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Hard-Surfaced Floors for Farm Buildings

J. L. Wiersma

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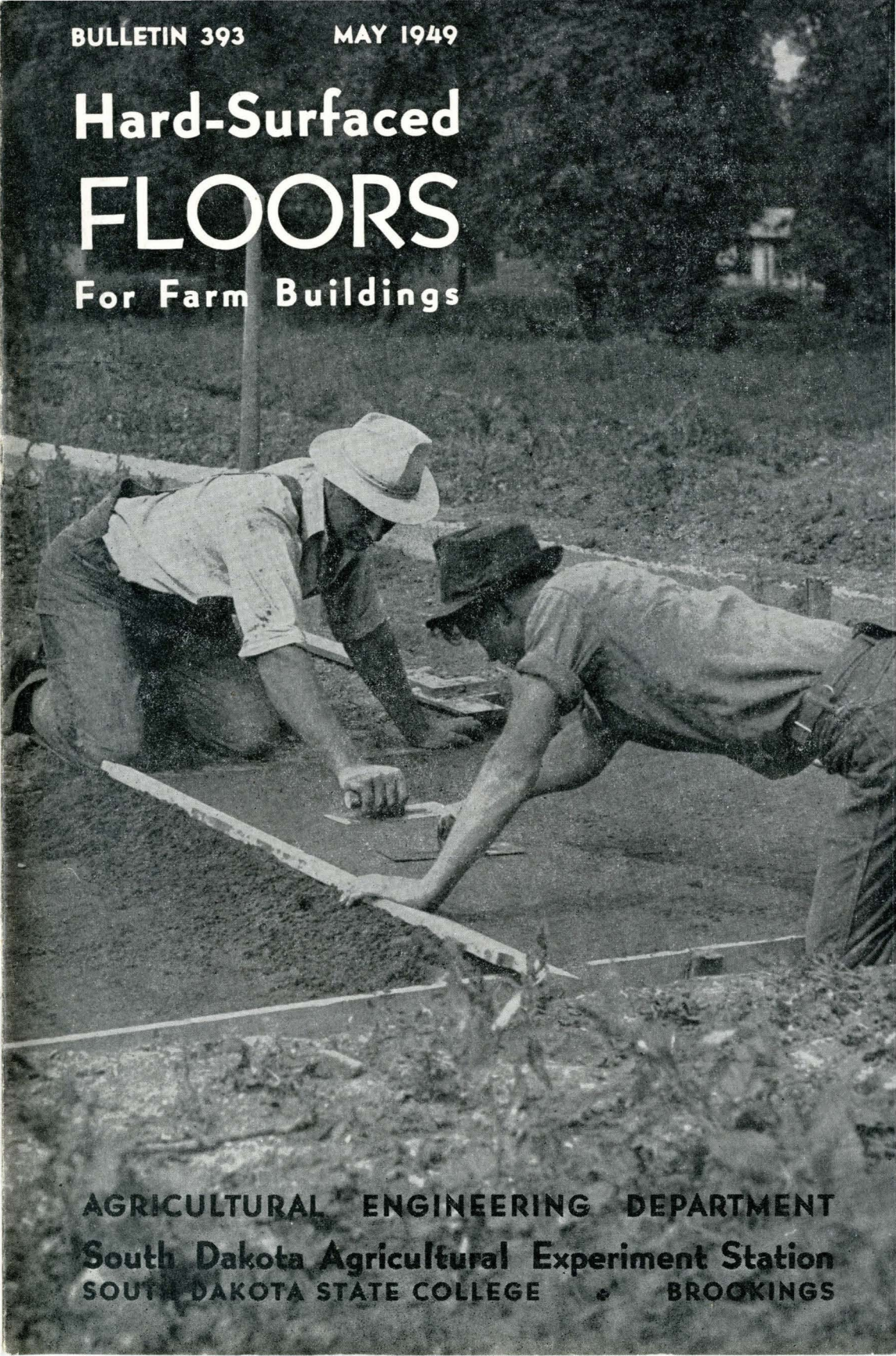

AGRICULTURAL ENGINEERING DEPARTMENT
South Dakota Agricultural Experiment Station
SOUTH DAKOTA STATE COLLEGE • BROOKINGS

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Hard-Surfaced Floors
For Farm Buildings

By JOHN L. WIERSMA[1]

Introduction

One of the most profitable improvements for a livestock farm is a hard-surfaced feeding floor. When hogs and cattle are fed in a paved lot, the saving on feed ordinarily lost in the mud in one year alone will often pay for the floor. The convenience, added efficiency, improved sanitary conditions and saving of manure should not be overlooked.

Experimental work on hard-surfaced floors by the Agricultural Engineering Department at this station has developed some floors that are very practical for both indoor and outdoor use. The principal advantages of these are the low cost and the labor saved.

Size of Floors. The size of the feeding floor depends upon individual circumstances. Under certain conditions a narrow strip next to the barn will be sufficient and then again, under different circumstances, it would be profitable to pave an entire lot. On an average, cattle feeders figure on building from 30 to 40 square feet per head of cattle, and hog feeders figure on building from 10 to 15 square feet of floor per hog. With few exceptions, indoor floors cover the entire indoor area. Walks and driveways should be at least two feet wider than the widest implement planned to use it.

Preparation of Floor Site. The ground should be cleared of all tree roots, vegetation and manure, and graded to the proper slope or level. If fills are necessary under the floor they should be placed in horizontal layers not more than six inches thick and thoroughly tamped to avoid any future settlement. The fills should be brought to the correct level so that the hard-surfaced floor will be of uniform thickness throughout.

A porous sub-base is necessary for both inside and outside floors where the soil is heavy and holds water. Also a sub-base is advisable if it is necessary to fill in the space below the floor with loose dirt. Six to eight inches of gravel, coarse sand, or cinders is sufficient, provided it is well compacted by wetting and tamping. Where the soil is porous and well-drained the floor may be placed directly on the ground. Sometimes tarred felt is placed under an inside floor to help prevent dampness.

Preferably, all floors should be located where drainage is good, so that no water will remain in the sub-base. Small trenches, filled with coarse gravel or cinders, sloping to lower ground make an effective sub-base drainage; also the floor itself should be sloped so that no water will stand on it. This is done by pitching the floor from one-eighth to one-fourth inch per foot to some form of outlet. It is also desirable to have the floor located higher than the surrounding ground so that no drainage water from other areas will run over it or remain on it.

[1]Agricultural Engineer.

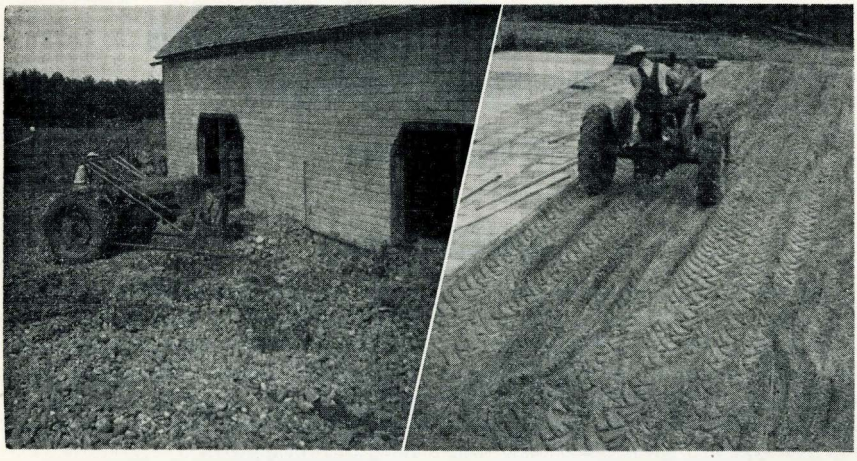


Fig. 1. PREPARING THE BASE. (Left) Placing an 8-inch coarse gravel base under a feeding floor. The use of a loader greatly reduced labor. (Right) Sand was placed over coarse gravel to form a smooth bed for a block floor. The sand was wet down thoroughly to form a well-compacted base.

Concrete Floor

Ingredients. The ingredients used in making a concrete floor are cement, sand, coarse gravel or crushed rock, and water.

Cement should be a free-flowing powder when used. If it has lumps that cannot be broken between finger and thumb it should not be used. It must be stored in a dry place and not stacked over eight bags high.

The fine aggregate (sand) should be hard and well graded. That is, it should vary in size from fine to coarse. A stronger concrete will be obtained than when a uniform size grain is used. Aggregate that contains salt or alkali should not be used. It also should be free of organic matter, loam or any considerable amount of clay. If the hands are soiled when a small amount of sand is rubbed in them it is doubtful if it should be used.

The coarse aggregate (gravel or crushed rock) should be hard and free of salt, alkali or organic matter. The maximum size particle is governed by the thickness of the floor. Ordinarily the largest particle should not be over one-third of the thickness of the floor.

