Two-way Slabs Using a Dual Banded Tendon Layout

Jonathan Hirsch

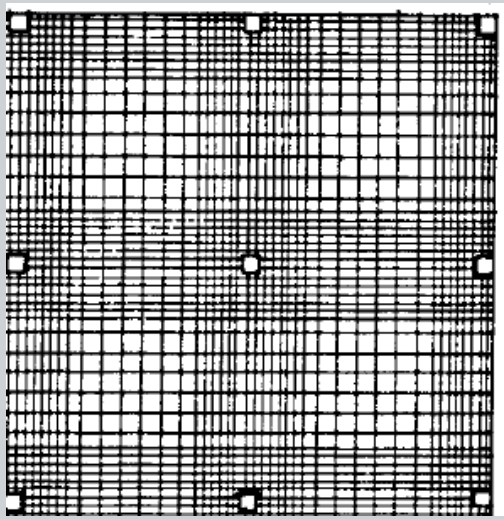
Rashid Ahmed

Asit Baxi

POST-TENSIONING INSTITUTE ®

Tendon Layouts - History

- Primary tendon layout in the 1950's and 1960's was the "Basket Weave" layout with 60/40 to 75/25 ratio used for the tendons in the Column Strip (CS) / Middle Strip (MS).
- Drawbacks of this layout were:
  - Cumbersome to detail and install
  - Complex to design – at irregularities



Tendon Layouts - History

- First known “Banded Flat Plate” (banded/distributed) ever to be built was the Watergate Apartment in Washington, D.C. in 1968. Conceptualization of this idea came from the design team because no alternate design seemed feasible. (Banded Tendons in Flat Plates, Ken Bondy, Seminar Proc. SEASC, 1985)
- This tendon layout system revolutionized post-tensioning in the US.
- Reduced labor costs by 25% and easy to visualize – band is like a ‘beam’ with the slab spanning between the bands or ‘beams’
- Numerous tests with this layout were performed in the 70’s and 80’s.

Tendon Layouts - History

Tendon Layouts

- What's wrong with what we do now?
- Why change?
- What is preventing us?

Tendon Layouts

- “For uniformly distributed loads, spacing of tendons or groups of tendons in at least one direction shall not exceed the smaller of 8 times the slab thickness and 5 feet.” (ACI 318-11)

Tendon Layouts

- To this day, section R18.12.2 of ACI 318-2011states

  " Tests indicate that the moment and shear strength of prestressed slabs is controlled by total prestressing steel strength and by the amount and location of nonprestressed reinforcement, rather than by tendon distribution"

