**Type Your Title Here Using Title Case; 70 Characters Maximum; Spell Out Any Acronyms or Abbreviations**

by John Smith and David Lee

(please ensure names match exactly how they are written in the Author Bios. First name, middle initial [if any], last name [given name first, followed by family name or surname])

# Biography: (75 Words Maximum for each author. Please include author’s name, current job title, and place of employment [including location, if possible]. Also include education [degrees received and schools attended, including location], ACI affiliations only [committee membership and/or awards received], and research interests.)

# Examples:

# ACI member John Smith is a Professor in the Department of Civil and Environmental Engineering at the University of Michigan, Ann Arbor, MI*.* He received his BS from Michigan State University, East Lansing, MI; his MS from The University of British Columbia, Vancouver, BC, Canada; and his PhD from Harvard University, Cambridge, MA. He is a member of ACI Committees 221, Aggregates; 302, Construction of Concrete Floors; and 325, Concrete Pavements. His research interests include the durability of reinforced concrete structures in the marine environment.

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# ABSTRACT/SYNOPSIS

# (150 Words Maximum. Should be a concise statement of the principal findings and conclusions. Do not cite references, figures, or tables in this section.)

# *A detailed investigation of concrete specimens (3.94 in. [100 mm] diameter and 7.87 in. [200 mm] height) made with different chemical admixtures was carried out after 10 years of tidal exposure. Chemical admixtures included air-entraining admixture (vinsol), water-reducing admixture (lignosulfonate group), various high-range water-reducing and air-entraining admixtures (naphthalene, melamine, polycarboxyl, and amino-sulfonate groups), and drying-shrinkage-reducing admixture (glycol ether plus amino alcohol derivatives). The specimens were tested for compressive strength, Young’s modulus of elasticity, carbonation depths, chloride ingress, pore-size distribution, electrochemical and physical evaluation of steel bar’s corrosion in concrete, examination of steel-concrete interfaces, and mineralogy of the mortar portions of concrete.*

**Keywords:** 9 keywords maximum. Type keywords alphabetically, all lowercase style, and separated by semicolons, with a period following the final keyword. Any keyword containing an acronym should be spelled out, with the acronym following the keyword in parentheses. “cement” or “concrete” should not be included in this list.

# INTRODUCTION

(All acronyms are to be spelled out at first mention from this point of the paper onward. Acronym can be used on its own thereafter. **Do not place notations or symbols in text boxes unless they cannot otherwise be typed in plain text.**)

Water-reducing chemical admixtures are used to produce concrete of higher strength, obtain a specified strength at a lower water-cement ratio (*w*/*c*), or increase the slump of a given mixture without an increase in water content. Numerous studies on the properties of fresh concrete mixed with different chemical admixtures were carried out to investigate the fresh concrete properties or the concrete properties at an early age of exposure. There were also several international conferences held focusing on the chemical admixtures in the last couple of decades. Detailed studies on the long-term performance of concrete mixed with different chemical admixtures, however, are very scarce in the technical literature. Therefore, studies on the long-term performance of chemical admixtures will be (…)

# RESEARCH SIGNIFICANCE

# (100 Words Maximum; should identify the significance and potential impact of the reported work on the state of the art or state of practice)

Different types of high-range water-reducing and air-entraining chemical admixtures were developed in the last couple of decades. Most of the studies on these admixtures were carried out to judge the properties of fresh concrete, or the properties of concrete at an early age. Studies on the long-term performance of concrete made with different water-reducing admixtures are very scarce in the technical literatures. The authors believe that this detailed study dealing with the long-term performance of different chemical admixtures is carried out for the first time and will be very useful to concrete technology. (…)

### Experimental Investigation (Or experimental procedure)

(This section may involve laboratory investigations and/or field investigations)

