August 25, 2022

Case studies for Precast low-rise buildings (wall panel structures)

M.Hiramatsu

About the speaker

Michiaki Hiramatsu

Precast Concrete Laboratory
PCaLab Co.,Ltd.
President

Member of EQSD Structural Consultants

Member of the committee to make the structural design guidelines for thick-slab-wall structure of the Architectural Institute of Japan (AIJ)

Member of the committee to make the wall structure rebar arrangement guidelines of the Architectural Institute of Japan(AIJ)

Education
- Graduate of KINDAI University (M.A.)

Work Experience
- TAISEI U-lec Co.,Ltd.
  (Technical Consultant Dep., Structural Development Dep., Product Development Dep., Structural Design Dep.)

Skills
- Master in Engineering
- **JPN. Registered 1st class Architect**
- JCI. Registered Concrete Engineer

Achievements
- Development of Precast Wall Construction (8 cases)
- Development of structural analysis software for wall structure
- Diagnosis of concrete structures (fire, earthquakes, etc.)
- On-site construction technology guidance(foundation structures, Support workers, etc.)
- Sound insulation design, Thermal environment design

Number of patents, Paper Submission
- Number of patents for precast construction (8 cases)
- Number of patents for foundation construction (1 cases)
- Paper Submission(AIJ National Conference) (35 cases)

(my history)

1989～1991

KINDAI university

(Subject : Developments of Reinforced Masonry Buildings)

This study was conducted as part of the U. S. –JAPAN coordinated earthquake research program.

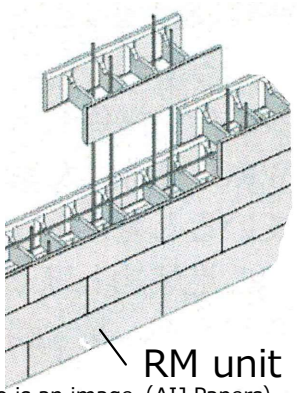


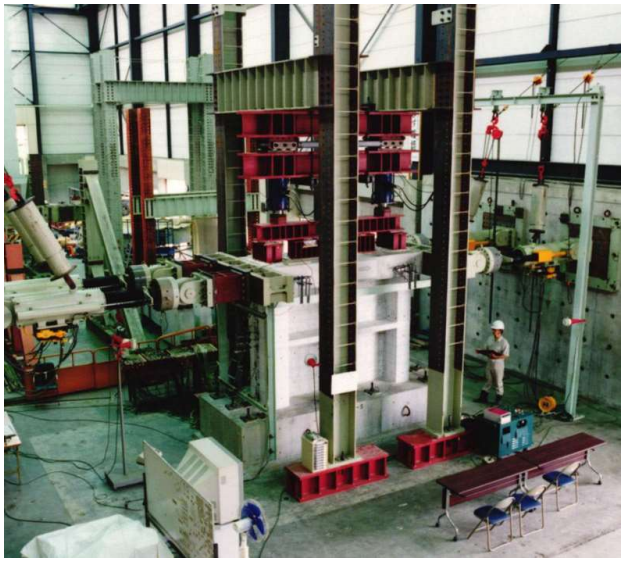
Photo is an image (AIJ Papers)

A test of masonry prism strength

1991 ～ June 2022

TAISEI U-LEC Co.,Ltd.

(Subject : Developments of Mid-High-rise wall panel structures)



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A test of High-rise wall panel structures

July 2022 ～

PCaLab (Precast Concrete Laboratory)
EQSD (Structural Consultants)

(Subject : Promotion of wall panel structures. Bringing good things from overseas to Japan and good things from Japan to overseas)

pci JOURNAL may/June 2005

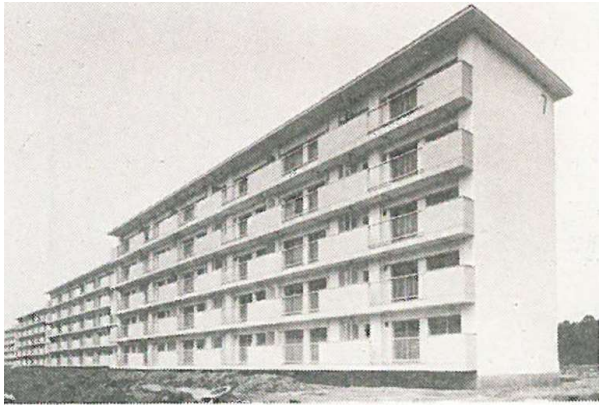
Example : Long span slabs(USA)

Contents

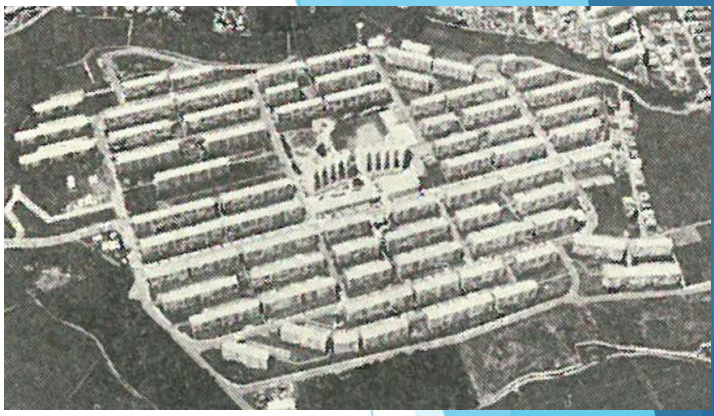
1. History of WPC in Japan
2. Outline of wall panel structures
3. Advantages of precast wall structures
4. About the structural design
5. Manufacturing and Installation of panels
6. Photos of completed buildings
7. Conclusion

1. History of WPC in Japan

1964 Prototype house(WPC)



1965 Start of Supply (WPC)



1974 Large Scale Development (WPC)

1982 High Rise (WPC)

present （WPC） : 3-5 floor buildings （WRPC） : 6 Floor or above

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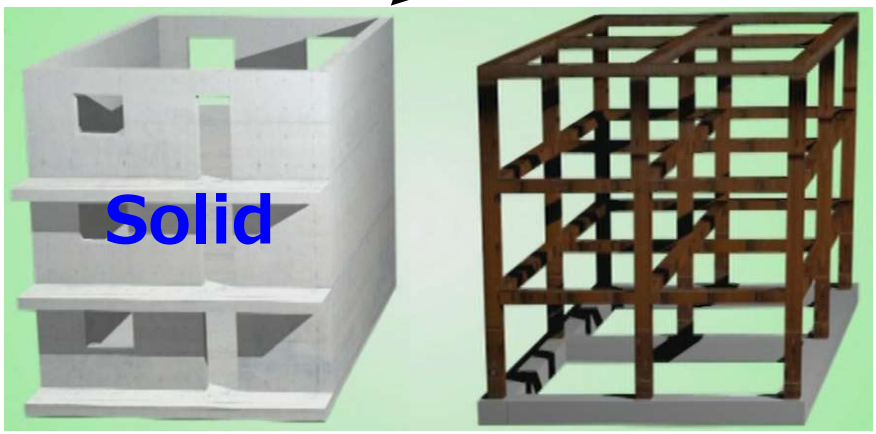
2. Outline of wall panel structures

