

# CONTAINED EARTH REINFORCEMENT OPTIONS

## IMPROVED CONSTRUCTION DETAILS FOR SEISMIC RISK

FEBRUARY 28, 2018

BUILD SIMPLE INC., [www.BuildSimple.org](http://www.BuildSimple.org)

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**INTRODUCTION:**

CONTAINED EARTH (CE) IS A SPECIAL TYPE OF EARTHBAG CONSTRUCTION:

- **USING COHESIVE SOIL FILL OF KNOWN (OR ESTIMATED) STRENGTH**
- **USING REINFORCEMENT CHOSEN FOR SPECIFIC LEVELS OF HAZARD**
- **THAT IS BUILT WITH CONSISTENTLY DAMP FILL AND TAMPED IN PLACE FOR CE TO RESIST HAZARDS IT MUST BE WISELY BUILT.**

CONVENTIONAL EARTHBAG AND MOST CE IS MODULAR, WITH FABRIC SEPARATING COURSES AND/ OR BAGS. SOLID CE (A.K.A. HYPERADOBÉ) IS FORMED IN MESH TUBING WITH ENOUGH FILL MOISTURE TO CREATE A MONOLITHIC WALL BETWEEN COURSES. SOLID CE SHOWS HIGHER STRENGTH THAN MODULAR, BUT MAY HAVE LESS RESILIENCE.

MOST CE RELIES ON TWO TYPES OF STEEL:

- BARBED WIRE- TWO STRANDS BETWEEN EACH COURSE FOR NEEDED FRICTION AND TENSILE STRENGTH
- STEEL REBAR INSERTED INTO DAMP WALLS DELAYS AND DECREASES WARPING UNDER STRESS.

EARTHBAG CAN BE BUILT OF SEPARATE BAGS OR LONG TUBES. LONG TUBES RESIST SOME TYPES OF DAMAGE BETTER THAN BAGS AND ARE RECOMMENDED FOR CE WALLS IN SEISMIC RISK.

STRONGER SOIL CAUSES BETTER TRANSFER OF FORCES FROM EARTHEN FILL TO STEEL. FIELD SOIL TESTS CAN BE COMPLETED IN 24 HOURS WITH MINIMAL EQUIPMENT (HOW STRONG IS MY SOIL? AND SOIL TEST RESEARCH 2017 AT [WWW.BUILDSIMPLE.ORG/RESOURCES](http://WWW.BUILDSIMPLE.ORG/RESOURCES)).

CE INCLUDES PLASTER OR STUCCO EMBEDDED ON MESH THAT IS TIED TO THE STRUCTURAL BARBED WIRE OR TO VERTICAL STRAPPING. EVEN WEAK MESH INCREASES WALL STRENGTH AND DELAYS DAMAGE.

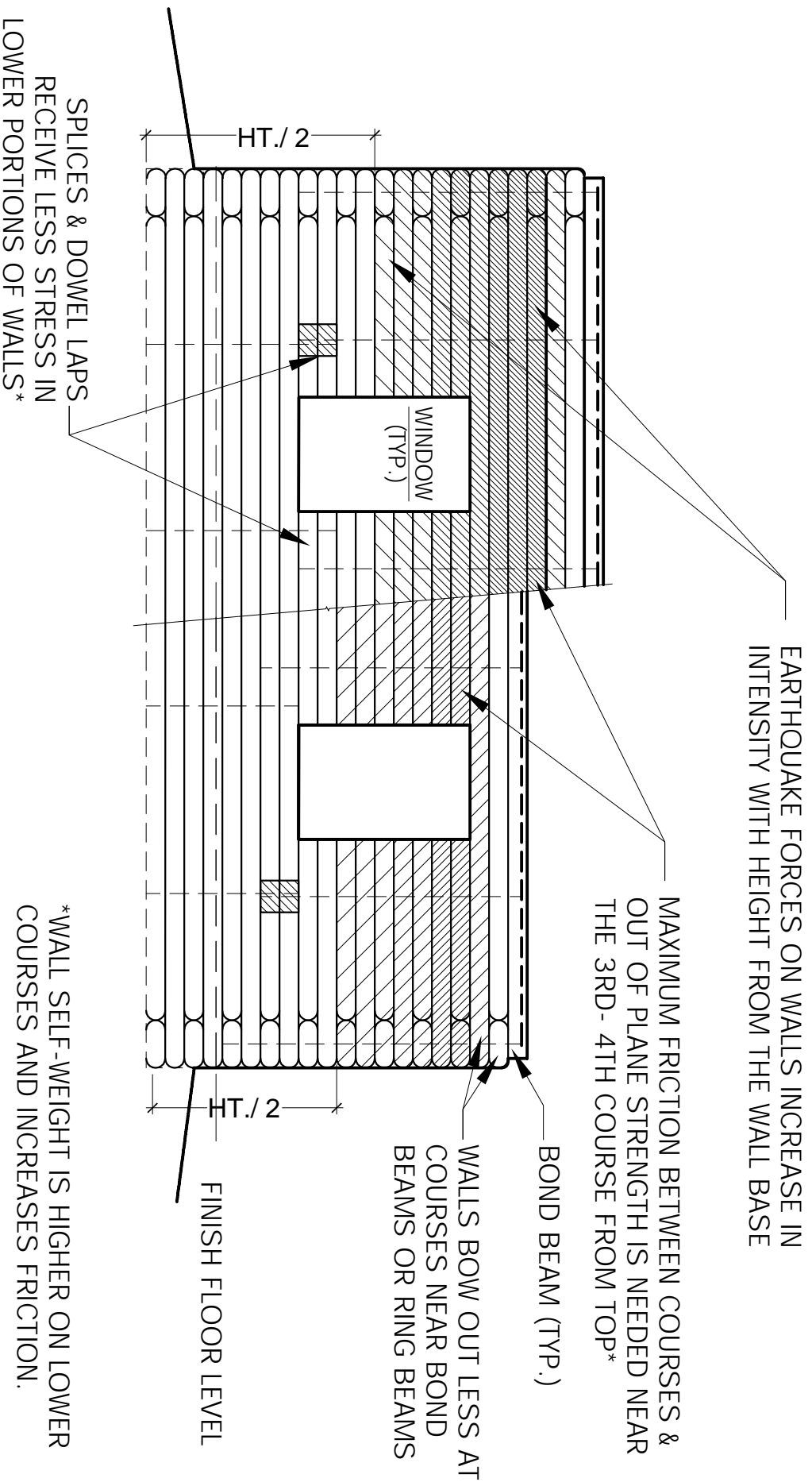
REINFORCED WALLS REQUIRE A FULLY INTERCONNECTED FRAMEWORK. WALLS FAIL AT THE WEAKEST LINK. FOR MODERATE TO HIGH SEISMIC RISK, HEAVY EARTHEN WALLS NEED VERTICAL STEEL THAT IS BOTH BASE-ANCHORED TO A FOOTING AND EMBEDDED IN OR ANCHORED TO A STRONG BOND BEAM.

THESE SUGGESTED REINFORCEMENT OPTIONS FOR CONTAINED EARTH ARE UNDER DEVELOPMENT. PLEASE SHARE YOUR SUGGESTIONS FOR IMPROVED CONSTRUCTIBILITY OR BETTER STRENGTH. EMAIL [SIMPLE\\_EARTH@YAHOO.COM](mailto:SIMPLE_EARTH@YAHOO.COM).

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**INTRODUCTION TO CONSTRUCTION DETAILS FOR SEISMIC RISK; CONTAINED EARTH REINFORCEMENT OPTIONS**



ELEVATION DIAGRAM

NOTES:  
 DIAGRAMS SHOW 6" HIGH COURSES  
 STRESS LOCATION IS BASED ON CONTAINED SAND RESEARCH BY ROSS AND CROFT.  
 FOR MORE STRUCTURAL RESEARCH INFORMATION, SEE DRAFT SUMMARIES OF CE TESTING AT  
 WWW.BUILDSIMPLE.ORG/ RESOURCES UNDER STRUCTURAL INFORMATION.

\*WALL SELF-WEIGHT IS HIGHER ON LOWER COURSES AND INCREASES FRICTION.

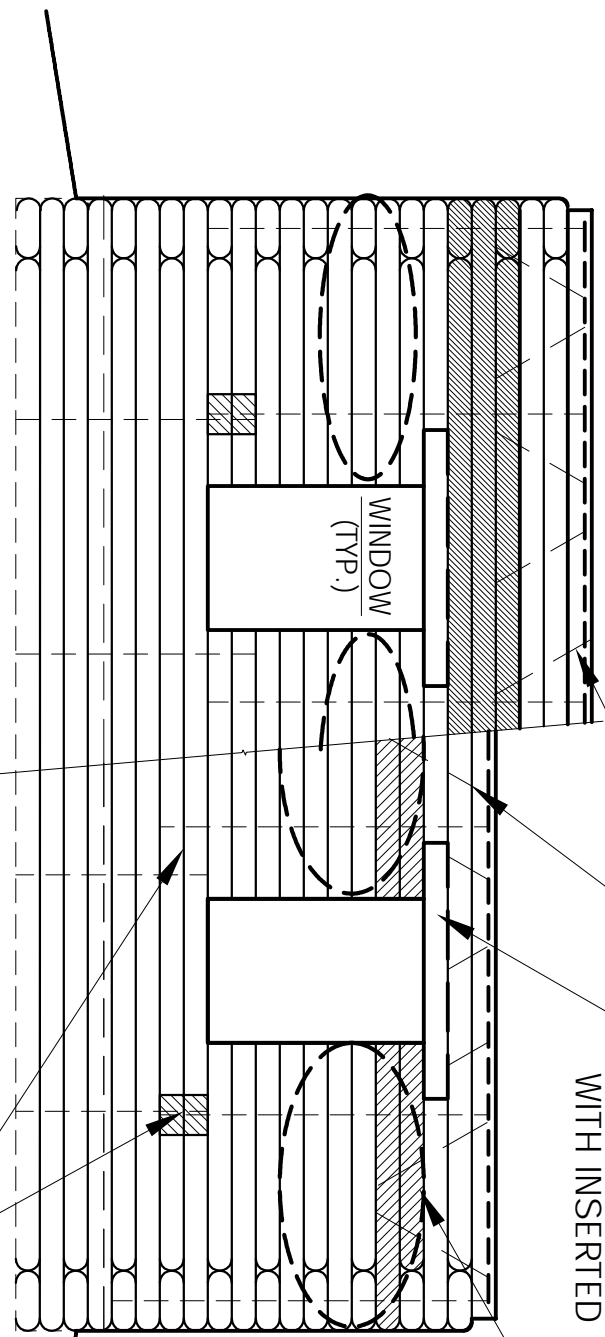
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**CONTAINED EARTH STRESSES**  
**CONTAINED EARTH REINFORCEMENT OPTIONS**

SCALE: NOT TO SCALE

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ALTERNATING DIAGONAL DOWEL PINS ATTACH BOND BEAM TO UPPER COURSES\*

MOST TYPES OF LINTELS INTERFERE WITH INSERTED REBAR

FORCES ON WALLS ARE CONCENTRATED BETWEEN WALL OPENINGS

FINISH FLOOR LEVEL

\* 60 cm (24") LONG DIAGONAL DOWEL PINS PIERCE A BOND BEAM AND 3 COURSES MAXIMUM.

