Austin City Code - Volume II
TITLE 25 LAND DEVELOPMENT\CHAPTER 25-12 TECHNICAL CODES\ARTICLE 1: UNIFORM BUILDING CODE\25-12-3 LOCAL AMENDMENTS TO THE BUILDING CODE

Chapter 36 - STRAW BALE CONSTRUCTION

SECTION 3601 - PURPOSE.

This appendix chapter establishes minimum prescriptive standards of safety for the construction of structures that use baled straw as a load-bearing or non-load-bearing material.

SECTION 3602 - SCOPE.

This chapter applies to all straw bale wall construction, including privacy and landscape walls. Load-bearing straw bale walls are limited to use in Occupancy Group R, Division 3 (one and two-family dwellings) and Occupancy Group U (accessory structures).

SECTION 3603 - DEFINITIONS.

In this chapter:

STRAW means the dry stems of cereal grains left after the seed heads have been removed.

BEARING BALE WALL or **LOAD-BEARING BALE WALL** means a straw bale wall that supports more than 100 lbs. per linear foot of superimposed load.

BALES mean rectangular compressed blocks of straw, bound by strings or wire.

FLAKES mean slabs of straw removed from an untied bale that are used to fill small gaps between the ends of stacked bales.

LAID FLAT refers to stacking bales so that the sides with the largest cross-sectional area are horizontal and the longest dimension of this area is parallel with the wall plane.

LAID ON-EDGE refers to stacking bales so that the sides with the largest cross-sectional area are vertical and the longest dimension of this area is horizontal and parallel with the wall plane.

O.C. means on center.

PINS mean vertical stakes used to attach a bale to the course of bales above and below it and include construction grade 1 x 2 wooden stakes 24" (minimum) in length or #4 rebar and other materials approved by the building official.

SECTION 3604 - MATERIALS.

3604 Specifications for Bales.

3604.1.1 Type of Straw. Bales of various types of straw, including, but not limited to, wheat, rice, rye, barley, oats and similar plants, may be used in bales if they meet the minimum requirements for density, shape, moisture content, and ties prescribed by this section.

3604.1.2 Shape. Bales must be rectangular in shape.

3604.1.3 Dimensions. Bales used within a continuous wall must be of consistent height and width to ensure even distribution of loads within wall systems.

3604.1.4 Ties. Bales must be bound with ties of either polypropylene string or baling wire. Bales with broken or loose ties may not be used unless the broken or loose ties are replaced with ties that restore the original degree of compaction of the bale.

3604.1.5 Moisture Content. Moisture content of bales, may not exceed 20 percent of the total weight of the bale at the time interior and exterior finish materials are applied. Moisture content of bales may be determined by either of the following methods prescribed in this section.

3604.1.5.1 Field Method. A suitable moisture meter, designed for use with baled straw or hay, and equipped with a probe of sufficient length to reach the center of the bale, may used to determine the average moisture content of 5 bales randomly selected from the bales to be used.

3604.1.5.2 Laboratory Method. A total of 5 samples, taken from the center of each of 5 bales randomly selected from the bales to be used, may be tested for moisture content by a recognized testing lab.

3604.1.6 Density. Bales must have a minimum calculated dry density of 7.0 pounds per cubic foot. The calculated dry density is determined after reducing the actual bale weight by the weight of the moisture content, as determined in Section 3604.1.5. The calculated dry density is determined by dividing the calculated dry weight of the bale by the volume of the bale.

3604.1.7 Customer Size Bales. A customer-made partial bales must be of the same density, 7.0 pounds per cubic foot as measured in 3604.1.6, same string or wire tension, and, use the same number of ties as the standard size bales.

SECTION 3605 - CONSTRUCTION AND GENERAL REQUIREMENTS.

3605.1 General. Bale walls, when covered with plaster, drywall, or stucco are considered to have the equivalent fire resistive rating as wood frame construction with the same wall-finishing system.

3605.2 Wall Thickness. Nominal minimum bale wall thickness must be 14 inches.

3605.3 Wall Height. Bale walls may not exceed one story in height and the bale portion may not exceed a height to width ratio of 5.6:1, unless the structure is designed by an engineer or architect licensed by the State to practice as such, and approved by the building official. For example, the maximum height for the bale portion of a 23-inch thick wall would be 10 feet - 8 inches, unless designed by an engineer or architect and approved by the building official.

Exception: In the non-load-bearing exterior end walls of structures with gable or shed roofs, an approved continuous assembly is required at the roof bearing assembly level.

3605.4 Unsupported Wall Length. The ratio of unsupported wall length to thickness, for bale walls, may not exceed 15.7:1, unless the structure is designed by an engineer or architect licensed by the State to practice as such, and approved by the building official. For example, for a 23 inch thick wall, the maximum unsupported length allowed is 30 feet, unless designed by an engineer or architect and approved by the building official.

