

ORIGINAL PAPERS AND DISCUSSIONS

THE STORING AND HANDLING OF RAW CLAYS

BY T. W. GARVE

Purpose of Storage.—We have pointed out in a previous paper¹ that “raw clays are stored for the purpose of sufficient supply during winter or during bad weather; to help over any breakdown at the mine or bank; to secure a better and more uniform mixture; and to improve the working conditions of the clay and the quality of the ware.

“The clay storage equipment should be an independent feature of the plant that can be in use continuously or intermittently, as conditions require, so that all unnecessary rehandling be avoided. It should face the clay bank, and later extension should be possible.”

Crushing.—Shales are often crushed before being placed in storage and we have shown such layouts in our illustrations. This, however, may not have any bearing upon the system of storing and handling the clay or shale, hence the methods of storage can be considered by themselves.

If the shale is won by steam shovel there are frequently large pieces to go into the cars, and the sooner they are crushed the better for further handling. Where weathering or mixing are desirable or essential there will naturally be better results if the crushing is done ahead of the storing.

While it is recommendable to crush shales before their storage, it may be difficult to do so in certain cases, for instance, where

¹ “The Designing of Factory Layouts for the Clay Industries,” *J. Am. Ceram. Soc.*, 2, p. 194.

the factory is far from the storage intake and where no electric power is available. This difficulty might be overcome in certain installations by placing the crusher or any other grinding or preparing machinery at the factory end of the storage building where direct drives from the line shaft can be had, and conveying the crushed material backward to storage. In this way the direct use of unstored clay is easily accomplished.

Weathering.—Storing may have but little to do with weathering; and yet, to a certain extent, the process of handling and storing will more or less improve the working conditions of the clay and so the quality of the ware. Considering shales, the pre-grinding will be a factor in favor of the above claim.

It can readily be seen that by the methods of storing and handling we are opening up the raw materials and expose them more freely to the air just as we improve the soil by plowing it. A lot of air is being entrapped within the lumps or particles of shale or clay as they roll down over the storage pile to be rebuilt and repacked.

Mixing.—While there seems to be no real systematic mixing done by using a storage shed and dumping the clay down on piles, the result is often sufficient for practical purposes.

The storage alone would not be a sufficient means of mixing where it is essential to get an average of the clay bank from top to bottom and from end to end, and it will be necessary in such cases to get a mixture at the pit and work the clay or shale bank accordingly, by a clay digger, or shale planer, or hand method, or any other suitable manner. In any case, the material dumped will spread out in thin sheets over the storage pile, the voids being filled by the new layer, etc. This relaying of the clay bank so to speak, will unquestionably have a mixing effect to a degree determined by the manner of manipulation.

For mixing lengthways, it is an easy matter to have the clay car dump at different places along the shed or to set the tripper ahead at times or to use a continuously moving tripper which discharges along the storage while traveling back and forth. If there is a side discharge from car or belt, the sides can be altered at certain intervals. A certain amount of mixing again

is being done by drawing from storage. For perfect mixing or blending of different clays a method as shown in figure 10 may be used. A number of modifications can be worked out on this principle to suit the particular problem.

Clay to Storage.—The raw material can be taken to storage direct from a dump car, which can have a bottom, side or end discharge, or the car may be emptied by a dumping device. Since a dumping device would be a stationary affair, the dump car is to be preferred since it will permit of delivery at any place along storage. We can accomplish the same thing by the installation of conveyors of various types or, if the storage can be high without extending over a large area, a high elevator with a swivel spout, or distributing spouts might be used, or a rotating elevator. For more specific information see Conveying and Storage Systems.

Clay from Storage.—From storage the material can be carried out either by cars or suitable conveyors. For feeding the material to these, we can use removable boards or spouts or feeders of various types, as reciprocating feeders, disc feeders, or screw feeders. If boards are used, an opening, closed with removable boards, should be left at one end of storage building above the belt to enable the start of emptying a completely filled storage. For more specific information see Conveying and Storage Systems.

Belt Conveyors.—In regard to belt conveyors, the troughing type is used to quite some extent in clay plants, since it does not seem to spill the clay as the flat conveyor does and has greater capacity. However, the flat conveyor has its advantages, especially if used wide enough to prevent spilling of material. While a troughing conveyor will have about 60 per cent more capacity than a flat conveyor of the same belt, the life of a flat conveyor is considerably longer, perhaps half as long again.

The belt should be carried on idlers and not on boards. For a troughing conveyor, all idlers should be cylindrical and the side idlers should be set at an angle to form the trough of the belt, but no conical idlers should be used since their circumferential speed varies, causing rubbing and wear on the belt and shortening

its life. Large head and tail pulleys also will tend to lengthen the life of the belt. The belt speed should be around 125 feet per minute.