ELEVATION DIAGRAM

NOTE:  
 INSERTED DOWELS APPEAR TO PREVENT OR DELAY SHEAR OR OUT-OF-PLANE SEPARATION, BUT THEY DO NOT PREVENT FLEXURE OR RACKING.  
 LAPPED UNCONNECTED DOWELS USED IN CONVENTIONAL EARTH BAG DO NOT STRONGLY RESIST UPLIFT OR PREVENT RACKING. SPLICED REBAR THAT ARE NOT ANCHORED IN A FOOTING CAN ALSO NOT RESIST UPLIFT.

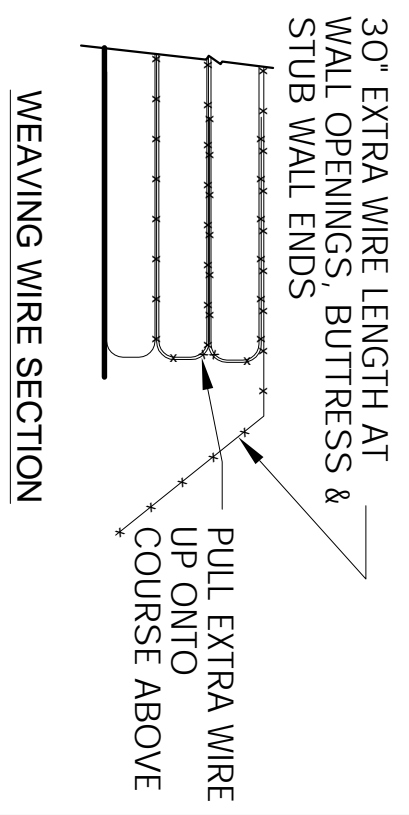
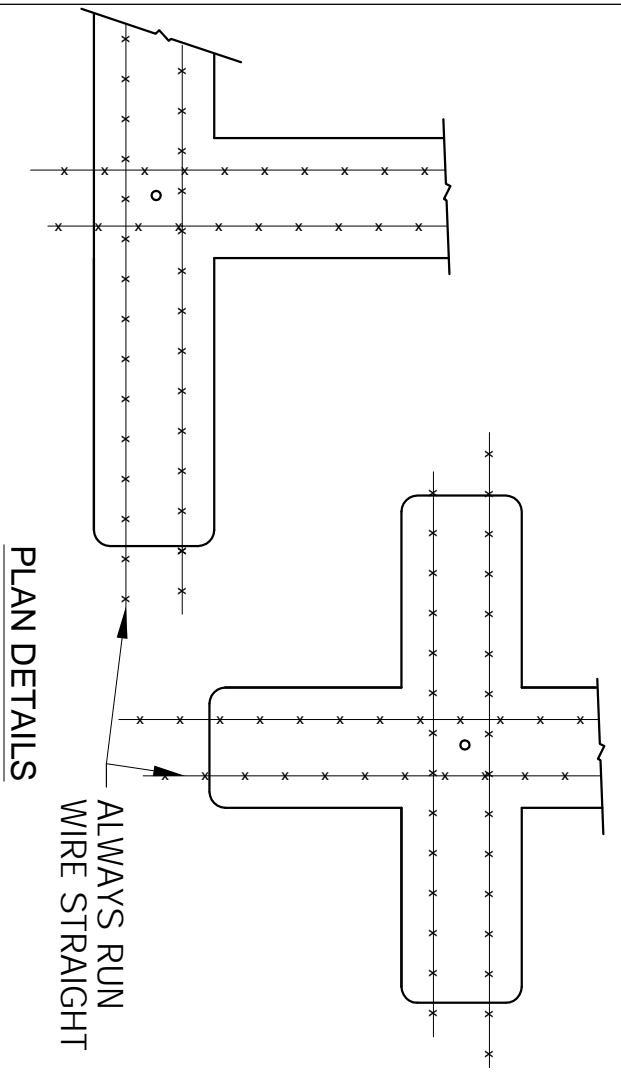
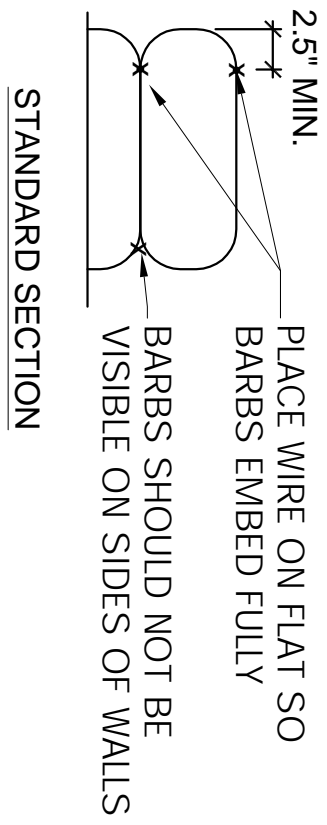
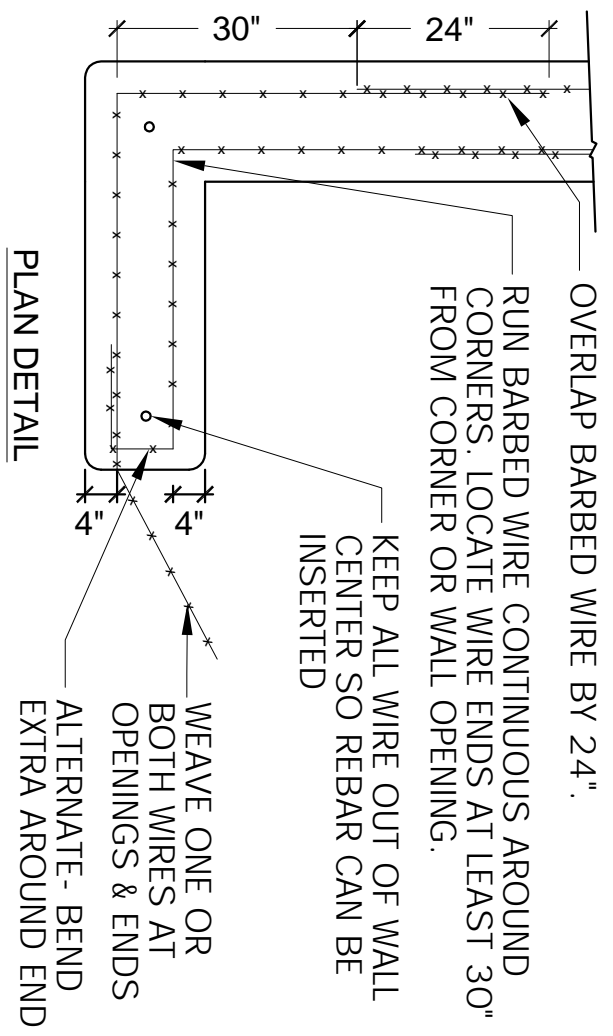
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CONTAINED EARTH REBAR LOCATIONS  
 CONTAINED EARTH REINFORCEMENT OPTIONS

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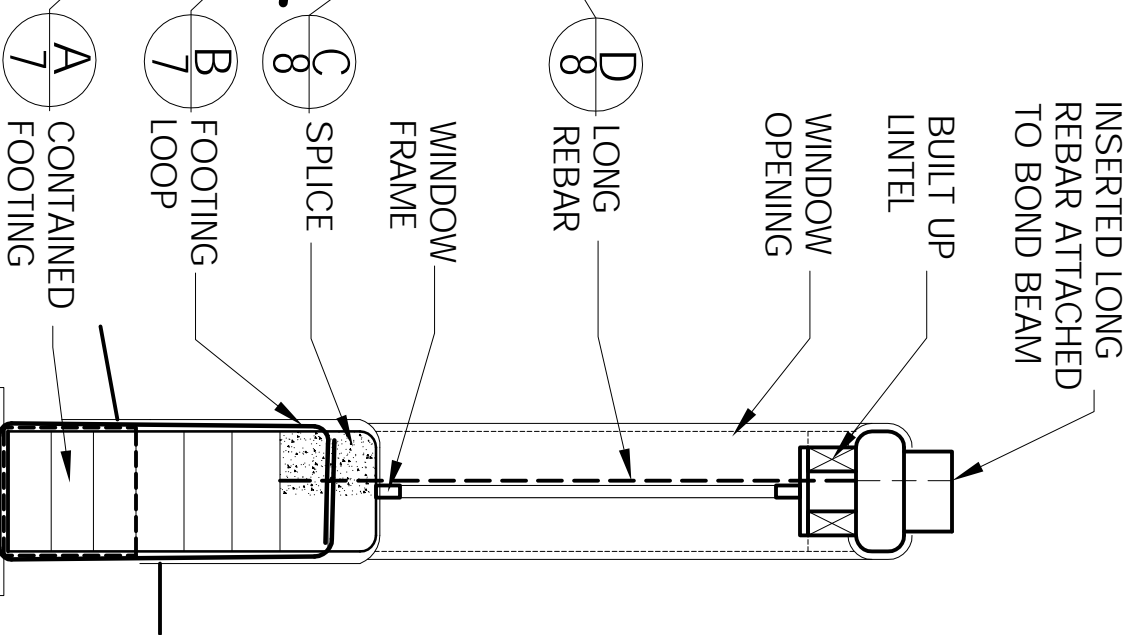
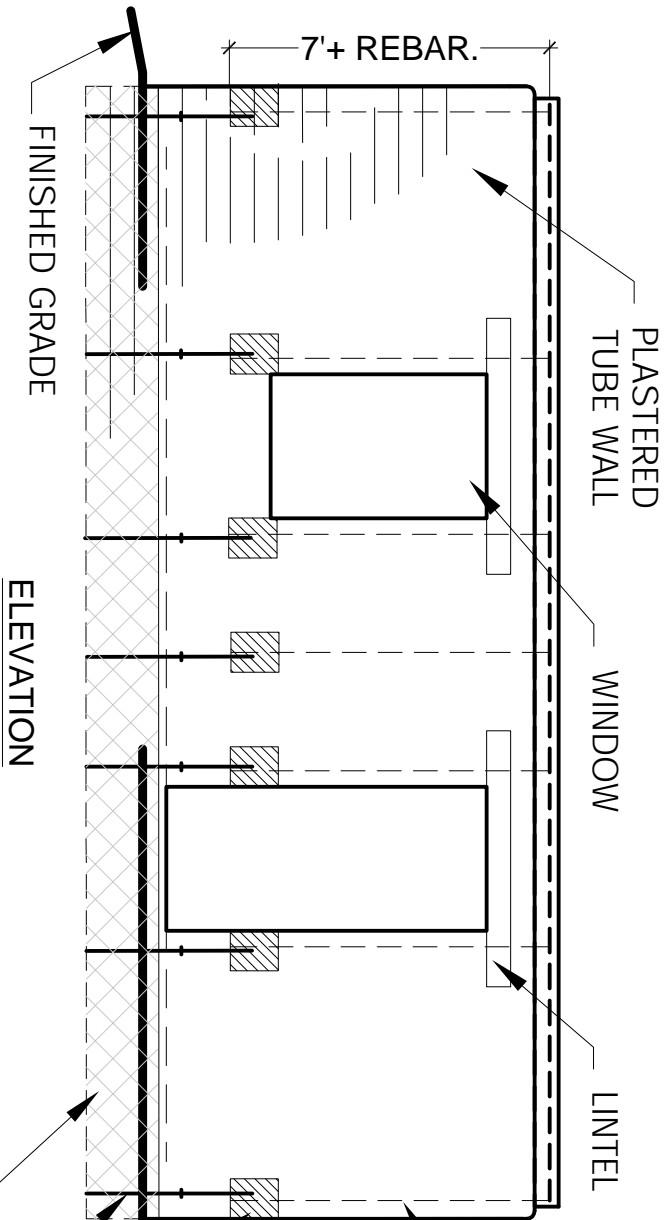
CONTAINED EARTH BARBED WIRE LOCATIONS  
CONTAINED EARTH REINFORCEMENT OPTIONS

