Practical Grain Bin Design Manufacturing and Erection Considerations

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PRACTICAL GRAIN BIN DESIGN

MANUFACTURING AND ERECTION CONSIDERATIONS

By George T. Halmos and G. Peter Koens

INTRODUCTION

Growing and harvesting grain for food is a cyclic process, whereas consuming food is a continuous, daily activity. The need, therefore, to store food to abate hunger at a later date has always been a concern of mankind. Special structures for storing food can be traced back to the stone age, they are mentioned in early clay tablet and described in the Bible. Storage structures have been made from all kinds of material: stone, clay, brick, wood, straw, concrete and metals.

The first corrugated metal bins were most likely developed by the manufacturers of corrugated culvert pipes. Most culvert plants had 10 ft. brakes to produce 2-2/3" x 1/2" corrugation and to pierce the sheets which were curved and then fastened together in vertical ring position at the site.

For a long time, the bins were designed on a hit or miss basis; if a part failed, the next time it was made from a heavier gauge. To reduce costs, manufacturers of bins started to reduce the thickness of material until it failed, and in this way, established the most economical thickness combinations for different diameters and heights. Considerably later, more to prove the existing structures than to design new ones, since the turn of the century, the classical Jensen formula has been utilized. In the last one or two decades, the Jensen formula has been modified, expanded and improved by several researchers. The complex structural behaviour of the thin flexible walls, stiffened with rigid uprights, has been recognized; the significance of dynamic forces, the friction and flow of grain during filling and emptying the bin have been studied and have lead to improved design formulae. Adequately calculated structural properties, however, are not the only criteria to develop good grain bins. The bin must be manufactured at a competitively low price, easily erected and meet with the basic requirements of the customers, namely, to store grain, a living substance, for long periods without deteriorating its quality or quantity. Therefore, ideally, grain bins should be designed with the close co-operation of the civil (structural), mechanical (manufacturing) and agricultural engineers, erectors, farmers and grain bin marketing personnel.

Unfortunately, this full co-operation seldom happens. Foregoing such expertise, however, can lead to structural, financial and/or stored product losses or failures.

This presentation, though underlining the importance of structural and agricultural input, deals mainly with the influence of manufacturing and erection considerations on grain bin design.

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DESIGN OF GRAIN BINS

The following aspects should be considered during designing grain bins:

Strength (of all components)
Appearance (general, sidewall, door, roofcap)
Manufacturability (right quality at the lowest possible cost)
Erection (in shortest possible time by farmers or professional erectors)
Shipping and Storage (nestable major components, low cost packaging)
Identification of Components (easily identifiable, legible marking)
Inventory (utilization of common blanks, thicknesses, fasteners, etc.)
Corrosion (in storage and after erection)
Grain Handling (loading and unloading)
Access to Entering the Bin
Safety (in manufacturing, erection and in use)
Special Requirements (heating, ventilating, fumigating, controlling rodents and insects, etc.)
Support of Additional Structures (catwalks, augers, grain spreaders, etc.)
Patents, Licensing Agreements
Overall Costs

SIDE SHEETS

In addition to the physical properties and thickness of the material, the corrugation/embossing has the greatest influence on the strength of grain bin wall.

The shape, depth, radius of corrugation or embossing pattern may limit the maximum yield of material used for side sheets. For the usual sine wave corrugation, practically any yield strength can be specified. It is recommended, however, not to specify materials with wide range of yield strength if it is produced with one set of tooling. Low and high yield materials have different spring-back properties which results in expensive set-up changes to keep coverage. For the same reason, the tolerance on coverage (dimension between outside corrugations) should be reasonable.

The erection time, and therefore the cost, depends greatly on the accuracy of hole locations. To keep the holes within reasonable tolerance, it is suggested to pierce all holes into the corrugated (but not curved) sheets in one hit. The total force required to pierce all holes in thicker sheets can be large, up to the range of 1000 ton. Tool designer can reduce the forces exerted on the press by staggering the height of punches. Centre distances of holes pierced with one-hit die will be within 0.05 mm (.002") tolerance, but the hole to edge distances will depend on the method of manufacturing and type of equipment (see Figure 1).

The distance of holes from the longitudinal edge of the sheet (assuming these holes will be in the horizontal plane after assembly) is not very critical. The tolerance of this hole to edge distance will depend on the width of coil, changes in corrugation depth, spring-back of material, accuracy of entry guide position at the roll forming mill, camber of material, etc.

Due to hub tension in the loaded bin, the minimum distance of vertical row of holes from the edge of sheet is more critical. The manufacturing tolerance on this dimension depends greatly on manufacturing method and capability of equipment. Therefore, the hole to edge tolerance should be established after investigating the manufacturing process and standard tolerances.

The number of fasteners to join sheets, and so the number of holes, are dictated by the stresses as a function of material to be stored, bin diameter, height, thickness and strength of side sheet, and strength of bolts. Therefore, the plant has to manufacture standard sheets with different hole patterns and special sheets for doors or other purposes. A one-hit die to pierce all holes in a specific pattern may cost $30-50,000. To minimize tooling and set-up change costs, the location of holes in different sheets has to be carefully established and standardized. (Figure 2).

Correct curving is important for erection and appearance. To obtain uniform radius, in case of sine corrugation, the formed profile should match closely with the profile on the curving rolls. Deviation from the specified pitch and coverage is the main cause of sheets being produced with different radii at the top, centre and bottom. A short, may be 100 mm, non-curved length at the sheet ends is the result of curving roll configuration and is acceptable. Longer, non-curved lengths at the trail end of the sheet are usually related to incorrect curving method and lack of support during curving. Scalloping or angular looking bins can be the result of using sheets curved to too small or too large radii. To check correct curving radii, approx. 3 m (8-10 ft) long templates are recommended.

The curving of other than sinus wave corrugations should be carefully evaluated; experiments should be conducted before complete manufacturing processes and expensive tooling are completed.

ROOF SHEETS

Most grain bin roof sheets are pie shaped with flat sections between radial ribs. Depending on design and run quantities, a roof sheet can be completed in press brake, requiring 1-9 hits. One-hit press roof sheet dies produce high quality, complex, uniform products, but they are restricted in length and types. The initial tooling cost to produce roof sheets with separate press brake hits to pierce holes and form ribs is much lower, but it is difficult to keep tight tolerances especially at the narrow end of the pie shape roof sheet. Variation in rib distance may make the roof assembly very time consuming and difficult or impossible. (Figure 3).

Roll forming can produce, more or less, any length of roof sheet, but manufacturing costs would be higher than those produced in one-hit die. For trouble-free assembly, it is important to keep the rib (and hole) distances at tight tolerances, especially at the narrow end of the roof sheets and/or allow some erection adjustability with proper design and without enhancing water penetration.