Conveying and Storage Systems.—In the accompanying illustrations we have a number of different systems for storing and handling raw clays or shales. Each has its merits and any preference would depend upon conditions, as capacity and location of plant, length of season, kind and quality of ware, kind of bank equipment and distance, character of material, kind of power equipment and its size, arrangement of factory, money available, and expenditure justified.

In figure 1 we have sketched a plant for making brick or tile to bring out again the independence as well as the relationship of the clay storage building with the rest of the factory. The car above the storage can discharge its contents at any place of storage or direct into the screw feeder for the factory. For using stored clay, the underground belt conveyor will be operated for charging the feeder mentioned. By means of movable boards above the conveyor duct, beginning from one end of storage, the material will slide down to the conveyor belt. This requires one man. This is not an expensive installation and will do well for a small or medium sized plant. It allows for extension by moving out the trestle.

A somewhat different system is illustrated in figure 2 where an elevator, receiving the raw or crushed material, delivers it through a chute either to the belt conveyor above storage or direct to the underground belt conveyor for direct use in the factory. The stored material can be dropped to the underground conveyor or be fed into the elevator at the factory at whatever height the storage level happens to be.

There are two modifications or improvements of this arrangement for the use of unstored clay, by either extending the underground belt conveyor to the left to receive the material direct without elevating it, or by extending the top belt conveyor to the right into the factory. Either scheme would eliminate one elevator for using unstored clay. These extensions are shown in dot and dash on the drawing.

Another method is shown in figure 3 where no conveying machinery is used and all transferring is done by cars. The

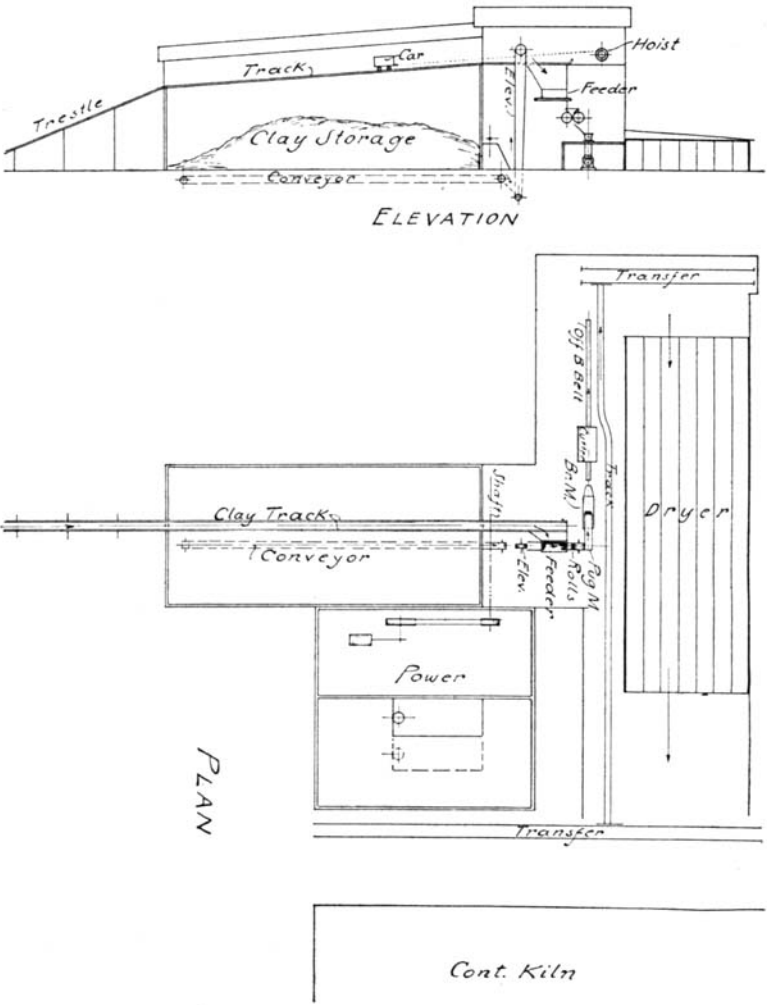


FIG 1

stored clay is taken or scraped down from storage pile and shoveled into cars, and these cars are then returned to the front of the

trestle to be pulled up by winding drum over the storage pile to the factory over the same track from which the clay is dumped into storage.

