NCDOI OSFM Evaluation Services

Scope of DOI Evaluations: The purpose of this document is to provide clarification to Code Enforcement Officials (CEO), acting as agents for the Authority Having Jurisdiction (AHJ), on code requirements or guidelines for consideration when presented with a method or material not prescriptively addressed by the NC State Building Codes. This evaluation contains the performance characteristics given by the code to determine if the method or material meets the intent of the code in accordance with Section 105 of the NC Administrative Code and Policies.

DOI File No: 016-10
Edition Date: August 30, 2010; Rev. 1: March 25, 2011; Rev. 2: August 22, 2012

Product Group: **Straw-bale Residential Construction**

Code Editions: North Carolina Residential Code, 2012 edition; North Carolina Energy Conservation code, 2012 edition, North Carolina Administrative Code and Policies, 2012 edition, North Carolina Electrical Code (NEC 2008), North Carolina Mechanical Code, 2012 edition, North Carolina Plumbing Code, 2012 edition**.**

Contents

1.0 Intent

A. This document addresses two types of uses for straw-bale in residential construction:

1. as wall infill within non-load bearing construction as per 2012 North Carolina Residential Code (NCRC), and
2. as load-bearing construction.

B. Prior to installation and in accordance with this document, the use of straw-bale as a material in residential construction must be submitted to the Authority Having Jurisdiction and shall not be installed unless approved by the CEO and permitted by the AHJ.

2.0 Code Requirements for Straw-bale Residential Construction as an Alternate Method

A. The use of straw or straw-bale is not addressed in the 2012 North Carolina State Building Codes (NCSBC).

B. Definitions:

1. There is no definition of "*straw"* or "*straw-bale"* in the 2012 NCSBC.

C. NC State Building Codes

1. 2012 NC Residential Code: Straw-bale is not a material for construction addressed in Chapter 3 of the NCRC. The CEO does not have legal authority to allow someone to build to a standard which is not addressed by North Carolina Code. However, the CEO can evaluate a request to determine if the proposed material, design or method provides, at minimum, the equivalent level of quality, strength, effectiveness, fire resistance, durability and safety as required by the intent of the Codes.

2. 2012 NC Administrative Code and Policies: Straw bale construction shall be reviewed and approved as an Alternate Material, Design or Method of construction, as addressed in Section 105 of the 2012 NC State Administrative Code and Policies. For more information go to: **http://www.ncdoi.com/OSFM/Engineering/engineering_wpt.asp**

or click on the link below

Process for Submission And Consideration Of Alternate Material Design Or Methods Of Construction And Equipment

3.0 Recommended North Carolina Minimum Prescriptive Guideline for Straw-Bale Construction to be used by CEO of the AHJ for Verification of Code Compliance or Equivalence

A. SCOPE

1. **Applicability**. The provisions of this document apply only to detached one-family dwellings and their accessory buildings and structures, as defined in the 2012 NCRC, Section R101.2, and utilizing straw-bales in the construction of wall systems. [This document does not address straw-bale construction for detached two-family or multiple single-family dwellings (town houses).]

2. **Note to user**: When all or part of this document is reproduced in contract documents or Alternate Material, Design or Method of Construction documentation, the word "should" must be changed to "shall".

B. DEFINITIONS

1. For the purposes of this evaluation, certain terms are defined as follows:

(a) **BALES.** Rectangular compressed blocks of straw, bound by strings or wire.

(b) **FLAKES**. Slabs of straw removed from an untied bale. Flakes are used to fill small gaps between the ends of stacked bales.

(c) **HAY**. Hay is *straw* that includes the grain (seed).

(d) **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. Typical dimension are 36in. x 14 in. x 18in. (914mm x 356mm x 457 mm). (see figure 1).

(e) **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. Typical dimensions are 36in. x 18in. x 14in. (914mm x 457mm x 356mm). (see figure 1)