Correct Proportions. In a concrete mix, cement and water form a paste which upon hardening acts as a binder, cementing the particles of sand and pebbles together into a permanent mass. The use of too much mixing water thins or dilutes the paste, weakening its cementing qualities. For example, with dry bank run gravel, the use of 5 gallons of water to one sack of cement, and such amounts of sand and pebbles as will make a workable mix, will produce concrete having nearly twice the strength of concrete using 7½ gallons of water per sack. It must be remembered the strength of concrete varies with the amount of water added.

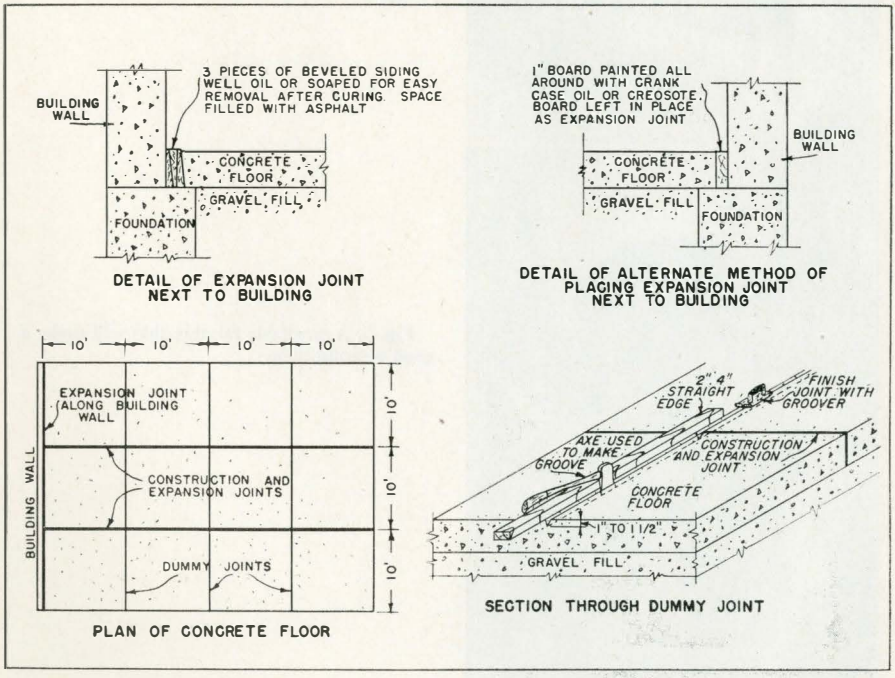
If a dry bank run gravel is used, 5 gallons of water per sack of cement will give the correct proportions. If a wet sand is used, 4½ gallons of water are needed.

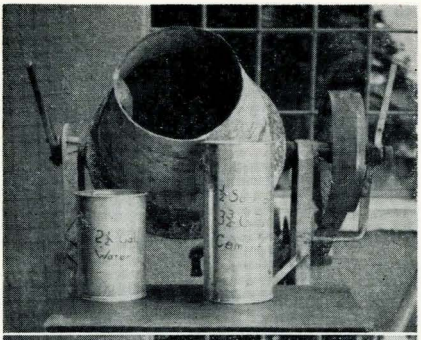
In order to determine the correct proportions to use, a trial batch is made first, the size depending upon the size of the mixer used. With a 5-cubic-foot mixer the following procedure should be followed: If the sand is dry, 2½ gallons of water and ½ sack of cement (3¾ gallons) would be placed in the mixer. To this the aggregate is added, using some measuring method. Perhaps the best method of measuring would be with a sand shovel such as is used with the regular work. An accurate count should be made of the number of shovels of aggregate added, until a mixture is obtained that is wet and plastic enough so that it can be placed in the forms readily and, with spading or tamping, will result in a dense concrete.

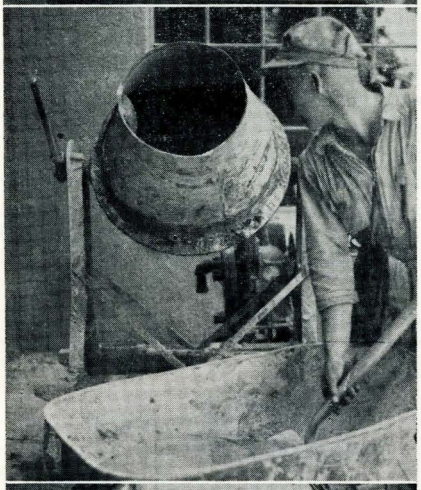
After this amount has been determined, never change this ratio of water and cement. If the mixture is too thick or heavy, vary the amount of aggregate added.

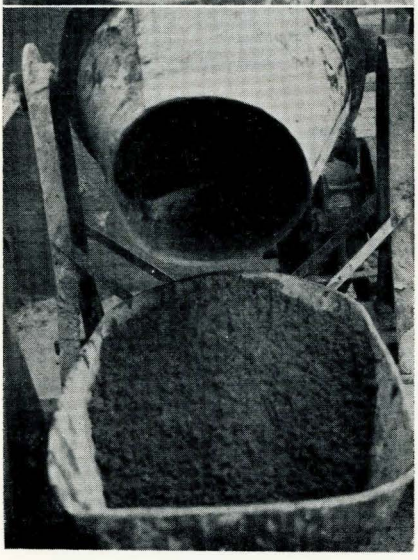
Placing and Finishing. A common error in placing concrete is to omit expansion joints, especially on indoor floors along foundation walls. A convenient method of installing the expansion joint is shown in Fig. 2. The same type joint can be placed between the curbing and the floor on outside floors. Another type of joint that is nearly as satisfactory is a one-inch board, treated with crankcase oil or creosote, placed the full depth of the floor next to the curb. Do not remove the board. An expansion joint should also be provided about every 10 feet in the floor itself. These can be placed in the construction joint very easily.

Fig. 2. DETAILS OF EXPANSION JOINTS.









Making a Trial Batch

Fig. 3. In making a trial batch, 2½ gallons of water and one-half sack (3¾ gallons) of cement, are placed in the mixer. If a small mixer is used the amounts can be made smaller, but use the same ratio.

Fig. 4. An accurate count of the shovels of aggregate added must be kept in order to determine how much should be added in following mixtures. The amount of sand added may be varied, but the ratio of water to cement is never changed.

Fig. 5. A workable mixture that will make a good wearing floor.

Satisfactory forms can be made with 2x4's for a 4-inch floor and 2x6's for a 6-inch floor. The forms are set to make sections about 10 feet square and the floor can be poured in either alternate 10-foot square blocks or can be poured in a continuous strip 10 feet wide. The block style makes the placing of expansion joints very easy.

The mixed concrete should be placed in the forms within 20 to 30 minutes after it is mixed. Tamp thoroughly to eliminate any air pockets, and then strike off with a straight edge, using form boards as guides. The surface should not be finished at once, but should be given some time to stiffen. Finishing the surface at once will cause fine particles to come to the top and produce a film of mortar on the surface, which does not wear well. Too much troweling should be avoided as over-finishing tends to bring excess water to the surface, making a soft top which will check and dust off.

Floors will give the best service if troweled with a wood float. A steel trowel will give a smoother and a much more slippery surface. However, a floor in a granary or corn crib should be smooth to prevent excess wear on shovels.

Curing. Moisture is necessary for the proper hardening of concrete. If this is kept in mind no difficulty will be encountered. On inside floors frequent sprinkling for 7 to 10 days may be sufficient. On outside floors that are exposed to the sun and wind, a covering of 2 or 3 inches of moist straw or sand after the floor is firm will usually be necessary. This should be kept on for at least 7 days. Proper curing should not be neglected.

Estimating Quantities of Materials. Using a water-cement ratio of 5 gallons of water per sack of cement for estimating would give a mixture of about 1 part cement to 2¼ parts of fine aggregate, to 3 parts of coarse aggregate. If the fine and coarse aggregate are purchased separately, for every cubic yard of concrete to be poured, purchase 6¼ bags of cement, 0.52 cubic yards of fine aggregate and 0.70 cubic yards of coarse aggregate.

If bank run or pit run aggregate is purchased, the amount of cement required per cubic yard of concrete depends upon the fineness of the aggregate. On an average, if the aggregate is comparatively fine, eight sacks of cement must be purchased per cubic yard of concrete; if the bank run is comparatively coarse, six bags of cement must be purchased per cubic yard of concrete. The number of yards of bank run gravel needed will be the same as the number of yards concrete to be poured, because the cement added to the aggregate will not add to the volume.

An example. What quantities of materials are required for a concrete feeding floor, with outside measurements of 30′ x 20′ and floor thickness of four inches?

If the floor is 30′ x 20′, the floor contains 600 square feet. Four inches thickness is equal to ⅓ foot, therefore, the volume is 600 x ⅓, which is 200 cubic feet. There are 27 cubic feet in 1 cubic yard. To convert to cubic yards, divide 200 by 27 which will give 7.4 cu. yds.

If the fine and coarse aggregates are purchased separately, the following materials would be needed:

Cement — 7.4 x 6¼ sacks per cubic yard = 46.25 or 47 sacks.

Fine aggregate — 7.4 x 0.52 = 3.85 or 4 cubic yards.