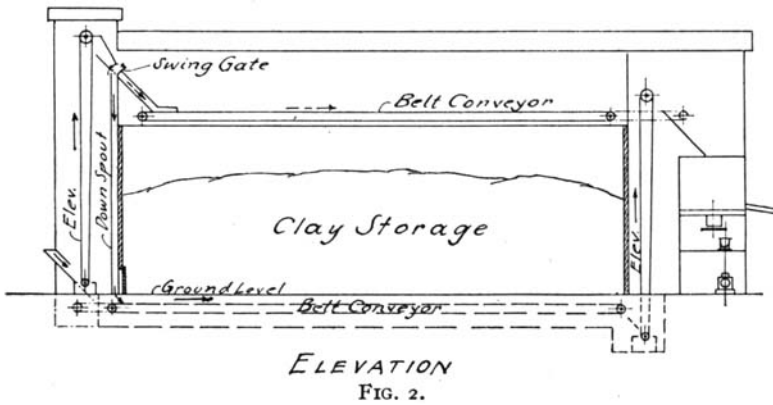


FIG. 2.

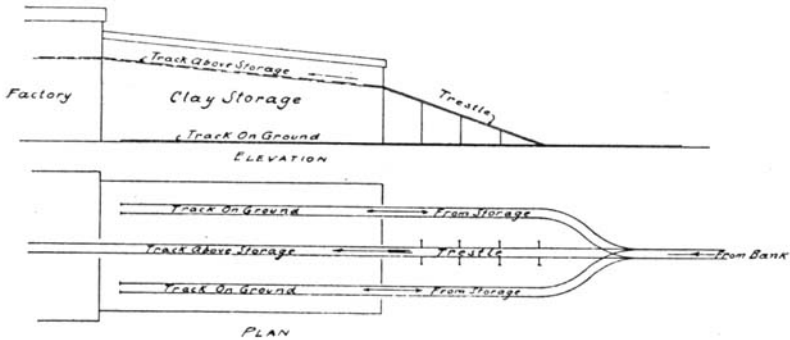
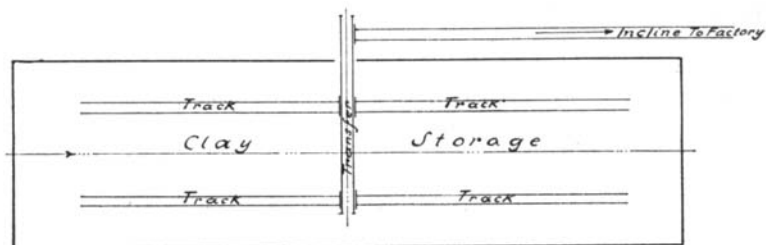


FIG. 3.

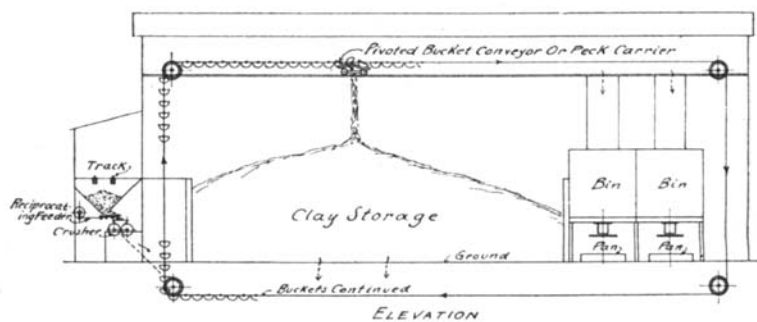
Figure 4 shows a somewhat different method for getting the clay from storage. The clay storage is divided into two piles at each side of the transfer track. The loading tracks are leading off to each side under the clay pile, and the clay is gradually worked down towards the end of each pile exposing more track as the emptying of storage proceeds. The inclined track to the factory is located to one side of the storage building and leads off from the transfer track.

In figures 5 and 6 we have two continuous systems for filling and emptying the storage. In the first system we have a continuous bucket conveyor or peck carrier, and in the second system



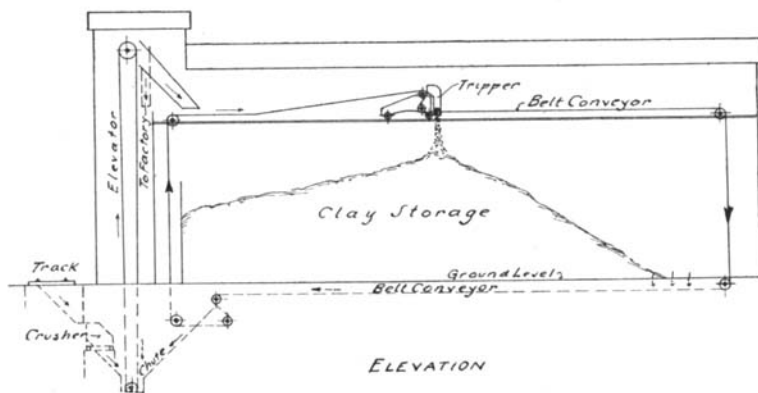
PLAN

FIG. 4.



