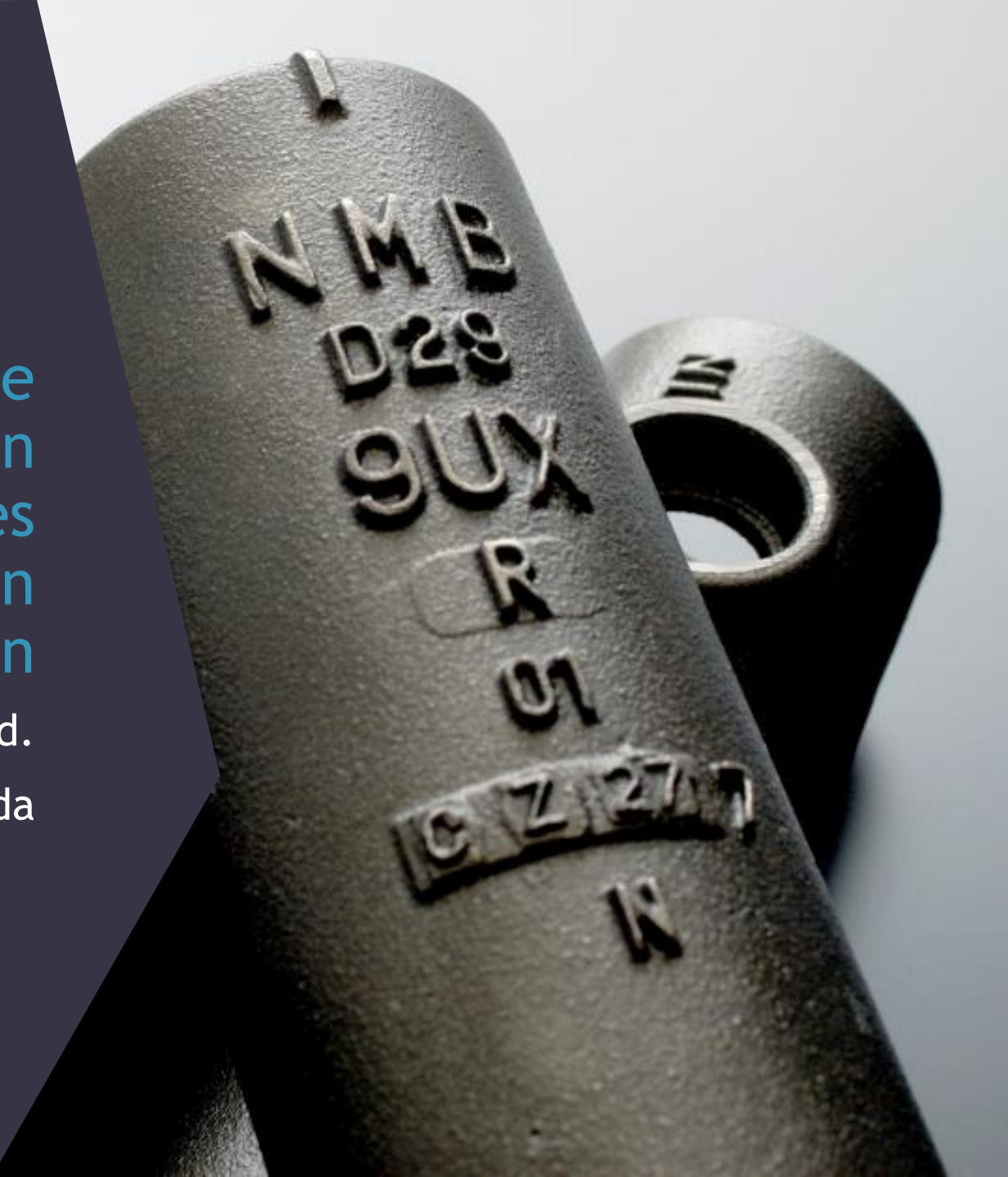
Precast concrete connections in seismic zones grout splices in Japan

Splice Sleeve Japan, Ltd.

Asao Sakuda



I ♥ PRECAST

NMB SPLICE SLEEVE SYSTEM

Agenda

- What are grout splices?
- Japanese requirements for mechanical splices
- Application examples of grout splices