Coarse aggregate — 7.4 x 0.70 = 5.18 or 6 cubic yards.

If a comparatively fine bank run aggregate is used, which would require eight bags of cement per cubic yard, the following material should be purchased:

Roto-Tilled Concrete Floor

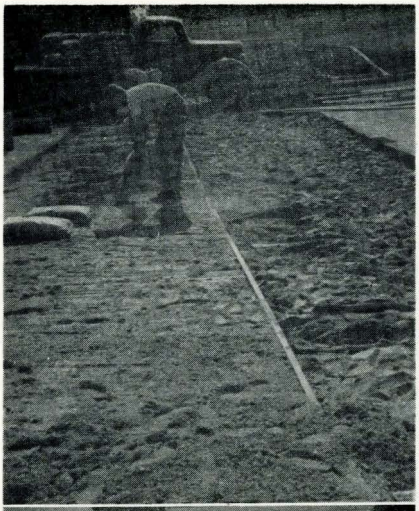


Fig. 6. Placing cement on top of the leveled aggregate. Note the spacing.

Fig. 7. Mixing the aggregate and cement. Care must be taken along the edges to insure good mixing throughout.

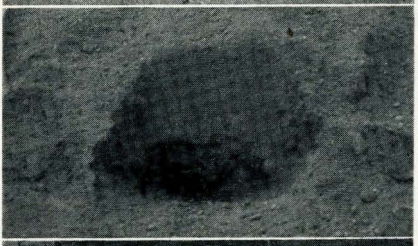


Fig. 8. The cement was mixed with the aggregate to a depth of 4 to 5 inches. With a little care, this depth may be reached accurately.

Fig. 9. Mixing in a measured amount of water after the aggregate and cement have been mixed. Speed counts here. The mixed concrete should be leveled within 30 minutes after water is in contact with the cement. A strip of floor of a size that can be leveled within this time limit should be mixed at one time.

7.4 x 8 sacks per cubic yard = 59.2 or 60 sacks of cement and 7.4 cubic yards of bank run.

If a comparatively coarse aggregate is used, which would require six bags of cement per cubic yard, the following materials should be purchased:

7.4 x 6 sacks per cubic yard = 44.4 or 45 sacks of cement and 7.4 cubic yards of bank run.

Roto-Tilled Concrete Floors

A rotary tiller was used to mix the ingredients for this concrete floor instead of the ordinary type concrete mixer. It was found that with the same crew of men this type floor could be put in, in less than one-half the time a conventional concrete floor could be. The site preparation, finishing, and curing process are identical to that of a conventional floor. Only the placing and mixing differ.

After the forms were constructed the aggregate was dumped directly into them from the gravel truck, and leveled with a template to the top of the forms. Care must be taken not to build too large a section of floor at one time, as not more than 30 minutes should elapse between the time mixing first begins until the floor is completed, not counting the finishing. If more time is taken the concrete will start to set and strength is lost. It is suggested that for a three-man crew the floor should be divided into sections of about 150 square feet each. The sections should be long and narrow.

For instance, if a section 4 feet wide, 30 feet long, and 4 inches thick is planned, and a comparatively fine, dry bank run aggregate used, the following procedure should be followed:

The volume of concrete is 30′ x 4′ x ⅓′ (4 inches). This is equal to 40 cubic feet or about 1½ cubic yards. Referring to the section on estimating quantities of materials on page 7, it takes eight sacks of cement per cubic yard of concrete. Therefore:

8 sacks x 1½ yards = 12 bags of cement.

To obtain the proper distribution, the 30-foot strip should be marked off in 12 parts, each 2½ feet long, and one bag of cement placed on each section. The aggregate and cement should then be thoroughly mixed with a tiller, taking extreme care along the edges. To do a proper job requires going over the floor from five to eight times.

The amount of water must be calculated accurately because the strength of the concrete varies with the amount of water added. To obtain proper strength, 5 gallons of water should be added per bag of cement. The section required 12 bags of cement, therefore 60 gallons of water should be added, provided the aggregate is dry. If it is wet, a lesser amount should be added. (See page 4.)

The best way to add water is during the mixing process. Enough water should be stored in containers so that not too much time is required to add it, because of the time limit of 30 minutes until the floor must be leveled. The rotary tiller should pass over the floor from 8 to 12 times. Again, take special precaution along the edges. After mixing, the floor should be tamped with a rammer, or spaded and leveled off. The finishing and curing process is identical to that of a concrete floor. Expansion joints are placed at each construction joint, and dummy joints, such as is shown in Fig. 2, are placed every ten feet the other way.

Mortar-Top Floor

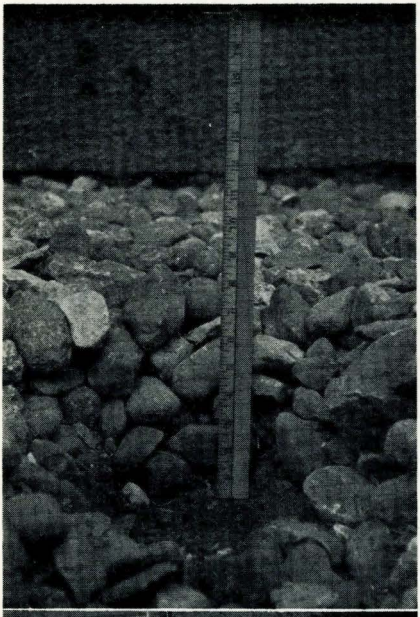


Fig. 10. The base for a mortar-top floor is from 7 to 12 inches thick.

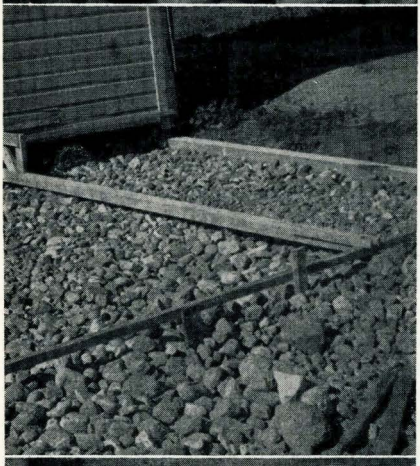


Fig. 11. This type template can be used next to walls and buildings. For ease in working the template the stakes on the form would be sawed off flush with the top. This has not been done here.

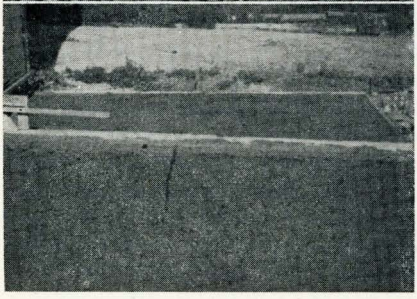


Fig. 12. Note the gravel top over the oversize base. An expansion joint has been placed next to the building, one at the center of the section and one next to the form. A cross expansion joint is also placed every 4 feet.

Mortar-Top Floor

There are times when a large supply of oversize gravel is available for an extra good base under a floor. If a floor is needed on which young pigs, calves, lambs and other light animals are to be placed, it can be built at a cost considerably less than that of a conventional concrete floor. Floors of this type have been built for feeding floors for beef cattle. Although they have stood up well, they are not recommended for the heavier animals.

This floor is made by placing a one-inch layer of mortar over a specially prepared base. In preparing the base, put 7 to 12 inches of oversize gravel on the proposed floor site. Care must be taken to see that it is very well packed because any movement or "give" in the base after the top has been poured will result in a failure. It would be better if the oversize could be placed and left undisturbed for a period of time to insure firmness. If this cannot be done, a heavy tractor can be driven over the base a number of times.

To insure an even thickness in the layer of mortar, a thin layer of sand should be placed over the oversize, using a template as is shown in Fig. 11. This sand layer must also be packed thoroughly. The template should be constructed so that from 1 to 1¼ inches remain between the sand layer and the top of the form for the mortar.

The sand used in the mortar should be screened through a ¼ or ⅜-inch screen so that no particle is larger than one-third the thickness of the top concrete layer. The procedure in determining the amount of sand that is to be added is identical to that of bank run gravel, as is explained on page 7, for a concrete floor. In estimating the quantities of sand and cement needed, it can be figured that it will take about 10 or 11 sacks of cement per cubic yard of top course, depending on the fineness of the sand.

A water-cement ratio of four gallons of water to one sack of cement should be used in the top one-inch course.

Because the concrete section is thin, special precaution should be taken in placing expansion joints. For an outdoor floor an expansion joint should be placed every four feet and for indoor use a joint every five feet.

In curing this floor, use the same process that is used in curing concrete floors.

The cost of the cement for this floor is approximately one-third of what it would be for a conventional concrete floor. If care is taken in compacting the base and placing the expansion joints, this floor will be satisfactory for lighter animals. If the oversize gravel must be purchased at the same price as concrete gravel a considerable amount, or even all, of the saving in this type floor will be lost.