ELEVATION

FIG. 5.



ELEVATION

FIG. 6.

the trick is being done by means of a continuous belt conveyor. They allow for carrying the material to storage or to the grinding plant by one continuous conveyor, operated from one drive. These installations are more expensive than the previous ones and require more power, but they are undoubtedly flexible and can be used to advantage in plants of large capacity or with large storage.

The elevator in the belt conveyor system can deliver the material direct to the factory, being right angle to storage, by turning the spout 90 degrees. The stored clay is delivered to the elevator at the opposite side of elevator boot.

A tripper, as shown, running on rails, is perhaps the best way for discharging a belt conveyor at a desired place, even though a tripper will add to the cost of the installation. Sometimes a scraper is used above the belt. A scraper will not clean the belt completely and some material will remain on the belt to be discharged at the end. The rubbing effect of the material on the belt behind the scraper will result in quite some wear on the belt.

Sometimes a drag conveyor is used as shown in figure 7 and

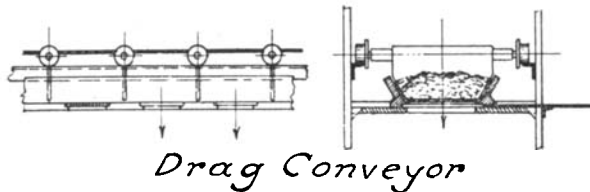


FIG. 7.

the clay is dumped through openings in the bottom or floor, and sliding gates are pulled out wherever the storage needs to be filled. Such a conveyor, single or continuous, can be used above and below storage.

Figure 8 represents a commendable system, initiated and fully described by Riddle in *Trans. Am. Ceram. Soc.*, Vol. XIX. The connecting link here between the dump pile and factory is a clamshell bucket attached to a crane. It allows piling at random with good mixing and can rightly claim flexibility.

In figure 9 we have a somewhat different system suggesting

round storage bins built of reinforced concrete or steel, being filled from a swivel spout of an elevator located in the center. Disc feeders at the bottom and one belt conveyor are to deliver

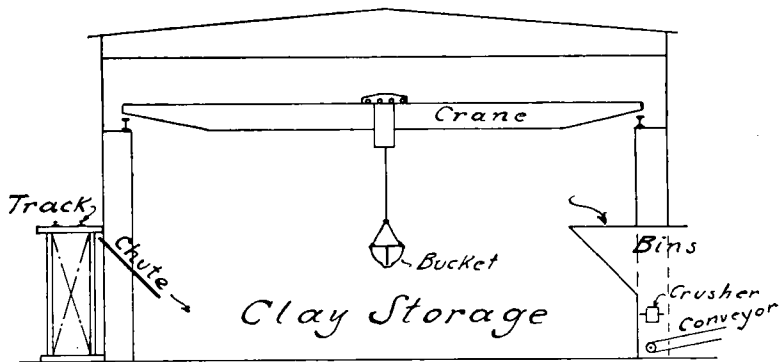


FIG. 8.

the stored clays to the factory. This system allows an excellent possibility for blending clays in proper and accurate proportions, and besides can be built within a small space. It can also be extended by adding more bins on the inside.

Returning Cars.—In order to return the car or cars from above storage, the track is sometimes sloped so that the cars including cable can return by gravity as shown in figure 3. Such a slope should be about one foot per 14 feet, or 7 per cent, but depends upon the conditions of the equipment.

Another way of returning cars automatically is to use a retriever as shown in figure 10. The extending loop near the upper end of the incline between rails is caught by a hook attached to the lower part of the car while being pulled up by the hoist. The car is pulled back by counterweights.

The counterweight shaft is connected with reducing gears to a cabledrum shaft which unwinds the cable attached to the car, pulling it back. The loop returns to its position between the rails when the car again passes this place on the upper incline on the return trip, the trip then being continued by gravity down