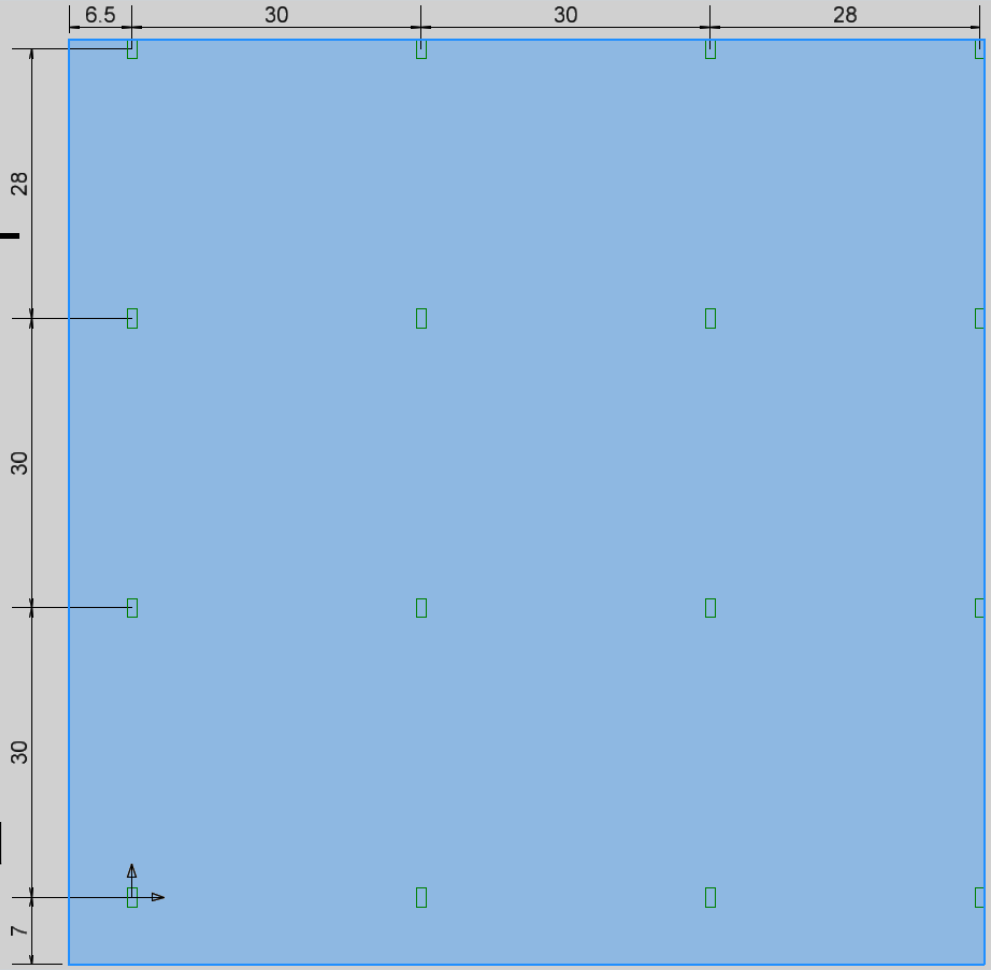
- This presentation provides results from considering a 100/0 – (CS/MS) tendon distribution ratio or a "Dual Banded Layout"

Advantages/Drawbacks of Dual Banded Tendon Layout

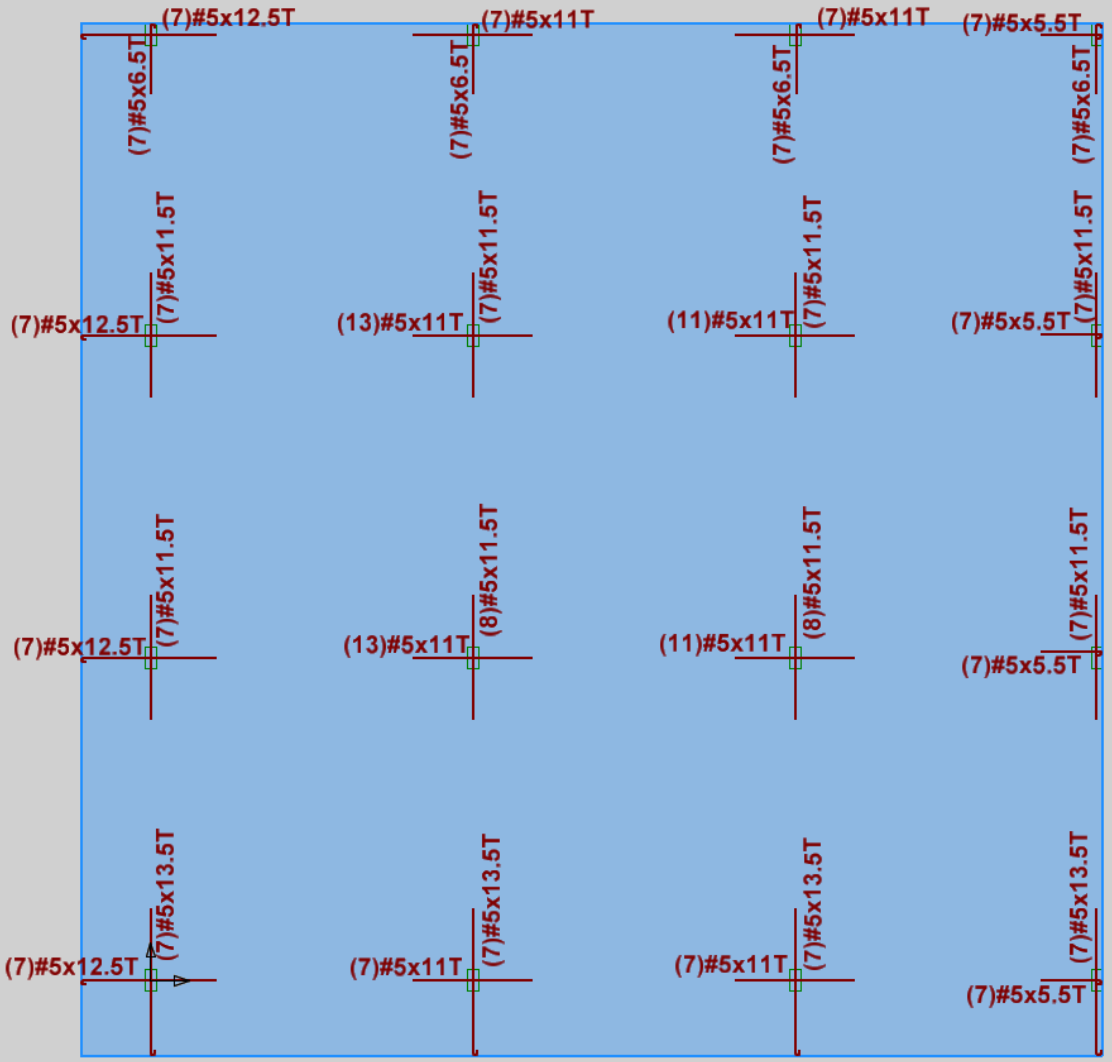
- Economic / use advantages
  - Placement costs
  - Post-construction coring
  - Allow alternate structural systems (slab voids)
- Structural advantages
  - Numerous
- Structural drawbacks
  - Reduced Drape
  - Higher tensile stresses in some areas
  - Higher initial stresses

