Existing Building Retrofit Research Needs

Bret Lizundia

Rutherford + Chekene

PEER

Why Isn't There More Retrofitting?

- Cost
- Disruption
- No champion
- Benefits have not been easily quantified or monetized
- Other things are just more important

- Lack of sufficient research

PEER

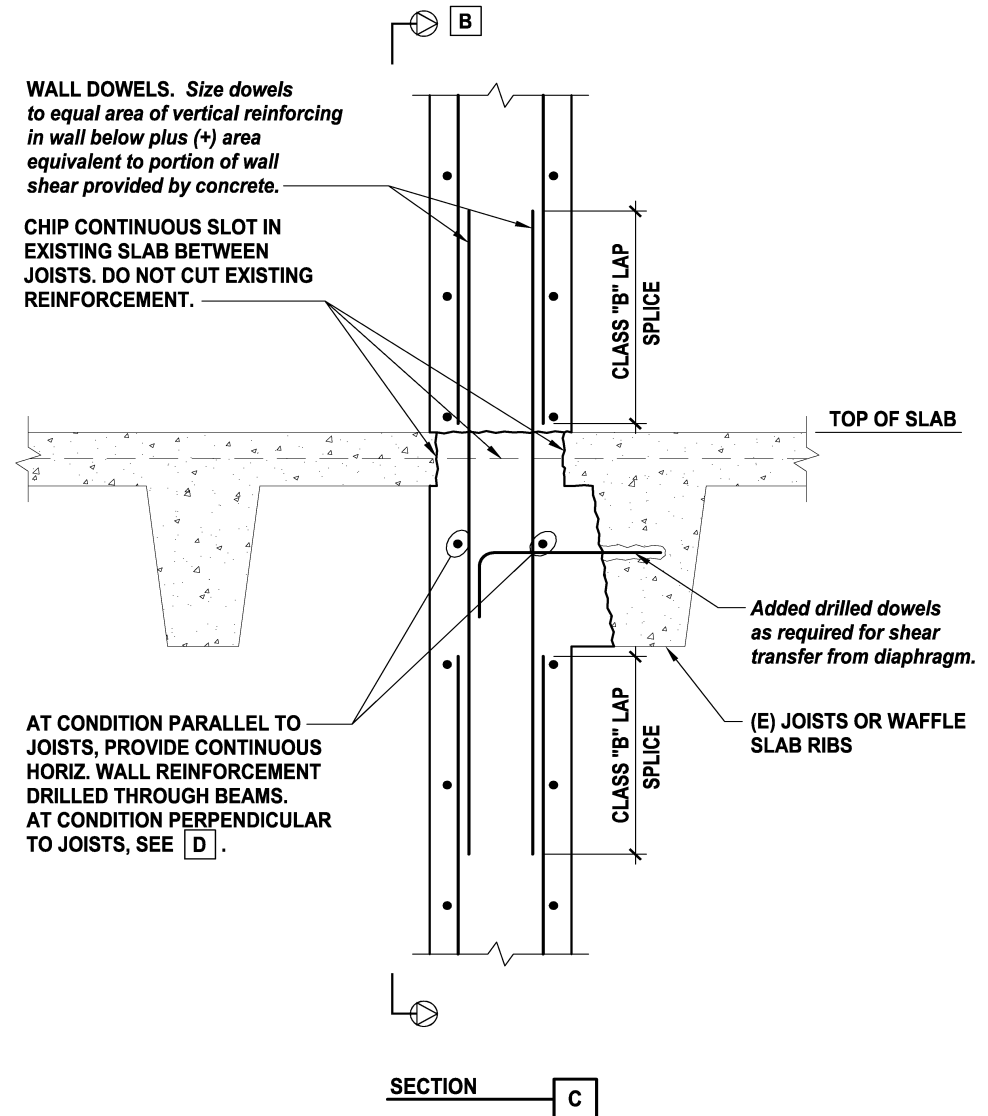# What Benefits does Research Provide to the Practitioner?

- Better understanding of what will happen, particularly when there is physical testing

- Can compare similar options and see which ones perform better

- Perhaps less expensive options still perform well enough

- Correlate simpler practitioner design approaches with more involved research findings

PEER

What Research is Needed by the Practice?

- It should apply to lots of buildings
- Design methodology and construction technique should be practical and relatively inexpensive
- Benefits of the retrofit should be clear and definable
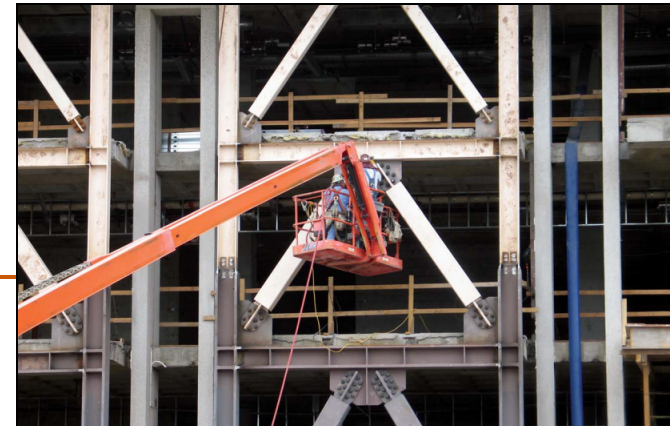- Design equations should accompany research recommendations

PEER

FEMA 547

- 220 figures in 571-page document

- 50 techniques for superstructure strengthening

- 11 diaphragm techniques

- 18 foundation techniques

- 3 techniques related to reducing demand

WALL DOWELS. *Size dowels to equal area of vertical reinforcing in wall below plus (+) area equivalent to portion of wall shear provided by concrete.*

CHIP CONTINUOUS SLOT IN EXISTING SLAB BETWEEN JOISTS. DO NOT CUT EXISTING REINFORCEMENT.

