



CONSTRUCTION INVESTIGATIVE SERVICES

SEA, Ltd.
13930 Lynmar Boulevard
Tampa, FL 33626
800-881-7324

Concrete :
Failure Modes

Office locations

- Atlanta (800)743-7672
- Baltimore/Washington (800)635-9507
- Charlotte (800)547-3262
- Chicago (888)597-5084
- Cleveland (800)343-4366
- Columbus (800)762-6951
- Ft. Lauderdale (888)771-0581
- Houston (800)880-7324
- St. Louis (800)473-9050
- Tampa (800)881-7324

www.SEAlimited.com

CONCRETE: FAILURE MODES

Paul R. McCullough, P.E., C.B.C.
SEA, Ltd.
Tampa, Florida



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AGENDA

1. History of Concrete
2. Concrete Today
3. Properties of Concrete
4. Concrete Failure Modes
 - Installation/Serviceability Failures
 - Controlled Failures
 - Catastrophic Failures



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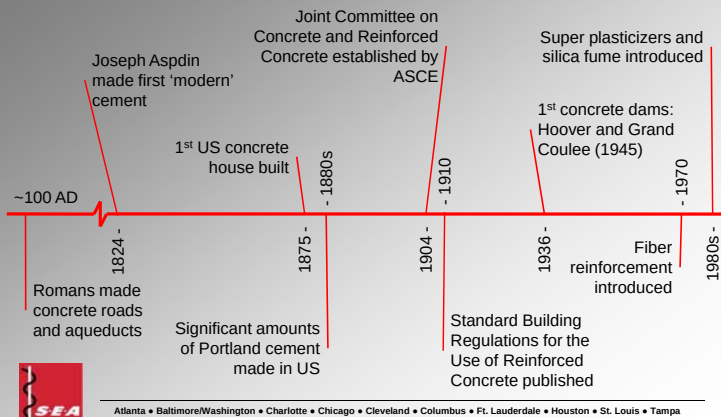
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HISTORY OF CONCRETE



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IS CEMENT THE SAME THING AS CONCRETE ?



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WHAT IS CONCRETE?

- Cement
- Aggregate
- Water



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CONCRETE



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HEAT OF HYDRATION

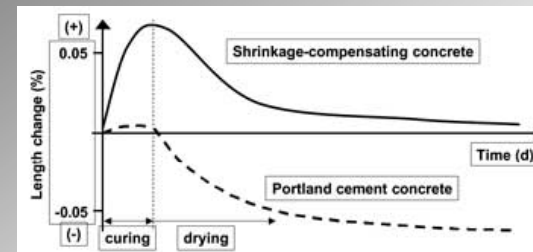
- Heat given off during curing of concrete



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SHRINKAGE

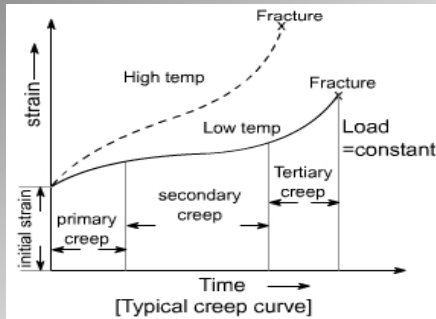
- Volume reduction over time



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CREEP

- Dimensional reduction due to loading



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WHY DESIGN WITH CONCRETE?

- Compressive Strength
- Shape Efficiency
- Regional Availability
- Durability/Life span



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DISADVANTAGES OF CONCRETE?

- Low Tensile Strength
- Requires formwork/shoring systems
- Modification difficult after installation
- Weight
- Requires Reinforcing Steel (rebar)



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UNREINFORCED MASONRY & CONCRETE MASONRY



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REINFORCING STEEL



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“THE CRACK”



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SHRINKAGE



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AGGREGATE SEPARATION



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SURFACE DELAMINATION



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CHALKING



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EFFLORESCENCE



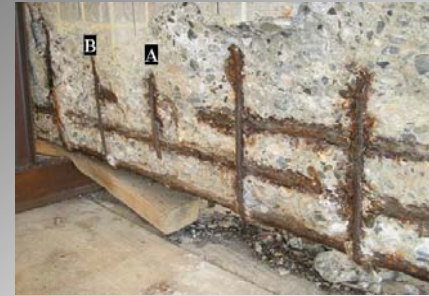
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SURFACE DEGRADATION



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RUST / CORROSION



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RUST / CORROSION



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HONEYCOMBS



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CONCRETE TESTING



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COMPRESSION / SLUMP TESTS



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COMPRESSION / SLUMP TESTS



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CONTROLLED & CATASTROPHIC FAILURES