Agenda

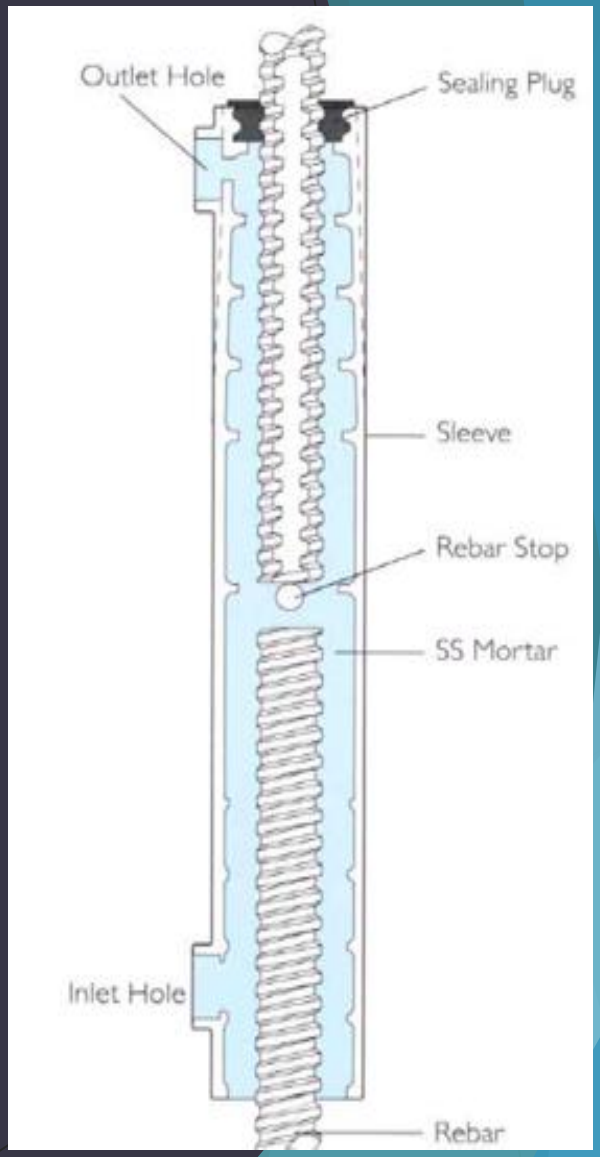
- What are grout splices?
- Japanese requirements for mechanical splices
- Application examples

What are grout splices?

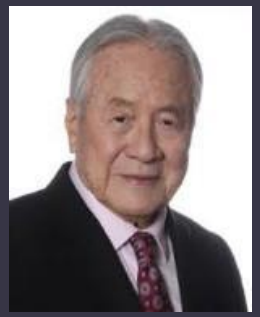
A grout splice consists of a cylindrical shaped coupler made of metal and a Portland cement based non-shrink, high-early-strength grout material.

NMB Splice Sleeve

Filling grout

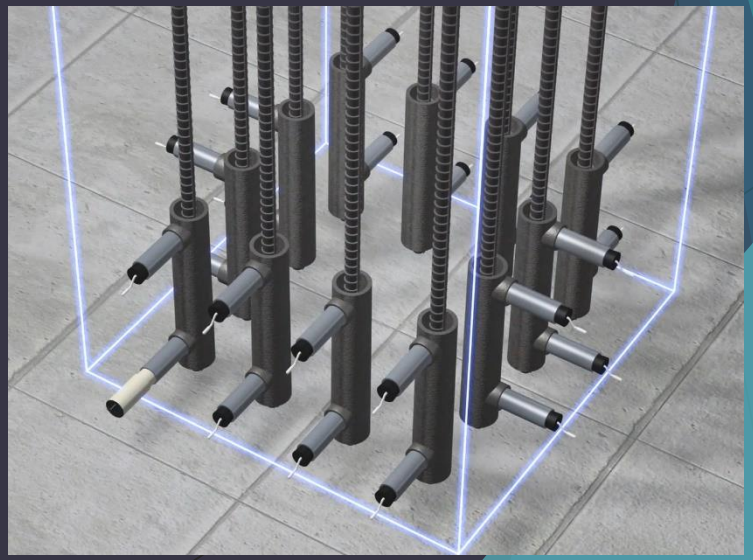


What are grout splices?

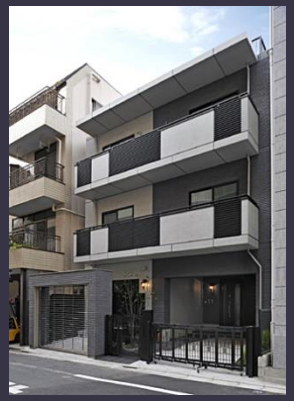
- Grout splices are reinforcing bar splices specially designed for the connection of structural precast concrete units.
- 
  They were invented by an American structure engineer, Dr. Alfred A. Yee in Hawaii in the early 1970's.
- Grout splices were used for the first time in the construction of a 38-story precast concrete building, the Ala Moana Hotel in Honolulu, Hawaii.

PCI Journal Volume 18, No.3 May-June 1973

What are grout splices?



What are grout splices?













Agenda

- What are grout splices?
- Japanese requirements for mechanical splices
- Application example

Mechanical splices requirements

Rebar Joint Performance Evaluation Standard（1982）updated in 2000, The Building Center of Japan

Class SA: The strength, rigidity and ductility are almost equivalent to those of the rebars to joint.