Cylinder specimens with and without steel reinforcements (3.94 in. [100 mm] diameter and 7.87 in. [200 mm] height [unit example 1]) of 19 separate cases were investigated. The variables include cement types (ordinary portland cement, blended cement replaced by slag powder of 4080 and 7900 cm2/g [unit example 2]), air-entraining (vinsol) chemical admixture, water-reducing (lignosulfonate type) chemical admixture, high-range water-reducing and air-entraining (naphthalene, melamine, polycarboxyl, and amino-sulfonate types) chemical admixture, drying-shrinkage-reducing chemical admixture (glycol ether plus amino alcohol derivatives), slag content, and *w*/*c*. The specimens were exposed to a tidal pool for 10 years using seawater. In each case, four specimens without reinforcement and three specimens with reinforcement were investigated. (…)

**Heading 2 (Sentence case, please)**

Ordinary portland cement (OPC) and blended cements by replacing a portion of the cement with slag powder were used. Two kinds of slag powders were used with Blaine fineness of approximately 7900 cm2/g (Slag 1) and 4080 cm2/g (Slag 2). The physical properties and chemical analysis of the cement and slag powders are listed in Table 1. River sand and crushed granite coarse aggregates were used. The specific gravity, water absorption, and fineness modulus of sand (passing through 0.20 in. [5 mm] sieve opening size) are 2.63, 1.63 and 2.73, respectively. (…)

The characteristics of CFRP tendons/CFCC strands are summarized in Table 2. (…)

## Specimens

Plain and reinforced cylinder specimens of diameter 3.94 in. (100 mm) and length 7.87 in. (200 mm) were investigated. The test setup is shown in Fig. 1. Round steel bars of diameter 0.35 in. (9 mm) and length 5.51 in. (140 mm) were embedded at cover depths of 0.79 and 1.79 in. (20 and 45.5 mm).

# Items of investigation

At the age of 28 days, plain concrete specimens were tested for compressive strength and Young’s modulus of elasticity of concrete as per JIS A1108 and JSCE G502, respectively. Also, after 10 years of continuous exposure, the specimens were transferred from the exposure site to the laboratory, cleaned, and then tested for compressive strength and Young’s modulus of elasticity. (…)

*Heading 3, if this level is necessary*—Content will follow.

**Heading 4, if this level is necessary:** Content will follow.

**Analytical investigation (or analytical procedure)**

(This section may include development of models and/or verification of existing procedures)

The maximum prestress force in the CFRP tendons should be limited to 65% of the specified tensile strength of tendons.4,5 It is suggested by Hognested14 that an appropriate value of the elastic modulus of a concrete member, subjected to bending and axial load, can be obtained from

 (1)

where *fc*′ is the cylinder strength of concrete (…)

 = 0.85*b*1  (18)

where *b*1 is the factor defined as the ratio of the depth of equivalent rectangular stress block to the distance from the extreme compression fiber to the neutral axis; *fc*′ is specified compressive strength of concrete; *ffu* is specified tensile strength of bonded prestressing tendons; and e*pbmi* is initial prestressing strain in bonded prestressing tendons of *m*-th row (bottom row).

# Comparison of predictions and experimental results

The comparison of the predictions using the analytical model developed in this study and the experimental results from the testing described previously or in the literature are shown in Table 3. It shows that the predictions are (…)

# EXPERIMENTAL RESULTS AND DISCUSSION

**Compressive strength and Young’s modulus of elasticity**

Compressive strengths and Young’s modulus of elasticity of concrete at 28 days and after 10 years of exposure in the tidal environment are shown in Fig. 2 and 3, respectively. (…)

Carbonation depth and chloride ion profile

The carbonation depth of the specimens was negligible irrespective of the cases investigated herein. Water- and acid-soluble chloride concentrations at the average sampling depths of 0.10, 0.39, 0.79, 1.28, and 1.79 in. (2.5, 10, 20, 32.5, and 45.5 mm) from the surface of the specimens are shown in Fig. 4 and 5 for Cases 1 to 16. (…)

**Load-deflection relationship**

The load-deflection relationship of slabs is shown in Fig. 6. (…)

# FURTHER RESEARCH (IF APPLICABLE)

It is desirable to test specimens at the age of 20 or more years of exposure, and efforts should be made to find out the possible ways to increase the chloride threshold value related to corrosion of steel bars in concrete. The results of such studies would directly benefit the construction industry. (…)