SCALE: NOT TO SCALE

4  
SHEET 4 OF 17

## RESILIENT CE WALLS

- CONTAINED FOOTING
- FLEXIBLY LINKED VERTICAL STEEL FROM FOOTING TO BOND BEAM



- NOTES FOR LONG DOWEL CE:
1. TEST LENGTH OF REBAR THAT CAN BE INSERTED ACCURATELY FOR YOUR SOIL STRENGTH AND CONSTRUCTION SPEED
  2. LINTELS MUST HAVE GAPS FOR REBAR
  3. STABILIZED FILL POSSIBLE: COURSE WHERE REBAR IS INSERTED COURSES AT SPLICE GAPS AND BELOW

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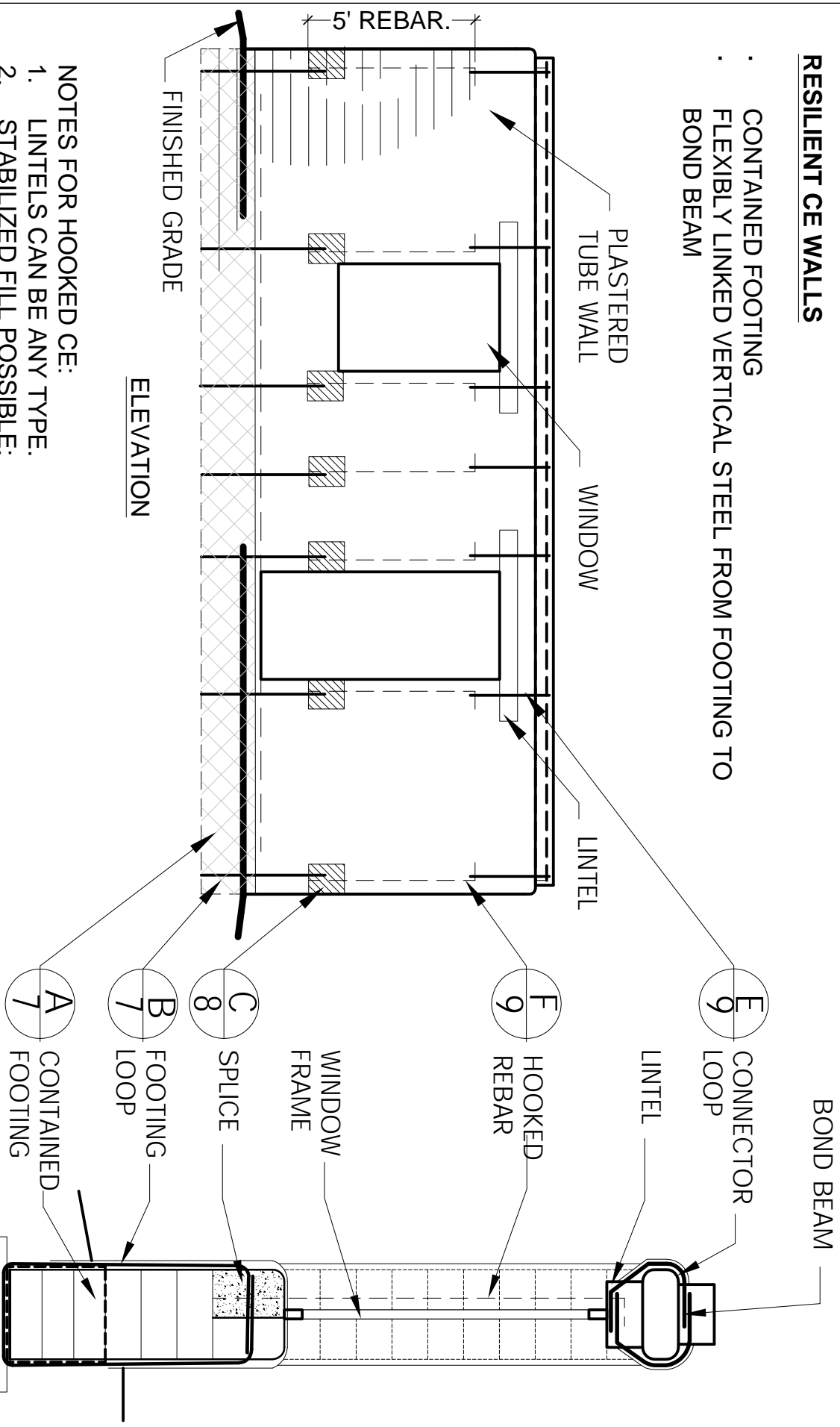
## RESILIENT CONTAINED EARTH: LONG REBAR CONTAINED EARTH REINFORCEMENT OPTIONS

SCALE: NOT TO SCALE

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**RESILIENT CE WALLS**

- CONTAINED FOOTING
- FLEXIBLY LINKED VERTICAL STEEL FROM FOOTING TO BOND BEAM



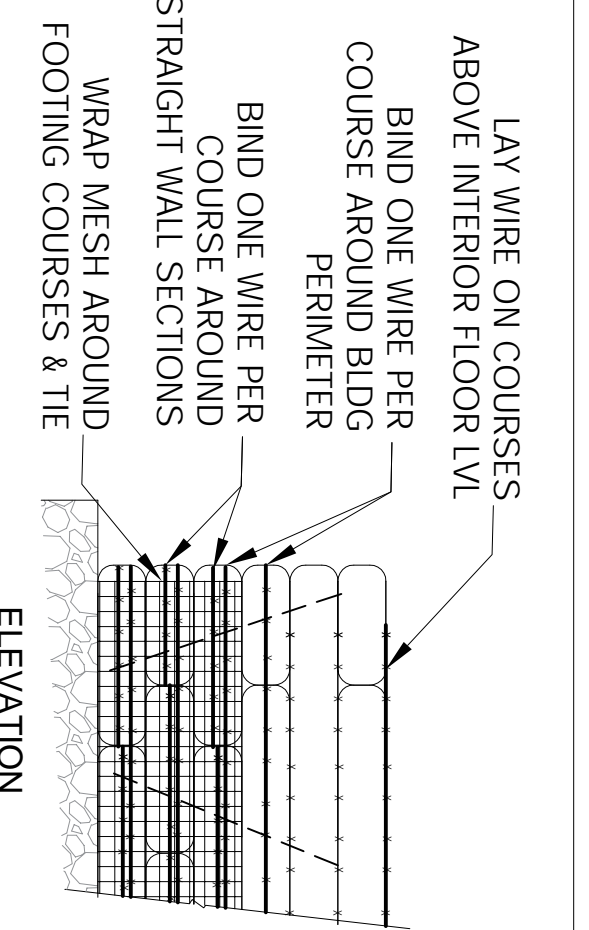
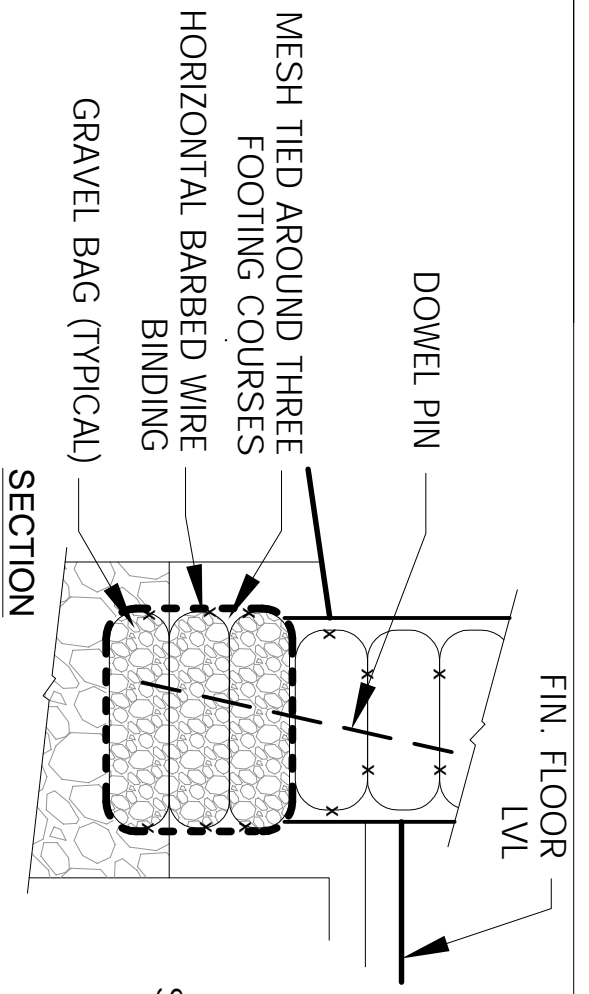
- NOTES FOR HOOKED CE:
- LINTELS CAN BE ANY TYPE.
  - STABILIZED FILL POSSIBLE:
- COURSE WHERE REBAR IS INSERTED  
 COURSES CONTAINING SPLICE GAPS  
 COURSES ABOVE HOOKS

