Foreword

The formulation of this National Standard was initiated by the Agricultural Machinery Testing and Evaluation Center (AMTEC) under the project entitled "Enhancing the Implementation of the AFMA Through Improved Agricultural Engineering Standards" which was funded by the Bureau of Agricultural Research (BAR) of the Department of Agriculture (DA).

This standard was reviewed by the Technical Committee for Study 3 – Development of Standards for Agricultural Structures and was circulated to various private and government agencies/organizations concerned for their comments and reactions. This standard was presented to the Philippine Society of Agricultural Engineers (PSAE) and subjected to a public hearing organized by the National Agriculture and Fisheries Council (NAFC). The comments and reactions received during the presentation and public hearing were taken into consideration in the finalization of this standard.

This standard has been technically formulated in accordance with PNS 01: Part 4:1998 – Rules for the Structure and Drafting of Philippine National Standards. This standard provides the general requirements for the construction of warehouse for bagged storage of grains.

In the preparation of this standard, the following publications/documents were considered:

Documentation of the GASGA. Seminar on Paddy Deterioration in the Humid Tropics in Baguio/Philippines. October 11-18, 1981.

National Food Authority - Good Warehousekeeping Concept

Phillippines Recommends Series No. 63-A. The Philippine Recommends for Rice Postproduction Operations. Philippine Council for Agriculture, Forestry and Natural Resources research and Development.los Baños, Laguna. 2001

Regional Workshop on Warehouse Management of Bag Storage of Grains. New Delhi.1986

Training in Storage and Preservation of Food Grains. Asian Productivity Organization Project PRC/IV/ 68

Warehousing for Farm Products in Asia. 1990 Asian Productivity Organization

Agricultural Structures – Warehouse for Bagged Storage of Grains

1 Scope

This standard specifies the requirements for warehouses for bagged storage of grains. It does not include storage for seeds.

2 Definitions

2.1
warehouse
building used for storing paddy or rice and other grains in bags, typical warehouse is shown in Figure 1

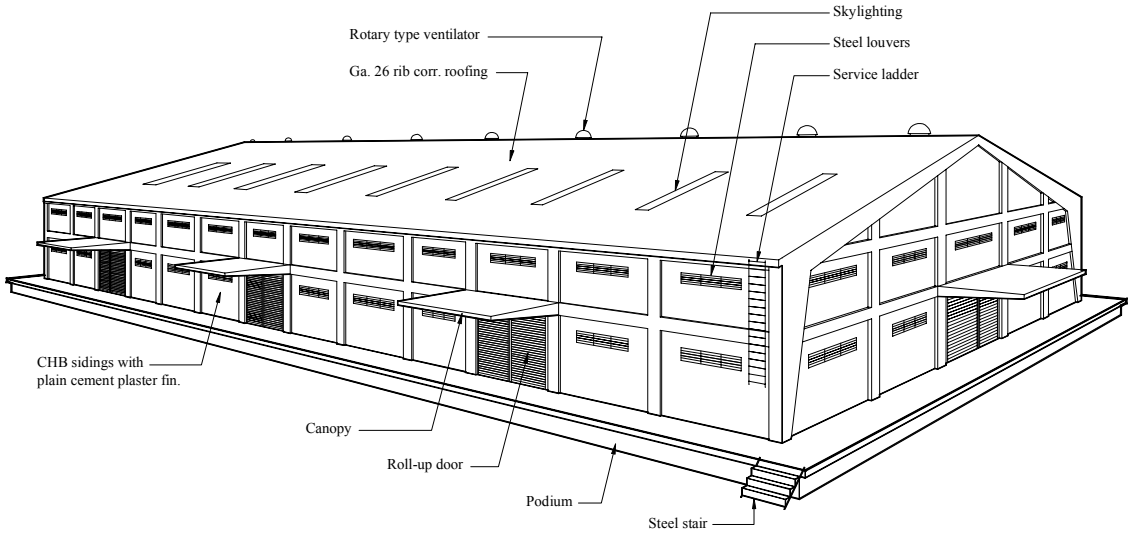


Figure 1 – Typical grain warehouse

2.2
bag storage
storing of paddy or corn kernels in bags usually made of jute (gunny) or polyethylene and normally accommodates 44-50 kilos

