

GUIDE

to Concrete Materials Specialization Program

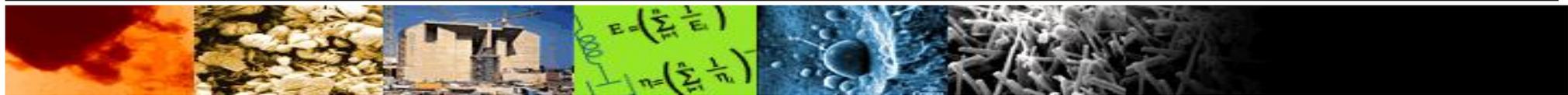


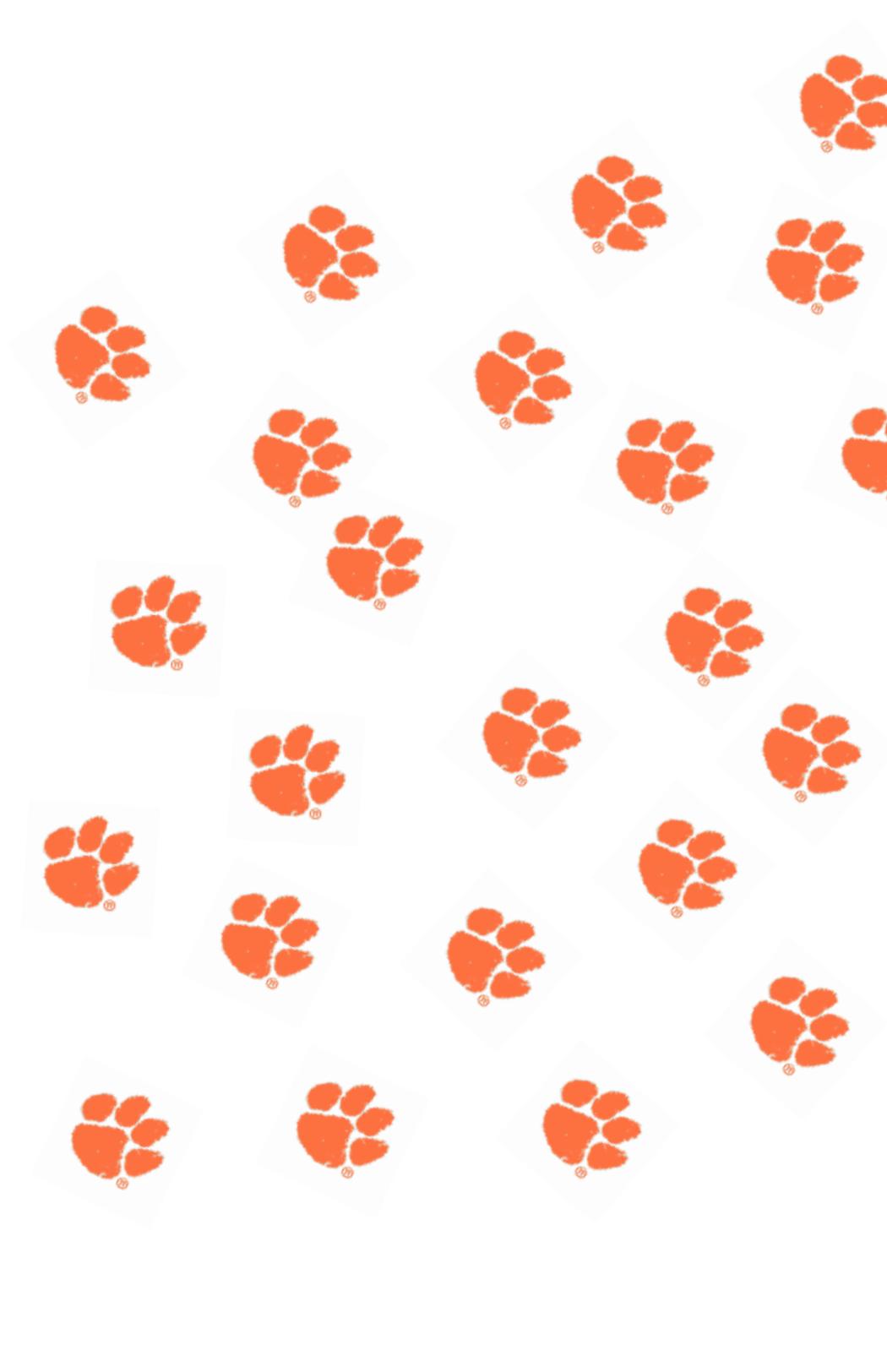
CLEMSON®

GLENN DEPARTMENT OF
CIVIL ENGINEERING



CONCRETE MATERIALS PROGRAM @ CU





Going through the **GUIDE.....**

Civil Engineering at Clemson

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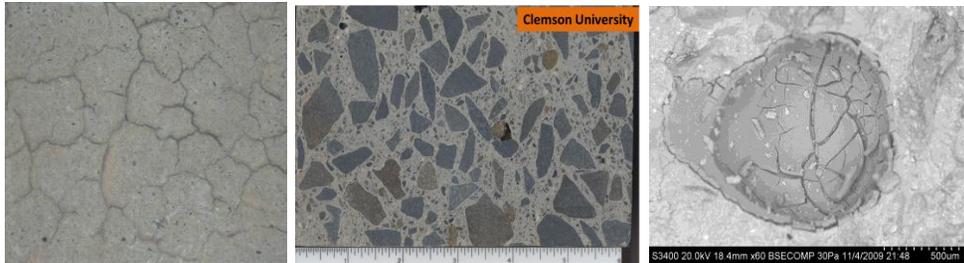
List of Recently Published Journal Articles



Civil Engineering at Clemson

Civil engineering has been taught at Clemson since the University was founded in 1889. Civil engineering became a department in 1932 at the same time the Engineering Department became the School of Engineering.

Today, the Glenn Department of Civil Engineering offers undergraduate and graduate course work in all major fields of civil engineering. Our Program Educational Objectives are evaluated on a regular basis to meet the needs of our constituents. The department offers graduate degree programs leading to the Master of Science and Doctor of Philosophy degrees with specializations in Applied Fluid Mechanics, Construction Materials, Construction Project Management, Transportation, Structural, and Geotechnical Engineering. Current enrollments are about 500 undergraduate and 140 graduate students. Student organizations include the American Society of Civil Engineers (ASCE), the Institute of Transportation Engineers (ITE), Clemson Engineers for Developing Countries (CEDC) and the Chi Epsilon Honor Society.



Faculty Advisor Concrete Materials Specialization