Soil-Cement Floor

The idea of the soil-cement floor was suggested by similarly prepared hard-surfaced roads that are being tested by the Federal government and by highway men of several states. After several years' trial the reports are quite favorable for light traffic highways built in this manner. This floor has been tested in both poultry houses and beef barns. It has proved very satisfactory as a poultry house floor, but cannot withstand the weight placed on it by fattening steers. It also cannot withstand outdoor use.

The soil-cement floor is made by adding 10 percent of Portland cement to the top layer of a good clay-gravel mixture of soil and packing it thoroughly in place. The floor is built in two layers. The bottom layer is rammed with just the right moisture to make it pack well but contains no cement. It is 1¾ inches thick when packed. The top layer is made out of the same mixture of soil except that it should contain no coarse gravel. To this is added 10 percent of Portland cement (1 shovel of cement to 9 shovels of soil-mixture) and it is 1½ inches in thickness after being packed. This makes the total thickness of the floor 3¼ inches.

To have a good smooth floor it is necessary to use forms and lay the loose material down evenly before ramming. It is best to build it in strips between two-inch forms in the same way as for concrete floors. In building highway surfaces of soil-cement, the moist material is packed by heavy rollers. In building poultry house floors the heaviest hand rollers are unsatisfactory because they do not pack sufficiently, and it is necessary to pack them by means of floor rammers.

Floor Rammers. Two sizes of floor rammers are preferable, but there is one size that can be used satisfactorily for the entire job if it is desired to avoid the purchase of two. This should be a heavy 6 x 6-inch rammer with a total weight of 20 to 25 pounds. (See Fig. 13.) When two rammers are used, one should be 10 x 10 inches square and weigh 15 to 20 pounds, while the other should have a small rammer head of 3½ to 4 inches square, weighing 12 to 17 pounds. This small rammer will pack just a little harder than the large ones, but the large ones are better for going over the first time and for smoothing or finishing the top surface.

The work does not go fast, but it can be done a portion at a time if necessary.

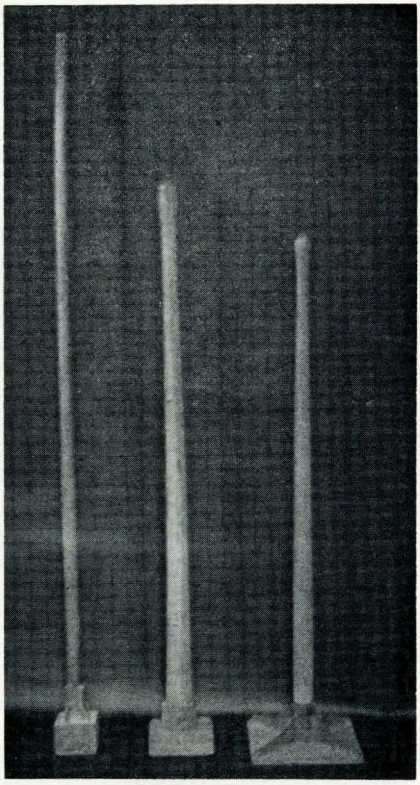


Fig. 13. FLOOR RAMMERS. The small rammer weighs 14 pounds, the center rammer 21, and the large rammer on the right, 16 pounds.

Two men can build a section of floor 12 x 20 feet in 10 hours if the material is on hand. For inexperienced workmen it would take just as long to build the same floor of concrete. As indicated above, these new type floors are developed for the person who has little money to invest and who is willing to do a little extra work in building a high quality hard-surfaced floor for himself.

The Soil Mixture For Soil-Cement

The soil mixture used for soil-cement floors is almost a gravel or sand. It should contain about 25 percent of silt and clay, and the rest should be sand and gravel.

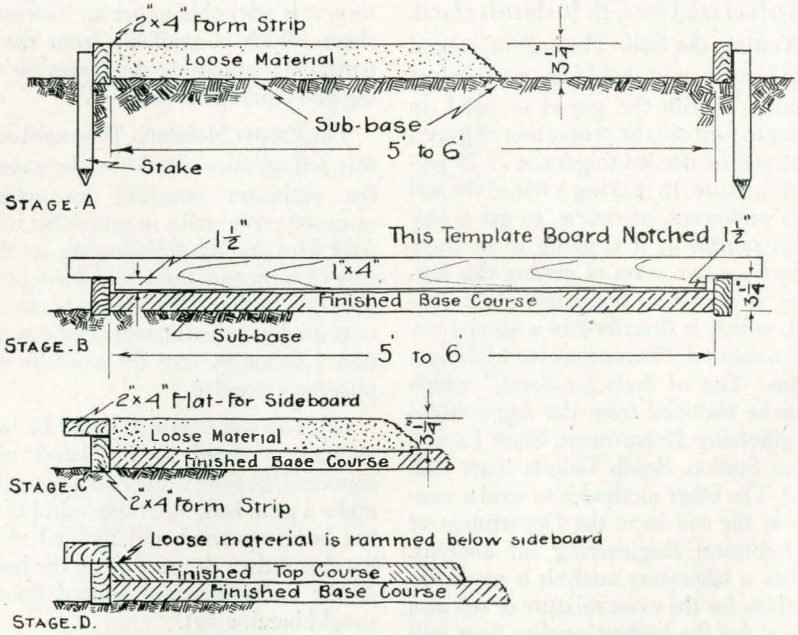


Fig. 14. SHOWING THE FOUR STAGES IN BUILDING THE FLOORS. **Stage A** shows the finished sub-base with the loose soil-mixture in the forms and ready to ram down for the base course. **Stage B** shows the finished base course after it is rammed in place. The template is shown in place for checking the remaining 1½ inches that should be left between the form strips. **Stage C** shows one edge of the form upon which side boards have been built to hold the loose top course material. A 2x4-inch, laid flat and nailed, is used for the side board. **Stage D** shows the top course after ramming. The top course should ram down about even with the original form strips and the side board may be removed.

A sandy subsoil might be satisfactory just as it is dug up in some localities, but generally additional sand will be needed to make the 75 percent sand. The color of the subsoil—black, yellow, or red—makes no difference. Although it may not appear to contain clay, it is likely to contain a sufficient amount. The average clay subsoil (6 inches or more below the surface) contains from 35 to 40 percent sand. When this is mixed with an equal amount of bank run gravel, the mixture will be just about right. This is for the average subsoil.

For soil, generally, the variation is great. It is safer not to use the top soil, as it may contain injurious organic matter. Coarse gravel is used only in the lower part, or base, of the floor and there is no advantage in using it at all except to save screening it out. For the top layer, the coarse gravel should be screened out (through a one-fourth inch screen) and only the sand should be used, but the ratio of sand and clay should be the same. A light sandy soil will be entirely satisfactory for making this type of floor. Fine sand in the soil is even better than coarse sand and almost any light soil will contain enough clay and silt, although it may not show it. The majority of soils will need an addition of from one to five

shovels of sand for each 10 shovels of soil.

Testing the Soil. The soil or subsoil that is to be used should be tested before mixing it with the gravel or sand, in order to find out the proportion of gravel that will be needed to get the 75-25 percent mixture. In making a test of the soil it is important, of course, to get a uniform sample as it is going to be used. There are two ways of getting this test. One, is to make a home test of the subsoil, which is described in a special circular entitled, "Directions for Making a Home Test of Soils for Sand," which may be obtained from the Agricultural Engineering Department, State Experiment Station, South Dakota State College. The other method is to send a sample of the soil in to the Department of Agricultural Engineering for analysis. When a laboratory analysis is made, directions for the exact mixture of soil and gravel for the highest quality floor will be furnished. Before obtaining the sample of subsoil to be sent into the laboratory, it is advisable to get an instruction sheet, which is available from the department, containing directions for taking and sending the samples.[2]

The Proper Moisture. The moisture in this soil-mixture should be the same as the optimum moisture for making rammed earth walls, in order that it will pack firm and hard. Following are three easy tests that are used to identify proper moisture in the soil. These were the only tests used in experimental floor construction. Laboratory tests for moisture were purposely avoided.

(1) The soil-mixture should be moist enough to mold in the hand when squeezed, but not quite moist enough to make a mud ball. After a handful of soil has been squeezed and molded in the hand and then dropped from the height of the waist-line onto a hard floor, it should break apart.

[2]The charge for making the laboratory soil analysis is $1.00 for builders in South Dakota, and $2.00 for builders outside the state.

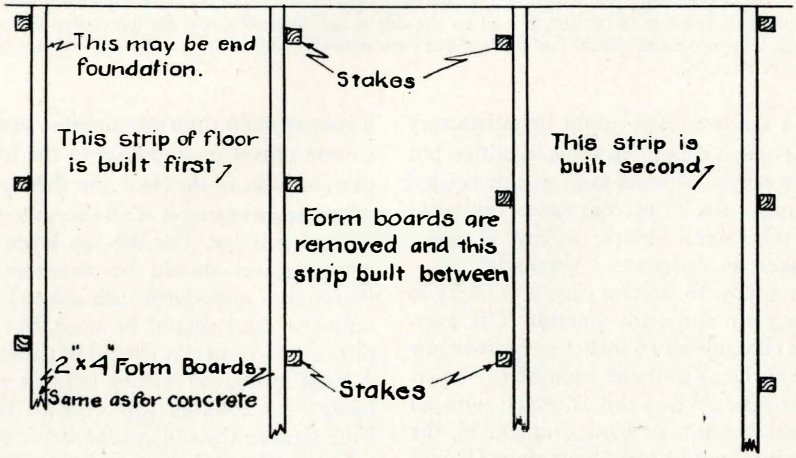


Fig. 15. METHOD OF SETTING FORM STRIPS FOR BUILDING EITHER OF THE FLOORS. The 2x4 inch strips are staked as shown above. In starting to build the floor, one or the other outside strip would not be used. The depth between the strips should be 3¼ inches, as shown in Fig. 14.