2.3
palay
paddy
rough rice
unhulled grain of *Oryza sativa L.*, that is grain with the hull/husk enclosing the grain

2.4
fumigation
process of using chemicals to control insects in grains in a form of fumes

2.5
moisture content
amount of moisture in the grain expressed as percentage of the total weight of the sample, wet basis

NOTE calculated as:

$$\text{moisture content, \% w.b.} = \frac{M_o - M_1}{M_o} \times 100$$

Where:

M_o = initial mass in grams of the test portion
M_1 = mass in grams of the dry test portion

2.6
dunnage
pallet
"tarima"
wooden frames used on concrete floors for stacking bags to prevent direct contact between the grains and the floor

2.7
aeration
moving of air through stored grains at low airflow rates (generally between 0.07 – 0.28 cubic meter per minute per ton) for purposes other than drying, to maintain or improve its quality

3 Location

3.1 It shall be accessible to land or water transport. There should be ample space to facilitate movement and parking of transport.

3.2 The site shall be dry and located at relatively high elevation to avoid water logging and safe from natural flooding calamities.

3.3 It shall not be near any facility where the danger of fire is constantly present.

3.4 Warehouses should preferably be protected by trees or other surroundings from steady direct sunlight. The long axes of the warehouses should be oriented East-West or sited across the prevailing wind. The building should be situated where it will not be exposed to afternoon sunlight.

3.5 Warehouses, which will be fumigated from time to time, shall not be located near busy public facilities such as schools, hospitals, etc.

3.6 The structure shall be on solid ground.

3.7 Ample space shall be provided for future expansion.

3.8 Surroundings in the vicinity shall be satisfactorily sanitary.

3.9 Electricity, water services and drains shall all be available and reasonably economical.

4 Functional requirements

4.1 Product sectionalism

4.1.1 Warehouse operations shall be identified and analyzed as to space requirements of the commodity and the in-out flow of stocks from one operation to another and identify the proper places of every operation.

4.1.2 The internal layout of the depot shall be designed in accordance with the First in - First out method of holding inventory.

4.2 Floor area requirement

4.2.1 Pallet dimension

The standard pallet size should be 152 cm x 61 cm.

4.2.2 System of piling

4.2.2.1 Small scale storage

Bags of grain in each lot should be stacked in basic patterns of cluster formation (Figure 2) so that bags can be easily counted, and quality maintained.

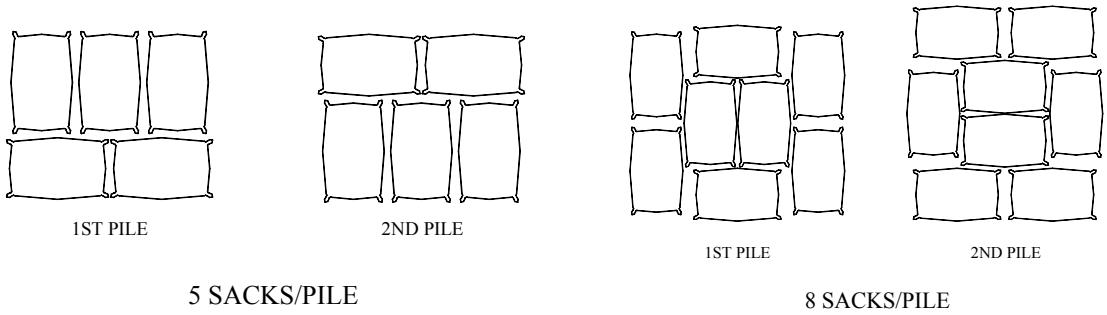


Figure 2 – System of piling for small scale

4.2.2.2 Large scale storage

4.2.2.2.1 Block stacking

In this type, six blocks are formed to make standard stack of 9.14m x 6m size. Each block is of the size 6m x 1.5m. In the block, one layer is put lengthwise and other breath-wise.

