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688-Straw Bale Code

STRUCTURAL CALCULATIONS

IN SUPPORT OF

ICC CODE CHANGE

CHAPTER 24

STRAWBALE CONSTRUCTION

**ALLOWABLE VERTICAL LOADS
(TABLE 2405.14)**

FEBRUARY 29, 2012

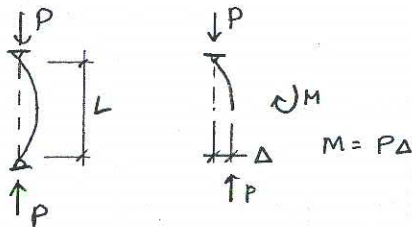
PAGE 1 OF 4



CHECK GLOBAL BUCKLING OF HARD-SKIN & CLAY PLASTER
TALL WALLS AS LIMITED BY 2405.12

REFER TO CALCS IN SUPPORT OF ICC CODE CHANGE
OUT-OF-PLANE LOADS (2/28/12) & SUPPLEMENTAL CALCS

NOTE:



THE EULER BUCKLING FORMULA

$$P_{CR} = \pi^2 EI / L^2$$

IS DERIVED FROM THE BALANCED AXIAL LOAD ASSOCIATED WITH ONLY FLEXURAL Δ ASSOCIATED WITH

$$\Delta_{FLEX} = \frac{5}{384} \frac{WL^4}{EI} \quad \text{TYPE } \Delta$$

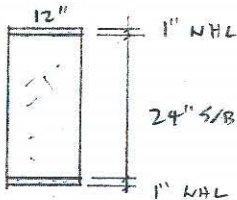
AND NOT SHEAR Δ ASSOCIATED WITH

$$\Delta_{SHEAR} = \frac{WL^2}{8GA_s} \quad \text{TYPE } \Delta$$

WHICH DOESN'T HAVE A DIFFERENTIAL EQUATION FEEDBACK TYPE RELATIONSHIP WITH P, Δ & M.

FIND BUCKLING LOAD ON HARD-SKIN WALL AT H²/T = 80, 2' WALL

SECTION:



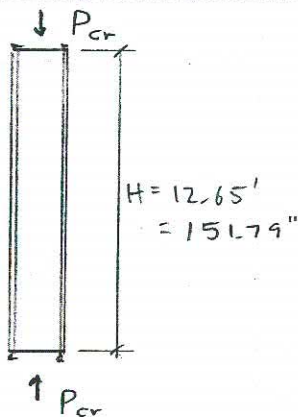
REFER TO OUT-OF-PLANE CALCS 2405.12 HT LIMIT

$$E_{NHL} = 1,200,000 \text{ psi}$$

$$I = 26^3 - 24^3 = 3752 \text{ in}^4$$

(NOTE: MIN 7/8" HARD PLASTER ON S/B IS 1" AVERAGE THICKNESS)

TALL WALL BY 2405.12, H²/T = 80 H = 12.65'



$$P_{CR} = \frac{\pi^2 EI}{H^2} = \frac{\pi^2 (1,200,000) 3752 \text{ in}^4}{(151.79)^2 \text{ in}^2} \#$$

$$= 1,928,668 \#$$

$$P_{CRUSHING} = 600 \text{ psi} (2") 12" = 14,400 \# \quad \text{GOVERNS}$$

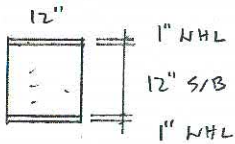
(NOTE: 600 psi IS SMALLEST DEMONSTRATED CRUSHING LOAD IN TABLE 2405.14)

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ICC CODE CHANGE
 STRAWBALE CONSTRUCTION
 JOB NO. _____ SH _____
 NO. 3 OF 4
 BY WED DATE 2/29/12

FIND BUCKLING LOAD ON HARD-SKIN WALL AT $H^2/T = 80$ 1' WALL

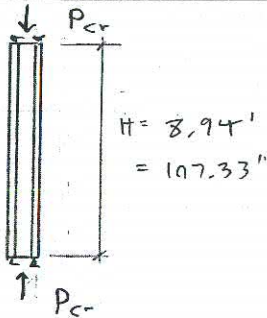
SECTION:



$E_{NHL} = 1,200,000 \text{ psi}$
 $I = 14^3 - 12^3 = 1016 \text{ in}^4$

REFER TO OUT-OF-PLANE CALCS 2405.12 HT LIMIT

TALL WALL BY 2405.12, $H^2/T = 80$ $H = 8.94'$

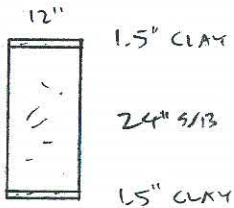


$P_{CR} = \frac{\pi^2 EI}{H^2} = \frac{\pi^2 (1,200,000) (1016 \text{ in}^4)}{(107.33)^2}$
 $= 1,044,558 \text{ \#}$