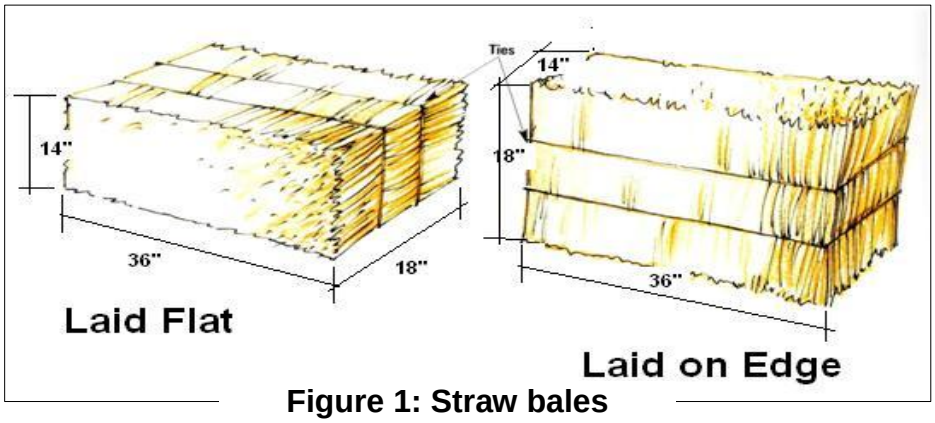

Figure 1: Straw bales

(f) **STRAW**. The tubular stalk or stem between the roots and the grain (seed) head of wheat, rye, oats, rice or barley.

(g) **LOAD BEARING**. The use of straw bale walls as structural load-bearing walls supporting the roof and resisting lateral loads.

(h) **NONLOAD BEARING (in-fill).** A structure where straw bales are used to in-fill between the supporting structural members. The exterior straw bale in-fill wall sections collect lateral loads resulting from wind or seismic activity and transfer these loads to the primary structure for resistance.

(i) **RECOGNIZED TESTING LAB.** A lab accredited by the International Accreditation Service (IAS) or accepted in writing by the International Code Council (ICC) as acceptable for the specific testing purposes and code section for which it is to be retained.

C. RECOMMENDED MATERIAL SPECIFICATIONS

1. Hay and straw, while similar in appearance, serve different purposes. Hay is used primarily as a feed, while straw is a byproduct. [*Hay is for horses, straw is for building*.] The presence of seed in hay predisposes the material to mold, decay, insect attack, and attack by rodents. Straw is the shaft that remains when grain, such as wheat, is harvested, and the seed is removed. Since straw has no seed, it is less susceptible to

mold, decay, insect attack, and rodents. As a result, straw is much more suitable as a building material than hay.

(a) **Type of straw:** Bales of various types of straw, including, but not limited to wheat, rice, rye, barley, oats and similar plants, should be acceptable if they meet the minimum requirements for density, shape, moisture content and ties.

(b) **Shape:** Bales should be rectangular in shape.

(c) **Dimensions:** Bales used within a continuous wall should be of consistent height and width to ensure even distribution of loads within wall systems.

(d) **Wall thickness:** Nominal minimum bale wall thickness should be 14 inches (356 mm).

(e) **Custom size bales:** Where custom made partial bales are used, they should be of the same density, same string or wire tension, and where possible, use the same number of ties as the standard size bales.

(f) **Binding of Bales**: Bales should be bound with ties of either poly-propylene string or bailing wire. Bales with broken or loose ties should not be used unless the broken or loose ties are replaced with ties which restore the original degree of compaction of the bale.

(g) **Moisture content:** Moisture content of bales, at time of installation and just prior to applying exterior weather protection such as stucco, should not exceed 20 percent of the total weight of the bale. Bales that become wet or exceed 20-percent moisture content should be replaced with dry bales or allowed to dry and be retested. Bales that exceed 20-percent moisture content should be replaced. Special inspection of the moisture content of bales should be performed using one of the following methods:

(i) **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, should be used to determine the average moisture content of five bales randomly selected from the bales to be used.

(ii) **Laboratory method**. A total of five samples, taken from the center of each of five bales randomly selected from each 500 bales or portion thereof to be used, and then tested for moisture content by a recognized material testing lab. These samples are to be placed into sealed containers or other method as required by recognized testing lab.

(h) **Density**. Bales in load-bearing structures should have minimum calculated dry density of 7.0 pounds per cubic foot (112 kg/m^3). The calculated dry density should be determined after reducing the actual bale weight by the weight of the moisture content. The calculated dry density should be determined by dividing the calculated dry weight of the bale by the volume of the bale.

2. All materials used in straw-bale construction should be galvanized metal, or other acceptable corrosive resistant material.

3. Wood members shall be protected from decay as per NCRC, Section R319.

D. FOUNDATION Requirements and Recommendations

1. **Foundations**. Baled straw is not to be used below grade. Foundations shall comply with the 2012 NCRC, Chapter 4. Foundations should be sized to accommodate the imposed live and dead loads from walls and roofs. The bales may overhang the exterior edge of the foundation by not more than 3 inches to accommodate rigid perimeter insulation. Straw bales should not be closer than 12” (304.8 mm) to grade.