CLASS "B" LAP SPLICE

TOP OF SLAB

Added drilled dowels as required for shear transfer from diaphragm.

(E) JOISTS OR WAFFLE SLAB RIBS

AT CONDITION PARALLEL TO JOISTS, PROVIDE CONTINUOUS HORIZ. WALL REINFORCEMENT DRILLED THROUGH BEAMS. AT CONDITION PERPENDICULAR TO JOISTS, SEE [D].

CLASS "B" LAP SPLICE

SECTION [C]

PEER

FEMA 547

Techniques for the
Seismic Rehabilitation
of Existing Buildings

FEMA 547/2006 Edition

- Description for each technique included a summary of the **research basis**

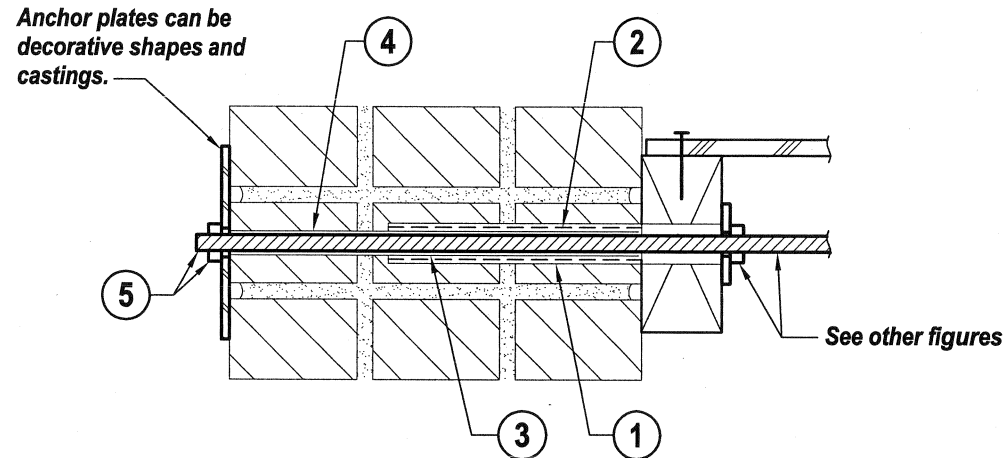- **Most** techniques being used **do not** have directly relevant research

URM Retrofit Needs
Wall-to-Diaphragm Testing

- Manufacturers have tests for the dowel to the wall

- Lots of vendor competition

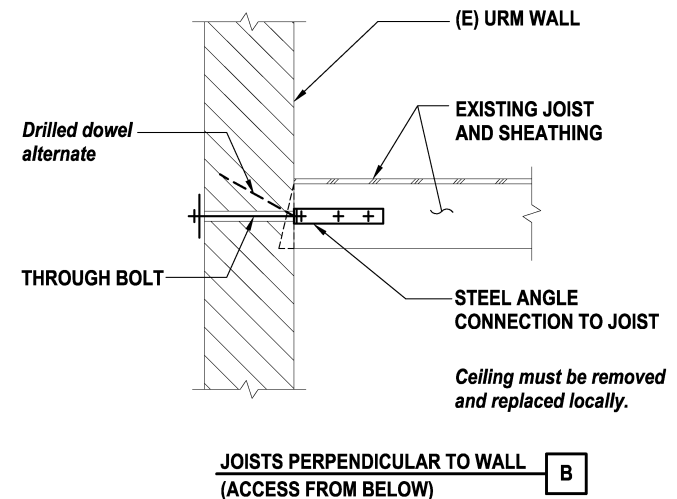- Design values and standards are available

Anchor plates can be decorative shapes and castings.

