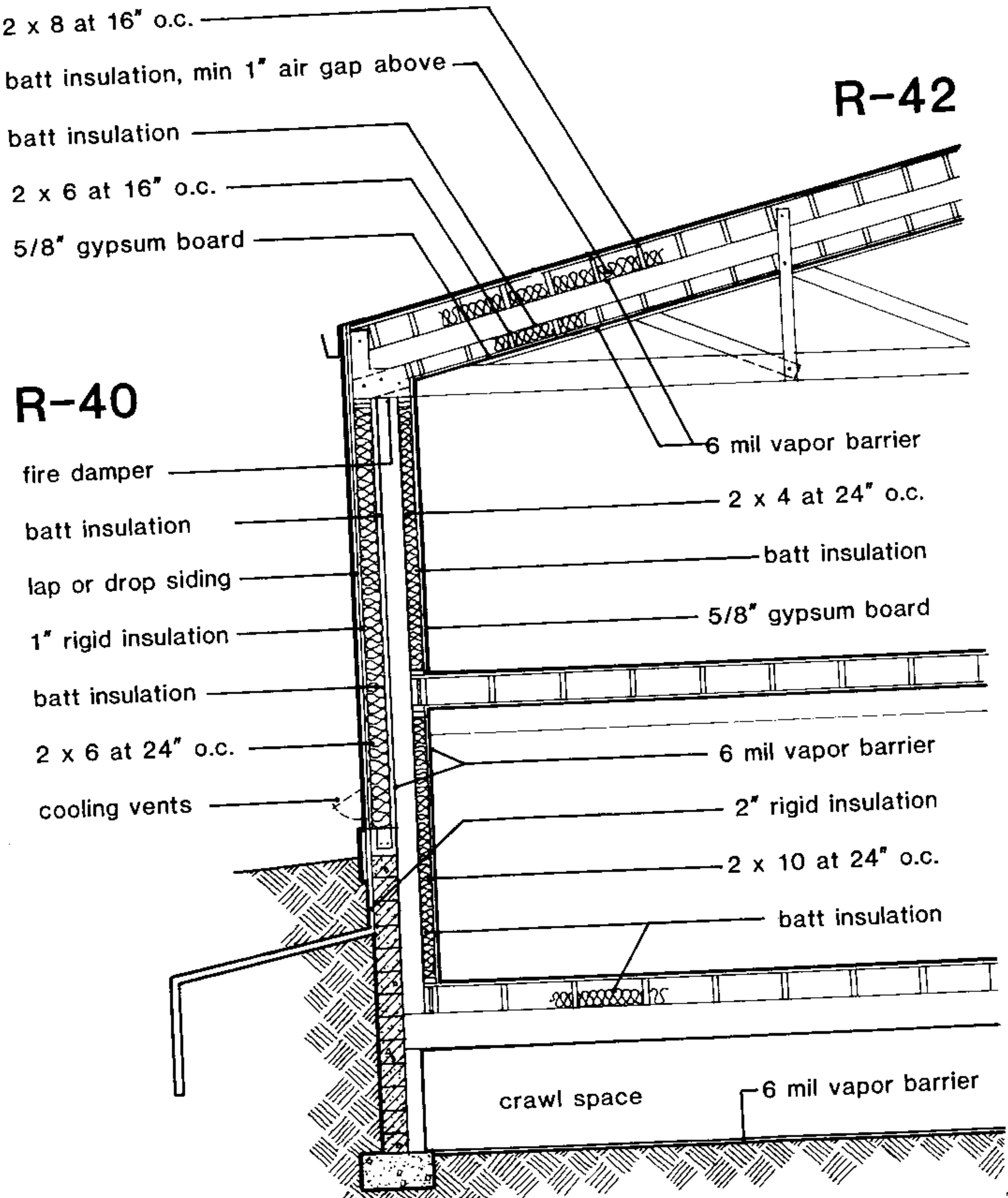
## GREENHOUSE

The greenhouse section (FIG 4-3) is a typical two-story passive solar greenhouse layout utilizing vertical glazing to reduce summer heat gain. Solar energy passes through the glass and is stored in the 12" concrete block wall between the greenhouse and living area. The cores of the concrete block should be filled with a sand and concrete grout to allow for better heat conduction to the interior of the house. With the aid of a fan, heated air can be moved from the top of the greenhouse through ductwork to the floor slab. Heat is transferred to the floor slab as it passes through PVC pipe embedded in the concrete. Cooled air is drawn into the greenhouse at the floor. The fan system is controlled by a thermostat located at the top of the greenhouse space. The greenhouse space is kept warm by solar heat stored in the mass wall and concrete floor slab. The slab has 2" of rigid insulation at the perimeter to control heat loss.

## DOUBLE SHELL

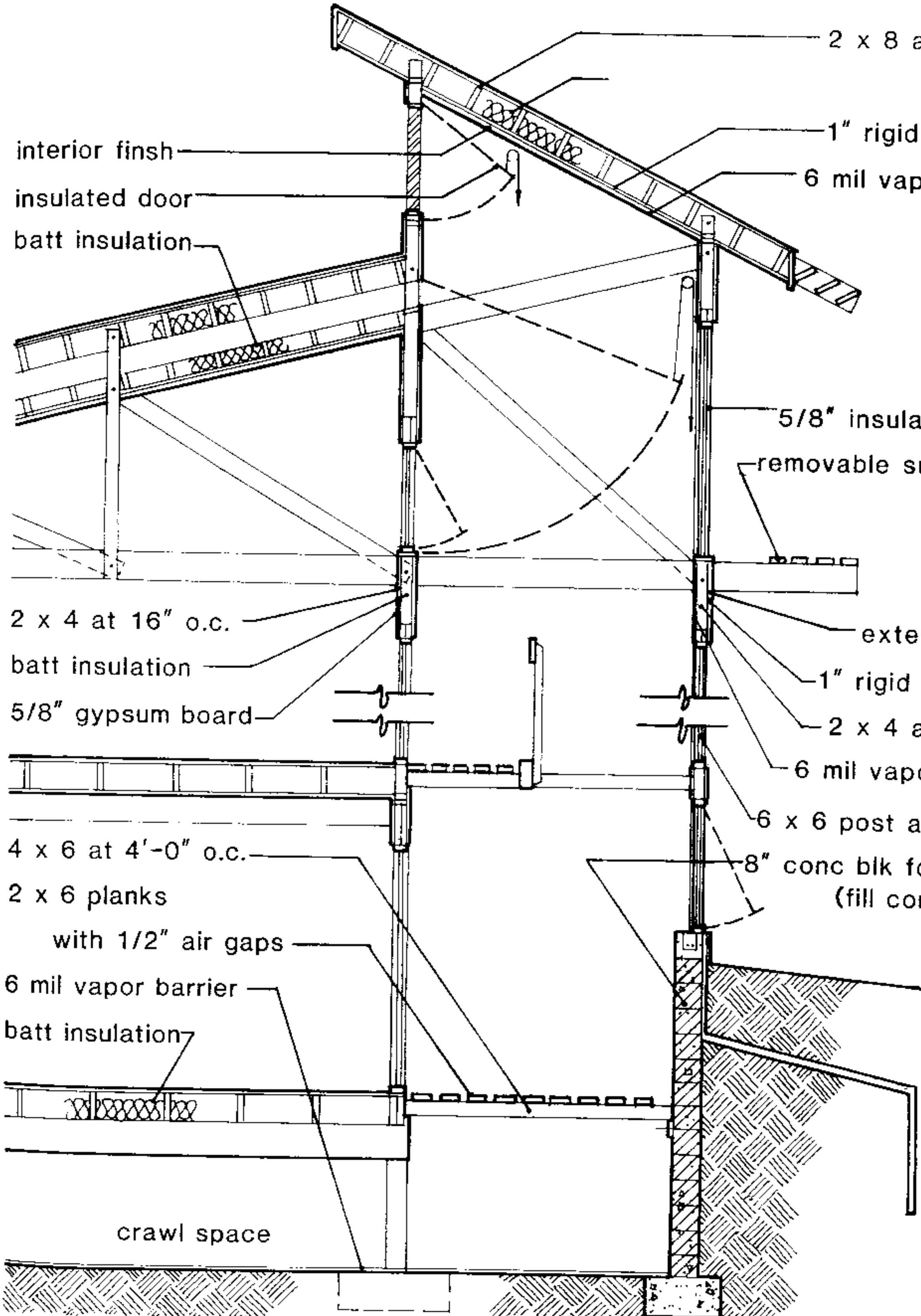
In a double shell design, increased insulation is placed in the outer roof and wall (FIG 4-4). This allows the energy from the heated air in the cavity to transfer more readily to the inside than to the outdoors. By extending the perimeter insulation away from the wall below grade, the lower wall and soil area can be used as additional thermal mass for heat storage. A cooling vent has been added to the wall above grade to reduce heat build up during the summer. A 6 mil vapor barrier has been added to the floor of the crawl space to reduce the moisture build up along greenhouse windows. Another 6 mil vapor barrier is located on the warm side of both the inner and outer walls to keep insulation dry and to reduce infiltration. Local codes may require fire dampers to keep a possible wall fire from spreading into the roof cavity.

The south side of a double shell contains the greenhouse space (FIG 4-5). Note that there is only vertical glazing, unlike many double shell buildings which have sloped glazing. With Nebraska's hot summer climate, this vertical-glazing-only scheme is much easier to shade with overhangs to keep the greenhouse space and house cool. A hinged insulated door behind the louvers at the top of the greenhouse will exhaust superheated air. The awning window at the bottom of the south glazing will allow cool air into the space.




# 4-4 DOUBLE SHELL NORTH WALL

scale: 1/4"=1'-0"




# 4–5 DOUBLE SHELL SOUTH WALL

scale 1/4" 1'-0"

# CONSTRUCTION DETAILS

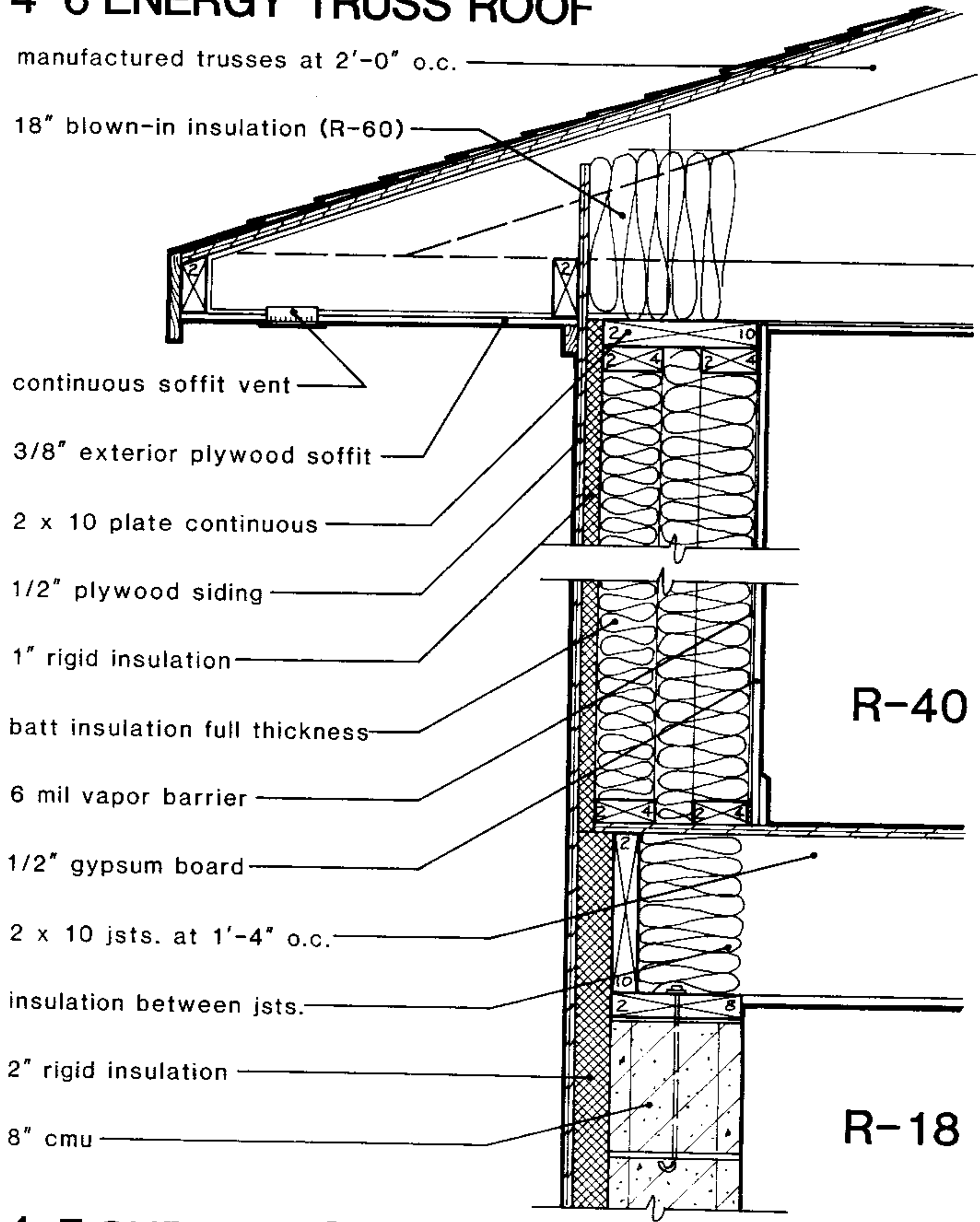
ENERGY TRUSS

The energy truss roof (FIG 4-6) is a modified wood truss which bears upon the lower cord or ceiling joist. This departure from the standard practice of bearing on the upper cord gives the energy truss greater depth for insulation, while allowing free air passage from the soffit vent to the attic space.