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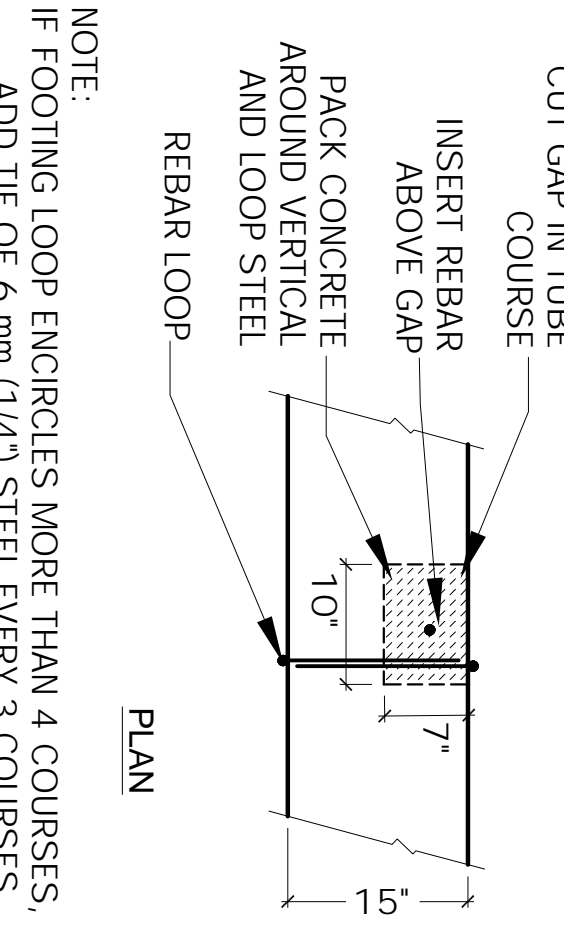
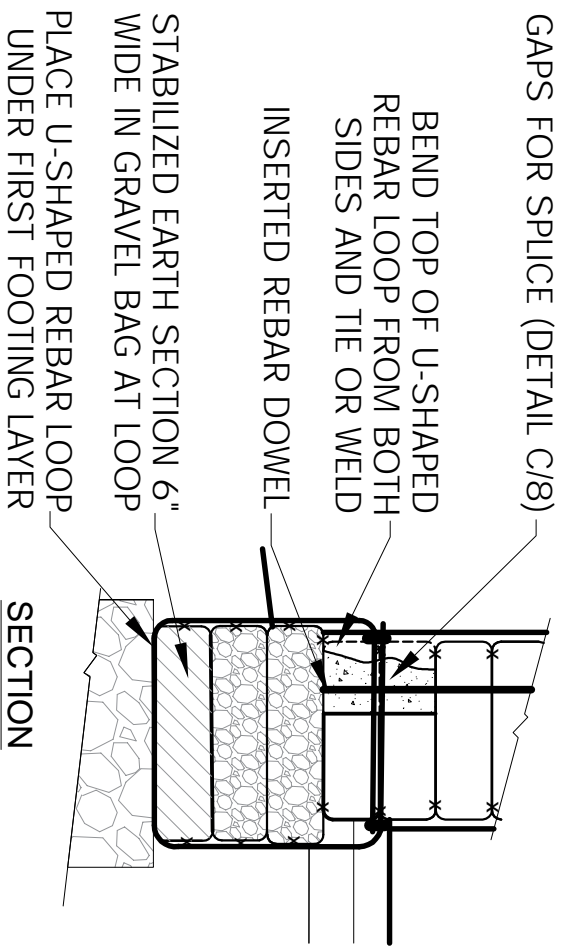
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**RESILIENT CONTAINED EARTH: HOOKED**  
**CONTAINED EARTH REINFORCEMENT OPTIONS**

SCALE: NOT TO SCALE



**A-CONTAINED FOOTING**



**B-FOOTING LOOP**

NOTE:  
IF FOOTING LOOP ENCIRCLES MORE THAN 4 COURSES,  
ADD TIE OF 6 mm (1/4") STEEL EVERY 3 COURSES

GAPS FOR SPLICE (DETAIL C/8)

BEND TOP OF U-SHAPED REBAR LOOP FROM BOTH SIDES AND TIE OR WELD

INSERTED REBAR DOWEL

STABILIZED EARTH SECTION 6" WIDE IN GRAVEL BAG AT LOOP

PLACE U-SHAPED REBAR LOOP UNDER FIRST FOOTING LAYER

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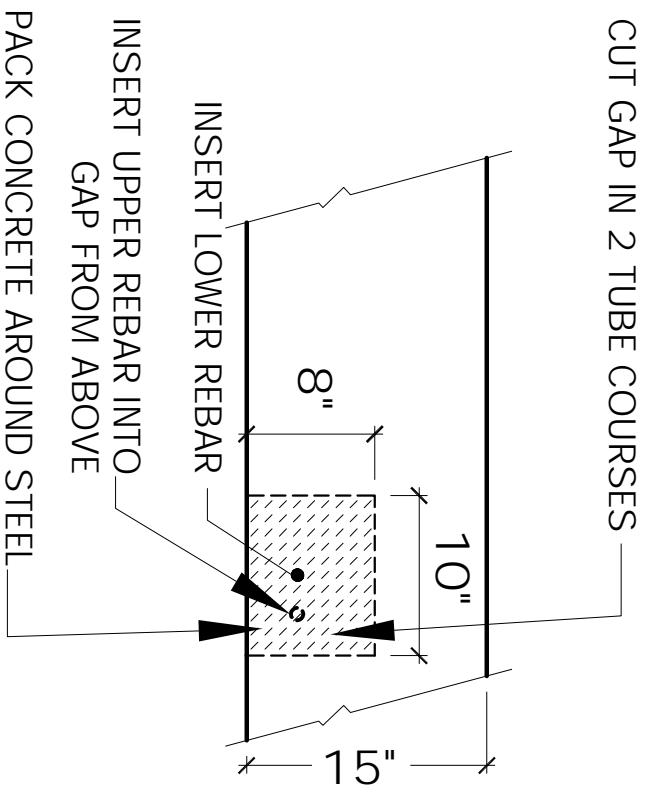
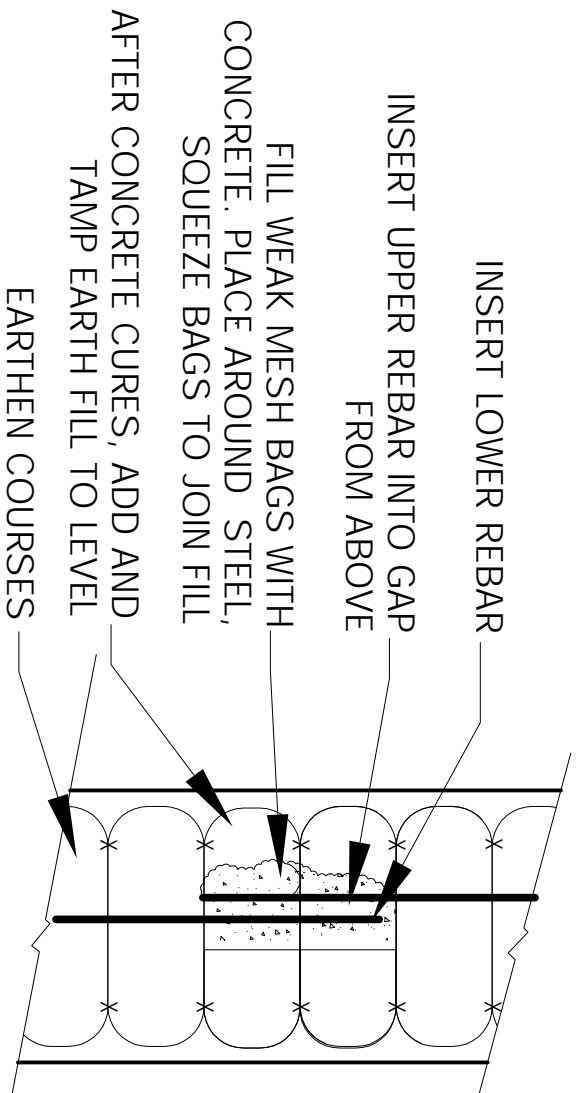
**RESILIENT CONTAINED EARTH DETAILS A - B**

**CONTAINED EARTH REINFORCEMENT OPTIONS**

SCALE: VARIES

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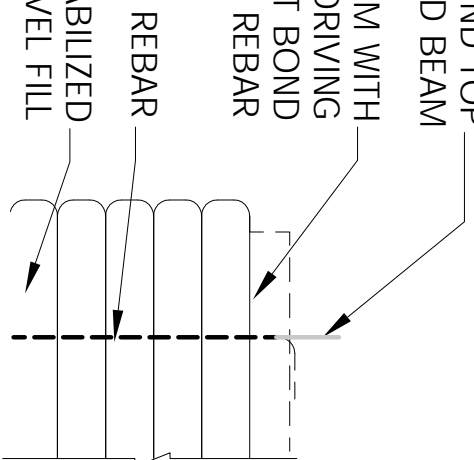


**C- SPLICE**

INSERT REBAR, THEN BEND TOP AND ATTACH TO BOND BEAM

PLACE WOOD BOND BEAM WITH DRILLED HOLES BEFORE DRIVING REBAR, OR POUR CEMENT BOND BEAM AFTER INSERTING REBAR

COURSES OF UNSTABILIZED EARTHEN FILL OR GRAVEL FILL



- OPTIONS FOR INSERTING REBAR LONGER THAN 1.5 m (5'):
1. CUT AN ANGLED POINT ON THE REBAR
  2. CREATE GUIDE HOLES WITH A 60 cm (24") LONG SMALLER, SMOOTH ROD. WELD A CROSS PIECE ON THIS ROD TO ALLOW EASIER REMOVAL.
  3. LONG REBAR WILL BOUNCE LESS IF HELD IN A SLIGHTLY LARGER STEEL PIPE WHILE HAMMERING.
  4. MAKE A DRIVER TOOL FROM A 20 mm (3/4") STEEL PIPE WITH A HEAVY METAL PLATE WELDED ON ONE END. SLIDE THE TOOL ON THE PIPE, LIFT IT 300 mm (12") ABOVE THE REBAR END, AND THROW IT OR LET IT FALL DOWNWARD ONTO THE REBAR END.

**D- LONG REBAR**

**RESILIENT CONTAINED EARTH DETAILS C- D**

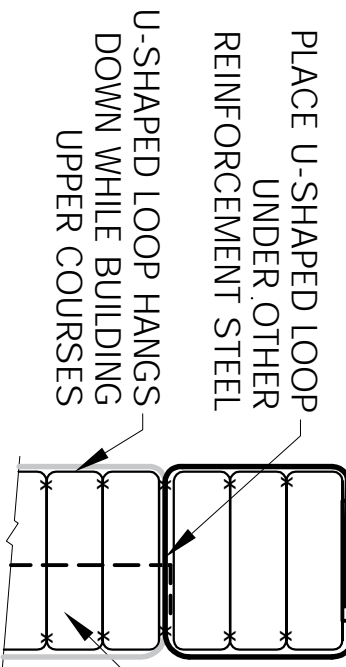
**CONTAINED EARTH REINFORCEMENT OPTIONS**

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SCALE: VARIES

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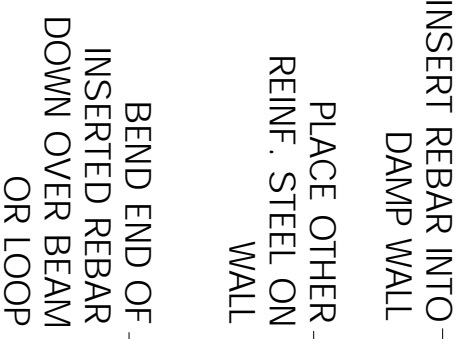
SECTION

EMBED OR ATTACH LOOP TO BOND BEAM

AFTER UPPER COURSES ARE COMPLETE, LIFT LOOP, BEND ENDS TO MEET OVER TOP COURSE AND THE OR WELD TOGETHER

**E-CONNECTOR LOOP**

NOTE:  
 1. IF CONNECTOR LOOP ENCIRCLES MORE THAN 4 COURSES, ADD TIE OF 6 mm (1/4") STEEL EVERY 3 COURSES  
 2. CONNECTOR LOOP ALTERNATE SHAPE - USE TWO C-SHAPED PIECES:  
 FORM 24 mm (1") DIAMETER SPACE AT LOWER LOCATION WITH WOODEN DOWEL WRAPPED IN PLASTIC. BUILD COURSES. REMOVE DOWEL. INSERT TWO HALVES FROM BOTH DIRECTIONS. TIE TOGETHER AT BOTTOM.