3605.5 Allowable Loads. The allowable vertical load (live and dead load) on the top of load-bearing bale walls may not exceed 400 pounds per square foot (psf) and the resultant load shall bear at the center of the wall. Bale structures must be designed to withstand all vertical and horizontal loads as specified in the Building Code.

3605.6 Foundations. Foundations must be sized to accommodate the thickness of the bale wall and the load created by the wall and roof live and dead loads. Foundation (stem) walls that support bale walls must extend to an elevation of not less than 8 inches above adjacent ground at all points. The minimum width of the footing must be the width of the bale it supports, with the following exceptions:

1.The bales may overhang the exterior edge of the foundation by not more than 3 inches to accommodate rigid perimeter insulation.

2.Pier and Beam Foundations require a 12" wide (minimum) footing.

3605.7 Wall and Roof Bearing Assembly Anchorage.

3605.7.1 General. Vertical reinforcing bars with a minimum diameter of 1/2" must be securely embedded in the foundation and must extend above foundation a minimum of 12 inches. These vertical bars must be located along the centerline of the bale wall, spaced not more than 2 feet part. A vertical bar must also be located within 1 foot of any opening or corner, except at locations occupied by anchor bolts.

3605.7.2 Intersecting Walls. Walls of other materials intersecting bale walls must be attached to the bale wall by means of one or more of the following methods or an acceptable equivalent:

1. Wooden dowels at least 5/8" in diameter of sufficient length to provide 12 inches of penetration into the bale, driven through holes bored in the abutting stud, and spaced to provide one dowel connection per bale.

2. Pointed wooden stakes, at least 12 inches in length and 1-1/2" by 3-1/2" at the exposed end, fully driven into each course of bales, as anchorage points.

3. Bolted or threaded rod connection of the abutting wall, through the bale wall, to a steel nut and steel or plywood plate washer, a minimum of 6 inches square and a minimum thickness of 3/16" for steel and 1/2" for plywood, in at least three locations.

3605.7.3 Anchoring. Load bearing bale walls and roof bearing assemblies must be anchored to the foundation by methods that are adequate to resist uplift forces resulting from the design wind load and are approved by the building official. There must be at least two points of anchorage per wall, spaced not more than 6 feet apart, with one located within 36 inches of each end of each wall. Two acceptable anchoring methods are listed below. Other methods may be used if approved by the building official.

Method #1. Load-bearing bale walls must be anchored to the foundation by 1/2" diameter steel anchor bolts embedded at least 7 inches in the foundation at intervals of 6 feet or less. A minimum of two anchor bolts per wall must be provided with one bolt located within 36 inches of each end of each wall. Sections of 1/2" diameter threaded rod must be connected to the anchor bolts, and to each other, by means of threaded coupling nuts and must extend through the roof bearing assembly and be fastened with a steel washer and nut.

Method #2. Wire tie-downs shall be placed 4'-0" o.c. and at each side of any openings. The wire must be a minimum 12 gauge galvanized high tensile wire (commonly called No. 3 Agricultural Wire) and must run through the foundation, up both sides of the walls and over the top plate. The wire must be secured by using wire locks. Wire locks must be uniformly tensioned. Where the wire comes in contact with the wood top plate, the top plate must be shielded by metal to protect the wood from shattering. The dead load of the roof and ceiling systems will produce vertical compression of the bales. Regardless of the anchoring system used to attach the roof bearing assembly to the foundation, before installation of wall finish materials, the anchoring system must be re-tensioned to compensate for this compression.

3605.7.4 Moisture Barrier. A moisture barrier must be used between the top of the foundation and the bottom of the bale wall to prevent moisture from migrating through the bottom course of bales. This barrier must consist of one of the following:

1. cementitious waterproof coating;

2. 30 pound felt or an asphalt emulsion;

3. sheet metal flashing, sealed at joints; or,

4. other building moisture barrier approved by the building official. All penetrations through the moisture barrier, as well as all joints in the barrier, must be sealed with asphalt, caulking or an approved sealant.

3605.7.5 Stacking and Pinning. Bales in load-bearing walls must be laid flat and stacked in running bond where possible, with each bale overlapping the two bales beneath it. Bales in non-loading-bearing walls may be laid either flat or on-edge and stacked in running bond where possible. Overlaps must be at least 13 inches. Gaps between the ends of bales that are less than 6 inches in width may be filled by an untied flake inserted into the gap. The first course of bales must be laid by impaling the bales on the vertical bars or threaded rods, extending from the foundation. As each subsequent course is laid, two pins, long enough to extend through the course being laid and a minimum of 8" into the course immediately below it, must be driven down through each bale 18" in length or longer. Bales less than 18" in length and greater than 12" in length must have a minimum of one pin per bale. Only full-length bales may be used at corners of load-bearing walls, unless exceptions are designed by an engineer or architect licensed by the state, and approved by the building official. Pins must be located 1 foot of all corners or door openings. Staples, made of #3 or larger rebar formed into "U" shape, at least 18 inches long with two 6 inch legs, must be used at all corners of every course, driven with one leg into the top of each abutting corner bale. Instead of staples, corner bales may be tied together by a method approved by the building official. Two alternative pinning methods are listed below. Other methods may be used if approved by the building official.

