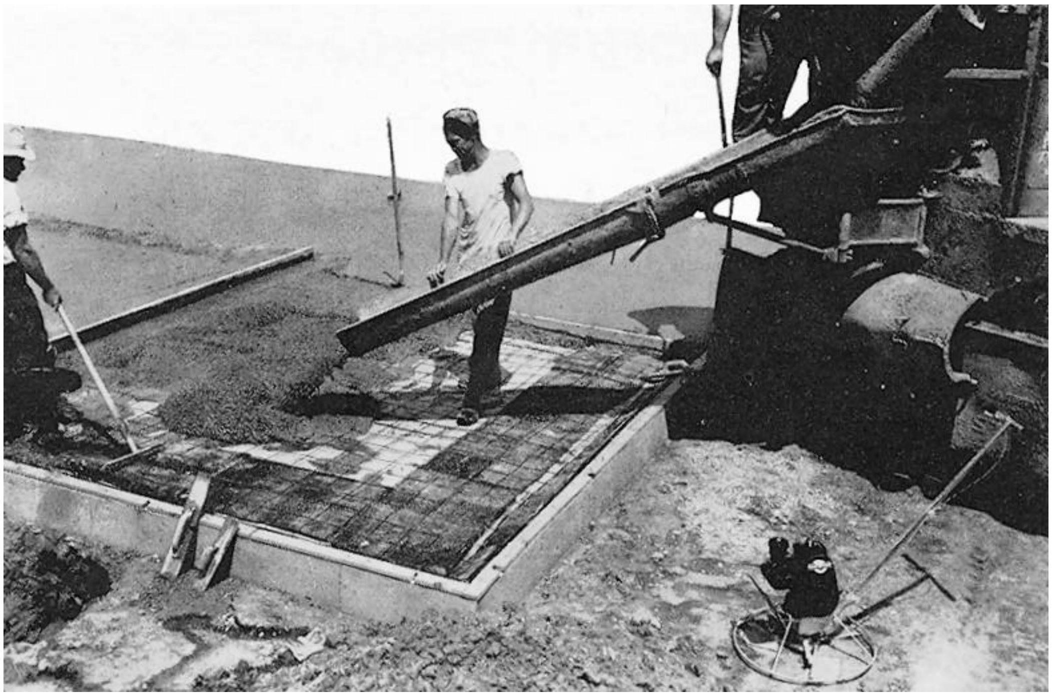
Slab-on-ground construction

Here are some simple procedures and minimum standards which can assure good results from what was once considered a tricky type of concrete construction.



Although this magazine has published several articles * expressing a rather strong bias toward basement-type residential construction, it is recognized that for economy reasons there will always exist a demand in some areas for slab-on-ground construction. Because the construction of concrete floors on the ground necessarily focuses a great deal of attention on the performance of concrete, especially when the results of such construction are less than satisfactory, the concrete industry has the strongest incentives for doing everything possible to encourage the highest standards of workmanship. This is particularly true since the shortcomings of most slab-on-ground construction have far more to do with faults or oversights of workmanship than to inherent shortcomings in concrete itself.

The purpose of this article is to call attention to some of the aspects of this type of construction which are most likely to cause trouble, and to suggest some precautions which the builder can observe to assure better results and thus protect himself and his product from criticism. Most of the recommendations discussed here are the outcome of a study conducted by the Building Research Advisory Board.

Moisture control is, of course, one of the most serious problems which arise in connection with slab-on-ground construction, and there is little doubt that most user dissatisfaction relates back in one way or another to the builder's failure to deal properly with this problem. The chief complaints on this score relate to the passage of excessive amounts of water vapor through the slabs, and to the too frequent failure of floor covering materials due to actual transmission of moisture through slabs. Other problems are caused by slab movements sufficient to damage floors and other structural elements, and perimeter heat losses which may cause condensation difficulties and excessive fuel bills.

grading the site

The best way to deal with the several aspects of the moisture problem in connection with slab-on-ground construction is through preventive rather than corrective measures, and the key to prevention is usually to be found through studies of the site itself and of the char-

*Bring Back the Basement! Jan. 1957, p. 8; and Step Down to More Living Space, Sept. 1959, p. 6.

acteristics of the soil. In short, successful slab-on-ground construction demands that the site be examined carefully from the standpoint of surface drainage and that such characteristics of the soil as capillarity and load-bearing capacity be determined. It is not too much to say that most of the serious trouble which has been experienced with this type of construction has resulted from careless planning, or total lack of planning, at the outset.

An essential requirement of effective site preparation is to provide surface drainage in every direction from the house, and in this connection the elevation of the slab above the finished grade is of the utmost importance. It is recommended that the finished grade at outside walls should be at least 8 inches below the top of the slab, when the slab is unheated or when heating coils are embedded in the concrete, and at least 2 inches below the bottom of ductwork next to foundation walls when warm air ducts are used in or under the slab.