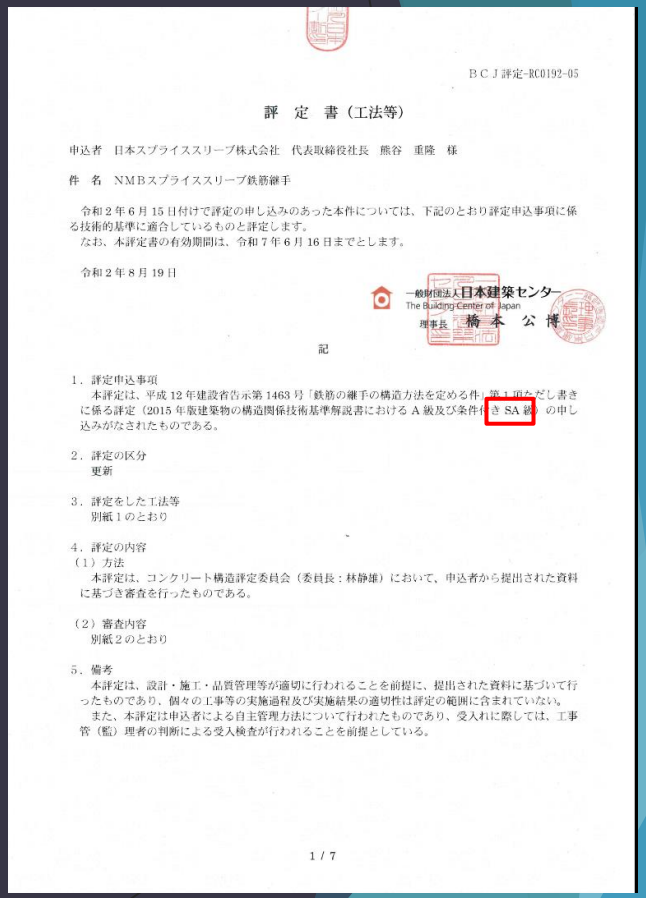
Class A: The strength and rigidity are almost equivalent, but the ductility is slightly inferior to the rebars to connect.

Class B; The strength and rigidity are almost equivalent, but other characteristics are inferior to the rebars to connect

Class C; The strength, rigidity etc. are inferior to the rebars to connect

Mechanical splices requirements

- Grout splices are the only mechanical splices qualified as class SA splices in Japan



BCJ評定-RC0192-05

評　定　書（工法等）

申込者　日本スプライススリーブ株式会社　代表取締役社長　熊谷　重隆　様

件　名　NMBスプライススリーブ鉄筋継手

令和２年６月15日付けで評定の申し込みのあった本件については、下記のとおり評定申込事項に係る技術的基準に適合しているものと評定します。
なお、本評定書の有効期間は、令和７年６月16日までとします。

令和２年８月19日

一般財団法人日本建築センター
The Building Center of Japan
理事長　橋本　公博

記

１．評定申込事項
本評定は、平成12年建設省告示第1463号「鉄筋の継手の構造方法を定める件」第１項ただし書きに係る評定（2015年版建築物の構造関係技術基準解説書における A 級及び条件付き SA 級）の申し込みがなされたものである。

２．評定の区分
更新

３．評定をした工法等
別紙１のとおり

４．評定の内容
（１）方法
本評定は、コンクリート構造評定委員会（委員長：林静雄）において、申込者から提出された資料に基づき審査を行ったものである。

（２）審査内容
別紙２のとおり

５．備考
本評定は、設計・施工・品質管理等が適切に行われることを前提に、提出された資料に基づいて行ったものであり、個々の工事等の実施過程及び実施結果の適切性は評定の範囲に含まれていない。
また、本評定は申込者による自主管理方法について行われたものであり、受入れに際しては、工事管（監）理者の判断による受入検査が行われることを前提としている。

1 / 7

Mechanical splices requirements

Requirements for class SA splices
1- high performance

(1) Monotonic tensile test $0 \rightarrow \sigma_{y0} \rightarrow$ failure

(2) Repeated tensile test $0 \rightarrow (0.02\sigma_{y0} \leftrightarrow 0.95\sigma_{y0}) \rightarrow$ failure
↑30 times

(3) Elastic cyclic test $0 \rightarrow (0.95\sigma_{y0} \leftrightarrow -0.5\sigma_{y0}) \rightarrow$ failure
↑20 times

(4) Plastic cyclic test $0 \rightarrow (2\varepsilon_y \leftrightarrow -0.5\sigma_0) \rightarrow (5\varepsilon_y \leftrightarrow -0.5\sigma_0) \rightarrow$ failure
↑4times ↑4times

σ_{y0}: specified yield strength of the rebar
ε_y: yield strain of the grout splice assembly at yield stress

Mechanical splices requirements

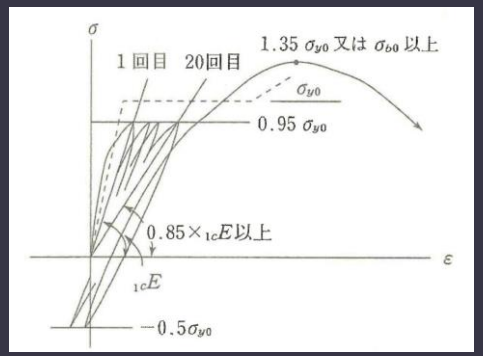
Requirements for class SA splices
1- high performance

