

## 8-3. Test Work

### Summary of Test Work

Table Summary of retrofit methods executed by "Test work"

	Retrofit method	Outline of each method
1	Concrete jacketing on column	Concrete jacketing on existing RC column (concreting after re-bar work, mortar grouting at the top of column) and increase strength and ductility of column (an example of column with beam only and without floor slab)
2	RC shear wall	An open frame was filled by reinforced concrete (RC walls) to increase strength. Post-installed anchors were installed on existing frame and reinforcing bars were provided.
3	RC wing wall	RC wing wall is provided on existing column to increase strength
4	Steel braced frame	Steel frame braces were inserted into the existing RC frame to increase strength. Post-installed anchors were installed on a frame and mortar grout was filled with bolted steel framed brace. This method was provided on a frame with window and other portion
5	Carbon fibre sheets wrapping	Existing column in buildings were jacketed with carbon fibre sheets to improve ductility. Mortar finishing was provided.
6	Slits on brick standing wall	Slits (crevices) were established between columns and attached standing walls, to prevent forming short column and to improve ductility of existing column. Steel angle member is provided on brick wall to prevent overturning. (This method will be used for evaluation overall structure and this method is not necessary recommended).
7	External steel braced frame	Steel framed bracing was installed at outside of frame so that existing windows are maintained. There are two methods, direct connection using anchor bolts, and indirect connection using grout mortar for embedded bolt and studded steel frame. Structural consideration for eccentricity is necessary.
8	Concrete jacketing on RC column (up to the bottom of floor slab)	Concrete jacketing on existing RC column up to the floor slab (concreting after re-bar work and mortar grouting at the top) to increase strength and ductility (an example in case floor slab exist).
9	Concrete jacketing on beam	Concrete jacketing on existing RC beam (concreting after re-bar work and mortar grouting at the top) to increase strength and ductility.
10	New beam on floor slab	New RC beam was provided under existing beam. Mortar grouting was provided at the top after concreting. There are many existing buildings without beams.



Column jacketing  
(Re-bar work  
and concreting  
after removal  
of finishing  
mortar)

1) Column jacketing



Chemical anchor,  
Grout mortar  
Existing column  
RC shear wall

2) RC shear wall



RC wing wall  
Existing column

3) RC wing wall



Chemical anchor,  
Grout mortar  
Steel braced  
frame  
Existing column

4) Steel bracing



Carbon sheet  
wrapping  
Mortar finish

5) Carbon fiber wrapping



Structural slit  
Reinforcement  
by steel angle  
member

6) Seismic slit on brick standing wall



Anchor bolts, grout mortar

Framed steel bracing

7) External framed steel bracing



Existing floor slab,  
Grout mortar at the  
top of column

Jacketing on  
existing beam

Jacketing on  
existing column

8) Concrete jacketing on existing column

9) Concrete jacketing on existing beam



Existing floor slab

New beam, grout mortar at the top

10) New beam under floor slab

Figure Construction methods of Test Work

(Construction sequence is shown by exposing each steps of construction such as anchoring, re-bar work, concreting, and mortar grouting etc.)



## Retrofitting Test Works by CNCRP

Md. Sohel Rahman  
Executive Engineer  
PWD Design Division-4  
and  
Team Leader, Component 3  
CNCRP Project

### Why Retrofitting Test Work



To know about

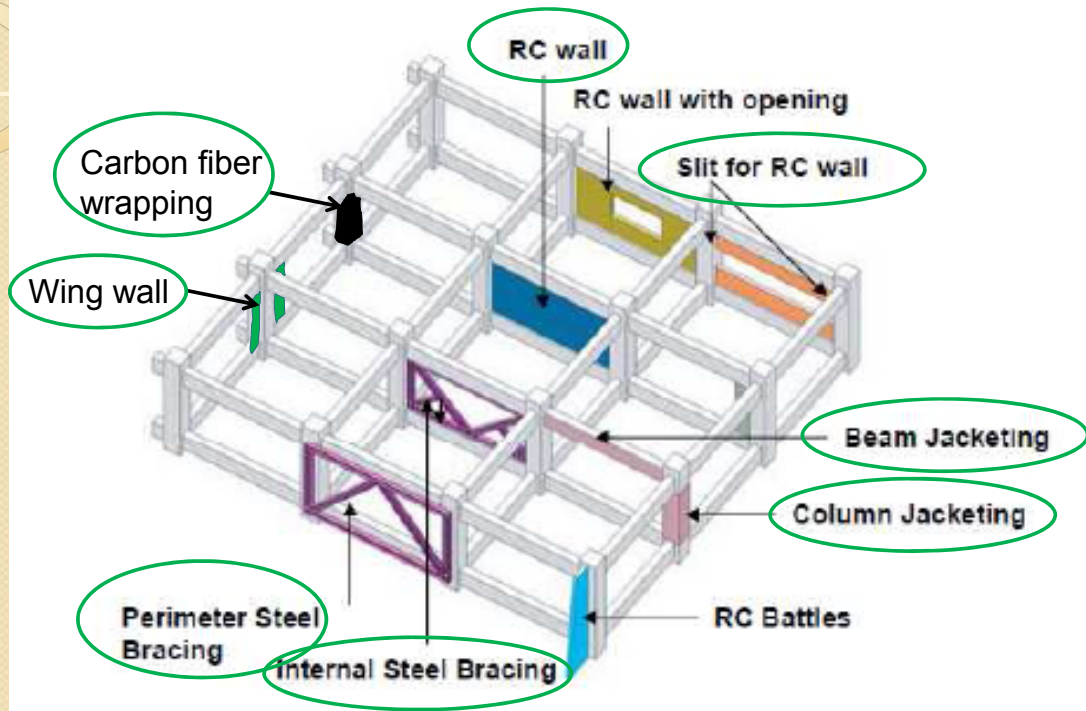
- **Material availability** in Bangladesh.
- **Cost** of each proposed retrofitting method.
- **Construction Time** and progress.
- **Difficulties** of construction.
- **Quality control** at the site.

And finally to find

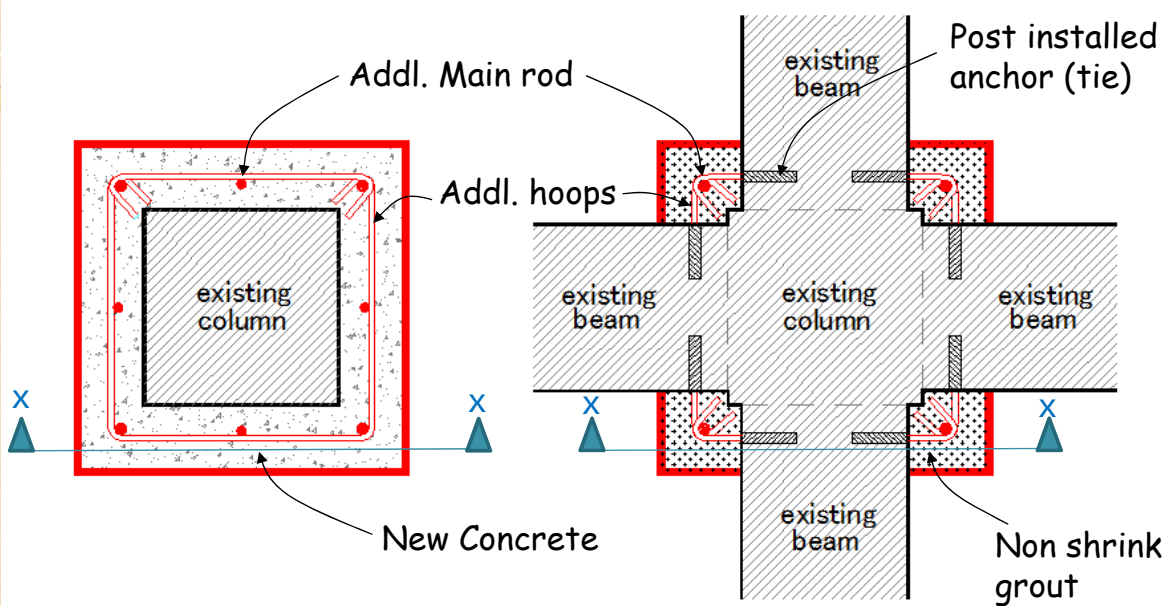
- **Cost Effective retrofitting methods** suitable for Bangladesh.



# Methods of Retrofitting



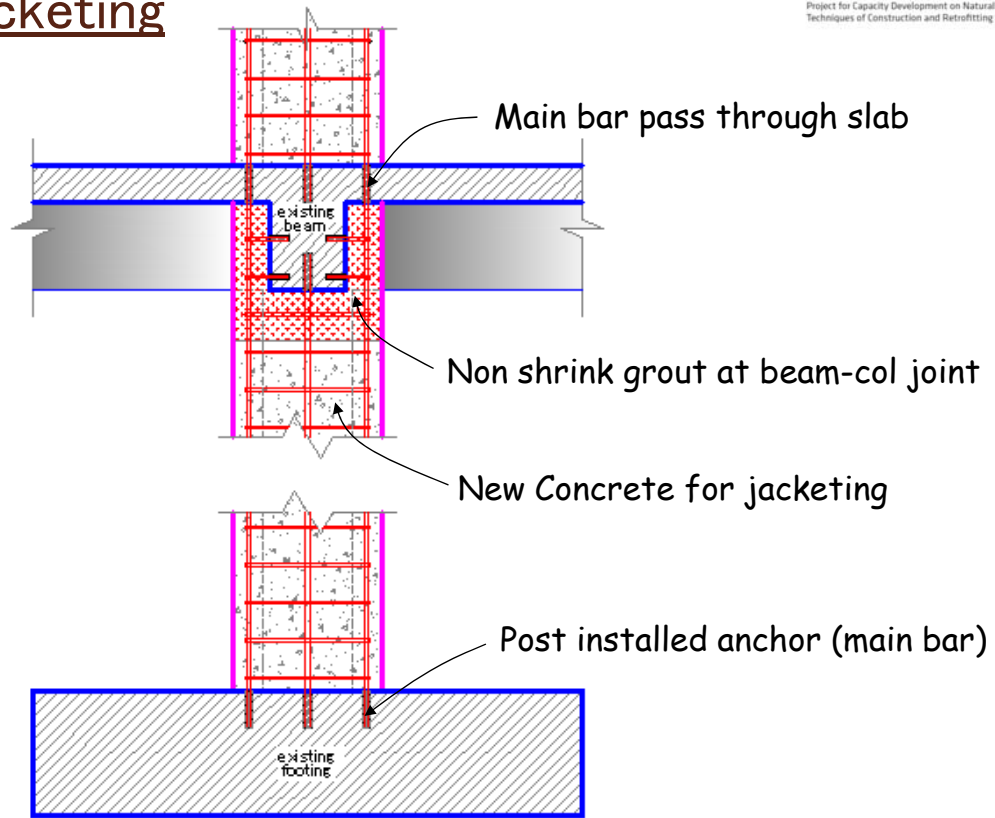
# Retrofitting with Column Jacketing



Section of column at mid span

Section of column at beam-col joint

# Retrofitting with Column Jacketing



Section of column jacketing

# Retrofitting with Column Jacketing



RC Column Jacketing through beam-col joint

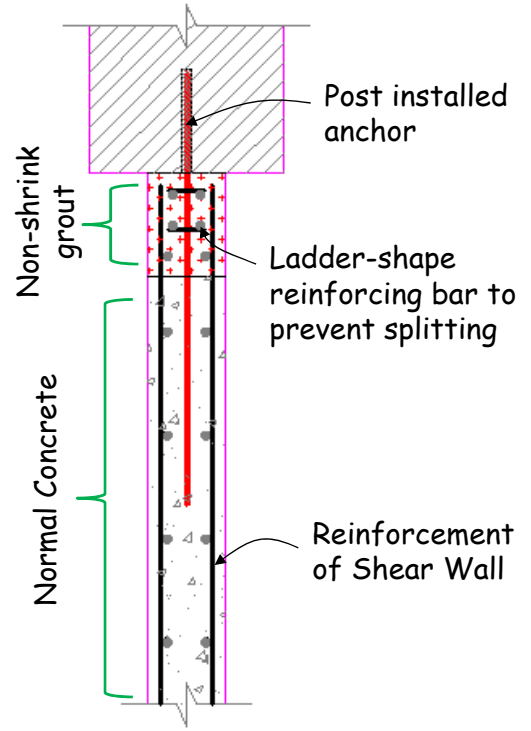
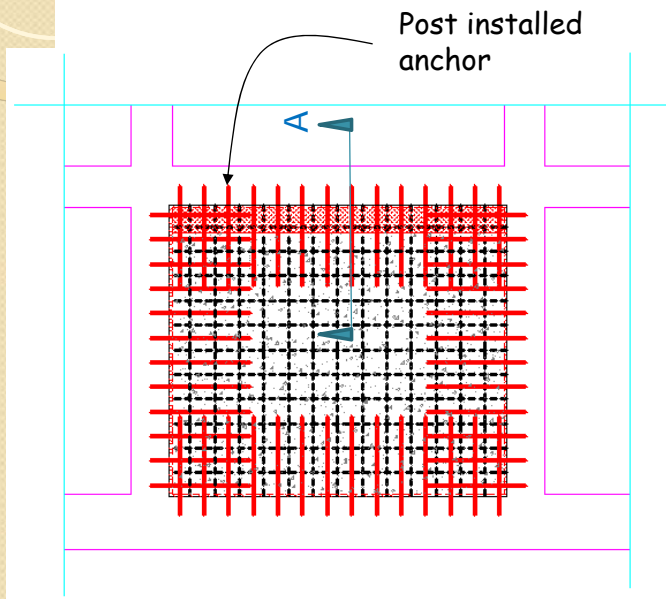
RC Column Jacketing