Roof sheets, fabricated from relatively thin sheets and ribs, are susceptible to damage during handling, shipping and erection. Care should be taken in piling the roof sheet bundles at storage area because the weight of upper bundles of sheets can distort the ribs of the bottom sheets, as shown in Figure 4.

DOORS AND OTHER OPENINGS

The door or other opening provides access into the bin to load, unload, sample, inspect or treat the grain.

Doors

The doors obviously must be strong enough to withstand the stresses, enhanced by the possible flexing of side sheets adjacent to the frame. The doors, however, are also an important sales feature of the bin. They must be good in appearance, easy to open and close, prevent water penetration in and grain flow out. The door, even if only used a few times a year, should be accessible and comfortable to enter the bin. (Figure 5). It should also provide uncomplicated means for sampling, inspecting and occasionally discharging grain. It is not an easy task for the designer to combine all these requirements while pressured for low costs and facing possible limitations in the availability of manufacturing equipment.

Roof Sheet Opening

The appearance and strength requirement of the roof sheet entry holes are not as critical as for the door, but it is not easy to provide watertight opening, easy and safe entry into the bin when available space between roof ribs is restricted. The distance between ribs has already been predetermined by the correlation between side sheet holes and number of roof sheets, available material widths, equipment, tooling, etc.

Collar and Cap

The roof collar and cap at the top of the bin have multiple functions. They serve to load the bin with grain, they can be used as an entry opening, or for ventilation. They must be structurally strong enough to support the roof under snow and wind load, men standing on the roof and support catwalk or handling equipment. In certain cases, they are required to be strong enough to lift the whole bin by the collar when erection or re-location procedure demands it. Their manufacturing costs should be low, and they should preferably give an identifiable "trademark" look to the bin. As a result of these various demands, the roof collar and cap design differs greatly from bin to bin. Recommendations on design for manufacturability and erection should therefore be given to suit each individual shape, quantity and method.

OTHER COMPONENTS

Uprights, Legs, Supports

To prevent accordion type of vertical bin failure, most bins employ supporting uprights (stiffeners). Actual test results indicate that the shape of the uprights has more effect than simple calculation would indicate. The location of uprights, relative to the side sheets, can greatly influence the number of holes and fasteners, thus the erection cost of the bin.

The erection method (either starting with roof and top ring of side sheets, lifting the bin and adding additional rings at the bottom or, alternatively, starting at the bottom ring and building up ring by ring) has an influence on the location where the uprights join in relation to the horizontal edge of sheets. The selection of upright lengths and length tolerances, coinciding with tolerances on the sheet coverage, can make erection simple or complicated and may override manufacturing cost considerations. Good nestability of uprights reduces manufacturing, storage and shipping costs.

Ring Angles, Clips

Horizontal flat surface is used at the bottom of the side wall to provide sufficient surface area to carry the vertical wall load and to seal the bin at foundation. At the eaves, angular connections are preferred to attach roof sheets to the side sheets.

Depending on design, on the demand of marketing personnel, on inventory policy, companies either include the abovementioned horizontal and angular surfaces into the side sheets (providing special top and bottom sheets as shown in Figure 6) or make separate components. If separate top and bottom rings are made, then the hole distances and curving procedure are critical in matching the holes in the side sheets, foundation and roof sheets. Hole locations in the ring blank (before curving) usually have to be confirmed by tests. The cross section of top or bottom angles will influence the equipment used for curving, the manufacturing cost and erection time. Separate clips to fasten roof sheets are easy to manufacture, but again, inventory and assembly cost should be considered.

ACCESSORIES

Grain is a living substance. To store it for a prolonged period and keep its good quality, the grain may have to be dried, ventilated, stirred, fumigated and/or chemically treated. The grain also has to be moved, loaded in the bin, evenly distributed and unloaded. Components to facilitate these requirements must be considered during the design stages of the bin by allowing for optional extras sold as standard add on kits.

Drying Floors

For successful storage, the moisture content of the grain must be below a specified level. The critical level depends on the type of grain, storage temperature, length of storage, etc. The moisture content of the grain can be reduced by ventilating or drying. Drying is frequently accomplished in bins equipped with special drying floors supported above foundation level. The drying floor must be strong enough to carry the weight of grain and to allow sufficient volume of air to pass through without grain falling through its openings. The narrow floor planks, normally used for drying floors, can be roll formed from steel strips with openings rotary pierced in the roll forming line or, alternatively, may be made of pre-perforated steel (see Figure 7). In-plant pre-piercing of steel strip by a press is also possible, but rotary piercing is usually faster and less costly. The design of slots (usually "break-through" type to provide formed flanges for added stiffening) should therefore conform to the rotary piercing technology. Good tool designer, toolmaker and set-up man are required to provide the correct opening size for air passage and grain retention.

Strips pre-perforated with small, round holes provide better control over hole dimensions, but cross embossing between longitudinal legs is required to stiffen the floor planks. Cost, availability of equipment and demand by customer will usually determine the method of piercing. For small grains, such as mustard seed, planks made out of steel strips with small pre-pierced holes are usually required. The location of the pre-pierced holes and distances from the formed edges have to be carefully specified by the designer. Holes in the bending lines will significantly reduce the strength of section.

Other Accessories

Due to the large variety of miscellaneous components (such as drying fans) usually required in small quantities, companies tend to purchase these instead of manufacture. Design suggestions for these components are therefore omitted from this paper.

FASTENERS

Very few designers recognize that the cost of fasteners can be higher than the total labour cost to produce the bin. The assembly cost per fastener is even higher because it usually requires one man outside and one man inside the bin. Therefore, the quantity and type of fasteners per bin is important. Fasteners, in most cases, are purchased items, but usually designed and specified by the bin manufacturer. Fasteners have multiple functions; they must be strong enough to withstand shear stresses, give a sturdy appearance, keep water out, withstand weathering and corrosion. The bolt head should be standard size and large enough for the washer. The nut should also fit standard drive sockets and be large enouth to cover the hole. The nut should start easily on bolt. In case of exerting a torque larger than specified, the bolt should fail under the tension above a specified limit, nut and bolt thread should never strip. Protective layers (cadmium, zinc, etc.) should not interfere with the threading and should provide equal or better corrosion protection than specified for side and roof sheets.

Washers should be pliable enough to conform to sheet shape without tearing or damage under heaviest torque. Washer material, plain or backed with steel, must be "weather proof" and should not deteriorate from ultra violet light, high or low temperature, water, oxygen or other elements normally to be found at grain storage locations.