4.2.2.2.1.1 Chinese method

Bagged grains with 14% moisture content or lower could be piled in Chinese method. Sacks are piled side by side and one on top of the other over malathion sprayed wooden pallets (Figure 3).

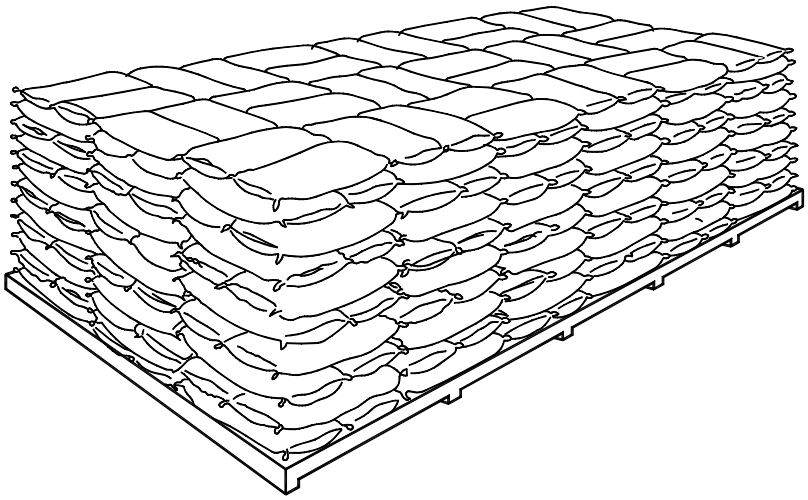


Figure 3 – Chinese piling

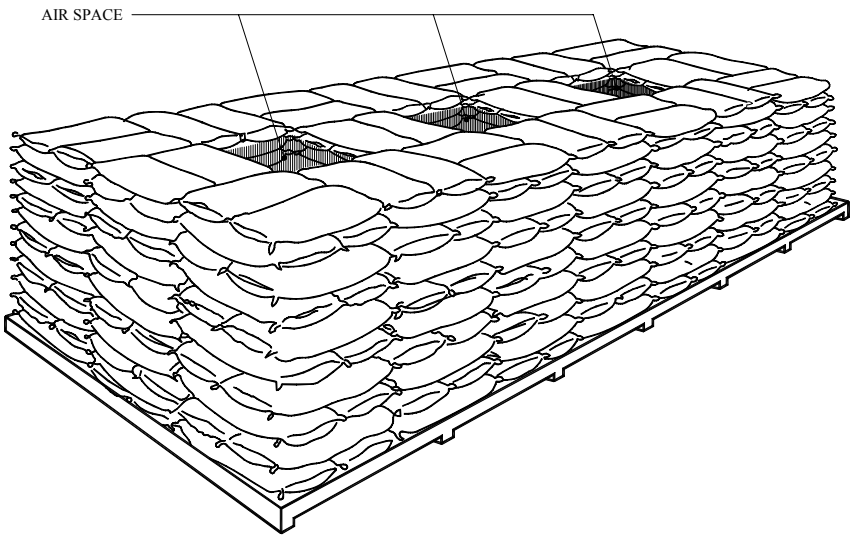


Figure 4 – Japanese piling

4.2.2.2.1.2 Japanese method

Bagged grains with moisture content of more than 14% are piled in this method. This system of stacking provides ventilation space between bags and allows circulation of convective air currents that provide a medium for heat dissipation (Figure 4).

4.2.2.2.2 Criss-cross stacking

In this type bags are laid in complete length-wise or breath-wise tiers in alternate layers systematically. The first layer will have 11 bags in 9.14m direction with 11 such rows. The second layer of bags would be laid width-wise with 16 bags in 9.14m direction of stack with 7 such rows.

4.2.3 Stack height

4.2.3.1 The height of stacks shall not exceed the height of the walls and a space of at least 1 meter shall be allowed between the tops of the stacks and roof frames.

4.2.3.2 Sacks made of woven polypropylene have a tendency to slide on each other, and therefore shall not be stacked more than 3 meters high. Jute sacks bind together better, and maybe stacked up to 6 meters above the floor.

