

IZMIR INSTITUTE OF TECHNOLOGY
DEPARTMENT OF CIVIL ENGINEERING
CE 576 – MECHANICS OF REINFORCED CONCRETE
SPRING 2025-2026

Instructor

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Course Summary

The course consists of two main parts. In the first part, mechanical properties of concrete and reinforcement are reviewed and theories of elasticity and plasticity, as applied to reinforced concrete, are examined. Constitutive models and failure criteria are introduced. Modified Compression Field Theory and rotating, smeared crack models are studied. Effects of pre-strains, offsets and crack slip distortions are discussed in conjunction with the Disturbed Stress Field Model. The second part of the course focuses on the implementation of the models and theories studied in the first part to the nonlinear finite element analysis. Finite element formulations for reinforced concrete are derived. Several case studies are conducted using a nonlinear finite element analysis computer program.

Prerequisites: CE 512, CE 513 or instructor's consent. Students are assumed to know basics of theory of elasticity and to have programming skills.

Topics

- Introduction to Nonlinear Mechanics of Reinforced Concrete
- Material Properties
- Linear Elastic Models
- Post-cracking Models and Introduction to Nonlinear Analysis
- Limit Analysis using Plasticity
- Failure Criteria for Concrete
- Modified Compression Field Theory (MCFT)
- Implementation of MCFT
- Accounting for Pre-strains, Disturbed Stress Field Model
- Nonlinear Finite Element Implementation
- Element Stiffness Formulations for Panel Elements
- Solution Procedures in Nonlinear Finite Element Analysis (NLFEA) and Introduction to an NLFEA computer package
- Case Studies

Reference Books

- Maekawa, K., Pimanmas, A., Okamura, H., "Nonlinear Mechanics of Reinforced Concrete", London , Spon Press, 2003.
- Collins, M. P., Mitchell, D., "Prestressed Concrete Structures", Toronto and Montreal, Response Publications, 1997.

Reference Papers

- Mitchell, D. and Collins, M. P. (1974). "Diagonal compression field theory – a rational model for structural concrete in pure torsion." American Concrete Institute Journal, Proceedings Vol.71, No.8, pp.396-408.
- Vecchio, F. J. and Collins, M. P. (1986). "The modified compression-field theory for reinforced concrete elements subjected to shear." ACI Journal, Vol.83, No.2, pp.219-231.
- Vecchio, F. J. (1990). "Reinforced concrete membrane element formulations." Journal of Structural Engineering, Vol.116, No.3, pp.730-750.
- Vecchio, F. J. (2000). "Disturbed stress field model for reinforced concrete: Formulation." Journal of Structural Engineering, Vol.126, No.9, pp.1070-1077.
- Wong, P., Vecchio, F. J. and Trommels, H. (2013). VecTor2 and Formworks User's Manual Second Edition, University of Toronto, Department of Civil Engineering.
- Hsieh, S.S., Ting, E.C., and Chen, W.F. (1979). "An Elastic-Fracture Model for Concrete." Proc. 3rd Eng.Mech. Div. Spec. Conf., ASCE, Austin, Texas, pp. 437-440.
- Kaufmann, W. and Marti, P. (1998). "Structural Concrete: Cracked Membrane Model", ASCE Journal of Structural Engineering, Vol. 124, No. 12, pp. 1467-1475.
- Walraven, J.C., and Reinhardt, H.W. (1981). "Theory and Experiments on the Mechanical Behaviour of Cracks in Plain and Reinforced Concrete Subjected to Shear Loading", Concrete Mechanics – Part A, Heron, Vol. 26, No. 4, 65 pp.

Course Evaluation

Weekly Assignments	%60
Take-home Project	%15
Final Exam	%25