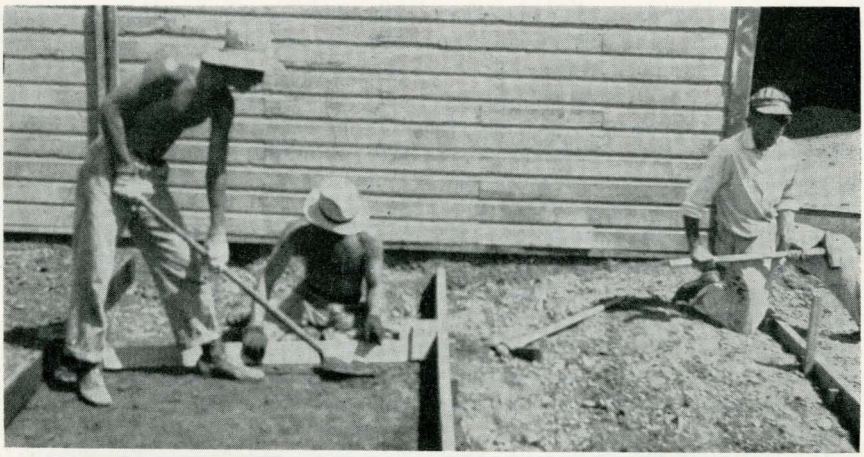


Fig. 16. PREPARING THE SUB-BASE AND CHECKING THE DEPTH. When the sub-base is settled with the rammer, the depth between the form strips should be 3¼ inches. The two men on the left are checking with a template board that is notched for that depth.

(2) When it is rammed with a steel rammer head, it should stick a little to the rammer, but should not be wet enough to become too spongy to ram down **solidly.**

Time will be saved and a harder floor secured also if the soil before use, is kept moist. When it is too dry, it is hard to get the moisture evenly distributed through it and the mixture will not pack as well. If the soil gets very dry it will pay to spread it out and sprinkle it good with water, mix it well and pile it up again. In two or three days the moisture will spread through it. In average weather, the moisture in the soil will be just about right as it is dug up, when mixed with dry sand. Soil that is too wet can be spread out and turned for drying.

How To Build Soil-Cement Floors

It is necessary to have the sub-base reasonably level and firm before starting to build the floor. As soon as the side forms are in place, the sub-base between should be given a final packing as the surface is leveled. The final leveling should be done with a template board similar to the one shown in Fig. 14, except that the depth of the notch should be 3¼ inches instead of 1½ inches as shown. This makes two templates that should be used in building the floor. In leveling and ramming the sub-base between the forms, it should be kept in mind that the soil probably will ram down from ½ to ¾ inches, thereby increasing the depth between the form boards which should measure finally very close to 3¼ inches.

Having the sub-base reasonably level makes certain that the top of the floor will be level. It is even important to spread the loose material in the forms with shovels in order to have the floor built up to a uniformly smooth surface. If material is dumped from a wheel barrow it should be shoveled over slightly to avoid a high point in the floor due to the material packing from the fall. Those who are experienced in dumping gravel will understand why this is important.

Mixing and Placing. The proper subsoil and gravel mixture which has been referred to as "soil mixture" has already

been discussed but the method of mixing it has not. Even light soils are likely to need some additional sand added to them and this is done best on a mixing board made for the purpose, or it may be done on a concrete or wood floor in an adjacent building if it is close enough. After mixing, it may be moved in place with a wheel barrow. In order to avoid building a mixing board, the first strip of floor might be allowed to cure for a week and then used as a mixing surface for the rest of the floor. A smooth place on the ground can also be used for mixing, although it is not quite so convenient.

If a laboratory soil analysis has been made of the soil, the builder should know how many measures of sand to add to the subsoil for the soil-mixture in order to have the best floor. These materials can be measured as they are shoveled onto the mixing board. If one part of sand was to be added to three parts of subsoil, count the shovelfuls as they are being shoveled onto the board. A certain amount of mixing can be done as they are shoveled on the board, but the material should be turned two or three times in addition until it is well mixed. If the soil is too dry, some moisture can be added (only by sprinkling) as this turning is done. The mixture for the bottom course will now be ready to spread in the forms and rammed in place. A concrete mixer is not satisfactory for mixing.

Packing the Layers. If two rammers are used, the large flat-faced rammer should be used the first time over for the loose layer, and the small-faced rammer should then be used about twice over. Small-faced rammers are slightly better to use for most of the work on both courses because they pack harder. Two times over with a fairly sharp ramming stroke will be sufficient. The rammers should not be more than four inches

Fig. 17. BUILDING A SOIL-CEMENT FLOOR. The floor is built in strips the same as for concrete. The outside strips are built first. The forms are then removed and the strip between is built. The strips should be the same width so the templates will fit. A width of 5 to 6 feet is best.

Fig. 18. STRIKING-OFF THE LOOSE SOIL-CEMENT MIXTURE BEFORE RAMMING IT FOR THE TOP COURSE. The back of the template board can be used for this purpose if it has a straight edge. Note the 2x4-inch laid flat for the side-boards. When this is rammed down the floor is finished. See Fig. 17.

square, and should weigh approximately 14 pounds.[3]

The Lower Course. After going over it twice with the small rammer, the lower course will be rough on top which is probably best, but it should also be level within one-fourth inch throughout and almost exactly 1½ inches below the top of the form strips. The template (see Fig. 16) is made for checking both depth and level. If the high spots cannot be brought down to proper level by ramming, it is possible to trim the high points with a sharp spade. This should be done before the loose material for the top course is laid down.

When the surface of the lower course is made to check with the template, this course is finished. A 2 x 4-inch strip is now laid flat on top of the other form strips for side-boards so as to make the right depth of loose material for the top course. (See Fig. 14.) If this depth is right the floor will ram down even and level with the bottom form strips. These flat strips can be quickly nailed down to the lower ones with 10d wire nails spaced about 36 inches apart. The form is now ready for the loose top layer. Before the placing of the top course, the surface of the lower course is sprinkled with water so the two will bond together.

The Top Course. The top layer is made of the same soil that was used for the bottom layer but 10 percent of Portland cement (by measure) is added to it. (One measure of Portland cement is mixed with nine measures of the soil-mixture.) The cement and soil-mixture should be mixed together thoroughly before any additional water is added. Hand mixing brought better results than the use of a concrete mixer for top course material.

A 70-shovel batch of top mixture seems to be a convenient-sized batch to mix up at one time. This will be made up

[3]See Agr. Exp. Sta. Bull. 277, pg. 10.

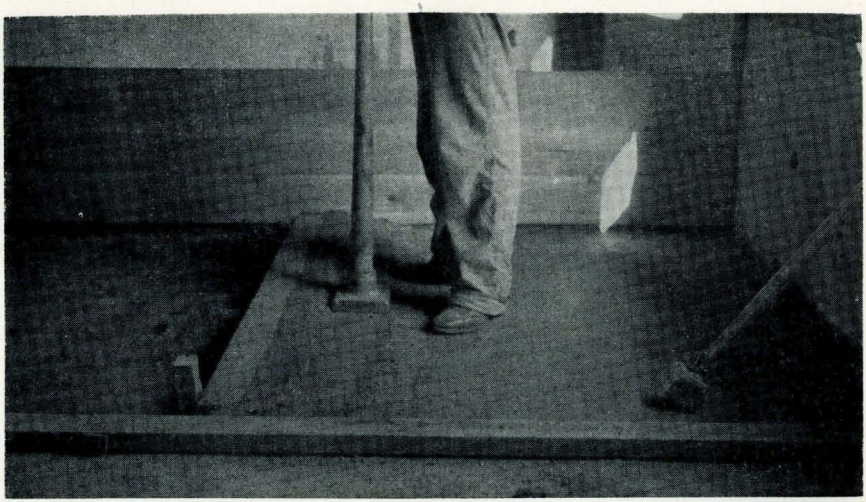


Fig. 19. FINISHING THE SOIL-CEMENT FLOOR. The loose top course is first gone over once lightly with a large or medium rammer. It is then gone over sharply twice, with the small rammer at the right and finished smooth with the large or medium rammer. The worker in the picture is using the medium-sized rammer. The stop board, which is mentioned in the instructions, is shown. A 2x4-inch piece laid flat does nicely. The stop board is used only when the work is stopped for an hour or more, which would allow the cement in the soil-mixture to set and spoil.

of 63 shovelfuls of the soil mixture and 7 shovelfuls of cement, making 1 shovelful of cement to each 9 shovelfuls of soil. In mixing, reasonable care should be used to get the shovelfuls the same size. Coarse pebbles larger than one-fourth inch should be screened out. If a large pebble came in the surface of the floor it might loosen later, leaving a hole in the surface and hastening deterioration.