Test Work of CNCRP in 2012

Test Work of CNCRP in 2013

# Retrofitting with Shear Wall



# Retrofitting with Shear Wall

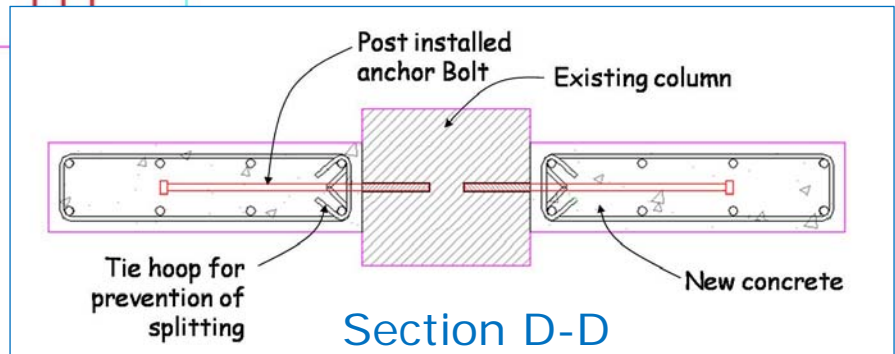
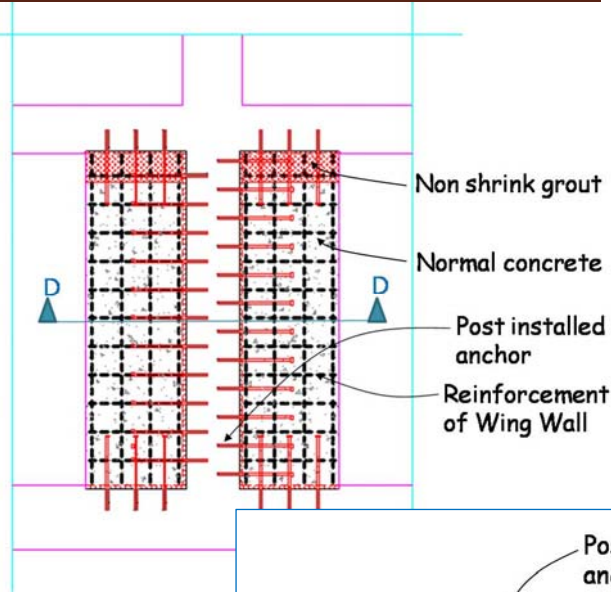
Providing RC Shear Wall in a open frame



Test Work of CNCRP in 2012



# Retrofitting with Wing Wall



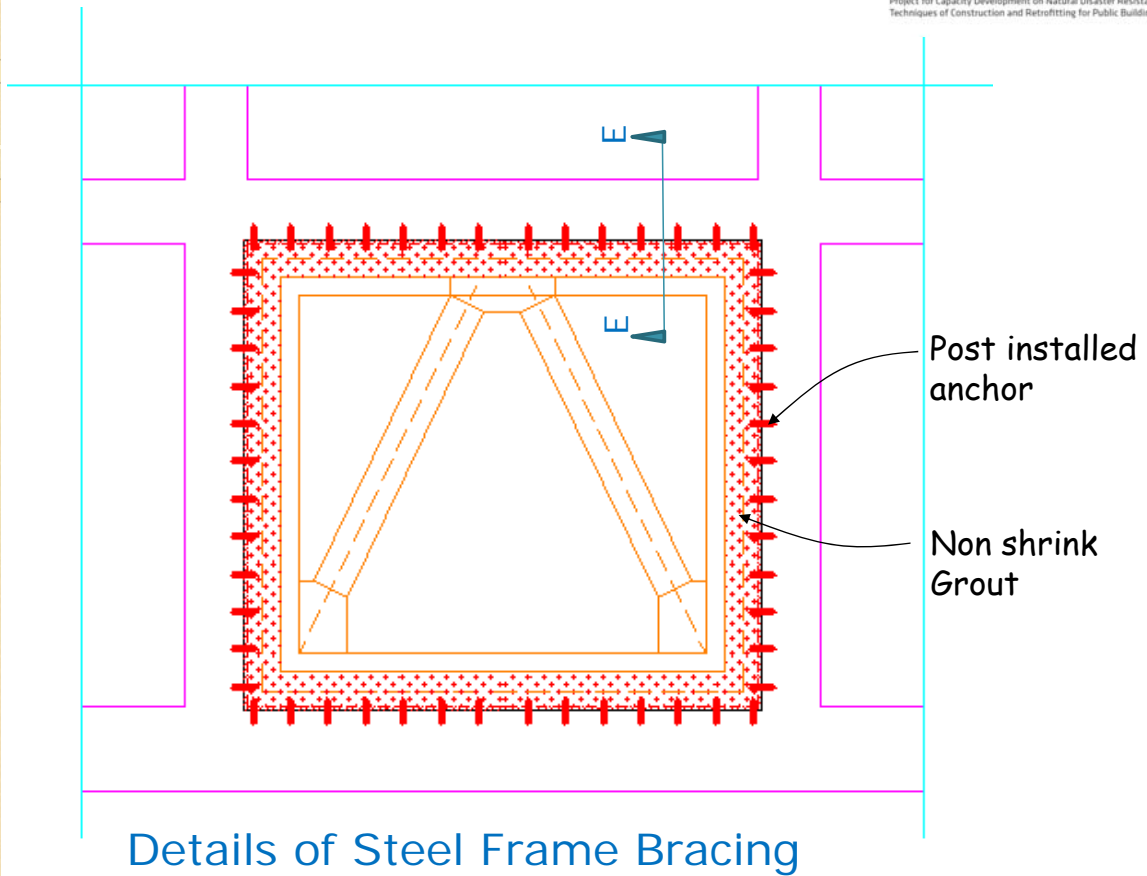
# Retrofitting with Wing Wall



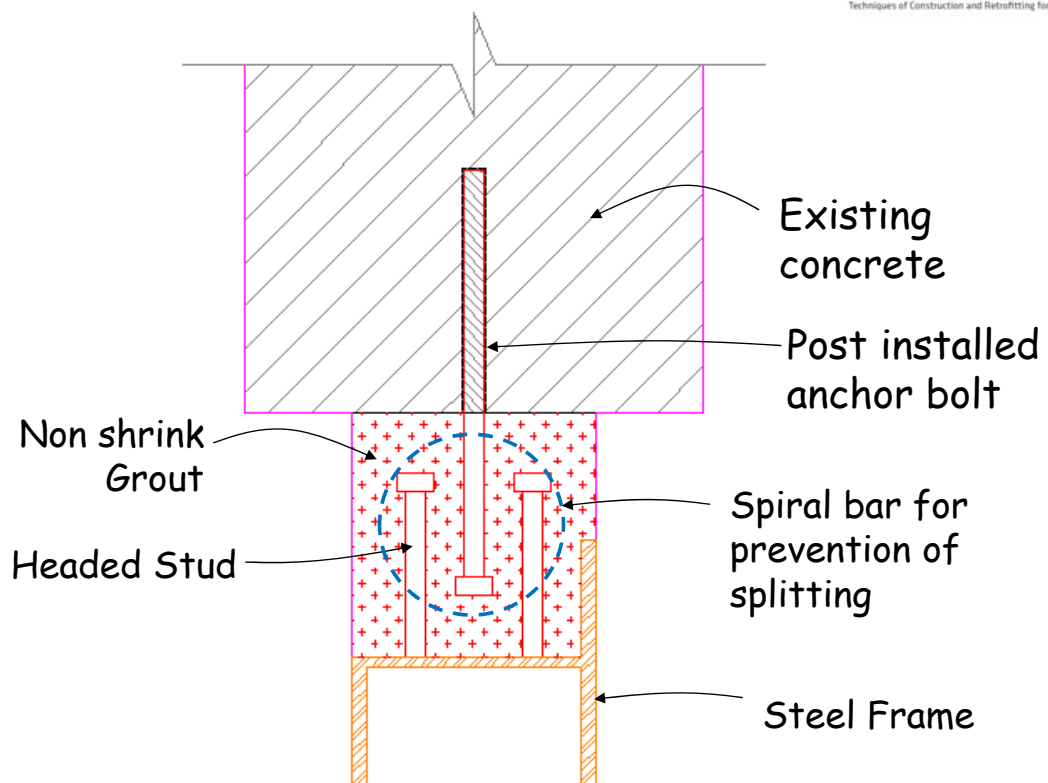
RC Wing Wall  
Provided at an  
existing column