2. **Anchorage to foundation**. The primary frame shall be anchored to the foundation by an anchorage system designed in accordance with Chapters 4, 6, and 44 of the NCRC or the 2012 NCBC, Chapters 16, 18, 19, and 23. 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 CEO of the AHJ. 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 CEO of the AHJ.

(a) **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.

(b) **Method #2**. Wire tie-downs should 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.

(c) **Re-tensioning of Anchors** 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.

3. **Wall anchorage to foundation**. Vertical reinforcing bars with a minimum diameter of ½ inch (12.7 mm) shall be embedded in the foundation a minimum depth of 6 inches (153 mm) with a 90 degree bend on the end of the bar embedded in the footing for anchorage [ACI 318 as referenced by 2012 NCRC, Chapter 44], and should extend above the foundation a minimum of one-and-one-half bales. (see figure 2)

(a) **Location**. The vertical bars should be located along the centerline of the bale wall, spaced not more than 2 feet (610 mm) apart and a minimum of two per bale.

(b) Corners and openings. A vertical bar should be located within 1 foot (305 mm) of any opening or corner, except at locations occupied by anchor bolts.

Figure 2: vertical reinforcing bars in foundation

4. Moisture barrier. To prevent moisture from migrating through the foundation into the bottom course of bales, a moisture barrier shall be used between the top of the foundation and the bottom of the bale wall. This barrier should consist of one of the following:

(a) Cementitous waterproof coating;
(b) Type 30 asphalt felt over an asphalt emulsion;
(c) Sheet metal flashing, sealed at joints; or
(d) Other approved building moisture barrier.
(e) All penetrations through the moisture barrier, as well as all joints in the barrier, must be sealed with asphalt, caulking or an approved sealant.

E. GENERAL WALL CONSTRUCTION Requirements and Recommendations

1. Fire resistance. Straw-bale walls, when covered with plaster, drywall, or stucco, should be deemed to have the equivalent fire resistive rating as wood-frame construction with the same wall-finishing system. Bale walls have been shown to pass a 2 hr and 1 hr fire-resistance test of a non-load-bearing wall as per ASTM E 119-05a (current reference is ASTM E119-07):

(a) 1 hour fire resistance compliance: A straw bale in-fill wall, with bales laid flat in a running bond pattern covered with 2 layers earthen plaster or cement stucco each having a minimum thickness of ½ inch (12.7 mm) on both sides. The first coat of earthen stucco mix is 3 parts clay, 2 parts chopped straw, 6 parts sand and water added to a sprayable consistency. The second coat is applied using hand trowels.

(b) 2 hour fire resistance compliance: A straw bale in-fill wall, with bales laid on-edge in a running bond pattern covered with 1½ x 17 galvanized self-furred stucco reinforcing mesh, with a 4 in. minimum overlap. The mesh was fastened to the top and bottom plates using 1½ in. -long coarse thread square drive screws with 1 in. diameter washers spaced at 6 in. o.c. and also stapled to the intermediate vertical support structure using 1 ½' long galvanized fence staples spaced 16"o.c., then covered with a minimum of 2 layers cement stucco, each having a minimum thickness of ½ inch (12.7 mm) on both sides. The cement stucco mix is 1 part lime, 3 parts Portland cement, 10 parts sand, and water added to a workable consistency. Both coats are applied using hand trowels.

2. Allowable loads. The allowable vertical load (live and dead load) on the top of load-bearing bale walls should not exceed 360 pounds per square foot (psf) (17.2 kPa) over

the width of the wall and the resultant load should act at the center of the wall. Bale structures shall be designed to withstand all vertical and horizontal loads as specified in 2012 NCRC, Chapter 3 and the 2012 NCBC, Chapter 16. Increases in stress and reductions of live loads specified in 2012 NCBC, Chapter 16 may be applied if loads are calculated in accordance with the NCBC. Live load reductions are not applicable to live loads specified in the NCRC. Structural design by a Registered Design Professional is required.