# CONCLUSIONS (OR SUMMARY AND CONCLUSIONS)

(Spell out any acronyms introduced at the beginning of the paper)

Based on the results of this experimental investigation under tidal environment, the following conclusions are drawn:

1. The naphthalene group of the high-range water-reducing (HRWR) and air-entraining chemical admixture shows the best performance against the strength development and chloride ion ingress prevention in concrete; and
2. The polycarboxyl group of the chemical admixture shows the least performance among the chemical admixtures investigated herein against long-term strength development, as well as chloride ingress prevention in concrete. (…)

### ACKNOWLEDGMENTS

(Use first initial and last name only when listing names of individuals)

# The authors wish to express their gratitude and sincere appreciation to the authority of Port and Airport Research Institute for financing this research work and also to several ongoing research projects related to the durability of concrete structures. The authors would like to also acknowledge the assistance of R. Kimble, K. Reed, and L. Braggs of the University of Michigan for their assistance in carrying out the experiments.

**NOTATION**

(Include list of Notation here, especially if the list of symbols is long. List in alphabetical Aa-Zz order (for example, *As*, *a*, *Bd*, *bod*, *bz*); variables with numbers as subscripts/superscripts can fall at the beginning of that letter’s list or the end (just be consistent). Greek letters come after Roman/Latin alphabet and follow Aa-Zz order. **Do not place notations or symbols in text boxes unless they cannot otherwise be typed in plain text.**

*a* = radius of slab

*c* = diameter/side length of loaded area

*ck* = parameter related to ratio of compressive to tensile strengths of concrete

**REFERENCES**

(Reference information should be complete and accurate, and include any applicable information such as author names, title of paper, title of publication, volume number, issue number, date, and page count/page range. ASTM Standard references should include full publication number and title; please do not cite any ASTM Books of Standards. Referenced work should be published or, at the very least, prepublished. If the document in question has been prepublished with an organization, please include as much information as possible, including a DOI [digital object identifier]. Please do not reference work that has only been accepted for publication.)

**Vancouver (numerical) style examples follow:**

1. Nagataki, S., “State of the Art Report on Air-Entraining High Range Water-Reducing Admixture, *Concrete Journal of JCI*, V. 28, No. 6, 1990, pp. 5-15.

2. Hattori, K., “Experiences with Mighty Superplasticizer in Japan,” *Superplasticizers in Concrete*, ACI SP-62, V. M. Malhotra, ed., American Concrete Institute, Farmington Hills, MI, 1979, pp. 37-66.

3. Lin, T. Y., and Burns, N. H., *Design of Prestressed Concrete Structures*, third edition, John Wiley & Sons, Inc., New York, 1981, 368 pp.

4. Naaman, A. E., and Alkhairi, F. M., “Stress at Ultimate in Unbonded Post-Tensioning Tendons: Part 2—Proposed Methodology,” *ACI Structural Journal*, V. 88, No. 6, Nov.-Dec. 1991, pp. 683-692.

5. Grace, N. F., and Abdel-Sayed, G., “Ductility of Prestressed Concrete Bridges Using CFRP Strands,” *Concrete International*, V. 20, No. 6, June 1998, pp. 25-30.

6. ASTM C150/C150M-22, “Standard Specification for Portland Cement,” ASTM International, West Conshohocken, PA, 2022, 9 pp.

**Harvard (last name and year) style examples follow:**

(When multiple name-date references could have the same attribution, use an additional letter after the year to differentiate; for example, 2022a, 2022b)

ACI Committee 318, 2019, “Building Code Requirements for Structural Concrete and Commentary (ACI 318R-19) (Reapproved 2022),” American Concrete Institute, Farmington Hills, MI, 624 pp.

CSA S806-12, 2012, “Design and Construction of Building Structures with Fibre-Reinforced Polymers,” CSA Group, Toronto, ON, Canada.

Hosseini, S. M.; Mousa, S.; Mohamed, H. M.; and Benmokrane, B., 2022a, “Structural Behavior of Precast Reinforced Concrete Tunnel Segments with Glass Fiber-Reinforced Polymer Bars and Ties under Bending Load,” *ACI Structural Journal*, V. 119, No. 1, Jan., pp. 307-319.

