





American Concrete Institute®
Advancing concrete knowledge

Post-Earthquake Repairs, Part 1

ACI Spring 2012 Convention
March 18 – 21, Dallas, TX

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Kenneth Bondy is a structural engineer with extensive experience in the retrofit and strengthening of existing concrete and steel structures. He is a member of ACI 318, 332, 423, and the Board Committee on Responsibility in Concrete Construction.


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SEISMIC RETROFIT USING EXTERNALLY APPLIED POST-TENSIONING TENDONS

KEN BONDY, SE, FACI


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EXTERNAL POST-TENSIONING

- External post-tensioning (EPT) is an effective method for strengthening and repair of existing structures.
- Used in concrete, steel and wood structures
- Increases strength and reduces deflection


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SEISMIC REPAIRS

- Has been used to repair many structures which have been damaged in earthquakes
- Our firm completed repairs on more than 20 buildings damaged in 1994 Northridge earthquake in So. California.
- Techniques for seismic repairs similar to other types of repairs

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PUNCHING SHEAR DAMAGE IN 2-WAY SLAB (NORTHRIDGE EARTHQUAKE)



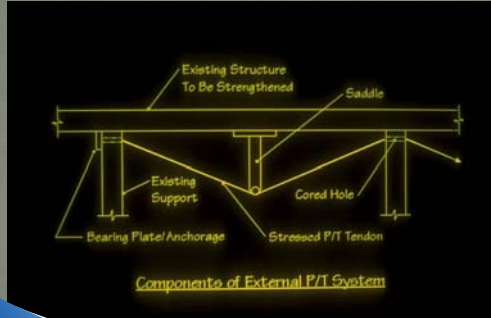
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ADVANTAGES

- Applies large beneficial loads with minimal headroom.
- Substantially weightless - no impact on existing columns, footings and seismic system.
- Can be adjusted to avoid existing HVAC and mechanical systems. Rarely requires any changes to existing systems
- Can be installed without disrupting building function

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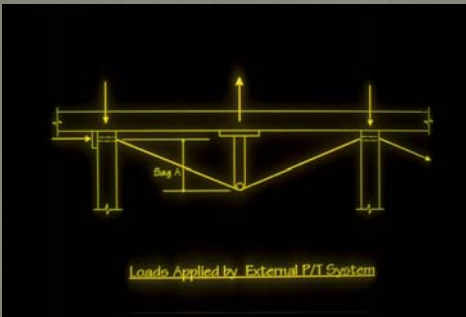
EXTERNAL POST-TENSIONING



The diagram illustrates the components of an external post-tensioning system. It shows a horizontal beam labeled 'Existing Structure To Be Strengthened'. Below the beam, a 'Stressed P/T Tendon' is shown in a curved path. The tendon is supported by an 'Existing Support' and a 'Saddle' on the top surface of the beam. At the ends of the tendon, there are 'Bearing Plate/Anchorage' and a 'Cored Hole' in the beam. The caption below the diagram reads 'Components of External P/T System'.

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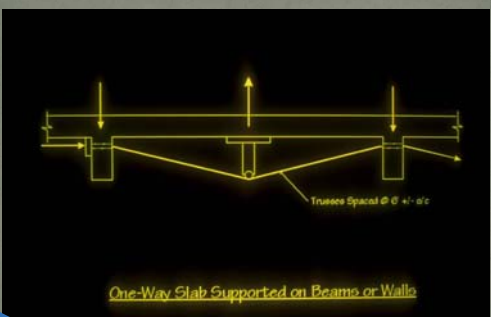
LOADS



The diagram shows a beam supported by two columns. A truss structure is attached to the bottom of the beam. Downward arrows represent applied loads, and an upward arrow represents the beneficial load from the truss. The caption below the diagram reads 'Loads Applied by External P/T System'.