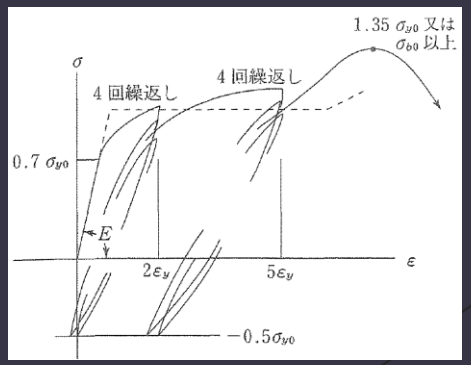
(3) Elastic cyclic test $0 \rightarrow (0.95\sigma y0 \leftrightarrow -0.5\sigma y0) \rightarrow$ failure
↑20 times

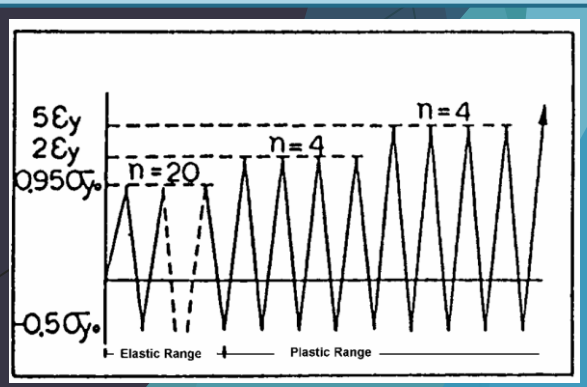
(4) Plastic cyclic test $0 \rightarrow (2\varepsilon y \leftrightarrow -0.5\sigma 0) \rightarrow (5\varepsilon y \leftrightarrow -0.5\sigma 0) \rightarrow$ failure
↑4times ↑4times

required tensile strength	$\sigma b > 1.35\sigma y0$ or $\sigma b > \sigma b0$
residual slip	elastic area 20c δs ≦ 0.3㎜
	plastic area 4c δs ≦0.3㎜ and δs 8c ≦ 0.9mm
failure mode	bar break

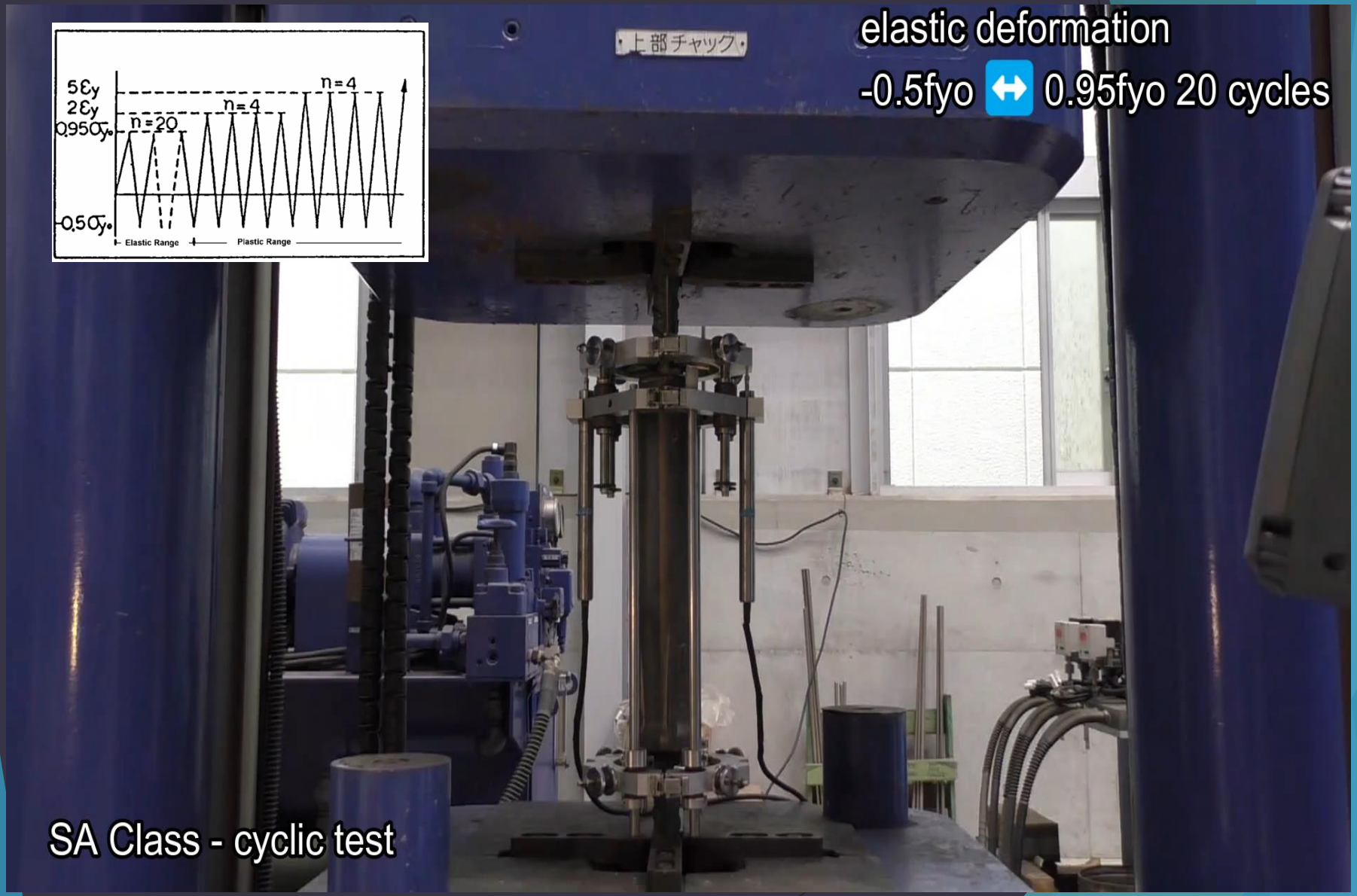
σy0:specified yield strength of the rebar
εy: yield strain of the grout splice assembly at yield stress
20c δs, 4c δs 8c δs: residual slip after 20 or 4 or 8 load cycles