2.1

After Panel assembly

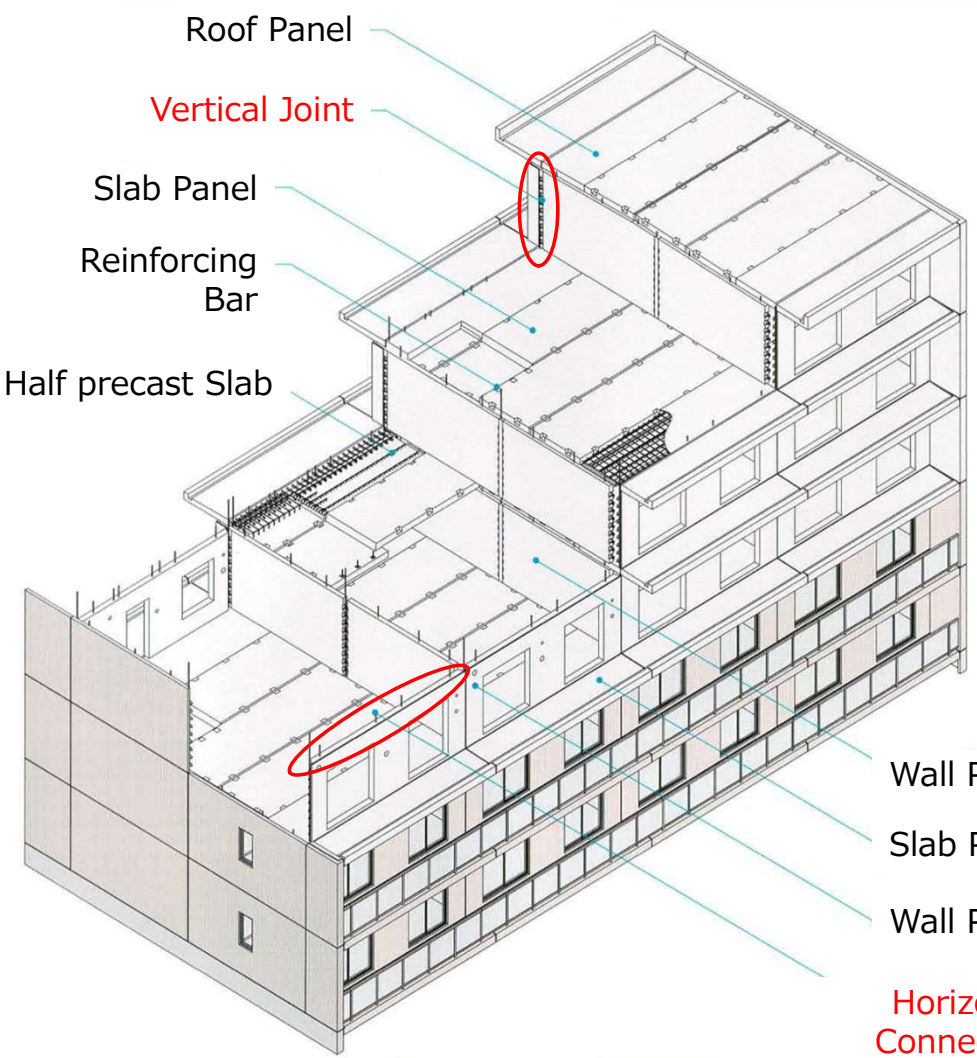
Monolithic construction



Wall panel structures

Frame structure

Overview of Wall Panel structures



Panels Composition

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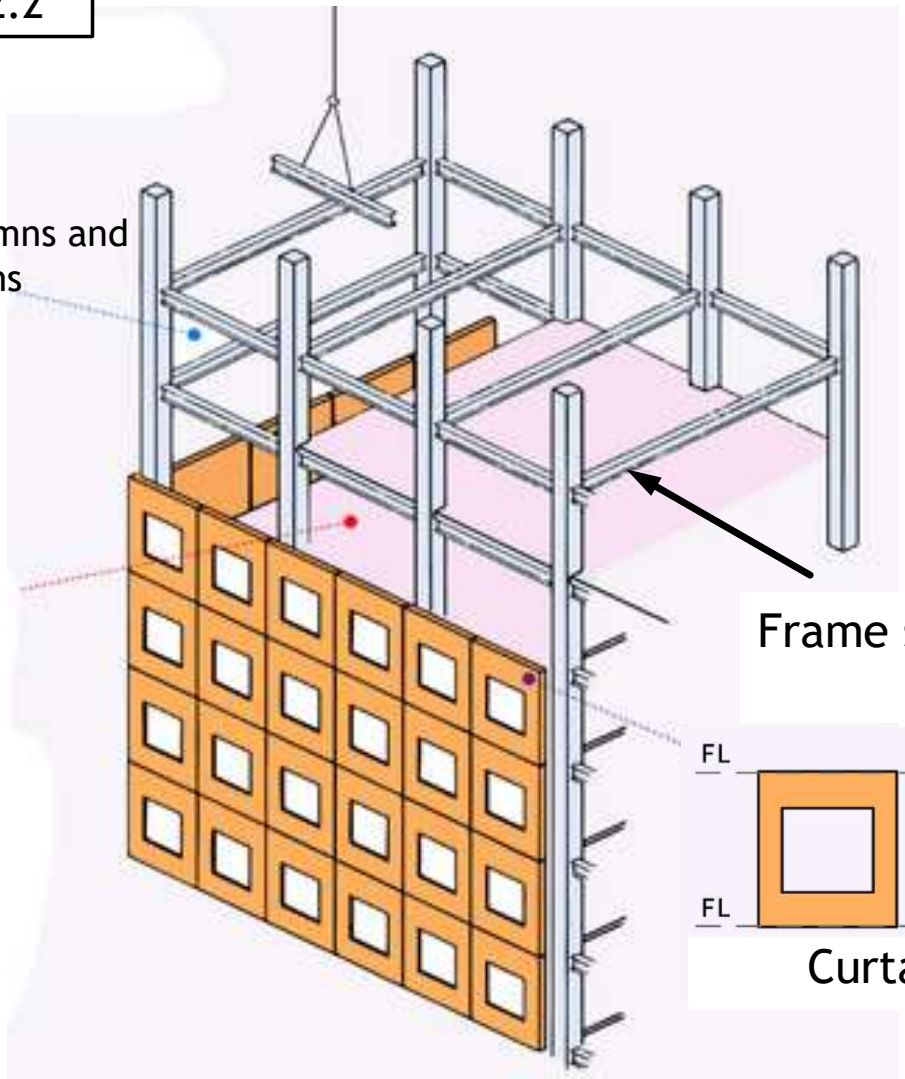
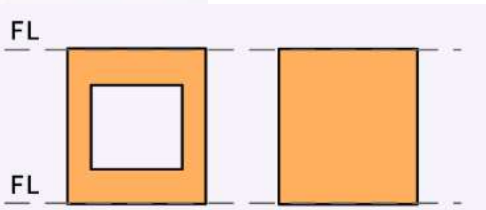
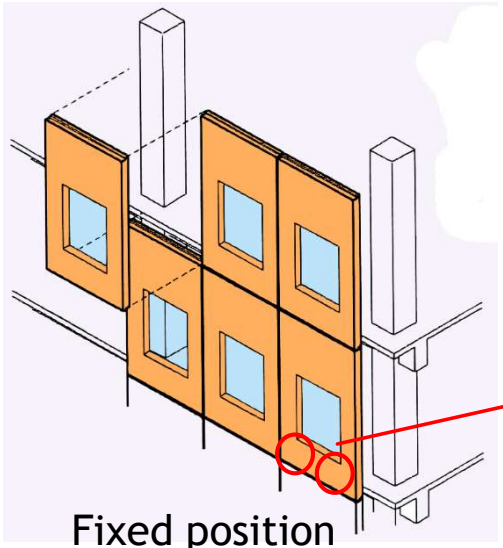
2.2