3. **Insulation**. For the purpose of calculating thermal performance using 2012 NCRC, Chapter 11, Table N1102.1, the insulation of straw bale wall can be assumed as R-1.5/in. when laid flat and R-2/in. when laid on edge. *[For example, an 18 inch (457mm) straw-bale wall laid flat would be R-27, and a 14 inch (356mm) straw-bale wall on edge would be R-28.]*

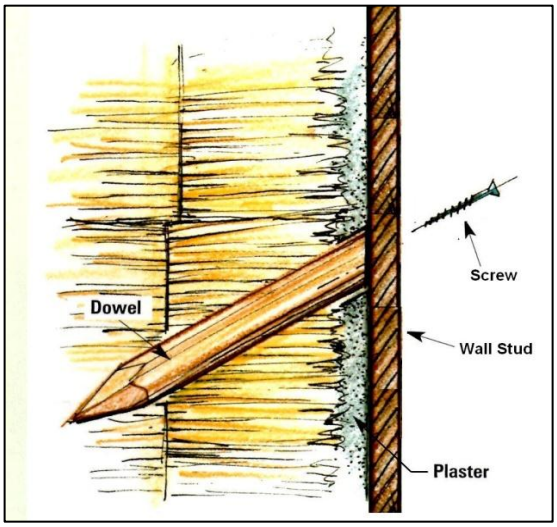

Figure 3: 5/8 in. dia. wooden dowel

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

(a) Wooden dowels at least 5/8 inch (16 mm) in diameter, of sufficient length to provide 12 inches (305 mm) of penetration into the bale, driven through holes bored in the abutting wall stud, and spaced to provide one dowel connection per bale. (see figure 3)

(b) Pointed wooden stakes, at least 12 inches (305 mm) in length and 1 ½ inch by 3 ½ inch (38.1 mm by 88.9 mm) at the exposed end, fully driven into each course of bales, as anchorage points.

(c) 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 (153 mm) square and a minimum thickness of 3/16 inch (4.8 mm) for steel and ½ inch (12.7 mm) for plywood, in at least three locations. (see figure 4)

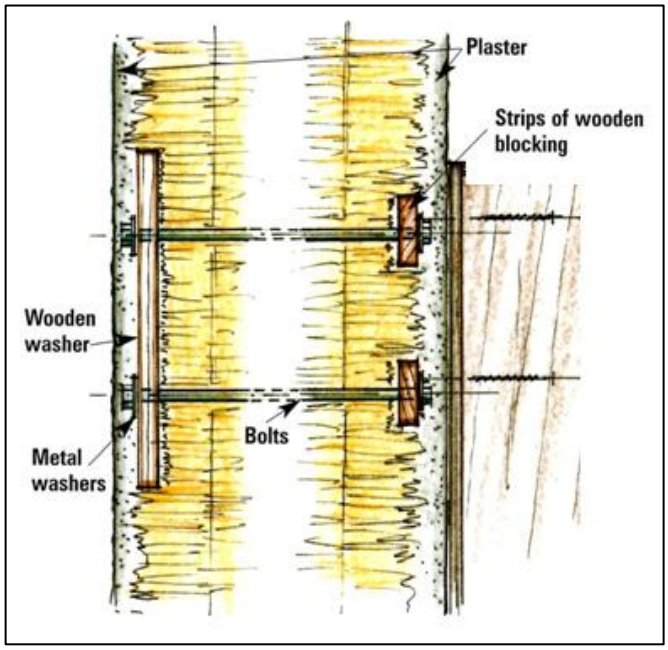

Figure 4: rod connection

F. NONLOAD-BEARING (IN-Fill) WALLS Requirements and Recommendations

1. **General.** A nonload-bearing wall is part of a structural system where the primary frame is an approved system complying with the design criteria specified in Section R301 of the 2012 NCRC. The straw bales are used as in-fill between structural framing members.

2. **Primary frame**. The primary frame (such as post and beam or pole building) shall comply with the design criteria specified in the NCRC or, if using engineered design option, with the 2012 NCBC, Chapter 16. Structural calculations sealed by a Registered Design Professional, for any members that cannot be sized from the tables in the code showing compliance shall be submitted with plans and application for building permits.

3. **Wall Anchors**

(a) Bale straw in-fill walls shall be securely anchored to all adjacent structural members to sufficiently resist horizontal displacement of the wall panels.