Mechanical splices requirements



Mechanical splices requirements

Requirements for class SA splices
2 - submission of performance mock-up tests results to prove high resistance during earthquakes

Conduction of performance mock-up test
- minimum 1/3 scale mock-up test
- shall use actual mechanical splices
- applied load shall be as an emulation of an earthquake

NMB Splice Sleeve mock-up results evaluated for class SA recognition columns 58 pieces, beams 12 pieces, walls 82 pieces total of 152 precast concrete units

Mechanical splices requirements

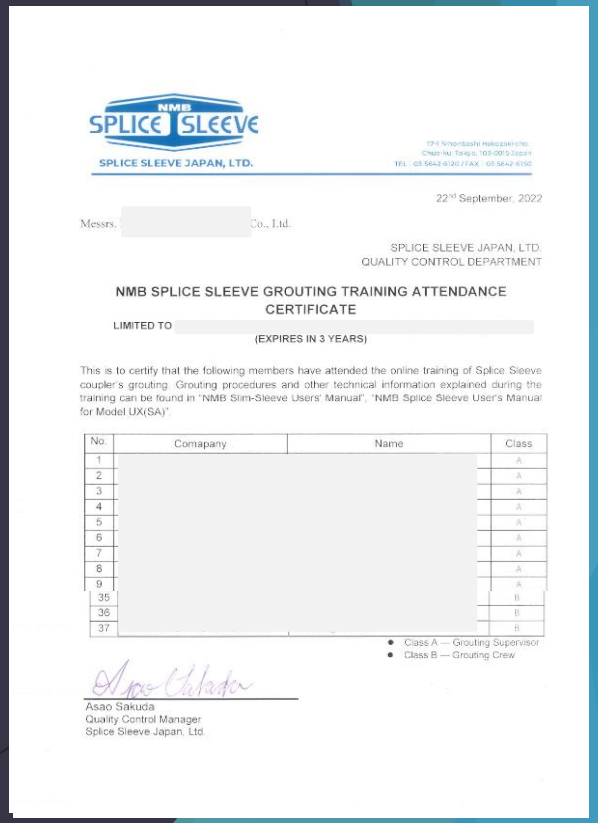
Requirements for SA class splices
3 – Design Guidelines
4 – Grouting Procedure's Instruction Manual

Design Guidelines contents
- Scope of application of grout splices
- List of existing standards to follow
- Additional information necessary to consider during design
- Rebars, grout splices, grout's scope of specifications

Grouting Procedure's Instruction Manual contents
- Quality control system
- Recommend tool and equipment
- Quality control check lists
- Quality control test criteria
- Training sessions for grouting work team members and leaders

Mechanical splices requirements

Requirements for SA class splices
3 - Design Guidelines
4 - Grouting Procedure's Instructions



SPLICE SLEEVE JAPAN, LTD.

22nd September, 2022

Messrs. Co., Ltd.

SPLICE SLEEVE JAPAN, LTD.
QUALITY CONTROL DEPARTMENT

NMB SPLICE SLEEVE GROUTING TRAINING ATTENDANCE CERTIFICATE

LIMITED TO

(EXPIRES IN 3 YEARS)

This is to certify that the following members have attended the online training of Splice Sleeve coupler's grouting. Grouting procedures and other technical information explained during the training can be found in "NMB Slim-Sleeve Users' Manual", "NMB Splice Sleeve User's Manual for Model UX(SA)".