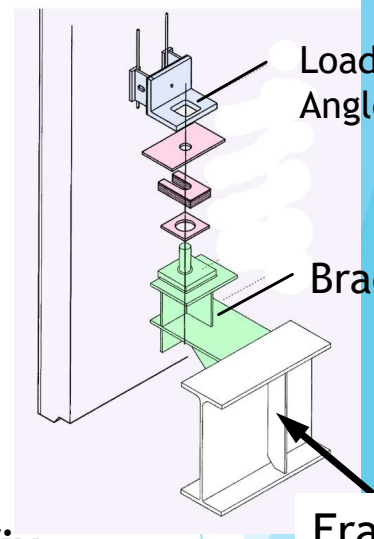


Outline of Curtain Wall



Curtain Wall





How to fix

Installation Works

3. Advantages of precast wall structures

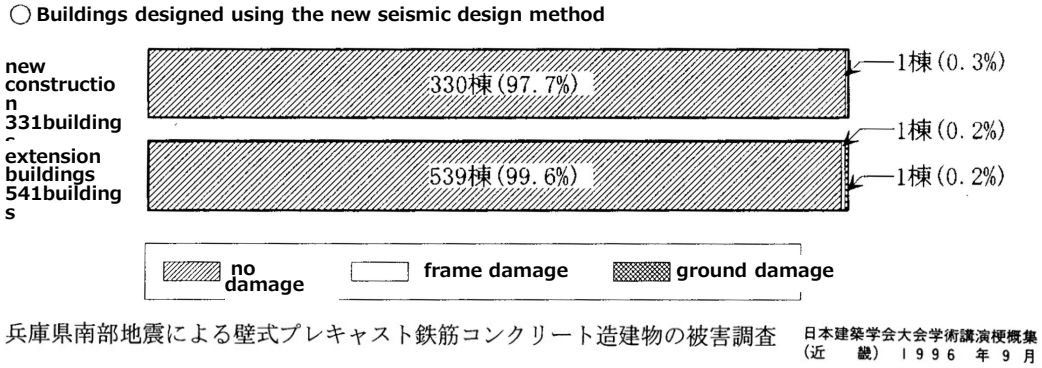
3.1

High disaster resistance (earthquake)

ASAHIGRPH Feb. 1995

1995 Kobe Earthquake

Tohoku earthquake (March 11, 2011)

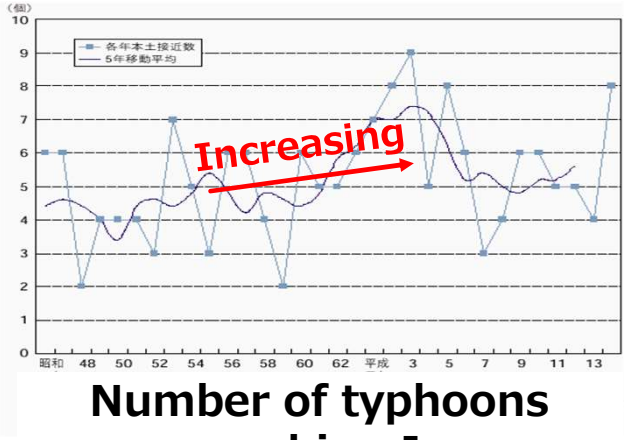


兵庫県南部地震による壁式プレキャスト鉄筋コンクリート造建物の被害調査 日本建築学会大会学術講演梗概集（近畿）1996年9月

: No significant damage due to earthquake shaking has been reported.

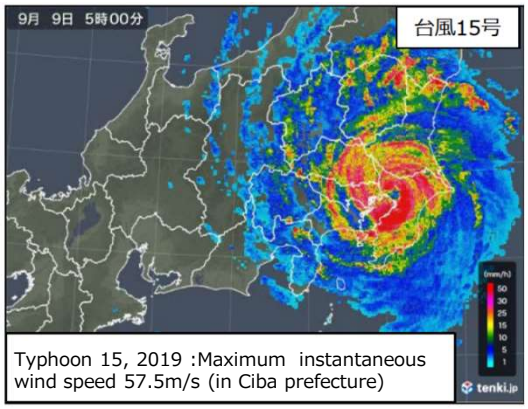
3.2

High disaster resistance （Typhoon）



Number of typhoons approaching Japan

Ministry of Land



Typhoon 15, 2019 :Maximum instantaneous wind speed 57.5m/s (in Ciba prefecture)

Tenj.jp

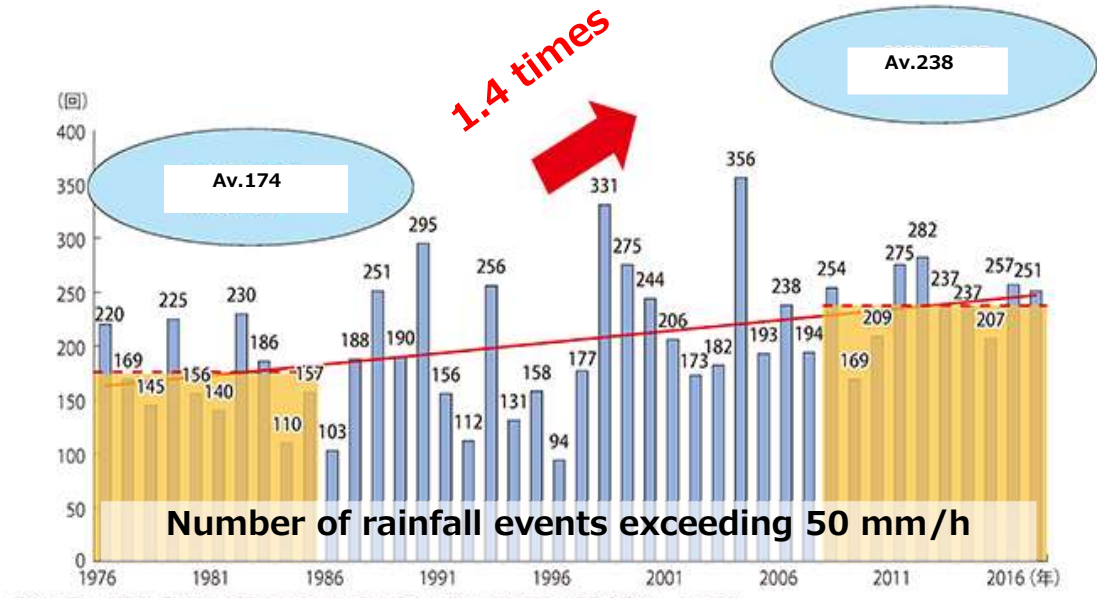
■: Wooden house with roof blown off（in Chiba） ASAHI.com

Okinawa Prefecture, where typhoons are common, has many RC housing.（RC is 93%.）

TAISEI Kensetsu Housing

3.3

High disaster resistance (Floods)