Hosseini, S. M.; Mousa, S.; Mohamed, H. M.; Eslami, A.; and Benmokrane, B., 2022b, “Experimental and Analytical Study on Precast High-Strength Concrete Tunnel Lining Segments Reinforced with GFRP Bars,” *Journal of Composites for Construction*, ASCE, V. 26, No. 5, Oct., p. 04022062. doi: 10.1061/(ASCE)CC.1943-5614.0001257

Naaman, A. E., and Alkhairi, F. M., 1991, “Stress at Ultimate in Unbonded Post-Tensioning Tendons: Part 2—Proposed Methodology,” *ACI Structural Journal*, V. 88, No. 6, Nov.-Dec., pp. 683-692.

Robert, M.; Cousin, P.; and Benmokrane, B., 2009, “Durability of GFRP Reinforcing Bars Embedded in Moist Concrete,” *Journal of Composites for Construction*, ASCE, V. 13, No. 2, pp. 66-73. doi: 10.1061/(ASCE)1090-0268(2009)13:2(66)

## Appendix A

## (Will not be published in the printed journal if the manuscript and appendixes combined exceed the 12,000 words or word-equivalent count. Instead, will appear in PDF format on the ACI website in their original, unedited form, as addenda of the published paper.)

## tables and figures

**List of Tables:**

**Table 1—**Physical and chemical compositions of cement and slags

**Table 2—**Characteristics of CFRP tendons/CFCC strands

**List of Figures:**

**Fig. 1—**Overview of specimen in position ready for testing.

(…)

**Fig. 6—**Peak lateral stiffness versus applied drift ratio.

**Table 1**—**Physical and chemical compositions of cement and slag**

|  |  |  |  |
| --- | --- | --- | --- |
|  | OPC | Slag 1 | Slag 2 |
| Specific gravity | 3.16 | 2.90 | 2.90 |
| Blaine fineness, cm2/g | 3190 | 7900 | 4080 |
| Loss of ignition, % | 0.7 | — | — |
| SiO2, % | 21.3 | 32.7 | 33.2 |
| Al2O3, % | 5.3 | 13.8 | 14.1 |
| CaO, % | 64.4 | 42.4 | 42.3 |
| MgO, % | 2.2 | 5.9 | 5.9 |
| SO3, % | 1.9 | 2.0 | 2.0 |
| Na2O, % | 0.28 | — | — |
| K2O, % | 0.6 | — | — |
| TiO2, % | 0.37 | — | — |
| MnO, % | 0.1 | — | — |
| Fe2O3, % | 2.6 | 0.2 | 0.2 |