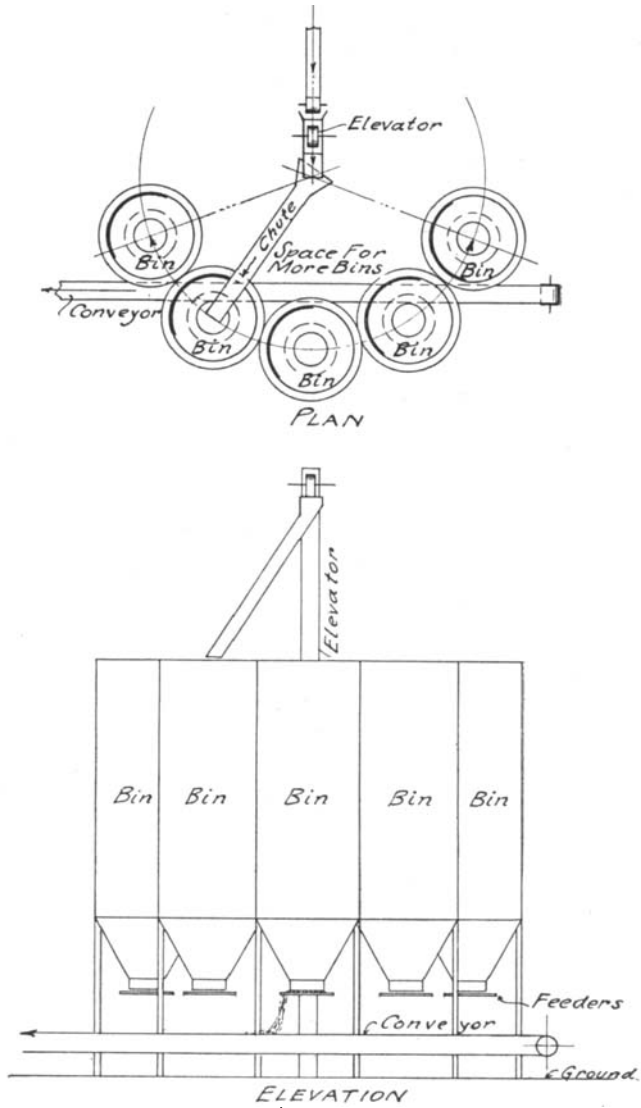
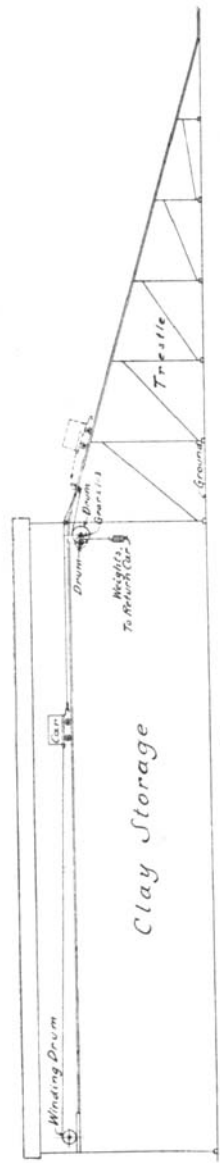


FIG. 9.

the incline. Instead of using counterweights, a second winding drum may be used for pulling the car back.



ELEVATION
FIG. 10

Sheds and Buildings.—The details must be worked out in every case for every plant, and it is not the place here to go into an elaborate discussion of them, and besides a number of them comprise the standards of an architect or engineer; however, in order to properly appreciate our storage problems and to allow comparison, it is necessary to throw some light upon some details of construction.

Before a clay storage shed of proper proportions can be designed, the angle of repose for the material in question should first be determined by experiment.

In figure 11 we have a cross section through a clay storage shed

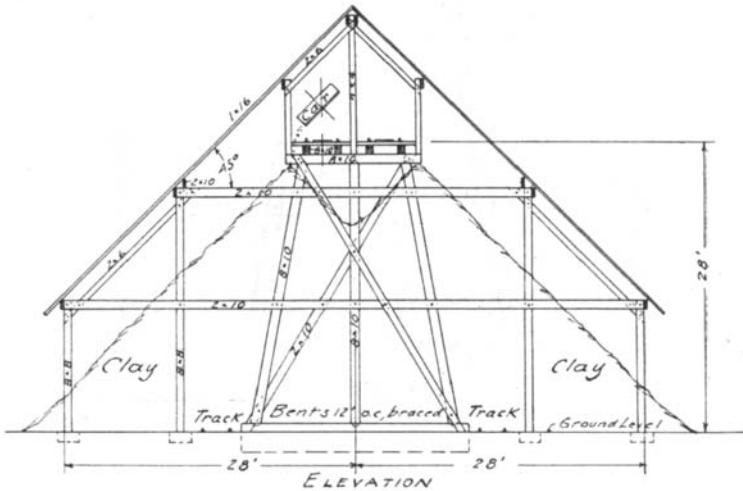


FIG. 11.

with a double track. It is put up of light timber and no rafters are used, instead the roof boards are placed at such an angle (at least 45 degrees), as to be self-supporting. It is a cheap construction, but has the disadvantage of much timber work within the clay pile with a tendency to breaking, due to unavoidable one-sided loading by clay. At the bottom the clay will roll out and form its own retaining wall. This shed requires about 7000 board feet of timber for 1000 tons storage capacity and is cheaper

than the other sheds mentioned later, mainly on account of the double track arrangement.