Ministry of Land,

The number of heavy rain events

KEYSTONE/AP Kyodo News

Flooding due to heavy rain

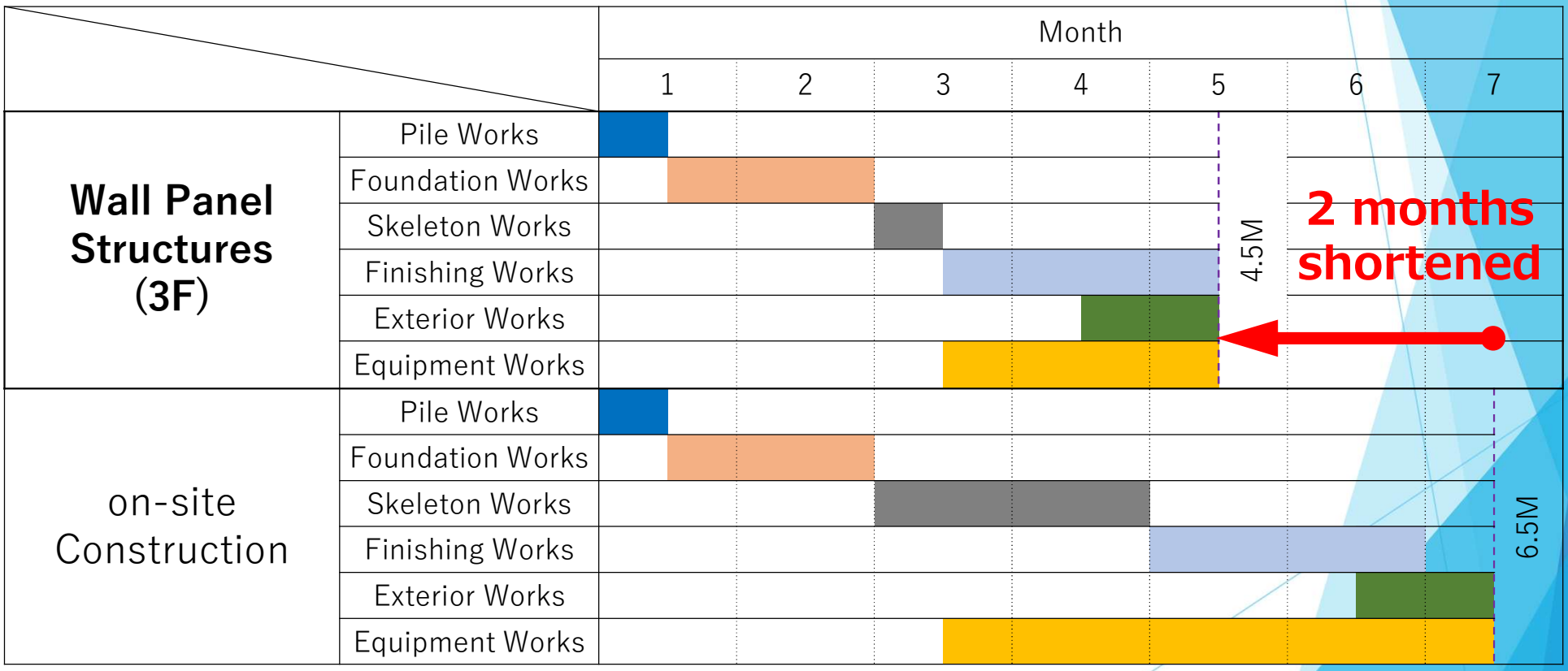
TAISEI Kensetsu Housing

Flood-damaged House

3.4

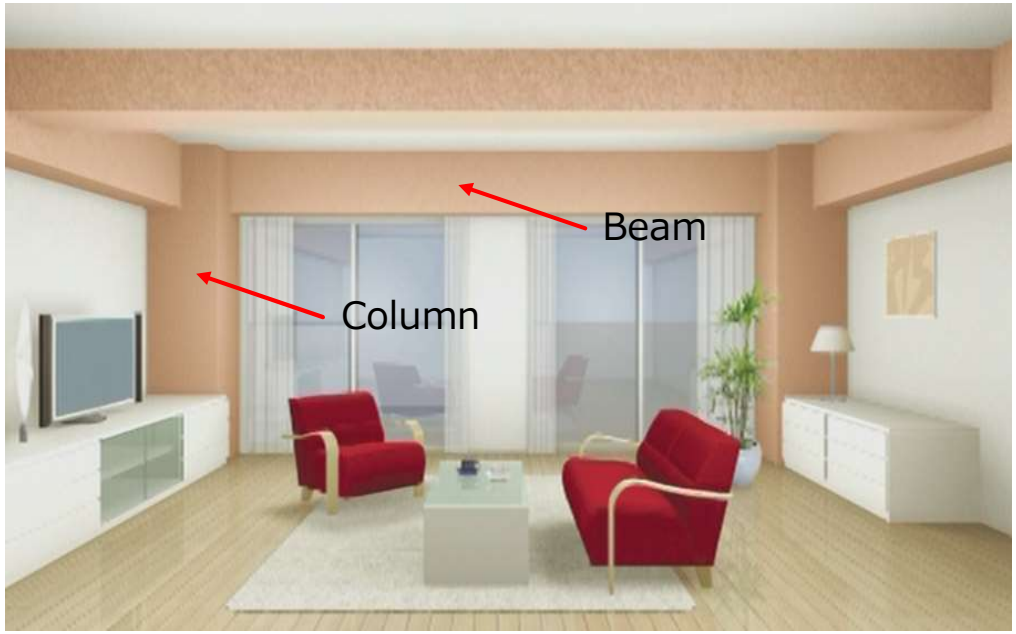
Short construction period

Comparison of construction time



Example of 15 units on 3 floors

Wall and Ceiling finishes are flat



Frame structure buildings

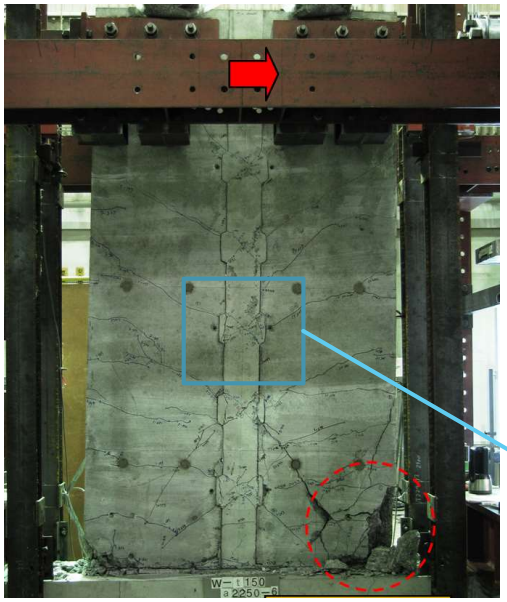
Wall panel structure buildings

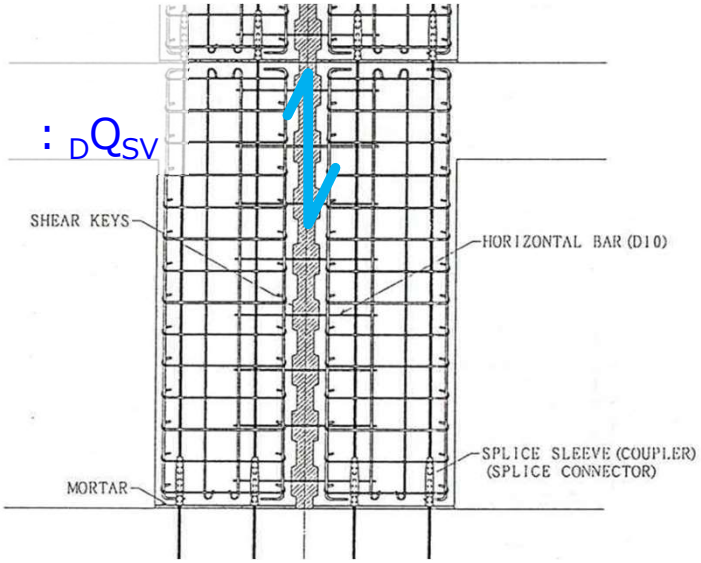
4. About the structural design

4.1

Structural design of joints : Ensure that seismic forces do not destroy joints

