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To: ICC-ES Evaluation Committee

From: Moneeb Genedy, Ph.D., P.E. and Aileen Vandenberg, Ph.D.

Date: June 10, 2025

Subject: Proposed Acceptance Criteria for Seawater Concrete for Use in Plain or FRP Reinforced Concrete Members (AC574)

MEMO

A proposed Acceptance Criteria for Seawater Concrete for Use in Plain or FRP Reinforced Concrete Members, Subject AC574-0625-R1, was outlined in our staff letter dated March 28, 2025.

During the 30-day public comment period for AC574, we received the following comments. Staff responses to each comment are as follows:

1. ***University of Miami:*** Given the unique chemical environment presented by seawater concrete, it would be beneficial to explicitly specify the curing conditions as well. ASTM C31 and ASTM C192 currently prescribe curing specimens in fresh (potable) water only, as only fresh water is currently being used, and, thus, do not address curing in seawater environments. Clarifying whether curing should occur in freshwater, seawater, or if both methods are acceptable would ensure consistency across laboratory and field applications, aiding accurate assessment of long-term durability and performance.

   ICC-ES Staff Response: The Acceptance Criteria has been expanded to include the option of seawater curing for seawater concrete. To address this, the following have been added:
   - Definition of Seawater Curing: Section 1.4.9,
   - Evaluation of concrete cured with seawater (Optional): Section 3.3,

   In addition, Table 2 “REQUIRED PHYSICAL PROPERTIES OF CONCRETE” has been divided into two tables: Table 3 “REQUIRED FRESH PROPERTIES OF CONCRTE” and Table 4 “REQUIRED HARDENED PROPERTIES OF CONCRTE”. Minor editorial changes were made throughout the AC to reflect the proposed changes.

2. ***Mateenbar:*** Section 2.1 – What is the standard test method for chemical composition of seawater? What elements must be reported? What will ICC-ES do with this information, and will there be some form of acceptance criteria and/or approval of the seawater based on this?

   ICC-ES Staff Response: Section 2.1 has been revised and Table 2 “SEAWATER COMPOSITION AND TEST METHODS” that includes a list of required seawater compositions to be reported and standard test methods. There is no acceptance criteria and/or approval of the seawater based on this information. This information will be included in the ICC-ES evaluation report as a quantitative description of the seawater used in producing the seawater concrete. Also, this information will be the reference for the quality control testing of seawater in accordance with Section 4.5 of AC574.

3. ***Mateenbar:*** Section 2.4 - This states that the FRP bars must be compliant with ACI 440.11, however ACI 440.11 refers to ASTM D7957. Would it be preferrable to reference ASTM D7957 directly, and possibly add in the recent ASTM D8505, which is not currently referenced in the ACI 440.11?

   ICC-ES Staff Response: Sections 1.2 and 2.4 have been modified to include ASTM D7957 and ASTM D8505.

4. ***Mateenbar:*** Section 2.5 – Is the packaging requirement for the seawater or the seawater concrete?

   ICC-ES Staff Response: The requirements in Section 2.5 are for the seawater concrete.

5. ***Mateenbar:*** Section 3.1.1 – Define “seawater source”. Is that by geographic location, and if so, how much area (distance) is covered ?

   ***ICC-ES Staff Response*:** A definition of “Seawater Source” has been added in Section 1.4.10.

6. ***Mateenbar:*** Following on from this point in Section 1.4.5 – Major Environmental Event should include flooding of rivers, which would alter the composition of the seawater close to a river mouth, etc.

   ***ICC-ES Staff Response*:** Major environmental events are not limited to the specific events listed in Section 1.4.5. Section 1.4.5 has been revised to include flooding of rivers when seawater source is located near river mouth as well as clarifying that the stated events are just examples.

7. ***Mateenbar:*** Section 3.3 – Since GFRP reinforced concrete is not allowed for fire-rated construction in the USA, it is ill-advised to include this optional provision. This may be a regional consideration.

   ***ICC-ES Staff Response*:** GFRP reinforced concrete is not allowed for fire-rated construction in accordance with IBC means that the typical minimum protection and assembly thickness in accordance with Table 721.1(a) and 721.1(2) cannot be used for GFRP reinforced concrete. However, the use of testing to determine the fire resistance rating would be allowed under Section 104.2.3 of the 2024 IBC (Section 104.11 of the 2021 IBC and earlier versions) as referenced in Section 703.2.3.