Figure 12 represents a single track shed of inexpensive and simple

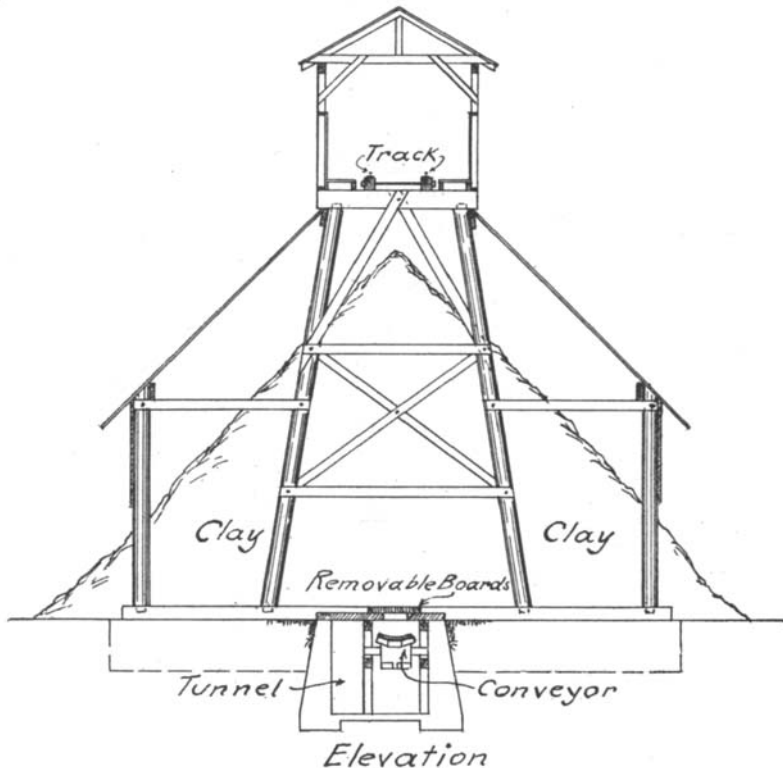


FIG. 12.

construction, well suitable for a small plant. The shed is, so to speak, built around the clay pile and little space is wasted. There are the self-supporting roof boards, but a heavier construction for the trestle.

For larger storage and where the angle of repose of the material is less steep, as, for instance, for coarse or perfectly dry material, a storage building as shown in figure 13 may be erected. The roof stringers are trussed, and they are resting on a concrete

retaining wall at one end and on the track cap at the other end. Such a wide building requires, for economic emptying, two underground tunnels with either conveyors or cars. To avoid the underground tunnels, the conveyor or car track can be placed above ground. This requires an overhead floor of heavy construction to carry the weight of the clay, but such buildings can be worked out and are in existence.

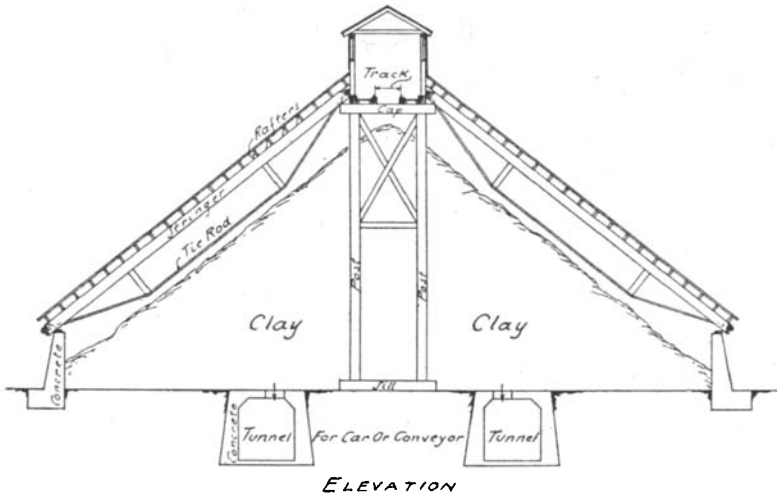


FIG. 13.

Where the clay storage building does not need to be very long, the grinding room or machinery building can simply be extended; and the clay track be placed within the roof truss. Such a construction is shown in figure 14. The truss may be built of steel, as shown, or of suitable timber and rods.

There is no question that buildings of a great variety of types can be designed and constructed, however, we can point out here but the most characteristic and most widely used types.

Retaining Walls.—The retaining wall is one of the most important elements in clay storage buildings, though we have shown cheaper types which did not have such walls. We can build such walls of timber, plain concrete, reinforced concrete,

steel, brick, or any combination of them. The following drawings of retaining walls are self-explanatory and hardly anything needs to be added.