No.	Comapany	Name	Class
1			A
2			A
3			A
4			A
5			A
6			A
7			A
8			A
9			A
35			B
36			B
37			B

- Class A — Grouting Supervisor
- Class B — Grouting Crew

Asao Sakuda
Quality Control Manager
Splice Sleeve Japan, Ltd.

Agenda

- What are grout splices?
- Japanese requirements for mechanical splices
- Application example

RC-full PCa building construction example

- Project name: new development in Tokyo area（multistory condominium, private project）
- Total period: September 2010～July 2012
- Structure:　RC & S　23 stories, 1 underground story
  1 penthouse　condominium（201 flats）
  B1～2F：cast in place
  2F～23F・PH：precast

Building area: 3,000 m^2

Total floor space: 20,000 m^2

RC-full PCa building construction example

Splice Sleeve Japan, Ltd.

Splice Sleeve Japan, Ltd.

RC-full PCa building construction example

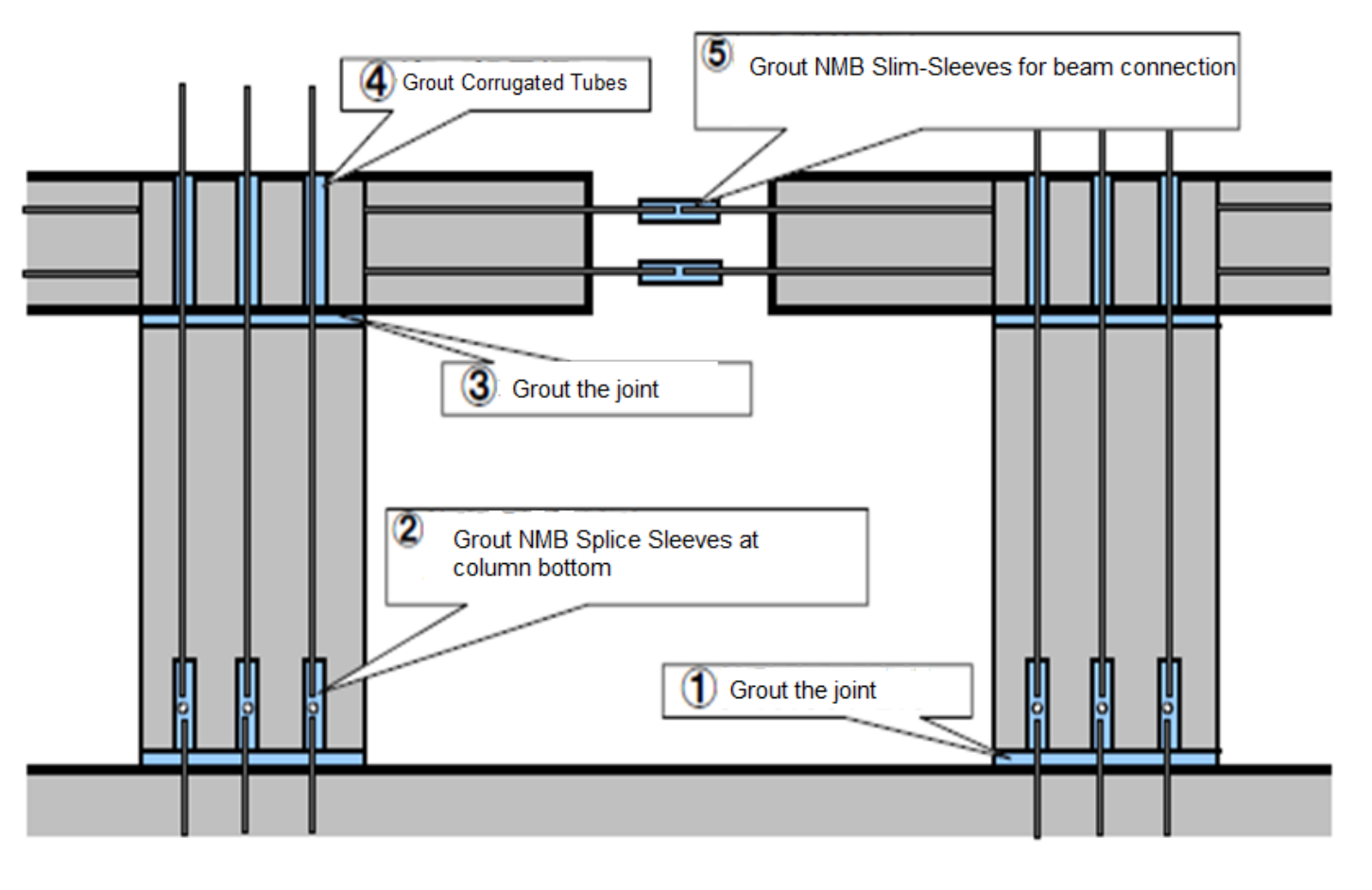
Precast concrete units

RC-full PCa building construction example

Precast concrete units

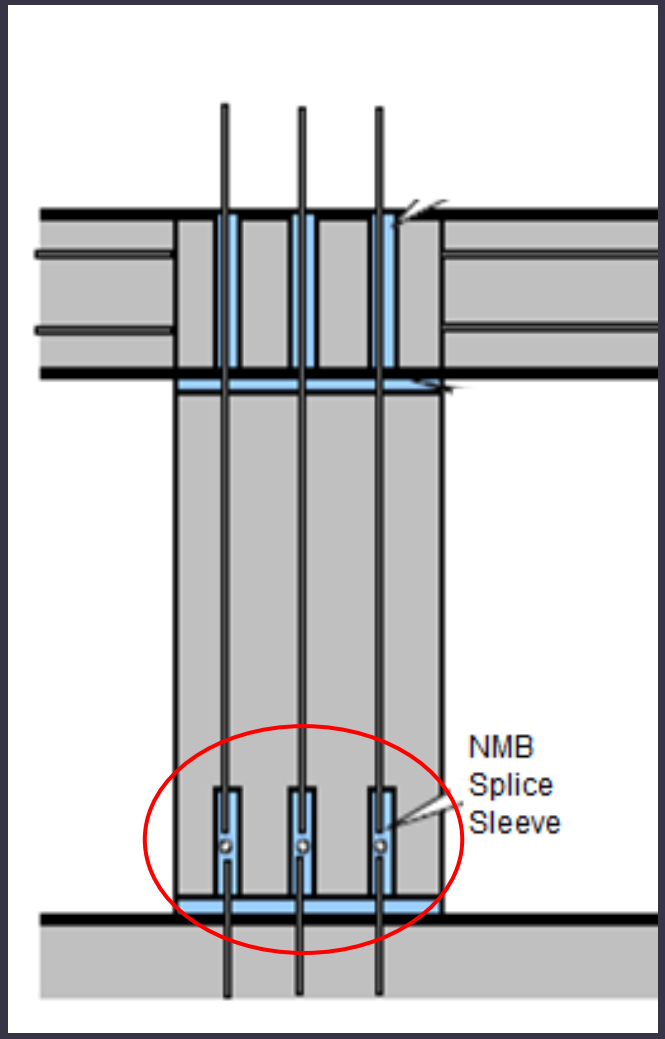
RC-full PCa building construction example