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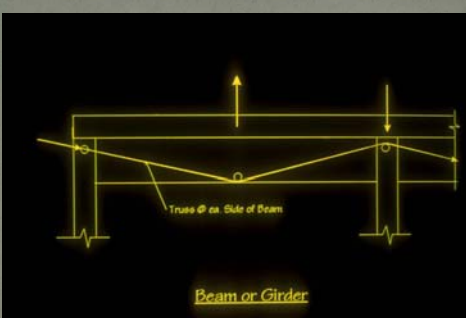
ONE-WAY SLABS



The diagram shows a one-way slab supported on two beams. A truss structure is attached to the bottom of the slab. Downward arrows represent applied loads, and an upward arrow represents the beneficial load from the truss. The caption below the diagram reads 'One-Way Slab Supported on Beams or Walls'.

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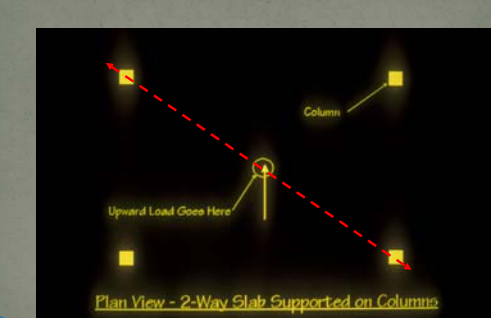
BEAMS AND GIRDERS



The diagram shows a beam or girder supported by two columns. A truss structure is attached to the bottom of the beam. Downward arrows represent applied loads, and an upward arrow represents the beneficial load from the truss. The caption below the diagram reads 'Beam or Girder'.

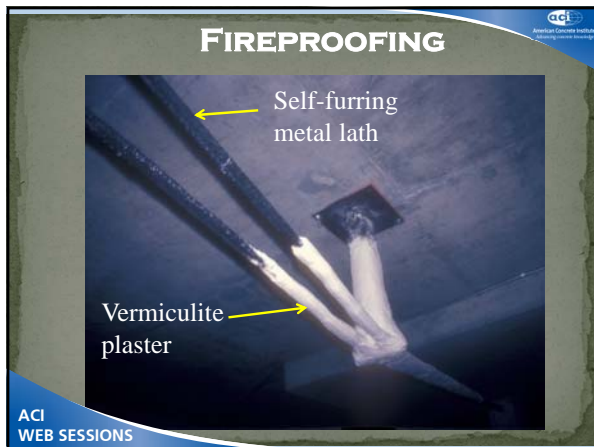
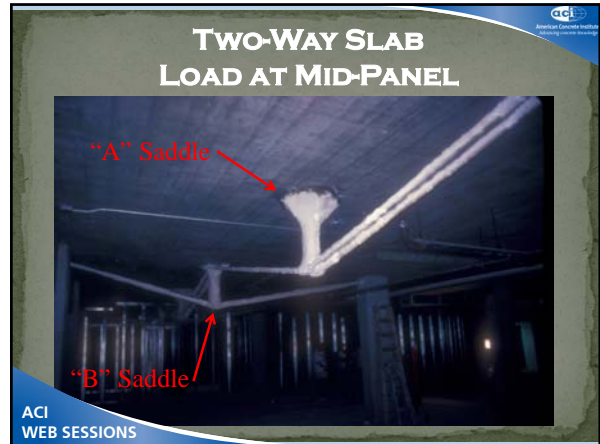
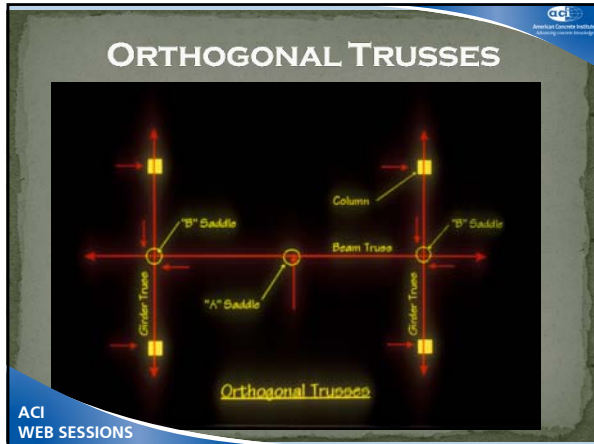
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TWO-WAY SLABS