Test Work of CNCRP in 2012

# Retrofitting with Steel Frame

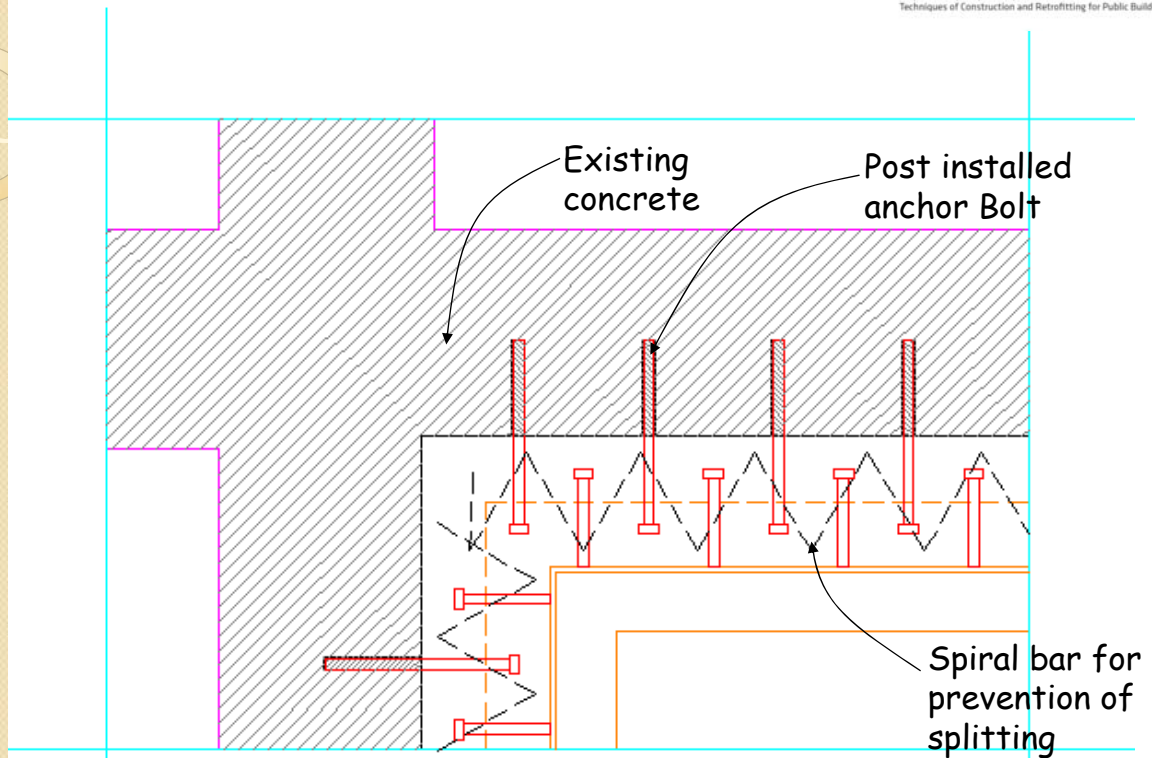


# Retrofitting with Steel Frame



Section E-E

# Retrofitting with Steel Frame



Detail of spiral bar

# Retrofitting with Steel Frame



Internal Steel  
Frame Bracing

Test Work of CNCRP in 2012



Connection Details, Test Work 2012

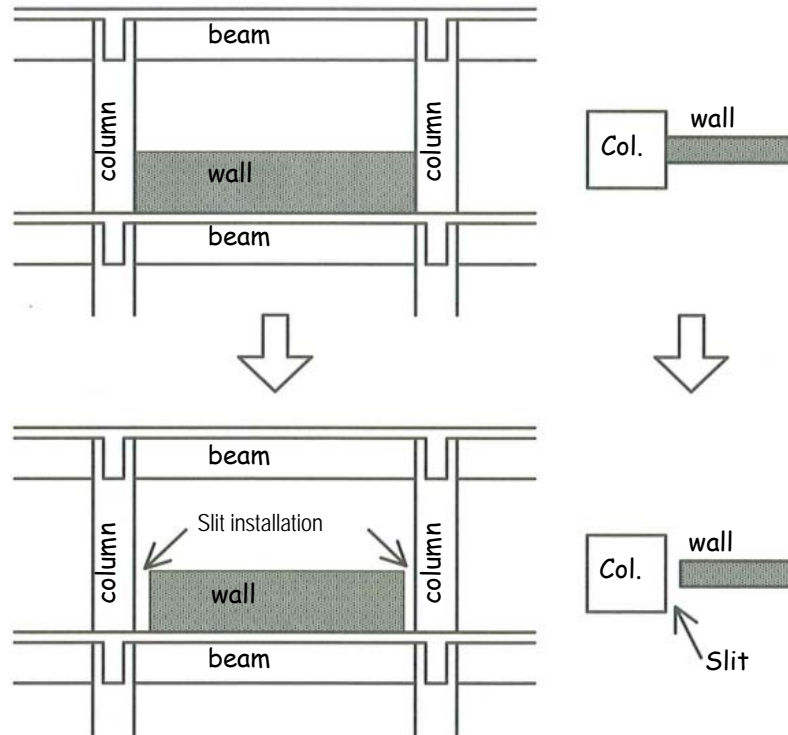
External Steel  
Frame Bracing



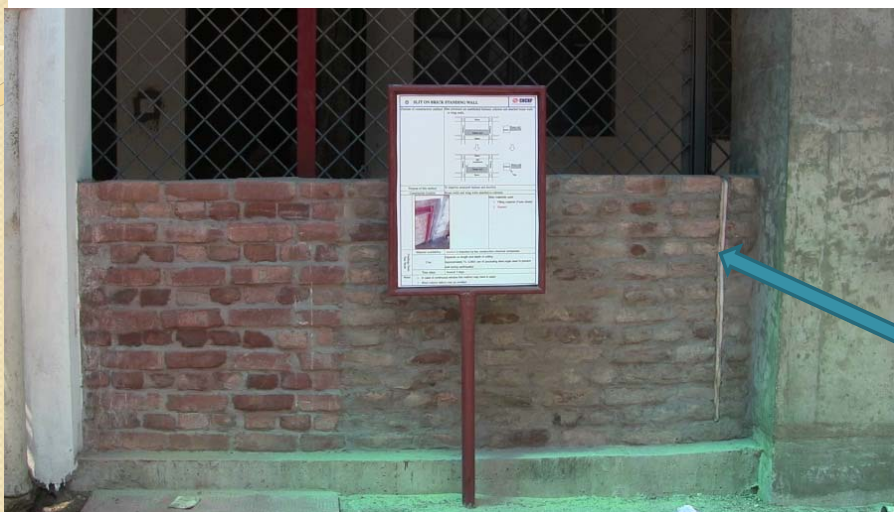
Test Work of CNCRP in 2013



# Retrofitting with Structural Slit



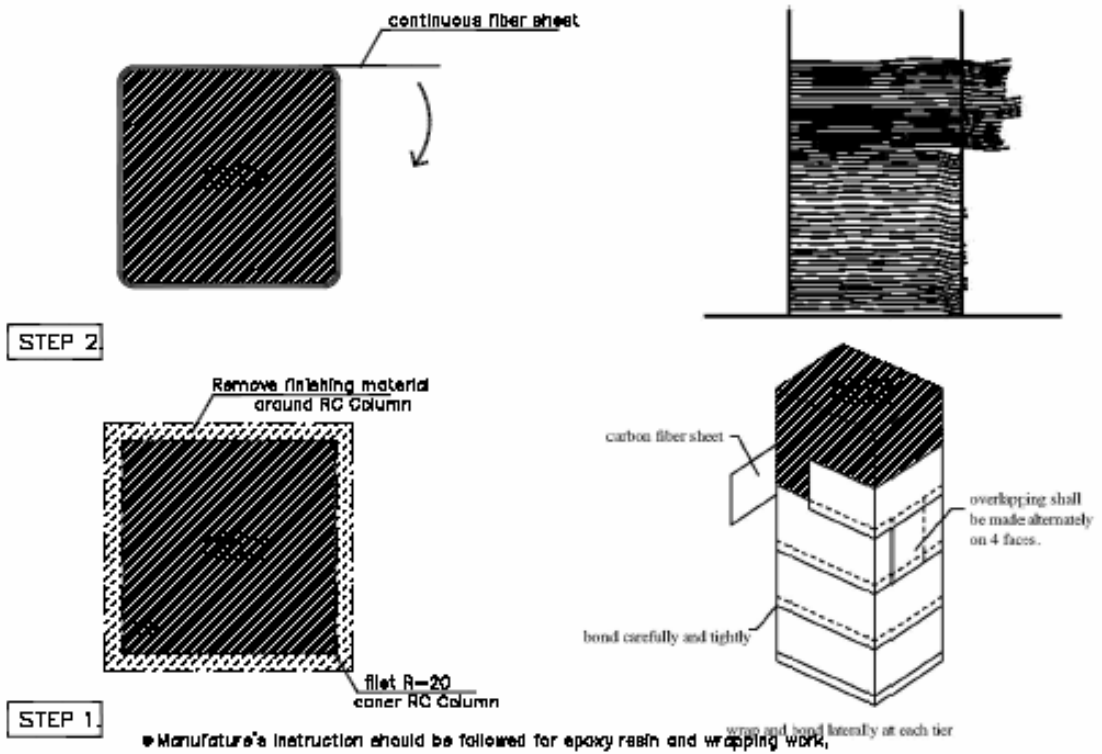
# Retrofitting with Structural Slit



Seismic Slit is provided at a brick wall

Test Work of CNCRP in 2012

# Carbon fiber sheet wrapping



# Carbon fiber sheet wrapping



Carbon Fiber Wrapping

Test Work of CNCRP in 2012



# Carbon fiber sheet wrapping

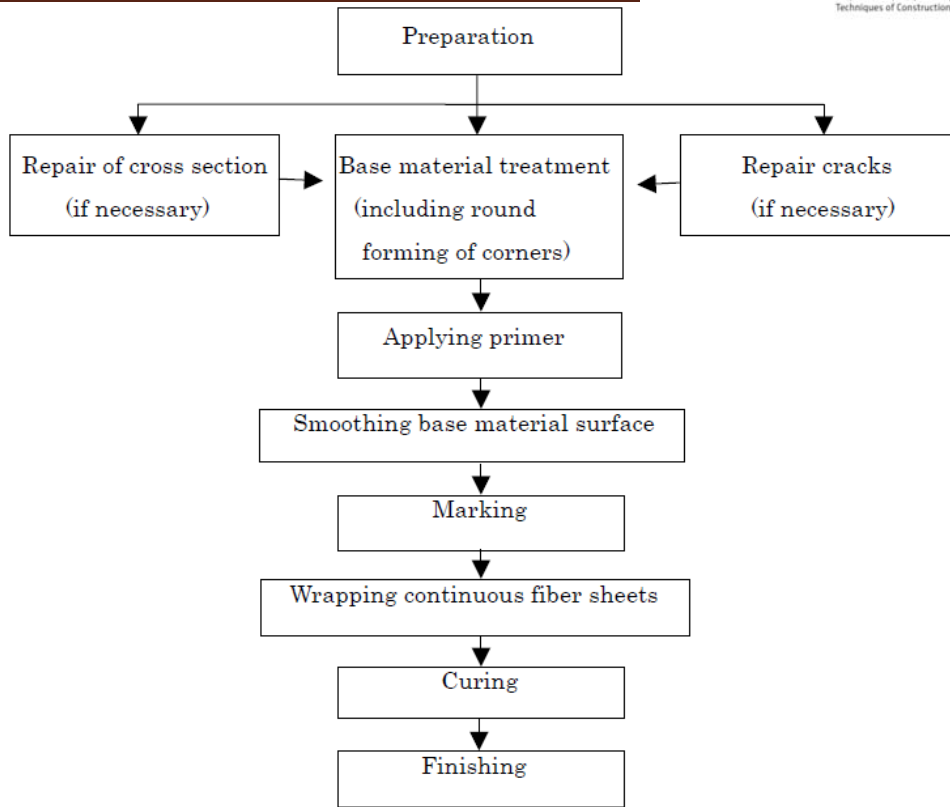
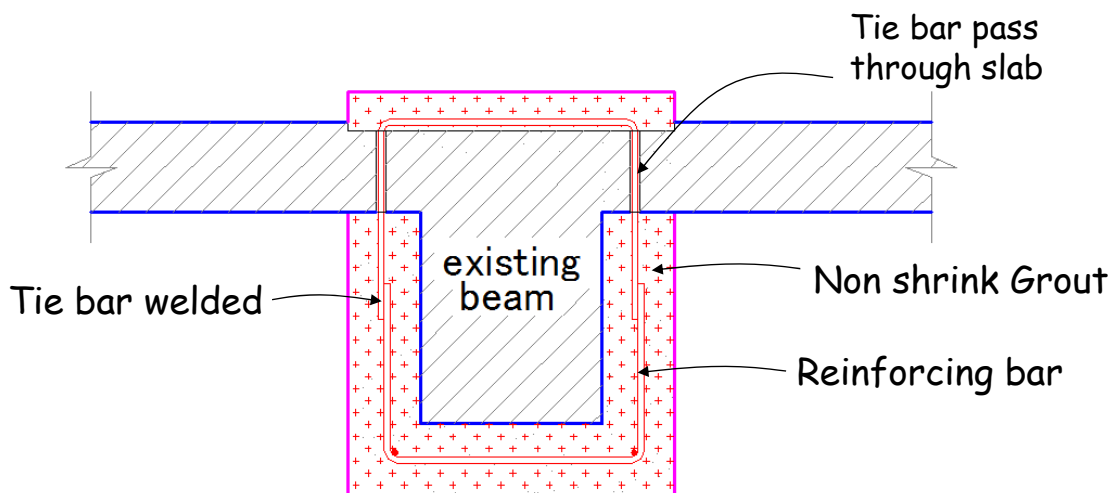


Figure 4.9-1 Flow of standard construction procedure

# Retrofitting with Beam Jacketing



Typical Detail of Beam Jacketing

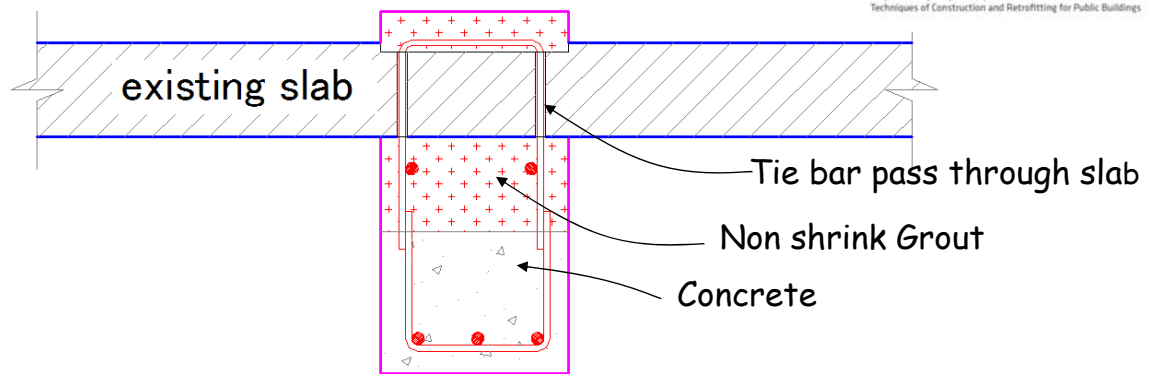
# Retrofitting with Beam Jacketing

RC Beam  
Jacketing

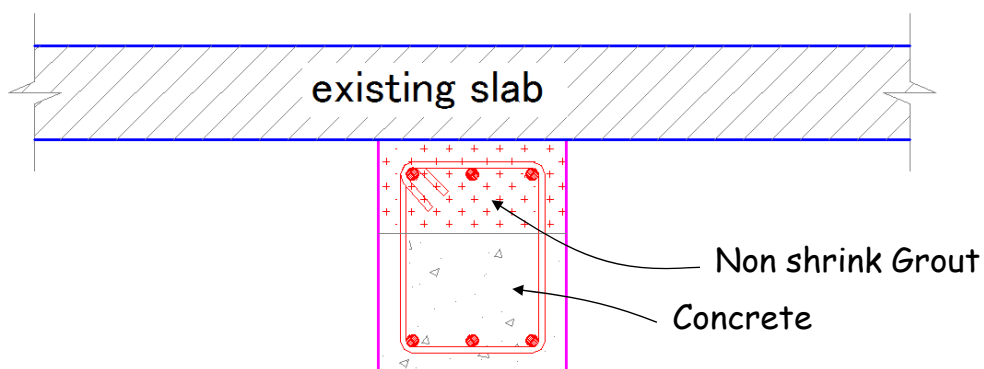


Test Work of CNCRP in 2013

# Retrofitting with Beam Insertion



Typical Detail of Beam Insertion (Option-1)



Typical Detail of Beam Insertion (Option-2)

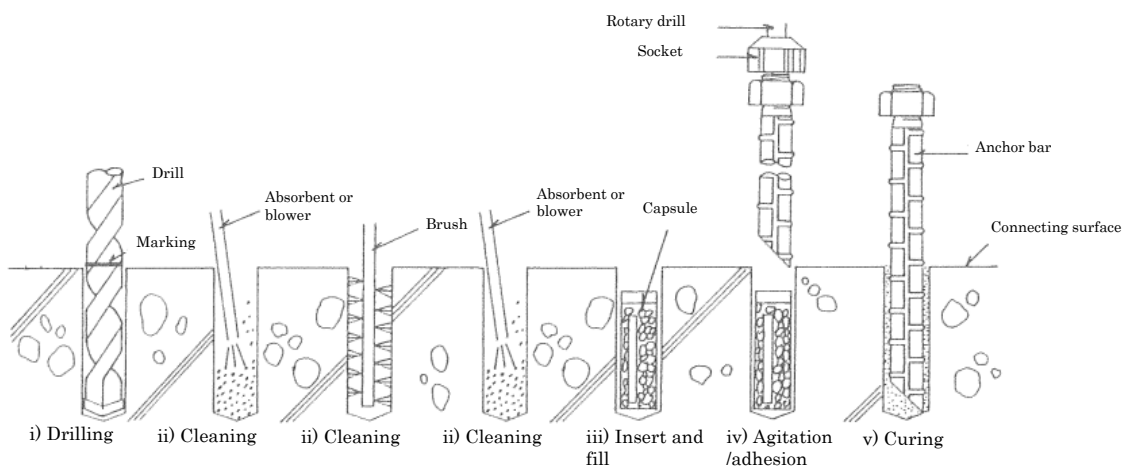
# Retrofitting with Beam Insertion

Beam is inserted  
below existing slab



Test Work of CNCRP in 2013

# Post-Installed Anchor Work





## Post-Installed Anchor Work



## Pressurized Grouting Work



- 9 different retrofitting methods has been performed as 'Test Work' in the last 2 years.
- More Test Work will be done in the coming year.
- An actual retrofitting work will be done as 'Pilot Work'