Alternative Method #1. When the fourth course has been laid, #4 rebar pins, or an acceptable equivalent, long enough to extend through all four courses, must be driven down through the bales, two in each bale, located so that they do not pass within six inches of, or through the space between the ends of any two bales. The layout of these pins must approximate the layout of the vertical bars extending from the foundation. As each subsequent course is laid, two pins, long enough to extend through the course being laid and the three courses immediately below it, must be driven down through each bale. This pinning method must be continued to the top of the wall. In walls seven or eight courses high, pinning at the fifth course may be eliminated.

Alternative Method #2. When the third course has been laid, vertical #4 rebar pins, or an acceptable equivalent, long enough to extend through all three courses, must be driven down through the bales, two in each bale, located so that they do not pass within 6 inches of, or through, the space between the ends of any two bales. The layout of these rebar pins must approximate the layout of the rebar pins extending from the foundation. As each subsequent course is laid, two pins, long enough to extend through that course and the two courses immediately below it, shall be driven down through each bale. This pinning method must be continued to the top of the wall.

3605.7.6 Roof Bearing Assembly. Load-bearing bale walls must have a roof bearing assembly at the top of the wall to bear the roof load and to provide a means of connecting the roof structure to the foundation. The roof bearing assembly must be continuous along the tops of structural walls. Acceptable roof bearing assemblies are listed below. Other systems may be used if approved by the building official.

Method #1-Wood Roof Bearing Assembly #1. The top plate must consist of two 2" x 6", or larger, framing members placed on edge, one located at the inner edge of the wall and the other at the outer edge. The top plates must be supported on a continuous 1/2" thick (minimum) plywood or OSB base which is within 2" of the width of the bales below, i.e., 21" wide

(minimum) for a 23" bale. The base must be fastened to the vertical top plate with 8d nails to 8" o.c.. Splices in the top plates must be staggered and connected with metal plates. Connecting the two top plates and located horizontally and perpendicular to the length of the wall must be 2" x 4" (minimum) cross members spaced no more that 24" o.c.. The cross members must be face nailed to the top plates with two 16d nails at each end. Corner connections must include overlaps nailed as provided in UBC Table 23-1-Q or an acceptable equivalent such as plywood gussets or metal plates.

Method #2-Wood Roof Bearing Assembly #2. Top plate must consist of two double 2" x 6", or larger, horizontal top plates, one located at the inner edge of the wall and the other at the outer edge. Connecting the two doubled top plates and located horizontally and perpendicular to the length of the wall must be 2" x 6" cross members spaced no more than 72 inches center to center, and as required to align with the threaded rods or cables extending from the foundation. The double 2"x6" top plates must be face nailed with 16d nails staggered at 16 inches on center, with laps and intersections face nailed with four 16d nails. The cross members must be face nailed to the top plates with four 16d nails at each end. Corner connections must include overlaps nailed as provided in UBC Table 23-1-Q or an acceptable equivalent such as plywood gussets or metal plates.

Method #3-Concrete Bond Beam Roof Bearing Assembly Form Work. Two 2" x 4" framing members placed on edge, connected by 1" x 4" stretchers at 3'-0" o.c. maximum Assembly must be within 2" of the width of the bales below, i.e., 21" wide (minimum) for a 23" bale. Splices in the 2" x 4" framing members must be staggered and connected with metal plates. The 2" x 4" framing members must have lag bolts or wood screws placed on the interior of the assembly at 6" o.c. to lock the forms to the concrete. Number 3 rebar pins 18" (minimum) in length must be driven into the top of the bale wall at 2'-0" o.c. (maximum) and must extend above the bale wall 3" to bond the concrete top plate to the bale wall. Concrete and reinforcing steel: Concrete must be reinforced with 2- #4 rebars continuous with #3 ties at 48" o.c. Concrete shall reach a compressive strength of 3000 p.s.i. after 28 days. Alternatives to this roof bearing assembly option must provide equal or greater vertical rigidity and provide horizontal rigidity equivalent to the aforementioned systems and must be approved by the building official. The connection of roof framing members to the roof bearing assembly must comply with the Building Code.