See other figures

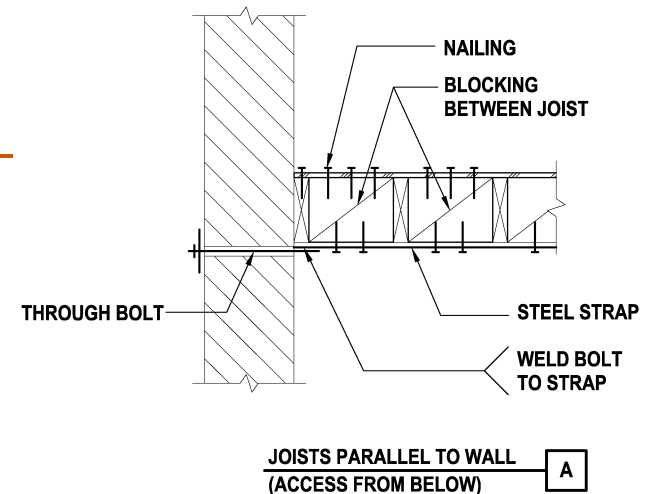SEQUENCE OF INSTALLATION

1. CORE DRILL HOLE.
   Typically 1" diameter x 8" deep.

2. PLACE SCREEN TUBE WITH ADHESIVE.
   Typically 15/16" diameter x 8" deep with plug at end.

3. INSERT STEEL SLEEVE.
   Typically 13/16" outside diameter.

4. AFTER CURING, DRILL HOLE THROUGH PLUG AND REMAINING MASONRY.

5. PLACE THREADED ROD AND ANCHOR PLATE.
   Typically 5/8" diameter and 6"x6"x3/8" respectively.

URM Retrofit Needs
Wall-to-Diaphragm Testing

- But they haven't tested the rest of the assembly and all the permutations

- What is the assembly stiffness?

- What is the weak link in the assembly?

NAILING
BLOCKING BETWEEN JOIST
THROUGH BOLT
STEEL STRAP
WELD BOLT TO STRAP

JOISTS PARALLEL TO WALL
(ACCESS FROM BELOW)   A

(E) URM WALL
Drilled dowel alternate
EXISTING JOIST AND SHEATHING
THROUGH BOLT
STEEL ANGLE CONNECTION TO JOIST

Ceiling must be removed and replaced locally.

JOISTS PERPENDICULAR TO WALL
(ACCESS FROM BELOW)   B

PEER

URM Retrofit Needs
Wall-to-Diaphragm Testing

- How much benefit does a concentric tie provide?

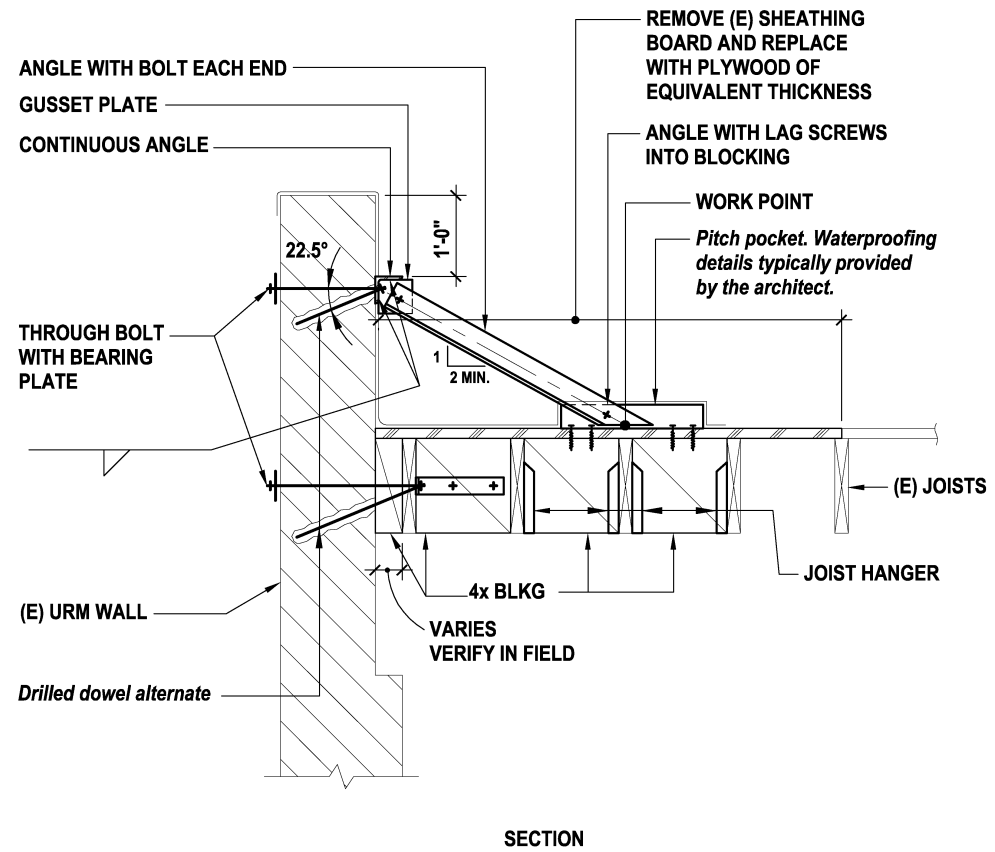- Is it worth cost?

- How important is the effect of the existing joist pocket?

(E) JOIST POCKET (E) JOIST

F ←

F →

e

Moment from eccentricity is M = Fe.

TIE-DOWN

BLOCKING

DRILLED DOWEL

ECCENTRIC TIE-DOWN PLAN DETAIL A

Offset holdowns so screws do not conflict.

SISTER (E) JOIST

CONCENTRIC TIE-DOWN PLAN DETAIL B

Drilled dowel misses existing joist pocket.