4.2.3.3 Factors like nature of grain, size, weight, and shape and strength of grain bag to stand the height of stack have direct bearing on stack height. Table 1 shows the optimum stack heights recommended for grain storage.

Table 1 – Optimum recommended stack heights

Type of grain	Stack height in layers	Stack height in meters
Wheat, barley and Maize	18	4.57
Paddy	16	4.27
Rice	16	4.27

4.2.3.4 The size of the piles should conform with fumigating sheets in situations where warehouses cannot be made airtight. Dimensions for maximum piling should be 7.3m x 21.9m x 4.5m.

4.2.3 Pathways

4.2.3.1 A central aisle ranges from 3-3.65 m wide or not less than 1m wider than the width of the widest vehicle loaded should be designed when two or more forklift trucks are being used simultaneously during warehouse operation,

4.2.3.2 If there is only one forklift to be used, the central aisle should be designed with a width of not less than 0.6m wider than the width of the widest vehicle loaded.

4.2.4 Side spacing

4.2.4.1 Space between piles shall be 0.6 meter wide.

4.2.4.2 A minimum of 0.5meter space between the edge of the pile and the wall shall be provided.

4.3 Physical dimensions of structure

Table 2 - Recommended dimensions of warehouse based on capacity

Number of cavans	Dimensions
10,000	10 m x 30 m
50,000	20 m x 48 m
100,000	25 m x 78 m
500,000	75 m x 142 m

NOTE There may be special designs of warehouse for irregular shaped lot.

Given the recommended dimensions of the warehouse and its corresponding capacity above, the number of buildings are doubled, tripled or quadrupled based on the desired capacity of the warehouse. For example a 200,000 cavans warehouse is required, two buildings (duplex) with dimensions of 25m x 78m each is recommended.

4.4 Height of structure

The height of the interior between the beam and floor is 6.0 meters (minimum) for normal temperature warehouse.

4.5 Building structure requirements

4.5.1 There shall be provisions for water tightness, to prevent liquid water from reaching the grain.

4.5.2 There shall be provisions for efficient loading and unloading.

4.5.3 There shall be provisions for aeration.

4.5.4 There shall be provisions for bird, insect and rodent proofing.

4.5.5 There may be provisions for air tightness and facilities during fumigation.

4.5.6 The building shall have a clear inside span and has no inside pillars which could obstruct stacking arrangement.

4.5.7 The building should have a ledge or podium.

4.5.8 Provisions for drying facilities that may be necessary in conjunction with the storage facilities to assure that food grains are in the range of 12 to 14 percent moisture content prior to storing.

4.6 Illuminations

4.6.1 There should be provisions for sky lightings.

4.6.2 Illuminations should be sufficient that lights shall not be too bright or too dim. Artificial lighting by fluorescent lamp is preferable for the interior of the warehouse.

4.6.3 The minimum requirement for illumination is 3 watts per square meter.

4.7 Electrical works

Receptacles for transporting equipment and wire distribution for electric fans shall be provided. If possible, conduit tubes shall be used. Electrical works should conform with the National Electrical Code.

4.8 Drainage

Efficient drainage shall be provided to prevent flooding.

5 Structural Requirements

5.1 Foundation

The construction shall conform with the National Building Code.

5.2 Floor

5.2.1 The floor should be adequately strong and capable of withstanding heavy loads and vibrations.

5.2.2 The floor shall be elevated or constructed higher than the existing ground.

5.2.2.1 The floor should be 1m above the ground to permit easy loading or unloading into trucks at the sides of the warehouse.

5.2.2.2 If loading and unloading of trucks will be permitted inside the warehouse the floor shall be 0.3m above the ground. Refer to Figure 5 for the floor construction.