8. ***Mateenbar:*** Section 3.1.7 If there is any treatment of the seawater, then the seawater composition (as per 2.1) samples should undergo the same treatment before testing to ensure they are representative.

   ***ICC-ES Staff Response*:** This is the intention of Section 3.1.7, and it has been revised to clarify this requirement.

9. ***Mateenbar:*** Section 3.3.1 – Correct typo “ASTM” and not “ASTEM”

   ***ICC-ES Staff Response*:** Thank you for pointing this out. It has been corrected.

10. ***Mateenbar:*** Section 4.5 – Is a 10% variation acceptable for all elements? Should the limit be +10% with a negative limit of -100% (i.e. Is there a problem if the seawater is 'more like' freshwater)?

    ***ICC-ES Staff Response*:** We agree. Section 4.5 has been revised to reflect this change.

11. ***Mateenbar:*** Section 4.6 – Is the inspection verification required for every seawater concrete batch?

    ***ICC-ES Staff Response*:** The compressive strength is required for each batch. The chemical composition of seawater shall be conducted monthly as stated in Section 4.5.

12. ***Mateenbar:*** Section 4.6 – Is the 10% variability between batches? If not, between what properties or items is the variability measured?

    ***ICC-ES Staff Response*:** The 10% variability is between the tested cylinders from each batch. Section 4.6 has been revised to clarify this point.

13. ***Mateenbar:*** Table 2 – For compressive strength, what test ages are required for non-seawater concrete? Is a one-year test age excessive? Even a 6-month test seems excessive. Strength versus age curves have been established for seawater concrete, so surely these could be used to extrapolate beyond 3 months (with factor of safety applied)."

    ***ICC-ES Staff Response*:** Seawater and non-seawater concrete shall be tested at the same age for all ages listed in Tables 4. The 6-month and one-year tests are included to evaluate the long-term effect of seawater on concrete as required by ASTM C494. However, an exception was included in Sections 3.2.2 and 3.3.2 to allow issuance of the evaluation report if the 3-month testing satisfies the requirements and the 6-month and 1-year testing could be submitted within 9 months of the issuance of the evaluation report.

14. ***Mateenbar:*** Table 2 – Footnotes 5 and 6 can be removed as they are redundant to the test method information included in the second column of the table for all properties."

    ***ICC-ES Staff Response*:** We agree. Footnotes 5 and 6 have been removed.

15. ***Mateenbar:*** Overall – What is the expectation for submittals for acceptance under this criteria? There are infinite possible mix designs even without considering seawater. It would seem that the water itself could just be tested in a similar manner to the existing water standard test method ASTM C1602; perhaps an addition to that standard test could suffice."

    ***ICC-ES Staff Response*:** We understand that there are infinite possible mix designs. Thus, the expectation is representative mix designs shall be tested with w/c between 0.45 and 0.5 as stated in Section 3.1.4. As for evaluating the seawater itself, not the seawater concrete, the evaluation of non-potable water in accordance with ASTM C1602 still requires testing of concrete samples and does not address all the concerns of mixing concrete with seawater. Thus, we believe that the comprehensive testing required in ICC-ES AC574 will address all safety concerns related to using seawater for mixing and curing concrete.

ICC EVALUATION SERVICE

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PROPOSED ACCEPTANCE CRITERIA FOR SEAWATER CONCRETE FOR USE IN PLAIN OR FRP-REINFORCED CONCRETE MEMBERS (AC574)

AC574 (24)

Proposed June 2025

PREFACE

Evaluation reports issued by ICC Evaluation Service, LLC (ICC-ES), are based upon performance features of the International family of codes, and may include other codes, as applicable.

For alternative materials, design and methods of construction and equipment, see Section 104.2.3 of the 2024 *International Building Code*® (IBC), Section R104.2.2 of the 2024 *International Residential Code*® (IRC), Section 104.11 of the 2021 IBC and earlier editions, and Section R104.11 of the 2021 IRC and earlier editions.

ICC-ES may consider alternate criteria for report approval, provided the report applicant submits data demonstrating that the alternate criteria are at least equivalent to the criteria set forth in this document, and otherwise demonstrate compliance with the performance features of the codes. ICC-ES retains the right to refuse to issue or renew any evaluation report, if the applicable product, material, or method of construction is such that either unusual care with its installation or use must be exercised for satisfactory performance, or if malfunctioning is apt to cause injury or unreasonable damage.