For purchasing, inventory, packaging and erection purposes, the minimum variety of fasteners should be used at each grain bin. Fasteners are packaged with a ± counting tolerance. During erection, fasteners are dropped and lost. The designer should be involved in the pre-determination of minimum number of fasteners supplied to job site, considering the cost, packaging errors and frustration when a few hours drive from the next supplier, the erector runs short of components.

CORROSION

Grain bins are usually fabricated from commercial galvanized steel (ASTM A525 Z275 or G90). Under normal conditions, erected bins will last over 40-50 years without rusting. Corrosion before erection, however, can create a major problem, headache and considerable loss of revenue for the manufacturing company.

At certain places of the continent, where humidity and temperatures are high, the fluctuation between day and night temperatures creates condensation on tightly packed side sheets and possibly roof sheets. After a short period of time, "white rust", a corrosive product of the zinc, appears on the surface. In presence of water, carbon dioxide from the air reacts with zinc, forming white, powdery zinc carbonate. Superficial, light deterioration will affect only the appearance of the bin, to the dismay of customer and sales personnel (Figure 8). However, under more severe and prolonged storage conditions, it can use up all the zinc coating until "red rust" appears. Change in storage method (indoor/outdoor) or application of protective coatings can remedy this situation.

Improper outdoor storage, such as collecting water in pockets, can also contribute to the corrosion problem. Incorrect packaging of fasteners may result in complete loss of protective coatings before erection. In extreme cases, the primer or paint used for trade mark of manufacturer's name identification will corrode the sheet.

Once the bin is erected, there is usually no corrosion problem under normal conditions. Chemical, especially acid, treatment of the grain, however, may create fumes which will destroy the protective zinc layer. The exposed steel will show red rust (ironoxide) and perforate in a relatively short time.

MISCELLANEOUS CONSIDERATIONS

Once the bin design is completed, it is recommended to review all components considering purchasing, common inventory, common manufacturing tooling and set-up, interchangeability, appearance, etc.

Components made or purchased in small quantities from a wide variety of thicknesses should be made of one specified (heaviest) thickness. The saving in quantity purchasing, taking out one thickness of sheet from inventory instead of many, process it, move it back to storage, etc., can far off-set the somewhat higher price for the heavier material.

Common hole locations, pierced with one common tool set-up, should be used wherever possible. Reducing set-up time will reduce the cost of the grain bin.

Establishing a good, simple part numbering and marking system is very important. The grain bin components are going through numerous hands before the bin is assembled at the farm. There are several operators, material handling personnel, shippers, transport operators, distributors, erectors involved. Many components such as side sheets, look alike though curving radii and thicknesses are different. A proper marking method, based on part number system, assures that the right quantity and quality components arrive at the point of erection.

Erection manuals also refer to the abovementioned part numbers. It is highly recommended that the designer of the bin should personally take part in the assembly and become involved in writing the erection manual. The original design of the most successful bins have been influenced and frequently modified after gaining erection experience.

There is no such thing as a "best grain bin design". Design cannot be dormant and kept forever without improvements. Changes in quantities, in material prices, in erection methods, in shipping rates, improvements made by competitors, Government regulations, may dictate changes in the design, material or manufacturing technology. Justified new equipment and tooling will also change the design. A good designer should always be abreast of development, constantly in touch with manufacturing, erection, sales personnel and customers. New ideas and new developments will come up many times during the lifetime of a grain bin design.

When changes are implemented, extreme care should be taken to minimize the losses due to obsolete inventory and non-compatible parts. The changes in drawings, Bills of Materials, computer programs, if any, packaging instructions, shipping documents, erection manuals, must also be carried out.

Caution is recommended to companies if they decide to copy others' grain bins or to start manufacturing under licensing agreement. If the grain bin is good and economical, then the designers must have taken the availability of the original manufacturer's equipment, tooling, inventory, local erection methods, climatic conditions, and yearly quantities produced into consideration. Under other conditions, with other equipment and tooling, with other manufacturing personnel, producing different quantities and/or the use of different erection methods under different climatic conditions can make the new operation unsuccessful. Sometimes the adaption can proceed without alteration, but most frequently, certain components should be modified or changed to suit new conditions. These changes should be made by personnel well versed in the design, manufacturing and erection of grain bins and familiar with equipment and tooling at the new manufacturing location.

GRAIN BIN ERECTION

To a customer, the total cost of a "ready-to-use" grain bin includes the cost of purchasing, foundation and erection. The cost ratio of these three items depends on bin sizes, local conditions, erection methods and others, but using as a very rough guideline, they can be considered equal assuming that foundation and erection are contracted out. Knowing the labour/material ratio in the cost of the bin, one can estimate that the erection labour cost is approx. 6-9 times as high as the manufacturing labour cost. This fact alone underlines the importance of the design consideration for erection.

For erection purposes, the grain bins with a large variety of diameters and heights can be divided into three major groups:

1. Small grain bins - 3.5 - 5.5 m (12-18 ft) diameter and 3.0 - 4.5 m (10-15 ft) high.
2. Medium grain bins - 5.5 - 9.0 m (18-30 ft) diameter and 4.5 - 12.0 m (15-40 ft) high.
3. Large grain bins - 11.0 m (36 ft) diameter or greater.

The erection manual should emphasize importance of reviewing the standard foundation and drainage practices. It must be ensured that the chosen site is well drained and the soil is capable of supporting the foundation of the loads.

When selecting the site, the overall requirement for storage system, both present and future, should be studied to ensure that all the material handling and related process equipment (celaning, drying, weighing, etc.) are chosen for compatibility and engineered to allow for proper flow and future expansion.

It is very important that different proposals be carefully evaluated before foundation drawings and erection are started. Many erectors can tell long stories of how they found out only after the operation had started that the structure should have been a few inches to the right or to the left of its present location.

<u>Group 1 - Small Grain Bins</u>

These grain bins when erected on small farms are used for multi-purpose storage. Many options and combinations, including a walk-in door, are sold with these grain bins, thus allowing for bag storage of fertilizer or seed which can be unloaded from the wagon or truck and walked directly into the bin.
During harvest season, the grain bin is used for winter grain storage. The grain stored is then sold during the winter, thus having an empty bin when the first fertilizer or seed discount pricing becomes available.

These bins are usually erected by the farmer, his relatives and neighbours. Consequently, from the erection point of view, this is the most troublesome group of bins with many complaints.