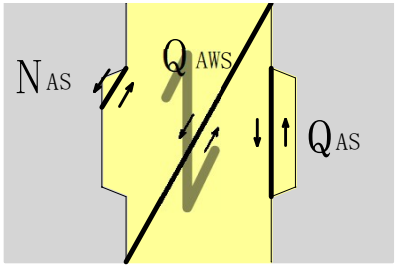
Shear force for design of Vertical joint (short-term allowable stress) : ${}_DQ_{SV}$





Shear strength of vertical joint :

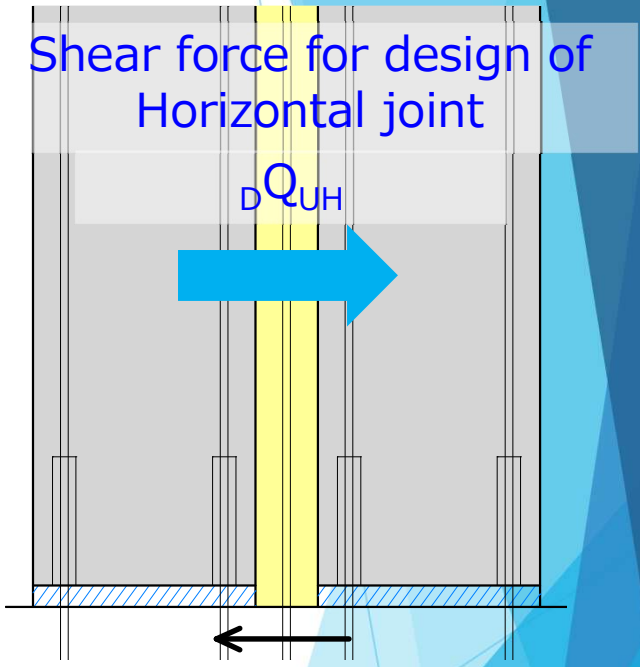
${}_AQ_{SV}=\min(Q_{AS},N_{AS},Q_{AWS})$



${}_DQ_{SV} \leqq {}_AQ_{SV}$

(Design of vertical joints in walls)

Shear force for design of Horizontal joint ${}_DQ_{UH}$



Shear strength of Horizontal joint :

$Q_{USH} = 0.7\ \{\Sigma(a_h \cdot \sigma_y) + N_h\}$

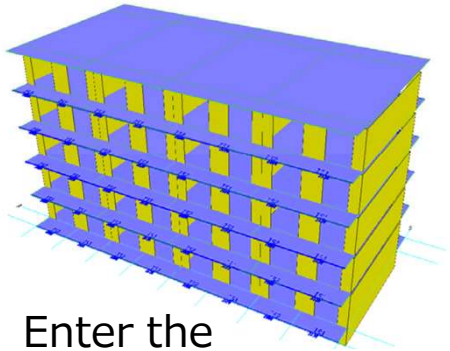
${}_DQ_{UH} \leqq Q_{USH}$

(Design of Horizontal joints in walls)