The diagram shows a plan view of a two-way slab supported on four columns. A dashed red line indicates the path of the truss. An upward arrow is labeled 'Upward Load Goes Here'. The caption below the diagram reads 'Plan View - 2-Way Slab Supported on Columns'.

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FIREPROOFING IBC Table 720.1(1)

"MINIMUM PROTECTION OF STRUCTURAL PARTS BASED ON TIME PERIODS FOR VARIOUS NONCUMBUSTIBLE INSULATING MATERIALS"

Table 720.1(1) - MINIMUM PROTECTION OF STRUCTURAL PARTS BASED ON TIME PERIODS FOR VARIOUS NONCUMBUSTIBLE INSULATING MATERIALS	Table 720.1(1) - MINIMUM PROTECTION OF STRUCTURAL PARTS BASED ON TIME PERIODS FOR VARIOUS NONCUMBUSTIBLE INSULATING MATERIALS	Table 720.1(1) - MINIMUM PROTECTION OF STRUCTURAL PARTS BASED ON TIME PERIODS FOR VARIOUS NONCUMBUSTIBLE INSULATING MATERIALS
1.1.1	1.1.2	1.1.3
1.1.4	1.1.5	1.1.6
1.1.7	1.1.8	1.1.9
1.1.10	1.1.11	1.1.12
1.1.13	1.1.14	1.1.15
1.1.16	1.1.17	1.1.18
1.1.19	1.1.20	1.1.21
1.1.22	1.1.23	1.1.24
1.1.25	1.1.26	1.1.27
1.1.28	1.1.29	1.1.30
1.1.31	1.1.32	1.1.33
1.1.34	1.1.35	1.1.36
1.1.37	1.1.38	1.1.39
1.1.40	1.1.41	1.1.42
1.1.43	1.1.44	1.1.45
1.1.46	1.1.47	1.1.48
1.1.49	1.1.50	1.1.51
1.1.52	1.1.53	1.1.54
1.1.55	1.1.56	1.1.57
1.1.58	1.1.59	1.1.60
1.1.61	1.1.62	1.1.63
1.1.64	1.1.65	1.1.66
1.1.67	1.1.68	1.1.69
1.1.70	1.1.71	1.1.72
1.1.73	1.1.74	1.1.75
1.1.76	1.1.77	1.1.78
1.1.79	1.1.80	1.1.81
1.1.82	1.1.83	1.1.84
1.1.85	1.1.86	1.1.87
1.1.88	1.1.89	1.1.90
1.1.91	1.1.92	1.1.93
1.1.94	1.1.95	1.1.96
1.1.97	1.1.98	1.1.99
1.1.100	1.1.101	1.1.102

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“1. Steel columns and all [members] of primary trusses”

- **1.6.2** – Perlite or vermiculite gypsum plaster over self-furring metal lath wrapped directly around column, lapped 1” and tied at 6” intervals with 0.049” (No. 18 B.W. gage) wire.