Acceptance criteria are developed for use solely by ICC-ES for purposes of issuing ICC-ES evaluation reports

PROPOSED ACCEPTANCE CRITERIA FOR SEAWATER CONCRETE FOR USE IN PLAIN OR FRP REINFORCED CONCRETE MEMBERS (AC574)

1.0 INTRODUCTION

1.1 Purpose: The purpose of this acceptance criteria is to establish requirements for the evaluation of concrete made with seawater, in ICC Evaluation Service, LLC (ICC-ES), evaluation reports under the code editions indicated in Section 1.3.

The reason for the development of this criteria is to provide guidelines for the evaluation of concrete made with seawater, because the codes do not provide requirements for testing and the use of seawater as mixing water in structural or non-structural concrete.

1.2 Scope: The acceptance criteria is limited to the use of seawater as mixing water for the production of hydraulic cement concrete, used only in applications as plain concrete or when FRP ~~rebars~~ reinforcing bars are used as the reinforcement. The seawater evaluated in this criteria is an alternative to code specified ASTM C1602 potable mixing water, as required by Section 26.4.1.4 of ACI 318-19, which is referenced by Chapter 19 of the 2024 and 2021 IBC.

The FRP reinforcing bars used in structural seawater concrete applications must comply with ASTM D7957 and ACI CODE 440.11 as referenced by Chapter 19 of the 2024 ~~IBC, or~~IBC or have an evaluation report under the ICC-ES Acceptance Criteria AC454. FRP reinforcing bars that comply with ASTM D8505 may also be used in structural seawater concrete applications. For nonstructural seawater concrete applications where FRP reinforcing bars are used as temperature and shrinkage reinforcement, FRP reinforcing bars must have an evaluation report under the ICC-ES Acceptance Criteria AC521.

Use of seawater as mixing water for concrete where conventional steel reinforcing bars or steel anchorage inserts are used is outside the scope of this criteria.

1.3 Codes and Referenced Standards: Where standards are referenced in this criteria, these standards must be applied consistently with the code upon which compliance is based. Where standards and code editions are not listed in this section, Table 1 summarizes the specific date applicable to each code.

1.3.1 2024 and 2021 *International Building Code*® (IBC), International Code Council.

1.3.2 2024 and 2021 *International Residential Code*® (IRC), International Code Council.

1.3.3 2021 *Dubai Building Code*® (DBC), Government of Dubai.

1.3.4 2018 *Saudi Building Code*® (SBC), Saudi Building Code National Committee.

1.3.5 ACI 318, Building Code Requirements for Structural Concrete, American Concrete Institute.

1.3.6 ACI 440.11, Building Code Requirements for Structural Concrete Reinforced with Glass Fiber-Reinforced Polymer (GFRP) Bars, American Concrete Institute.

1.3.7 ASTM C31/C31M, Practice for Making and Curing Concrete Test Specimens in the Field, ASTM International.

1.3.8 ASTM C33/C33M, Standard Specification for Concrete Aggregates, ASTM International.

1.3.9 ASTM C39/C39M, Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens, ASTM International.

1.3.10 ASTM C78/C78M, Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading), ASTM International.

1.3.11 ASTM C138/C138M, Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete, ASTM International.

1.3.12 ASTM C143/C143M, Standard Test Method for Slump of Hydraulic-Cement Concrete, ASTM International.

1.3.13 ASTM C150/C150M, Standard Specification for Portland Cement, ASTM International.

1.3.14 ASTM C157/C157M, Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete, ASTM International.

1.3.15 ASTM C192/C192M, Practice of Making and Curing Concrete Test Specimens in the Laboratory, ASTM International.

1.3.16 ASTM C231/C231M, Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method, ASTM International.

1.3.17 ASTM C232/C232M, Standard Test Method for Bleeding of Concrete, ASTM International.

1.3.18 ASTM C330/C330M, Standard Specification for Lightweight Aggregate for Structural Concrete, ASTM International.

1.3.19 ASTM C403/C403M, Standard Test Method for Time of Setting of Concrete Mixtures by Penetration Resistance, ASTM International.

1.3.20 ASTM C666/C666M, Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing, ASTM International.

1.3.21 ASTM C1012/C1012M, Standard Test Method for Length Change of Hydraulic-Cement Mortars Exposed to a Sulfate Solution, ASTM International.

1.3.22 ASTM C1260, Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method), ASTM International.

1.3.23 ASTM C1602/C1602M, Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete, ASTM International.

1.3.24 ASTMC1778 Standard Guide for Reducing the Risk of Deleterious Alkali-Aggregate Reaction in Concrete, ASTM International.