(b) Anchors should be placed at every horizontal joint or one per bale along vertical structure and a maximum of twenty-four inches (24") on center along horizontal structures at the top of bale wall panels beginning not more than twelve inches (12") from each end of the wall panel.

i Anchors shall be corrosion resistant material, such as galvanized metal strips, or decay resistant wood dowels. Metal strips should be six inches (6") wide expanded metal lath or FHA perforated metal strips which should be securely fastened to the vertical structural members and should extend at least twelve inches (12") onto the adjacent bale and should be pinned into the bale. Dowels should be one-half inch (1/2") minimum diameter wood or galvanized metal and should extend into the bale at least six inches (6").

4. **Lath**. At all points where the straw bales are butted against a different material (wood, concrete, steel, etc.), corrosive resistant lath should be used to cover the junction. Lath should extend a minimum of 6 inches (153 mm) over the edge of the straw bales and should be securely fastened to the straw bales.

5. **Openings and lintels**. The limitations of the openings relative to wall area are controlled by the design of the primary frame. Lintels shall be sized to transfer the weight of the wall above, any concentrated roof or floor loads imposed on the lintel, and wind loads on the wall above the lintel to the opening jambs. Jambs shall be sized to transfer the lintel reactions, vertical and horizontal, to the structure or foundation supporting the jambs.

6. **Wall height**. Nonload-bearing walls should not exceed 12 feet (3658 mm) in height, unless designed by the Registered Design Professional and approved by the CEO of the AHJ.

(a) **Gable end walls**. In the nonload-bearing exterior wall with gable or shed roofs, a continuous assembly as described in Section I shall be provided that continues through the gable end wall or shall meet the requirements of 2012 NCRC Section R601.2.

G. LOAD-BEARING WALLS Requirements and Recommendations

1. **Compression of Bales**. 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, prior to installation of wall finish materials, bolts, straps or cables should be retightened to compensate for this compression after the actual dead load of the roof framing and roofing have been applied.

2. **Height Limitations**. Buildings with load-bearing bale walls should not exceed one story in height, and the bale portion of the load-bearing walls should not exceed a height-to-width ratio of 5.6:1 [for example, the maximum height for the bale portion of a 23-inch-thick (584 mm) wall would be 10 feet, 8 inches (3251 mm)].unless designed by the Registered Design Professional and approved by the CEO of the AHJ.

3. **Length to Thickness Ratio**. The ratio of unsupported wall length to thickness, for load-bearing walls, should not exceed 13:1 [for a 23-inch (584 mm) thick wall, the maximum unsupported length allowed is 25 feet (7620 mm)]. unless designed by the Registered Design Professional and approved by the CEO of the AHJ.

4. **Openings and lintels**. All openings in load-bearing bale walls should be a minimum of one full bale length from any outside corner.

(a) **Openings**. Openings in exterior bale walls should not exceed 50 percent of the total wall area, based on interior dimensions, where the wall is providing resistance to lateral loads. Door and window frames (rough bucks) should be stabilized with ½-inch (12.7 mm) diameter hardwood dowels extending 12 inches (305 mm) into every adjacent bale or by means of a continuous metal lath applied to both the interior and exterior, extending a minimum of 12 inches (305 mm) onto adjacent bales, installed prior to the application of plaster or stucco.

(b) **Lintels**. Wall and/or roof load present above any opening shall be carried, or transferred to the bales below by one of the following:

i A structural frame.

ii A lintel, such as an angle-iron cradle, wooden beam, wooden box beam. Lintels should be at least twice as long as the opening is wide and extend at least 24 inches (610 mm) beyond either side of the opening. Lintels should be centered over openings and should not exceed the load limitations of Section E(4) by more than 25 percent.

iii A roof-bearing assembly designed to act as a rigid beam over the opening.

5. **Gable end walls.** In load bearing exterior walls with gable or shed roofs, a continuous assembly as described in Section I(1) should be provided that continues through the gable end walls.

6. **Stacking**. Bales in load-bearing walls should be laid flat and stacked in running bond where possible, with each bale overlapping the two bales beneath it. Bales in non-load-bearing walls may be laid either flat or on-edge and stacked in running bond where possible. (see figure 5) Overlaps should be minimum of 12 inches (305 mm). Gaps between the ends of bales which are less than 6 inches (153 mm) in width may be filled by an untied flake inserted snugly into the gap. Only full-length bales should be used at the corner of load-bearing walls.