- Columns
- Beams
- Deep Beams
- Slabs
- Column/Slab Interface
- Attachments



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COLUMN FAILURES CONTROLLED & CATASTROPHIC



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COLUMN FAILURES CATASTROPHIC



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COLUMN FAILURES CATASTROPHIC



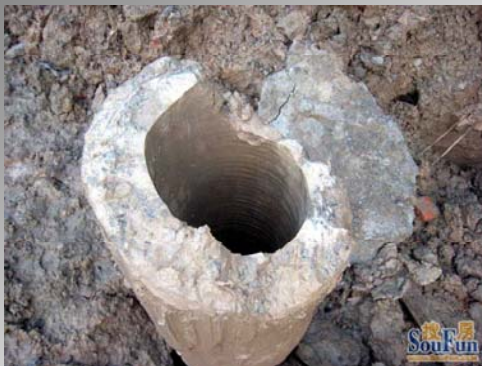
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COLUMN FAILURES CATASTROPHIC



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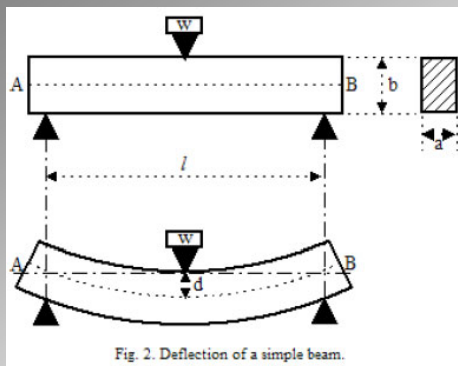
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BEAM FLEXURE



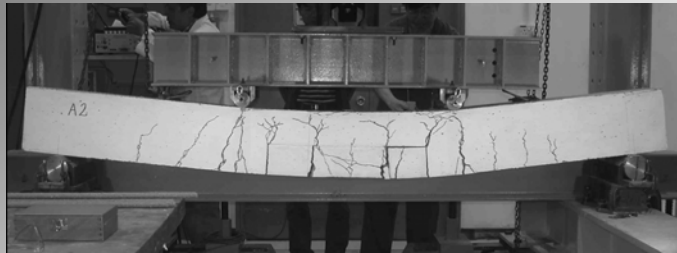
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BEAM FLEXURE CATASTROPHIC FAILURE



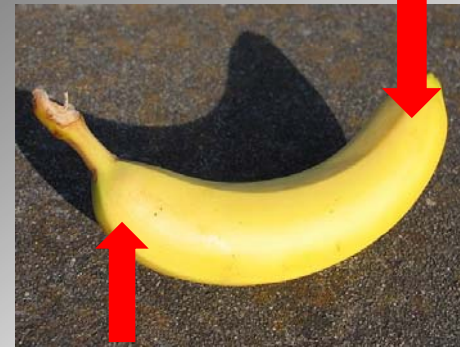
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BEAM FLEXURE CONTROLLED FAILURE



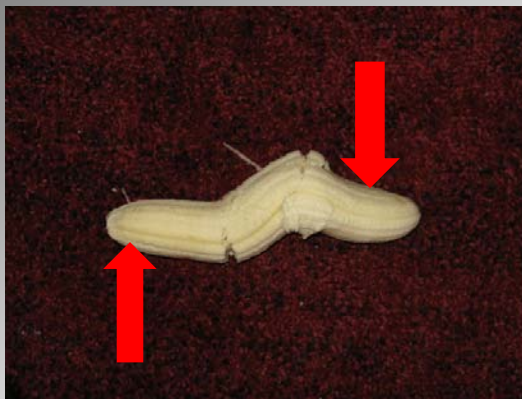
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BEAM SHEAR



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BEAM SHEAR



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BEAM SHEAR FAILURE CATASTROPHIC FAILURE



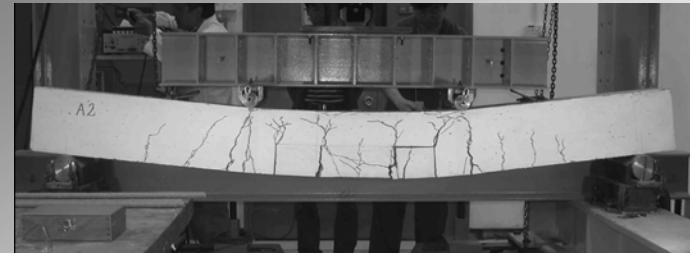
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BEAM SHEAR FAILURE CATASTROPHIC FAILURE



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BEAM FLEXURE CONTROLLED FAILURE