1.3.25 ASTM D1293 Standard Test Methods for pH of Water, ASTM International.

1.3.26 ASTM D1976 Standard Test Method for Elements in Water by Inductively-Coupled Plasma Atomic Emission Spectroscopy, ASTM International.

1.3.27 ASTM D4327 Standard Test Method for Anions in Water by Suppressed Ion Chromatography, ASTM International.

1.3.28 ASTM D5464 Standard Test Method for pH Measurement of Water of Low Conductivity, ASTM International.

1.3.29 ASTM D5907 Standard Test Methods for Filterable Matter (Total Dissolved Solids) and Nonfilterable Matter (Total Suspended Solids) in Water, ASTM International.

1.3.30 ASTM D7975/D7975M Standard Specification for Solid Round Glass Fiber Reinforced Polymer Bars for Concrete Reinforcement, ASTM International.

1.3.31 ASTM D8505/D8505M Standard Specification for Basalt and Glass Fiber Reinforced Polymer (FRP) Bars for Concrete Reinforcement, ASTM International.

1.3.32 ASTM E119, Standard Test Method for Fire Tests of Building Construction and Materials, ASTM International.

1.3.33 ASTM E136, Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C, ASTM International.

1.3.34 ICC-ES Acceptance Criteria for Fiber-reinforced Polymer (FRP) Bars for Internal Reinforcement of Concrete Members (AC454).

1.3.35 ICC-ES Acceptance Criteria for Proprietary Hydraulic Cement (AC459).

1.3.36 ICC-ES Acceptance Criteria for Fiber–reinforced Polymer (FRP) Bars and Meshes for Internal Reinforcement of Non-structural Concrete Members (AC521).

1.3.37 ICC-ES Acceptance Criteria for Low-carbon Alternative Cements for Use in Concrete (AC529).

1.3.38 UL 263, Standard for Fire Tests of Building Construction and Materials, UL, LLC.

1.3.39 ISO 21930-17, Sustainability in Buildings and Civil Engineering Works – Core Rules for Environmental product Declarations of Construction Products and Services, International Organization of Standardization (ISO).

1.4 Definitions:

1.4.1 Compressive Strength Ratio: Compressive strength ratio is the ratio between the compressive strength of the seawater concrete sample and the compressive strength of the reference sample.

1.4.2 Flexural Strength Ratio: Flexural strength ratio is the ratio between the flexural strength of the seawater concrete sample and the flexural strength of the reference sample.

1.4.3 Initial/Final Setting time deviation: Initial/~~Final~~ final setting time deviation is the difference between the initial/final setting time of the seawater concrete sample and the initial/final setting time of the reference sample.

1.4.4 Length Change Ratio: Length change ratio is the ratio between the length change of the seawater concrete sample and the length change of the reference sample.

1.4.5 Major Environmental Event: Major environmental event is an event that can affect the chemical composition of the water at seawater source (e.g., a hurricane~~ or~~, an oil spill, a flooding of rivers when the seawater source is located near river mouth, etc.).

1.4.6 Reference Samples: Reference samples are concrete samples that are made with potable mixing water in accordance with ASTM C1602.

1.4.7 Relative Durability Factor Ratio: Relative durability factor ratio is the ratio between the relative durability factor of the seawater concrete sample and the relative durability factor of the reference sample.

1.4.8 Seawater Concrete: Seawater concrete is concrete that is mixed with seawater.

1.4.9 Seawater Curing: Seawater curing is moisture curing of concrete samples in seawater in accordance with the procedure of ASTM C192.

1.4.10 Seawater Source: Seawater Source is defined as the combination of the on-shore location of the facility used to collect the seawater and the distance of the inlet collecting seawater from the shoreline.

1.4.11 Standard Curing: Standard curing is moisture curing of concrete samples in accordance with ASTM C192.

2.0 BASIC INFORMATION

2.1 Seawater composition: The pH, total dissolved solids, and chemical composition, in accordance with Table 2, of the seawater used in seawater concrete mixing must be submitted to ICC-ES.

2.2 Concrete Mix Design: The mix design of all seawater concrete mixes to be evaluated must be submitted.

2.3 Reference Cement Type: For ~~T~~the Cement used in seawater concrete, information showing compliance with Section 26.4.1.1.1 (a) of ACI-318 as referenced by Section 19 of the IBC or an evaluation report under the ICC-ES Acceptance Criteria AC459 or ICC-ES Acceptance Criteria AC529 must be submitted.