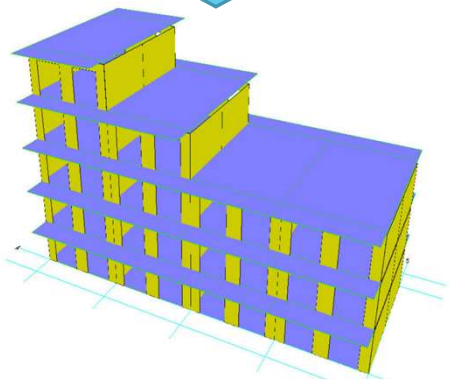
4.2

Structural design of building

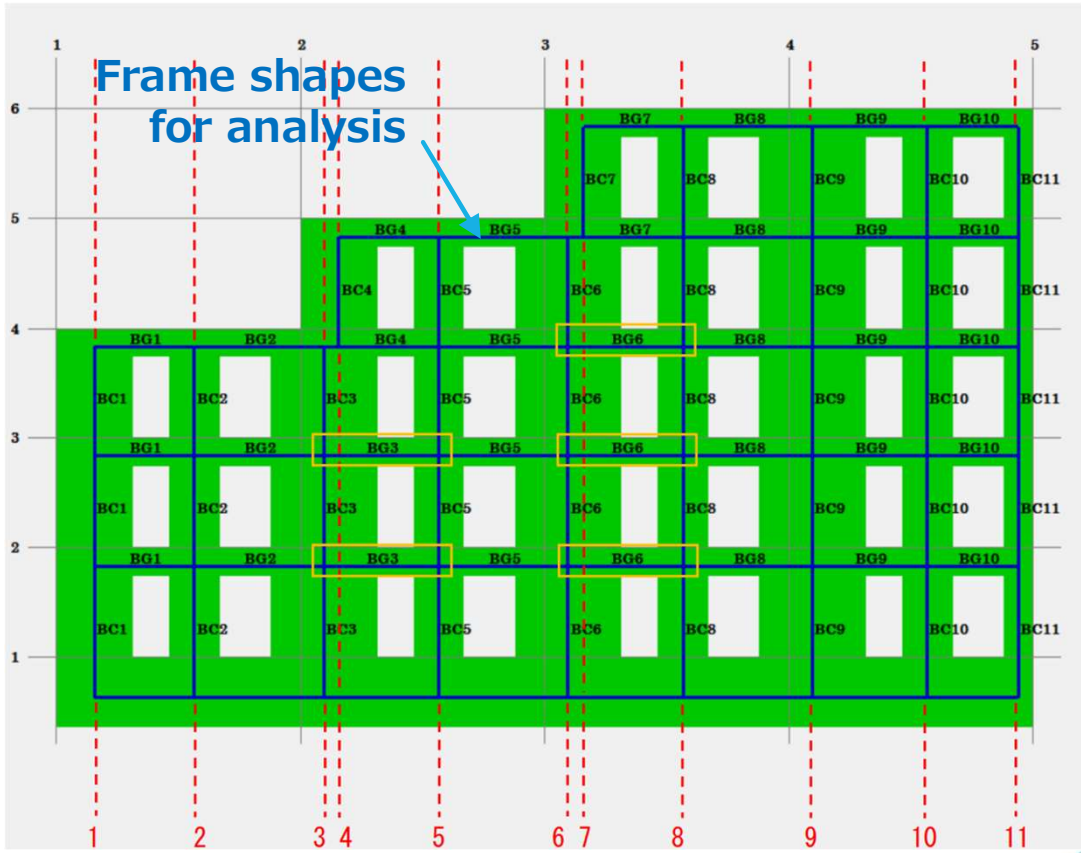
・Example of design using software



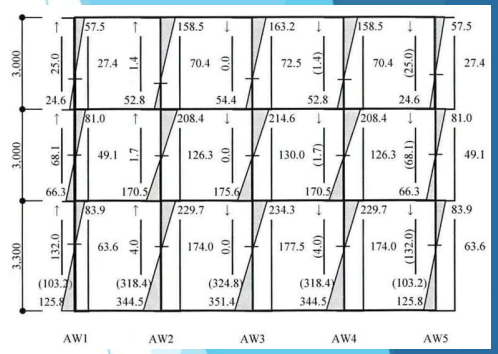
Enter the
Panel placement



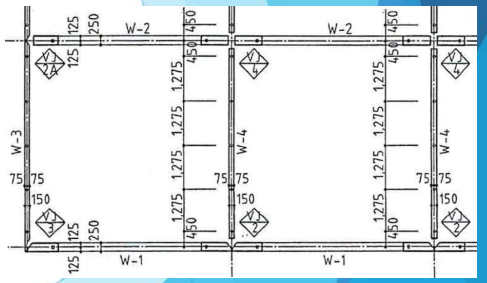
Adjust the shapes
(Example of data input)



(Replace panels with frame shapes in the software)



Stress Analysis



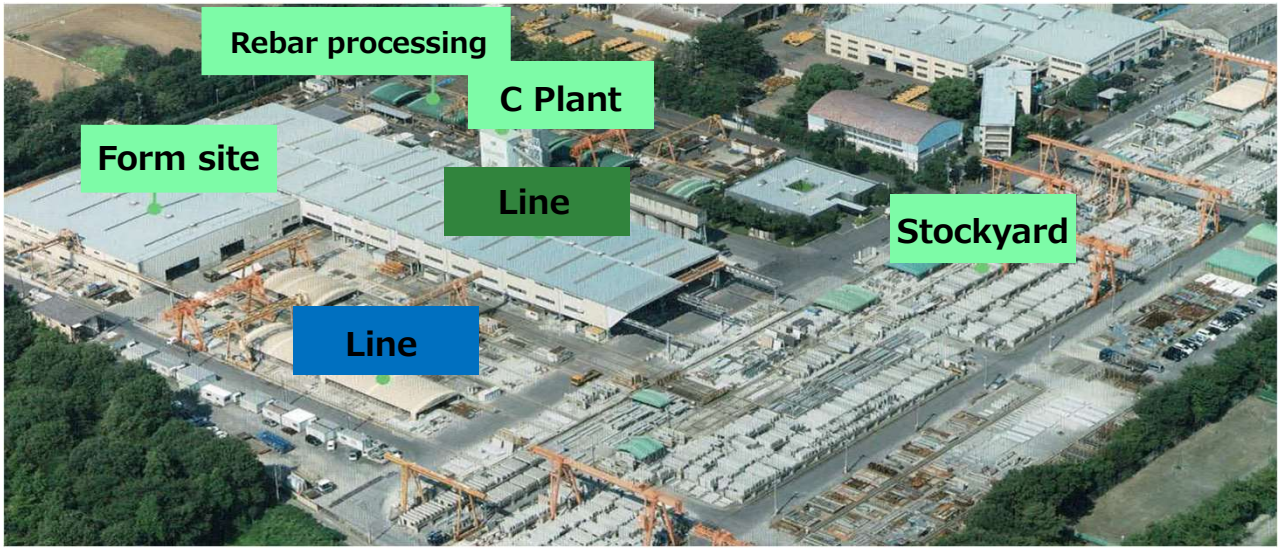
proportioning of section

(Stress Analysis and
proportioning of section)

5. Manufacturing and Installation of panels

5.1

Panel Manufacturing Overview



Panoramic view of the factory

Manufacturing line

Finish

Formwork

Rebar arrangement works

Concrete work

5.2

Flow line of half precast panels

TAKAMURA KENSETSU Co.,Ltd.