If we take a closer look at the possible problems, we find that, due to different optional combinations, the cylindrical portion must use half a sheet to allow for door or hatch to be installed anywhere around the perimeter (see Figure 9). Generally speaking, doors or hatches are welded structures with their inherent tolerance problems (see Figure 10). Half sheets are always a production problem due to small production runs as related to full sheets, creating additional tolerance problems. Added to this, the cylindrical portion is usually supplied in two gauges (thicknesses) of corrugated sheets. This means that, in most instances, the heavier sheet is curved to a slightly larger diameter than the thinner sheet. Unfortunately, none of these problems show up in the erection until the last three roof sheets are assembled and they won't fit. The cause of this problem is at the eave line where the circumferential holes on the cylindrical portion do not match the roof sheet holes. With the last three roof sheets, the leftover space is either too large or too small. Consequently, if the space is too small, you are trying to spread or enlarge the diameter of the cylindrical section, or if the space is too large, you are trying to shrink or decrease the diameter of the cylindrical section.

Most erection manual writers try to solve this tolerance problem by stating that none of the bolts on the cylindrical portion should be tightened until the roof is assembled. This will allow the tolerance between the holes and the bolts to be used as take-up to decrease or increase the diameter of the bin and with the use of drift pins along the eave line, assembly can be accomplished 99% of the time.

This category of small bins is also used as surge bins and we find in the prairies where large farms exist, the dealer virtually does the erection with a skilled crew in his yard, mounts the bins on skids, then the whole assembly is dragged into the field and placed on corners of the field to allow the combine to unload directly into these bins which now act as surge bins to prevent stopping or waiting time for the combine. Later, they are dragged to a common location for unloading. When these small bins are combined with a discharge hopper and legs, they are also frequently assembled on the dealer's premises. Then, with a specially designed trailer, are transported horizontally to the erection location and with hydraulics are set upright in place.

Group 2 - Medium Size Grain Bins

These grain bins are normally used either as part of a storage system on a large farm or as a commercial trading operation. Consequently, semi or fully professional erection crews are used. These crews have developed mechanical lifting aids thus allowing them to assemble one or two cylindrical rings and then the roof. The remaining cylindrical rings are then assembled by raising the roof structure and adding the corrugated rings to the bottom of the cylinder (Figure 11).

This method gives the following advantages:

Erecting the roof with one or two cylindrical rings eliminates the mismatch (tolerance) problem around the eave. The roof, when assembled, keeps the first ring perfectly round and to the correct diameter easily followed by the remainder cylindrical rings.

By lifting the roof up into the air, the crew can assemble the corrugated side sheets on the ground and, if desired, use pneumatic or power wrenches. To accommodate this erection procedure, the stiffeners are supplied in short sections either 2 or 3 rings high and are designed to come below the last sheet to allow the whole bin to rest on the stiffeners when changing the lifting hook locations.

The lifting methods change to suit the erection crew or the size of the bin. For the smaller diameter and up to 20 ft. high, installed at local farms, semiprofessional crews use what is known as a lifting pole. This is a pole placed in the centre of the bin using a large tire which is guided along this pole and pulled upwards using rope and pulleys by a tractor.

The roof and first cylindrical ring are assembled on top of the tire then, by progressively moving the tractor, the bin is hoisted upward and new cylindrical sections are added. Before the final sheets are assembled, several sheets are left out to allow for removal of the centre pole and tire. This method is fast and uses the minimum amount of erection people, but does require nearby structures to anchor the top of the pole by guy wires for stabilization.

Another method more commonly applied is the lifting jack method. For these medium size bins, tripods equipped with winches are used to lift the bins. The winches are similar to those employed when pulling a boat out of the water onto a trailer.

The number and lifting capacity of the winches is determined by the diameter and weight of the grain bin. By using the total shipping weight of the grain bin multiplied by 1.3 and divided by the capacity of each winch will give the number of winches required. This is then checked against the number of vertical seams available. If the calculated number of winches required is more than the available vertical seams, a larger capacity winch must be used.

The tripod is mounted on the outside of the grain bin with the two front feet resting on the concrete and preferably anchored. This requires that the outside diameter of the concrete foundation is 8"-12" larger than the bin diameter. The roof and the top rings are assembled first by using lifting lugs mounted to the vertical seams, the bin is lifted 30 to 60 inches, allowing the subsequent cylindrical rings to be attached, then the bin is set down. The lifting lugs are removed and attached close to ground level, then the cycle of lifting the bin 30 to 0 inches is repeated until the bin is completely assembled. (Figure 12).

Group 3 - Large Size Grain Bins

This group of bins is generally assembled by a professional crew. The roof and 2 - 3 top cylindrical rings are assembled first then inside the bin a structure is assembled to accommodate chain hoists. The number of hoists required is calculated taking the weight of the bin times 1.3 divided by the capacity of each chain hoist. The minimum to be used is six (6). A comprehensively designed structure is used for lifting the bin. The method used is the same as the tripod and lifting lugs are bolted to vertical seams and then the bin is lifted 5 ft. in the air thus allowing additional cylindrical rings to be attached.

However, due to its size, weight and possible wind loading, the bin must be guided (stabilized) during the lifting cycle. Therefore, the lifting structure is on the inside of the bin and supported from the centre (Figure 13), it uses heavy duty chain hoist and its support columns rest on the concrete foundations (Figure 14). It is recommended that these large bins be erected by experienced crews.

ERECTION CONSIDERATIONS FOR COMPONENTS

Side Sheets

When erecting side sheets, important consideration is given to the weather-tightness of the joints. Beads of caulking are used for vertical seams to overcome the problem of curvature at the end of the sheets. Bolts must have washers capable of following the curvature of the corrugated sheets both in the valley and crest. All horizontal lapping is assembled in such a way that it sheds the rain (Figure 15).

Joining four sheets at one point with one bolt should be avoided since this creates considerable gaps by the metal thicknesses and also the bolt holding the four sheets is subjected to additional push and pull during loading and unloading. This action creates space for water to seep around the bolt into the bin.

Roof Sheets

For erection purposes, the centre of the rib to centre of rib distance on each sheet must be kept at tight tolerance. Even with good fitting sheets, the scalloping between the ribs along the eave line is a frequent problem. This allows driving rain or snow to enter the bin. At the top where the roof meets, the roof collar or cap is hard to seal due to additional movement created by the weight and action of the loading equipment (Figures 16, 17).

Bolts located between the eave and the roof collar must be tightly fastened to prevent water movement due to capilliary action. The rib should be wide enough to accept standard tooling used by the erector working in the inside of the bin.

Doors and Openings

Doors and openings are a frequent source of problem because they are stiffened members while the corrugated sheeting around them is flexible. Careful attention must be given to the top member bolted to the corrugated sheet. It is hard to make a watertight seal due to change in curvature of the corrugated sheets due to loading and unloading while the door members are solid and do not change curvature.

