

# Early Age Strength Monitoring of Concrete Structures Using Embedded Transducers



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# Presentation Outline

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- Importance of early strength monitoring
- Current common practices
- Possible methods of investigation
- Conducted research using piezoelectric materials
- Future areas of study



# Importance of Early Strength Monitoring

- Construction efficiency → \$\$\$
  - Formwork removal time
  - Low early-age strength concrete (even greater importance)





# Current Common Practices

- Cubes or cylinder samples
  - 7 and 28 day compression tests
- Limitations
  - Late problem detection
  - In-situ conditions??
  - Integrity reliant on sample-taker





# Investigating Early Age Strength In-Place

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- Advantages

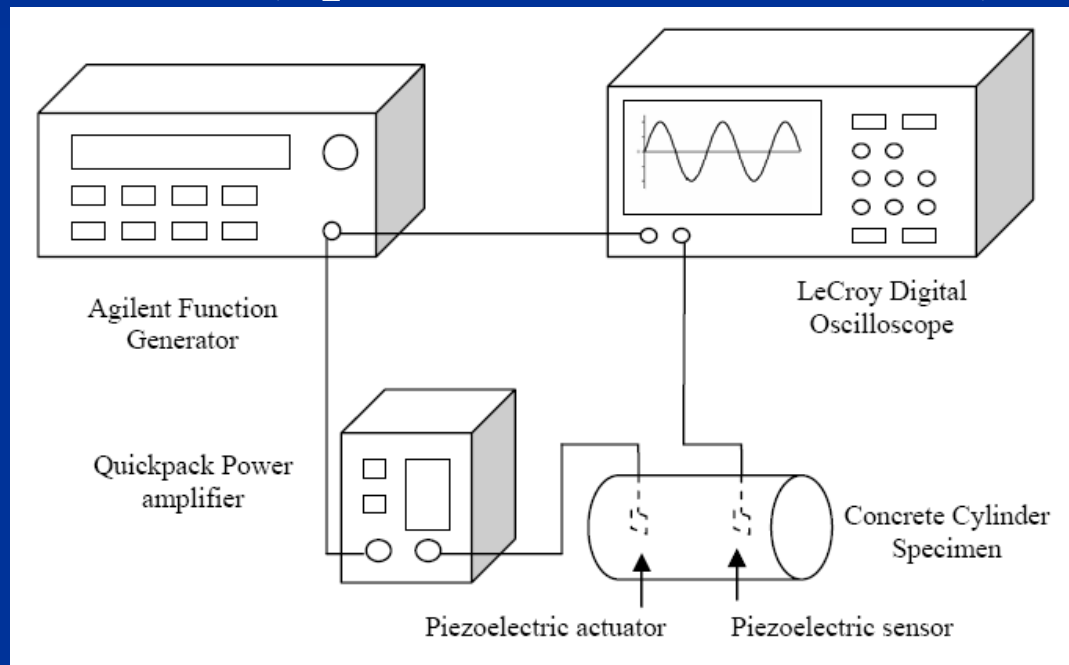
- Real-time information during curing process
- More efficient construction with knowledge of in-situ strength