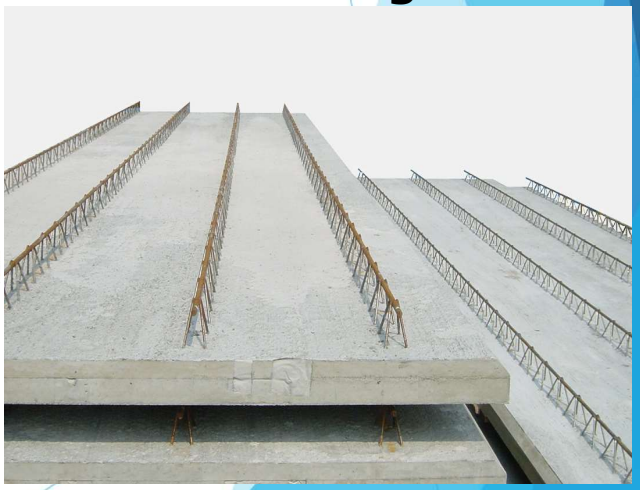
Rebar work

Formwork

Marking

Form and Rebar completed

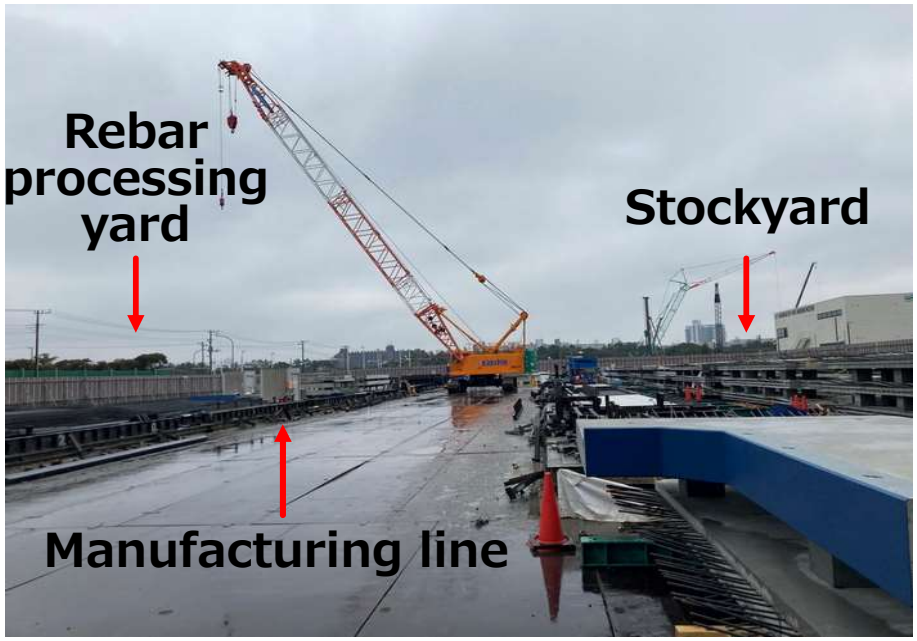
Concrete work



Finish

5.3

Example of the site plan



Panoramic view

Manufacturing line

Location

Manufacturing line

Boiler

5.5

Construction site

Foundation works

1st floor structure

Intermediate floor structure

Finish

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5.6

Cycle process

1. Wall panel ⇒ 2. Slab panel ⇒ 3. Rebar work⇒ 4. Concrete work⇒ 5. Curing⇒

1. Wall panel installation

2. Slab panel installation

3. Rebar Splicing

4. Put concrete into the joints and inject SS mortar into the NMB splice sleeves (see next pages)

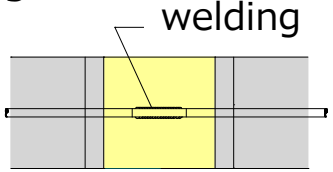
5.7

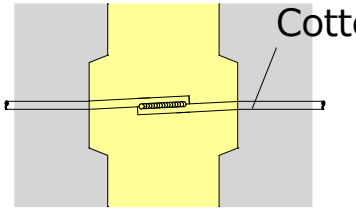
Panel-to-panel connection for Vertical

Welding

Rebar work of Vertical joints

Work situation

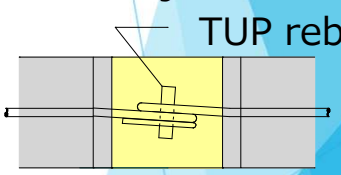


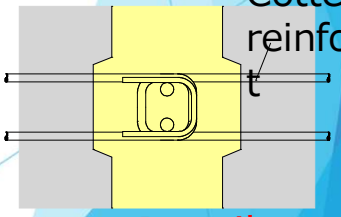


Detail

Welding joints

Work situation



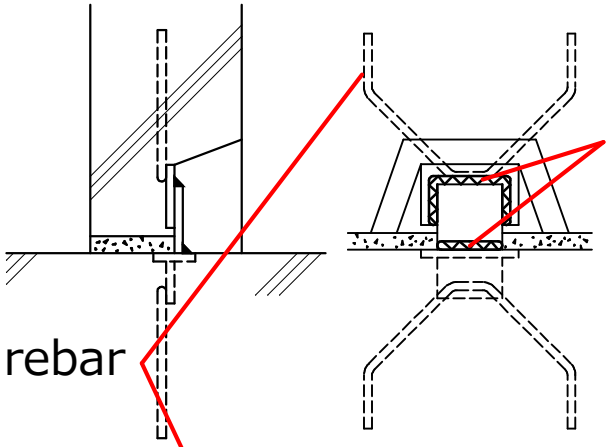


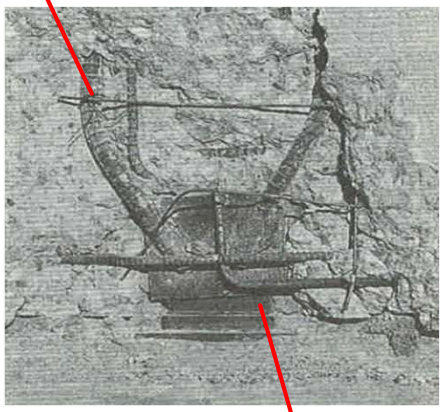
Detail

Loop rebar joints

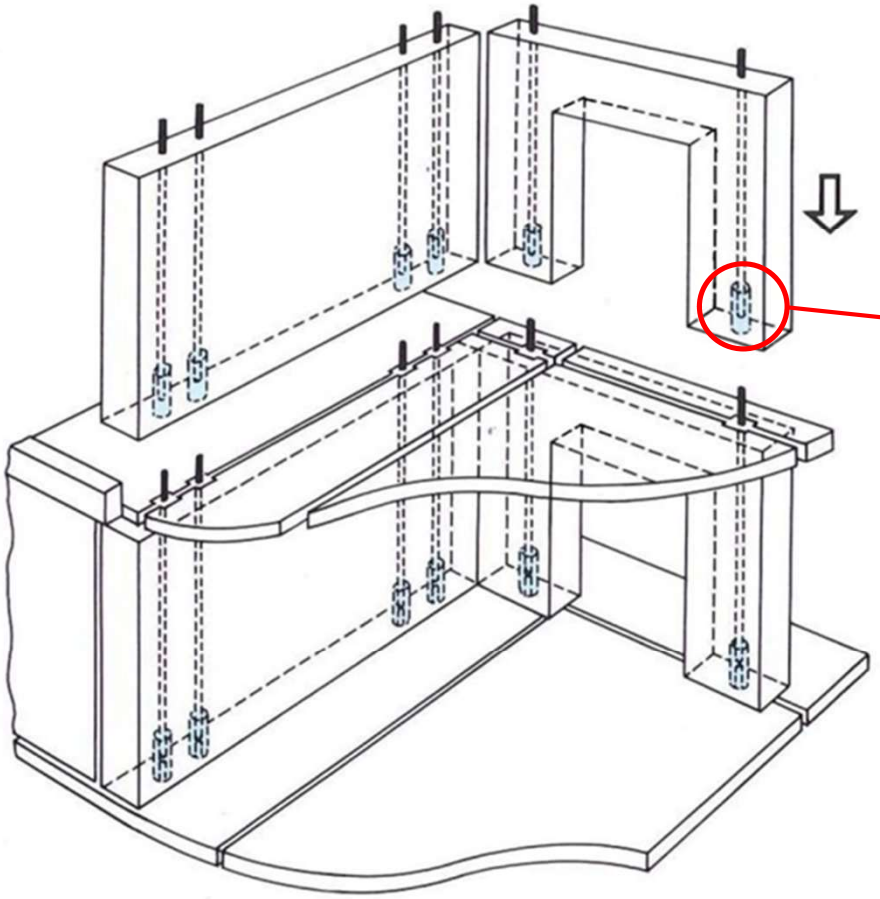
5.8

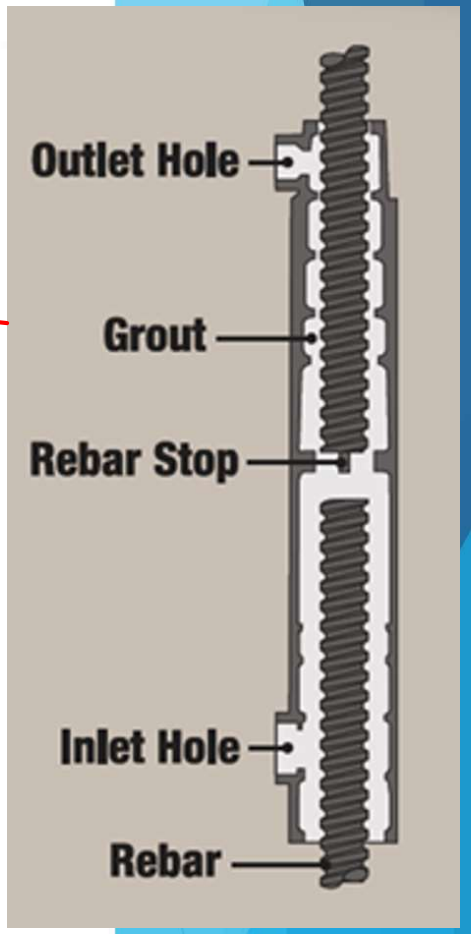
Panel-to-panel joints : In horizon joints





(welding joints)