2.4 FRP Reinforcing Bars: For FRP reinforcing bars used in structural seawater concrete applications, information showing compliance with ASTM D7957 and ACI CODE 440.11 as referenced by Chapter 19 of the 2024 IBC or compliance with ASTM D8505 or an evaluation report under the ICC-ES Acceptance Criteria AC454 must be submitted. For nonstructural seawater concrete applications where FRP reinforcing bars are used as temperature and shrinkage reinforcement, an evaluation report under the ICC-ES Acceptance Criteria AC521 must be submitted.

2.5 Packaging and Identification: A description of the method of seawater source labeling (i.e. transportation truck bill) shall be submitted. Product labeling shall include the evaluation report number. Product Identification shall be in accordance with the product identification provisions of the ICC-ES Rules of Procedure for Evaluation Reports. The ICC-ES mark of conformity, electronic labeling, and/or the evaluation report number (ICC-ES ESR-XXXX) along with the name, registered trademark, or registered logo of the report holder [and/or listee] must be included in the product label.

2.6 Testing Laboratories, Reports of Tests and Product Sampling:

2.6.1 Testing laboratories shall comply with Section 2.0 of the ICC-ES Acceptance Criteria for Test Reports (AC85) and Section 4.2 of the ICC-ES Rules of Procedure for Evaluation Reports.

2.6.2 Test reports shall comply with AC85.

2.6.3 Sampling of the seawater concrete for the tests under this criteria shall comply with Section 3.2 of AC85. The preparation of the test specimens for the tests required under this criteria shall be completed by the testing laboratory.

2.7 Qualification Test Plan: A qualification test plan shall be submitted to and approved by ICC-ES staff prior to any testing being conducted.

3.0 REQUIRED DATA TEST AND PERFORMANCE REQUIREMENTS

3.1 General: The seawater concrete shall be tested in accordance with Sections 3.2, 3.3, 3.4, and 3.45. Testing shall also comply with Sections 3.1.1 to 3.1.4 of this section.

3.1.1 Each seawater source shall be tested separately for concrete tests in Sections 3.2, 3.3, 3.4 and 3.45. Chemical composition of seawater from the source ~~can~~ must be used for quality control purposes.

3.1.2 Reference cement type must be reported in the final test report~~,~~ and to be included in the ICC-ES evaluation report.

3.1.3 Tests shall be conducted using concrete mixtures prepared with normal weight aggregates meeting the applicable requirements of ASTM C33. Optionally, when use of the seawater in lightweight concrete is desired, lightweight aggregates meeting the applicable requirements of ASTM C330 shall be used.

3.1.4 Tests shall be conducted using concrete mixtures prepared with the maximum water-to-cement ratio (0.45 – 0.50).

3.1.5 Due to being limited to FRP reinforcing bars only, the limits on fly ash as given in Section 26.4.2.2(b)(1) of ACI 318 are allowed to be exceeded for seawater concrete evaluated in accordance with this criteria, when Section 3.2 requirements of this criteria are met.

3.1.6 If applicable, placement technique considerations for the seawater concrete shall be reported by the testing laboratory, and concrete placement instructions from the manufacturer shall be included in the ICC Evaluation Service evaluation report, including specific instructions for project adjustments of workability and setting time, if necessary.

3.1.7 If applicable, any treatment for seawater used by the manufacturer in mixing and/or curing of the seawater concrete shall be used in mixing and/or curing of concrete samples tested in accordance with Section 3.2, 3.3, 3.4 and 3.5. The treatment process shall be reported by the testing laboratory, and ~~the treatment process from the manufacturer~~ shall be included in the ICC Evaluation Service evaluation report.

3.2 Physical Properties of Concrete: The purpose of this section is to evaluate the effect of seawater on the fresh and hardened properties of concrete.

3.2.1 Physical requirements specified in Tables ~~2~~3 and 4 shall be evaluated. Test specimens shall be prepared and tested in accordance with the ASTM standards or alternative test standards specified in Table ~~3~~5.

Exception: The relative durability factor measured by the freezing and thawing test per ASTM C666 as specified in Table ~~2~~4 is applicable only if the admixture is intended for use in air-entrained concrete that may be exposed to freezing and thawing while wet.