Prasad Rangaraju, Ph.D., P.E.
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Dr. Prasad Rangaraju is an Associate Professor at the Glenn Department of Civil Engineering in Clemson University. He received his Ph.D. from Purdue University, M.S from Iowa State University and Bachelor's from JNT University-Hyderabad (India) in Civil Engineering. He is a Registered Professional Engineer and a member of ACI (American Concrete Institute), TRB (Transportation Research Board), ISCP (International Society for Concrete Pavements), and ASTM (American Society for Testing and Materials). He also serves as the Editorial Board Member of ASTM Journal of Advances in Civil Engineering Materials, and as an Associate Editor of ASCE Journal of Materials in Civil Engineering. His research interests include Cement, Concrete, Aggregates and Supplementary Materials, Microscopy and Petrography of Cement based Composites, Repair Materials, Durability of Cementitious Systems, and Concrete Pavements: Design, Construction and Rehabilitation. Dr. Rangaraju is in the process of establishing a Sustainable Materials Research and Technology (SMART) Center at Clemson University to develop and promote technologies related to Green Construction Materials and Practices.



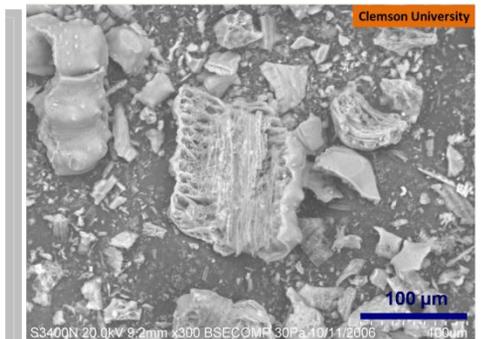
Graduate Student Enrollment in Concrete Materials Area

In the last 5 years Dr. Rangaraju research group consisted of 2 post-doctoral fellows, 9 PhD and 4 MS degree students. Currently, he is advising 4 PhD students and 2 MS students.