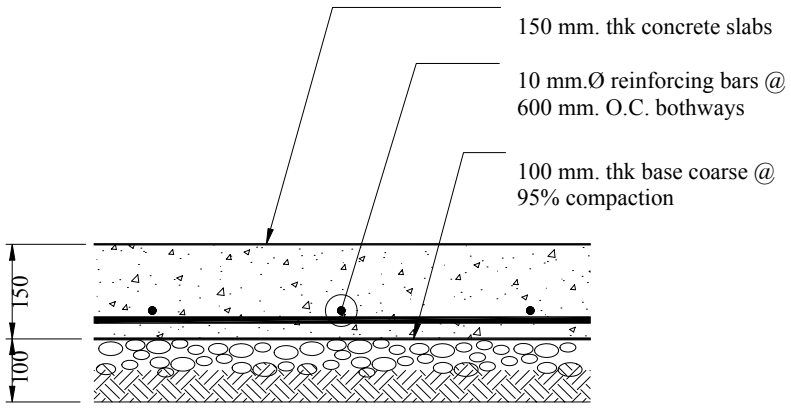


Figure 5 – Floor Construction

5.2.3 There shall be provisions for wear resistance and safety (refractoriness and elimination of skidding risks).

5.2.4 The floor should be smooth and easy to clean.

5.2.5 It should be free from cracks where moisture from the ground may affect the stored grain. Moisture sealing compound or asphalt should be provided to fill the floor cracks against moisture.

5.3 Walls

5.3.1 The internal surfaces of the walls shall be smooth and free from projections to eliminate dust-laden surfaces, facilitate cleaning of the store and avoid interference with other operations.

5.3.2 Gravel concentrations in concrete walls, protruding brick work, horizontal planes or rims, window sills, protruding door or window posts and other ledges should either be avoided completely or be shedded at a minimum angle of 60 ^{o}.

5.3.3 The walls shall be painted white, on the inside to facilitate the detection of insect pests and on the outside to help keep the warehouse look as cool as possible.

5.3.4 There shall be no opening between wall and roof.

5.3.5 The wall should be made of 150 mm thick concrete hollow blocks (CHB) with 12 mm diameter reinforcing bars with horizontal and vertical spacing of 600 mm (Figure 6).

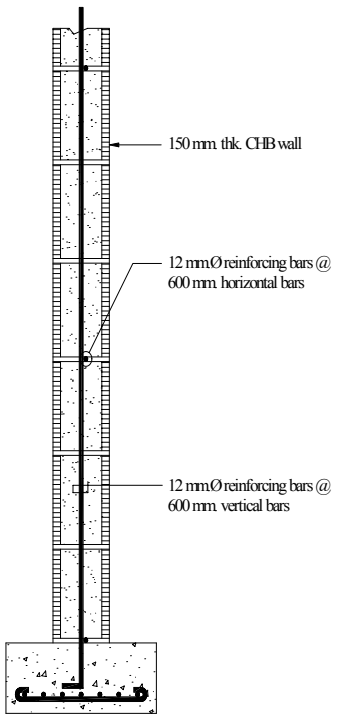


Figure 6 – Wall Construction

5.3.6 A water/damp-proof barrier should be incorporated into the base of the walls. Water proofing compound should be incorporated during the plastering and finishing of the walls.

5.3.7 A concrete strip about one (1) meter wide shall be laid around the warehouse to prevent rain from eroding the base of the walls below the damp course.

5.4 Roof

5.4.1 Internal pillars supporting roof frames shall be avoided because it can interfere with the pest control and other stock management procedures. A standard roof truss of 14.5-m span (or larger) should be used.

5.4.2 Roof frames made of wood or steel shall be designed so that they transfer the weight of the roof to the supporting columns or to the walls.

5.4.3 It must be provided with the necessary lateral and vertical wind brace to resist forces due to strong winds and earthquakes.

5.4.4 The strength of the roof construction should be sufficient to handle the weight of the strongest winds that can be expected

5.4.5 The roofing materials made of galvanized iron sheets shall be in light colors (white or beige).

5.4.6 The chosen materials may be fire proof and highly refractory.

5.4.7 The inclination of the roofs should be sufficient to drain rainwater quickly, taking into account that the water may be forced up by the wind.

5.4.8 Rainwater drainpipes should be closely spaced, of sufficient size and installed without bends.

5.5 Doors

5.5.1 There shall be at least two doors so as to be able to rotate stocks on a “first in, first out” basis.

5.5.2 The door shall be wide for easy access, yet fit tightly for insect control and fumigation. Roll up doors are generally used because of its capability to close tightly.