- Two major categories

- Hydration heat-based
- Physical properties-based

# Previously Conducted Research

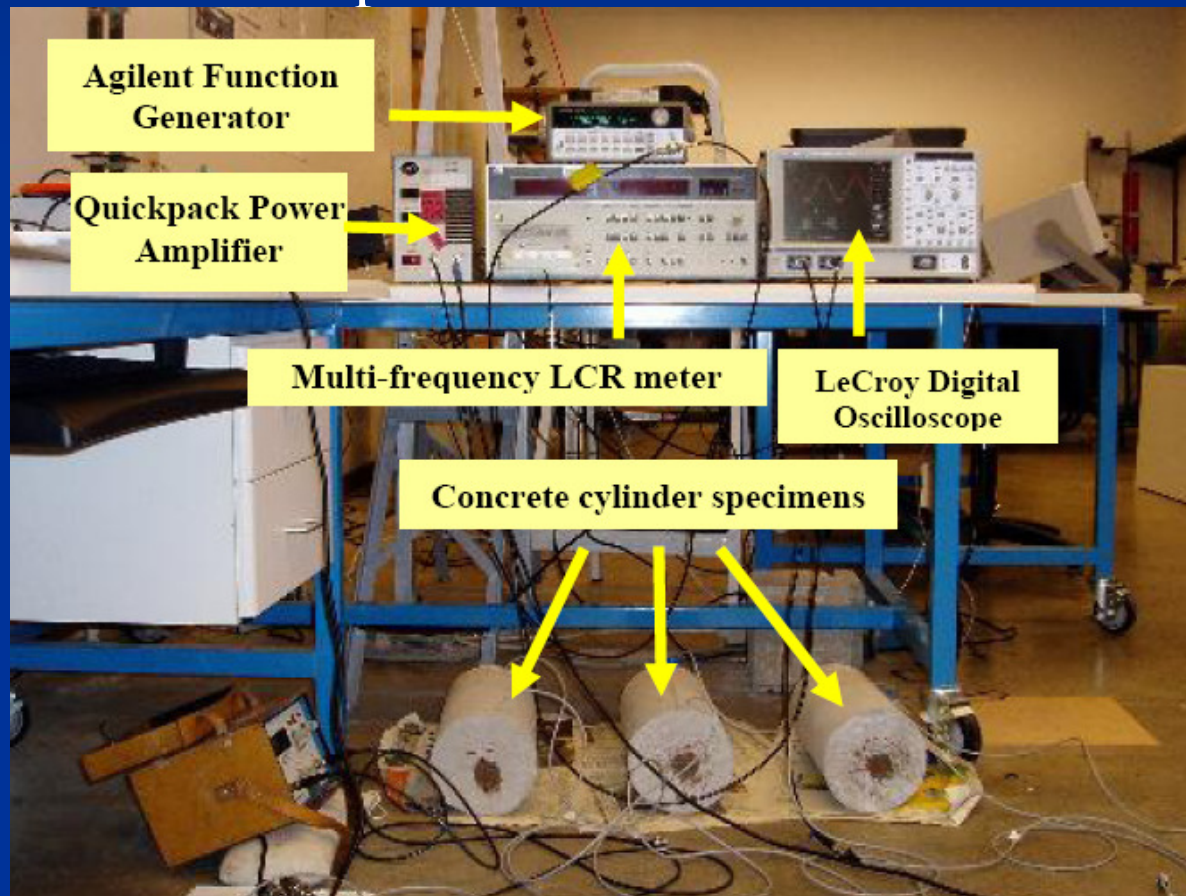
- Physical properties-based
  - Conducted by professors at University of Houston



