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SUMITOMO-MITSUI QUICK RC INTEGRATION METHOD (SQRIM) PRECAST SYSTEM/DRY PRECAST BEAM-COLUMN JOINT SYSTEM

CSI Sections:

03 40 00 Precast Concrete
03 41 00 Precast Structural Concrete
03 45 00 Precast Architectural Concrete
03 48 00 Precast Concrete Specialties

1.0 RECOGNITION

The Sumitomo-Mitsui Quick RC Integration Method (SQRIM) Precast System/Dry Precast Beam-Column Joint System recognized in this report has been evaluated for use as a structural reinforced concrete load-bearing and lateral force-resisting system. The structural performance and physical characteristics properties of the SQRIM Precast System/Dry Precast Beam-Column Joint System comply with the intent of the provisions of the following codes and regulations:

- 2024, 2021, 2018, and 2015 International Building Code® (IBC)
- 2024, 2021, 2018, and 2015 International Residential Code® (IRC)

2.0 LIMITATIONS

Use of the SQRIM Precast System/Dry Precast Beam-Column Joint System recognized in this report is subject to the following limitations:

2.1 Fabrication of the SQRIM Precast System/Dry Precast Beam-Column Joint System assemblies shall comply with Section 3.3 of this report and with approved construction drawings specified by a registered design professional approved by SMCC and shall be performed on the premises of a fabricator registered and approved by the building official in accordance with Section 1704.2.5.1 of 2024, 2021, and 2018 IBC or Section 1704 of 2015 IBC.

2.2 The SQRIM Precast System/Dry Precast Beam-Column Joint System shall be designed, fabricated, erected, and installed in accordance with the IBC or IRC, the manufacturer's published installation instructions, and this report. Where there is a conflict, the most restrictive requirements shall govern.

2.3 Construction documents in accordance with Section 3.2.1 of this report shall be submitted to the building official for approval.

2.4 Erection shall comply with Section 3.3 of this report and the approved construction drawings prepared by a registered design professional and specified by SMCC.

2.5 Special inspection, structural observation, and testing shall be in accordance with Section 3.4 of this evaluation report.

2.6 Use of the SQRIM system shall be authorized by SMCC.

2.7 Fire-resistance ratings are beyond the scope of this report.

2.8 The SQRIM components recognized in this report are produced by SMCC authorized and approved locations.

3.0 PRODUCT USE

3.1 General: SQRIM is a fully precast reinforced concrete method that acts as the building's main structural elements such as the columns, beams, and the beam-column joint. In SQRIM, the beam and beam-column joint are fabricated as a single precast element. As an alternative, in SQRIM-H, the column and beam-column joint core are fabricated as one element. These elements are installed at the construction site. Grouted mechanical sleeves are used to join the precast elements. The SQRIM system complies with ACI 318 18.9.2.3 based on tests in accordance with ACI 374.1.

3.2 Design:

3.2.1 General: The structural design of moment frames incorporating the SQRIM beam-column joints shall comply with IBC Sections 1601.1, 1616.2.1, and 1905, and ACI 318. Construction documents shall comply with IBC Section 1603, ACI 318 Chapter 26, and shall demonstrate:

a) A continuous uninterrupted load path to the foundation exists for all members subjected to dead load, live load, wind load, earthquake motions, and other loading types described in Chapter 16 of the IBC.

b) The integrity of the entire load path when the entire structure and each story are subjected to the design story drift limitations of ASCE/SEI 7 Section 12.12.1.

c) Distribution of the total lateral forces to the participating members of the lateral force resisting system in

proportion to the rigidities of each member in accordance with IBC Section 1604.4.

d) Where the moment frames support gravity loads, the lateral-force-resisting system shall be well distributed throughout the structure.

e) The surfaces where the SQRIM beam-column joint and the precast column or precast beam connect shall be detailed to minimize the effects of crushing or spalling where the concrete members bear against each other.

f) Conformance to ACI 318 4.12, 9.2.2.2, 10.2.2.2, 16.2, and 16.3, as applicable.

3.2.2 Strength

3.2.2.1 The nominal strengths at all locations shall be calculated in accordance with the requirements of ACI 318 and this report.

3.2.2.2 Design strengths shall be taken as the nominal strengths multiplied by the applicable strength reduction factors in ACI 318.