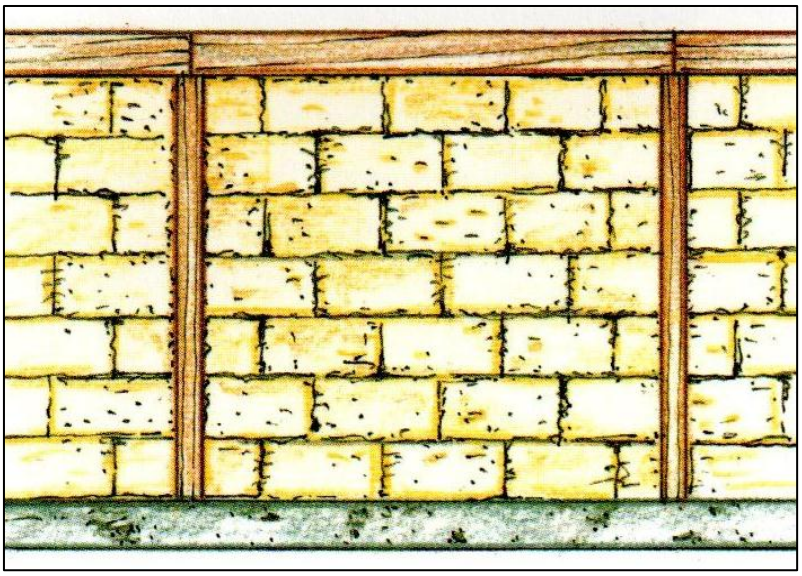

Figure 5: straw bales in running bond pattern (non-load bearing wall)

(a) **Pinning.** Bales are to be anchored to foundation by impaling the first course of bales on the vertical bars or threaded rods extending from the foundation. When the fourth course has been laid, No. 4 rebar pins, or an acceptable equivalent, long enough to extend through all four courses, should be driven down through the bales, two in each bale, located so that they do not pass within 6 inches (153 mm) of, or through the space between the ends of any two bales. The layout of these pins should approximate the layout of the vertical rebar extending from the foundation. As each subsequent course is laid, two such pins, long enough to extend through the course being laid and the three courses immediately below it should be driven down through each bale. This pinning method should be continued to the top of the wall. In walls seven or eight courses high, pinning at the fifth course may be eliminated. (see figure 6) **.**

(b) **Corners and openings**. Vertical No. 4 rebar pins, or an acceptable alternative, should be located within 1 foot (305 mm) of all corners or door openings.

(c) **Staples at corners**. Staples made of No. 3 or larger rebar formed into a “U” shape, at least 18 inches (457 mm) long with two 6-inch (153 mm) legs, should be used at all corners of every course, driven with one leg into the top of each abutting corner bale.