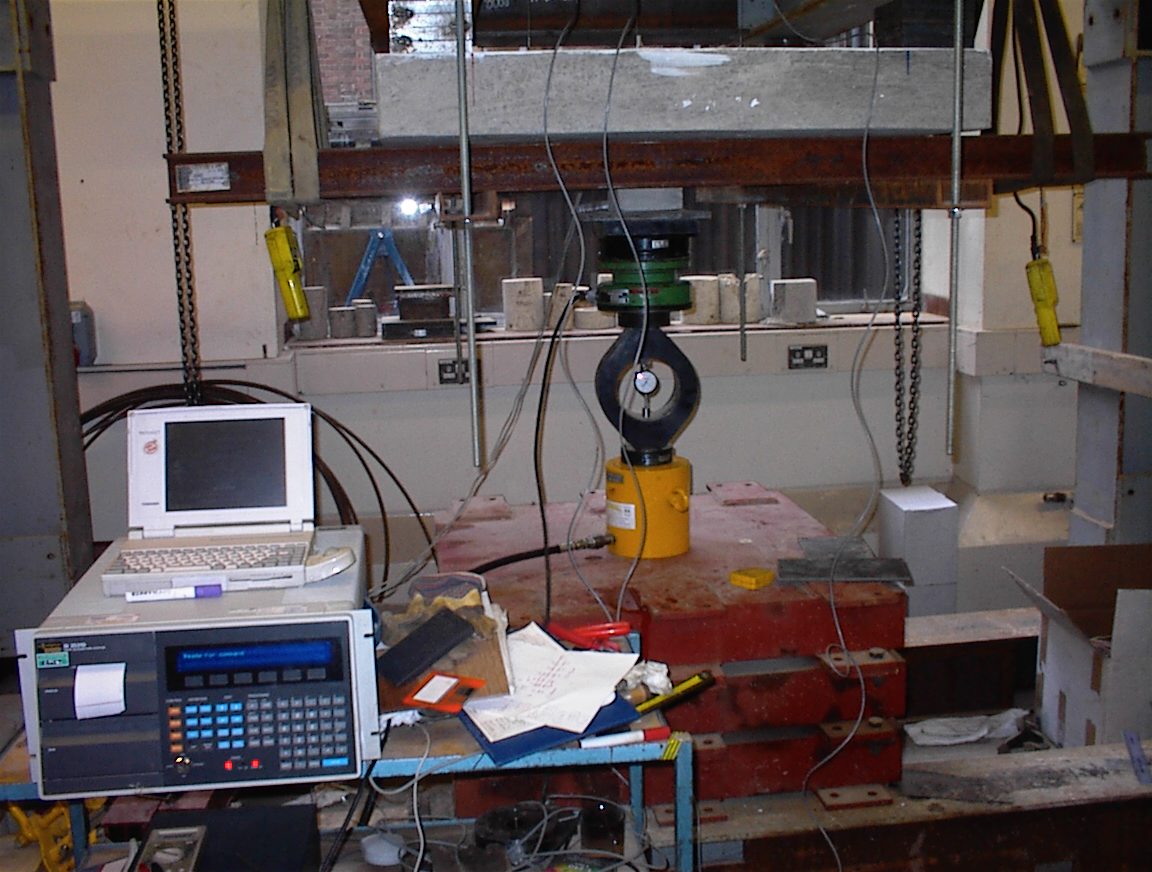
Note: “—” isnot measured items.