PLATE WASHER

STEEL STRAP

BLOCKING
Takes reaction from diagonal strap.

PLATE WASHER

Drilled dowel is offset from end of blocking so it can also serve as a shear tie.

V-STRAP PLAN DETAIL C
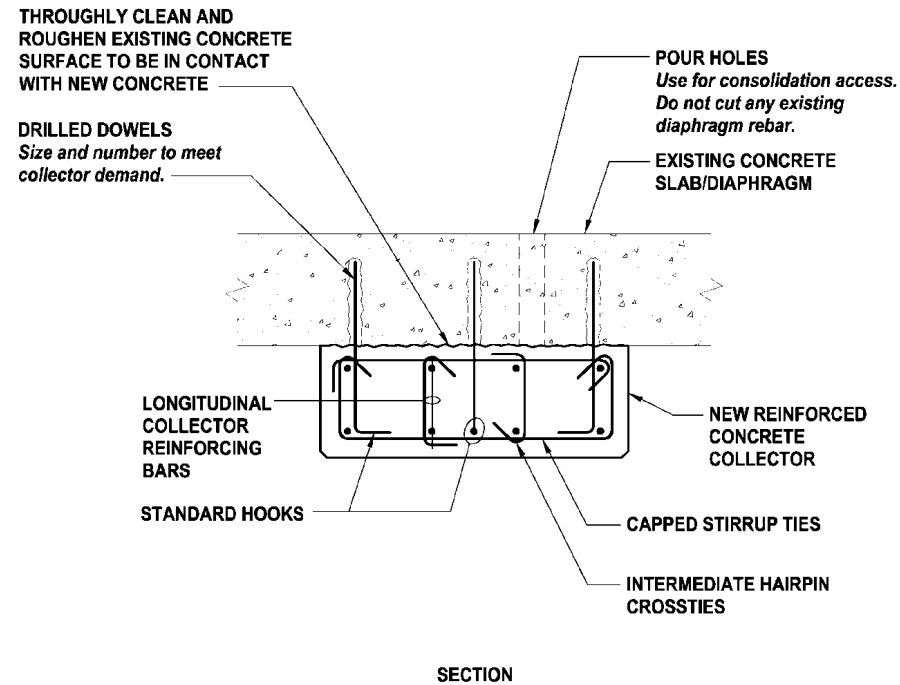
URM Retrofit Needs
Parapet Strengthening

- What is the optimum spacing?
- How stiff should the roof framing be?
- How much of the diaphragm needs to be strengthened?
- Limit on brick above the top anchor
- Can this take really big shaking?

ANGLE WITH BOLT EACH END

GUSSET PLATE

CONTINUOUS ANGLE

REMOVE (E) SHEATHING BOARD AND REPLACE WITH PLYWOOD OF EQUIVALENT THICKNESS

ANGLE WITH LAG SCREWS INTO BLOCKING

WORK POINT

Pitch pocket. Waterproofing details typically provided by the architect.

THROUGH BOLT WITH BEARING PLATE

22.5°

1'-0"