**Thank you very much**



**1<sup>st</sup> Year Test Work**  
**6 methods**

**JICA EXPERT TEAM (JET)  
COUNTER PART : PUBLIC WORKS DEPARTMENT (PWD)**

**THE PROJECT FOR CAPACITY DEVELOPEMENT  
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IN  
THE PEOPLE'S REPUBLIC OF BANGLADESH**

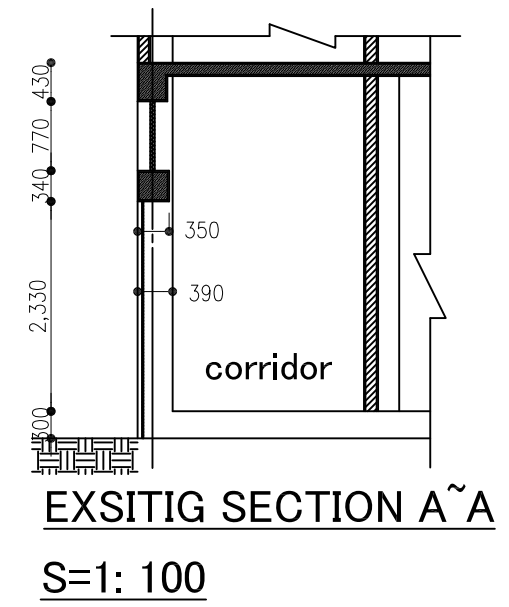
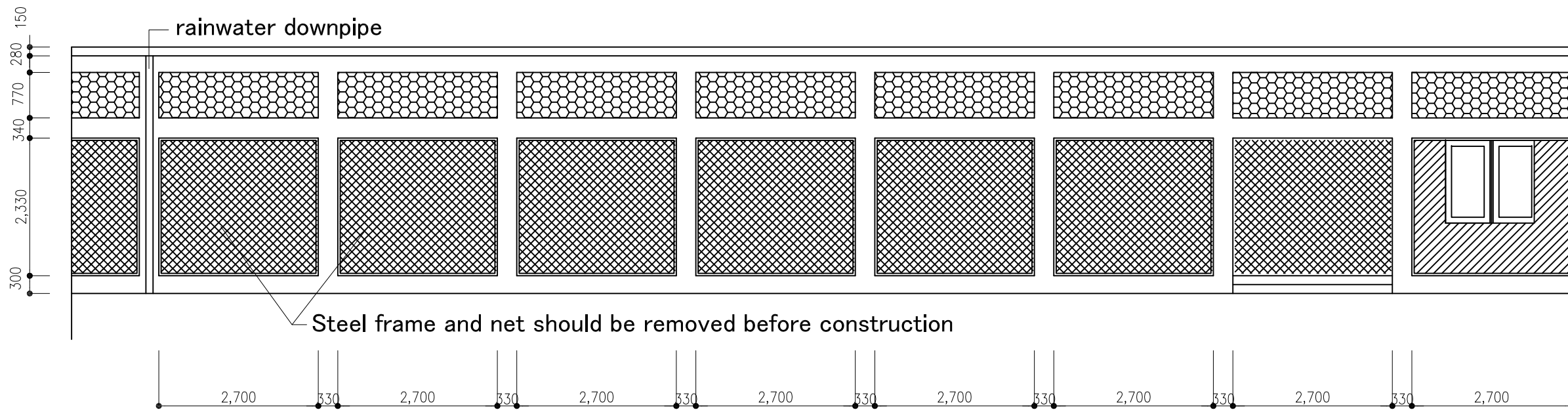
**DRAWINGS  
FOR  
TEST WORKS**

**NOVEMBER, 2011**

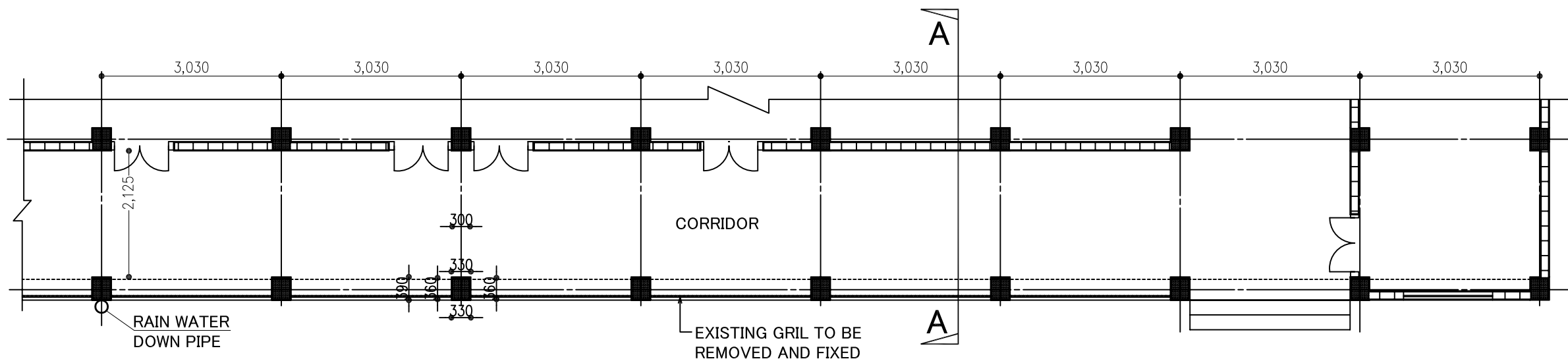
**OYO INTERNATIONAL CORPORATION**

**MOHRI ARCHIECT & ASSOCIATES. INC  
AND**

**PUBLIC WORKS DEPARTMENT (PWD)**

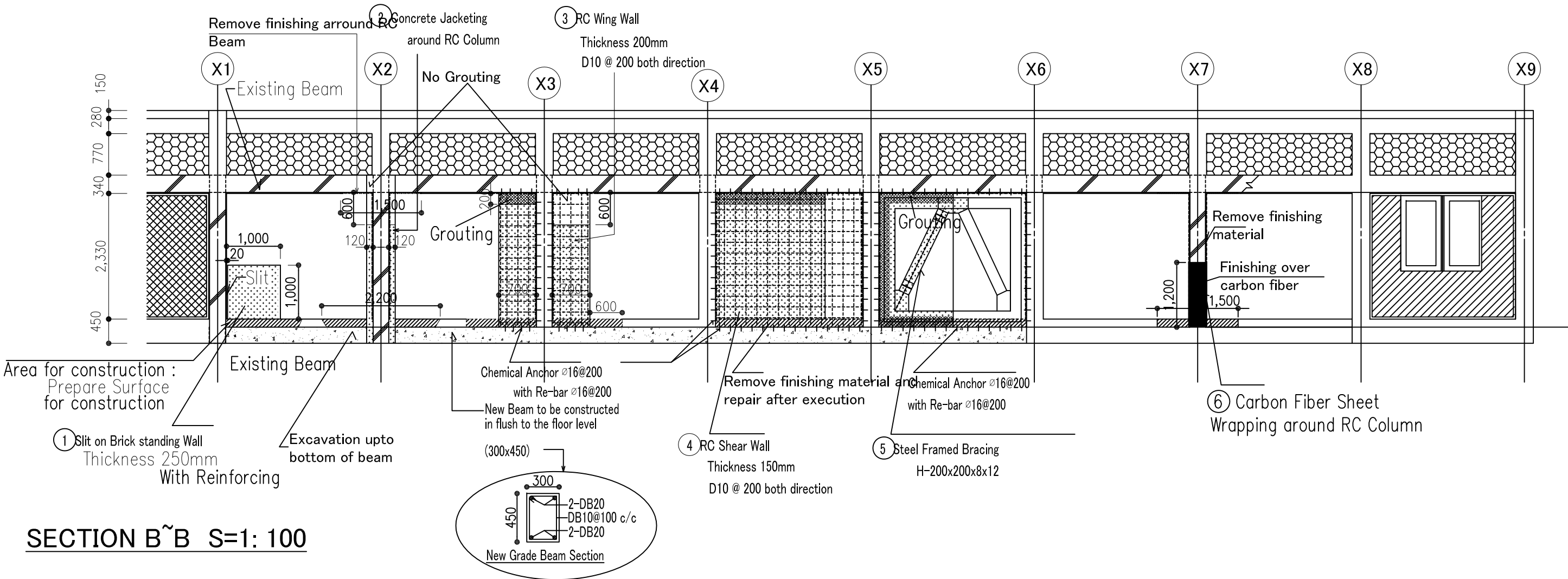


**EXSITIG ELEVATION S=1: 100 ( ONLY GROUND FLOOR SHOWN)**

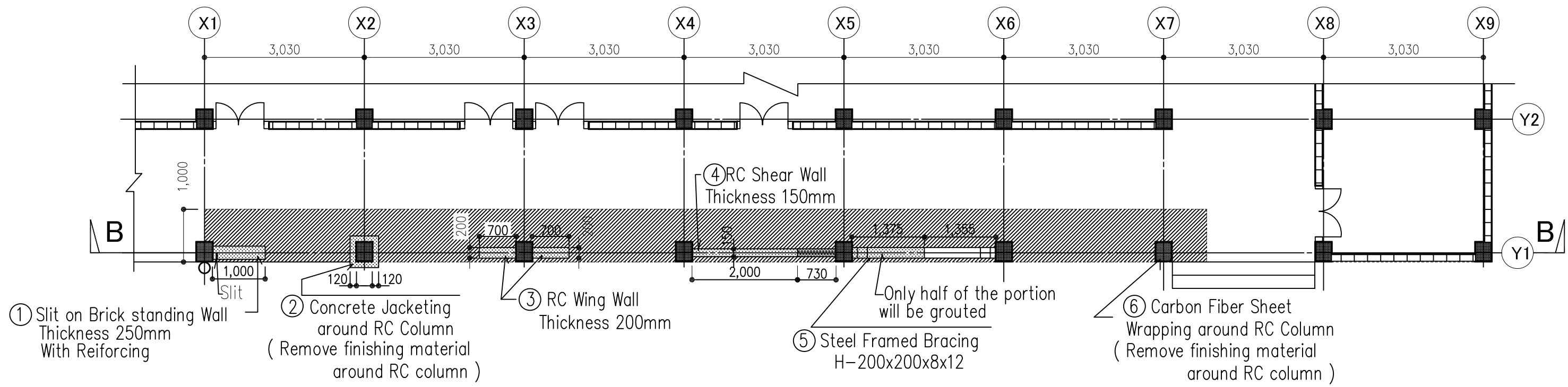


**EXSITIG PLAN S=1: 100**

CONSULTANT : OYO INTERNATIONAL CORPORATION and MOHRI ARCHITECT & ASSOCIATES. INC	PROJECT : THE PROJECT FOR CAPACITY DEVELOPMENT ON NATURAL DISASTER-RESISTANT TECHNIQUES OF CONSTRUCTION AND RETROFITTING FOR PUBLIC BUILDINGS IN THE PEOPLE'S REPUBLIC OF BANGLADESH	AGENCY : JICA EXPERT TEAM (JET) C/P : PUBLIC WORKS DEPARTMENT (PWD)	DATE	DRAWING TITLE	SCALE	DRAWN	NO.
				EXSITIG WARE HOUSE PLAN AND SECTION	1:100	JET	D - 1/8