SUPER INSULATED

The super insulated wall system (FIG 4-6, 4-7) is one of several methods of using large amounts of insulation in a frame wall. The framing system consists of staggered 2x4 framing stud walls 2' on center. One 2x4 wall supports exterior siding while the other 2x4 wall supports the gypsum board on the inside. The 2x4 stud walls are separated by a 2-1/4" center space. By separating the stud walls in this manner, the transfer of heat directly through the studs to the outside is eliminated. Also, because the net wall width is greater than customary, the batt insulation throughout most of the wall is a full 11 1/4" and the minimum is 7 3/4". Combined with 1" of thermax insulation, the wall has a total R value of 40. The wall is extended over the joist to allow for the use of increased insulation around the foundation while maintaining a flush appearance. By placing rigid insulation on the exterior of the foundation, the block wall can be exposed to the interior; this adds thermal mass to the building.

# 4-6 ENERGY TRUSS ROOF



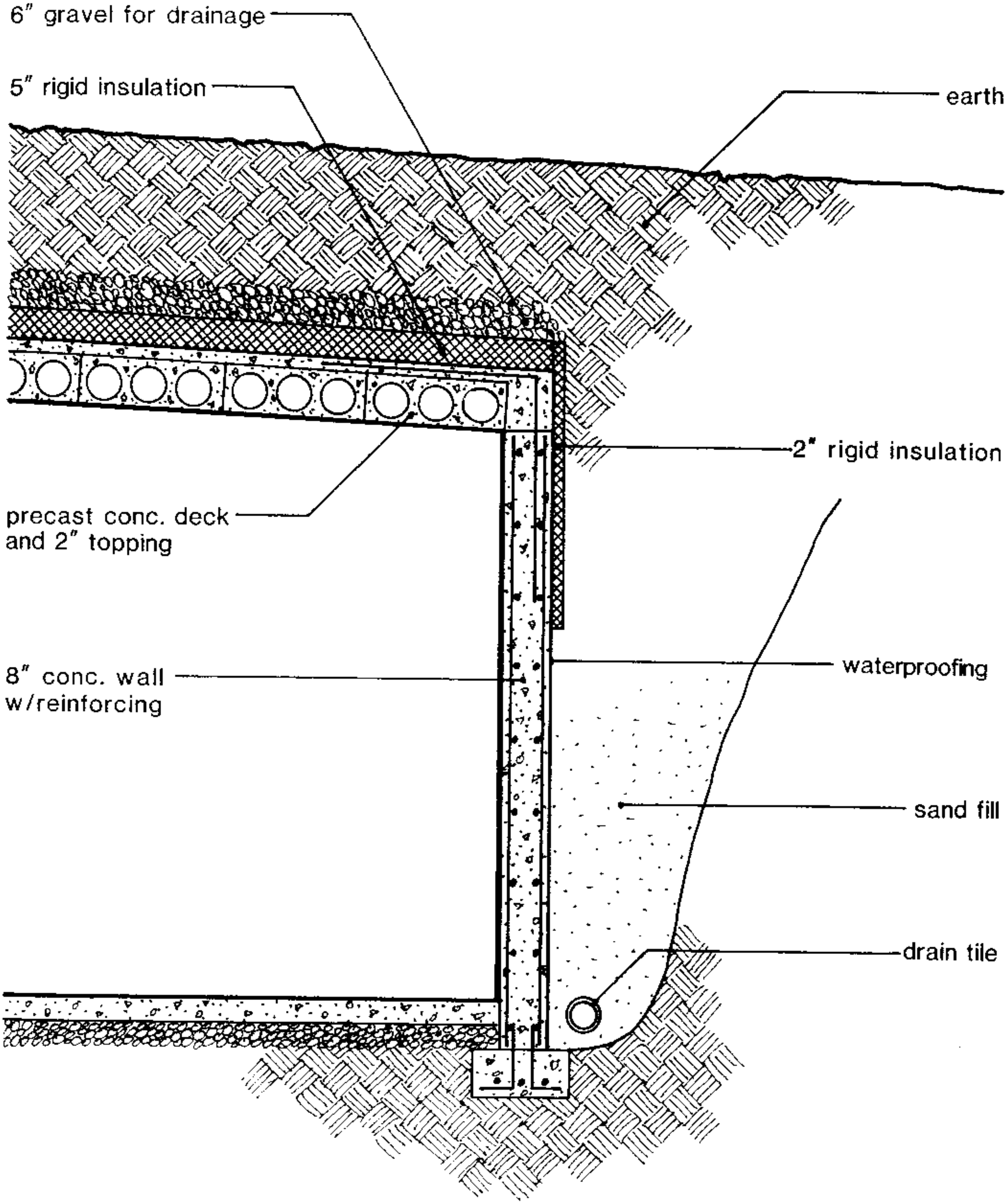

# 4-7 SUPER INSULATED WALL

scale: 1 1/2" = 1'-0"

## EARTH SHELTERED

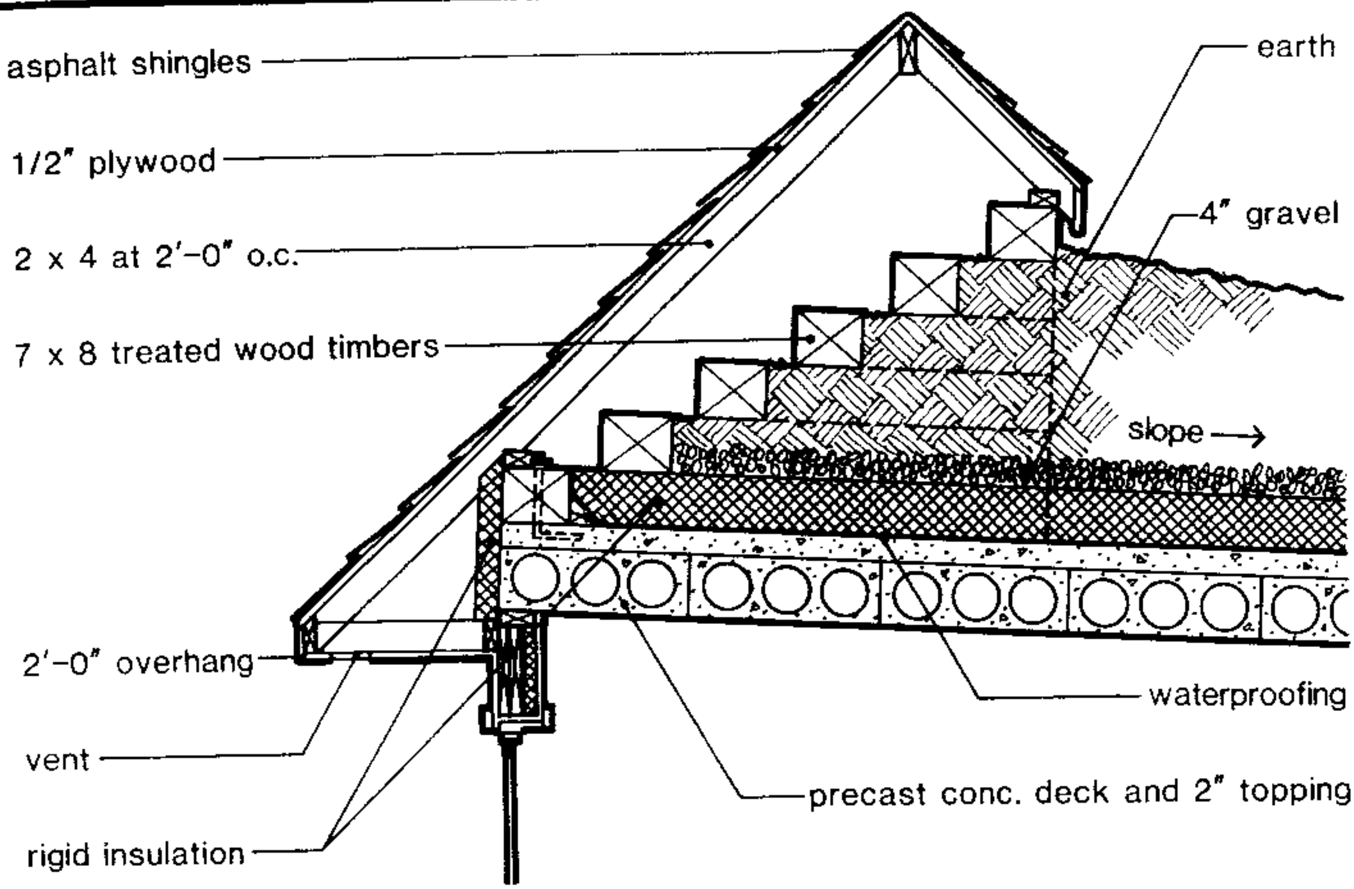
The earth sheltered wall section (FIG 4-8) is a reinforced poured concrete wall with a precast concrete roof deck. The roof deck should be sloped to provide positive drainage and prevent water from ponding in the middle of spans. The wall and roof should be waterproofed before the insulation is installed. Gravel backfill is placed over the insulation to provide drainage away from the insulation and the building. A drain tile at the bottom of the footing is used to carry water away from the building. In Nebraska, 12" to 24" of earth should maintain vegetation growth over the roof. Greater earth cover does little but add to the structural problems encountered in placing soil on a roof deck.

Two methods of retaining earth at the roof edge of an earth sheltered building are the mansard and canted parapets (FIG 4-9). The mansard parapet uses treated wood timbers that are stacked with each timber placed 1' behind the one below. This system prevents frozen ground from pushing against the parapet. The mansard roof can also prevent accidental falls from the roof, keep moisture away from the roof edge, and give a more conventional look to the structure. The canted parapet performs substantially the same function as the mansard but can be cheaper to build.

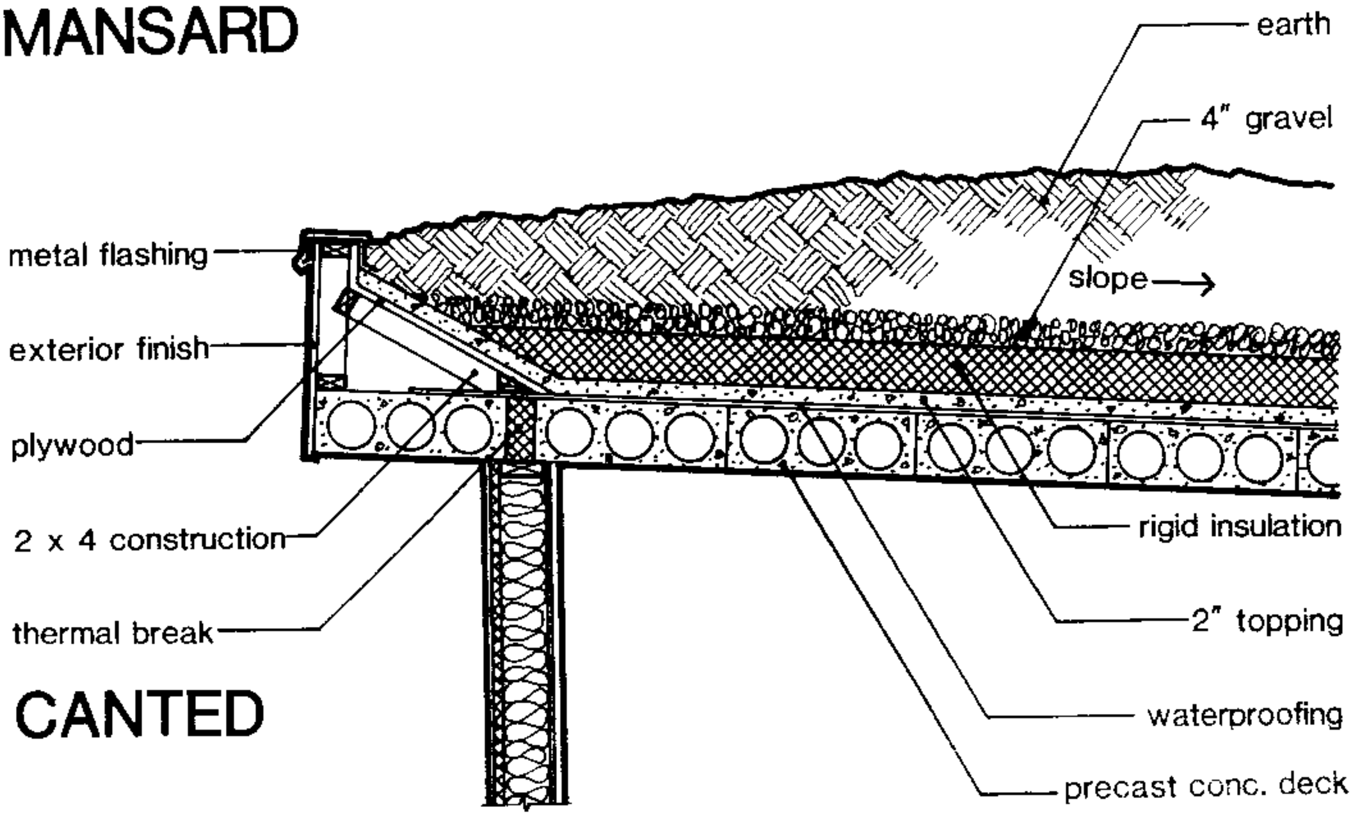



# 4–8 EARTH SHELTERED WALL

scale: 1/2 = 1'–0"