The finished grade adjacent to slab-on-ground construction should whenever possible provide a 12-inch drop in a distance of 25 feet in all directions, and this 4 percent slope should be maintained as a minimum when obstructions or property lines are encountered within 25 feet of the slab. Some positive method of drainage should be provided whenever the proximity of a driveway, terrace or other detail prevents the maintenance of a 4 percent slope. Grading of hillside building sites should be carried out in such a way as to divert surface water around slab-on-ground construction.

the slab bed

The two most common causes of moisture problems in slab-on-ground construction are water transfer by capillarity and the movement of water vapor from the soil beneath the slab. While proper drainage may take care of both of these problems, many building sites require additional protective measures. The use of granular materials under the slab will generally solve the problem of capillary water, and vapor transmission can be effectively and economically limited with any of a number of vapor barrier materials. The latter under some conditions will also provide a satisfactory stop for capillary water, but many jobs require both of these protective measures. It should also be noted that neither of these measures is likely to be successful on a building site which involves a hydrostatic pressure condition near (less than 6 inches from) the natural surface of the ground.

The distance which capillary water will rise from the water table varies for different types of soil. It ranges from a maximum of about 2 ½ feet for coarse sand to around 7 ½ feet for fine sand to 11½ feet for silt and clay. Dimensions of saturation zones, of course, run considerably less—from a little over 2 feet for coarse sand to perhaps 4½ feet for fine sand and around 5½ feet for clay and silt.

Obviously it is essential to know the type of soil with which you are dealing and the highest known level of the water table. If this information indicates that capillary water may reach the underside of the concrete slab, the use of a base material of limited capillarity should be considered. Except in definitely arid climates, a limited capillarity base should probably be provided whenever the subsoil consists of clay or silt. Crushed stone, gravel and many coarse aggregate materials ¼ inch and larger form excellent capillary barriers, but it is often desirable to have such materials tested, particularly to determine the permanence of the protection they will provide.

If there is no need for a capillary break, the slab may be placed on foundation fill graded to the proper elevation and compacted in layers not more than 4 inches thick to assure uniform support. Topsoil, roots, vegetation and any other foreign matter should, of course, be removed completely, and the desired grade established with clean fill.

If conditions require a base of limited capillarity, the material selected for this purpose should be thoroughly compacted by either rolling or tamping. The resulting slab bed should be not less than 4 inches thick.

vapor barrier

Water vapor, which has a density only $1/205{,}000^{th}$ that of water at 32°F., can readily pass through most building materials, and it is recognized today as being one of the most destructive of the forces that attack the modern home. It is a more severe problem today than ever before because of the many ways in which modern construction successfully lowers heat transfer through walls, doors, windows and roofs. Since we have thus made it harder for water vapor to escape from our modern homes, it has become correspondingly important that we take steps to prevent it from entering. The alternative is a host of such costly household evils as buckled and mildewed floor coverings, peeling paint, rusted metals, crumbling plaster and rotting wood.

Most water vapor gets into a home through the ground area beneath the foundation. This is equally true of slab-on-ground and basement type construction. The ground area under an average home may release as much as 20 gallons of water in the form of water vapor each 24 hours—compared with around 3 gallons per day which may be created inside the home through all of the water-vapor-producing activities of a family of four people.

While there is mounting evidence to indicate that water vapor should be combated in some way in most types of residential construction, there are problems in connection with the use of certain flooring materials over concrete which make the inclusion of a suitable vapor barrier imperative. Wood floors of all types, cork tile, linoleum and all felt- or fabric-backed composition materials should be included under this heading. Asphalt, rubber, vinyl-asbestos, and flexible (unbacked) vinyl tiles all seem to get along equally well with or without a vapor barrier. However, if more than 20 percent of a slab is to be left exposed, the use of a vapor barrier should be regarded as mandatory.

There are many vapor barrier materials on the market today. They include papers, plastic films, combinations of paper and plastic film, felts, glass and mineral fibres, mineral aggregates, metals and asphalts. In selecting a particular material the user should be guided by the manufacturer's reputation, backed up whenever possible by his own experience. In addition to providing an effective barrier against water vapor, the selected material should be capable of standing up under the rough handling and heavy traffic which are inevitable on all construction sites.

It is believed that the use of an effective vapor barrier also results in producing a concrete slab which is denser and more impermeable because sand and cement cannot filter down into the porous base material on which the slab rests. When it is desired to accomplish this purpose alone, a structural separator material can be used which may be less costly than a vapor barrier.

slab insulation

The entire perimeter of the slab in slab-on-ground construction should be insulated with a waterproofed, rigid material not less than 1 inch thick. When the highest known water table is less than 2 feet below grade, perimeter insulation should be placed in a horizontal position; otherwise the material may be positioned either horizontally or vertically, but in all cases the vertical edge of the slab should be insulated.