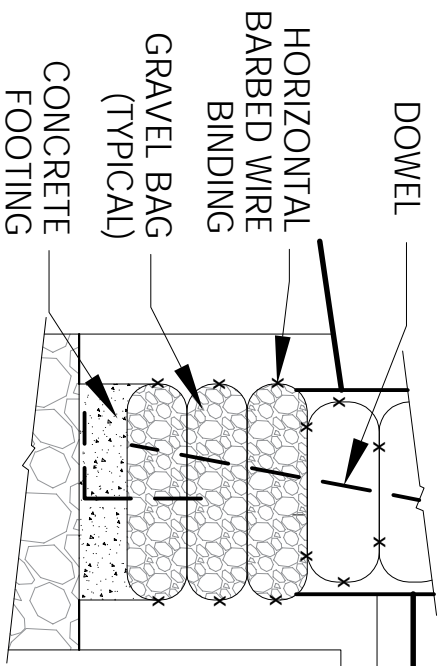


SECTION

NOTE:  
 BEND REBAR AFTER INSERTING.  
 HOLD THE REBAR NEAR THE WALL SURFACE WITH A HEAVY PIPE WRENCH. SLIDE A LONG PIPE OVER THE END TO USE AS A LEVER.

BEND 12 mm (1/2") REBAR COLD IN 75 mm (3") DIAMETER TO 90 DEGREES

**F-HOOKED REBAR**



SECTION

**G-CONCRETE FOOTING**

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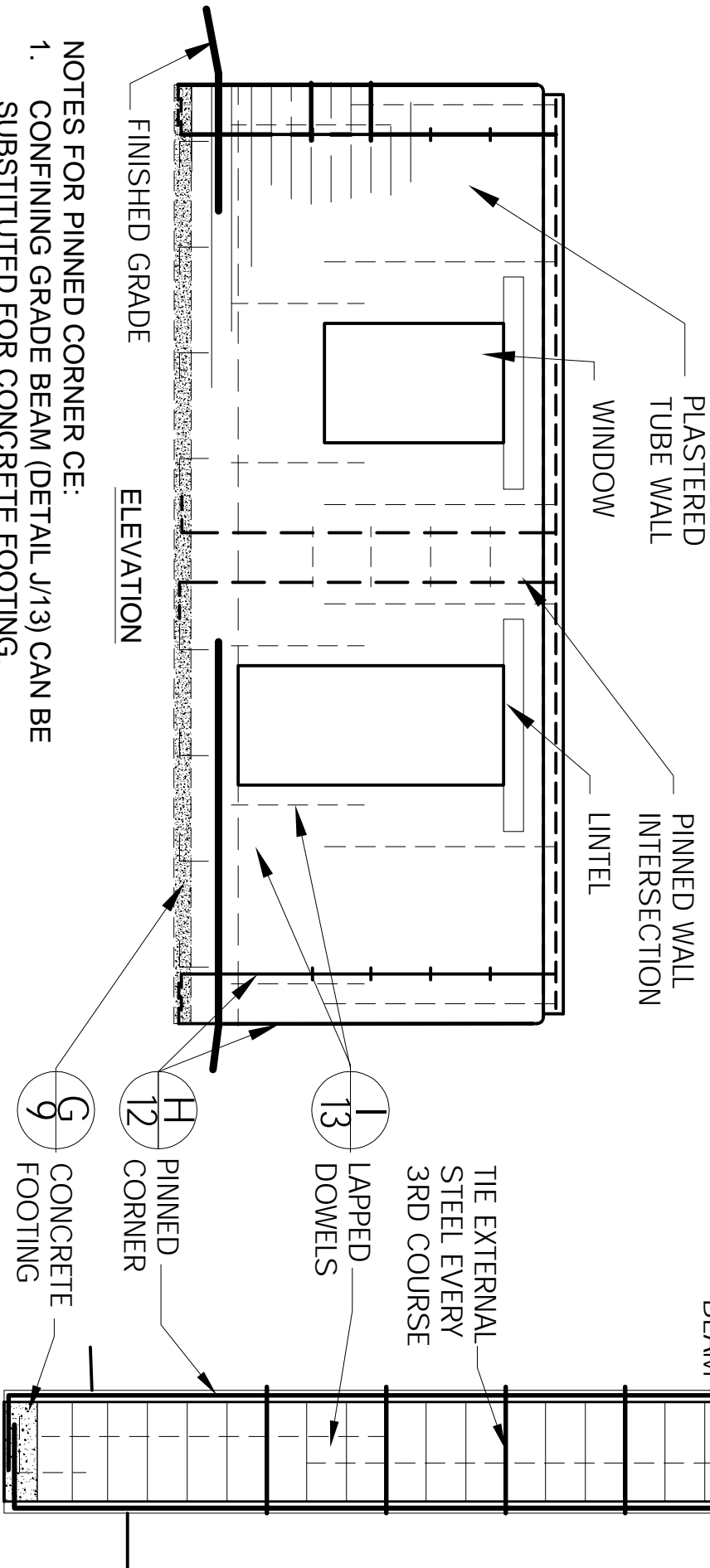
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**RESILIENT CONTAINED EARTH DETAILS E - F**  
 CONTAINED EARTH REINFORCEMENT OPTIONS

SCALE: VARIES

# REINFORCED CE WALLS

- REINFORCED FOOTING
- BRACED FRAME OF VERTICAL STEEL FROM FOOTING TO BOND BEAM



- NOTES FOR PINNED CORNER CE:
1. CONFINING GRADE BEAM (DETAIL J/13) CAN BE SUBSTITUTED FOR CONCRETE FOOTING.
  2. LINTELS CAN BE ANY TYPE.
  3. BUTTRESSES CAN ALSO BE PINNED.
  4. STABILIZED FILL POSSIBLE:
- COURSE WHERE DOWELS ARE INSERTED COURSES BELOW INSERTED DOWELS

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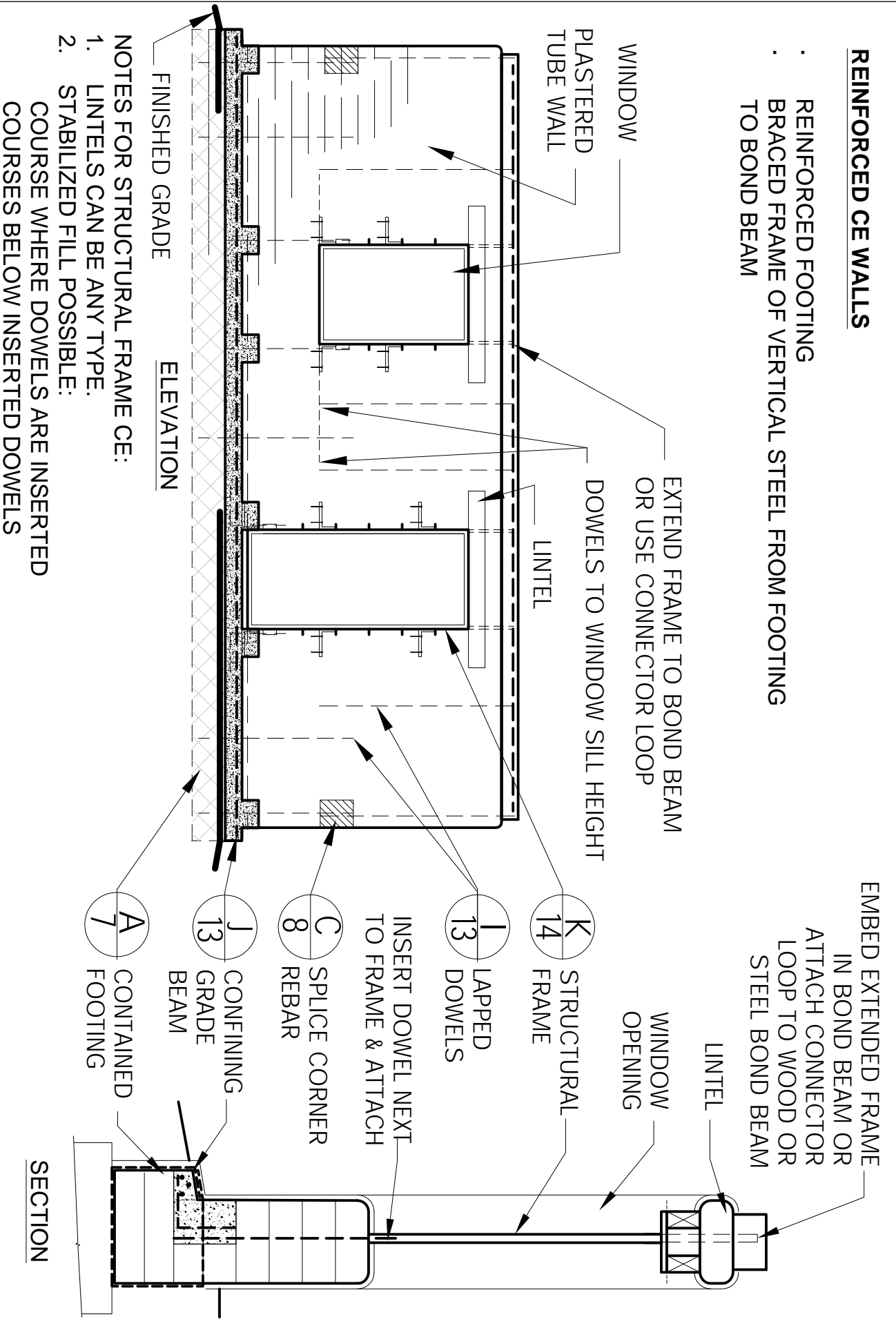
REINFORCED CONTAINED EARTH: PINNED CORNER  
CONTAINED EARTH REINFORCEMENT OPTIONS