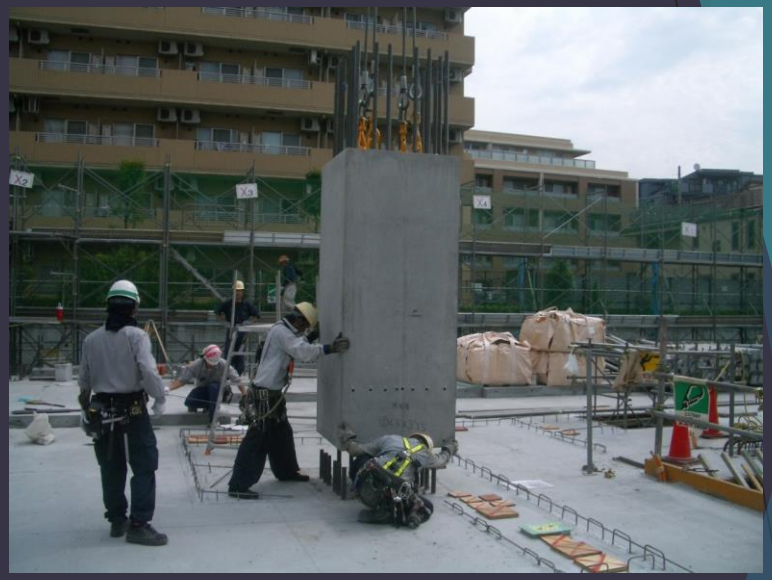
Precast concrete units



RC-full PCa building construction example

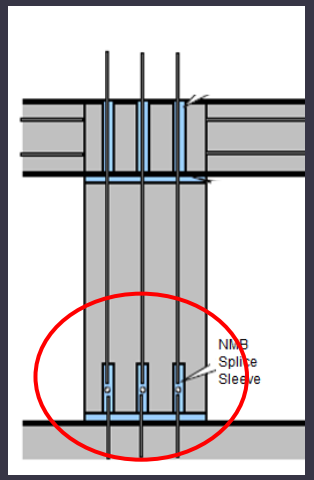
Precast column's erection

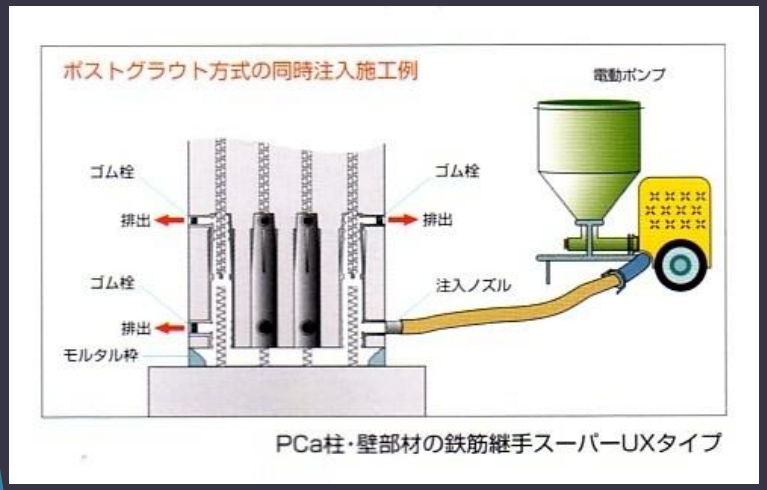




RC-full PCa building construction example

Precast column / column connections



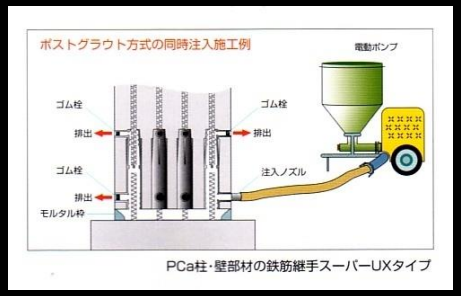


column/column joint sealing

（sealing method: high strength low-flowable grout, grouting Sleeve schedule to be conducted the next day）

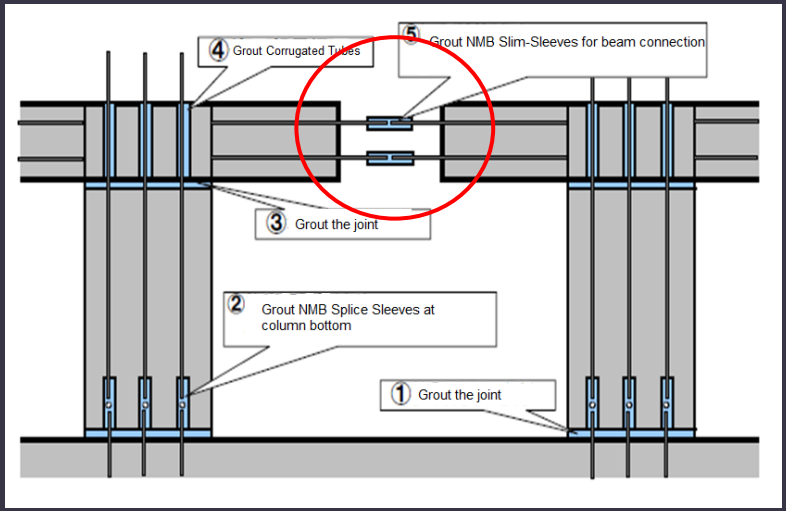
RC-full PCa building construction example

Precast column / column connections



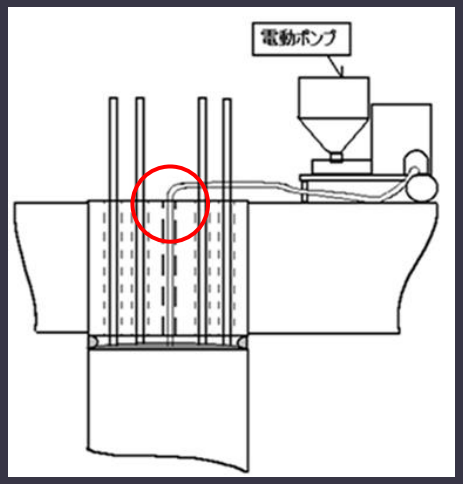
RC-full PCa building construction example

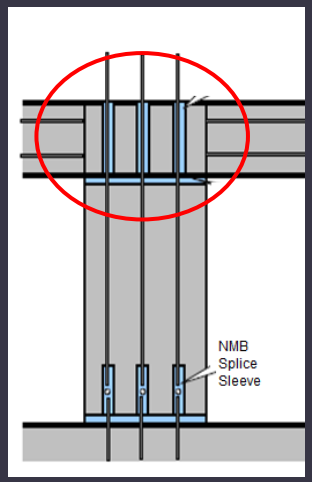
Beam / beam connection's location



RC-full PCa building construction example

Precast column/beam connection grouting





High-rise buildings

High rise building
56 stories, Tokyo

High rise building
53 stories, Tokyo

High rise building
100 stories, Australia

ig. 1. Ala Moana Hotel in Honolulu, Hawaii, neari

- “The new vertical support technique was designed to overcome a difficulty in joining precast units. Designers and builders are continually working on new joinery for structural precast units that will provide continuity at minimum cost. This new technique appears to be a promising one. ”

PCI Journal Volume 18, No3
May-June 1973

Thank you for your attention

arigato gozaimashita

ありがとうございました

www.splice.co.jp