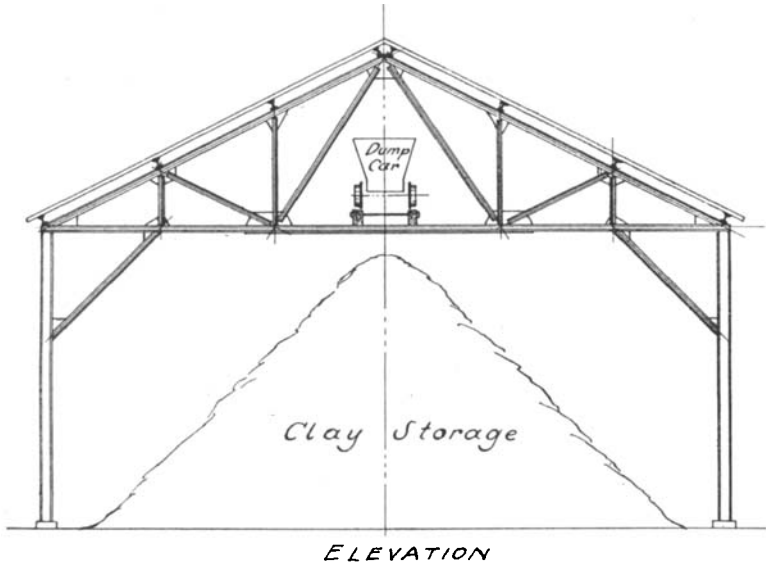


FIG. 14.

In figure 15 we have three representatives of frame retaining walls. In figure 16 we have plain concrete and reinforced concrete walls. This is not the place to go into a discussion of reinforced concrete design, which is a study by itself. We merely wish to mention that the steel bar reinforcements are placed where the wall is under tension. Figure 17 gives a retaining wall, using concrete, steel and timber. It is a strong construction and can be carried high. Figure 18 offers a suggestion for a wall built of steel and brick.

Retaining walls should be calculated to do the work and to be safe as the rest of the structure. While all these calculations are problems for the architect or engineer for the particular case, we wish to add a few words regarding the theory of retaining walls. There is a literature on retaining walls, and anyone interested can supply himself with much theoretical data.

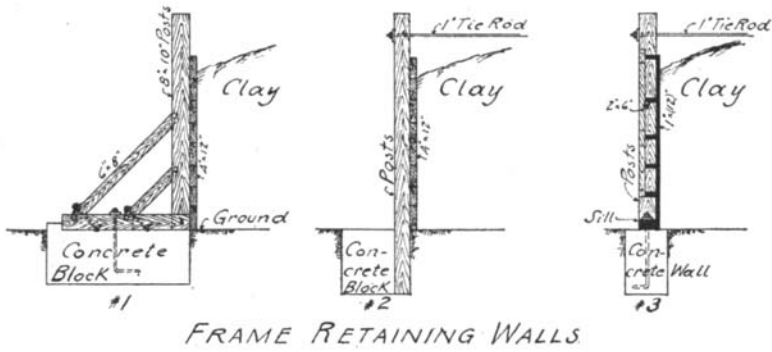


FIG. 15.

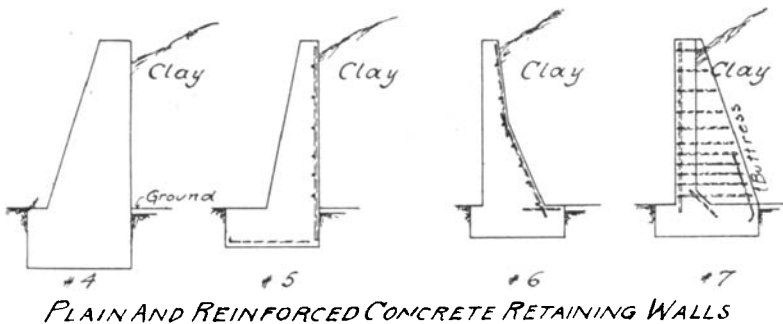
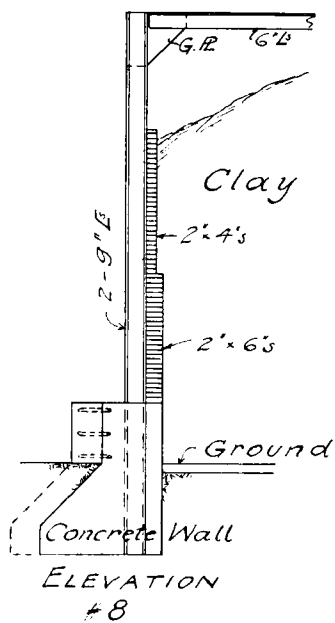


FIG. 16.