Typical Courses Taken by Students in Concrete Materials Focus Area

- CE 8260 - Properties of Portland Cement and Concrete (Dr. Rangaraju)
- CE 8270 - Special Cements, Admixtures and Concretes (Dr. Rangaraju)
- CE 8280 - Repair and Rehabilitation of Concrete Structures (Dr. Rangaraju)
- CE 6910 – Sustainable Construction Materials (Dr. Rangaraju)
- CE 8930 – Advanced Material Characterization Techniques (Dr. Rangaraju)
- CE 8920 – Infrastructure Corrosion (Dr. Poursaei)
- CE 6910 – Non-Destructive Testing Methods (Dr. Poursaei)
- CE 8020 – Advanced Reinforced Concrete Design (Dr. Cousins)
- CE 8040 – Prestressed Concrete Design (Dr. Ross)
- CE 6560 – Pavement Design and Construction (Dr. Putman)
- CE 6570 – Material Testing and Inspection (Dr. Putman)
- CE 8230 – Asphalt Materials (Dr. Putman)





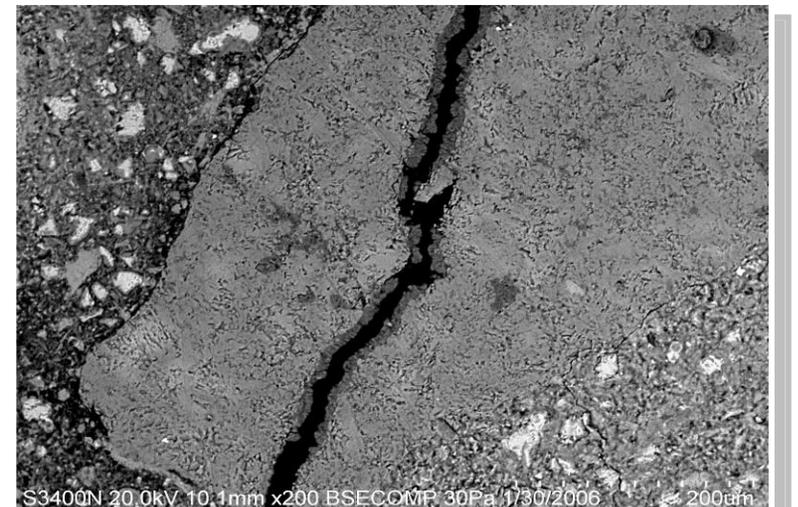
On-Going/Completed Research Topics

- Development of Miniature Concrete Prism Test (MCPT) for Evaluating Alkali-Silica Reaction Potential in Concrete Mixtures (AASHTO TP110)
- Development of Ultra-High Performance Concrete Mixtures (UHPC)
- Development and Evaluation of Low Carbon Rice Husk Ash Pozzolan
- Influence of Deicing Chemicals on Alkali-Silica Reaction (ASR) in Concrete
- Evaluation of ASR Mitigation Measures in Presence of Deicing Chemicals
- Life Cycle Cost Analysis for Pavement Selection
- Influence of Crumb Rubber Characteristics on Selected Properties of Asphalt and Portland Cement Concrete Mixtures
- Evaluation of Alternative Pozzolanic Materials in Concrete
- Rapid Set Patching Materials for Portland Cement Concrete
- Evaluation of Lithium Compounds for Mitigation of ASR Caused by Deicing Chemicals
- Effect of Deviation in Standard Aggregate Gradations on Properties of Concrete
- Development of Test Methods to Evaluate Rheological Properties of Pervious Concrete Mixtures



Up-Coming Research Topics

- Evaluation of Recycled Glass Powders as Mineral Admixtures in Concrete.
- Evaluation of Coefficient of Thermal Expansion in Concrete Mixtures.
- Sensitivity Analysis of AASHTO TP110 Test Method (MCPT) in Detecting Marginally Reactive Aggregates in Concrete
- Evaluation of Ultra-Pure Lignin Derivatives as Chemical Admixtures for Ultra-High Performance Concrete Mixtures
- Evaluation of Moisture Sensitivity of MgO Cements
- Evaluation of Durability and Shrinkage Behavior of UHPC





Funding -Financial Assistantships

All graduate students are currently funded through either a research assistantship and/or a teaching assistantship. Opportunities exist in the University for a Departmental/College/University/Industry-sponsored Scholarships and Fellowships for outstanding students.