1

2 MIN.

(E) JOISTS

JOINT HANGER

4x BLKG

(E) URM WALL

VARIES VERIFY IN FIELD

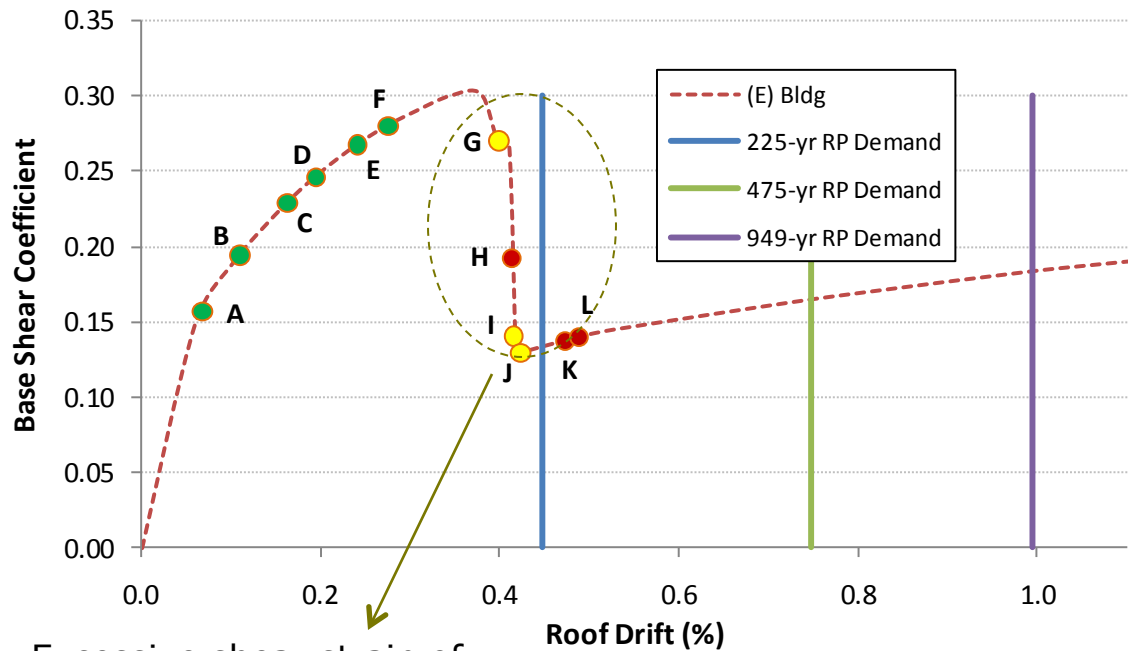*Drilled dowel alternate*
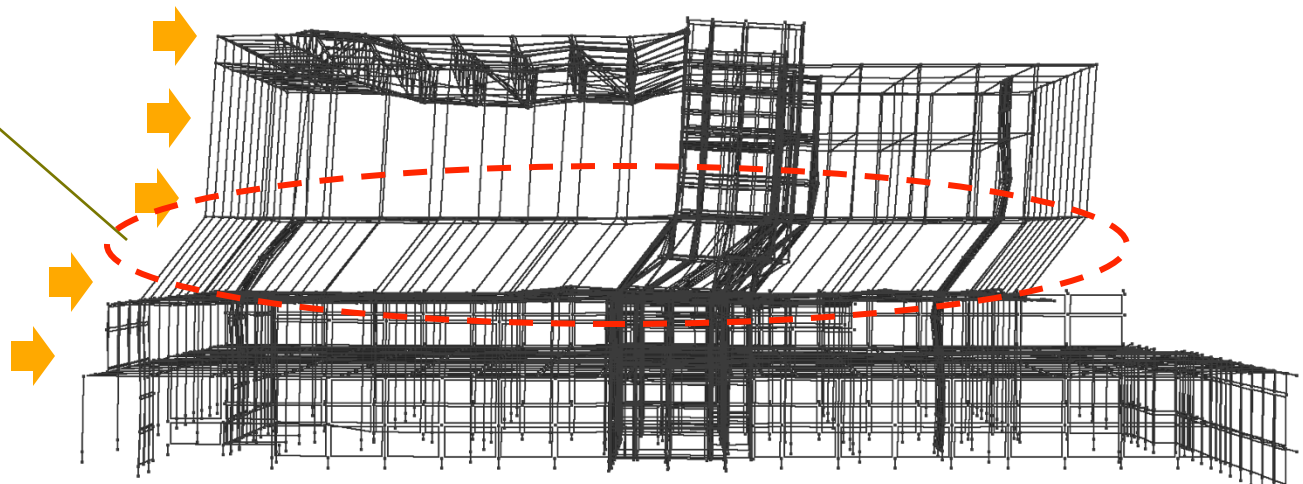
SECTION

PEER

Concrete Retrofit Needs
FRP on Shear Wall

- Collectors
  - Concrete, steel, FRP
  - Strain compatibility

- FRP on shear walls

- Guidance on modeling in commonly used software

THROUGHLY CLEAN AND ROUGHEN EXISTING CONCRETE SURFACE TO BE IN CONTACT WITH NEW CONCRETE

DRILLED DOWELS
Size and number to meet collector demand.

LONGITUDINAL COLLECTOR REINFORCING BARS

STANDARD HOOKS

POUR HOLES
Use for consolidation access. Do not cut any existing diaphragm rebar.

EXISTING CONCRETE SLAB/DIAPHRAGM

NEW REINFORCED CONCRETE COLLECTOR

CAPPED STIRRUP TIES

INTERMEDIATE HAIRPIN CROSSTIES

SECTION

PEER

UC Berkeley MLK Student Union

Excessive shear strain of several walls above Third Story

Concrete Retrofit Needs
FRP on Shear Wall

FORM CURVED CHAMFER WITH EPOXY RESIN PUTTY

EXISTING FLOOR

TYPICAL FIBER ANCHOR

FRP OVERLAY

EXISTING CONCRETE HEADER

ROUND CORNER (TYP.)

FRP AT WALL HEADER — A2

EXTEND FRP AROUND END OF WALL

EXISTING CONCRETE WALL

FIBER ANCHOR

PLAN SECTION — A1

A2

FLOOR SLAB

FRP OVERLAY AT HEADER WITH FIBERS ORIENTED VERTICALLY

FRP OVERLAY WITH FIBERS ORIENTED HORIZONTALLY

A1

OPENING

PERPENDICULAR WALL

PERPENDICULAR WALL (WHERE OCCURS)