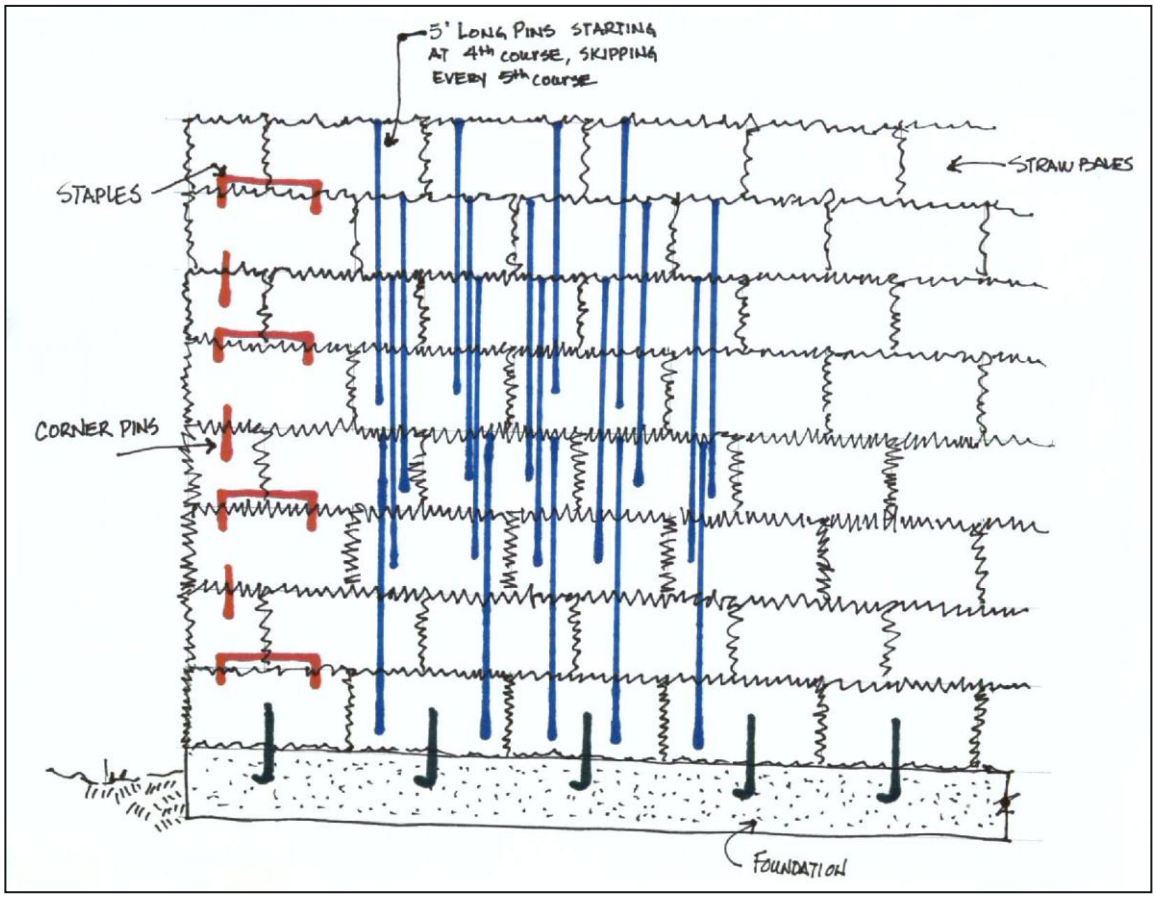

Figure 6: Examples of Pinning

H. WALL FINISHES Requirements and Recommendations

1. **Moisture protection**. All exterior walls constructed with straw bale shall be protected from water damage. An approved building moisture barrier should be used to protect the lower one-third of the vertical exterior wall surface. The moisture barrier should have its upper edge inserted at least 6 inches (153 mm) into the horizontal joint between two courses of bales, and should extend at least 3 inches (76 mm) below the top of the foundation. In order to allow natural transpiration of moisture from the bales, the upper two-thirds of vertical exterior surfaces are to be protected by a vapor permeable moisture barrier. Bale walls shall have special moisture protection provided at all window sills. This moisture protection should be installed in such a manner as to prevent water from entering the wall system at window sills or at the top of the walls. A vapor barrier paint, for locations as per the 2012 NCRC, R601.3, having a 1-perm dry cup rating or less shall be applied to the interior wall finish of exterior straw bale walls and straw bales walls which separate heated from non-heated spaces.

2. **Protection**. Interior and exterior surfaces of bale walls should be protected from mechanical damage, flame, animals, and prolonged exposure to water or snow. Walls adjacent to bath and shower enclosures should be protected from moisture damage. Control joints are strongly recommended to avoid shrinkage cracking.

(a) **Stucco**. Cement stucco should be reinforced with galvanized woven wire, stucco netting or an acceptable equivalent. Such reinforcement should be secured by attachment through the wall at a maximum spacing of 24 inches (610 mm) horizontally and 16 inches (406 mm) vertically, using a method approved by the CEO of the AHJ. Where bales abut other materials the plaster/stucco should be

reinforced with galvanized expanded metal lath, or an acceptable equivalent, extending a minimum of 6 inches (153 mm) onto the bales.

(b) **Plasters**. Earthen and lime-based plasters may be applied directly onto the exterior and interior surface of straw bale walls without reinforcement, except where applied over materials other than straw. [Note: The use of lath (reinforcement) is recommended to prevent shrinkage cracking] Weather-exposed earthen plasters should be Portland cement stabilized using methods of application approved by the CEO of the AHJ.

I. ROOF-TO-WALL CONNECTION Requirements and Recommendations

1. **Roof-bearing assembly**. Load-bearing bale walls shall 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 shall be continuous along the tops of load bearing bale walls.

(a) **Assembly option**. An acceptable roof-bearing assembly option consists 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 double top plates and located horizontally and perpendicular to the length of the wall should be 2 x 6 cross members spaced no more than 72 inches (1829 mm) center to center, as required to align with the threaded rods extending from the anchor bolts in the foundation. The double 2 x 6 top plates should be face nailed with 16d nails staggered at 16 inches (406 mm) on center, with laps and intersections face nailed with four 16d nails. The cross members should be face nailed to the top plates with four 16d nails at each end. Corner connection should include overlaps nailed as above or an acceptable equivalent such as plywood gussets or metal plates. Alternatives to this roof-bearing assembly option should provide equal or greater vertical rigidity and provide horizontal rigidity equivalent to a continuous double 2 x 4 top plate. The connection of roof framing members to the roof bearing assembly should comply with the appropriate sections of the NCRC.