SCALE: NOT TO SCALE

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**REINFORCED CE WALLS**

- REINFORCED FOOTING
- BRACED FRAME OF VERTICAL STEEL FROM FOOTING TO BOND BEAM



**NOTES FOR STRUCTURAL FRAME CE:**

- LINTELS CAN BE ANY TYPE.
- STABILIZED FILL POSSIBLE: COURSE WHERE DOWELS ARE INSERTED COURSES BELOW INSERTED DOWELS

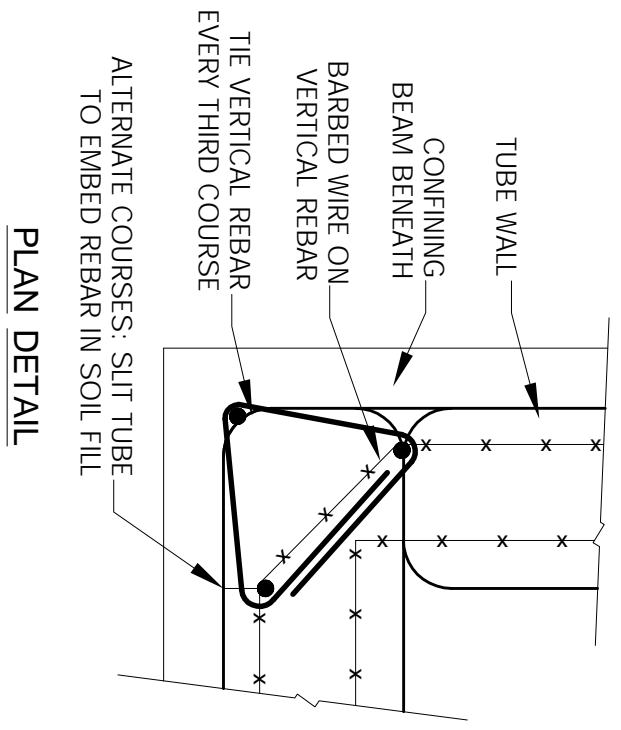
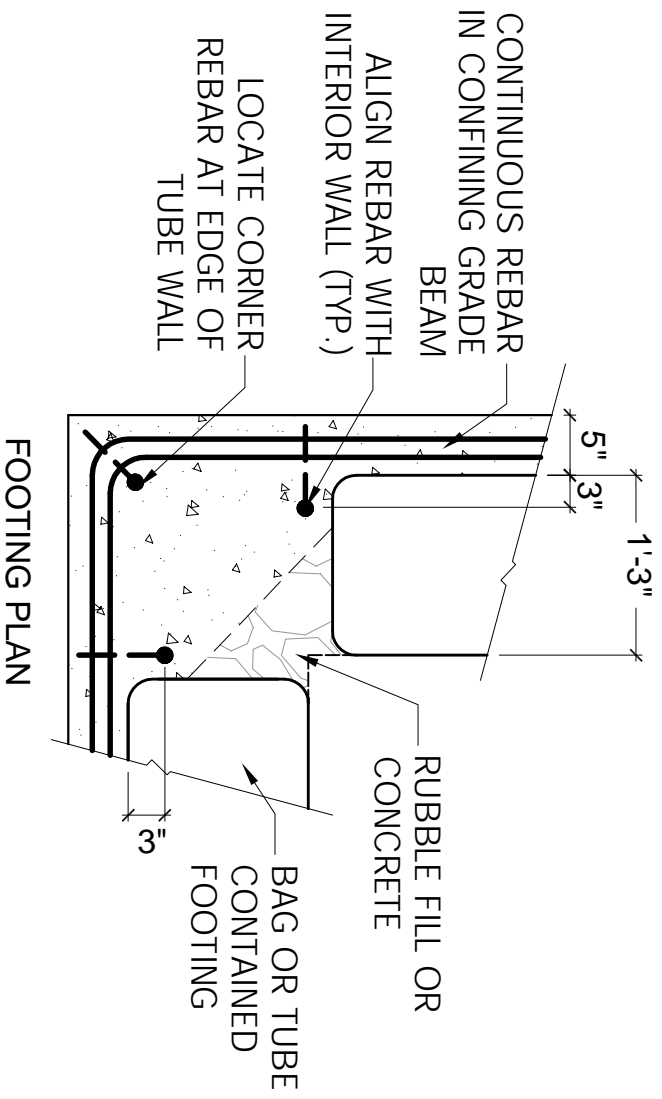
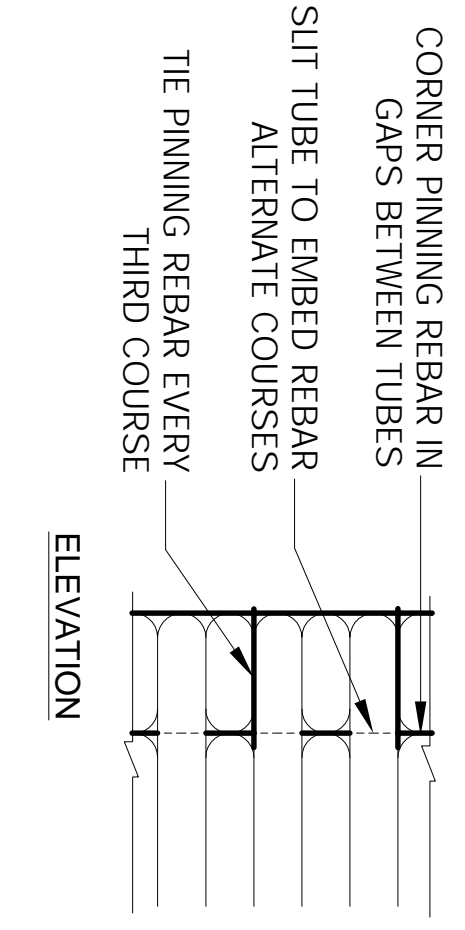
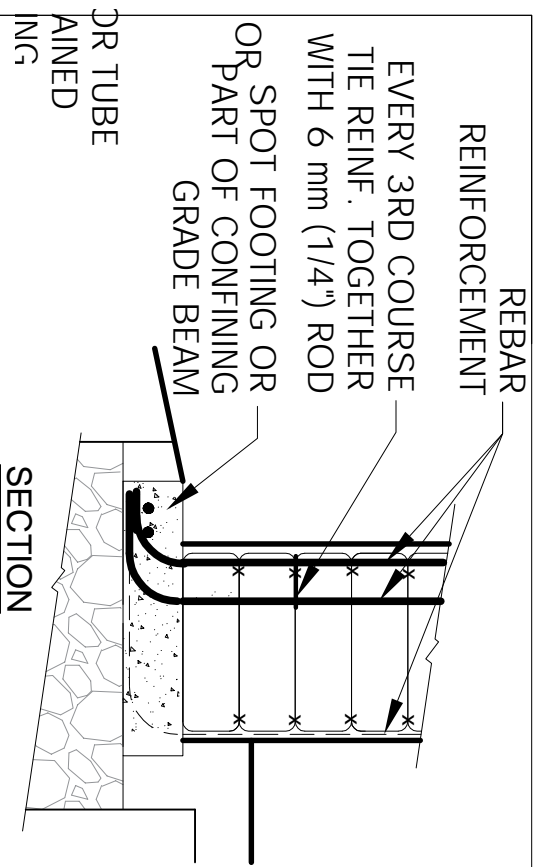
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**REINFORCED CE: STRUCTURAL FRAMES  
CONTAINED EARTH REINFORCEMENT OPTIONS**

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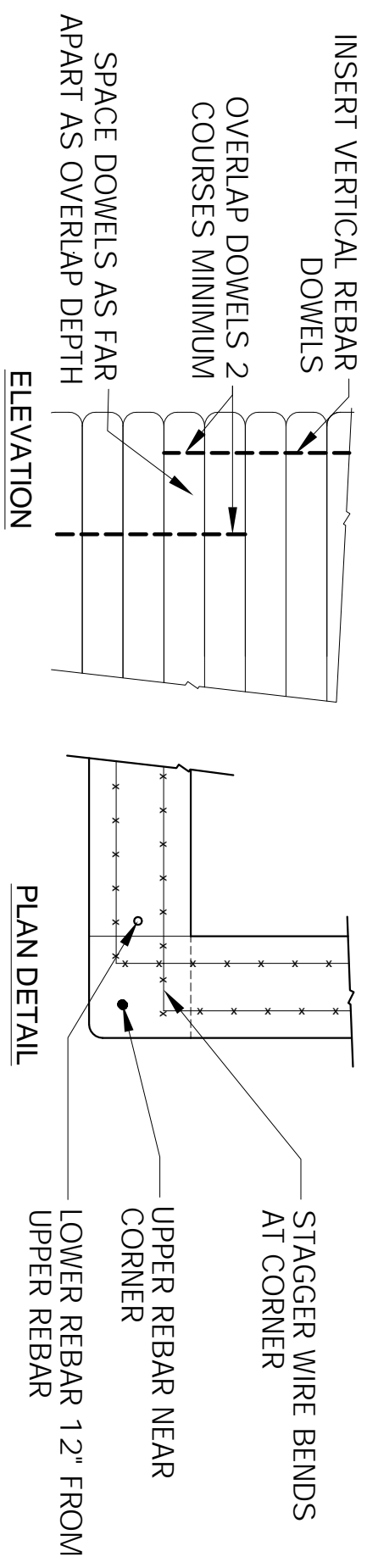
**H- PINNED CORNER**

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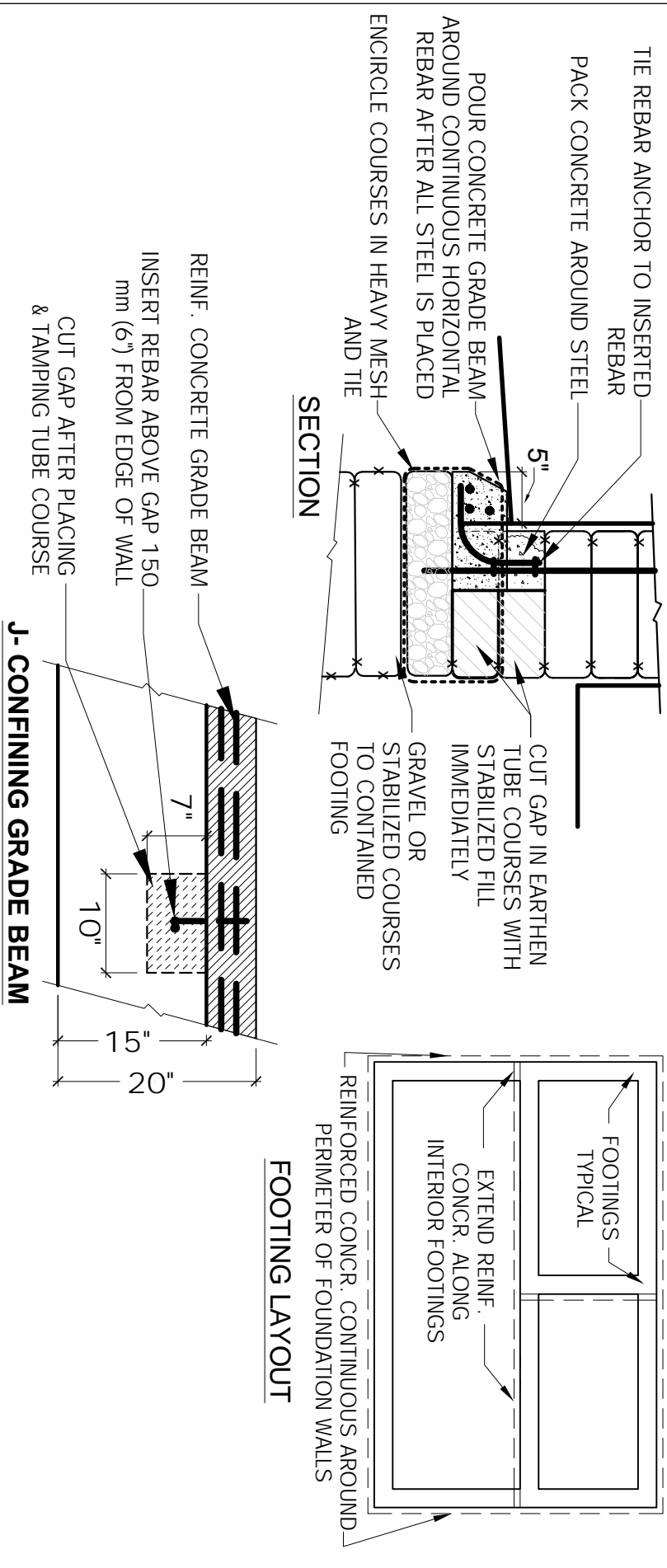
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**REINFORCED CONTAINED EARTH DETAIL H  
 CONTAINED EARTH REINFORCEMENT OPTIONS**