**Table 2**—**Characteristics of CFRP tendons/CFCC strands**

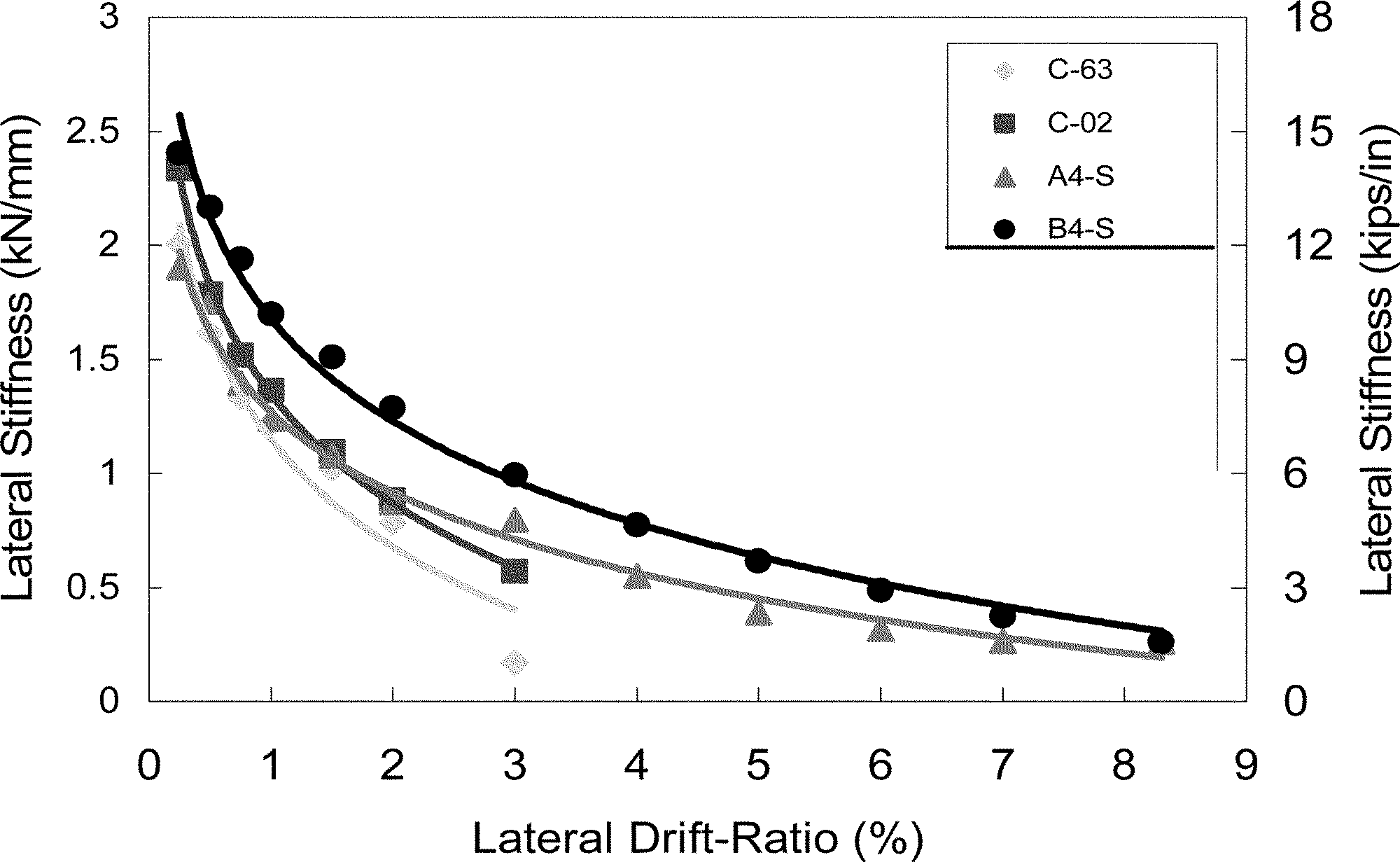
|  |  |  |  |
| --- | --- | --- | --- |
| Characteristics | Leadlineä(MCC25) | CFCC 1 x 7 (Tokyo Rope26) | CFCC 1 x 37 (Tokyo Rope26) |
| Nominal diameter, in. (mm) | 0.39 (10) | 0.5 (12.5) | 1.57 (40) |
| Effective cross-sectional area, in.2 (mm2) | 0.111 (71.6) | 0.118 (76.0) | 1.17 (752.6) |
| Guaranteed tensile strength, ksi (kN/mm2) | 328 (2.26) | 271 (1.87) | 205 (1.41) |
| Specified tensile strength\*, ksi (kN/mm2) | 415 (2.86) | 305 (2.10) | 271 (1.87) |
| Young’s modulus of elasticity, ksi (kN/mm2) | 21,320 (147) | 19,865 (137) | 18,419 (127) |
| Elongation, % | 1.9 | 1.5 | 1.5 |
| Guaranteed breaking load, kip (kN) | 36.4 (162) | 31.9 (142) | 240.5 (1070) |
| Ultimate breaking load, kip (kN) | 46 (204.7) | 36 (160) | 316.9 (1410) |

\*Ultimate tensile strength characteristics of tendons and strands were obtained from test, whereas manufacturers supplied other properties.

(If more symbols are required in the footnotes section, please use in this order: \*, †, ‡, §, ||, #. If there are more than six footnotes, go back to asterisk (\*) and double-up: \*\*, ††, ‡‡, and so on)



**Fig. 1**—**Overview of specimen in position ready for testing.**



**Fig. 6**—**Peak lateral stiffness versus applied drift ratio.**

**Additional notes for tables and figures:**

Add dual units opposite to main units only if units are in US (in.-lb)

In the case of very complex and large tables and figures, two options are acceptable:

(a) Provide a duplicate table or figure with the secondary units.

(b) Provide the conversion factors for the units used in the table or figure under the table or figure (only possible if space prevents item (a)).

Any notes in figure captions should go in parentheses.

Unnecessary articles should not be included in table footnotes and figure captions (a, an, the)

Use em dashes (Alt + 0151) in figure captions, table titles, and to indicate blank spots in tables.