**SECTION B~B S=1: 100**

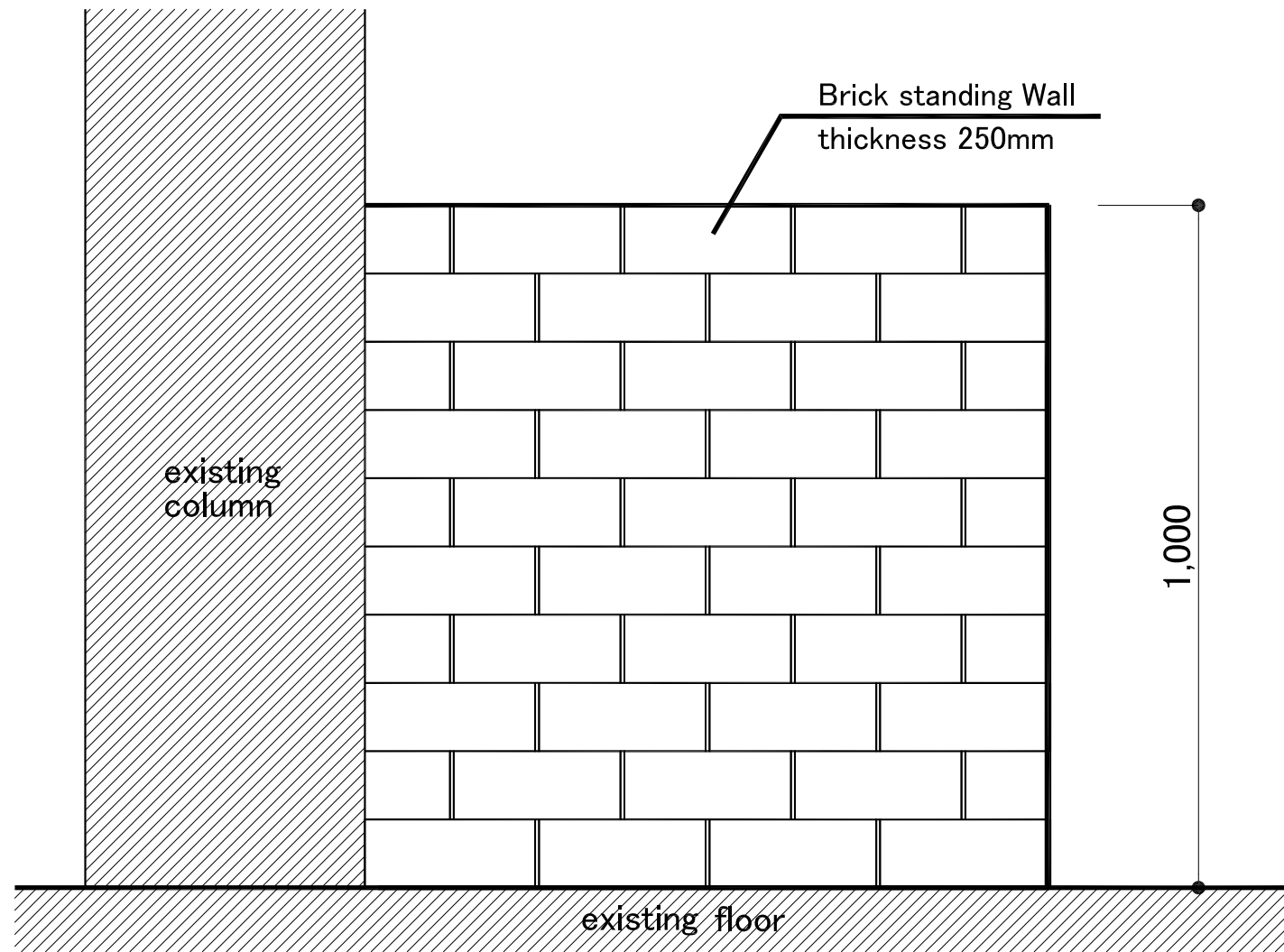


**EXECUTION PLAN S=1: 100**

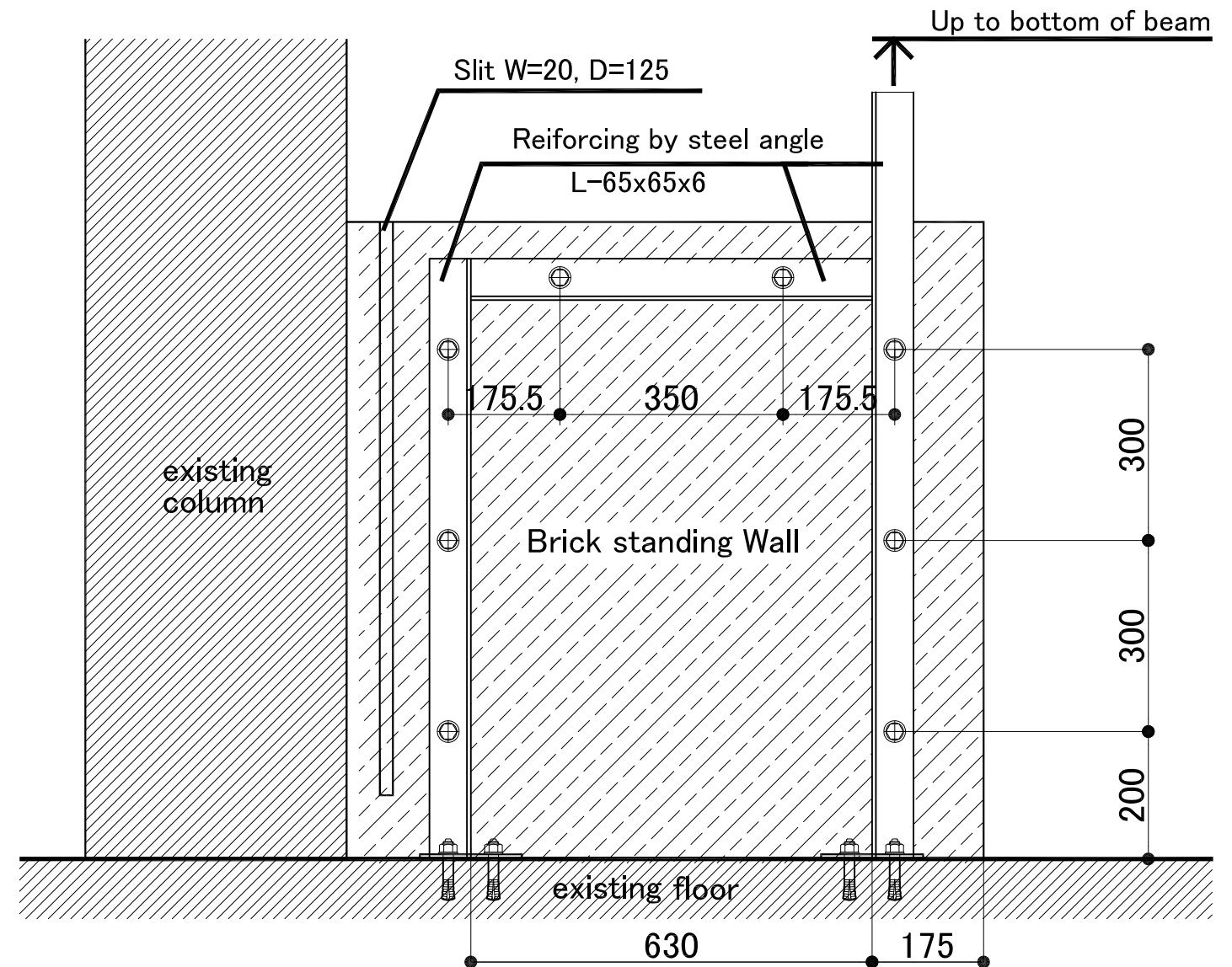
① Slit on Brick standing Wall

Thickness 250mm

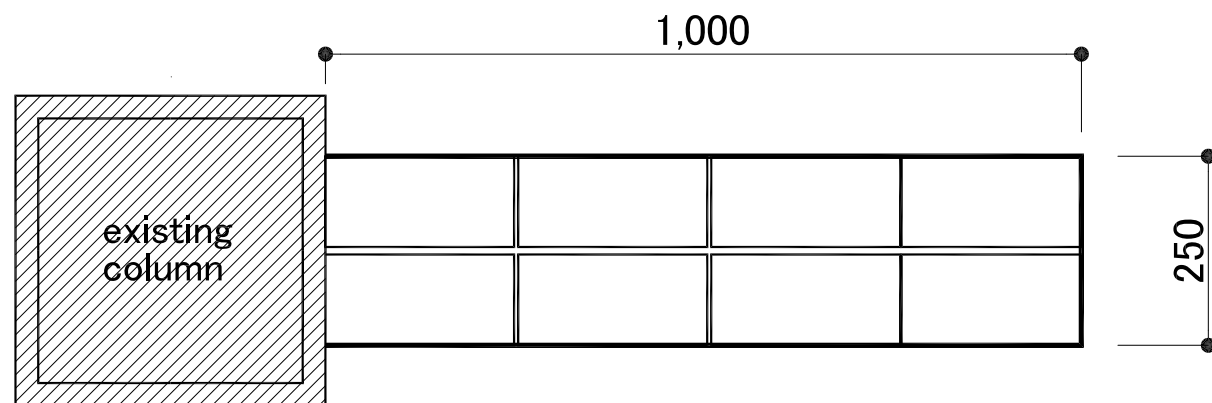
With Reinforcing



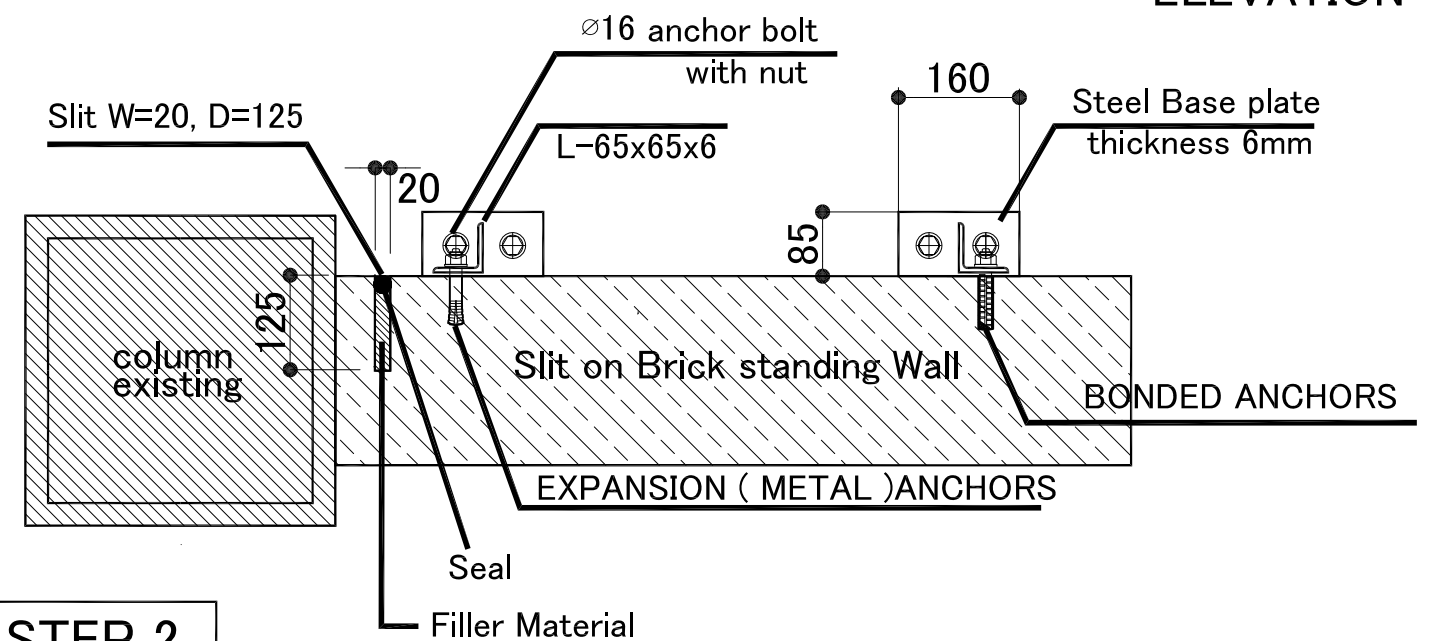
ELEVATION



ELEVATION



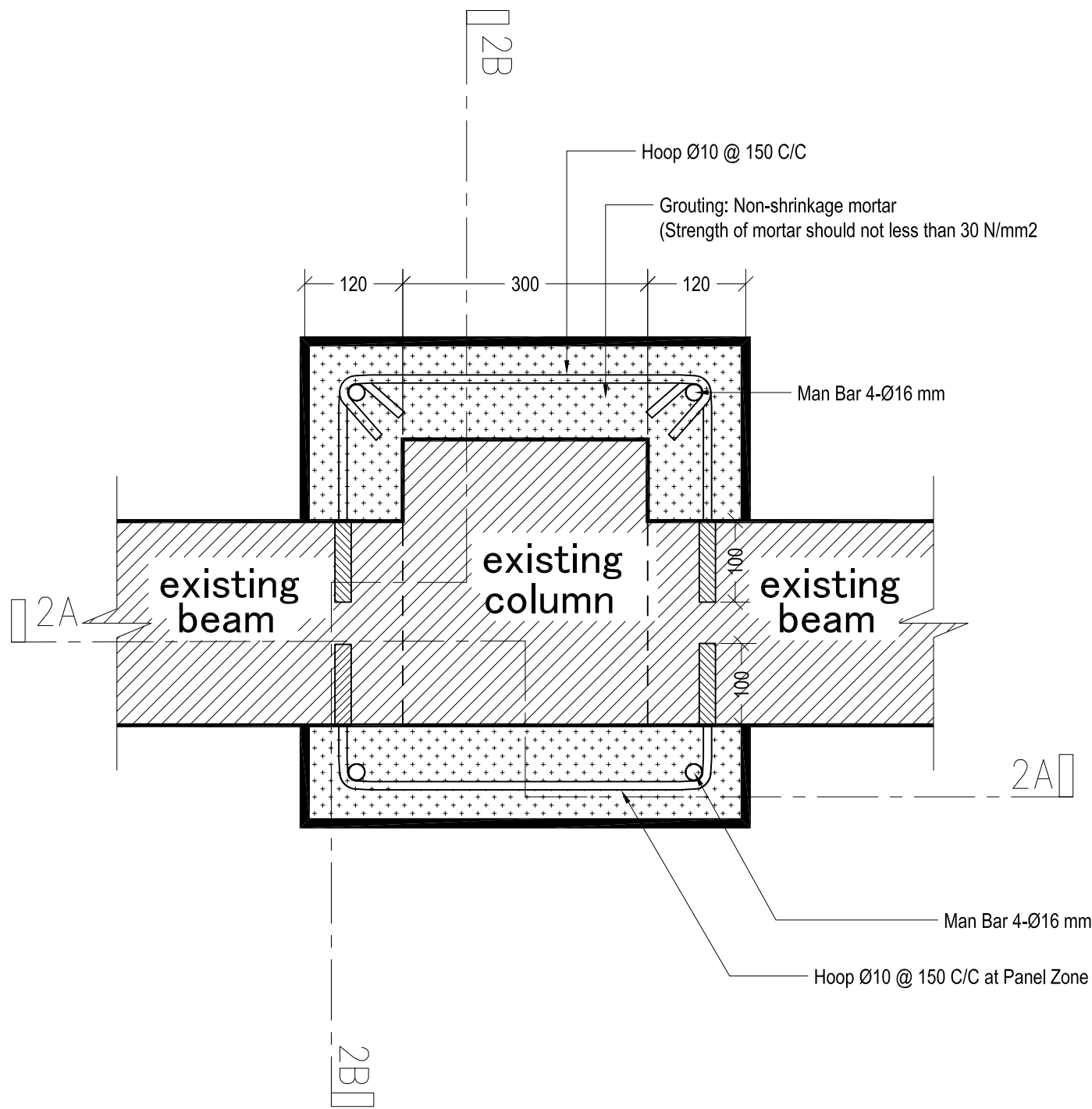