FLOOR SLAB OR FOOTING

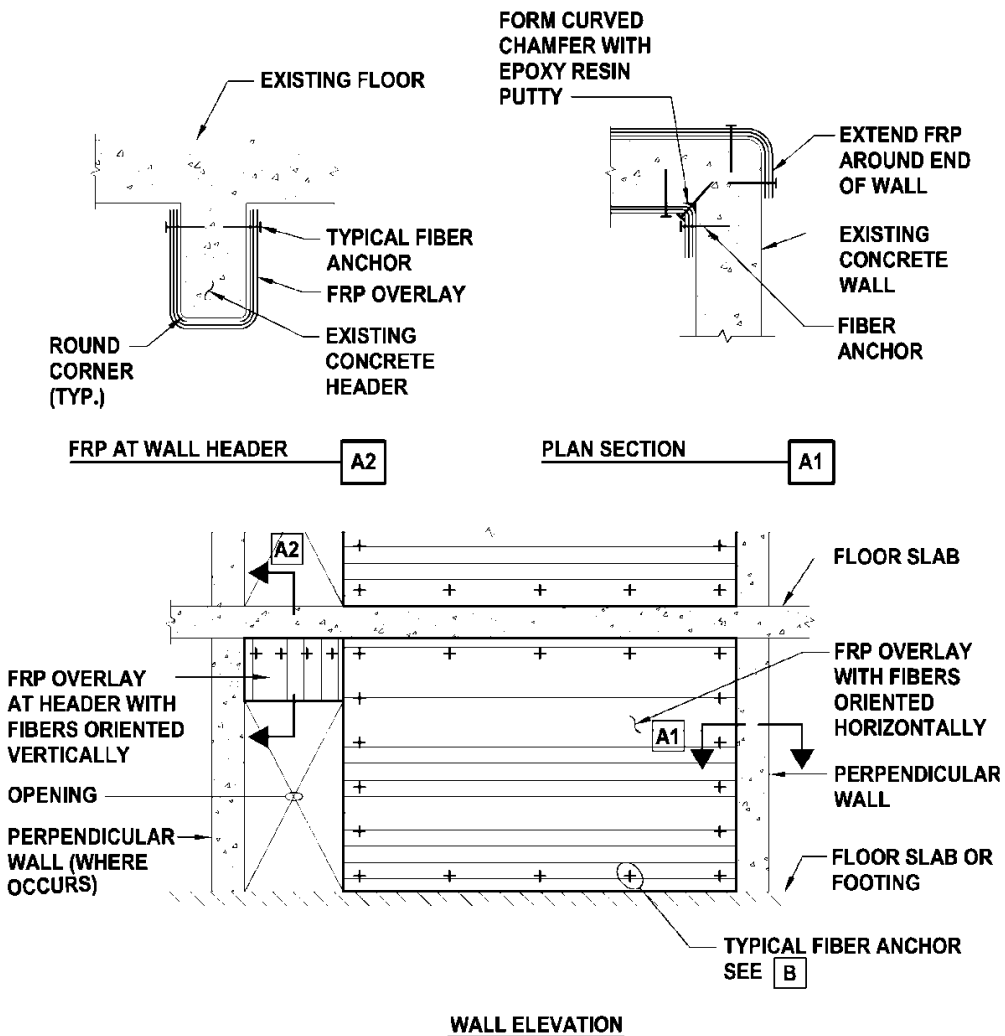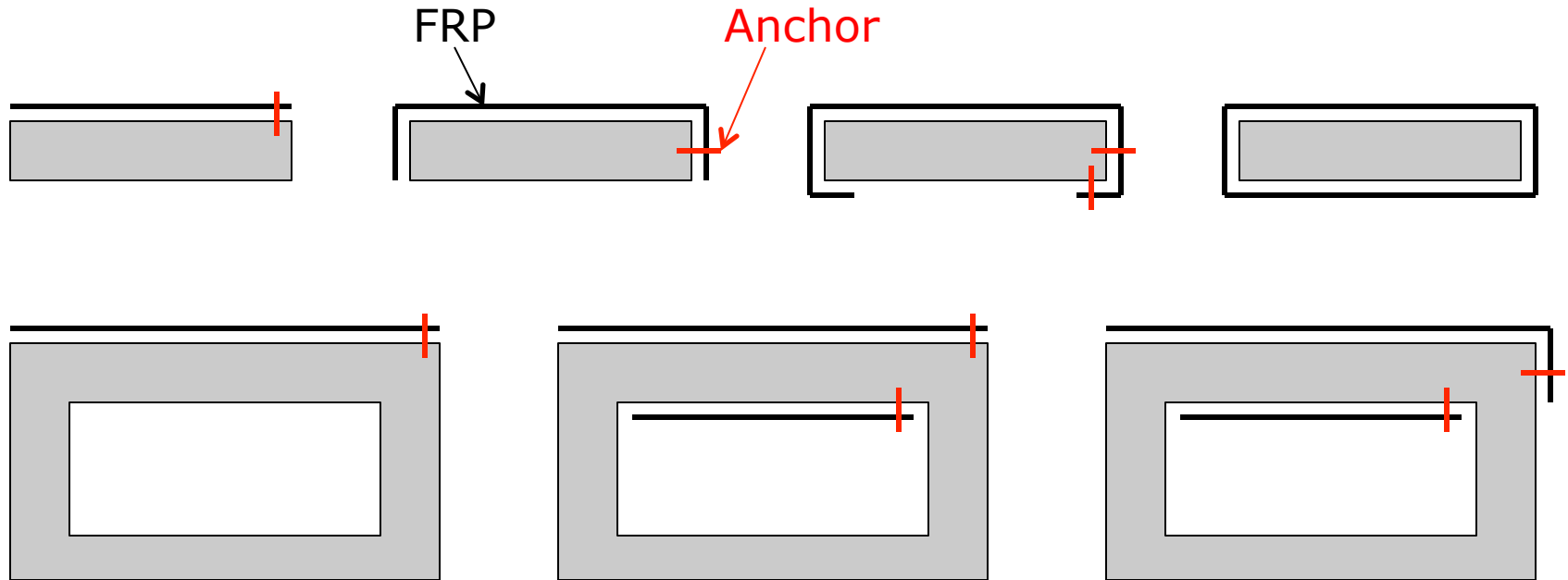TYPICAL FIBER ANCHOR SEE B