3.2.2.3 The design strengths shall equal or exceed the required strengths for all factored strength load combinations in Section 1605 of the IBC. The minimum flexural strengths of the SQRIM beam-column joint shall conform to ACI 318 18.7.3. Design Shear strengths of beams shall comply with ACI 318 18.6.5 and 18.8.4, and design shear strengths of columns shall comply with ACI 318 18.7.6 and 18.8.4.

3.2.2.4 Factored strength load conditions requiring the overstrength factor, Ω_o, shall be determined in accordance with ASCE/SEI 7.

3.2.2.5 The provisions of ACI 318 18.9.2.1 shall apply except 18.9.2.1(c).

3.2.2.6 The nominal flexural strength at the beam-column interface for both positive and negative moments at $\Theta_{Ldesign}$ shall be calculated based on 22.2.1 to 22.2.3 of ACI 318 and satisfying the applicable equilibrium and deformations compatibility requirements.

3.2.2.7 The probable flexural strength, M_{pr}, at a beam-column interface for both positive and negative moments shall be calculated based on the provisions given in Sections 3.2.2.7.1 to 3.2.2.7.4 of this report, 22.2.1 to 22.2.3 of ACI 318, and satisfying the applicable equilibrium and deformations compatibility requirements.

3.2.2.7.1 As the connection at the interface opens, the elongation of the longitudinal reinforcement shall be assumed to be directly proportional to the distance from the neutral axis.

3.2.2.7.2 The strain in the longitudinal reinforcement in tension, ε_t, shall be calculated using the standard strain equation for bonded reinforcement due to tension and flexure.

$$\varepsilon_t \leq \varepsilon_u \qquad \text{(Eq. 3.7.7.7.2a)}$$

Where:

ε_u = strain in reinforcement at its tensile strength f_u.

The steel stress corresponding to ε_u shall be taken from actual stress-strain properties for the steel heat. Otherwise, the tensile stress in the reinforcement at M_{pr} shall be assumed as the specified minimum f_u for ASTM A706 or ASTM A615 Grade 60 and the strain ε_u shall be

$$\varepsilon_u = \varepsilon_{es} - 0.02 \qquad \text{(Eq. 3.7.7.7.2b)}$$

Where:

ε_{es} is the strain at the minimum elongation specified in ASTM A706 or ASTM A615 Grade 60 for the bar diameter.

3.2.2.7.3 The stress in the longitudinal reinforcement in compression is calculated from the deformation compatibility geometry for the compressed concrete and actual stress-strain properties for the steel heat. Otherwise, the stress in that reinforcement at M_{pr} shall be assumed as $0.65f_y$.

3.2.2.8 Development length, l_d, for longitudinal reinforcement anchored in ducts, shall be taken from 25.4 of ACI 318 where f'_c is the grout compressive strength.

3.2.2.9 Anchorages for the top and bottom reinforcement crossing the beam-column interface in exterior one-way and corner joints shall be headed deformed bars complying with ACI 318 18.8.5.2, 20.2.1.6, and 25.4.4, and headed bar manufacturer's requirements.

3.2.2.10 SQRIM beam-column joints shall be designed in accordance with 18.8 of ACI 318. Nominal shear strengths shall be calculated using effective joint areas, Aj.

3.2.2.11 The design shear strength of the beam-column joint when the probable moments M_{pr} act on opposite sides of the beam-column joint shall be a maximum of 1.0 times the value specified in 18.8.4.3 of ACI 318.

3.2.3 Serviceability

3.2.3.1 The total drift ratio shall be calculated as the lateral displacement at the top of the structure divided by its height.

3.2.3.2 The story drift ratio shall be calculated as the relative lateral displacement between the top and bottom of a story, divided by the story height.

3.2.3.3 The design total drift ratio, Θ_{design}, and design story drift ratio for the SQRIM structure shall be calculated in accordance with Sections 12.8.6, 12.9.1, or 12.9.2 of ASCE/SEI 7. Foundation flexibility shall be considered and included in the linear analysis, where applicable. The analysis

shall account for the soil type supporting the moment frame and conform to Section 12.13.3 of ASCE/SEI 7.

3.2.3.4 The design total drift ratio, Θ_{design}, and design story drift ratio at the design displacement and the limiting factored strength load combinations involving the earthquake loading E, calculated as required in Section 3.2.4 of this report, shall not exceed the lesser of 2 percent or the limits in ASCE/SEI 7 Section 12.12.1for a design emulating cast-in-place construction and 3.5 percent for a performance-based design. Performance-based procedures shall comply with IBC Appendix O, the ICC Performance Code for Buildings and Facilities (1CCPC), and ASCE/SEI 7 Section 1.3.1.3.

