**Design Report**
**Poultry Dry Litter Storage Building**

M&E Consultants was engaged by Universal Forest Products, Western Division, Inc. to Design and develop plans for a Wood Frame Poultry Litter Storage Building. The building has a clear open span of 40 feet, with an eave height of 11 feet. The length of the building is variable with the length determined by the litter storage volume required. Minimum building length is 50 feet. The building consists of wood truss with wood truss legs (columns), wood purlins, sheet steel roofing material and exterior wall of sheet steel siding. The truss legs are attached to a concrete wall 2 feet above the interior floor level. A concrete floor slab is optional. A 4 foot height of treated plywood is attached to the interior side of the wall girts above the 2 foot high concrete wall to allow for litter to be stacked against the wall and not come in contact with the exterior siding. The exterior metal siding extends up to within two feet of the eave level to provide a 2 ft high opening for ventilation. One end of the building is open. The opposite end is closed with an optional 12 ft x 12 ft door opening. The design does not include the truss design. Commercially available trusses with a minimum design loading of 16 psf live load (20 psf for components and cladding) and 5 psf dead load are to be used.

**Loads**

The structural design of the foundation elements and anchorages for the truss legs considers loading combinations of section 2 ASCE Standard 7 – 02, *Minimum Design loads for Buildings and Other Structures*. Wind loads were determined based on requirements of ASCE 7-02. A basic wind speed of 100 mph was used for this design. Wind loads are computed for building risk category 1 (agricultural buildings), exposure category of open farmland, and a rigid structure resulting in a gust factor of 0.85. The building is assumed to not be located on an escarpment or ridge. The magnitude and sense of the internal pressures due to wind loading are for "partially enclosed" enclosure classification. This is based on the location and size openings.

The unit weight of the litter was estimated to be 30 lbs per cu ft and the ratio of vertical to lateral stress assumed to be about 1/3 resulting in a lateral load of the stacked material of 10 lb /sq ft per ft hydrostatic type loading.

The snow load for the central portion of east Texas is 5 psf. This is also equivalent to 1 inch of ice. Although ice loading is not specifically applicable to buildings, historically collapse of poultry buildings due to ice has been experienced in east Texas. Five psf uniformly distributed over the roof, representing 1 inch of ice, produced a greater reaction than the unbalanced snow load computed by provisions of ASCE 7-02 and was used for the snow load in load combinations evaluated. In addition the structure is designed to be stable for the "minimum roof live load" of 16 psf , which accounts for unspecified live loads.

Component and cladding loads and pressures were used to design the purlins. Attachment of the sheet metal roofing and siding is to be as recommended by the manufacturer.

**Analysis**

The foundation elements are designed to accommodate a truss configured as a rigid frame, consisting of a connection at the ridge capable of carrying moment as well as the leg to gable connection capable of carrying moment. The two legged rigid frame is assumed to be hinged at the bases and is statically indeterminate. The reactions were determined using charts from the _Structural Engineering Handbook_ by Gaylord and Gaylord. For the range of relative stiffness of legs and gables expected the horizontal reaction is approximately ½ of the vertical reaction. The horizontal reaction is resisted partially by passive resistance of the soil outside of the wall and by the floor slab where the slab is specified. Where a floor slab is not used a counterfort or a pier created by drilling a 16 inch diameter hole and filling with concrete are used to assist in resisting the lateral thrust at the truss locations. The counterfort may be constructed in a short trench perpendicular to the foundation wall. The floor slab is tied to the wall by reinforcing bars enabling the dead weight and friction between subgrade and underside of the slab to be utilized to resist the lateral thrust. Lateral loads on the foundation, in addition to the thrust from truss loading, are produced by the loading of the stored litter against the wall and by wind. The wind may produce horizontal loading either inward or outward depending on orientation of the wind direction. A loading combination in which the lateral load of the litter, horizontal reaction due to vertical load and the wind are additive was included in the load combinations evaluated. It can be assumed the loading operation, in which additional lateral load may be put on the wall, does not take place concurrently with the maximum wind or snow load.

Lateral soil loads and resistance is assumed to be that from a soil material with a moist unit weight of 110 lb/cu ft, active lateral coefficient of 0.5 and passive lateral coefficient of 2.0. which are conservative values for granular soils and relatively conservative for low plasticity fine grained soils and soils consisting of mixture of coarse grained and low plasticity fine grained materials.