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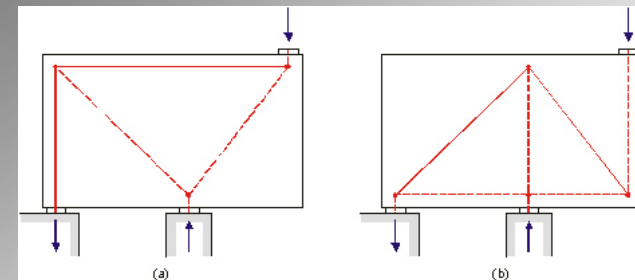
CONTROLLED & CATASTROPHIC FAILURES

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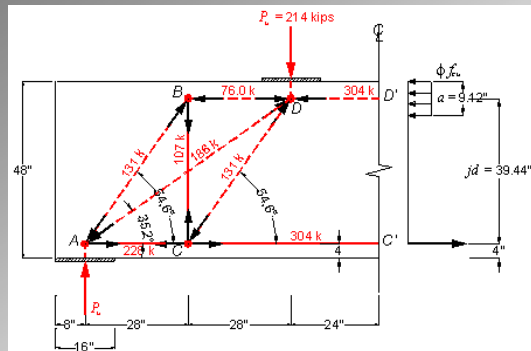
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DEEP BEAM DESIGN



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DEEP BEAM DESIGN



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DEEP BEAM DESIGN



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John A. Gerstak
Uncle Dave's Brass Bridge



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BEAM & COLUMN FAILURES



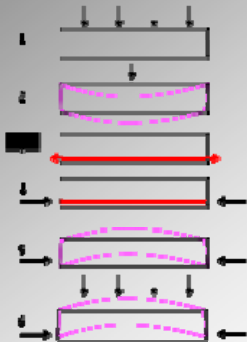
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BEAM & COLUMN FAILURES



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PRESTRESSED & POST-TENSIONED BEAMS



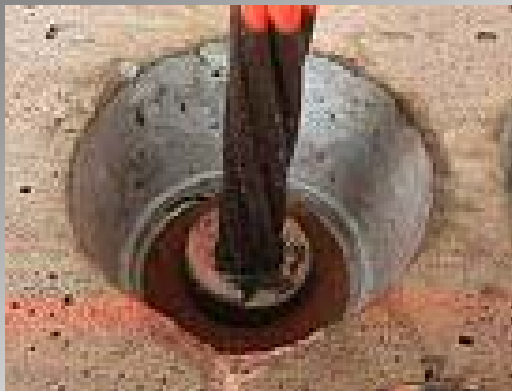
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POST-TENSIONING



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POST-TENSIONING



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POST-TENSIONING



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POST-TENSIONING



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POST-TENSIONING



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CONTROLLED & CATASTROPHIC FAILURES

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SLABS (SHALLOW BEAMS)



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SLABS (SHALLOW BEAMS)



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HOLLOW CORE SLABS



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TENDON FAILURE



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TENDON FAILURE



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TENDON FAILURE



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SLAB FAILURE



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SELF-HEALING CONCRETE



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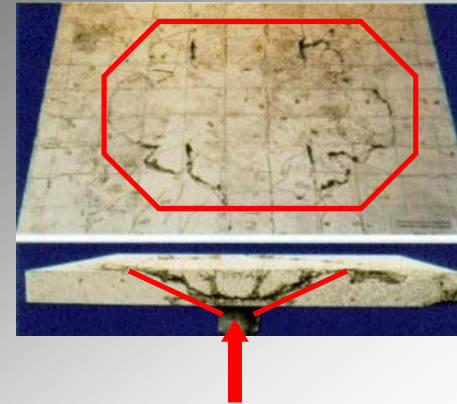
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PUNCHING SHEAR FAILURE



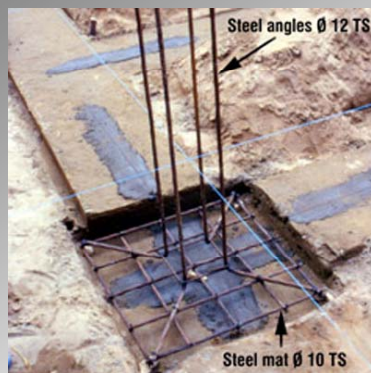
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PUNCHING SHEAR FAILURE



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PUNCHING SHEAR REINFORCEMENT



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ATTACHMENT FAILURE

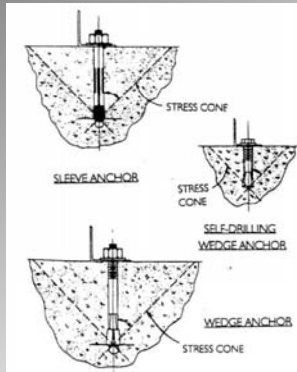


Fig. B.7-1—Typical details of expansion anchors



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POTENTIAL STUCCO DELAMINATION



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STUCCO DELAMINATION



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PARTIAL STUCCO DELAMINATION



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QUESTIONS?



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