After the cement is added and mixed in with the soil it will be necessary to add considerably more water to the mixture because the dry cement will absorb it. On the first batch it is advisable to try an additional measured amount and make it just a little wetter than the bottom layer seemed. If it rams down solid it is not too wet, and if it does not stick to the steel rammer head it is too dry. The same test methods used for the bottom-course mixture should be used for this top course.

It is important to have enough moisture. If the top course is too dry, a poor floor will result. One man should check all batches for moisture until the crew becomes experienced with it. It must be remembered that only small batches of the top course can be mixed at one time because when the cement comes in contact with moist soil it begins to set. Only batches that can be rammed in place within the hour, or possibly 1½ hours, should be mixed at one time.

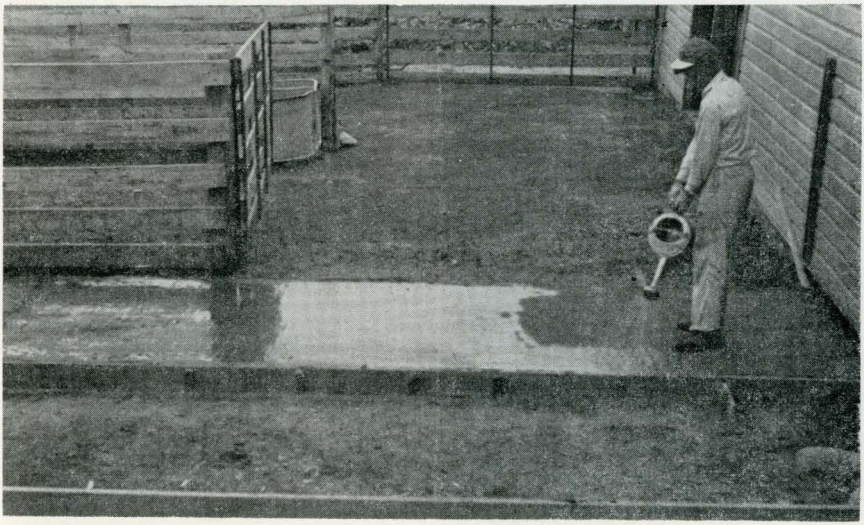
The surface of the bottom course should be sprinkled fairly heavily with water just before spreading the top course in the forms. However, water should not stand on the surface. A hose using a light spray is best, but a garden sprinkling can, or a can with very small holes punched in the bottom, is satisfactory for the purpose.

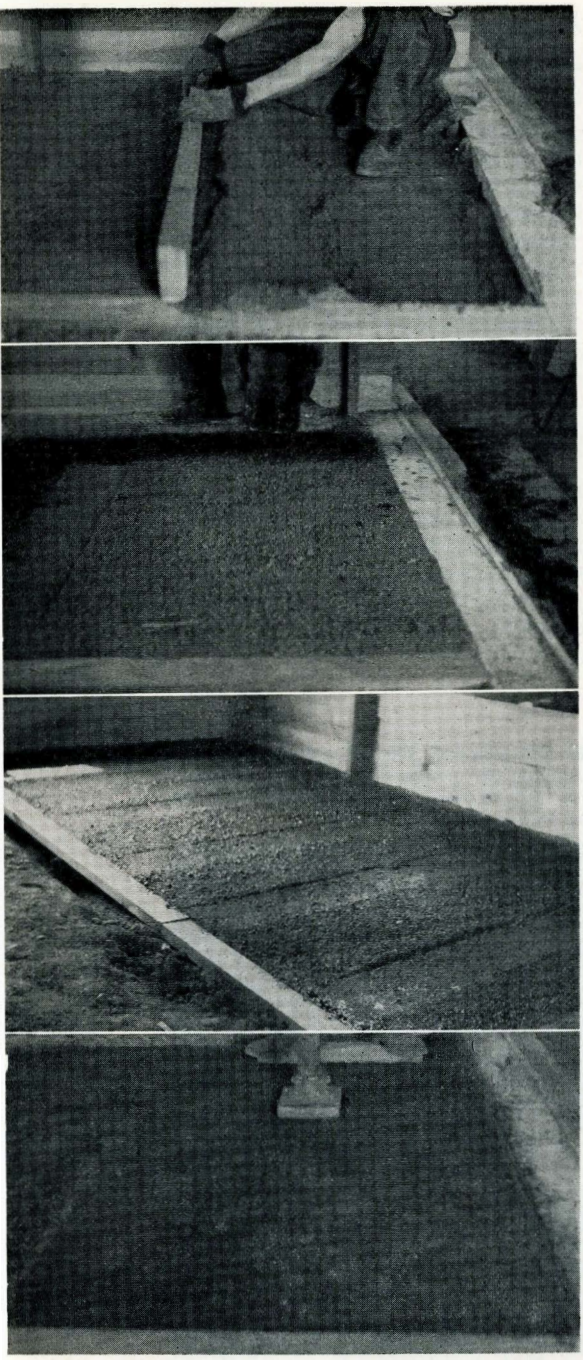
The mixture for the top course is spread evenly in the form and rammed to finish the floor. The loose material is

first struck off level with the top of the form strips by using a sawing motion of the straight-edge or template. Only about six feet of length in a floor strip should be tried for the first time because it should be rammed twice over with the small rammer and twice with the large one before the cement begins to set. A 70-shovel batch is about right and will make a top strip of floor about 6 feet square. If the one 6 x 6-inch rammer is used, the layer should be gone over at least four times, lapping the strokes slightly. Another batch is then mixed and place in the form and rammed down.

The loose top-course material between the form strips cannot be rammed to the very edge of each batch, because the edge will flatten or "feather-out" unless a stop-board is put in to hold it. While working right along, it is best to ram to about two feet from the edge and then mix another batch, put it in forms and continue the ramming. The extra 15 minutes required to mix up the next batch will not hurt the edge of loose material that has waited this long for ramming. In quitting work at noon or at night it would not be advisable to leave this edge unrammed for so long a time as the cement will set up and spoil. It will be necessary to put a "stop board" in the form and ram all of the loose material that has been mixed with cement (see Fig. 19). This stop board will need one stake in the center and nails or stakes at each end to hold it in place. When a stop board is used a joint will be made in the floor and when the work is continued some care must be used to get the surface smooth at this joint.

Fig. 20. CURING A SOIL-CEMENT FLOOR BY SPRINKLING. The soil-cement floor should be cured the same as concrete. Keeping the surface damp for two or three days, at least, is necessary to secure a tough and resistant floor. A sprinkler can be made by punching small holes in an old pail or large can. Unlike concrete, this floor can be walked on immediately.





Oil-Surfaced Floor

Fig. 21. Striking off the loose soil mixture for the top course with straight-edge, ready for the oil.

Fig. 22. Sprinkling the cut-back oil onto the loose soil mixture from an old can with perforated bottom. The worker must stand on a plank in doing this.

Fig. 23. The oil has been sprinkled evenly over the surface at the rate of one gallon to 12 square feet and is drying. It should be ready to ram in 18 to 24 hours. Note the marks of the plank made in the soft mixture before the oil was sprinkled. The plank was moved ahead of the sprinkling.

Fig. 24. Ramming the first time over rather lightly with a medium or large rammer. Twice over with a small rammer should follow and then smoothing of the surface with one of the larger rammers. The floor is then finished except for the seal coat of oil from the same barrel.

The Oil-Surfaced Floor

Oiled-gravel floors that are made like "black-top" hard surfaced roads have not been very popular for farm poultry houses because they are hard to build. In the first place the heavy oil that is used in them must be heated. This is not easy to do on the farm. In the second place the methods used for mixing, spreading and packing the highways cannot be used in building inside floors. The problem was to develop a new, simple method of building an oiled floor that would be practical for the farm. This was done by using a light or thin rapid-curing oil that did not require heating before use, by sprinkling the oil on the surface of the loose soil to get good penetration, and by tamping the material in place instead of packing and rolling it as is done in highway building.

The oil-surface floor is built so nearly like the soil-cement floor that many of the instructions for building are the same. The soil mixture is exactly the same as for the soil-cement floor (about 75 percent sand and 25 percent clay and silt). The same test of the subsoil and of moisture is used. Coarse gravel is left in the base course, but for the top course the material is all passed through a one-fourth inch screen. The filling and grading is done, and the forms used in exactly the same way. Also two layers of floor are used of the same dimensions.

The difference in making the soil-cement and asphalt floors is that instead of mixing Portland cement with the loose top-layer of floor, cut-back asphalt oil is used.

The difference in building the oil-surfaced floor from that of oil-gravel or "black-top" highways is that instead of mixing the oil with the loose soil before placing, the oil is sprinkled on the loose top-layer in place—which it penetrates. It is allowed to dry for at least 18 to 24 hours and is then packed with the hand rammers.