Research Sponsors

Research Projects are funded through grants from agencies such as

- U.S. Dept. of Navy
- U.S. Department of Transportation
- South Carolina Department of Transportation
- South Carolina Dept. of Health and Environmental Control
- Federal Aviation Administration
- FMC Lithium Corporation
- PPG, Inc.
- Portland Cement Association (PCA)
- University Research Grants

Recruiters of our Graduate Students

- | | |
|-------------------------------|------------------------------|
| • S&ME Inc. | • Sika Admixtures |
| • Terracon Consulting | • NIST |
| • Carasquillo & Assoc, Inc. | • Faculty, IIT-Kanpur, India |
| • Kiewit Construction Co. | • Faculty, AUST, Bangladesh |
| • Kimley-Horn | • Faculty, OUAT, India |
| • Gillibrand Ind. Sands, Inc. | • Corhart Refractories Co. |
| • Landmark Const. Co. | • Quikrete |



Research Facilities (Rms. 23 and 29 Lowry Hall & ARTS)

Equipment and facilities for conducting concrete materials research at Clemson University include following: (number of units of equipment indicated in parentheses):

1. Badger Aggregate Crusher (1)
2. Bico Aggregate Pulverizer (1)
3. Aggregate Sieving Equipment : Gilson Testing Screens & Ro-Tap Sieve Shakers (5)
4. Gilson LA Abrasion Testing Machine (2)
5. Gilson Micro-Deval Abrasion Testing Machine (1)
6. Gilson Sulfate Soundness Testing Apparatus (1)
7. 5-qt. Hobart Mixers (5)
8. 30-qt. Hobart Mixer (1)
9. 30-qt. Univex Mixer (1)
10. 1 liter and 4 liter Waring High-Shear Blenders (2)
11. Concrete Drum Mixers: 0.25, 3, 6 and 9 ft³ mixers (4)
12. Vibrating Table and Needle Vibrators (2)
13. Concrete Curing Room measuring 8 ft (w) x 15 ft (d) x 15 ft (h) (1)
14. Sample Molds for Prisms, Cylinders, Cubes
15. 27 ft³ - Despatch Forced Convection Ovens (4)
16. Thermal Product Solutions Blue Convection Oven (1)
17. 38°C and 60 °C Constant Temperature Rooms (2)
18. -20 °C Freezer Chests (2)
19. Logan Freeze-Thaw Testing Machine (1)
20. Caron Environmental Chamber (Constant Temp-RH), Model 6030. (1)
21. Humboldt Comparator for Length-Change Measurements (3)
22. Custom-Built Concrete Pore Solution Expression Die (2)
23. Grindo-Sonic MK5 unit (based on impulse excitation technique) for Dynamic Modulus Determination (1)
24. Proceq 4-Point Wenner Resistivity Probe (1)
25. Proceq Profile Grinder (2)



Research Facilities (contd.)

26. Proceq Dyna Pull-Off Tester (1)
27. Proceq Relative Humidity Probe (1)
28. Pundit Ultrasonic Pulse Velocity Meter (1)
29. RLC Rapid Chloride Ion Permeability Apparatus (1)
30. Test-Mark Compression Testing Machine – 300,000 and 500,000 lb capacity (2)
31. Masonry Saw (for slabing concrete specimens) (1)
32. Trim Saw (for obtaining sections for lapping and polishing) (1)
33. Oil Saw for preparation of specimens for moisture sensitive specimens (1)
34. Allied Hi-Tech Slow Speed Diamond Saw (1)
35. Diamond-Pacific Lapping Machine for Polishing Concrete Specimens (2)
36. Allied-High Tech Dual Chamber Polishing Wheels (1)
37. Vicat Apparatus (for consistency and setting time measurement) (1)
38. Acme Mortar Penetrometer (for setting time measurement of concrete) (1)
39. Flow Table (2)
40. Isothermal Calorimeter (1)
41. Precision Concrete Match-Cure System with 6 Cylinders (1)
42. Maturity Meter (1)
43. TECA Cold Plate (1)
44. Auto-Titrator (1)
45. pH meter (2)
46. Autogenous Shrinkage Measuring Device (1)
47. Nikon SMZ1000 Stereo Microscope with SPOT Insight Color Camera and Software for Petrographic Examination of Test Specimens (1)
48. Scanning Electron Microscope (Advanced Materials Characterization Labs)
49. TGA/DTA/DSC/Mercury Intrusion Porosimetry/XRD/ICP/AA/XRF (Other labs on campus)