Test Slabs

- 30’ typical spans
- 40 psf LL, 20 psf DL
- 12” x 24” columns
- 8” thick PT slab
- 5000 psi concrete
- ACI 318-11
- 3 tendon layouts
  - Distributed/distributed
  - Banded/distributed
  - Banded/banded

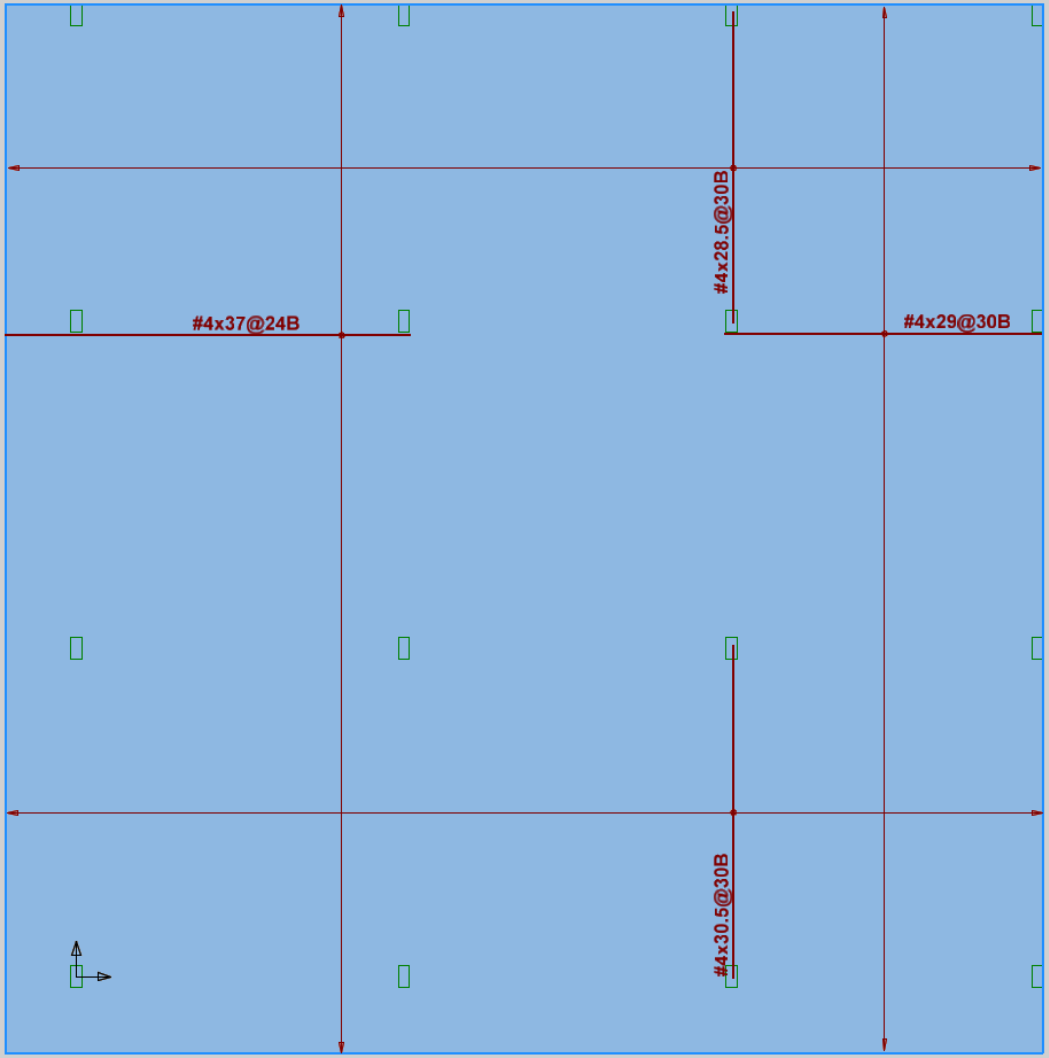


Test Slabs – Top Reinforcement