5.5.3 Preferably the door shall be made of steel or at least reinforced along their lower edges with metal plate as protection against rodents.

5.5.4 If swing doors are fitted, they shall be open outwards in order not to reduce the storage capacity of the warehouse.

5.5.5 Preferably the door should be doubly sheeted, with adequate clearance, having good shock absorption and sufficient heavy-duty hinges.

5.5.6 The door should be fire retardant and provided with a locking system not too sensitive to dust.

5.5.7 The size of the entrance is 6 meters wide and 4 meters high for normal temperature warehouse.

5.5.8 A canopy shall be constructed over every entry door to allow continuous loading and unloading even when it rains.

5.6 Ventilation

5.6.1 Vents should be provided near the floor level, at the top of the walls near the grid line and at the top of the roof and the ridge.

5.6.2 Ventilation openings such as louvers shall be fitted on the outside with anti-bird grills (20mm mesh) and on the inside (10 cm behind the grills) with insect screens (removable for cleaning), which will deter most insects.

5.6.3 Adequate natural ventilation openings shall be provided with shutters so that ventilation may be controlled.

5.6.4 Rotary ventilators or continuous ridge vent are built on the roof top which provide good ventilation in addition to the louvers all over the warehouse.

5.6.5 The total surface area of windows and light wall panels, compared to the total surface of the outside walls should never be too large.

5.6.6 In addition to natural ventilation exhaust fans could be introduced for forced ventilation.

5.7 Rat stop

If the structural set-up of doors is unsatisfactory the rat stop may be attached. An iron sheet used for rat stop should have an optimum size but not obstruct the entrance. As shown in Figure 7, its height should be little over 60 centimeters and fixed by a mortise and tenon joint or by hinge. Polished artificial stone is usually used for wall rat stop.

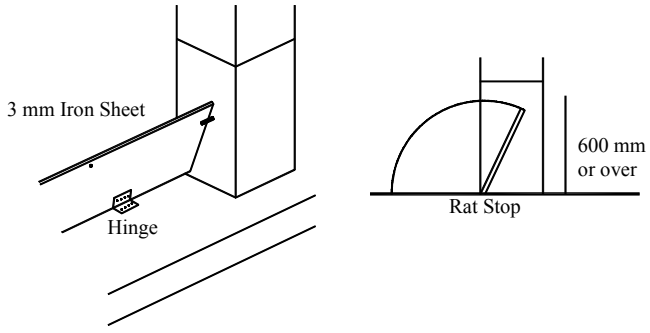


Figure 7 – Rat stop

6 Warehouse management

6.1 Fumigation

In cases of insect infestation and presence of mold, fumigation should be carried out. The appropriate chemical should be used for insect pests or microorganisms. During fumigation dosage of the chemical and airtight conditions must be carefully observed.

6.4 Facility requirement

6.4.1 Quality control laboratories

6.4.2 Workshops

6.4.3 Garage for vehicles

6.4.4 Dead stock store

6.4.5 Bag stacker

6.4.6 Poisonous chemicals store

6.4.6 Isolation shed

6.4.7 Toilets and washing facilities

6.4.8 Personnel office

6.5 Safety

6.5.1 Guards for machines should be provided.

6.5.2 Illuminations should be sufficient that lights shall not be too bright or too dim.

6.5.3 Warning signs or boards shall be fixed in hazardous/dangerous places.

6.5.4 Fire fighting equipment (fire extinguishers, fire hydrants) shall be provided and be installed in a conspicuous and accessible location.