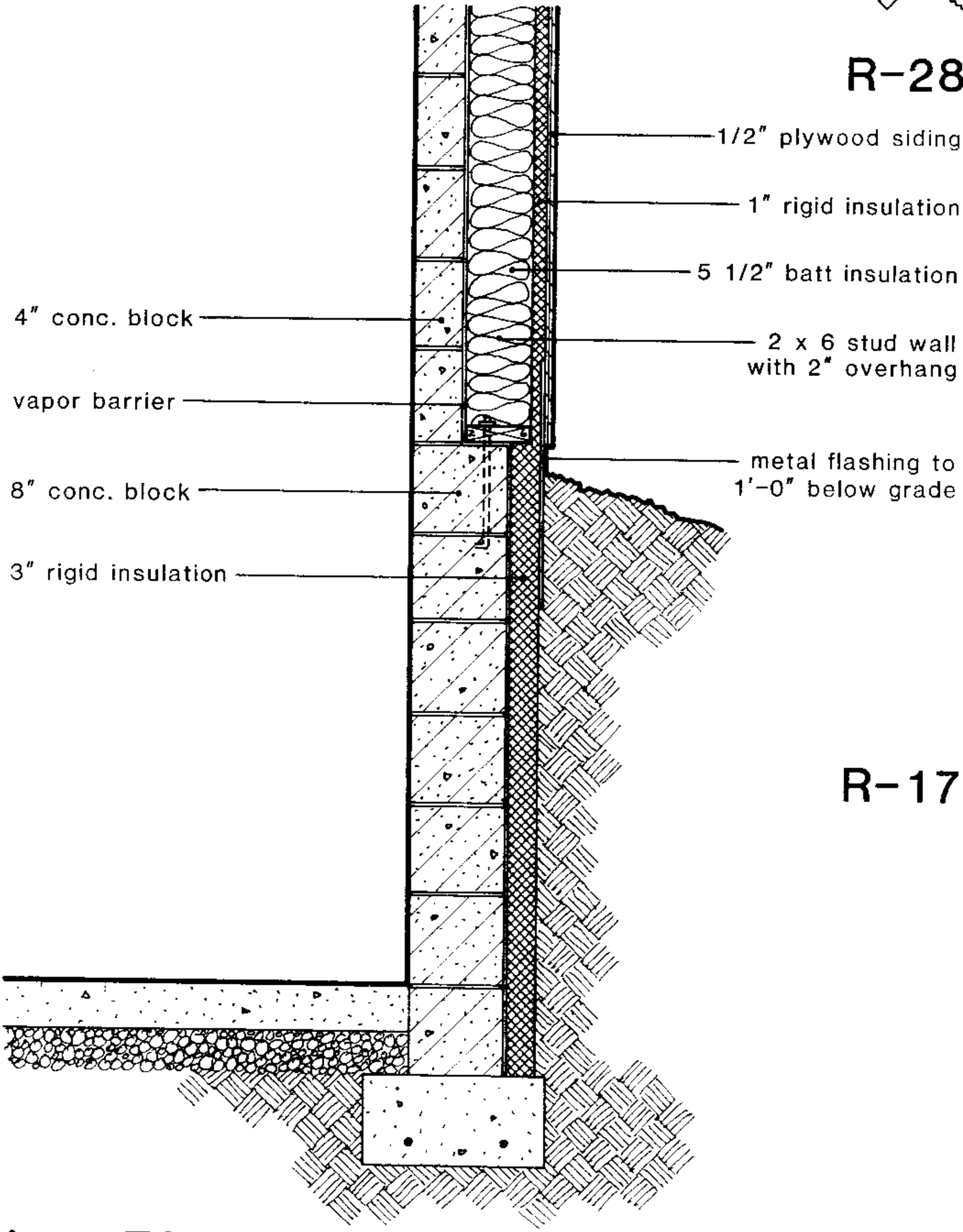

## MANSARD




## CANTED

# 4–9 EARTH SHELTERED PARAPETS

scale: 1/2" = 1'-0"




# 4-10 EARTH BERM

scale: 1" = 1'-0"

# CONSTRUCTION DETAILS

## AT GRADE AND BELOW GRADE DETAILS

The earth berm detail (FIG 4-10) is typical of those used in many passive solar homes. The concrete block wall exposed to the interior acts as solar storage mass. The 2x6 stud wall insulates the mass from the cold outside and is extended over the foundation edge 2" to allow for increased insulation below grade.

There are a number of options in placing rigid insulation below grade. Insulation of uniform thickness down to the footing is easy to install but it is not the most effective use of the material (FIG 4-11). Insulating part-way down the wall provides greater insulation where it is needed most, near cold frozen ground. The lower portion of the wall is exposed to the ground which increases the potential for ground cooling during the summer (FIG 4-12). Overlapping insulation places the most insulation at the top while providing decreasing amounts of insulation to the bottom of the footing (FIG 4-13). This system can provide the greatest heat loss protection per square foot of insulation material available.

Another technique places insulation next to the wall for the first few feet below grade (FIG 4-14). Below the frost line, the insulation is extended at an angle down to a point level with the footing. This adds earth mass to the building mass without increasing material costs. One problem with this approach, however, is the extra cost involved in placing the backfill under and over the insulation. Settlement in the soil backfill can also create gaps in the insulation, resulting in a lower R value.

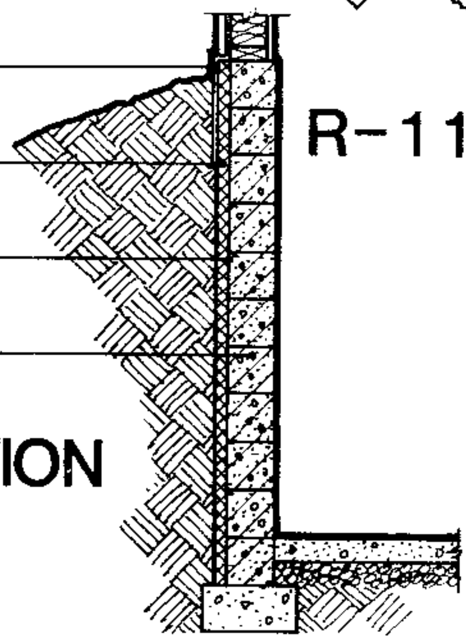
Cheaper batt insulation can also be used below grade on the exterior of the masonry foundation (FIG 4-15). To be successful, high grade waterproofing and drainage away from the foundation are needed to keep treated foundation-grade plywood from leaking.

All the preceding exterior insulation techniques require protection from damage during backfill as well as protection from deterioration due to exposure to sunlight. The method of protection may be dependent on the placement of the frame wall on the foundation.

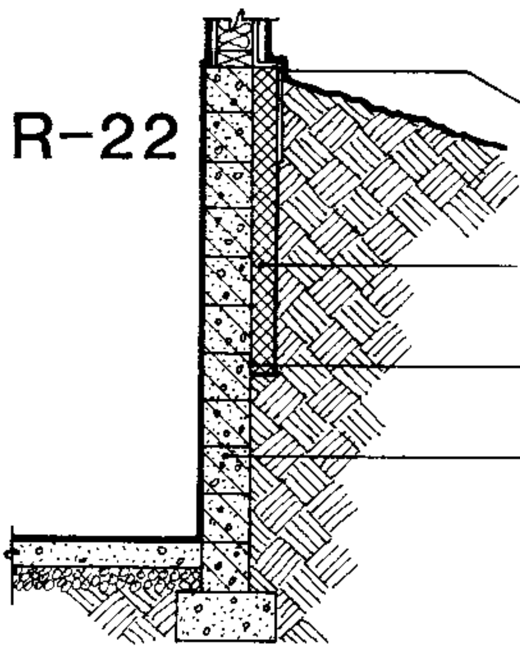
Flush insulation is very simple to install and protect with a band of flashing which extends 1' below grade and behind exterior siding material (FIG 4-16). Cantilevering the frame wall over the foundation increases insulation thickness levels at the foundation but requires metal flashing bent to seal the top of the foundation. If cantilevered placement is not used, the increased insulation can be extended and covered by bent metal flashing. Metal flashing can be galvanized metal (to prevent rusting), painted or anodized aluminum to match window and door trim.

Cement asbestos board or shingles can be nailed to the sill plate to mimic the look of concrete while protecting the rigid insulation (FIG 4-17).

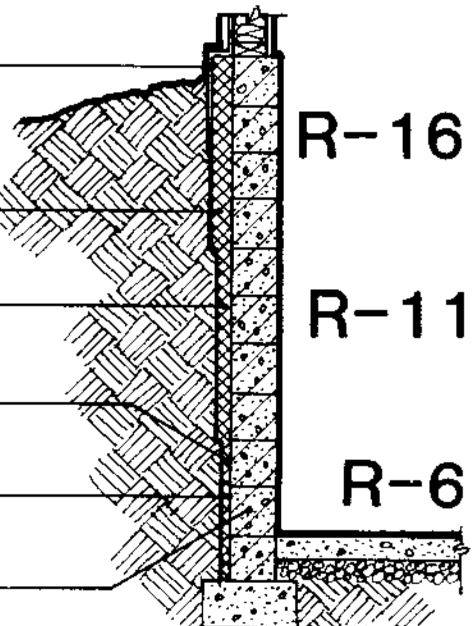
There are several products which can be used to coat rigid insulation, and those which are waterproof are ideal for exterior use (FIG 4-18). Most have fiberglass reinforcing mesh for strength.




# 4-11 CONTINUOUS INSULATION

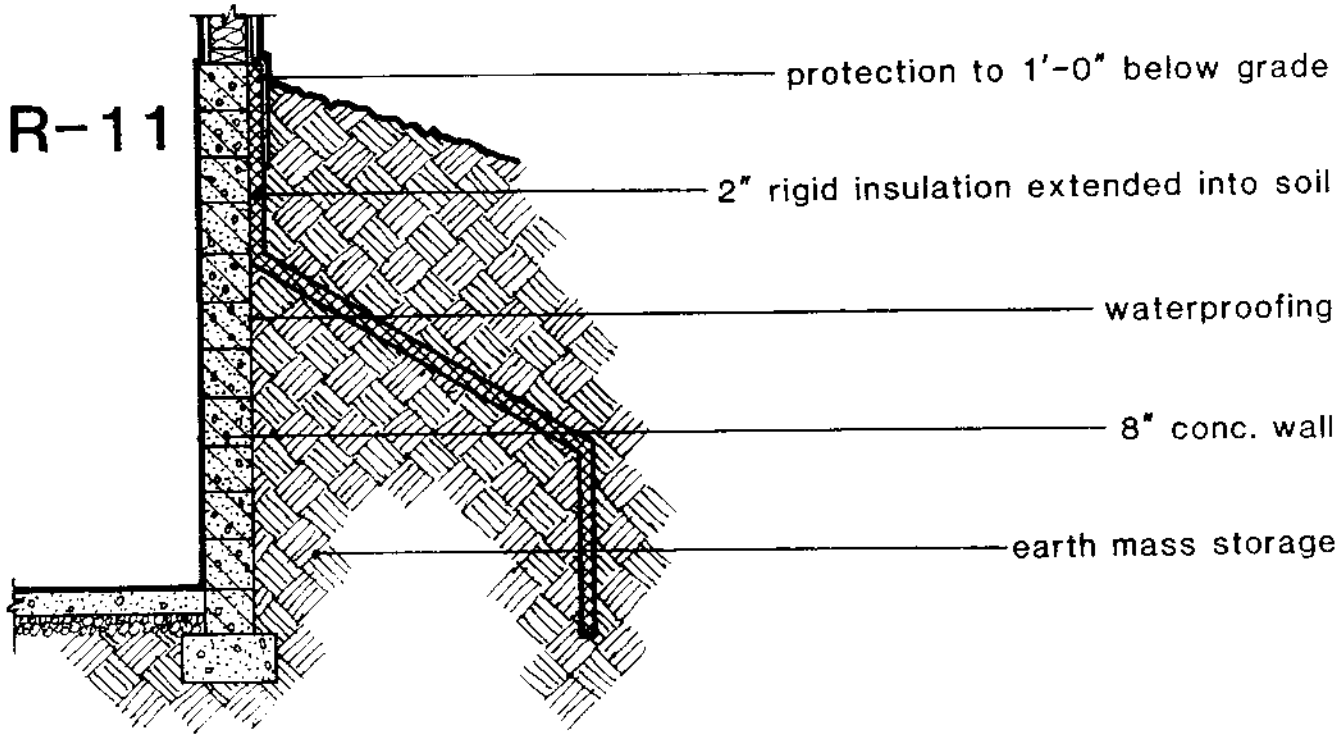



# 4-12 PARTIAL INSULATION



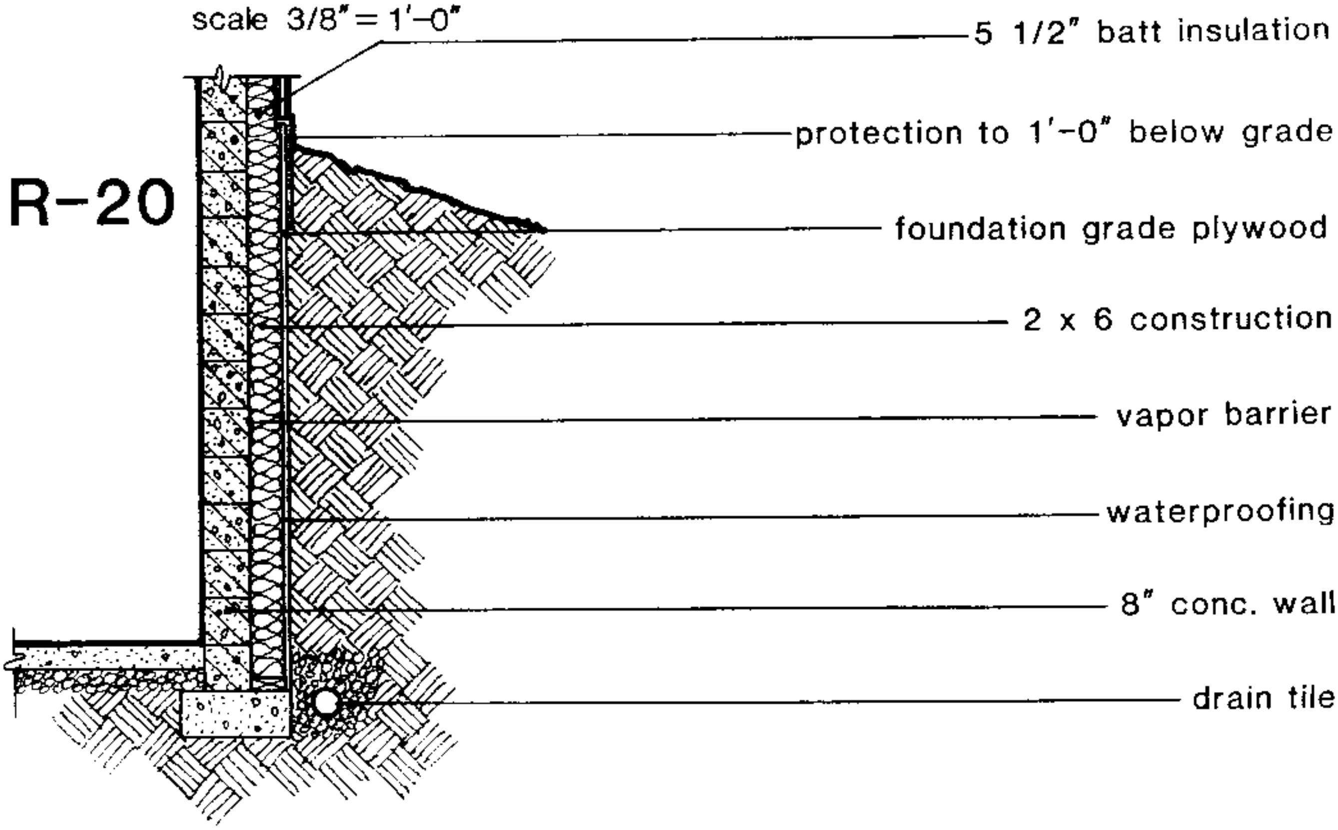

# 4-13 OVERLAPPING INSULATION

scale: 3/8" = 1'-0"