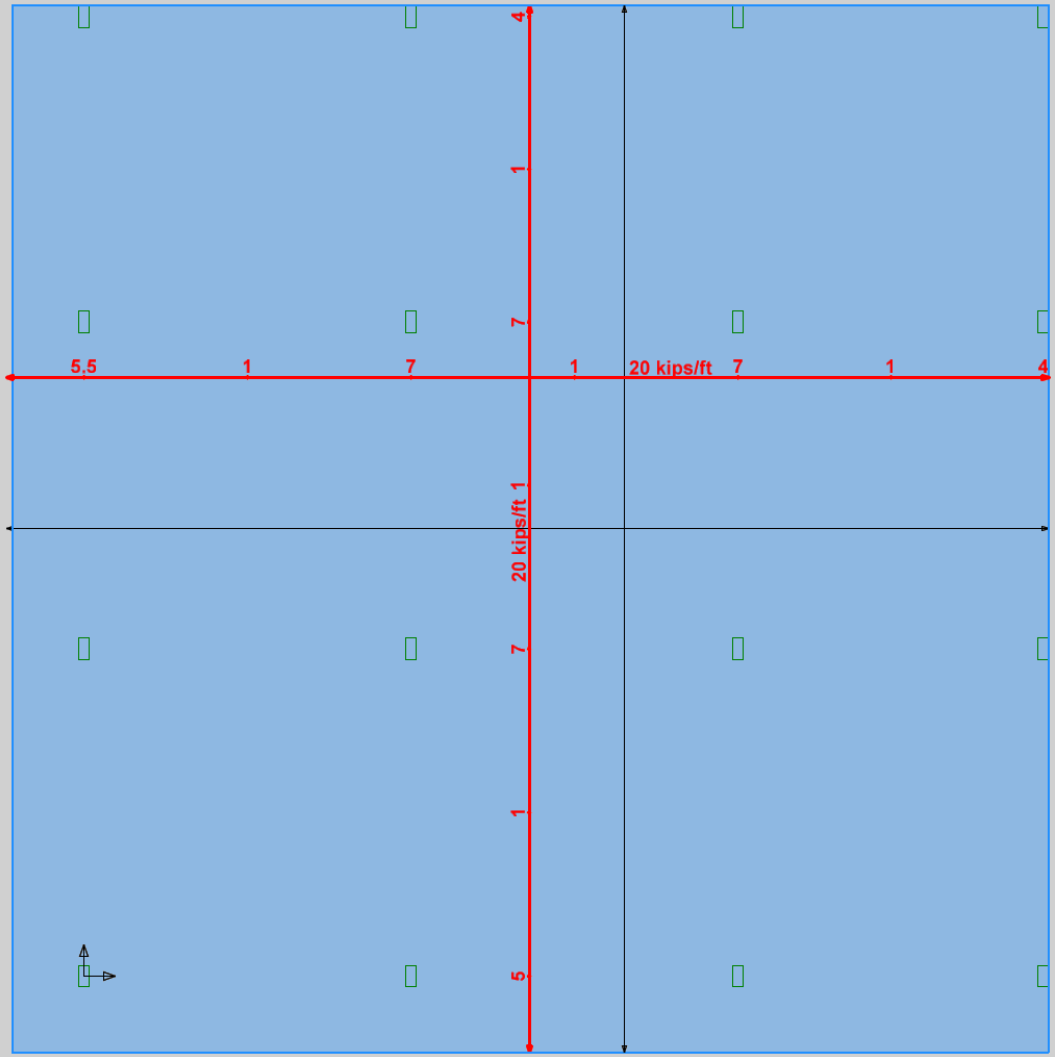


POST-TENSIONING INSTITUTE ®

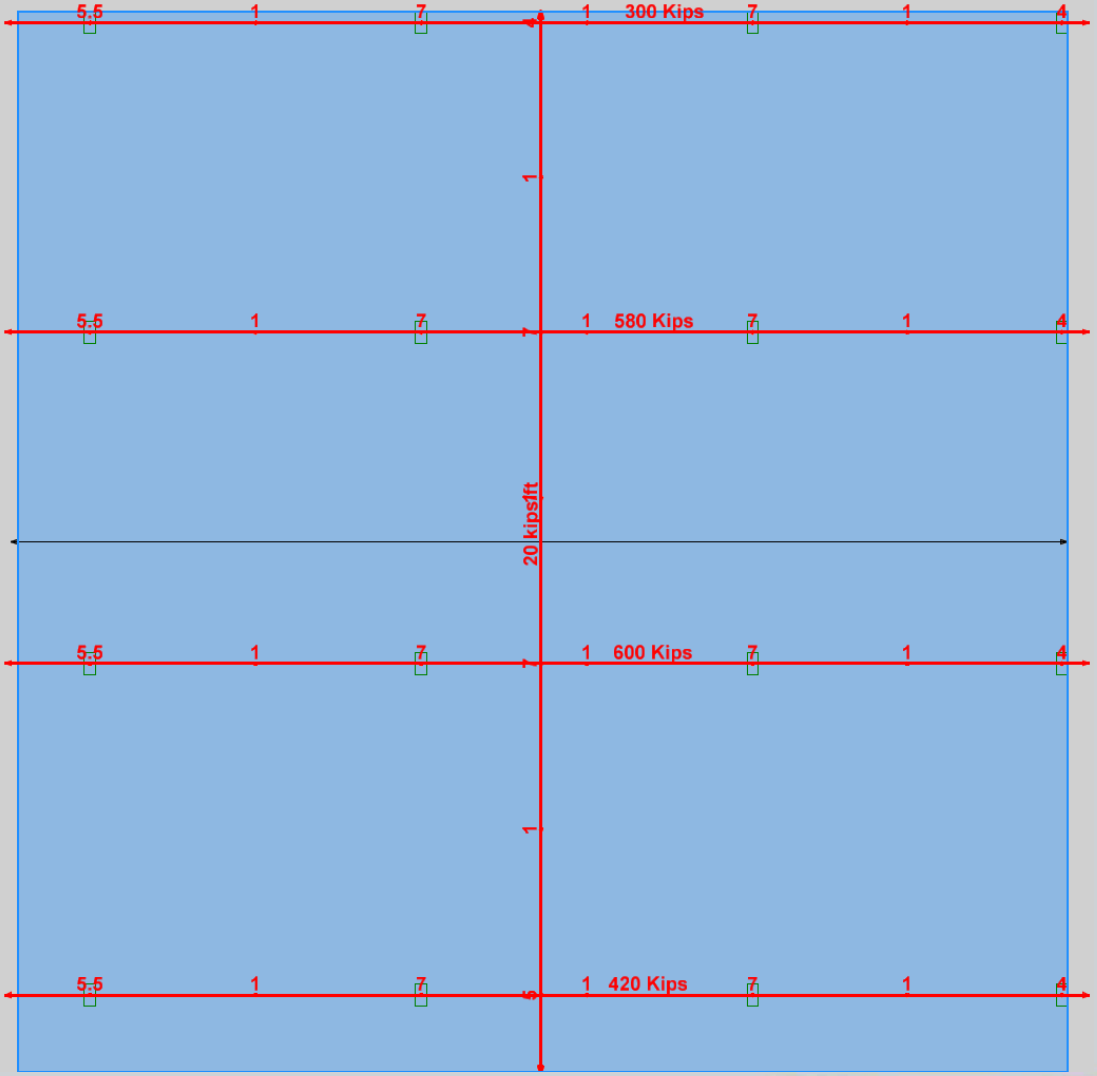
Test Slabs – Bottom Reinforcement