3.2.2 For the results of compressive and flexural strength, the specimens shall be tested for compliance at each time interval specified by the physical requirements of ASTM C260 and C494, as applicable, and shall be determined in comparison to reference samples. The starting point (time zero) for each of these time intervals is the time at which the test specimens are initially cast.

Exception: For initial evaluation, submittal of the six months and one-year compression strength tests may be supplied within nine months of evaluation report issuance, provided reports of tests demonstrate provisional compliance with the alternative compressive strength requirements in Table ~~2~~4.

3.3 Seawater Curing (Optional): Seawater concrete cured in seawater shall demonstrate the performance requirements listed in Table 4 when compared with reference samples cured under standard curing conditions.

3.3.1 Physical requirements specified in Table 4 shall be evaluated. Test specimens shall be prepared and tested in accordance with the ASTM standards or alternative test standards specified in Table 5.

Exception: The relative durability factor measured by the freezing and thawing test per ASTM C666 as specified in Table 4 is applicable only if the admixture is intended for use in air-entrained concrete that may be exposed to freezing and thawing while wet.

3.3.2 For the results of compressive and flexural strength, the specimens shall be tested for compliance at each time interval specified by the physical requirements of ASTM C260 and C494, as applicable, and shall be determined in comparison to reference samples. The starting point (time zero) for each of these time intervals is the time at which the test specimens are initially cast.

Exception: For initial evaluation, submittal of the six months and one-year compression strength tests may be supplied within nine months of evaluation report issuance, provided reports of tests demonstrate provisional compliance with the alternative compressive strength requirements in Table 4.

3.4 Use in Fire-resistance Rated Construction (Optional): When evaluation is sought for use on assemblies required to be of fire-resistance-rate construction, reports of tests in accordance with ASTM E119 or UL 263 must be submitted for each assembly to be included in the evaluation report. Additionally, the aggregate type used in fire-resistance tests must be reported in the ICC Evaluation service report.

3.4.1 Conditions of Acceptance: The conditions of acceptance must comply with AST~~E~~M E119 or UL263, as applicable.

3.5 Use in Buildings of Types I, II, III, and IV Construction (Optional): When evaluation is sought for use in Types I, II, III, or IV construction where the assembly must be constructed of non-combustible materials, the seawater concrete must be tested in accordance with ASTM E136.

3.5.1 Conditions of Acceptance: The specimens of seawater concrete must comply with the requirements of IBC Section 703.4~~3~~. Otherwise, use shall be limited to Type V construction only.

4.0 QUALITY CONTROL

4.1 Quality documentation complying with the ICC-ES Acceptance Criteria for Quality Documentation (AC10) shall be submitted.

4.2 A qualifying inspection shall be conducted at each manufacturing facility in accordance with the requirements of the ICC-ES Acceptance Criteria for Inspections and Inspection Agencies (AC304).

4.3 An annual inspection shall be conducted at each manufacturing facility in accordance with AC304.

4.4 Seawater must be free of any foreign impurities visible at a magnification of 5X as addressed in the quality control program. For additional requirements, see Sections 2.1, 3.1.1, 3.1.7, and 3.2 of this criteria.

4.5 The ~~chemical~~ composition of seawater must be tested in accordance with Table 2 monthly and after each major environmental event at the seawater source as addressed in the quality control program. The ~~chemical~~ composition of the seawater shall be in compliance with ICC-ES evaluation report with ~~maximum variability of 10 percent~~no component more than 110 percent of the values reported in the ICC-ES evaluation report.

4.6 Special inspection shall be required in accordance with Sections 1705.1.1 and 1705.3 of the IBC during the mixing and placing of the seawater concrete. In addition, the report applicant shall submit inspection procedures to verify proper usage. The inspection shall include verification that the chemical composition of the seawater and the concrete compressive strength are in compliance with the ICC-ES evaluation report. Concrete cylinders are to be field cured in accordance with ASTM C31 or Section 1.4.9, as applicable, and tested in accordance with ASTM C39 with maximum variability between tested cylinders of 10 percent.

5.0 EVALUATION REPORT REQUIREMENTS

5.1 The evaluation report shall state that seawater concrete used under the IBC, DBC, or SBC is subject to approval by the registered design professional.

5.2 The evaluation report shall state the source geographical location of seawater used as mixing water in seawater concrete.

5.3 The evaluation report shall include a statement that the seawater recognized in this evaluation report can be used in lieu of ASTM C1602 specified potable water for structural or nonstructural concrete production in which FRP ~~rebars~~ reinforcing bars are used as reinforcement.