$P_{CRUSHING} = 600 \text{ psi} (2") (12") = 14,400 \text{ \#}$ GOVERNS

FIND BUCKLING LOAD ON CLAY-PLASTER WALL AT $H^2/T = 65$, 2' & 1' WALLS

REFER TO ABOVE & PREVIOUS CALCS

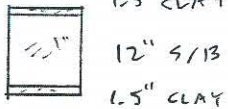


$H = 11.40'$
 $= 136.82"$

$E_{CLAY} = 3,000 \text{ psi}$ $I = 27^3 - 24^3 = 5859 \text{ in}^4$

$P_{CR} = \frac{\pi^2 (3000) 5859}{(136.82)^2} = 9267 \text{ \#}$

$P_{CRUSHING} = 100 \text{ psi} (3") (12") = 3600 \text{ \#}$ GOVERNS



$H = 8.06'$
 $= 96.75"$

$E_{CLAY} = 3,000 \text{ psi}$ $I = 15^3 - 12^3 = 1647 \text{ in}^4$

$P_{CR} = \frac{\pi^2 (3000) 1647}{96.75^2} = 5210 \text{ \#}$

$P_{CRUSHING} = 100 \text{ psi} (3") (12") = 3600 \text{ \#}$ GOVERNS

NOTE: CRUSHING GOVERNS OVER GLOBAL BUCKLING FOR ALL TALL WALLS AS LIMITED BY 2405.12

TABLE 2405.14

TO DETERMINE ALLOWABLE LOADS ON PLASTERED WALLS

BY PREVIOUS PAGES, CRUSHING OF PLASTER GOVERNS OVER WALL BUCKLING IN ALL CASES

ALL OUT-OF-PLANE TESTING DEMONSTRATES GOOD COMPOSITE SECTION BEHAVIOR, WHICH DEPENDS ON GOOD BOND & SHEAR FLOW BETWEEN STRAW "WEB" & PLASTER "FLANGES."

GOOD BRACING, ENGAGEMENT & ADHESION WAS OBSERVED AT THE STRAW/PLASTER INTERFACE IN ALL OUT-OF-PLANE TESTING, AND MEASURED BEHAVIOR CONFIRMED COMPOSITE ACTION OF SECTION AND GOOD MECHANICAL BOND AT INTERFACE.

WALL A 1/2" CLAY PLASTER, USE FACTOR OF SAFETY OF 8, 100 psi ← DEMONSTRATED STR
 $P_{allow} = 100 \text{ psi} (1.5")^2 (12") / 8 = \underline{450 \text{ #/ft}} > 400 \text{ #/ft}$

WALL B 1" SOIL-CEMENT, USE FACTOR OF SAFETY OF 10, 1000 psi
 $P_{allow} = 1000 \text{ psi} (1.0")^2 (12") / 10 = \underline{2400 \text{ #/ft}} >> 800 \text{ #/ft}$

WALL C 7/8" LIME, USE FACTOR OF SAFETY OF 10, 600 psi
 $P_{allow} = 600 \text{ psi} (.875")^2 (12") / 10 = \underline{1260 \text{ #/ft}} >> 500 \text{ #/ft}$

WALL D 7/8" CEMENT-LIME, USE FACTOR OF SAFETY OF 10, 1000 psi
 $P_{allow} = 1000 \text{ psi} (.875")^2 (12") / 10 = \underline{2100 \text{ #/ft}} >> 800 \text{ #/ft}$

WALL E 7/8" CEMENT, USE FACTOR OF SAFETY OF 10, 1400 psi
 $P_{allow} = 1400 \text{ psi} (.875")^2 (12") / 10 = \underline{2940 \text{ #/ft}} >> 800 \text{ #/ft}$

CHECK LOAD TRANSFER THROUGH STAPLES AT TOP PLATE

BY ESR-1539 14, STAPLES ≥ 2" BOTH SKINS

$$9\text{-f. } 75 \text{ #} (12/2) 2 = \underline{900 \text{ #/ft}} > 800 \text{ #/ft}$$

OK FOR ALL VALUES ABOVE

NOTE: REFER TO "LOAD-BEARING STRAWBALE CONSTRUCTION" BY BRUCE KING IN www.ecobuildnetwork.org

ALL VALUES ON ALL TESTS ON PLASTERED BALE WALLS ON PP. 8-11 HAVE ULTIMATE LOADS WELL LARGER THAN ALLOWABLE VALUES ABOVE, AND ARE CONSISTENT WITH VALUES ABOVE.