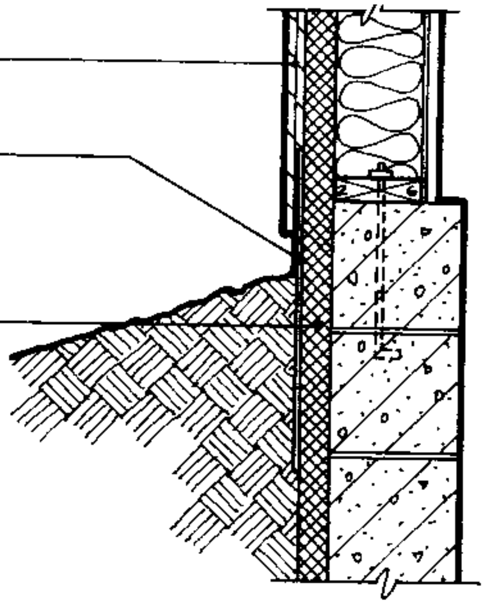

## 4-14 INSULATION EXTENDED INTO SOIL

scale 3/8" = 1'-0"

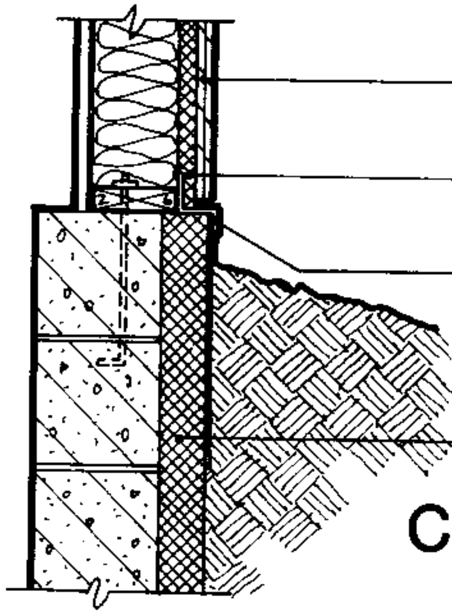



## 4-15 CONTINUOUS BATT INSULATION

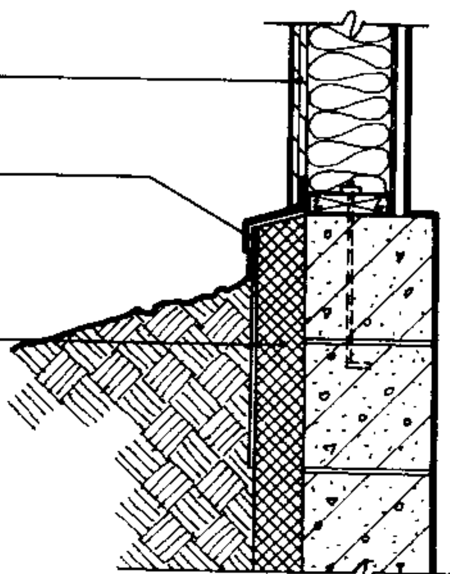
scale 3/8" = 1'-0"




## FLUSH



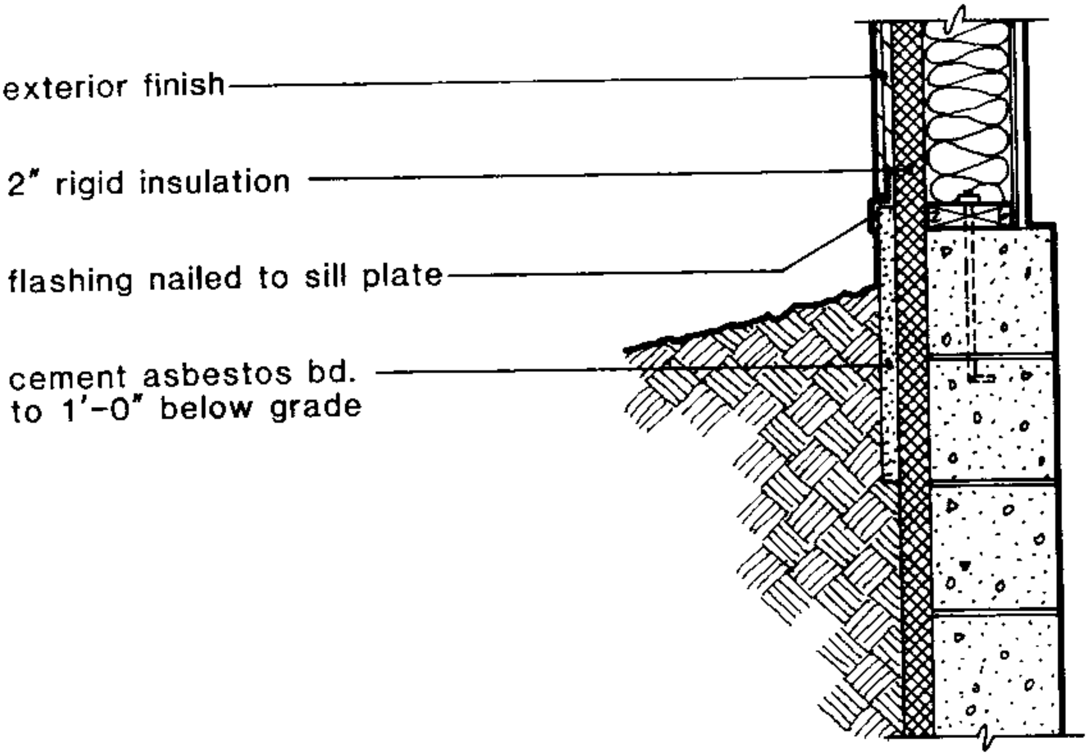

## CANTILEVERED PLATE




## EXTENDED

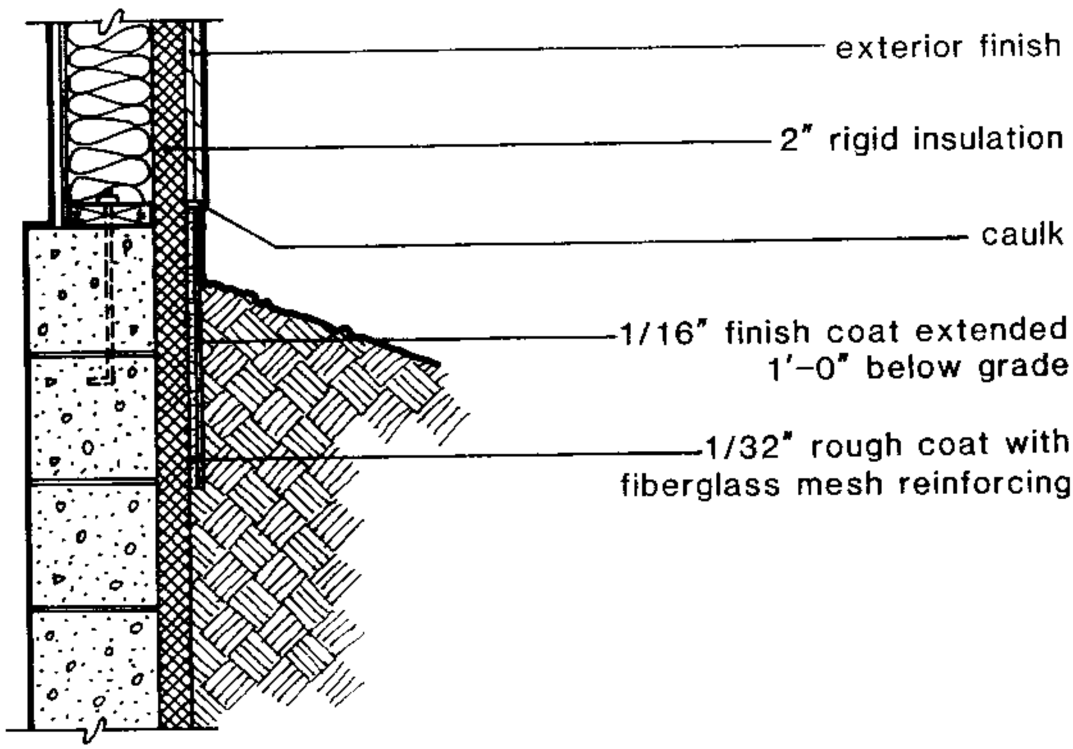
# 4–16 METAL FLASHING AT GRADE

scale 1"= 1'-0"




# 4-17 CEMENT ASBESTOS BD. AT GRADE

scale: 1"= 1'-0"




# 4-18 SKIM COAT AT GRADE



scale: 1"= 1'-0"

## WALL SECTIONS

Rigid insulation is frequently used to insulate a masonry storage wall. A thin fiberglass reinforced coating gives the appearance of concrete or stucco and comes in several colors (FIG 4-19). This system works well on existing masonry structures.

For thicker rigid insulation installations, two furring strips can be attached to masonry (FIG 4-20). A lath system spans the rigid insulation and serves as a base for the stucco coating. Stucco on lath can also be held in place with wire ties inserted into masonry joints (FIG 4-21).

Wood furring strips placed vertically and horizontally can be used effectively in providing a well-insulated wall of minimal thickness which will receive conventional siding (FIG 4-22). A more typical approach to wall construction places rigid insulation between brick and concrete block (FIG 4-23). Another alternative uses a masonry storage wall as a structural wall. A wood stud wall provides insulation space and a nailing surface for siding (FIG 4-24).

Multi-layered gypsum board storage walls can be used to provide solar storage where heavier mass storage materials, such as concrete, masonry, and water, cannot be used (FIG 4-25). Although lighter in weight than most storage wall materials, gypsum board can be distributed over wall surfaces to provide necessary storage. The wall should be multi-layered if it will receive direct sunlight during a portion of the day, and the gypsum boards should be bonded together to eliminate airspaces.

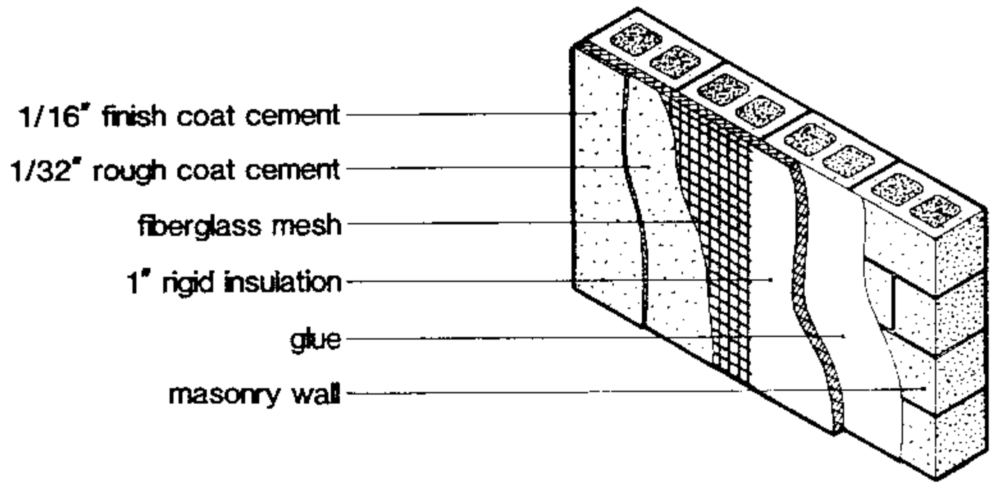
A possible detail for super insulating a commercial building wall uses precast concrete double tees placed vertically (FIG 4-26). A new exterior finish leaves a 10" cavity for insulation, and the concrete facing the interior can be used as mass.

Where the exterior siding used does not permit the use of rigid insulation as sheathing, the rigid insulation should be placed on the interior between the stud wall and the gypsum wall (FIG 4-27). This application can be used in retrofit situations where interior finish material is removed; the exposed frame cavity makes the addition of batt insulation relatively easy.

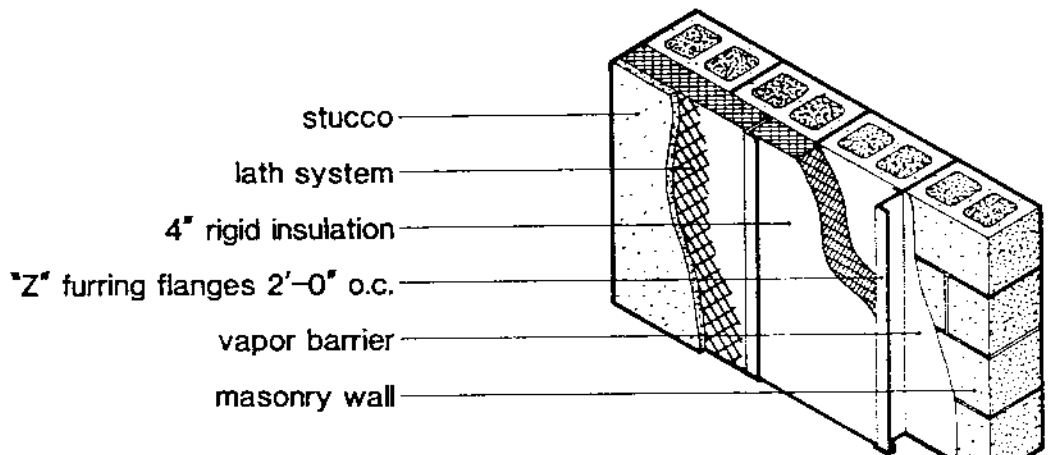
Rigid insulation can replace sheathing on the exterior of a frame wall to isolate the stud from cold outside temperatures and retard the flow of heat through this insulation weakspot (FIG 4-28). Where rigid insulation is used in place of sheathing, care must be taken to ensure the structural stability which wall sheathing normally provides.