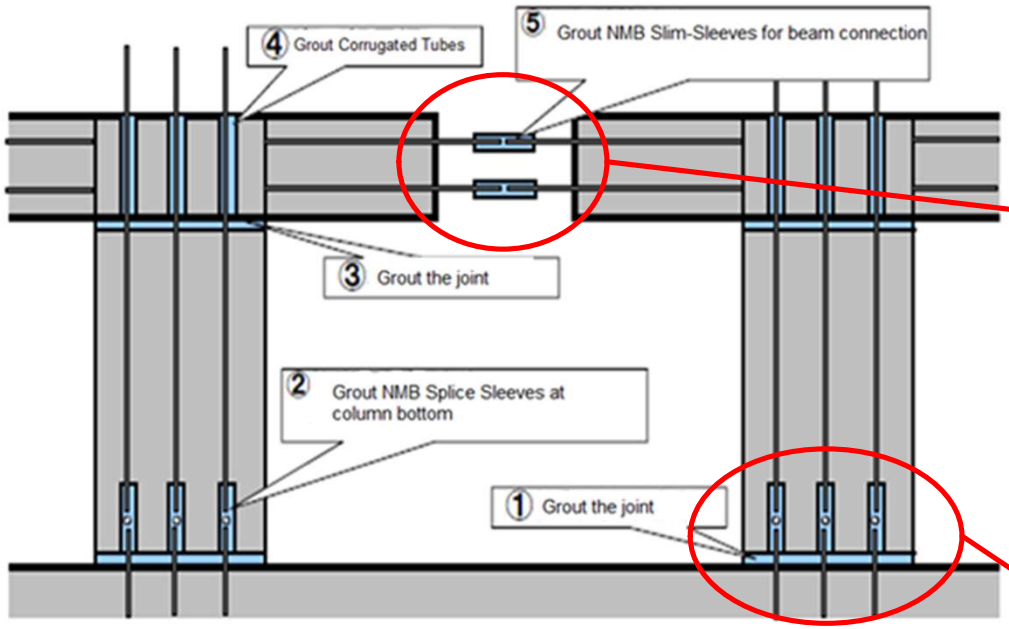


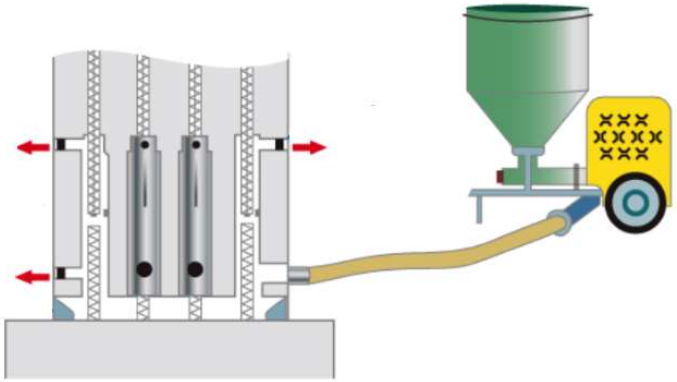


present (NMB SPLICE SLEEVE SYSTEMS)

5.9

Splice sleeves applied in many parts of the frame structure as well





① ② Grout the joint

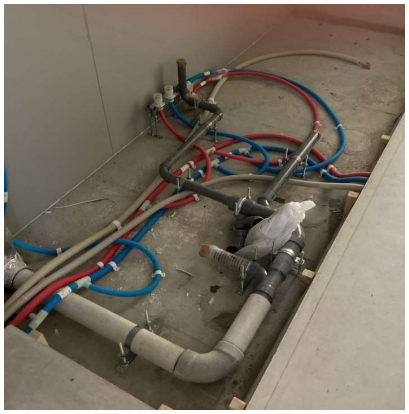
⑤ NMB SLIM-SLEEVE+SS Mortal

5.10

Interior works

Thermal insulation, Partitions, Cloth

Finish



Bathroom, Toilet, Kitchen

6. Photos of completed buildings

6.1

Example of entrance: Frame structure used together

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(Inside the entrance)

4 floors (student dormitory)

6.2

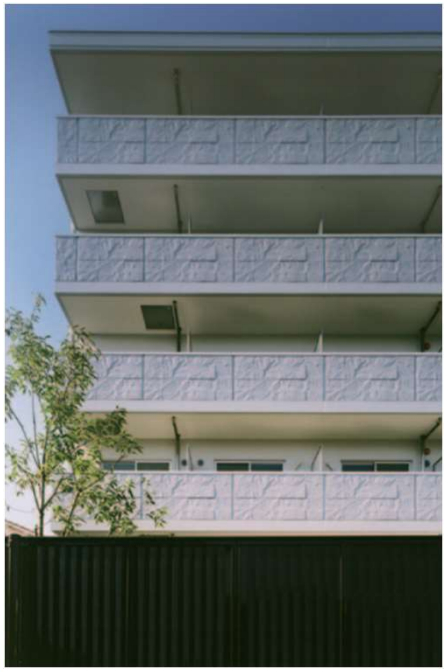
Harmony with common spaces : Frame structure used together

TAISEI　ULEC

Connected buildings with the common space.

6.3

Example of calm exterior



TAISEI　ULEC

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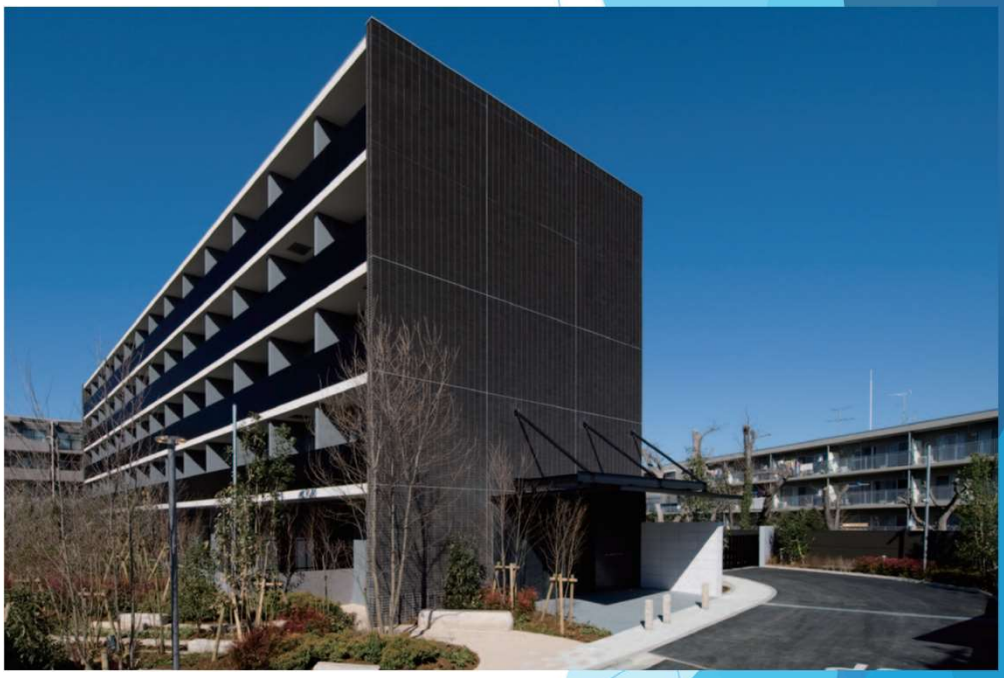
Luxury Entrance



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Gable side entrance

6.4

Example of a 10-story precast structure building

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Exterior view of the corridor side

TAISEI ULEC

Exterior view of the Balcony side

6.6

Other structures using precast

FH・HOYA-II : Motokura Makoto

only consisting with the thick-precast panels

FH・HOYA-I : TAKASAKI

Partial use of precast members

7. Conclusion

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- Disaster prevention
- Construction period
- High quality
- Design