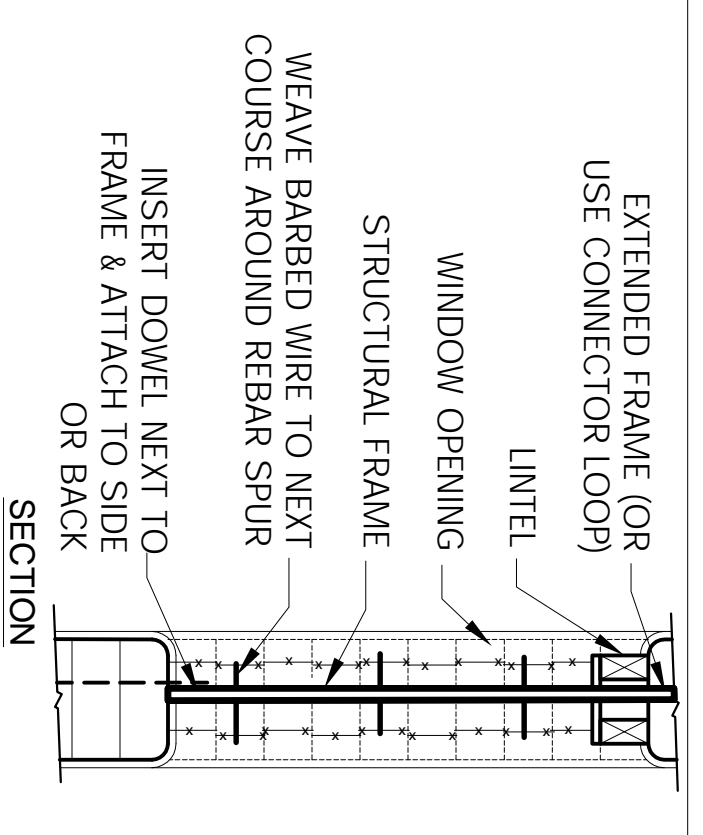
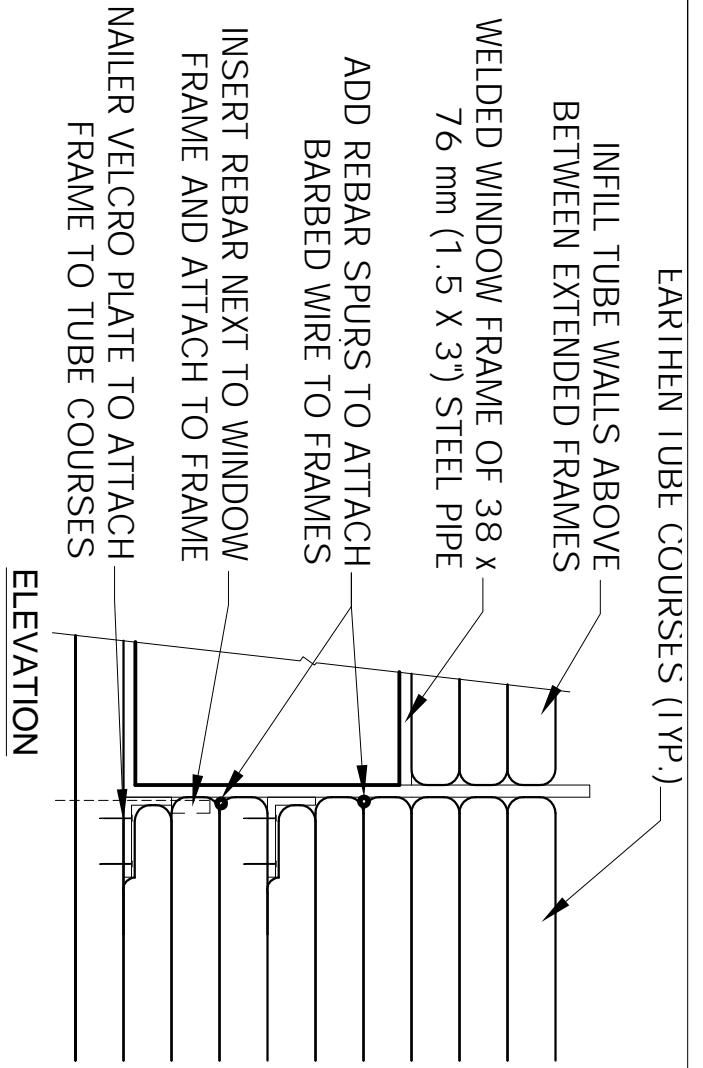
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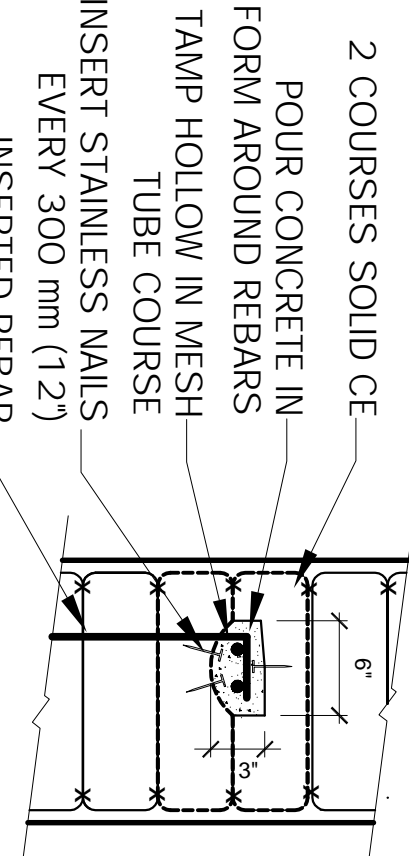
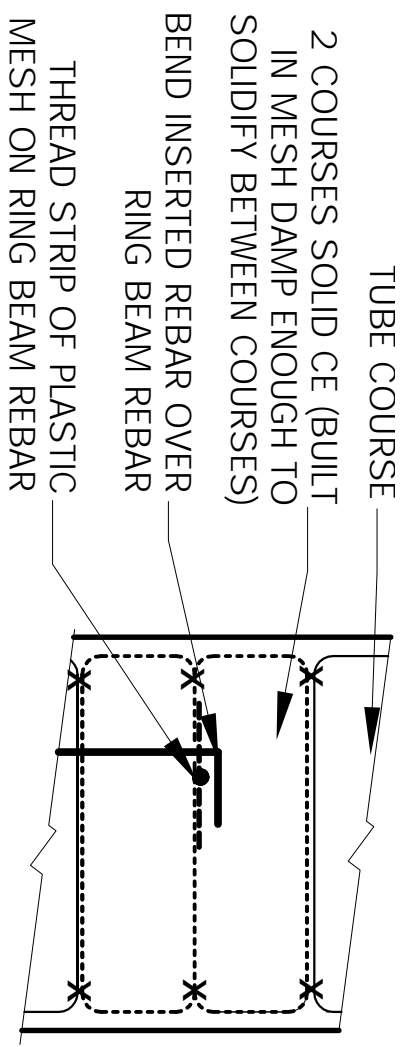
**I-LAPPED DOWELS**



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<b>REINFORCED CONTAINED EARTH DETAILS I-J</b> <b>CONTAINED EARTH REINFORCEMENT OPTIONS</b>		<b>13</b>
SCALE: VARIES		SHEET 13 OF 17



**K-STRUCTURAL FRAME**



**L-RING BEAMS**

**SANDWICH RING BEAM SECTION**

**CONCRETE RING BEAM SECTION**

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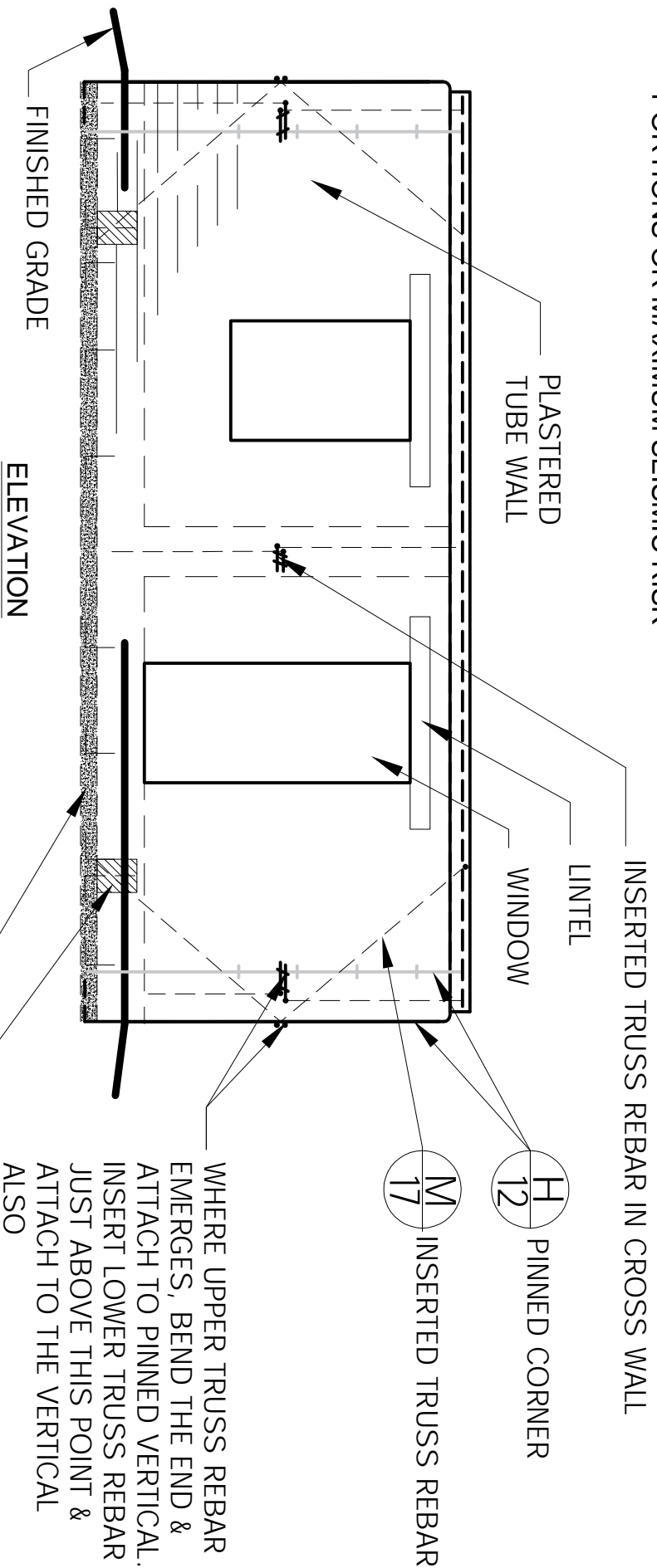
REINFORCED CONTAINED EARTH DETAILS K-L  
CONTAINED EARTH REINFORCEMENT OPTIONS