Uprights

These are normally located inside the bin with the exception of some medium bins where they are located on the outside. Outside stiffeners are usually specified when the bin is used for seed storage. In case of inner uprights, the grain can accumulate between the corrugated sheet and the upright stiffener. When the bin is filled with different types of grain, contamination is possible. To avoid the grain accumulation, contamination or grain rotting, the space between the stiffeners and corrugated sheets may be filled. It is important that the uprights should be bolted tightly to the corrugated sheets since the vertical loads are transferred to the uprights through the fasteners.

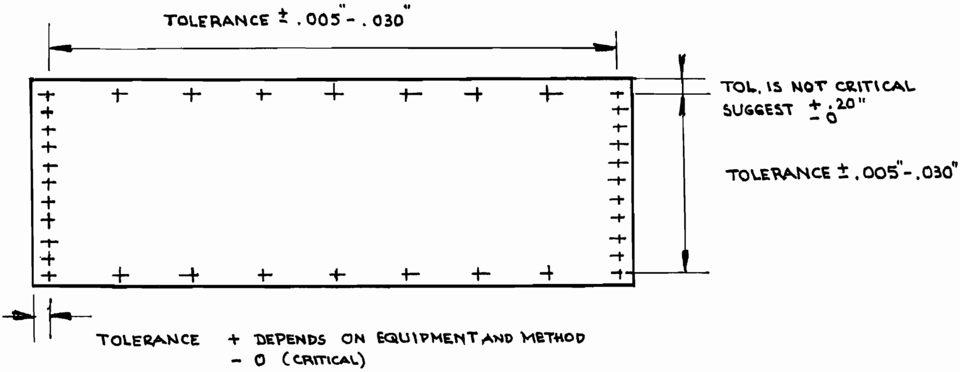


Figure 1. Grain Bin Side Sheet - Tolerances on Hole Location

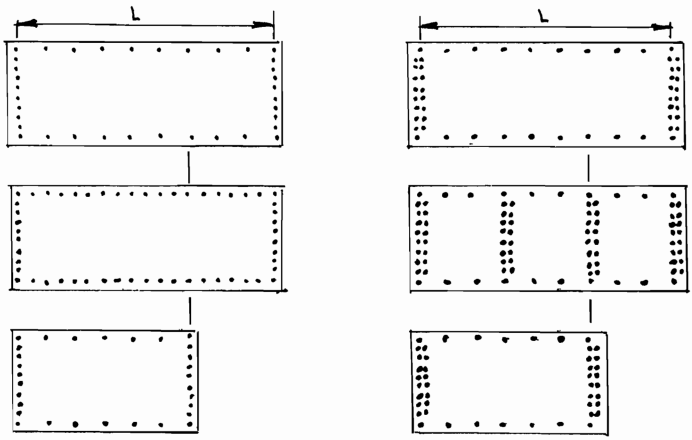
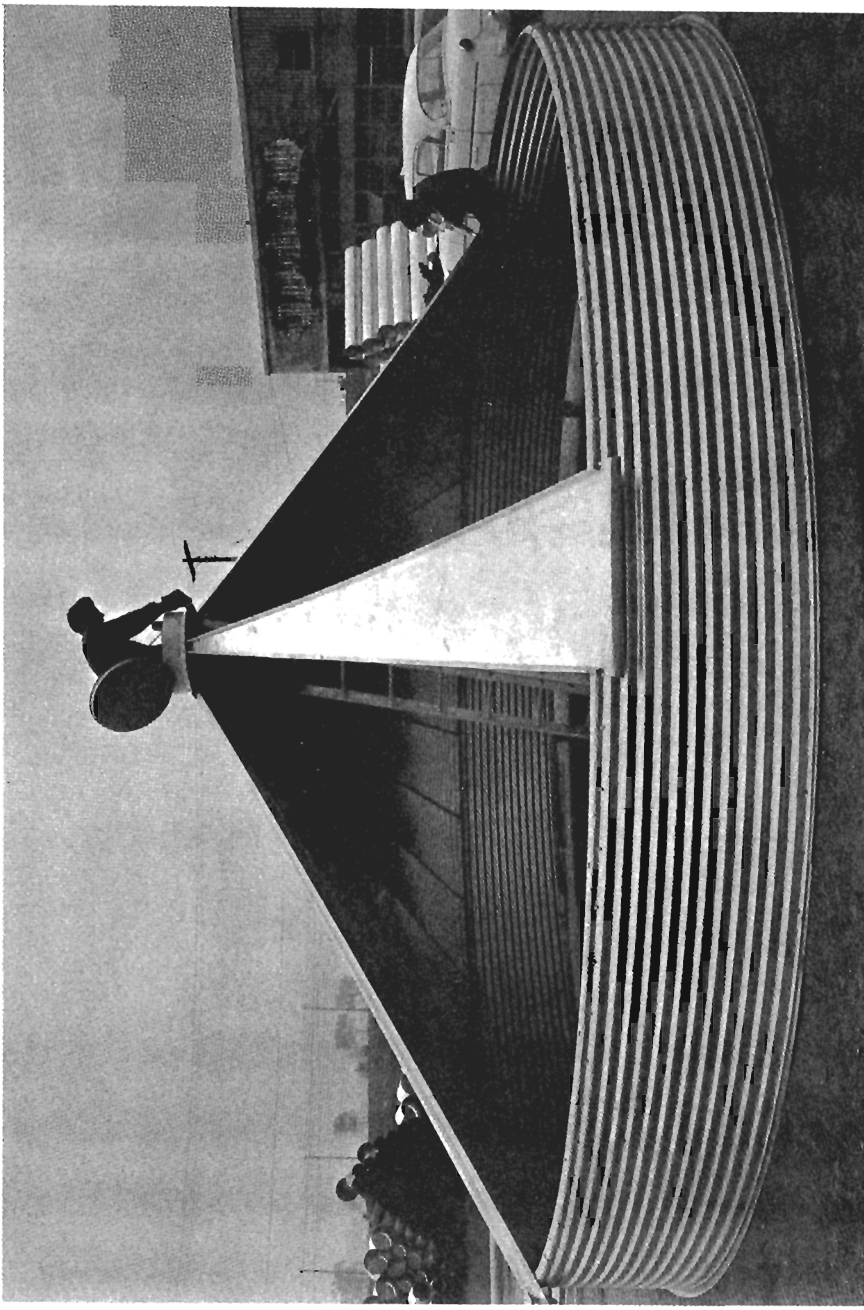