Rigid insulation placed on both the exterior and interior walls gives superior insulation with minumum stud width (FIG 4-29).

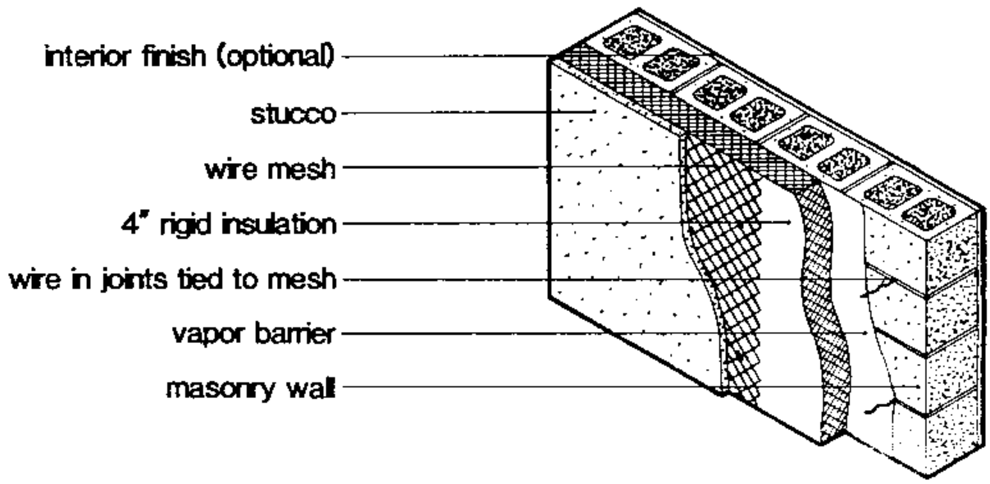
A super insulation scheme for walls uses a system of two 2x4 stud walls placed on a 2x10 sole plate creating an 11 1/4" insulation cavity (FIG 4-30). The double stud wall stops heat transfer from the inner wall to the outer wall. The exterior wall may be covered with a thin sheet of rigid insulation before siding is installed.