3605.7.7 Openings. All openings in load-bearing bale walls must be a minimum of one full bale length from any outside corner, unless exceptions are designed by an engineer or architect licensed by the State to practice as such, and approved by the building official. Openings in exterior bale walls must not exceed 50 percent of the total wall area, based on interior dimensions, where the wall is providing resistance to lateral loads, unless the structure is designed by an engineer or architect licensed by the state and approved by the building official. Wall and/or roof load above any opening must be supported or transferred to the bales.

3605.7.8 Moisture Protection for Walls. All weather-exposed bale walls must be protected from water damage. A moisture barrier may be used to protect the bottom course of the bales. The barrier must be water vapor permeable and must cover no more than the lower one-third of the vertical exterior wall surface, in order to allow natural transpiration of moisture from the bales. The moisture barrier must have its upper edge inserted at least 6 inches into the horizontal

joint between two courses of bales, and must extend at least 3 inches below the top of the foundation. Bale walls must have special moisture protection provided at all window sills and other openings. Unless protected by a roof, the tops of walls must also be protected. This moisture protection must consist of a waterproof membrane, such as asphalt-impregnated felt paper, polyethylene sheeting, or other acceptable moisture barrier, installed in such manner as to prevent water from entering the wall system at window sills, other openings, or at the tops of the walls.

3605.7.9 Wall Finishes. Interior and exterior surfaces of bale walls must be protected from mechanical damage, flame, animals, and prolonged exposure to water. Bale walls adjacent to bath and shower enclosures must be protected by an approved moisture barrier, or a 3-1/2" air gap. Cement stucco must be reinforced with galvanized wire mesh, 20 gauge minimum or an acceptable equivalent. The reinforcement must be secured to the wall at a maximum spacing of 24 inches horizontally and 16 inches vertically, using a method approved by the building official. Where bales abut other materials the plaster/stucco must be reinforced with galvanized expanded metal lath, or an acceptable equivalent, extending a minimum of 6 inches onto the bales. Earthen and lime-based plasters may be applied directly onto the exterior and interior surface of bale walls without reinforcement, except where applied over materials other than straw. Weather-exposed earthen plasters must be stabilized using a method approved by the building official. Lime based plasters may be applied directly onto the exterior surface of bale walls without reinforcement, except where applied over materials other than straw.

3605.7.10 Electrical. All wiring within or on bale walls must meet all provisions of the National Electrical Code adopted by this jurisdiction. Type NM or UF cable may be used, or wiring may be run in metallic or non-metallic conduit systems. Electrical boxes must be securely attached to wooden stakes driven a minimum of 12 inches into the bales, or an acceptable equivalent.

3605.7.11 Plumbing. Water or gas pipes within bale walls must be encased in a continuous pipe. Where pipes are on mounted bale walls, they must be isolated from the bales by a moisture barrier.

SECTION 3606 - PRIVACY AND LANDSCAPE WALLS.

3606.1 General. This section covers free-standing or attached bale privacy or landscape walls, not exceeding 6 feet in height, from final grade to top of wall. Bales may be stacked either flat or on-edge. Alternate methods, other than those listed in this section, may be approved by the building official.

3606.2 Foundations. The minimum foundation must consist of an 8 inch thick reinforced concrete stem wall, over an approved footing. Minimum width of the stem wall must be equal to the width of the bottom bale. Stem walls must have continuous horizontal reinforcement consisting of two #4 bars with 24 inches minimum lap at splices.

3606.2.1 Reinforcement. Vertical reinforcing bars, a minimum 3/8"in diameter, must be placed in the center of the stem wall, two per bale, and extend up a minimum of 24 inches, and be embedded a minimum of 4 inches into the concrete stem wall. Bales must be pinned per Section

3605.7.5. or using two 3/8" diameter bars per bale, and use pins long enough to provide at least one vertical bar from stem wall to top of wall, with a minimum of one full bale overlap where not continuous. Wire mesh must be mechanically attached to the wall. An acceptable method must be 12d or larger common duplex nails embedded in the concrete a minimum of 1 inch below the top of the stem wall, with the heads embedded a minimum of 2 inches into the concrete, and the points extending a minimum of 3/4" from the face of the stem wall, and spaced a minimum of 6" on center on both sides of the wall.

3606.2.2 Moisture Barrier. An approved moisture barrier must be used between the top of the stem wall and the first course of bales. A moisture barrier must be used to protect the tops of bales at the top of walls, and must extend 6 inches down on either side of the wall.

3606.2.3 Stucco Mesh. Stucco mesh, 20 gauge or heavier, must be attached by means of clinching the embedded nails on one side of the wall, stretching a continuous piece of netting tightly over the top of the wall, and fastening the netting the same manner on the opposite wide of the wall.

3606.2.4 Wall Finish. Walls must be finished with cement stucco, or stabilized mud plaster, with a minimum thickness of 7/8".