Figure 2. Common Hole Pattern Reduces Tool, Set-Up and Manufacturing Cost



Tight Tolerance on Rib to Rib Distance is important for Easy Assembly

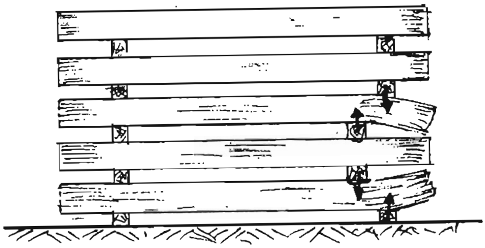


Figure 4. Incorrect Piling of Roof Sheets Can Buckle Ribs

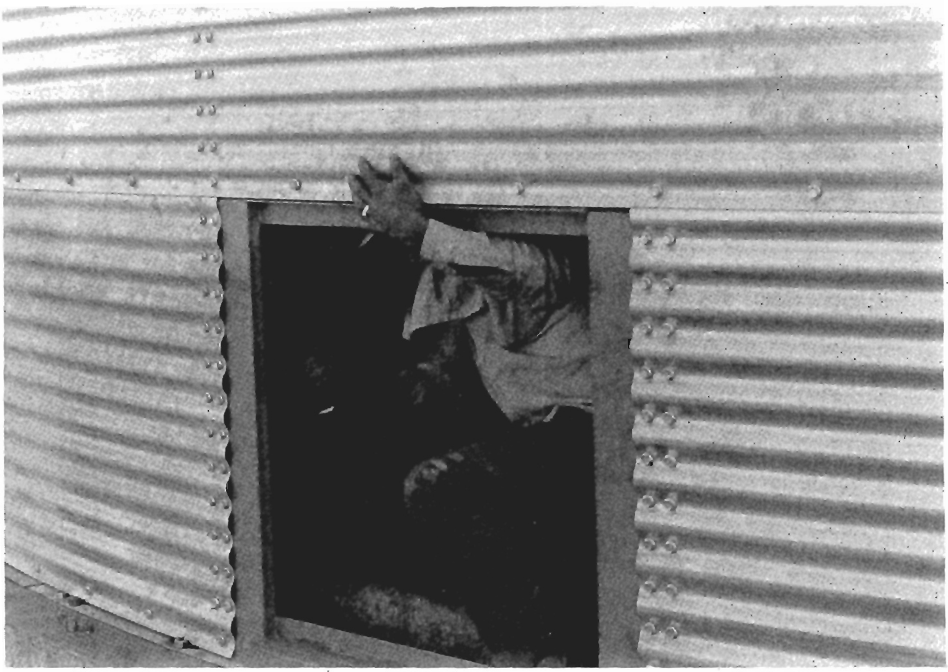


Figure 5. Door Should be Accessible

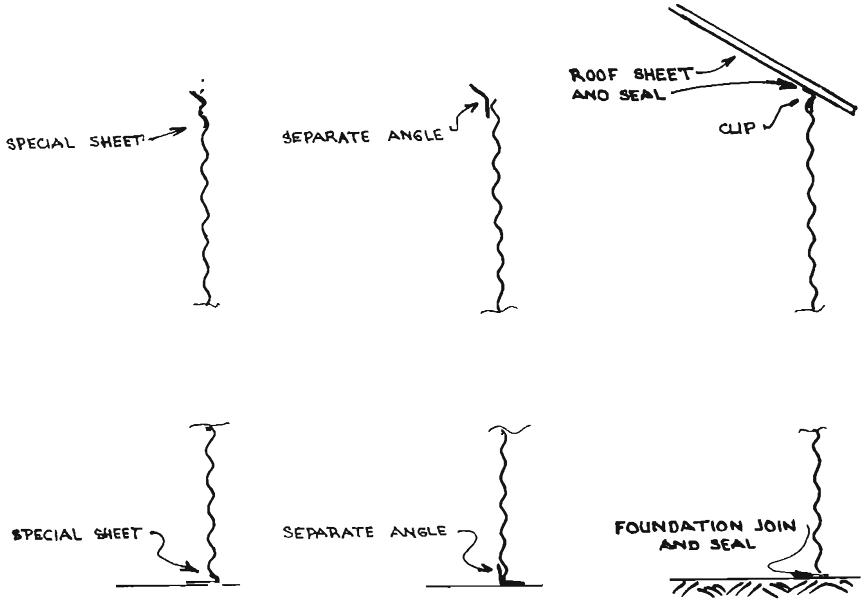


Figure 6. Roof Sheet and Foundation Joint

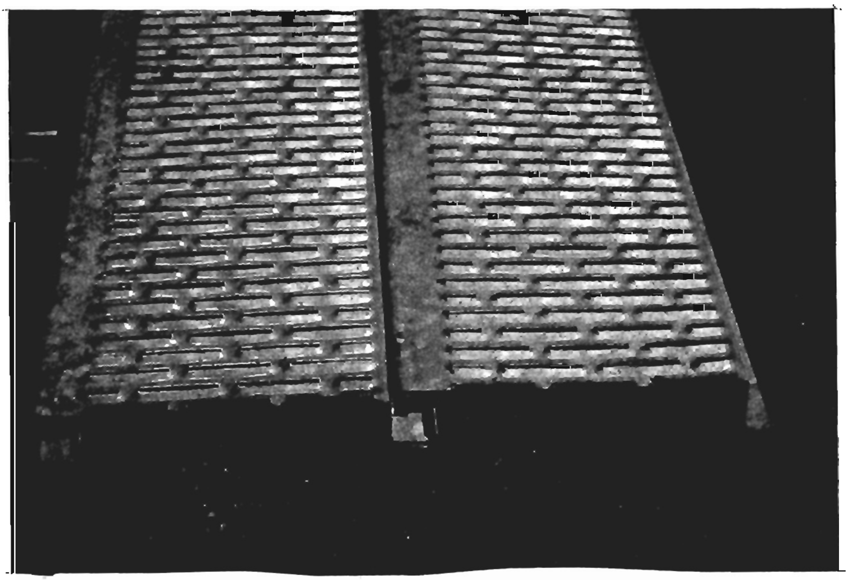


Figure 7a. Rotary Pierced Drying Floor Plank