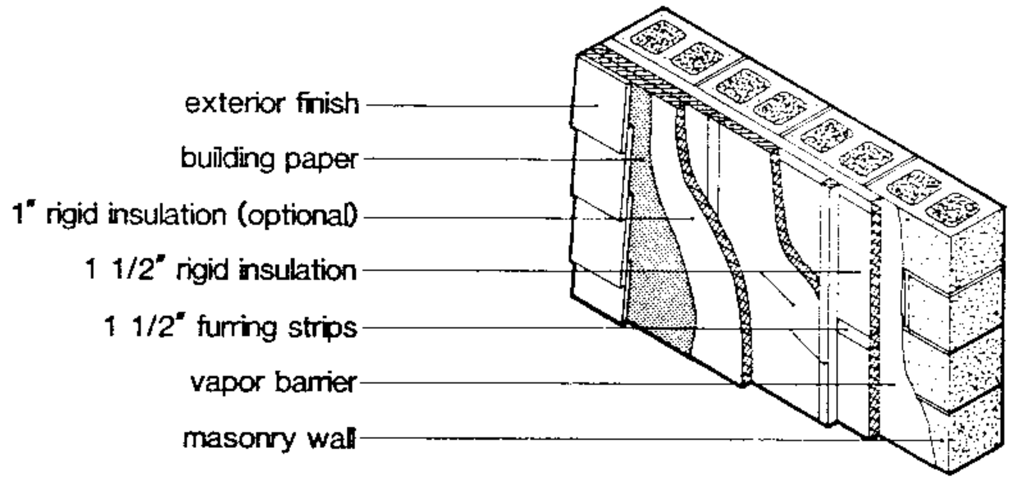

4-19 STORAGE WALL: SKIM COAT OVER FIBERGLASS MESH R-10



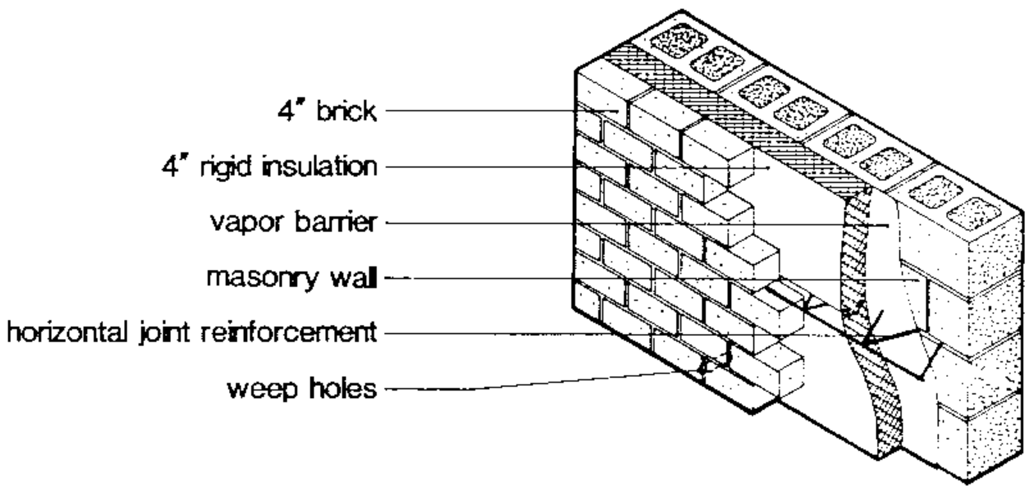

4-20 STORAGE WALL: STUCCO ON LATH WITH METAL FURRING STRIPS R-25



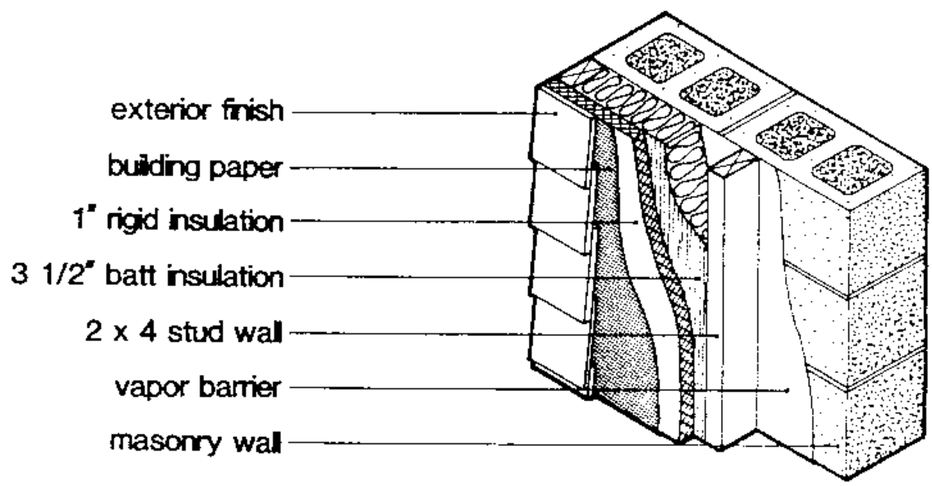

4-21 STORAGE WALL: STUCCO ON LATH WITH WIRE TIES R-25



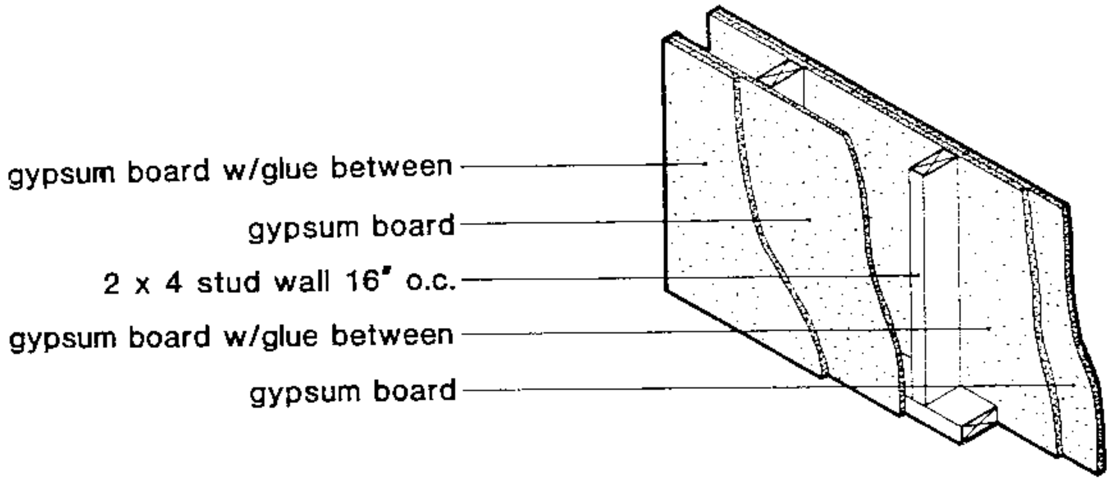

4-22 STORAGE WALL: SIDING ON WOOD FURRING STRIPS R-26



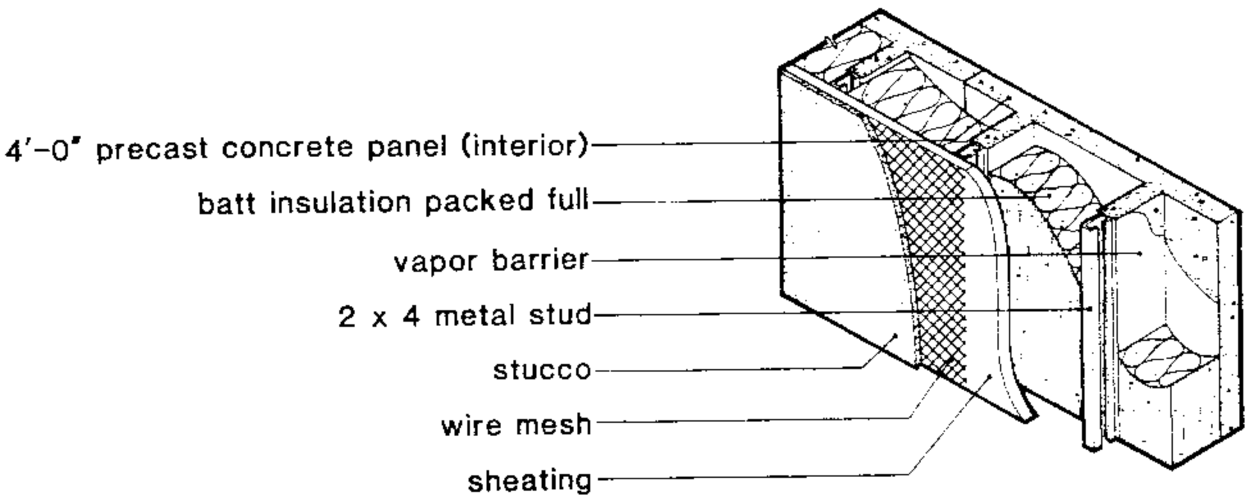

4-23 STORAGE WALL: INSULATED MASONRY CAVITY WALL R-26



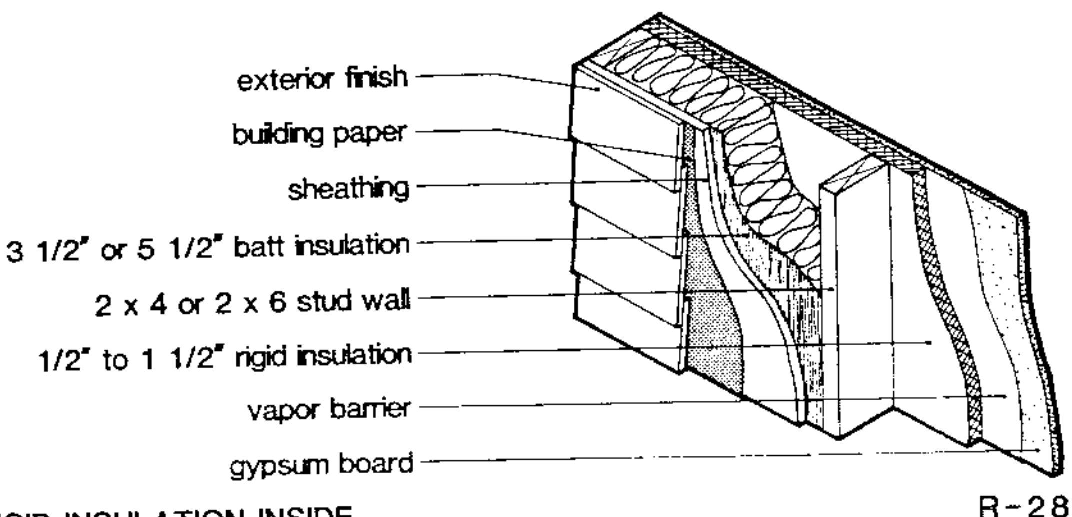

4-24 STORAGE WALL: INSULATED STUDS & SIDING R-22



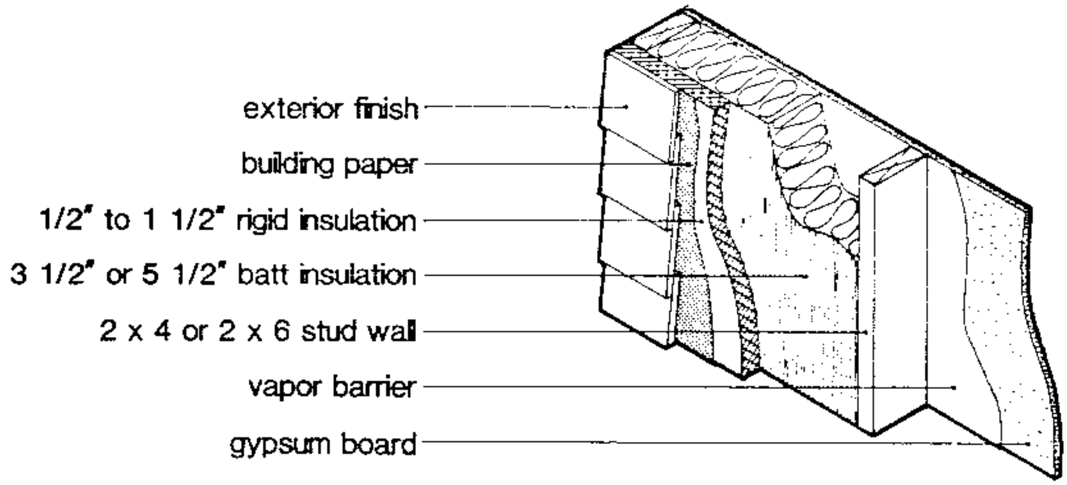

4-25 INTERIOR STORAGE WALL: MULTILAYERED GYPSUM



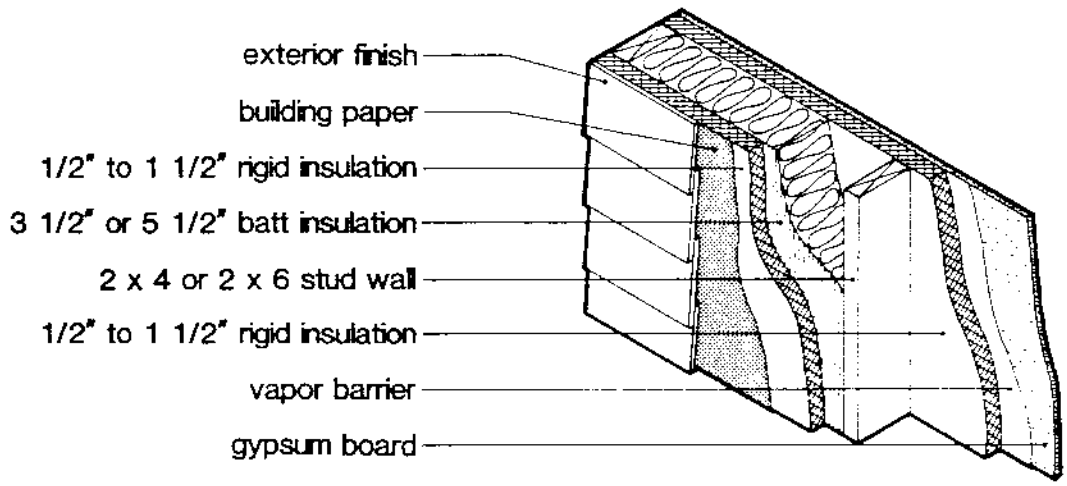

4-26 WALL: COMMERCIAL BUILDING



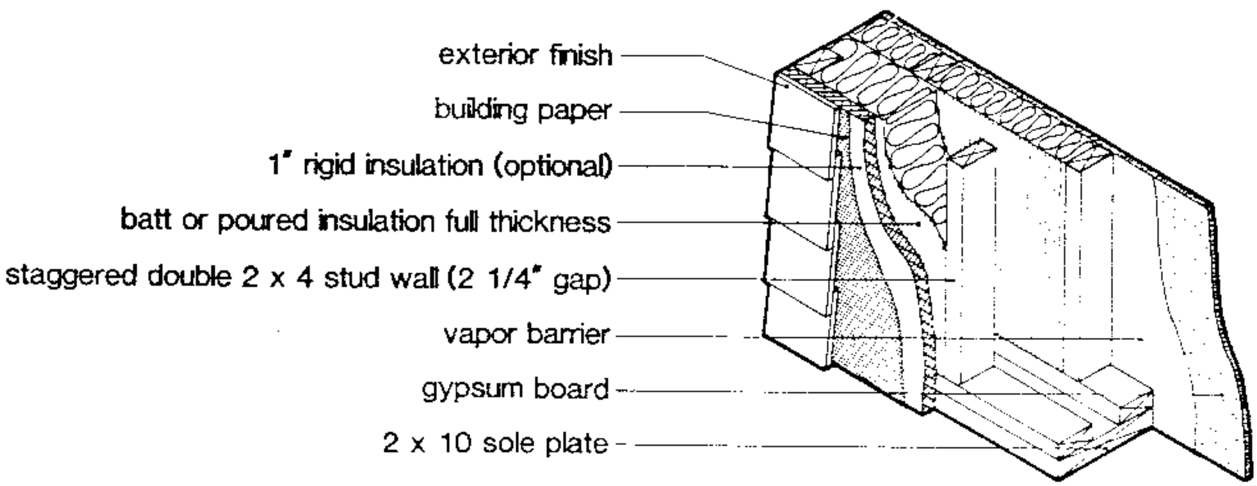

4-27 WALL: RIGID INSULATION INSIDE




4-28 WALL: RIGID INSULATION OUTSIDE — R-28




4-29 WALL: RIGID INSULATION INSIDE & OUTSIDE — R-35




4-30 WALL: SUPER INSULATED — R-40

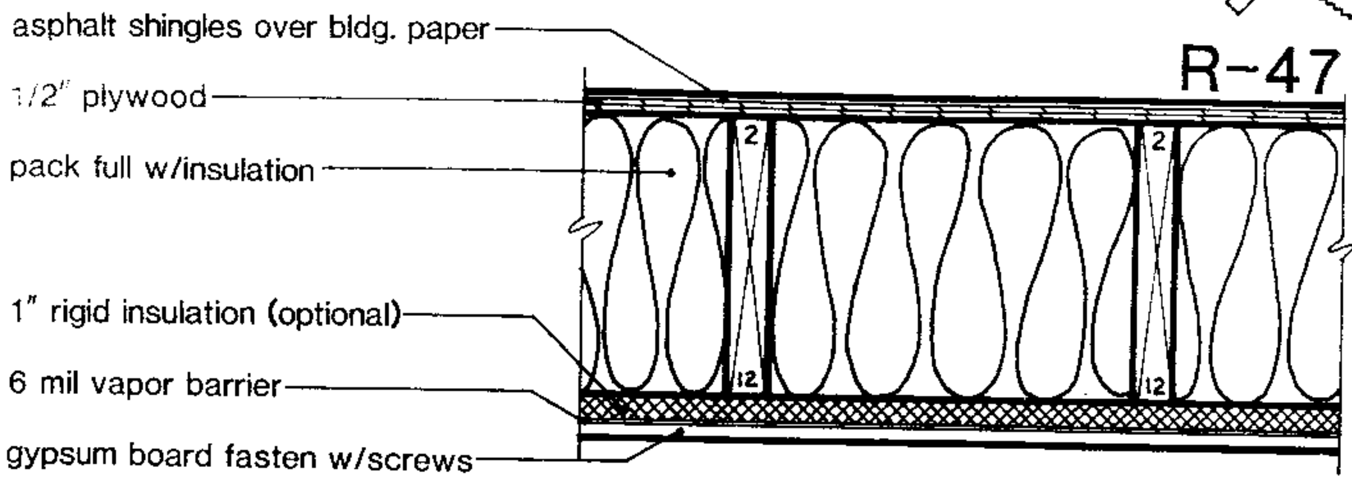
## ROOFS

The cathedral ceiling shown has insulation completely filling the cavity space with neither ridge nor eave vents being used (FIG 4-31). When using this option, the insulation must be protected by a tight fitting vapor barrier to stop moisture generated in the house. Air spaces left in the ceiling will trap heat which radiates into the space. This system gives maximum insulation values within the framing depth, and rigid insulation placed between the bottom of the rafters and the gypsum board can further raise these values. The use of rigid insulation requires longer nails or long screws to hold it in place.

An alternative cathedral roof scheme is not filled completely with batt insulation (FIG 4-32), instead a 2" air space is left to vent moisture and, in summer, excess heat. Additional rigid insulation may be required to equal the R value of the preceding cathedral roof detail.

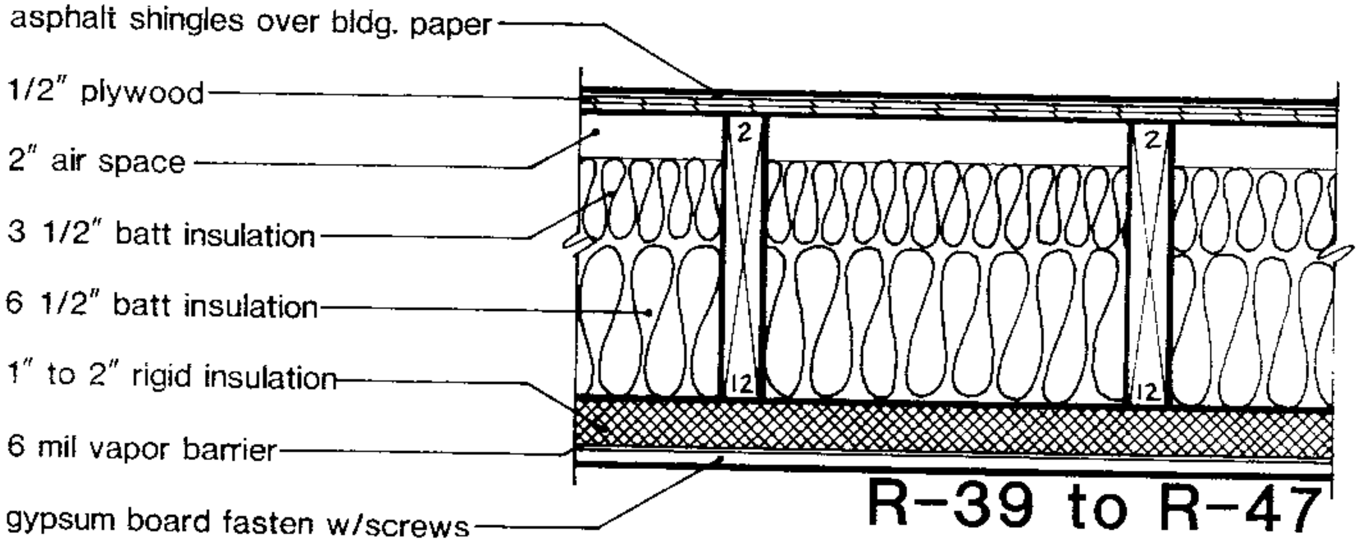
The double shell roof (FIG 4-33) has a greater amount of insulation in the roof and a lesser amount over the interior ceiling joists. The cavity should be free from obstructions for unrestricted airflow and be protected from moisture by a vapor barrier on the warm side of the roof and ceiling frames.

The wood truss roof (FIG 4-34) effectively controls framing costs while providing a deep cavity for insulation placement as well as a few inches of venting space.



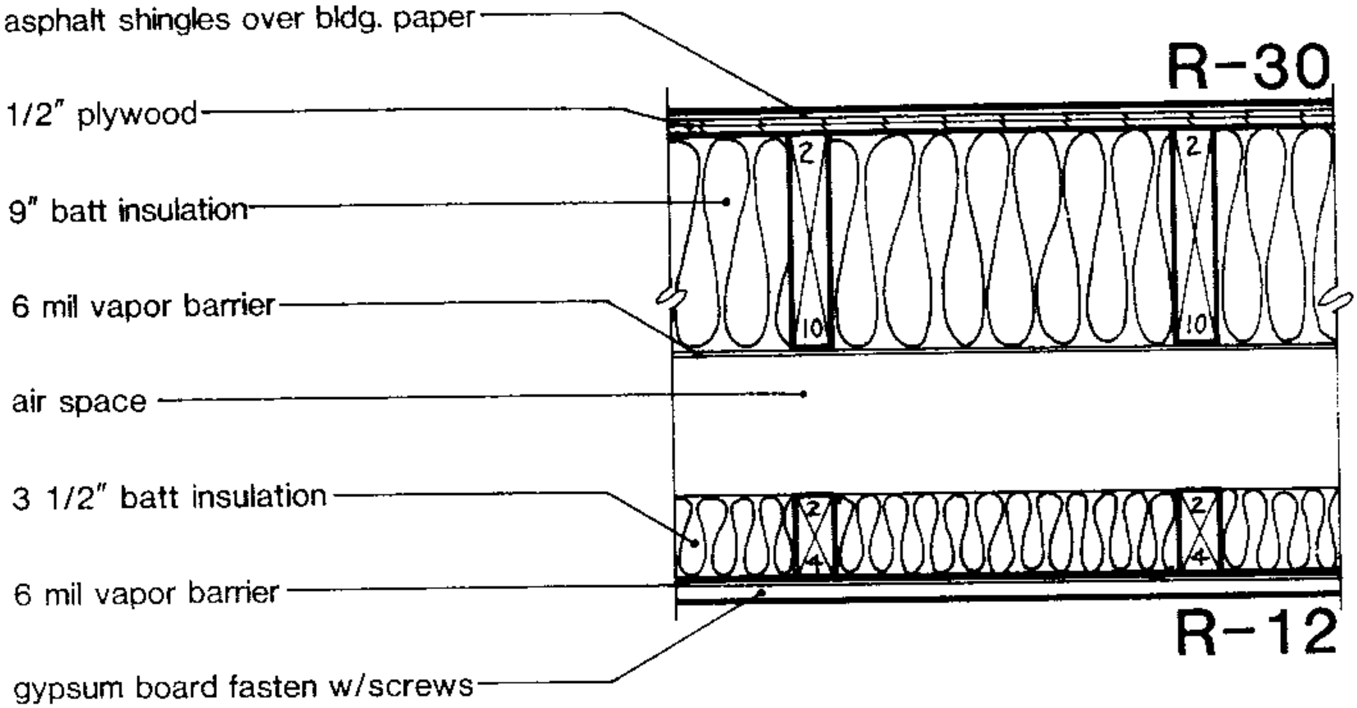

# 4-31 ROOF: CATHEDRAL PACKED FULL

scale: 1 1/2" = 1'-0"