Test Slabs – Dist/Dist PT Layout

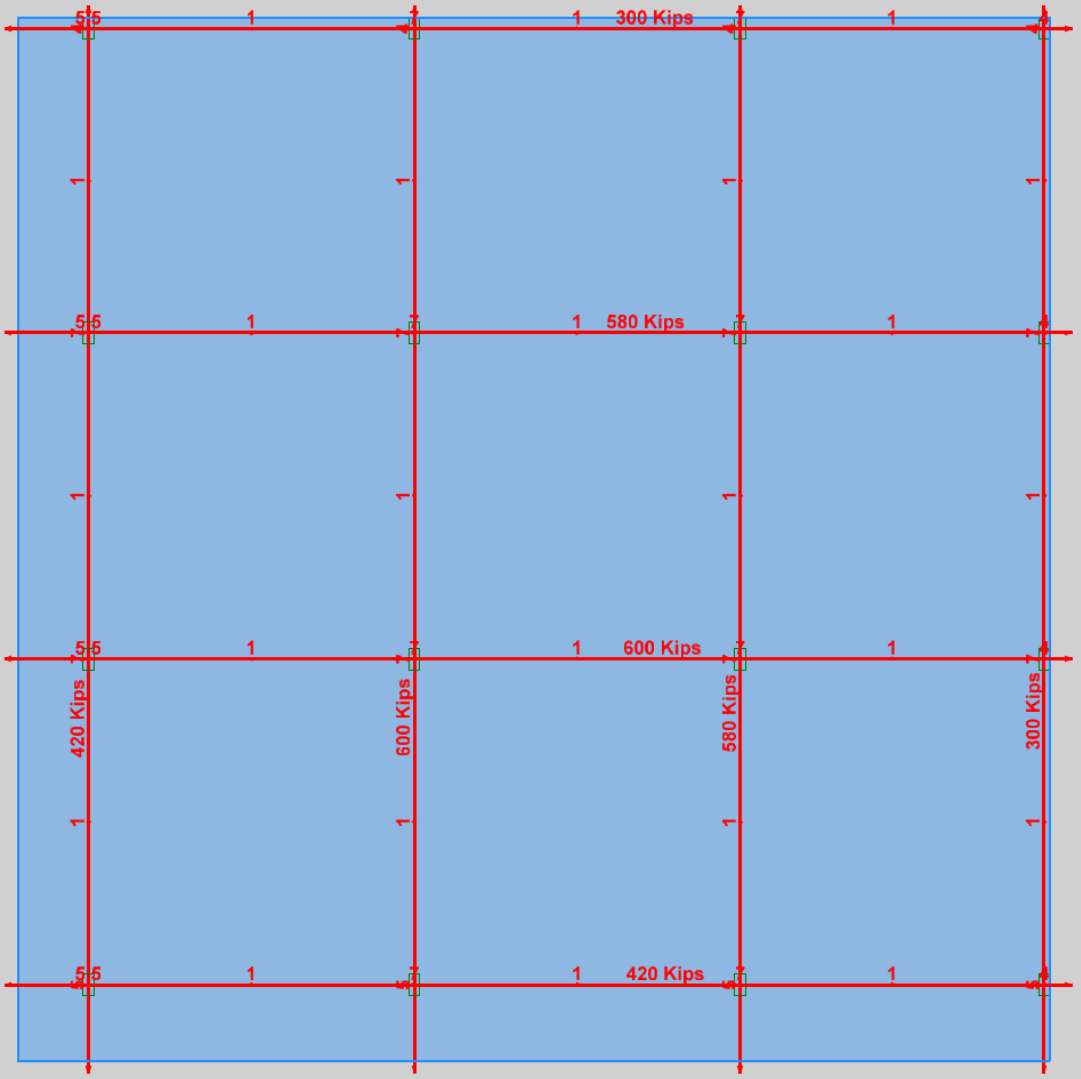


Test Slabs – Band/Dist PT Layout



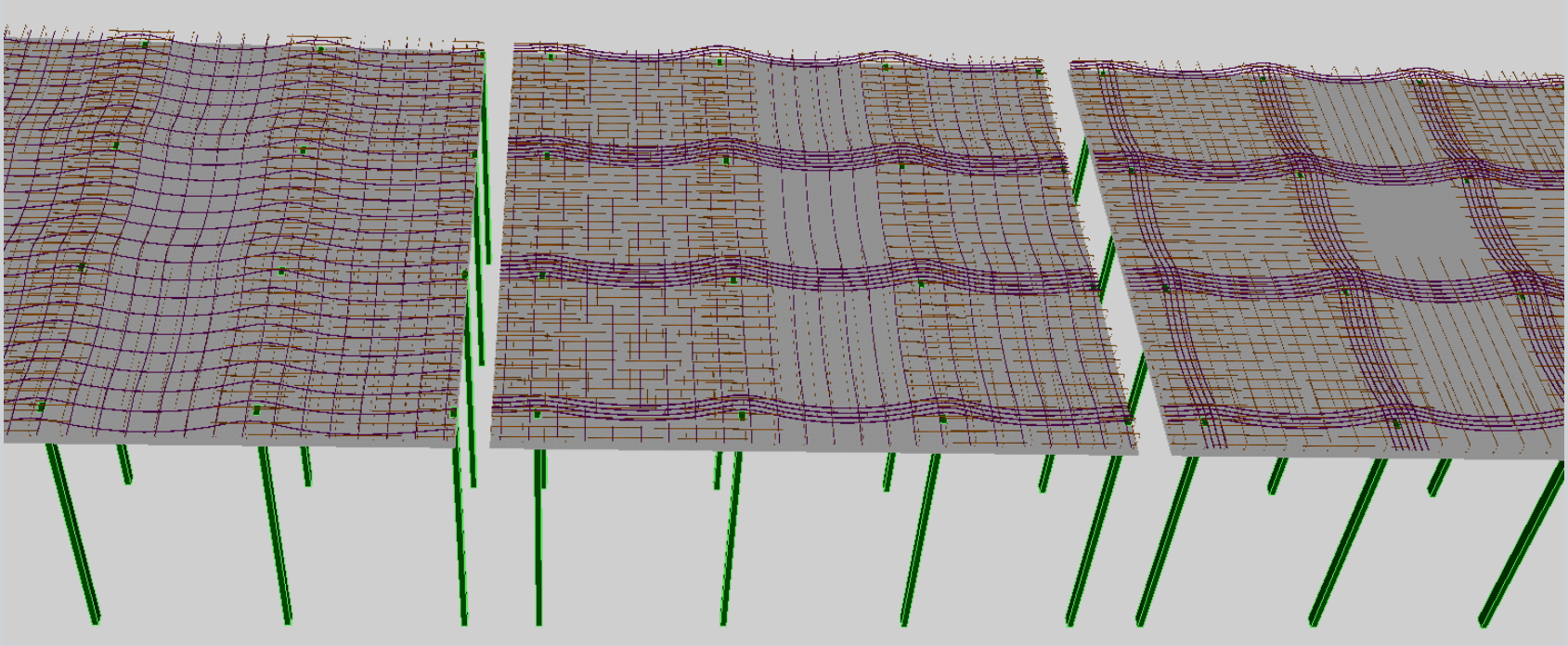