5.4 The evaluation report shall include a statement that the FRP reinforcing bars used in structural seawater concrete applications must comply with ASTM D7957 and ACI CODE 440.11 as referenced by Chapter 19 of the 2024 IBC or comply with ASTM D8505 or have an evaluation report under the Acceptance Criteria AC454.

5.5 The evaluation report shall include a statement that for nonstructural seawater concrete applications where FRP reinforcing bars are used as temperature and shrinkage reinforcement only, FRP reinforcing bars must have an evaluation report under the Acceptance Criteria AC521.

5.6 The evaluation report shall state whether the seawater concrete is evaluated for the use in air-entrained concrete that may be exposed to freezing and thawing while wet.

5.7 The initial setting time deviation, final setting time deviation, compressive strength ratio, flexural strength ratio, length change ratio, and relative durability factor of the seawater concrete as determined in accordance with Sections 3.2 and 3.3 shall be reported in the evaluation report for consideration by the registered design professional, as applicable.

5.8 Use in fire-resistance rated construction as determined in accordance with Section 3.~~3~~ 4 shall be described in the evaluation report. The assembly or assemblies qualified in accordance with Section 3.4~~-~~5 shall be described in the evaluation report.

5.9 Use in buildings of Types I, II, III, and IV construction as determined in accordance with Section 3.4 5 shall be described in the evaluation report.

6.0 ENVIRONMENTAL PRODUCT DECLARATION (Optional)

Environmental impacts shall be assessed via an Environmental Product Declaration (EPD) based on a Life Cycle Assessment (LCA). The LCA and EPD shall be conducted in accordance with ISO 21930 and the appropriate Product Category Rule(s) for the product type.■

TABLE 1 – 2024 IBC, 2021 IBC, 2021 DBC, and 2018 SBC APPLICABLE EDITIONS OF REFERENCED STANDARDS[1]

STANDARDS INCLUDED IN CRITERIA	2024 IBC	2021 IBC	2021 DBC	2018 SBC
ACI 318	-19	-19	-19	-14
ACI 440	-19	-	-	-
ASTM C33	-18	-18	-18	-13
ASTM C39	-18	-18	-18	-14a
ASTM C78	-22	-22	-22	-22
ASTM C138	-17a	-17a	-17a	-17a
ASTM C143	-20	-20	-20	-20
ASTM C157	24e1	24e1	24e1	24e1
ASTM C192	-18	-18	-18	-18
ASTM C231	-17a	-17a	-17a	-14
ASTM C232	-21	-21	-21	-21
ASTM C330	17a	17a	17a	-09
ASTM C403	-23	-23	-23	-23
ASTM C666	-15	-15	-15	-15
ASTM C1012	-18b	-18b	-18b	-13
ASTM C1567	-23	-23	-23	-23
ASTM C1602	-18	-18	-18	-12
ASTM D1293	-18	-18	-18	-18
ASTM D1976	-20	-20	-20	-20
ASTM D4327	-17	-17	-17	-17
ASTM D5464	-25	-25	-25	-25
ASTM D5907	-18	-18	-18	-18
ASTM D7957	-17	-17	-17	-17
ASTM D8505	-23	-23	-23	-23
ASTM E119	-20	-18b	-18b	-12a
ASTM E136	-22	-19	-19	-12
UL 263	-11	-11	-11	-11

[1]When a specific edition of a standard is referenced in this table under a specific edition of the code, products must be shown to comply with the specified edition of the standard.

TABLE 2 – SEAWATER COMPOSITION AND TEST METHODS

SEAWATER COMPOSITION	TEST METHOD
Chloride (Cl^-)	ASTM D4327
Sulfate (SO_4^{2-})	
Sodium (Na^+)	ASTM D1976
Magnesium (Mg^{2+})	
Calcium (Ca^{2+})	
Potassium (K^+)	
Alkalies as ($Na_2O+0.658\ K_2O$)	
Total Dissolved Solids (TDS)	ASTM D5907
pH	ASTM D1293 or ASTM D5464

PROPOSED ACCEPTANCE CRITERIA FOR SEAWATER CONCRETE FOR USE IN PLAIN OR FRP REINFORCED CONCRETE MEMBERS AC574 (24)