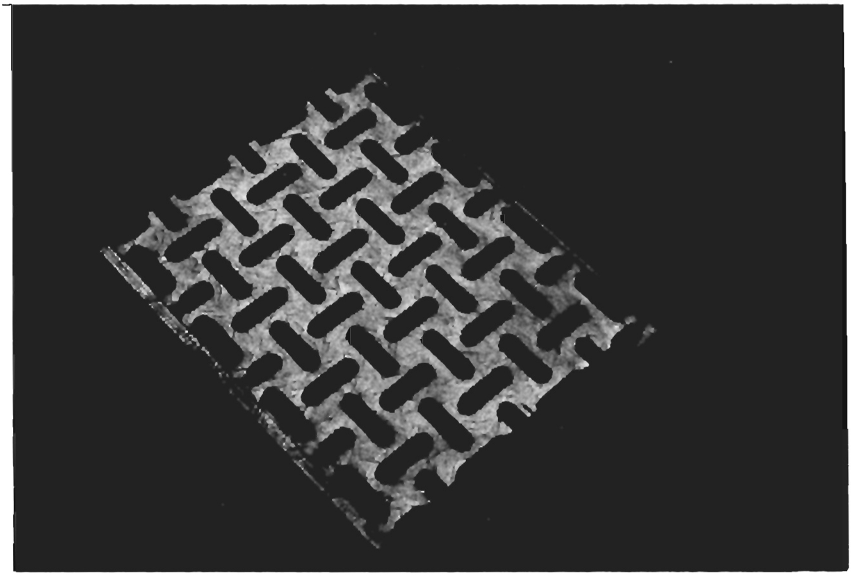


Figure 7b. Alternative Pierced-Embossed Pattern

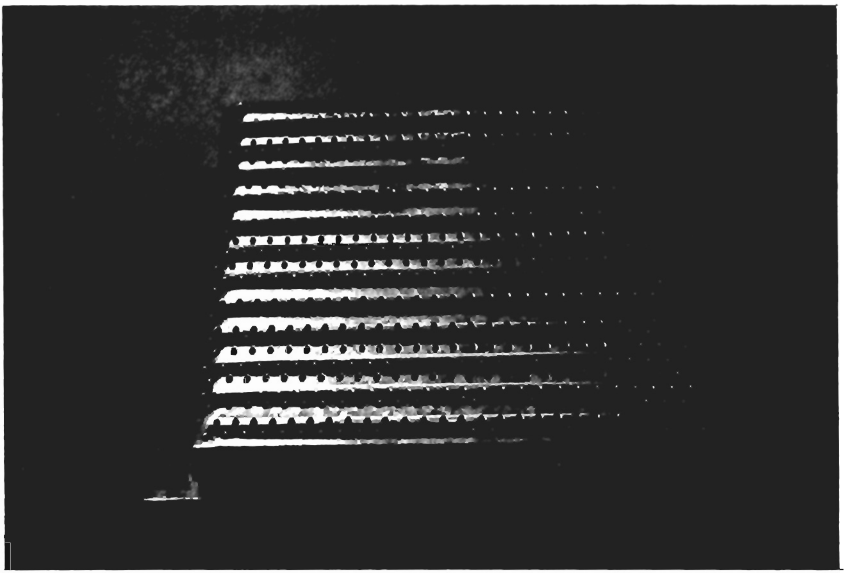


Figure 7c. Drying Floor Plank Made From Pre-Pierced Strip

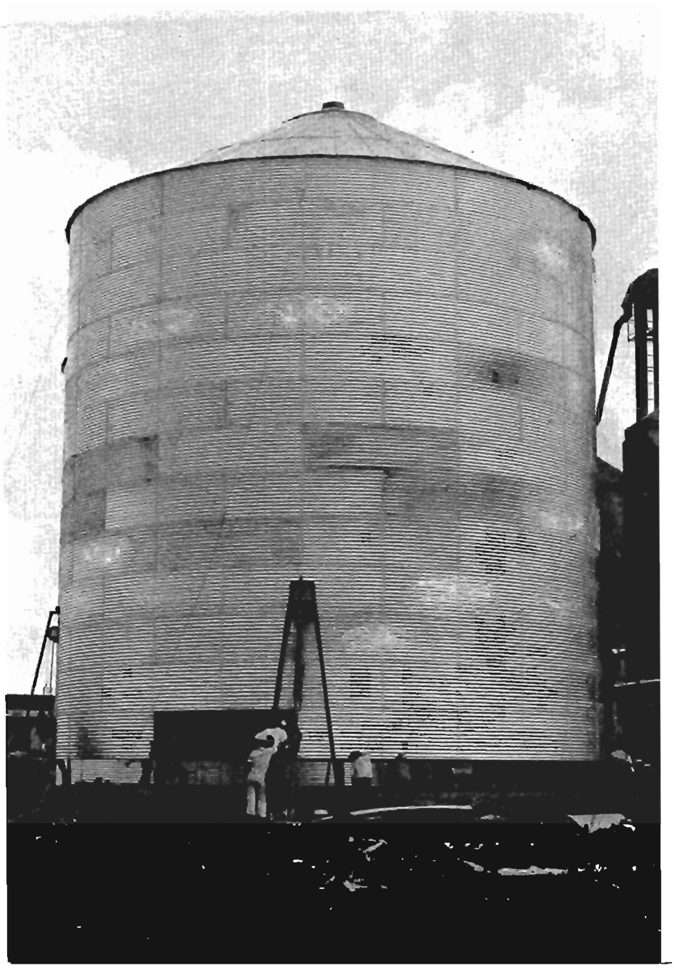


Figure 8. Side Sheets Corroded Before Erection

Figure 9. Location of Hatch Opening with Small Sheets

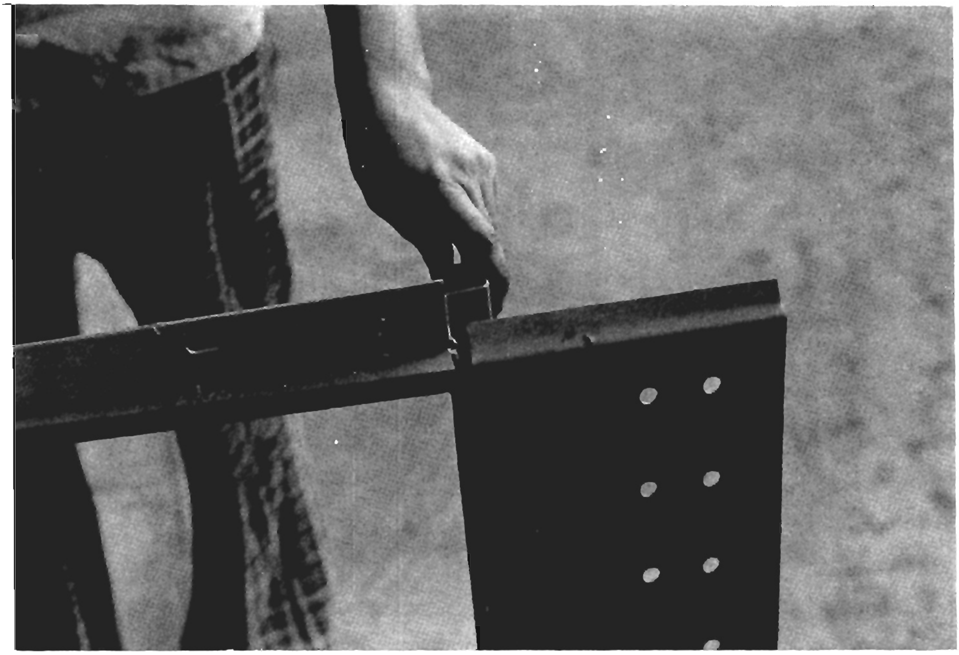


Figure 10. Welding of Corners on Doors or Hatches

Figure 11. Erection of Bins by Raising Cylinder and Roof and Adding Sheets at Ground Level