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MINIMUM PROTECTION

- 2-hour
 - 1” cover
- 3-hour
 - 1-3/8” cover
- 4-hour
 - 1-3/4” cover

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EPT WITH "AESTHETIC" FIRE PROOFING



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CORING – ROTO-HAMMER



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CORING - LARGER HOLES

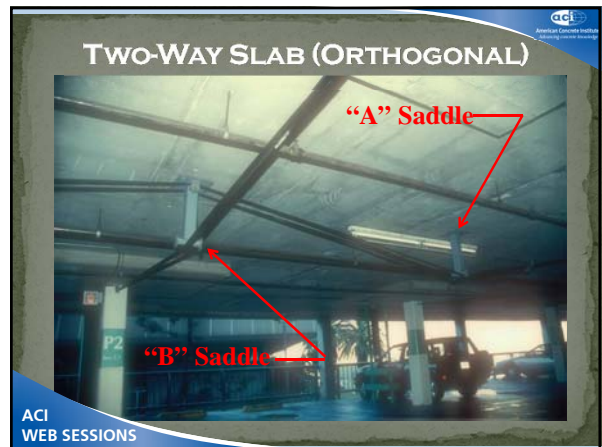
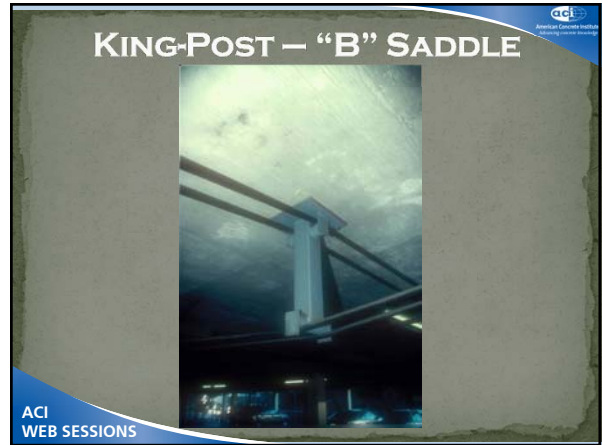
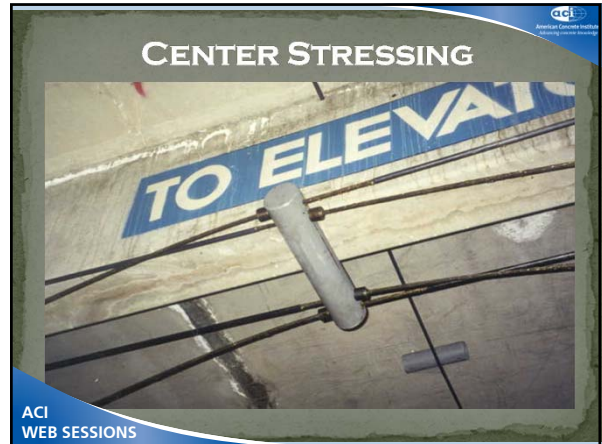


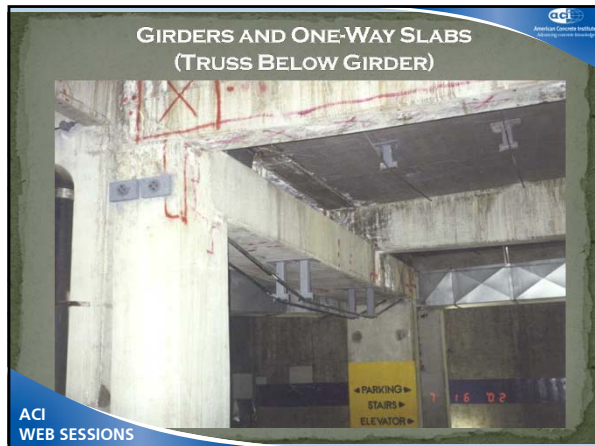
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STRESSING TENDONS



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SUMMARY

- EPT is a powerful method for strengthening existing buildings
- Applications:
 - Design errors (increases flexure and shear strength)
 - Occupancy change (increased live load)
 - Damage
 - Corrosion
 - Seismic
- Weightless
- No disruption to existing utilities
- Can generally be executed while building remains in service

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The slide features a dark green background with a white border. The title 'SUMMARY' is in bold white text. The list of applications is bulleted. The ACI logo and 'ACI WEB SESSIONS' text are in the bottom left corner.