- Basic concept – as  $E \uparrow$ , amplitude  $\downarrow$

# Previously Conducted Research

- Actual test setup





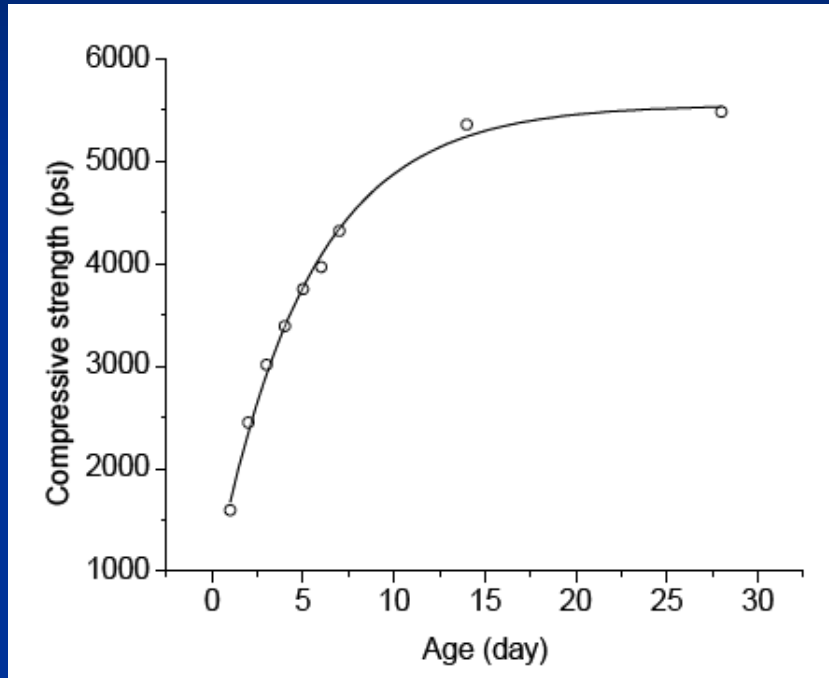
# Previously Conducted Research

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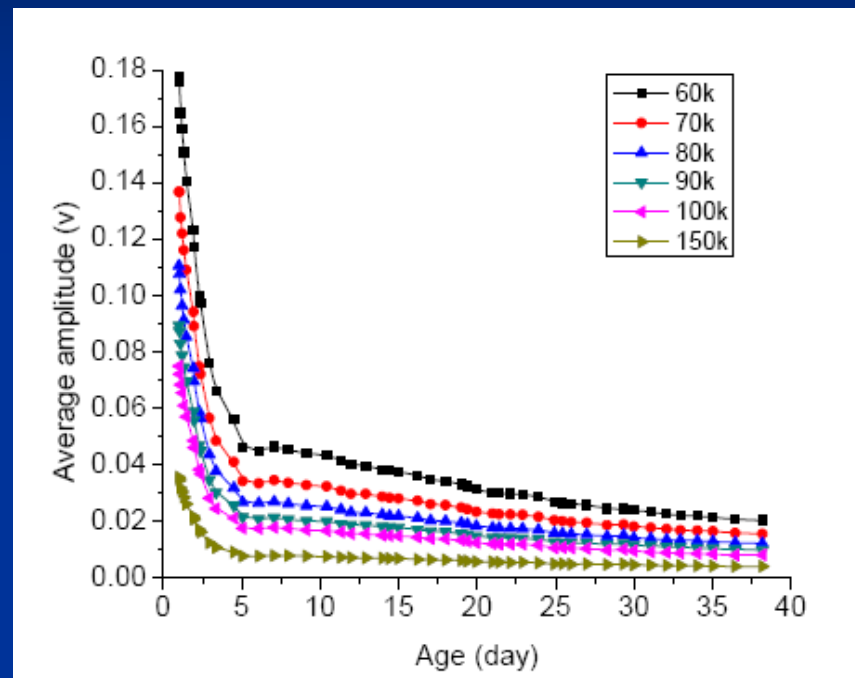
- Data acquisition and analysis
  - Experimental output/analysis input – harmonic amplitude
  - Analysis output – compressive strength
  - Correlation needed (difficult for concrete)
- Technique used → Fuzzy logic analysis
  - Suitable for nonlinear and uncertain systems
  - Can be trained using early values



# Research Results



Compressive Strength vs. Age



Average Amplitude at Different Excitations

- Correlation test using 14 days of data for training

- Estimated 28 day strength – 5560.3 psi

- Actual 28 day strength – 5483 psi → within 2%



# Summary and Future Work

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- Certain benefit to greater understanding of early age concrete strength
- Research shows embedded piezoelectric transducers as viable approach
- Future work could evaluate effectiveness with different concrete mixes, curing conditions, or larger samples



# References

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- Gu, H. et al. (2006). “Early age monitoring of concrete structures using embedded smart piezoelectric transducers.” *Proc., Advanced Sensor Technologies for Nondestructive Evaluation and Structural Health Monitoring II*, SPIE, San Diego, Ca., 61790H
- Soutsos, M.N. et al. “In-Situ Strength Assessment of Concrete – The European Concrete Frame Building Project,” Germann Instruments
- Upadhyaya, S. et al. (2007). “Evaluation of In-Place Strength of High Volume Fly Ash Concrete.” *Proc., 1<sup>st</sup> International Conference on Recent Advances in Concrete Technology*, Washington, D.C.