PLAN



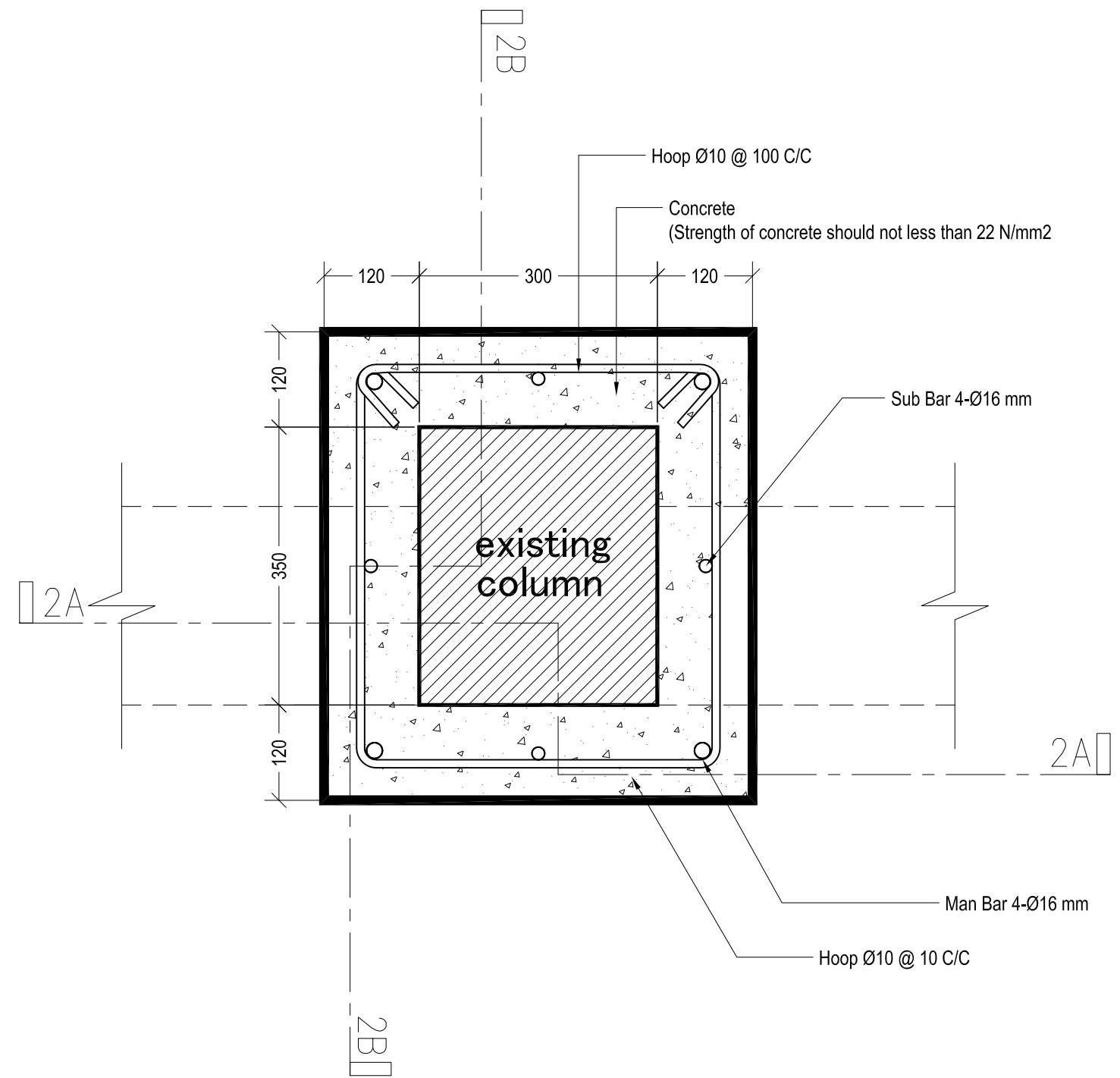
STEP 2.

STEP 1.

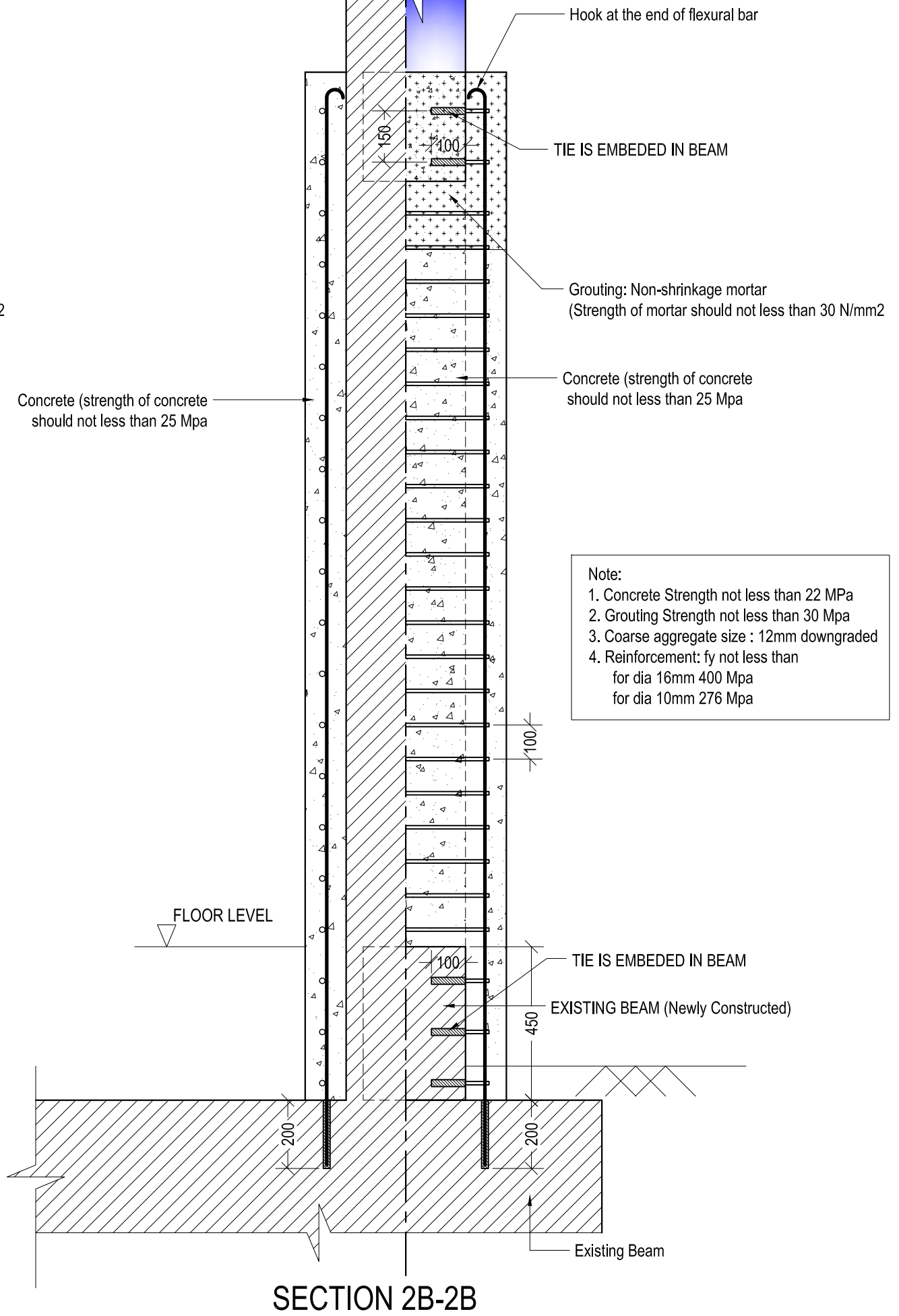
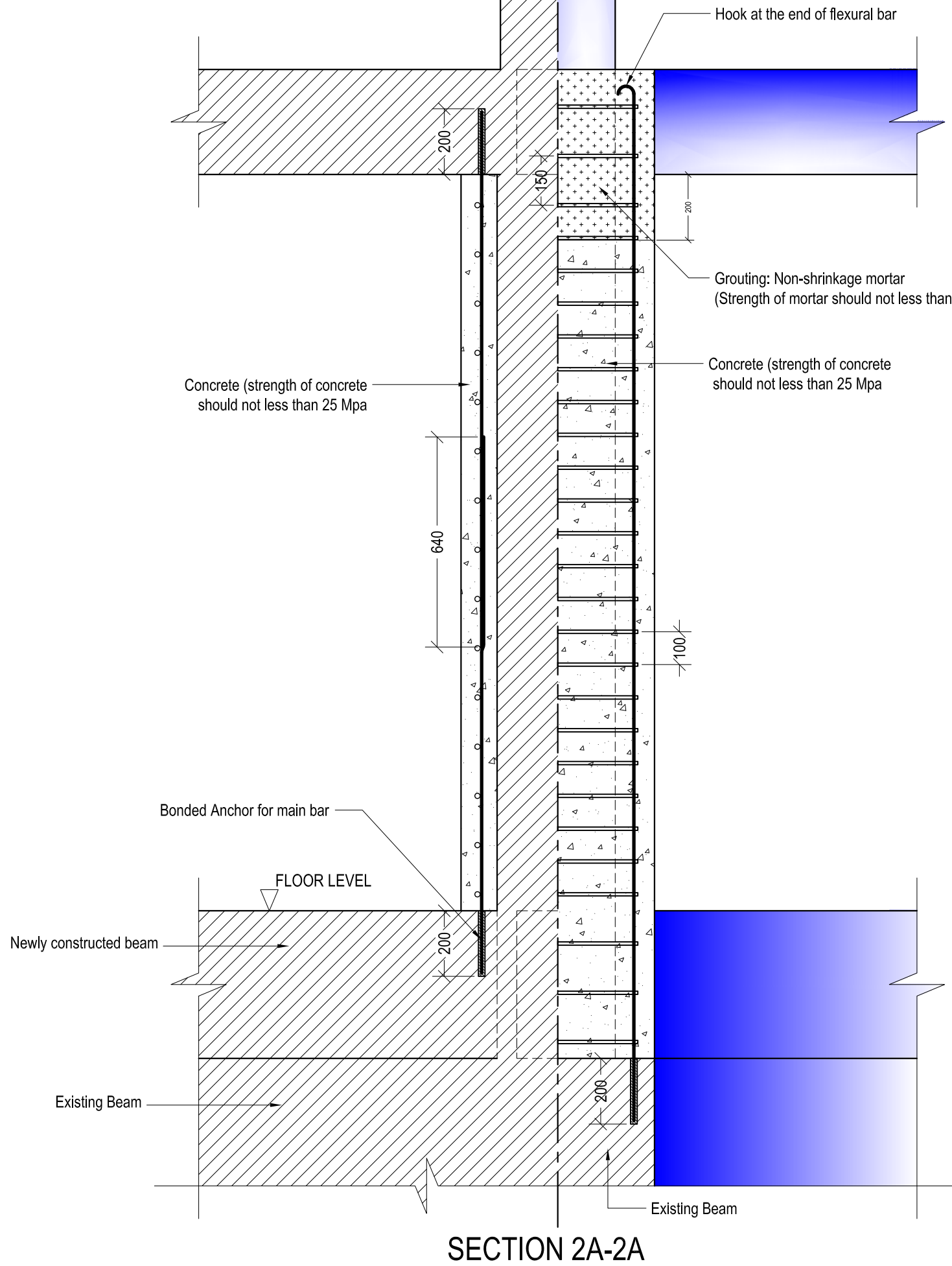




**DETAILS OF COLUMN JACKETING**  
(PLAN SECTION AT BEAM COLUMN JOINT)



**DETAILS OF COLUMN JACKETING**  
(PLAN SECTION AT MID HEIGHT OF COL)

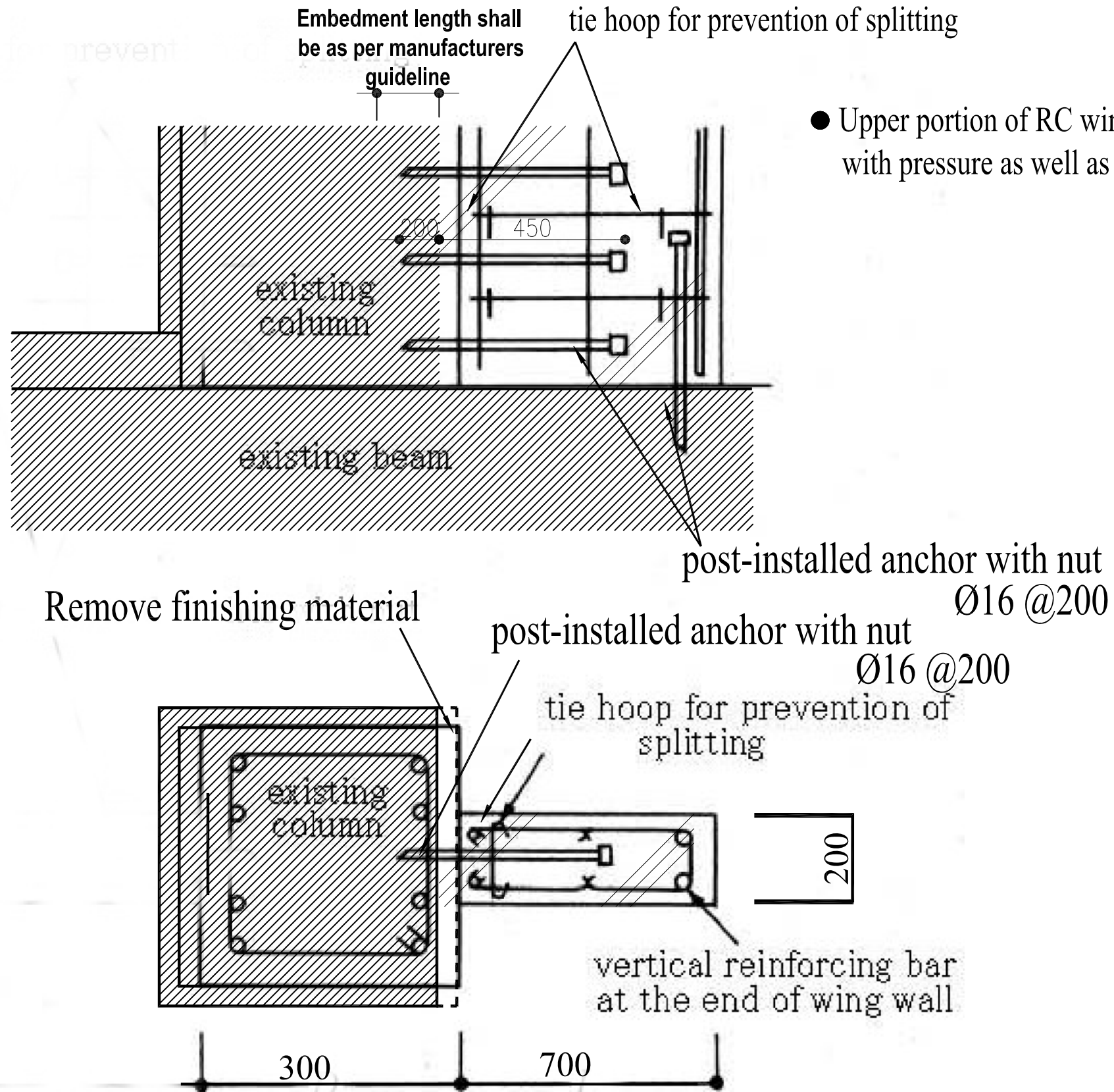


Note:

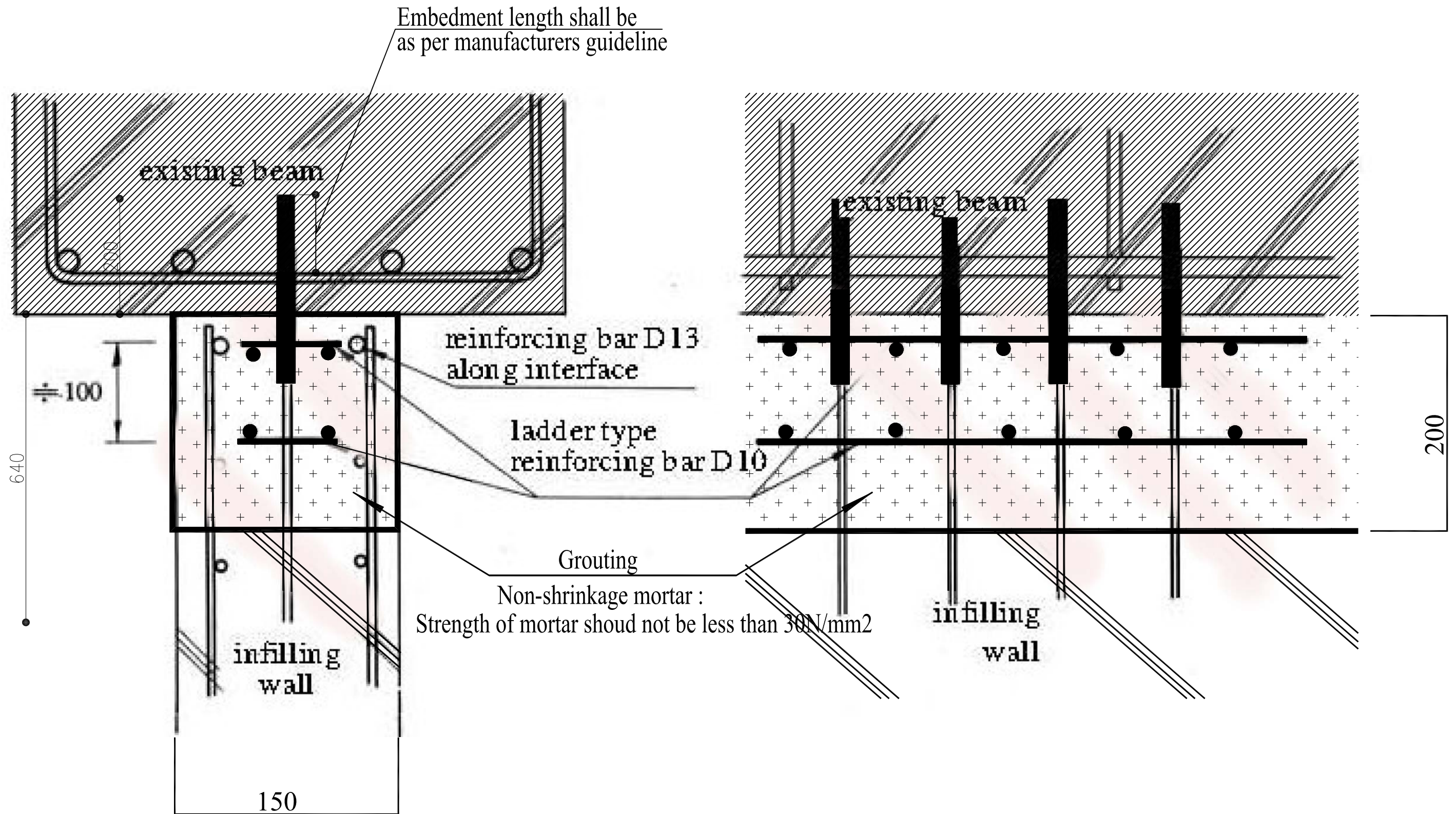
1. Concrete Strength not less than 22 MPa
2. Grouting Strength not less than 30 Mpa
3. Coarse aggregate size : 12mm downgraded
4. Reinforcement: fy not less than  
for dia 16mm 400 Mpa  
for dia 10mm 276 Mpa

③ RC Wing Wall : Thickness 200mm,

D10 @ 200 both direction double

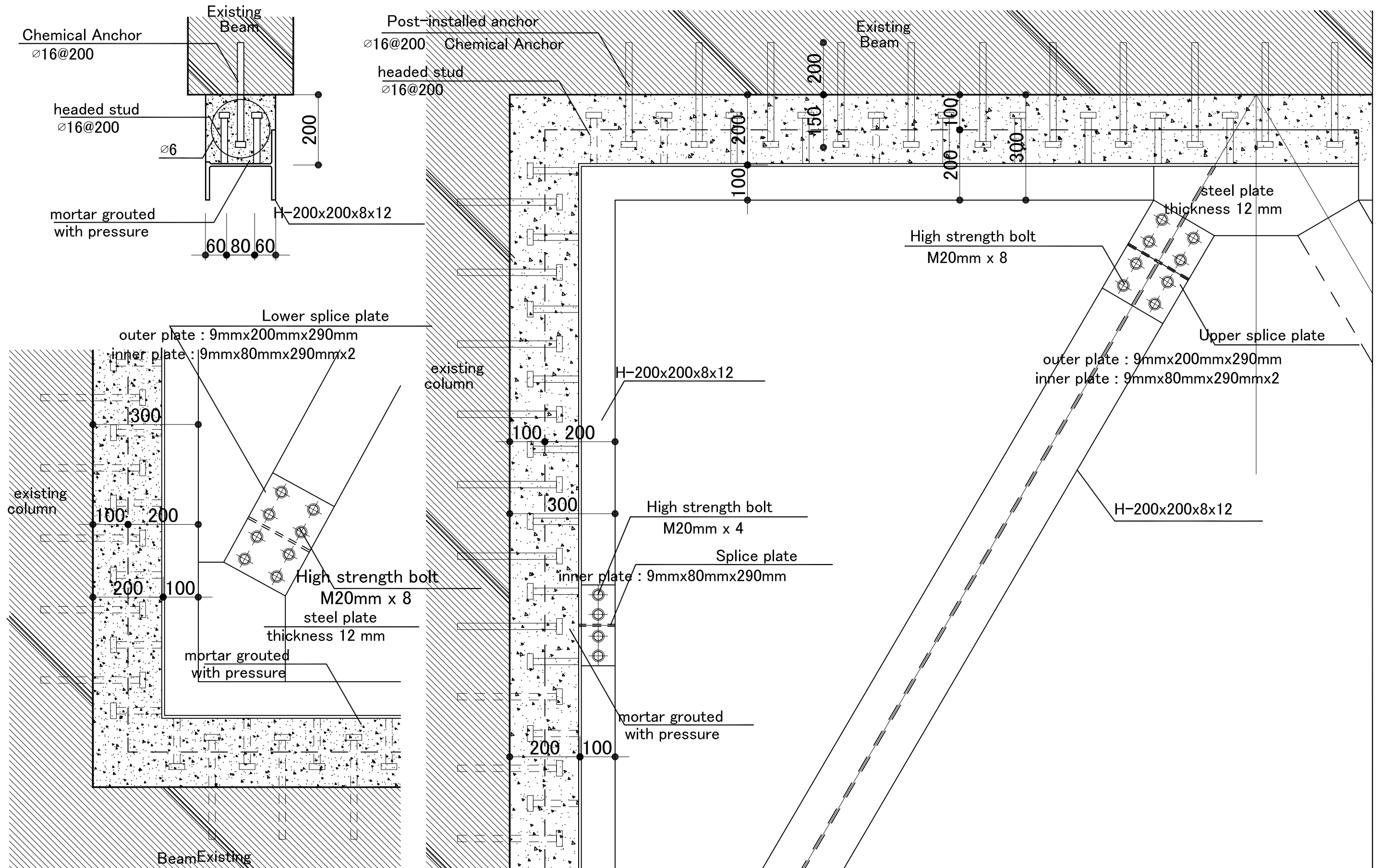


④ RC Shear Wall : Thickness 150mm, D10 @ 200 both direction double

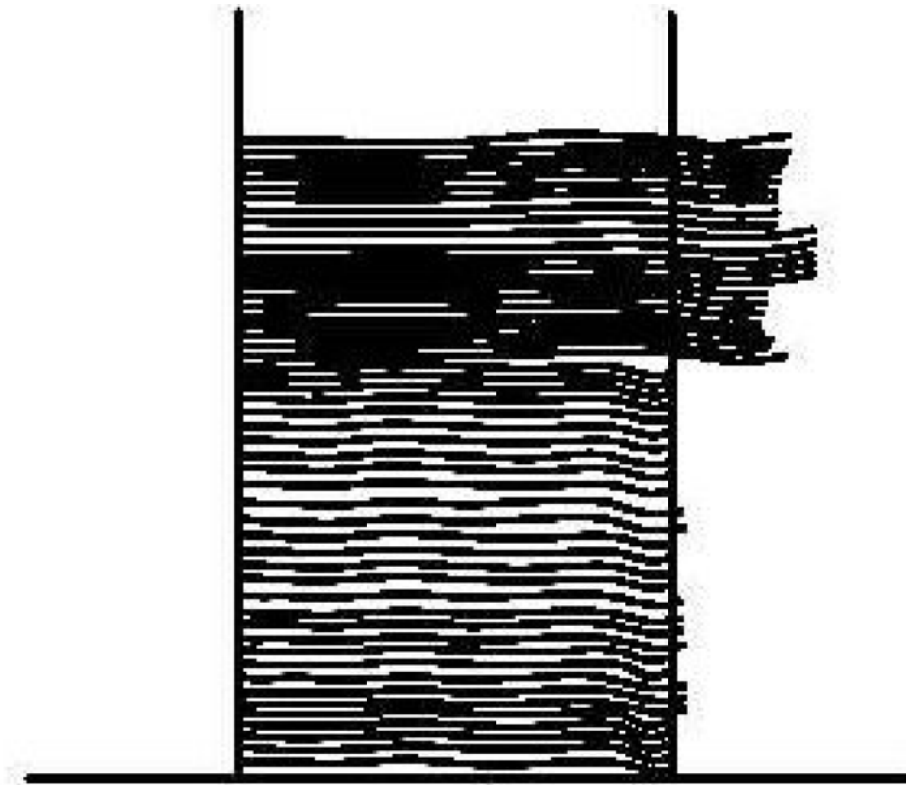
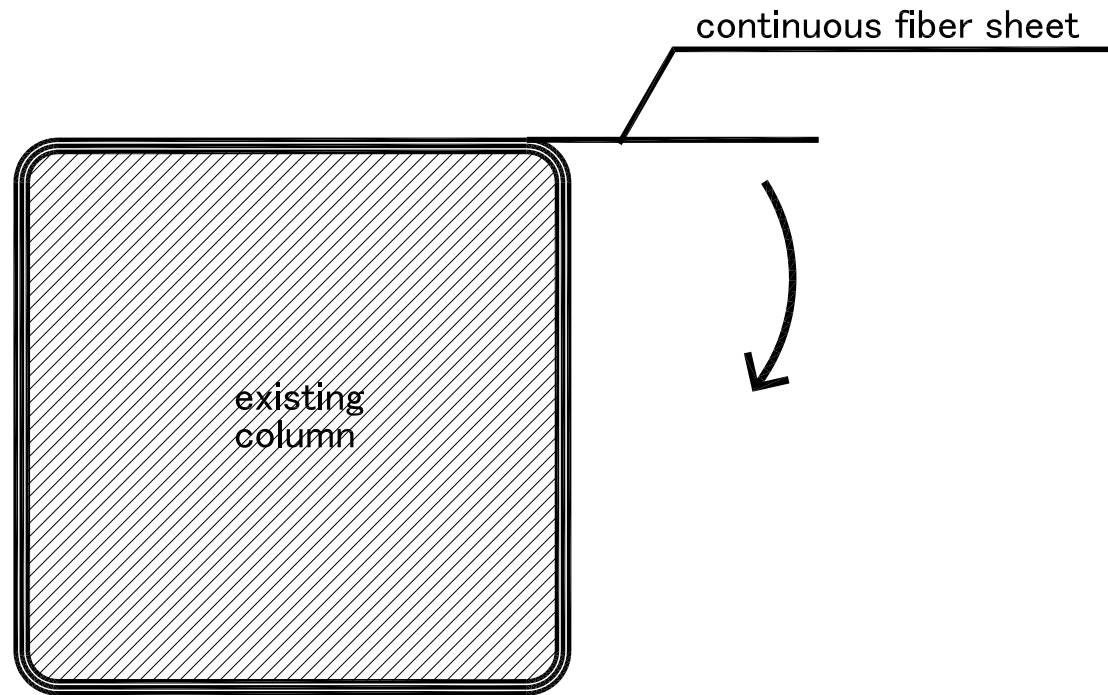