6.5.5 There shall be provisions for first aid facilities.

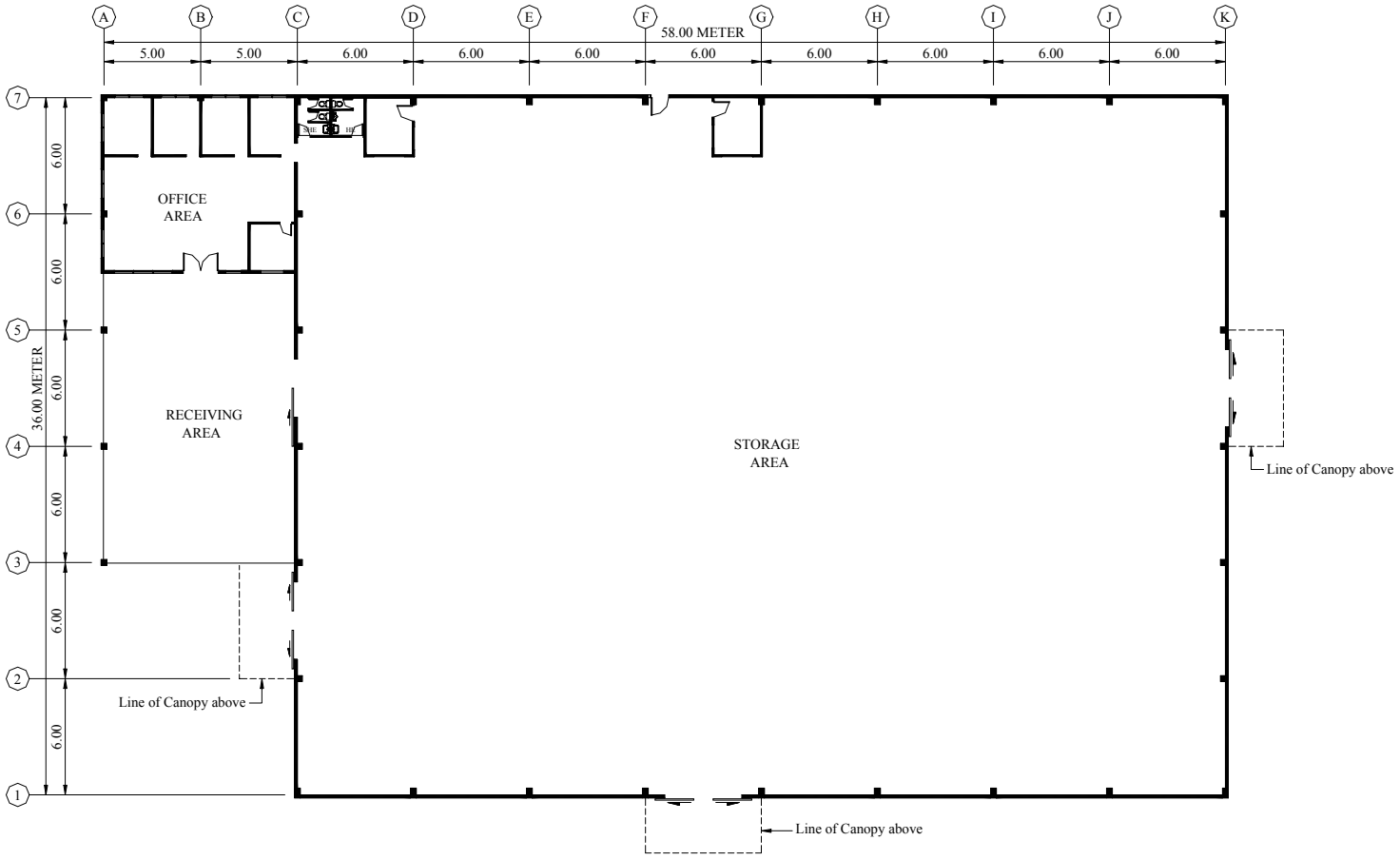
6.5.6 There shall be provisions for proper exhaust and ventilating system.

6.6 All utilized warehouses shall be identified by their warehouse name, code and location printed on a standard billboard exhibited outside the warehouse. A daily Stock Status Board for purposes of continuously monitoring stock inventories within the warehouse shall be maintained.