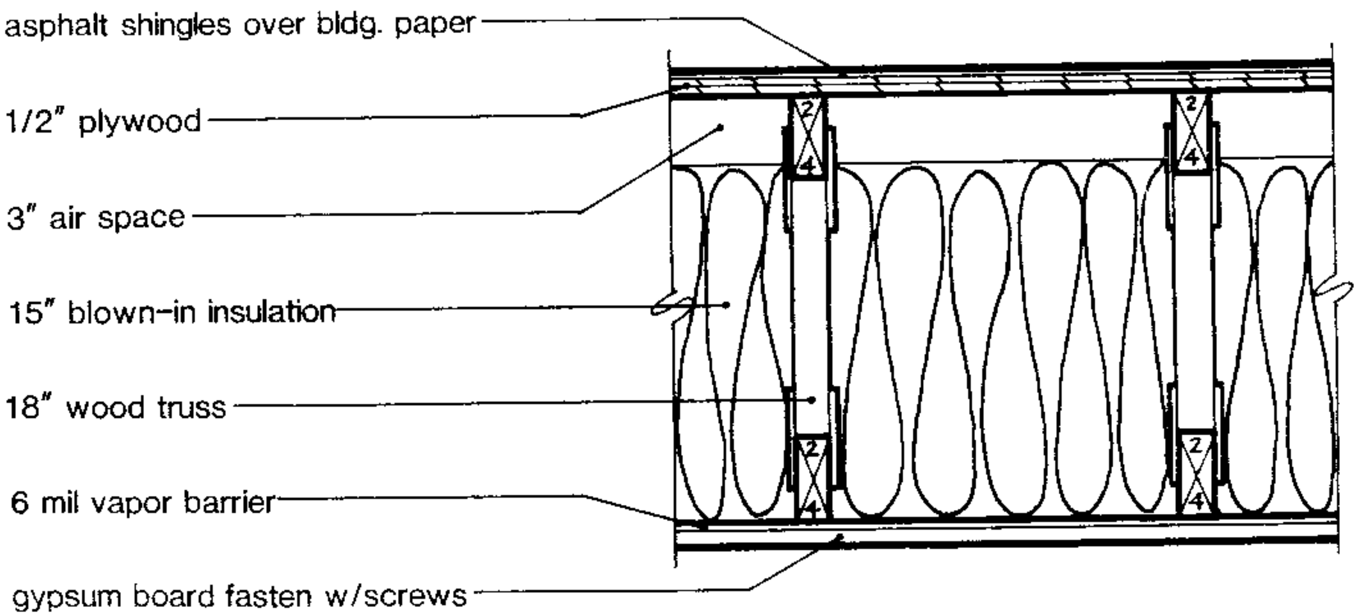

# 4-32 ROOF: CATHEDRAL WITH AIR SPACE

scale: 1 1/2" = 1'-0"




## 4-33 ROOF: DOUBLE SHELL R-42

scale: 1 1/2" = 1'-0"




## 4-34 ROOF: WOOD TRUSS R-50

scale: 1 1/2" = 1'-0"

## FLOORS

The concrete storage floor (FIG 4-35), a standard commercial construction technique, is very effective when placed in direct sunlight. The slab can be thickest where the sunlight strikes, tapering to a standard depth in shaded areas. The floor can be painted a dark color to increase absorption and should not be carpeted, although small rugs can be used sparingly.

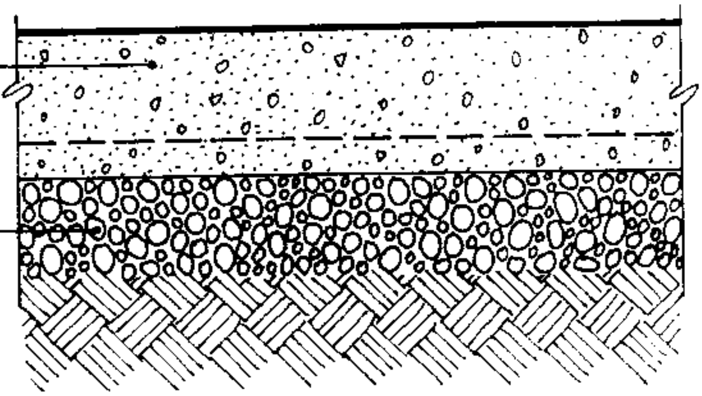
Brick pavers can cover the concrete slab for a more attractive appearance (FIG 4-36). Dark colors and non-reflective surfaces should be selected to aid in energy absorption.

PVC pipes imbedded in a concrete slab can increase the heat transfer to the concrete mass (FIG 4-37). Solar heated room air can be moved by fans from the warmest areas of the building through air ducts to a manifold which directs air to the individual pipes in the concrete.

Quarry tile can be added to a wood joist floor by placing the tile in a 1 1/2" concrete bed or adhering it directly to the plywood deck (FIG 4-38). When sizing wood floor joists, consideration must be given to the extra deadweight of the concrete or tile. Quarry tile should be dark in color and non-reflective in finish.

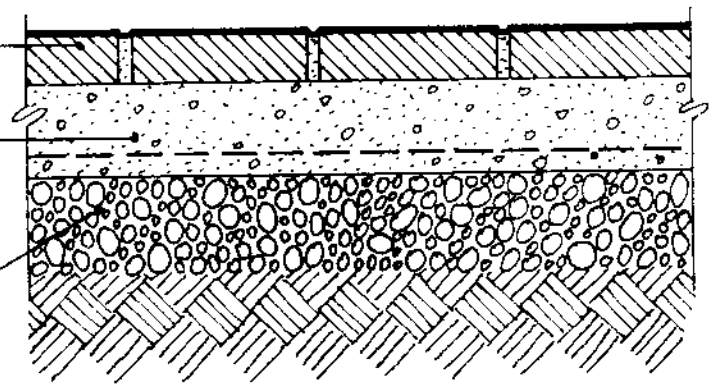
Concrete slabs on a steel deck and joist system are commonly used in commercial construction (FIG 4-39). This method of solar storage works well because it transfers heat to two levels of a building at the same time. Heat radiates from the slab to the upper level as well as to the lower level (provided the deck is not covered by carpet and the underside of the joist is not covered by a finished ceiling).

Precast concrete planks can function much like PVC pipe buried in a concrete slab in transferring heat to the deck (FIG 4-40). The planks have the advantage of being a radiant surface to two levels of a structure, like the concrete on a steel deck and joist system, and give the added benefit of a finished ceiling to the space below.



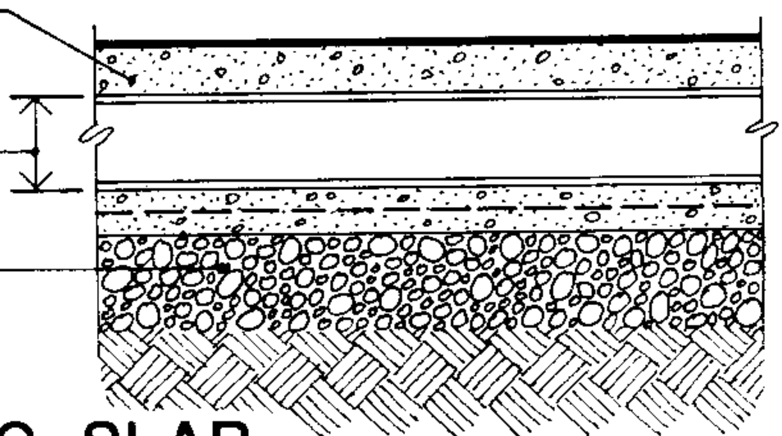

## 4–35 CONC. STORAGE FLOOR

scale: 1"=1'-0"



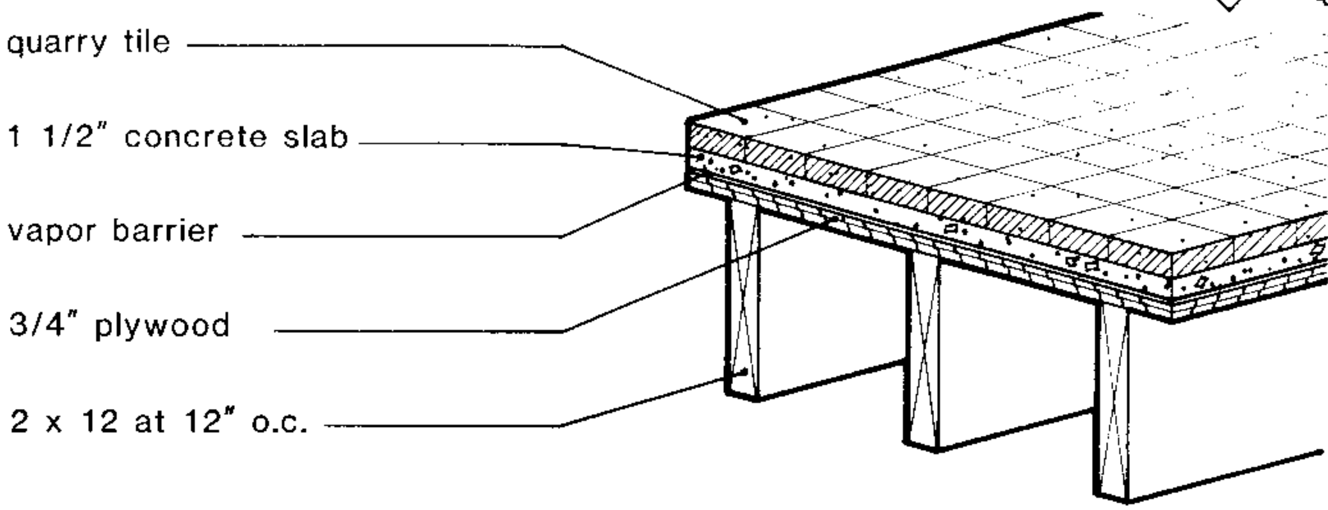

## 4–36 BRICK STORAGE FLOOR

scale 1 1/2"=1'-0"



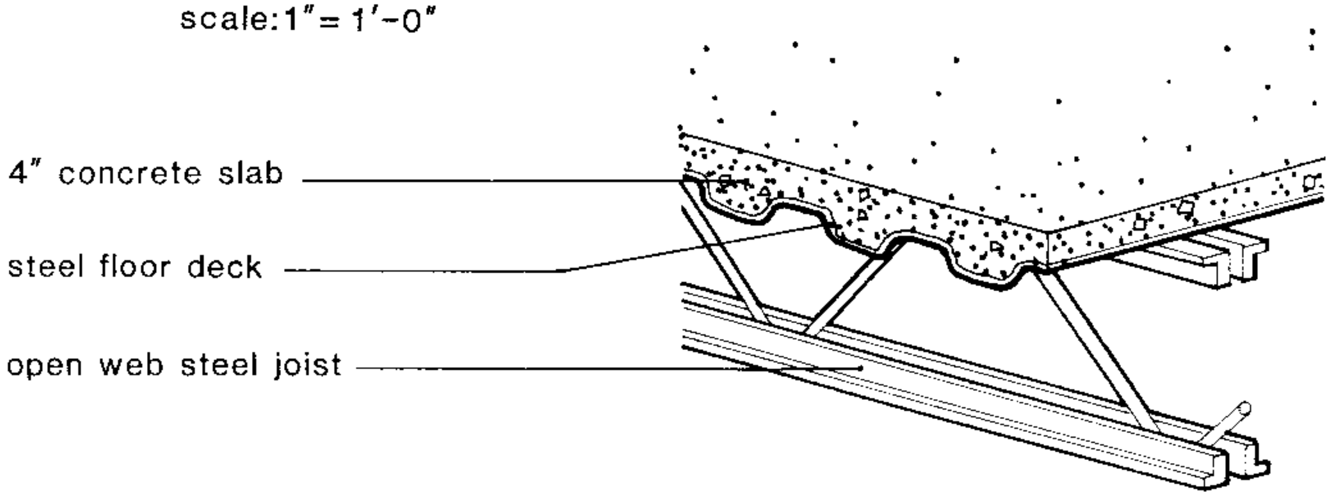

## 4–37 PVC IN CONC. SLAB

scale 1 1/2"= 1'-0"



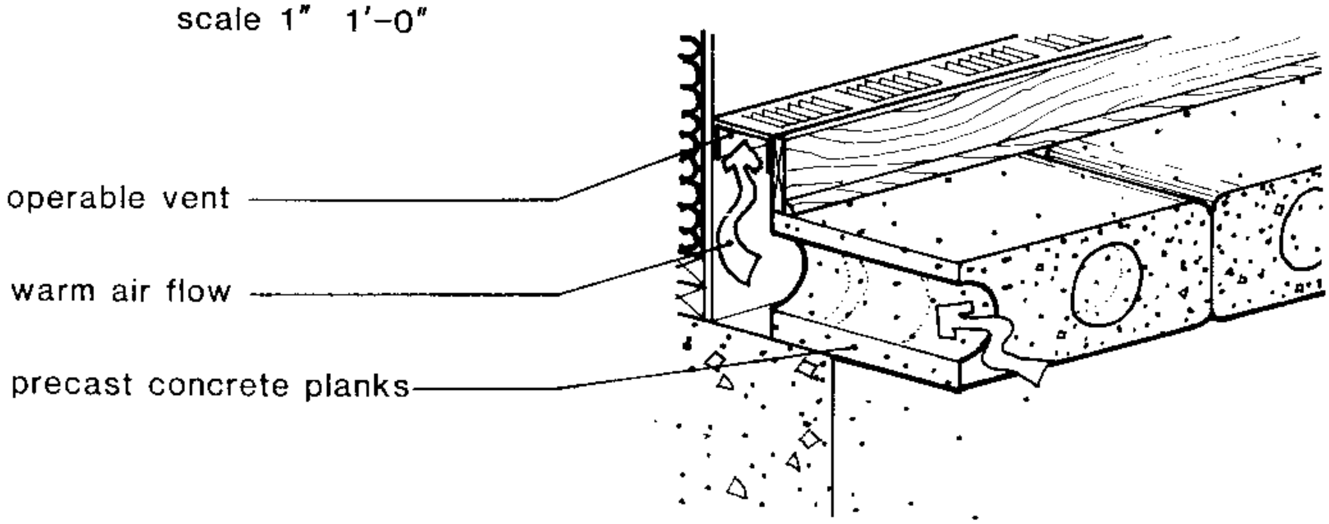

## 4–38 FLOOR: QUARRY TILE ON JOISTS

scale:1"= 1'–0"