How To Build the Oil-Surfaced Floor

A cut-back asphalt oil is used for this purpose. This oil is substantially the same as type RC-2 road oil and is light enough to use as a seal coat for bituminous or "black top" road surfaces, although RC-1 oil is still lighter and is generally called "seal coat" oil. RC-1 is more commonly known as "cut-back asphalt oil-cold mix."[4]

It is a black oil but is thin or light, and flows freely in summer weather. In cool weather it may be advisable to leave the sprinkling of the oil until the warmest part of the day. The oil may be applied at once. If the work is outside and it is desired to delay the sprinkling of the oil, then the surface should be covered with a tarpaulin or something similar to retard the drying out and protect the surface.

Cut-back asphalt oil contains volatile oils that evaporate readily, like gasoline. This oil is used because it will dry on the surface in 18 to 24 hours, so that it can be rammed. This light oil also penetrates rapidly—which is an advantage. The reason for sprinkling the oil on this loose top course is to secure good penetration, and to do it by an easy method.

After the surface is dry, the loose course is packed thoroughly with hand rammers. The same instructions on rammers used for soil-cement floors also apply to the oil-surfaced floor. If two sizes of rammers are used, the large-faced rammer is used for the first time over. The small-faced rammer should be used

[4]This oil was obtained from the local Service Station of one of the leading companies, and can be bought from the local stations.

for going over the floor two or three times and the large-faced rammer is then used to smooth the surface. The oiled surface, upon drying, forms a tough rubber-like cover over the loose material, and in ramming the first time over it is better to go over it fairly easy. In this way the cover will not be chopped up so much. A satisfactory floor can be built with a single 6 x 6-inch rammer (see Fig. 13) if the floor is gone over an extra time and rammed a trifle harder.

The Oil and Rate of Applying

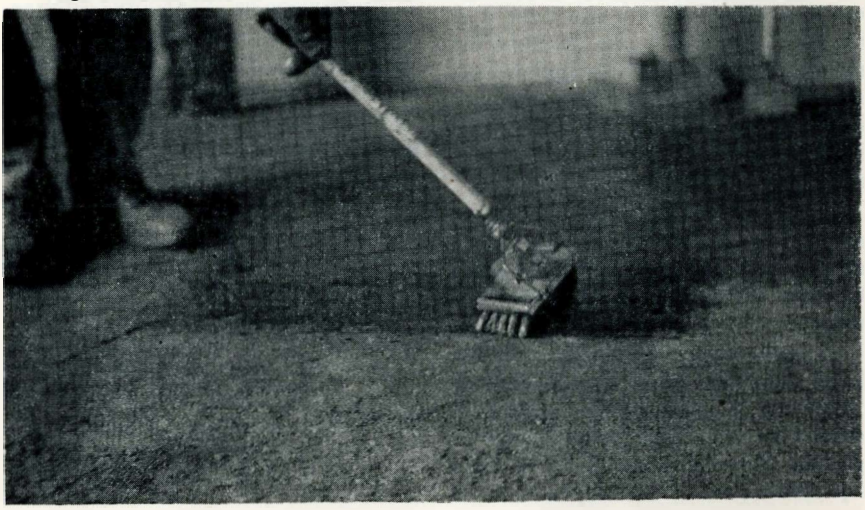
The same type of oil is used for all operations in building this floor. This makes it easy to build. Cut-back asphalt —cold mix, is used for the primer coat between the lower and upper course of the floor, for filling the top course and for the seal-coat on the surface. It will require 48 to 50 gallons of oil to build a floor for a 20 x 24 foot poultry house. One 50-gallon barrel will do it nicely.

Priming Coat. The priming coat is sprinkled on the surface of the lower or base course at the rate of one quart to 16 square feet, or 6 quarts per 100 square feet of surface and is brushed out before placing the top course.

Filling Oil. The top course is sprinkled with the oil at the rate of one gallon of oil to 12 square feet or 33 quarts per 100 square feet of surface, allowed to penetrate, and left to dry undisturbed. It may be finished just as soon as it will not stick to the rammers. Different rates of applying the roller oil were used in the tests, varying from one gallon to 8 square feet to one gallon to 21 square feet. The heaviest application of one gallon to 8 square feet made the mix too soft to pack and is not satisfactory. An application of 1 to 16 was used on the 3¼-inch floor shown on page 20 and this floor is standing in perfect condition. However, a later floor upon which an application of one gallon to 12 square feet was used, finished nicely by allowing 18 to 24 hours for drying, and it appears that the additional oil makes a slightly higher quality floor. It would take about 10 additional gallons of oil for a 20 x 24 foot farm poultry house.

Seal Coat. A seal coat is a thin coat of

Fig. 25. BRUSHING OUT THE SEAL COAT ON THE FINISHED SURFACE.



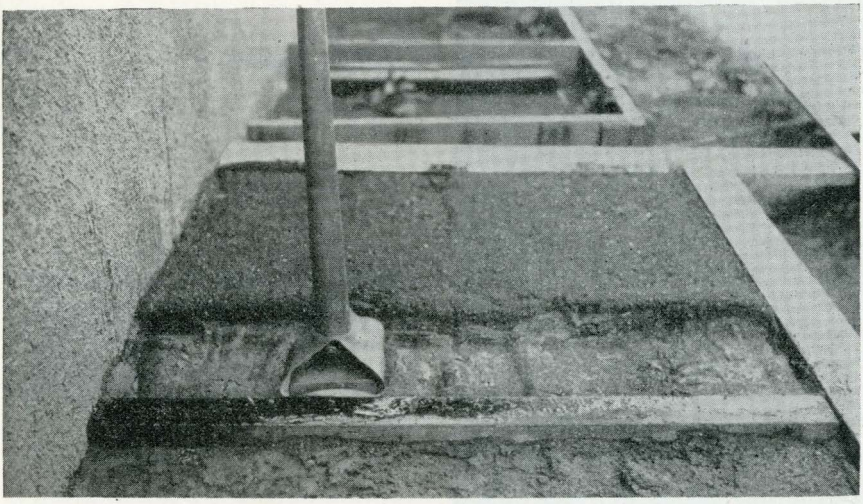


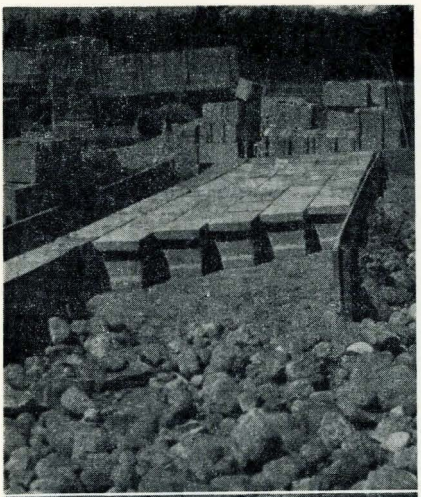
Fig. 26. TOO MUCH OIL WAS USED IN THIS FLOOR. In this floor one gallon of oil was used for each 8 square feet of floor. This is definitely too much oil. The floor is spongy and will not ram down solidly.

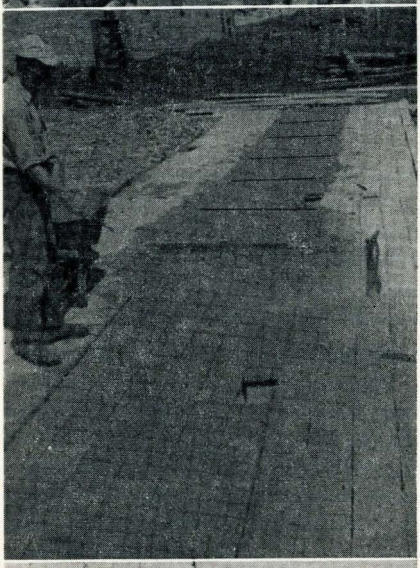
light, rapid-curing oil that is spread on the surface of bituminous or "black-top" highway surfaces. The same cutback asphalt oil is satisfactory. It should be sprinkled on the surface of these floors and brushed out with a scrub brush equipped with a handle as shown in Fig. 25. One quart of oil to 20 square feet of surface or 5 quarts to 100 square feet is used for the seal coat. It takes a little time for the seal to dry before the floor can be put into service, the time depending upon the weather. If it is necessary to hurry it, a light sifting of fine sand may be used on the surface of the seal coat.

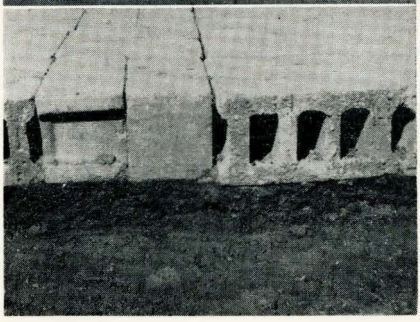
This floor also has some outstanding features that may make it even more popular than the soil-cement floor. Although it is not as resistant to heavy service as the soil-cement, it has easily withstood any service required in the poultry house. It is quite water resistant and it is a better insulating material. It costs less than the asphalt or tar oil-gravel (black-top road type) floors and is definitely easier and more practical to build on the farm. Not only is the same oil used throughout, in building this oil-surfaced floor, but the oil does not require heating. It is used as it comes from the barrel, and this is a definite advantage.