3.2.3.5 The demand drift ratio and drift ratio capacity for any beam-column joint shall be calculated as the sum of the components caused by the:

a) Inelastic deformations at the beam-column interfaces at the probable flexural strengths M_{pr} for those interfaces.

b) Sum of the corresponding elastic deformations of the beams and columns framing into that joint and of the joint shear deformations.

3.2.3.6 The structure shall be designed to have a total drift ratio capacity, Θ_{Lmax}, and story ratio capacities, equal to or greater than 0.035.

3.2.3.7 The story drift ratio capacity for any story shall be the least drift ratio capacity for any beam-column joint in that story.

3.2.4 Special Moment Frame Requirements

3.2.4.1 General: The SQRIM beam-column joints described in this report are intended to be used in precast reinforced concrete special moment frames and shall conform to Section 18.9 of ACI 318, and the following:

3.2.4.1.1 Interior, exterior, and corner configurations are permitted.

3.2.4.1.2 Dimensions shall conform to ACI 318 18.6.2, 18.7.2, 18.8.2.3 (ACI 318-19 only), and 18.8.2.4 (ACI 318-14 only), except as follows:

a) beam width shall be less than or equal to the adjacent column width.

3.2.4.1.3 The interfaces between the columns-and-the-beam-column joints, beams-and-the-beam-column joints, and the columns-to-foundations shall be the only nonlinear locations.

3.2.4.1.4 For multistory precast columns, the splices of longitudinal bars in columns in any given story shall be permitted where the Type 2 SQRIM Groutec F series couplers are located near the interfaces of the column and the beam-column joint, or anywhere along the length of the column. The locations shall be specified in the approved plans.

3.2.4.1.5 The openings at the interface of the beam-column joint-and-the-precast-column, and the beam-column joint-and-the-precast-beam under seismic motions shall be analyzed to assess effects on the function of both the gravity load resisting system and any diaphragm.

3.2.4.1.6 The floor and roof members and connections to the beams shall be designed and detailed to accommodate design displacements of the moment frame at each story level.

3.2.4.1.7 The longitudinal reinforcement in the beams shall comply with ACI 318 18.6.3, 18.8.2.1, 18.8.2.2, and 18.8.5 and the transverse reinforcement shall comply with ACI 318 18.6.4. Transverse reinforcement in the joint shall comply with ACI 318 18.8.3. The longitudinal reinforcement in the columns shall comply with ACI 318 18.7.4 and 18.8.5, and the transverse reinforcement shall comply with ACI 318 18.7.5.

3.2.4.1.8 Transverse reinforcement shall enclose the SQRIM Groutec F series couplers in accordance with ACI 318-19 10.7.6.1.6, as applicable.

3.3 Fabrication and Erection:

3.3.1 Fabrication: The SQRIM Precast System/Dry Precast Beam-Column Joint System precast concrete components shall be manufactured by an approved fabricator in accordance with Section 1704.2.5.1 of the 2024, 2021, and 2018 IBC, Section 1704 of the 2015 IBC, fabrication manuals by an SMCC-authorized fabricator, and fabrication drawings from a registered design professional authorized by SMCC. The specified concrete cover for reinforcement, couplers, and end fittings shall comply with ACI 318 20.5.1.3.3 and 20.5.1.4.2.

3.3.2 Erection: The erection sequencing is illustrated in Figures 1A and 1B of this report. Member markings, support, bracing, and details of any lifting devices and embedments shall be provided in accordance with ACI 318 26.9.