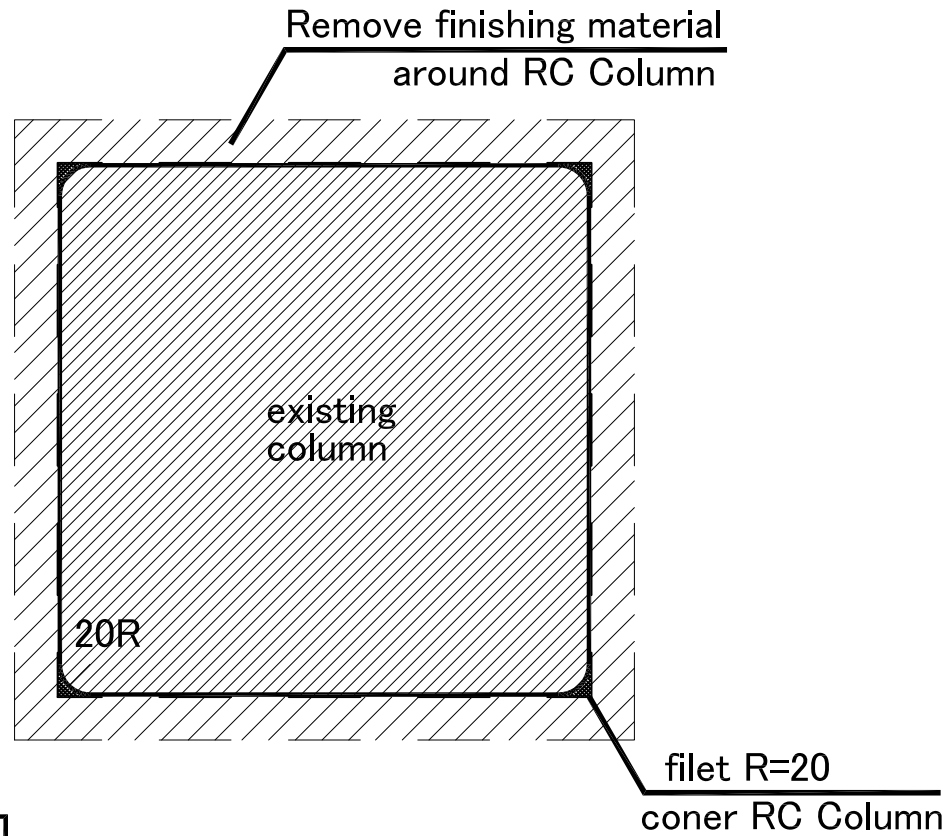
# ⑤ Steel Framed Bracing : H-200x200x8x12,



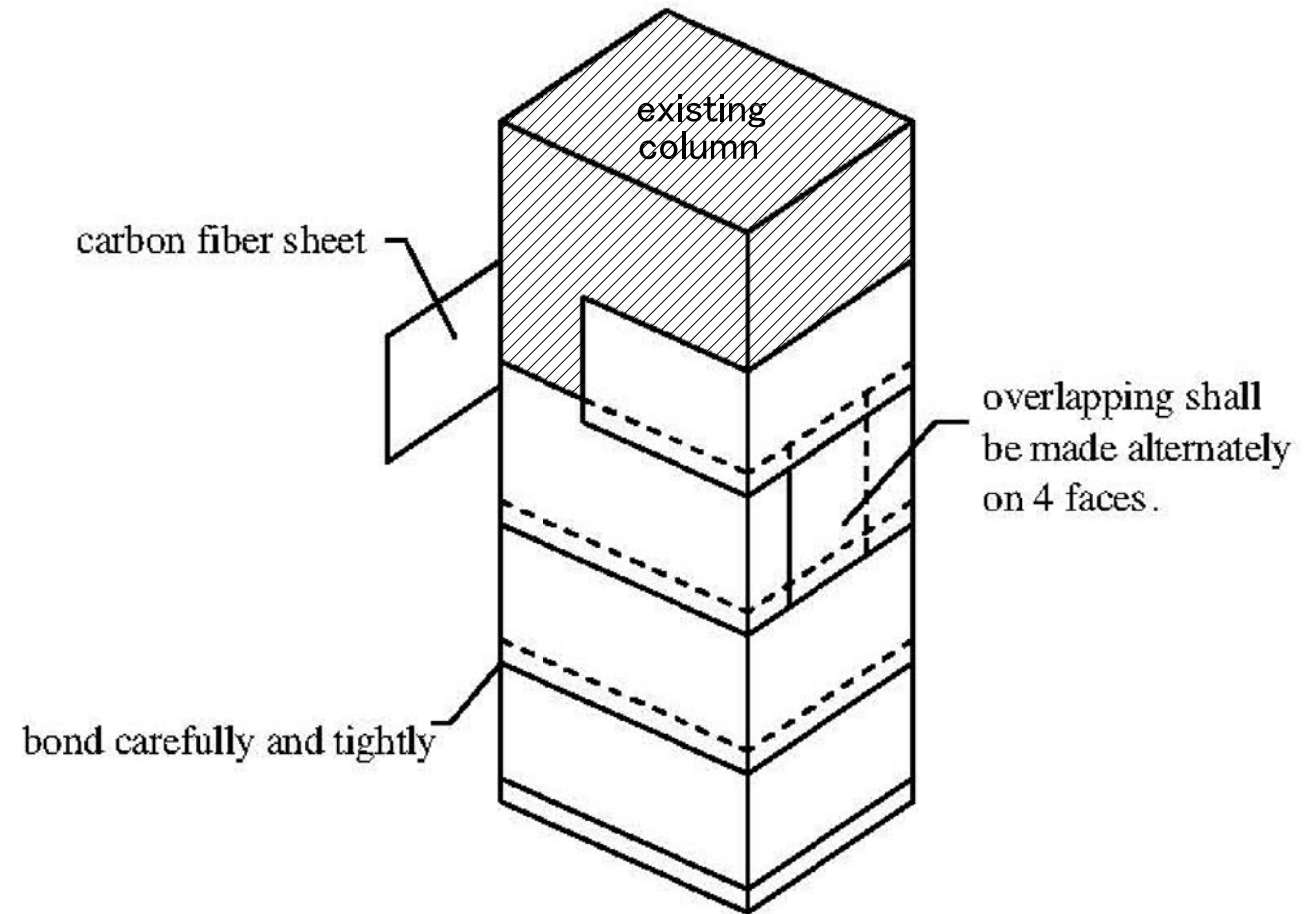
⑥ Carbon Fiber Sheet Wrapping around RC Column



STEP 2.



STEP 1.



wrap and bond laterally at each tier

● Manufacture's instruction should be followed for epoxy resin and wrapping work,

**2<sup>nd</sup> Year Test Work**  
**4 methods**



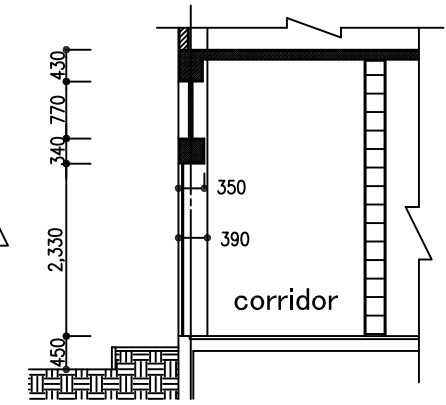
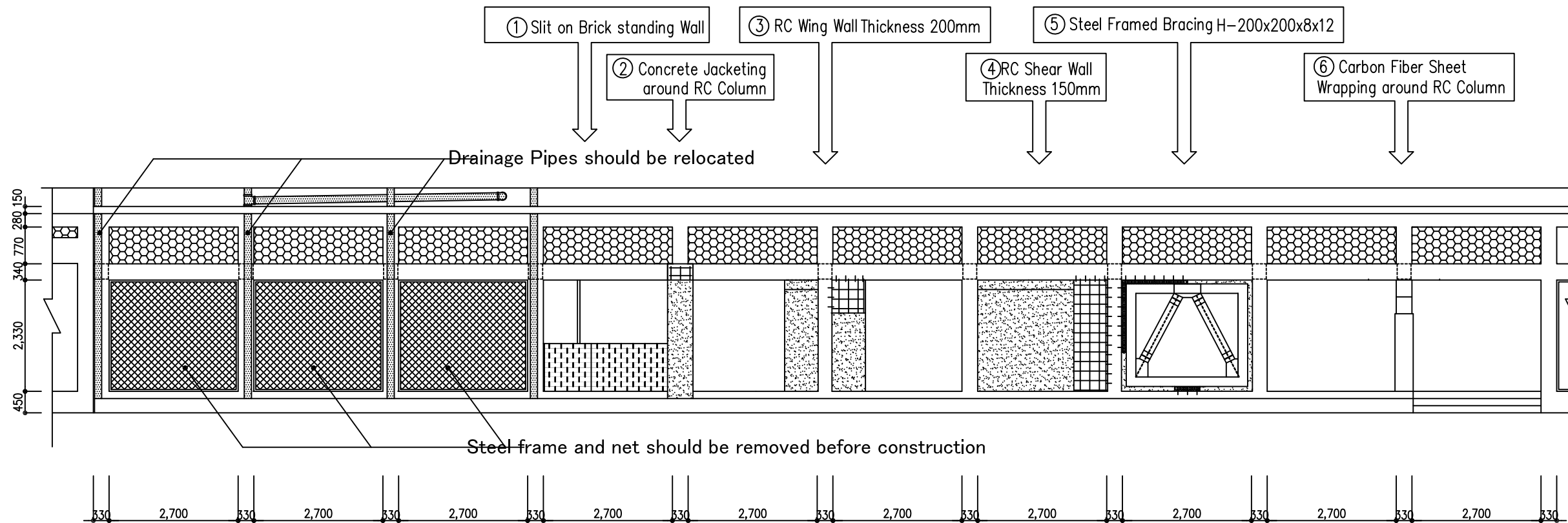
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**DRAWINGS  
FOR  
TEST WORKS**

**SEPTEMBER, 2012**

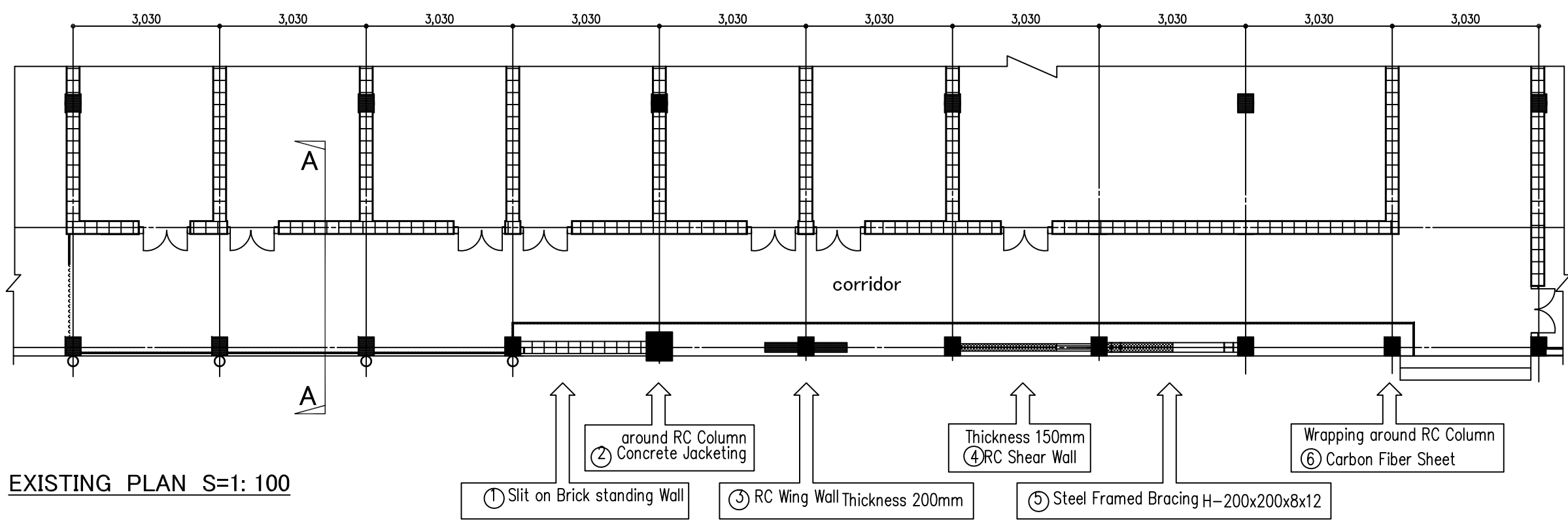
**PUBLIC WORKS DEPARTMENT**





EXISTING SECTION A~A  
S=1: 100

EXISTING ELEVATION S=1: 100 ( ONLY GROUND FLOOR SHOWN)



EXISTING PLAN S=1: 100