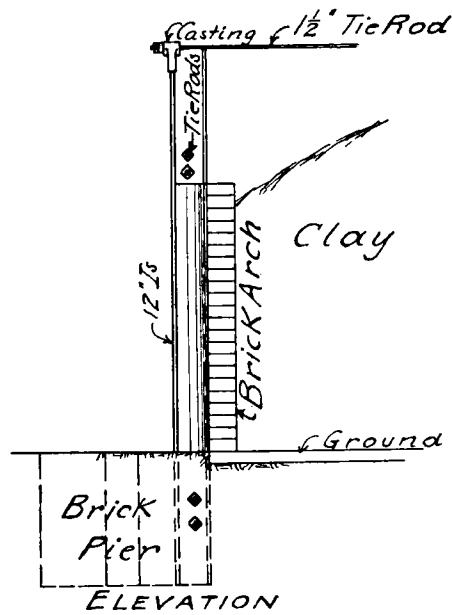
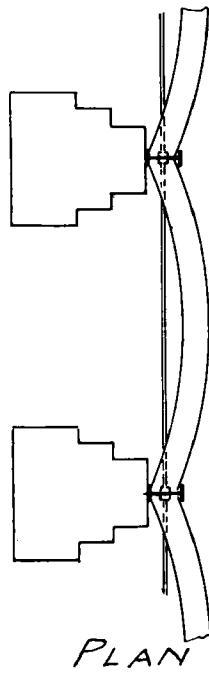
While there is a great variety of shapes of retaining walls for the many different purposes, we will assume that for the clay worker it dissolves itself into a wall with a straight and vertical back, a battered front, and a toe, as shown in figure 19.

The wall must be strong enough in itself to prevent cracking or failure, it must be safe against overturning and safe against sliding. The clay behind the wall, tending to slide on itself and the surcharge, will tend to overturn it. The weight of the wall and footing or toe will be the resisting factors. The farther back we can keep the center of gravity of the wall the less it will tend to overturn. The soil pressure must be investigated, and if it is greater under the toe than the allowable unit pressure the base must be increased in area by extending the toe forward.



RETAINING WALL BUILT OF
CONCRETE, STEEL, AND TIMBER

FIG. 17.



#9

RETAINING WALL BUILT OF
STEEL AND BRICK

FIG. 18.

There are a number of theories on the design of retaining walls; but assumptions have to be made here, and many engineers are guided by practical experience rather than by theoretical considerations. However, all the earth pressure theories assume that the surface of rupture behind the wall is a plane, that the point of resultant pressure is at one-third the height of the wall from the bottom, and that the resultant makes a definite angle with the horizontal.

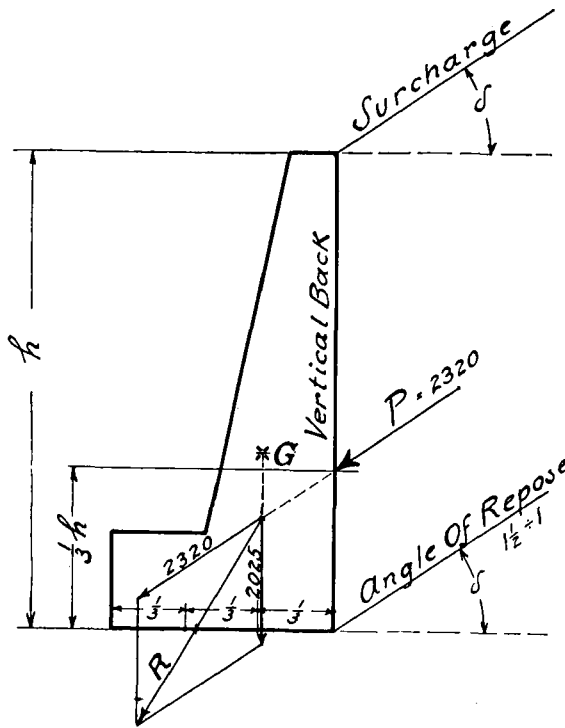


FIG 19

While there are, as mentioned, a number of theories, we wish to give here but a short and convenient method of checking the safety of a wall with a vertical back against overturning. The angles of repose and of the surcharge are assumed to be the same. The resultant earth pressure P then is parallel to these angles.

For this condition Rankine's formula receives the simple expression:

$$P = \frac{1}{2} w h^2 \cos \delta$$

where w is the weight of the filling per cubic foot

h is the vertical height of the wall in feet

δ is the angle of repose and surcharge.

In our case:

$$\begin{aligned} P &= \frac{1}{2} \times 100 \times 7.5 \times 0.83 \\ &= 2320 \end{aligned}$$

This represents the resultant earth pressure behind the wall for the length of one foot.

The weight of the wall per foot figures 2025 pounds.

The resultant R of these two forces should fall within the middle third of the base, which we find to be the case.

NOTICE.—Further discussion of this subject is solicited. All communications should be sent to the Editor.