Method of Protecting the Floor

After the loose top course is sprinkled with the filler oil and while it is left to dry out before it is ready to be given the final packing, the floor must be protected carefully from livestock as well as from rain. During the 24-hour period a rubbery covering is forming over the surface, which must not be broken. If an animal should walk on the surface during this period the tracks will be extremely hard to repair and it is almost impossible to get a good surface where the tracks were made. Care must be used of course by the operator not to step on this surface before ramming. If it has been allowed to dry sufficiently he will be able to stand on it and follow the rammer as he gives it the first ramming.







Block Floor

Fig. 27. A good base must be placed under a building block floor. If mortar joints or a mortar top is placed on the floor, any settlement in the base will cause a crack in the floor. If there is good underdrainage in the original ground, no rock base would be needed. A thin layer of sand to level the ground would be sufficient.

Fig. 28. In applying a mortar top to a block floor the blocks must be wet down to prevent the block from absorbing the water in the cement. If the concrete dries too quickly a weak floor will result. Note the placing of expansion joints in the finished floor.

Fig. 29. An alternate method of laying a block floor. In laying the block in this manner, there will be no long channels. This will help to reduce the rodent problem in a floor of this type.

Other Types of Floors

Building Block Floors

Considerable interest has been shown in a floor made of 8″ x 16″ building blocks laid on the side. There are numerous ways in which they could be laid.

A three-hole block would be much better than a two-hole block. It would also be advantageous to buy end blocks. This would eliminate the protruding end at one end of the block.

Three different general types of floors that were built proved satisfactory. On all floors a rock and sand base was placed underneath. Any settlement in the base will cause an uneven cracked floor. If good underdrainage is present a sand layer thick enough to just level the base would be sufficient.

The first floor was constructed by placing the block side by side with no top covering and the joints left unmortared. This floor must have good underdrainage because the cracks allow water to seep into the base rather than shedding water as most floors do. Fig. 27 shows the method of laying.

The second floor was laid like the first except that a three-fourths inch layer of mortar was placed on top. Care must be taken to get enough expansion joints in such a floor. The minimum distance between joints is 4 feet. The concrete mixture should be identical to that used in a floor as explained on page 4.

The third floor was laid with the joints mortared with a mortar similar to that used in regular concrete block building construction. Considerable difficulty is encountered in maintaining these joints. If labor is a factor, the three-fourths inch layer of mortar placed on top of the floor can be placed cheaper than mortaring the joints.

Both the mortar-top and mortared-joint floor must be cured carefully. It would be well to place a moist covering of straw or soil over the floor for at least 10 days.

The cost of this floor will vary considerably in localities, depending on the distance to the block plant and the plant's supply of suitable aggregates. One hundred and twelve blocks will build 100 square feet of floor. The time saved in construction will nearly offset the greater material cost of this floor.

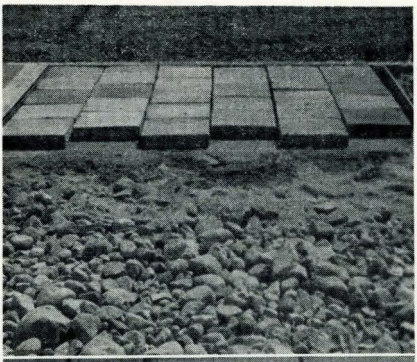
All the floors built have stood up well. Outdoor floors were used as beef cattle feeding floors. Indoor floors were placed under dairy cattle.

A floor of this type is a warmer floor than other types of concrete floor. The alternate method of laying blocks as is shown in Fig. 29 is a better method for insulating because the short air channels prevent the circulation of air.

Stepping Stone Floors

A number of concrete block manufacturers make 16-inch square blocks about 3½ inches thick that are used for semi-permanent walks. With proper construction they make a durable but rough floor.

A well prepared sub-base identical to that for building block floors is a prerequisite. The base is leveled by means of a template run over side boards as is shown in Fig. 18. A thin layer of sand leveled upon the oversize gravel will insure good contact between block and base. The blocks are laid one-half inch apart so that a mortar may be placed between the blocks. If too narrow a space is left considerable difficulty is experienced in mortaring the joints. The expansion joints are placed between blocks so that there is a joint every six blocks in width. A treated fiber board three-fourths inch thick and a depth equal to the block thickness makes a durable easily installed joint.



Stepping Stone Floor

Fig. 30. The base and sub-base must be well constructed to insure against the settling of the blocks. Any settlement will hinder in cleaning the floor and in time will cause failure.

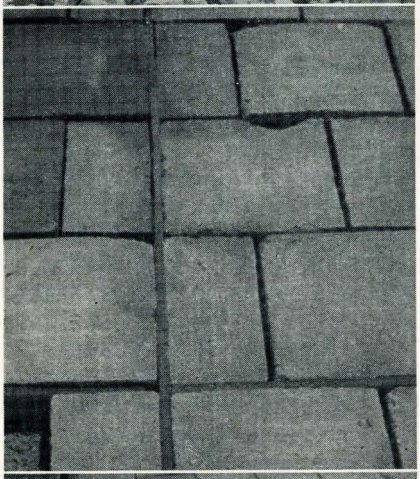


Fig. 31. Expansion joints are easily placed between the blocks before joints are mortared. Half-blocks must be used next to the expansion joint.

Fig. 32. Joints are mortared after the blocks are laid in place. The mortar is worked in the joints with a trowel.

A floor of this type is quickly and easily installed. The construction time is considerably less than for a building block floor. In most localities a floor of this type is perhaps more expensive than it should be, because in many concrete block plants the equipment is not adapted to make this type block and too much hand labor is involved causing an expensive block.

If a farmer had a building in which it did not freeze, these blocks could easily be made during slack seasons.

Vermiculite Floors

A number of vermiculite insulated type floors have been installed in dairy barns and the results have been very satisfactory. This type of insulated floor makes a lightweight warm dry floor that would be satisfactory for any indoor purpose.

For a hoghouse, poultry house, or dairy barn floor the following procedure is recommended:

1. Fill area with 6 or 8 inches of gravel, cinders or crushed rock so that the floor will be protected from ground moisture. This fill should be tamped and well settled.

2. Lay heavy asphalt roofing paper over the fill to prevent moisture from coming up through the floor due to capillary action.

3. Place a 3-inch slab of vermiculite insulating concrete, 6:1 mixture, level, and allow to stand overnight to set.

4. Place a 2-inch slab of sand and cement concrete topping for a wearing surface. Note that sand is recommended rather than gravel for the top layer of concrete. The water-cement ratio for this layer should be 4 gallons of water per sack of cement. Vermiculite concrete would not be strong and dense enough to withstand the concentrated weight from the hooves of any animal. Therefore the sand-cement top course is necessary.

The mixing directions for the average type of vermiculite that can be purchased would be as follows for a 6:1 mix:

1. The correct amount of water shall first be placed into the mixer.

2. Then the correct amount of cement shall be added and thoroughly mixed with the water.

3. The vermiculite concrete aggregate shall be added and mixed long enough to effect even distribution of cement and water throughout the aggregate and produce a free flowing mixture. This usually requires from 3 to 5 minutes of mixing time.

To obtain a 6:1 mixture the following ratio should be used:

6 cubic feet of vermiculite aggregate
1 bag cement
19 gallons of water (this is approximate)

If smaller batches are desired, cut all of these proportionately. For example, if the mixer can hold only half this amount use 3 cubic feet of aggregate, ½ bag of cement, and 9½ gallons of water. Or if the mix must be cut down still more, use 1½ cubic feet of aggregate, ¼ bag of cement and 4½ gallons of water.

Vermiculite concrete requires the same rules of handling, placing, and care as ordinary concrete. Usually the manufacturer supplies information with his product as to how to use his particular type vermiculite.

Sawdust Cement Floors

A sawdust cement floor was difficult to make because it was necessary to have the moisture exactly right when mixing. This was difficult to do even with laboratory equipment because of variations

in the sawdust. Even though the test floors were made exactly to specifications, and with laboratory equipment to determine moisture content, the floors failed within two years in every case.

Cinder Concrete Floors

Cinder concrete makes an excellent floor for nearly any purpose. This floor is lighter in weight and slightly warmer than the conventional concrete floor and nearly as durable. The cinders should not contain too much of the fine ash and the coarse particles must be hard. Unburned coal and soft pieces should not be used in cinder-concrete. The cinders should be fine enough so that about one-half of them would pass through a one-fourth inch mesh screen. The cement is then mixed with the cinders in the same way as for sand and gravel. The site preparation, forms, mixing, placing, and curing procedure is identical to that of a conventional concrete floor.

ACKNOWLEDGEMENT

The author is indebted to the late R. L. Patty who did the pioneer work on this project.