The requirements of NRCS Conservation Practice Standard 313, Waste Storage Facility, indicate a maximum control joint spacing in the slab of 10 feet for installations such as this. However, the joint spacing may be increased if steel reinforcing is added based on subgrade drag theory. Alternative joint spacing of 20 and 40 feet are provided in this design proportioning the reinforcing steel based on the subgrade drag theory. The equipment anticipated to be operating on the slab is small to medium farm tractors and equipment with axel loads not exceeding 5000 pounds. For structural requirements this range of loading is considered to be lightly loaded slab on grade as classified by Corps of Engineers design methodology. This design conforms to the recommendations of Army TM 5-809-2/AFM 88-2, _Structural Design Criteria For Buildings_ Chap 2 and appendix B and C for lightly loaded slab subject to typical exposure and subgrade conditions. Typical subgrade conditions are characterized by the absence of frost penetration, a wet environment and expansive soils and where volume changes due to change in moisture content are limited. Typical subgrade conditions also include only USCS classified soils ML, any of the S and G groups or CL and CM where the modulus of subgrade reaction is grater than 100 lb/in$^3$. Appendix A of this design report is a copy of Table c-2 from the

TM 5-809-2 appendix c and may be used as a guide to estimating the modulus of subgrade reaction.

Roof purlins were designed for gravity roof live load and for internal pressure due to wind. The purlins are oriented perpendicular to the roof slope thus the vertical gravity loads result in bending about both axis of the beam. The roofing provides lateral support to the compression face for bending due to gravity loads, however for loading due to internal pressure the compression face of the beam is not laterally supported and allowable stress was reduced accordingly.

Anchors for the connection of the truss legs at the top of the wall were evaluated for combined shear and normal forces in accord with ACI 318-02, *Building Code Requirements for Structural Concrete*, Appendix D.

**Materials**

Steel sheet used as roof covering and the exterior sidewalls is 29 ga or heavier. Fasteners shall be as recommended by the manufacturer. Purlins and wall girts are to be dimension lumber. The plywood interior wall is to be of treated plywood to protect against decay from contact with the litter. It is reported that CCA (chromated copper arsenate) wood treatment is being phased out and being replaced by alternative treatments not containing arsenic. There are reports the new alternative treatments are more corrosive to metals in contact with the wood, particularly in the presence of high moisture in the wood. High quality galvanized or other high quality corrosion protected fasteners should be used in attaching the treated plywood.

Concrete shall be minimum 3000 psi. design strength. Reinforcing bar steel shall be grade 40, 50 or 60. Welded wire reinforcement shall be manufactured from 65,000 psi or 70,000 psi yield strength wire.

Lumber shall be standard dimensioned finished four sides. Requirements for the purlins are:

| | | | |
|---|---|---|---|
| 10 ft. truss spacing | 2x6 | #2 or better | Southern Pine |
| | 2x4 | select structural | Southern Pine |
| 8 ft truss spacing | 2x4 | #2 or better | Southern Pine |

Wall girts and closed end of the building shall be constructed of #2 or better of dimensions shown on the drawings.

This standard drawing is fully applicable when foundation soil is granular or low plasticity fine grained material. This includes USCS soil types GW, GP, SW, SP, AND SM, GM, SC, GC, ML AND CL with Plasticity Index less than 20. It is anticipated these materials possess only limited volume changes with changes in moisture content.

In no case should a foundation of highly organic soils, or very loose, compressible low density soil foundations used. Also care should be taken not have abrupt changes in foundation characteristics.

**High Shrink –Swell foundation soils**

Since the building is not rigid and does not have masonry walls it can withstand some differential movement with little or no distress, with the exception of the floor slab. It is likely not economically feasible to provide a stiffened concrete floor slab, either post tensioned or conventionally reinforced, for this application. Specific recommendations for high shrink swell soil foundations should not be made without the assistance of a qualified geotechnical engineer and site specific information. A general recommendation which can be made is extending the wall deeper below grade will place the foundation lower in the soil profile and subject to less changes in moisture content. Minimizing the change in moisture content reduces potential volume change and will result in less movement of the foundation thus enhancing the stability of the building. Conditions which maintain uniform moisture content in the foundation soils will also help prevent severe foundation movements.

STATE OF TEXAS
WILLIAM H. ERION
84920
LICENSED
PROFESSIONAL ENGINEER

Submitted:

William H. Erion, P.E.
M&E Consultants

September 30, 2008