ANNEX A
(Informative)

Sample Design of a Typical Warehouse
(Capacity 50,000 cavans)

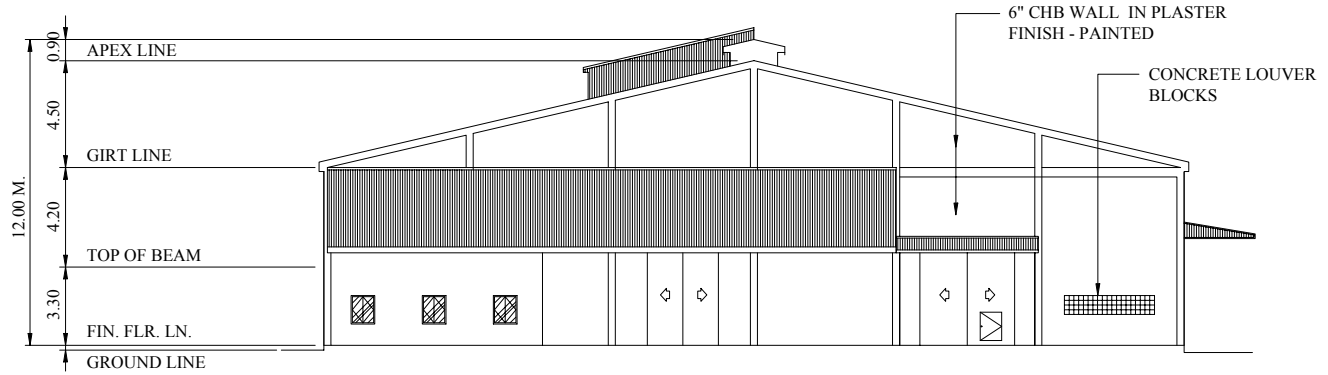
A.1 Floor Plan



FLOOR PLAN

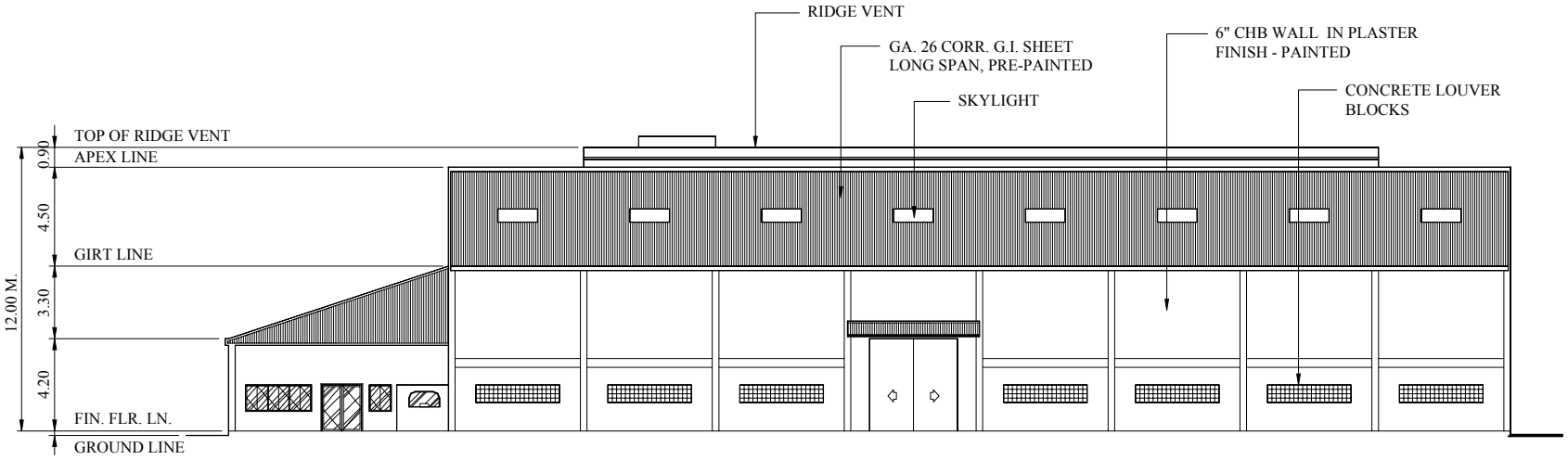
SCALE: 1 : 100 METER

A.2 Elevation



FRONT ELEVATION

SCALE: 1 : 100 METER



RIGHT SIDE ELEVATION

SCALE: 1 : 100 METER