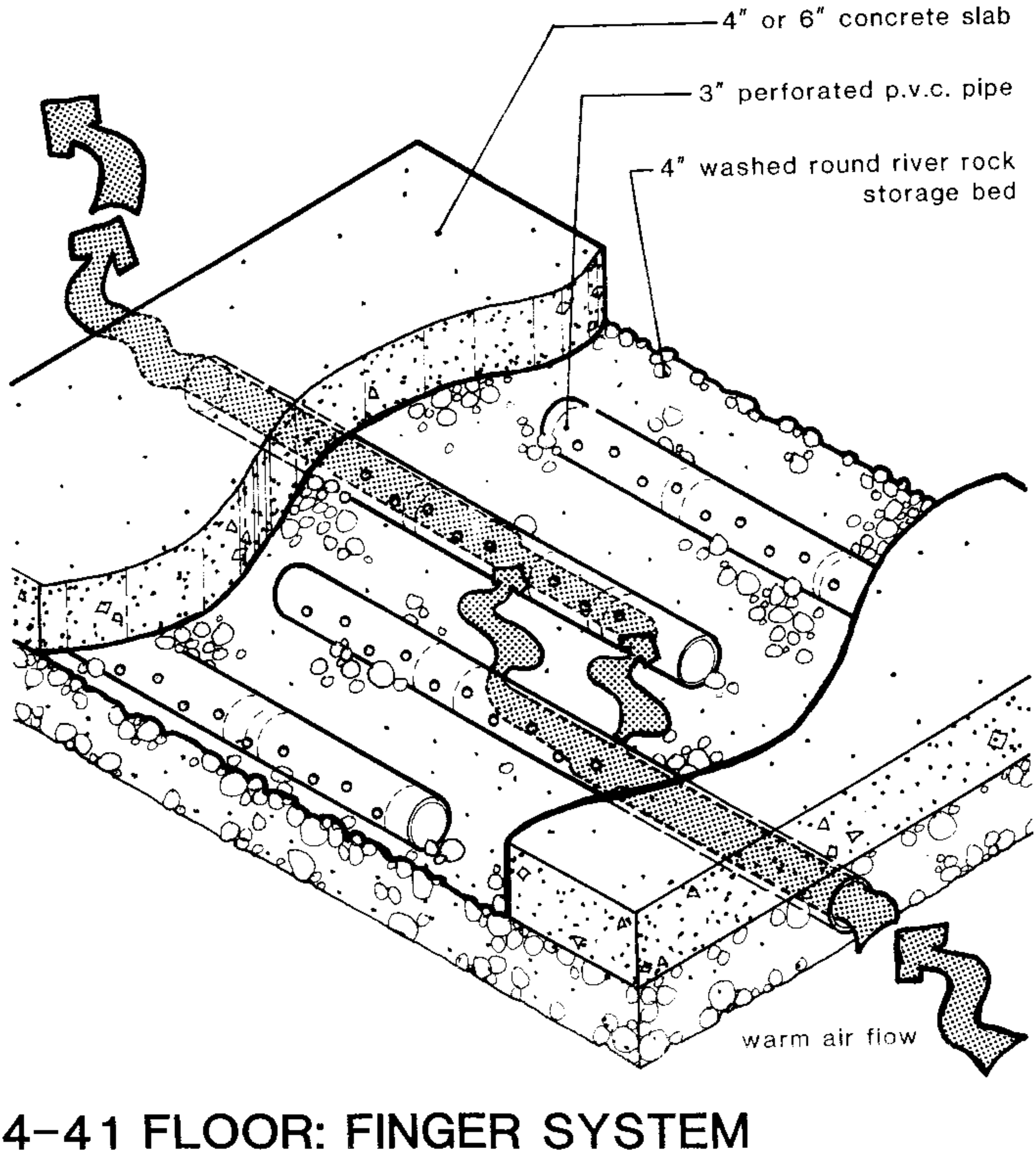

## 4–39 FLOOR: CONC. ON JOISTS

scale 1" 1'–0"




## 4–40 FLOOR: PRECAST CONC. PLANKS

scale 1" 1'–0"




# 4-41 FLOOR: FINGER SYSTEM

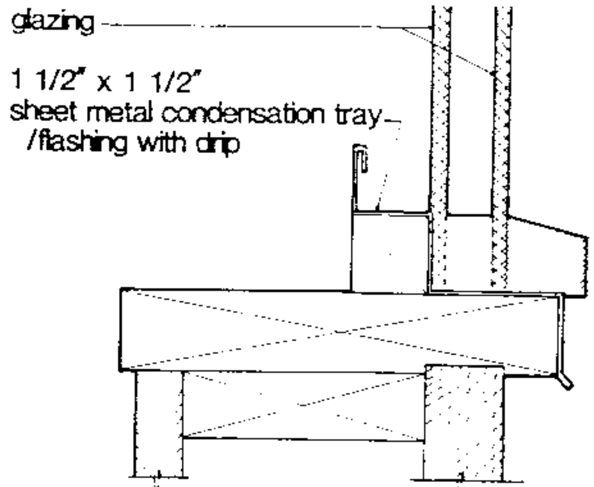
## MISCELLANEOUS DETAILS

The finger floor slab system (FIG 4-41) is a conventional concrete slab over a 4" round river rockbed through which air can be moved in a horizontal charge configuration. This system provides the benefits of a rockbed system without the expensive, time- and space-consuming drawbacks of traditional rockbed systems.

Early morning condensation on glass in damp spaces such as greeenhouses and bathrooms can be a problem. A condensation tray gives the water condensate a place to collect and evaporate from while protecting wood windows from rotting (FIG 4-42).

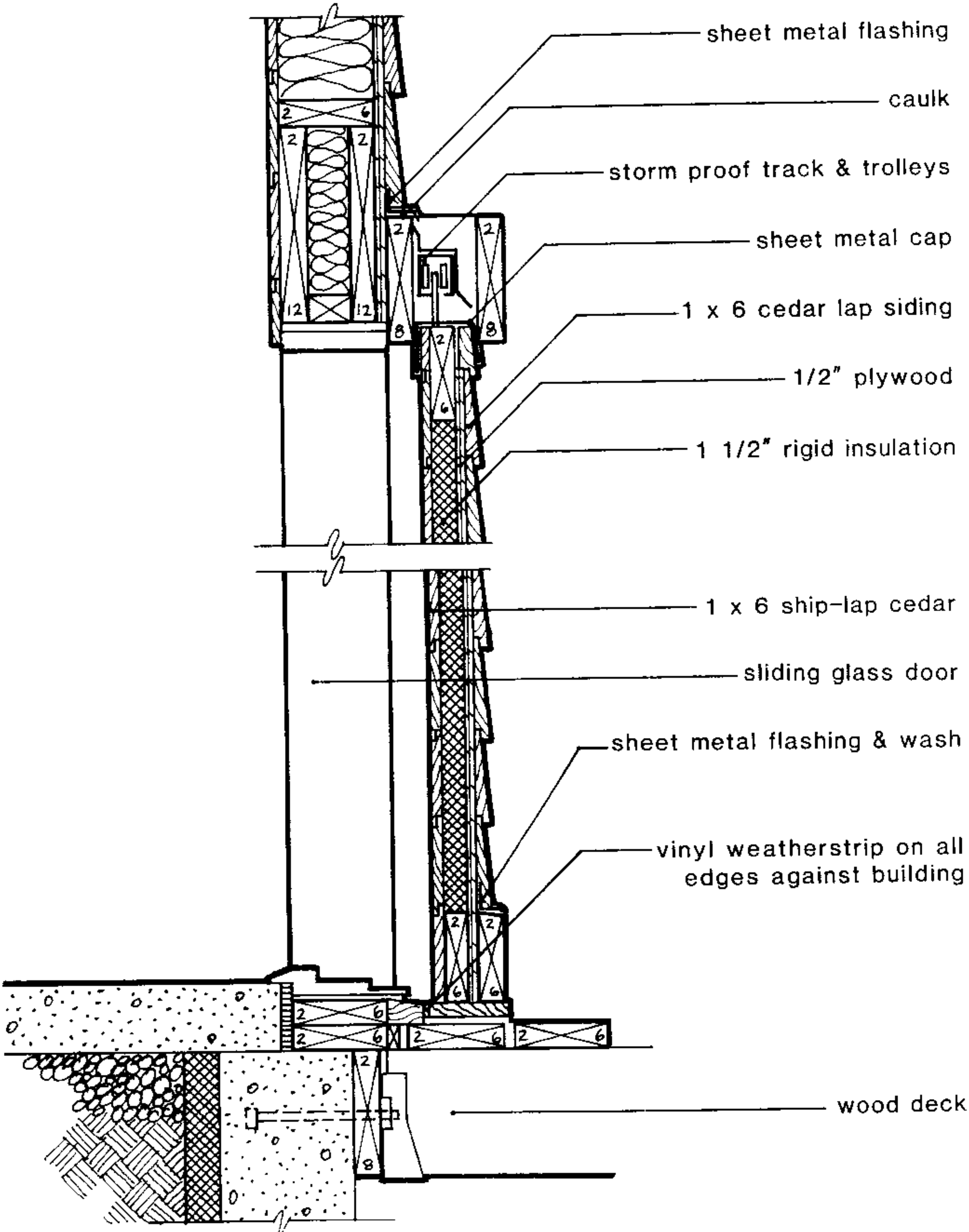
Exterior movable insulation prevents heat loss and solves window condensation problems by keeping the glass surface warm. In a storm-proof track and trolley system (FIG 4-43), the insulation slides out of the way during the day. The weight of the panel ensures a tight seal at the bottom of the track.

Interior movable insulation systems can be designed to be lightweight, inexpensive and removable. The system (FIG 4-44) can be designed to accept any thickness of panel by altering the width of the block separating the pieces of the bulletin board molding frame. The bottom edge of the fabric-covered rigid insulation panel should be protected with a plastic channel.



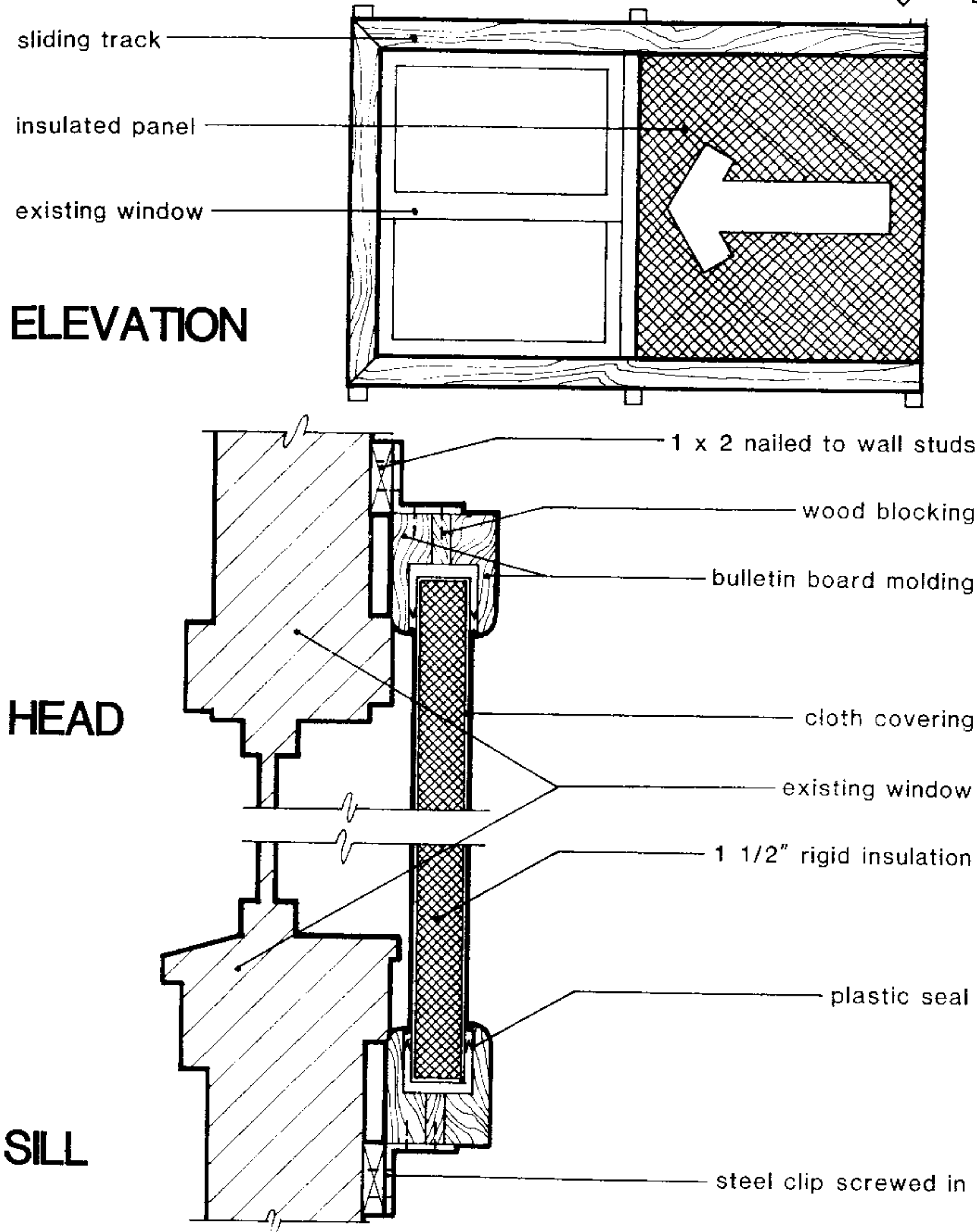

4-42 WINDOW SILL: CONDENSATION TRAY

# CONSTRUCTION DETAILS




## 4-43 WINDOW: OUTSIDE MOVABLE INSUL.

scale 1 1/2" = 1'-0"




# 4-44 WINDOW: INSIDE MOVABLE INSUL.

scale 3"= 1'-0"