List of Recently Published Refereed Journal Articles

- Li, Z., Harish, K.V. and Rangaraju, P.R. "Effect of Sand Content on the Properties of Self-Consolidating High Performance Cementitious Mortar", Journal of Transportation Research Board, (Accepted for Publication), 2014.
- Afshinnia, K. and Rangaraju, P.R. "Effectiveness Of Ground Glass Powder From Recycled Glass In Mitigating Alkali-Silica Reaction In Concrete", Journal of Transportation Research Board, (Accepted for Publication), 2014.
- Latifee, E. and Rangaraju, P. (2014). "Miniature Concrete Prism Test: Rapid Test Method for Evaluating Alkali-Silica Reactivity of Aggregates." *ASCE Journal of Materials in Civil Engineering*, (In Print) [http://www.dx.doi.org/10.1061/\(ASCE\)MT.1943-5533.0001183](http://www.dx.doi.org/10.1061/(ASCE)MT.1943-5533.0001183), 04014215.
- Jimma, B. and Rangaraju, P.R. "Film-Forming Ability of Flowable Cement Pastes and its Application in Mixture Proportioning of Pervious Concrete", *Construction and Building Materials Journal*, Vol. 71, No. 30, November 2014, Pages 273-282, <http://dx.doi.org/10.1016/j.conbuildmat.2014.08.018>.
- Pattnaik, R.R. and Rangaraju, P.R. "Investigation on Flexure Test of Composite Beam of Repair Materials and Substrate Concrete for Durable Repair" *Journal of the Institute of Engineers (India): Series A*, 2014. (Accepted for Publication).
- Harish, K.V. and Rangaraju, P.R. "Effect of Grinding of Low-Carbon Rice Husk Ash (RHA) on the Microstructure and Properties of Cementitious Systems Containing RHA", *Cement and Concrete Composites*, Vol. 55, 2015, pp. 348-363. <http://dx.doi.org/10.1016/j.cemconcomp.2014.09.021>.
- Pattnaik, R.R. and Rangaraju, P.R. "Relationships between Properties and Compatibility of Repair Materials with Substrate Concrete" *Indian Concrete Journal*, Vol. 88, 2014, p.12.
- Harish, K.V. and Rangaraju, P.R. "Effectiveness of Lithium Nitrate in Mitigating Alkali-Silica Reaction in the Presence of Fly Ashes of Varying Chemical Compositions." *ASCE Journal of Materials in Civil Engineering*, Vol. 26, No. 14, July 2014.
- Harish, K.V. and Rangaraju, P.R. "Evaluation of Sulfate Resistance of Portland Cement Mortars Containing Low-Carbon Rice Husk Ash." *ASCE Journal of Materials Civil Engineering*, Vol. 26, No. 4, April 2014.
- Gadkar, S. and Rangaraju, P.R. "Freeze-Thaw Durability of Portland Cement Concrete Containing Crumb Rubber", *ASTM Journal of Advances in Civil Engineering Materials*, Vol. 2, No. 1, October 2013.
- Harish, K.V. and Rangaraju, P.R. "Decoupling the Effects of Chemical Composition and Fineness of Fly Ash in Mitigating Alkali-Silica Reaction", *Cement and Concrete Composites*, Vol. 43, 2013, pp. 54-68.
- Harish, K.V. and Rangaraju, P.R. "Material Characterization Studies on Low- and High-Carbon Rice Husk Ash and Their Performance in Portland Cement Mixtures," *ASTM Journal of Advances in Civil Engineering Materials*, Vol. 2, No. 1, 2013, pp. 1-24.
- Math, S., Wingard, D. and Rangaraju, P.R. "Assessing Potential Reactivity of Aggregates in Presence of Potassium Acetate Deicer – Revised EB-70 method", *Transportation Research Record: The Journal of Transportation Research Board*, Vol. 2232, p. 10, 2011.
- Harish, K.V. and Rangaraju, P.R. "Effect of Blended Fly Ashes in Mitigating ASR", *Transportation Research Record: The Journal of Transportation Research Board*, Vol. 2240, p. 10, 2011.
- Rangaraju, P.R., Olek, J. and Diamond S. "Role of Inter-Aggregate Spacing on Properties of Portland Cement Concrete" *Cement and Concrete Research*, Vol. 40, No. 11, pp. 1601-1608, 2010.
- Harish, K.V., Rangaraju, P.R., and Vempati, R.K. "Fundamental Investigation into Performance of a Carbon Neutral Rice Husk Ash As a Supplementary Cementing Material", *Journal of Transportation Research Board*, Vol. 2164, p. 11, 2010.