WALL ELEVATION

Photo by Rutherford+Chekene

Note: Taking shear "around corner" (wall to slab, or slab to wall) creates large pull-away tension force at corner that must be resisted.
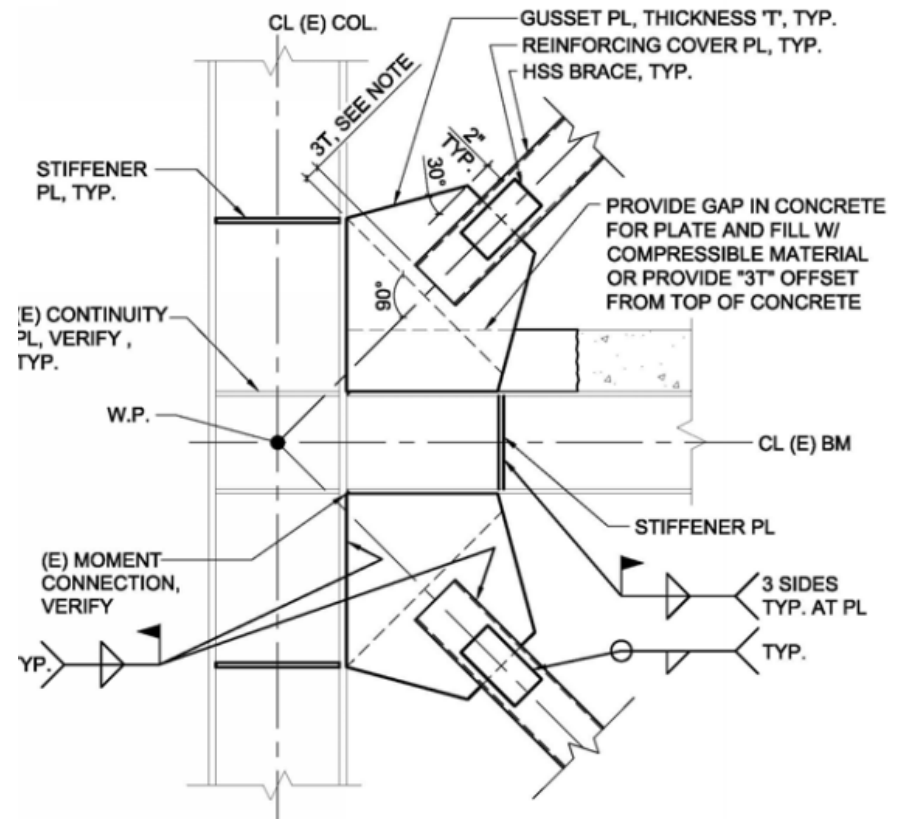
Concrete Retrofit Needs
FRP on Shear Wall: Capacity Variations

FRP

Anchor

- Whether to anchor
- Type of returns
- Type of anchor
- Spacing of anchors

PEER

Steel Retrofit Needs

- Adding a braced frame to an existing moment frame

- Adding a concrete wall to a moment frame

- Adding cover plates or boxing of existing members

CL (E) COL.

GUSSET PL, THICKNESS 'T', TYP.
REINFORCING COVER PL, TYP.
HSS BRACE, TYP.

3T, SEE NOTE

2" TYP.

30°

STIFFENER PL, TYP.

PROVIDE GAP IN CONCRETE FOR PLATE AND FILL W/ COMPRESSIBLE MATERIAL OR PROVIDE "3T" OFFSET FROM TOP OF CONCRETE

90°

(E) CONTINUITY PL, VERIFY, TYP.

W.P.

CL (E) BM

(E) MOMENT CONNECTION, VERIFY

STIFFENER PL

3 SIDES TYP. AT PL

YP.

TYP.