TABLE ~~2~~3–REQUIRED ~~PHYSICAL~~ FRESH PROPERTIES OF CONCRETE

PROPERTY	TEST METHOD	NUMBER OF SPECIMENS PER MIX DESIGN	ACCEPTANCE CRITERIA
Slump	ASTM C143	3 (one per batch)	+- 1 inch of reference mixture
Fresh Density	ASTM C138	3 (one per batch)	+- 5 percent of reference mixture
Air content	ASTM C231	3 (one per batch)	+- 1 percent of reference mixture-
Initial Time of setting	ASTM C403	3 (one per batch)	Not 1:00 earlier nor 1:30 later
Final Time of setting	ASTM C403	3 (one per batch)	Not 1:00 earlier nor 1:30 later
Bleeding	ASTM C232	3 (one per batch)	Max. 2% over reference sample
~~Compressive strength~~	~~ASTM C39~~	~~9 (three per test age from 3 separate batches)~~	~~Min. 90% of reference sample~~
~~Flexural strength~~	~~ASTM C78~~	~~9 (three per test age from 3 separate batches)~~	~~Min. 90% of reference sample~~
~~Length change~~	~~ASTM C157~~	~~3 (one per batch)~~	~~Same as reference mixture length change or less~~
~~Freezing and Thawing[4]~~	~~ASTM C666~~	~~3 (one per batch)~~	~~Min. 90% of reference Sample~~
~~Sulfate attack resistance~~	~~ASTM C1012~~	~~6 (two per batch)~~	~~Must be within permitted level in accordance with ACI 318 - Table 26.4.2.2(c)~~
~~Alkali silica reaction~~	~~ASTM C1260~~	~~3 (one per batch)~~	~~Must be class R0 in accordance with ASTM C1778 (i.e., <0.10% expansion)~~

~~[1]Fresh Concrete~~
~~[2]Test shall be conducted at 3 days, 7 days, 28 days, 90 days, 6 months, and 1 year.~~
~~[3]Test shall be conducted at 3, 7, and 28 days.~~
~~[4]Applicable only if the admixture is intended for use in air-entrained concrete that may be exposed to freezing and thawing while wet.~~
~~[5]Test shall be conducted in accordance with ASTM C1012.~~
~~[6]Test shall be conducted in accordance with ASTM C1260.~~

TABLE 4–REQUIRED HARDENED PROPERTIES OF CONCRETE

PROPERTY	TEST METHOD	NUMBER OF TEST AGES	NUMBER OF SPECIMENS PER MIX DESIGN	ACCEPTANCE CRITERIA
Compressive strength	ASTM C39	6[1]	18 (three per test age from 3 separate batches)	Min. 90% of reference sample
Flexural strength	ASTM C78	3[2]	9 (three per test age from 3 separate batches)	Min. 90% of reference sample
Length change	ASTM C157	1	3 (one per batch)	Same as reference mixture length change or less
Freezing and Thawing[3]	ASTM C666	1	3 (one per batch)	Min. 90% of reference Sample
Sulfate attack resistance	ASTM C1012	1	6 (two per batch)	Must be within permitted level in accordance with ACI 318 - Table 26.4.2.2(c)
Alkali silica reaction	ASTM C1260	1	3 (one per batch)	Must be class R0 in accordance with ASTM C1778 (i.e., <0.10% expansion)

[1]Test shall be conducted at 3 days, 7 days, 28 days, 90 days, 6 months, and 1 year.
[2]Test shall be conducted at 3, 7, and 28 days.
[3]Applicable only if the admixture is intended for use in air-entrained concrete that may be exposed to freezing and thawing while wet.

TABLE ~~3~~5~~–~~ TEST STANDARDS FOR REQUIRED PHYSICAL PROPERTIES OF CONCRETE

PHYSICAL PROPETIES	ASTM STANDARD	ALTERNATIVE STANDARD[2]
Slump	ASTM C143	BS EN 12350-2
Fresh Density	ASTM C138	BS EN 12350-6
Air content	ASTM C231	BS EN 12350-7
Time of setting	ASTM C403	BS EN 196-3
Compressive strength	ASTM C39	BS EN 12390-3
Flexural strength	ASTM C78	BS EN 12390-5
Length change	ASTM C157	BS EN 12390-16
Freezing and Thawing[1]	ASTM C666	-
Bleeding	ASTM C232	-

[1]Applicable only if the admixture is intended for use in air-entrained concrete that may be exposed to freezing and thawing while wet.

[2] Evaluation report shall state the EN standard for any reported value in evaluation report if EN standard is used in lieu of ASTM standard during the qualification tests. (Note: unless they are exactly the same).