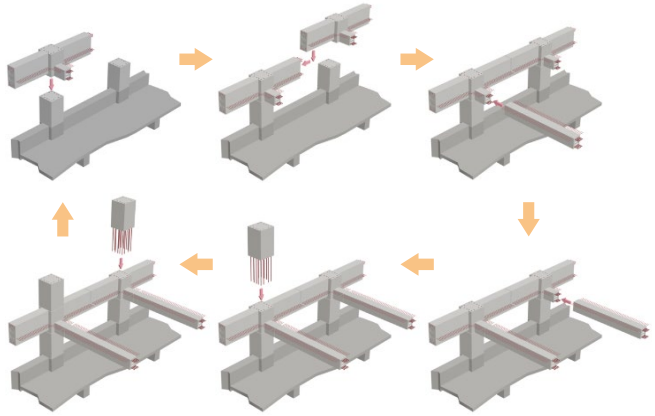

Figure 1A: SQRIM General Erection Sequence

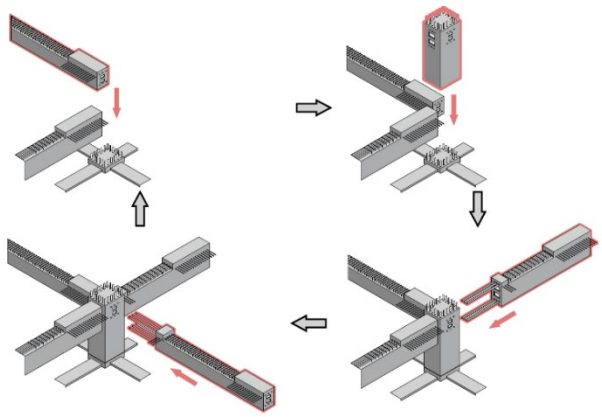

Figure 1B: SQRIM-H General Erection Sequence

3.4 Special Inspection:

3.4.1 Erection. Precast concrete elements shall be lifted, assembled, and braced in accordance with approved fabrication and erection documents.

3.4.2 Connections. All connections in the beam-column joints, columns, and beams shall be in accordance with approved documents and applicable sections of the IBC and ACI 318.

3.4.3 Grout: Proper grout materials shall be used as specified. Samples for grout strength shall be prepared for testing.

4.0 PRODUCT DESCRIPTION

4.1 Concrete:

Normalweight concrete shall conform to Sections 1901 to 1905 of the IBC and ACI 318, as applicable. Concrete used in special moment frames shall also comply with requirements in ACI 318 Chapters 18 and 19. Compressive strength shall comply with ACI 318 19.2.

4.2 Reinforcement:

4.2.1 Seismic Design Category (SDC) A: The reinforcing bars shall conform to Sections 1901 to 1905 of the IBC and ACI 318 20.2, as applicable.

4.2.2 Seismic Design Categories (SDC) B through F: For shear and lateral support, the reinforcing bars shall conform to Sections 1901 to 1905 of the IBC and ACI 318 20.2, as applicable, provided the maximum value of f_y used in the design calculations is 60,000 psi. For flexure, axial loads, shrinkage, and temperature, the reinforcing bars shall conform to Sections 1901 to 1905 of the IBC and ACI 318 20.2, as applicable, and comply with ASTM A706 Grade 60.

4.2.3 Alternative Reinforcement Types:

Where ASTM A706 Grade 60 reinforcement is specified in this report, alternative types, such as ASTM A615 Grade 60, are permitted. The alternative reinforcement shall be compatible with the Groutec F series couplers recognized in IAPMO UES ER-780, and the deformation heights, yield strength, tensile strength, and ultimate elongation shall conform to ASTM A706 Grade 60 and the supplemental requirements in ACI 318 20.2.2.5(b). The maximum value of f_y used in the design calculations is 60,000 psi.

4.3 Mechanical Couplers: The mechanical couplers are the SQRIM Groutec F series, recognized in IAPMO UES ER-780 as Type 2.

4.4 Grout: The Grout is SikaGrout-870 SQRIM, recognized in IAPMO UES ER-780. The grout's compressive strength shall attain a minimum value equal to or greater than the concrete compressive strength specified in the design by the design professional.

5.0 IDENTIFICATION

The mechanical couplers and grout shall be identified in accordance with ER-780.

IAPMO UES ER-827

6.0 SUBSTANTIATING DATA

6.1 Test reports are from laboratories in compliance with ISO/IEC 17025.

6.2 Test reports in accordance with the Acceptance Criteria for Moment Frames Based on Structural Testing (ACI 374.1-05), Reapproved in 2019.

6.3 Analyses in accordance with ACI 318 and ACI 374.1.

7.0 STATEMENT OF RECOGNITION

This evaluation report describes the results of research completed by IAPMO Uniform Evaluation Service on the Sumitomo-Mitsui Quick RC Integration Method (SQRIM) Precast System/Dry Precast Beam-Column Joint System to assess conformance to the codes shown in Section 1.0 of this report and serves as documentation of the product certification. Products are manufactured under a quality control program with periodic inspection under the supervision of IAPMO UES.

For additional information about this evaluation report please visit www.uniform-es.org or email us at info@uniform-es.org