The material selected for perimeter insulation should not be permanently impaired by wetting, and it should be non-capillary. It should not be damaged by contact with wet concrete and it should be highly resistant to termite and fungus attack.

Vertical insulation can generally be 18 inches in length, this measurement being made from the bottom of the slab. In mild climates, however, this length may be reducible to 12 inches or even 6 inches. Vertical insulation should be increased inch for inch whenever the height of the foundation wall above grade exceeds 8 inches.

Most slab-on-grade designs require that horizontal (or L-type) insulation be 24 inches long, but exceptions may occur in connection with warm-air perimeter heating systems.

reinforcement

Few aspects of slab-on-ground construction are as likely to touch off debate as the question of reinforcement. Even the BRAB committee was not unanimous on this subject, but the final recommendation states that distributed steel reinforcing should be required for the following conditions:

(1) In all slabs supporting load-bearing partitions or partitions of substantial weight, if such partitions are located more than 4 feet from the center axes of the slab.

(2) In all slabs placed on fill more than 2 feet deep.

(3) In any slabs for which more than 10 percent of the area within the foundation wall has been excavated and backfilled.

(4) In all unheated slabs longer than 30 feet in their longest dimension.

(5) In all slabs in which heating ducts or pipes are imbedded.

The BRAB report makes these minimum recommendations for distributed steel in nominal 4-inch slabs without substantial partition loads (i. e., not more than 1000 pounds per foot):

10-gage at 6 inches in both directions for all heated slabs up to 45 feet long

10-gage at 6 inches for unheated slabs over 30 feet and up to 45 feet long.

8-gage at 6 inches for slabs over 45 feet and up to 55 feet long.

6-gage at 6 inches for slabs over 55 feet long.

When a partition transmits a total load of 1000 pounds per foot or more, and is located more than 4 feet from the slab center, the BRAB report recommends an increase in steel area perpendicular to the partition in the amount of 0.020 square inches per foot. Provision is also made for thickening slabs by 2 inches under partitions transmitting total loads of 1000 pounds per foot, and by 4 inches for partitions transmitting total loads of 1500 pounds per foot. A properly designed separate footing is recommended for all partitions or loads exceeding 1500 pounds per foot.

the slab itself

The ready mixed concrete used for the slab itself, as well as for any bearing partition footings required, should be made with a well-graded, durable aggregate. The total water content should not exceed 6 gallons per sack of cement, this amount including any water present in the fine aggregate.

In the absence of vapor barriers or separators, it is important (especially in hot weather) to sprinkle the slab bed to prevent excessive loss of water from the concrete. To reduce the danger of segregation, place the concrete against other concrete already in place whenever possible, avoiding excessive drops and long lateral movement. The minimum thickness of the slab should be 4 inches, and pipes or reinforcing within the slab should be covered by at least 1 inch of concrete.

After the concrete is placed on the slab bed, it should be compacted, either by vibrating or by tamping and spading, and then screeded to the proper grade. The surface should then be compacted by working it with a wood float to obtain an absolutely level surface. Steel troweling should be delayed until the sheen of water has disappeared from the surface of the concrete and then it should be done sparingly to avoid bringing an excessive amount of fine material to the surface.

For L- or T-shaped slabs having offsets that exceed 10 feet, it is important to provide contraction joints where such offsets join the slab proper. Some builders also believe that very large slabs should be divided into smaller units by locating dummy contraction joints at partitions and other points where the appearance of such joints will not be objectionable.

The necessary duration of moist curing will vary somewhat with the time of year, and it will also need to be somewhat longer when the slab is to be left exposed. The BRAB report has this to say on the subject: "During the early hardening period of 10 days to 2 weeks, moisture for wet curing should be provided, or steps taken to prevent the evaporation of existing moisture in the mix." The same report also urges that the concrete be protected from freezing and rapid drying during the curing period. It is recommended that 60 days elapse between the placing of concrete and the application of flooring materials, but the minimum time specified is 30 days.

conclusion

Good slab-on-ground construction appears to hinge to a considerable extent on the willingness of the designer and the builder to exercise the same sound judgment required for other types of construction, plus a little extra emphasis on the moisture problem. Indeed, it would seem that if the vogue of slab-on-ground work had done nothing else than draw attention to the importance of moisture control in ALL types of concrete construction, it has perhaps served a most useful purpose.

Some builders object to the emphasis which slab-on-ground construction places on the need for careful study of building sites and soil conditions, but here again there is a mountain of evidence to support the notion that every such effort exerted in the planning stages is bound to pay off in the construction stages—by speeding up work and by preventing the costly failures which do so much to impair the reputation of concrete.

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