Note:
AISC recommends 2T to allow for restraint-free plastic rotations. 3T is shown here to accomodate overcutting of HSS slots.
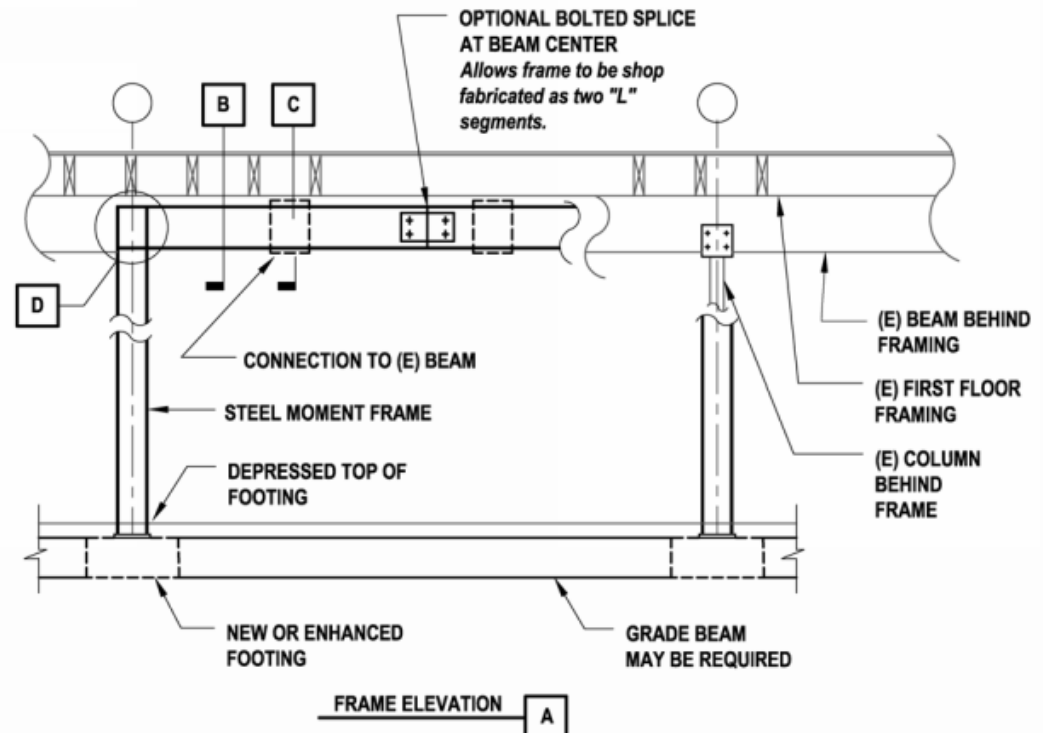
PEER

Steel Retrofit Needs

- Adding collector in concrete fill on metal deck

- Enhancing connection of column to footing

- Enhancing column splices

- Converting gravity frame to moment frame
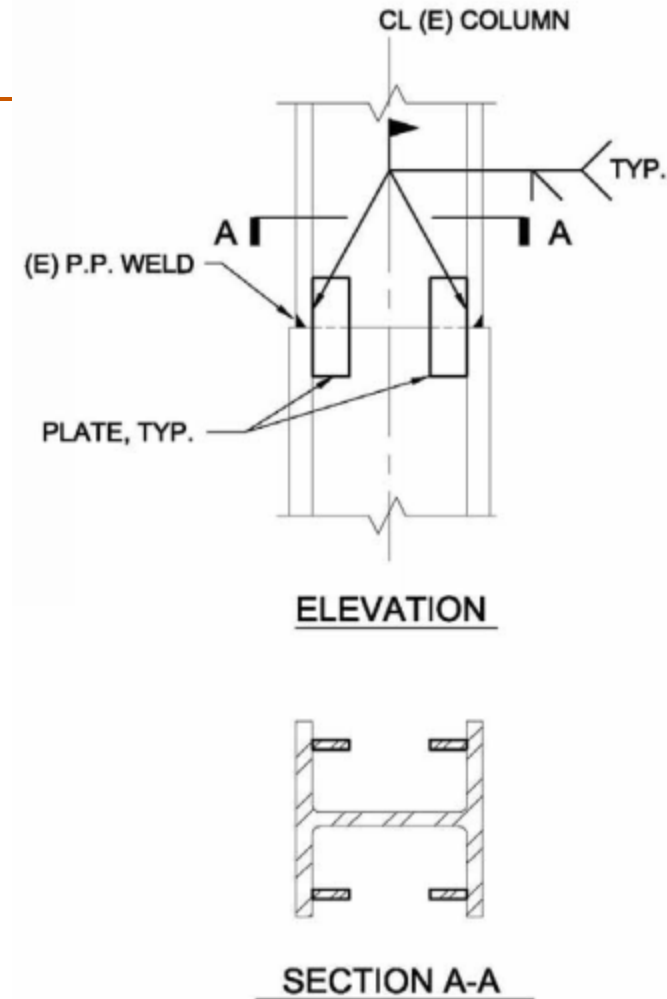
Wood Retrofit Needs

- Collectors
  - Flexibility
  - Weak link

- Bracing of steel moment frame retrofits
  - Is it needed?
  - Wood floor stiff enough?

OPTIONAL BOLTED SPLICE AT BEAM CENTER
Allows frame to be shop fabricated as two "L" segments.

B   C

D

CONNECTION TO (E) BEAM

STEEL MOMENT FRAME

DEPRESSED TOP OF FOOTING

NEW OR ENHANCED FOOTING

(E) BEAM BEHIND FRAMING

(E) FIRST FLOOR FRAMING

(E) COLUMN BEHIND FRAME

GRADE BEAM MAY BE REQUIRED

FRAME ELEVATION   A

PEER

Discussion

PEER