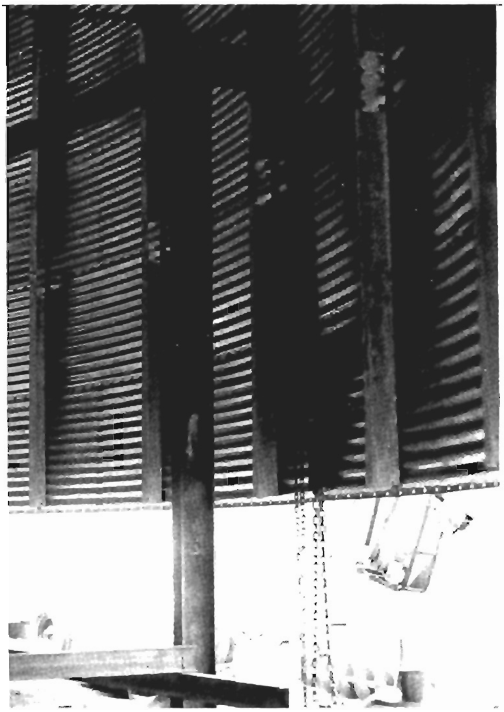


Figure 12. Removeable Lifting Lug with Chain Hoist

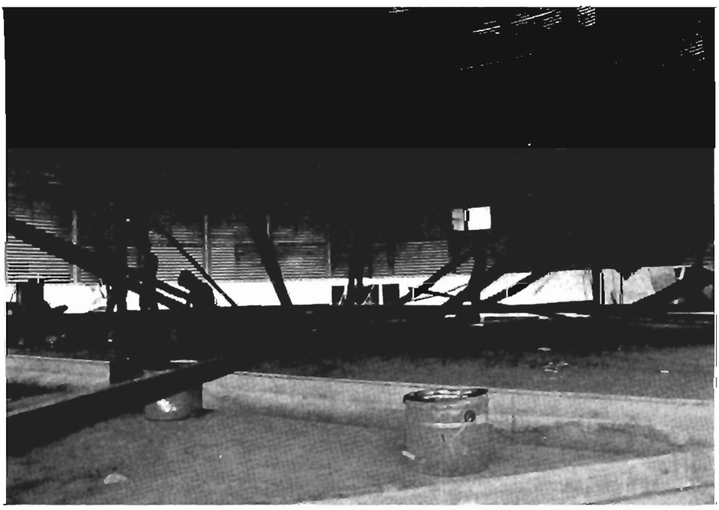


Figure 13. Lifting Structure on Large Diameter Bins

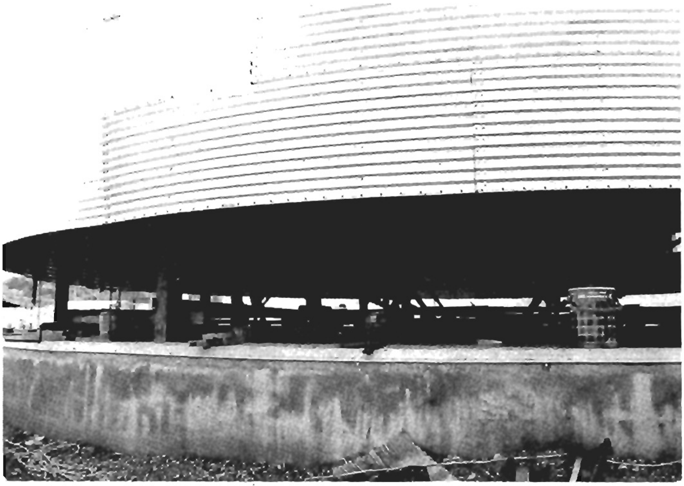


Figure 14. Support Structure

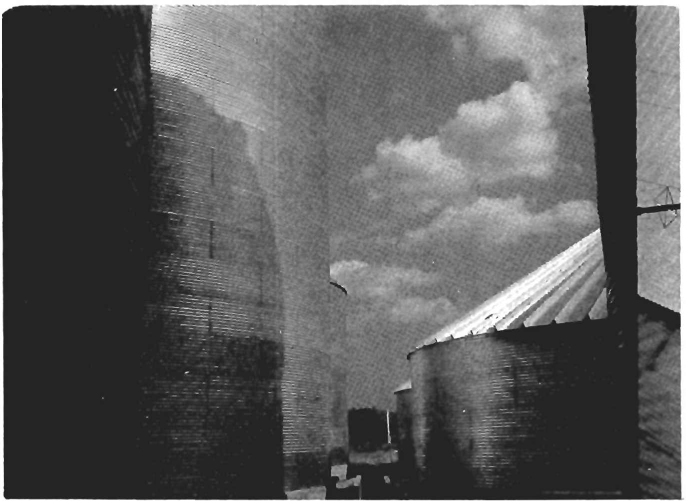


Figure 15. Overlap of Corrugated Sheets to Shed the Rain

Figure 16. Down Spouts Supported by Roof Cap

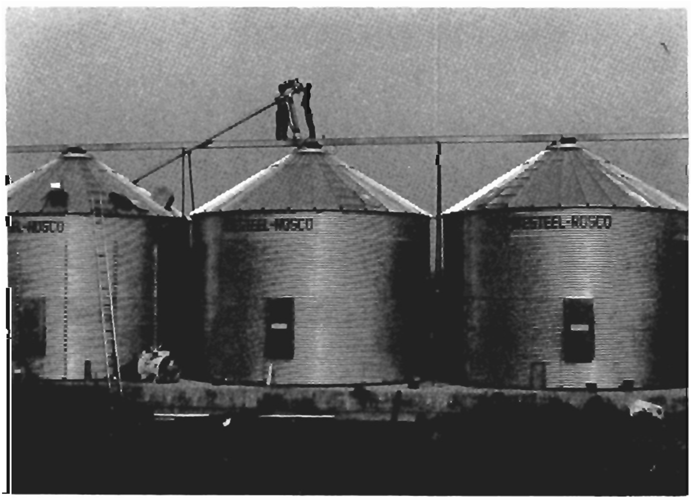


Figure 17. Conveyors and/or Catwalks Supported by the Roof