J. ELECTRICAL, PLUMBING AND MECHANICAL Requirements and Recommendations

1. **Electrical**. All wiring within or on bale walls shall meet the provisions of the North Carolina State Electrical Code.

(a) Type NM or UF cable may be used, or wiring may be run in metallic or nonmetallic conduit systems.

(b) Electrical boxes should be securely attached to the bales. This can be accomplished by either attaching to wooden stakes driven a minimum of 12 inches (305 mm) into the bales, or another method acceptable to the AHJ.

2. **Plumbing**. All Plumbing work within or on bale walls shall meet the provisions of the North Carolina State Building Code.

(a) Water or DWV pipes within bale walls should be encased in a continuous pipe sleeve to prevent leakage within the wall. Where pipes are mounted on bale walls they should be isolated from the bales by a moisture barrier.

3. **Mechanical**. All Mechanical work within or on bale walls shall meet the provisions of the North Carolina State Building Code.

(a) Gas pipes within bale walls should be encased in a continuous pipe sleeve to prevent leakage within the wall. Where pipes are mounted on bale walls, they should be isolated from the bales by a moisture barrier.

4.0 Submittals to the AHJ Upon Request for Verification of Code Compliance or Equivalence:

A. Submittal of written request from the owner or designer of record to review and approve as an Alternate Material, Design or Method of construction, as addressed in Section 105 of the 2012 NC State Administrative Code and Policies. See Section **2.0 C** above.

B. Plan(s) signed and sealed by a Registered Design Professional.

5.0 Job Site Considerations by AHJ

A. Smoking should not be allowed on job site.

B. Additional Inspections:

(1) Moisture content of Straw bales

(2) Density of Straw bales

(3) Verify framing is in compliance with the plans.

(4) Verify anchorage of the bales to the foundation.

(5) Verify pinning of the bales to each other.

(6) Verify installation of required moisture barriers.

6.0 References/Resources

A. 2012 International Residential Code

B. 2012 International Building Code

C. Process For Submission And Consideration Of Alternate Material Design Or Methods Of Construction And Equipment

D. ASTM E 119-05a Straw bale Fire Test http://www.ecobuildnetwork.org/what-we-do/straw-bale-test-program

(1) Fire Test of Building Construction and Materials- 2-HR Fire resistance test of a non-load bearing Wheat straw bale wall- Project # 3098054A July 31, 2006, revised July 9, 2007 by INTERTEK ETL SEMKO

(2) Fire Test of Building Construction and Materials- 1-HR Fire resistance test of a non-load bearing straw bale wall- Project # 3098054B July 31, 2006, revised July 9, 2007 by INTERTEK ETL SEMKO

E. 2008 Oregon Residential Specialty Code,

F. 2006 New Mexico Non-Load Bearing Baled Straw Construction Building Standards

G. Prescriptive Code for Load-bearing and Non-load Bearing Straw Bale Construction as approved by the Pima County Board of Supervisors and the Mayor and City Council of Tucson, Arizona, January 2, 1996

H. http://www.dcat.net/about_dcat/current/codes.php

I. *The Straw Bale House* by Athena Swentzell Steen, Bill Steen, David Bainbridge

J. *Building Green* by Clarke Snell &Tim Callahan

K. *Serious Straw Bale* by Paul Lacinski and Michel Bergeron

L. *Design of Straw Bale Buildings* by Bruce King

M. http://www.skillful-means.com/strawbale/codes.htm

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7.0 Figure References

A. Figure 1- Based on illustration* from *Building Green* by Clarke Snell &Tim Callahan, page 344

B. Figure 2- http://brightgreenresearchblog.files.wordpress.com/2010/04/img_4884.jpg?w=600&h=450

C. Figure 3- Based on illustration* from *Building Green* by Clarke Snell &Tim Callahan, page 380

D. Figure 4- Illustration* from *Building Green* by Clarke Snell &Tim Callahan, page 380

E. Figure 5- Illustration* from *Building Green* by Clarke Snell &Tim Callahan, page 146

F. Figure 6- Drawn by Helen DiPietro

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