SCALE: VARIES

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**EXTRA STRENGTH CE WALLS**

- BETTER SERVICEABILITY FOR VULNERABLE PLAN PORTIONS OR MAXIMUM SEISMIC RISK



- NOTES FOR TRUSSED CORNER CE:
1. START TRUSSES ON ABUTTING WALLS AT DIFFERENT DISTANCES FROM CORNER OR DIFFERENT ANGLES TO AVOID INTERFERENCE.
  2. CAN BE USED WITH DIFFERENT REINFORCEMENT TYPES AND FOOTINGS.
  3. USE NEAR CORNERS, WALL INTERSECTIONS, ENDS OF STUB WALLS OR BUTTRESSES.

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EXTRA STRENGTH CE: TRUSSED CORNER  
 CONTAINED EARTH REINFORCEMENT OPTIONS

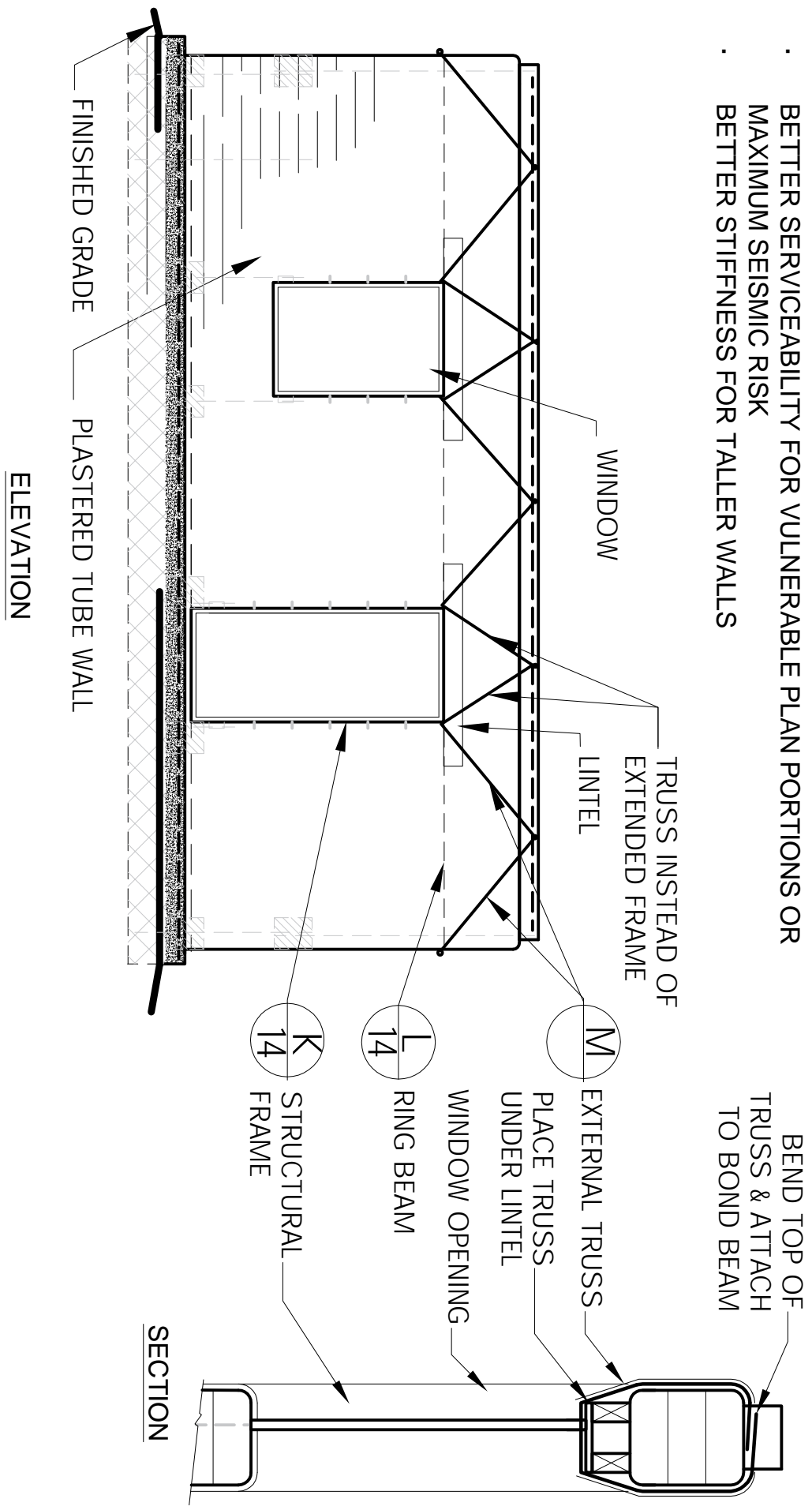
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**EXTRA STRENGTH CE WALLS**

- BETTER SERVICEABILITY FOR VULNERABLE PLAN PORTIONS OR MAXIMUM SEISMIC RISK
- BETTER STIFFNESS FOR TALLER WALLS



- NOTES FOR EXTERNALLY TRUSSED CE:
1. CAN BE USED WITH DIFFERENT TYPES OF REINFORCEMENT.
  2. CAN BE COMBINED WITH INSERTED PINS.

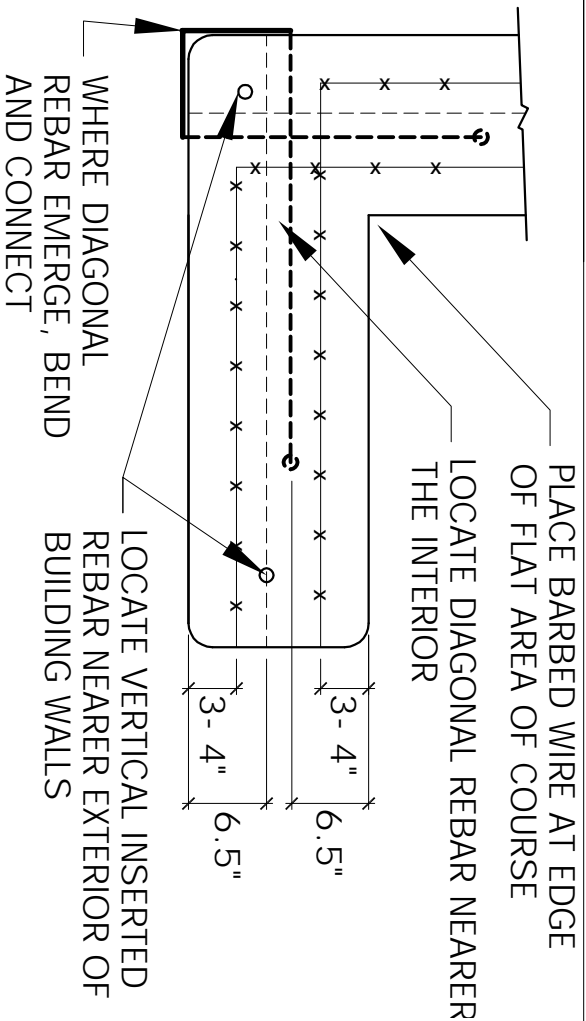
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EXTRA STRENGTH CE: EXTERNAL TRUSSES  
CONTAINED EARTH REINFORCEMENT OPTIONS

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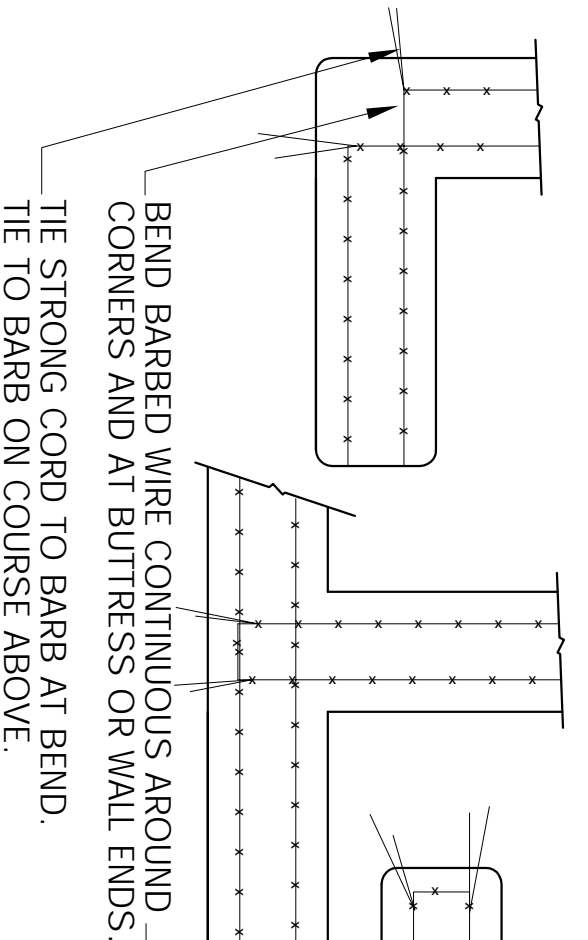
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**PLAN DETAIL**

**M-INSERTED TRUSS REBAR**

- NOTE:**
1. INSERT LOWER REBAR JUST ABOVE EMERGING END OF UPPER REBAR. BEND AND CONNECT TOGETHER.
  2. WHEN USING PINNED CORNER REBAR, ATTACH ENDS OF TRUSS REBAR TO EXTERNAL CORNER REBAR, BOTH EMERGING ENDS FROM UPPER ROD AND INSERTION ENDS FROM LOWER ROD.



**PLAN DETAIL**

**N-TIED BARBED WIRE**

**NOTE:**  
ALWAYS TIE SECTIONS OF BARBED WIRE PERPENDICULAR TO THE WALL OR BUTRESS END. THE GOAL IS TO PUT TENSION ON A WIRE TO STRETCH IT STRAIGHT.

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Revisions:

**REINFORCED CONTAINED EARTH DETAILS M-N**  
**CONTAINED EARTH REINFORCEMENT OPTIONS**

SCALE: VARIES

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