POST-TENSIONING INSTITUTE ®

Test Slabs – Band/Band PT Layout



POST-TENSIONING INSTITUTE ®

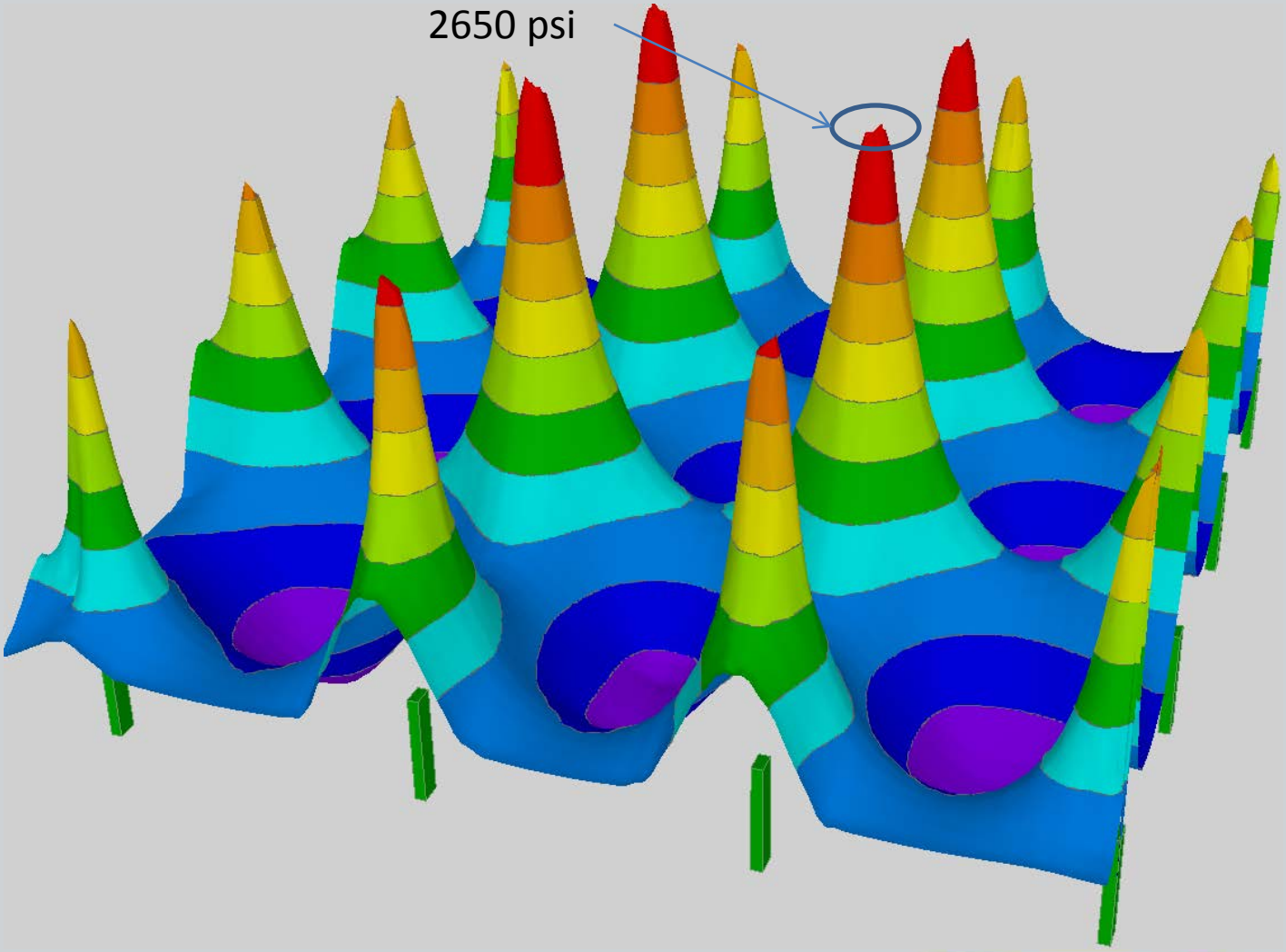
Test Slabs



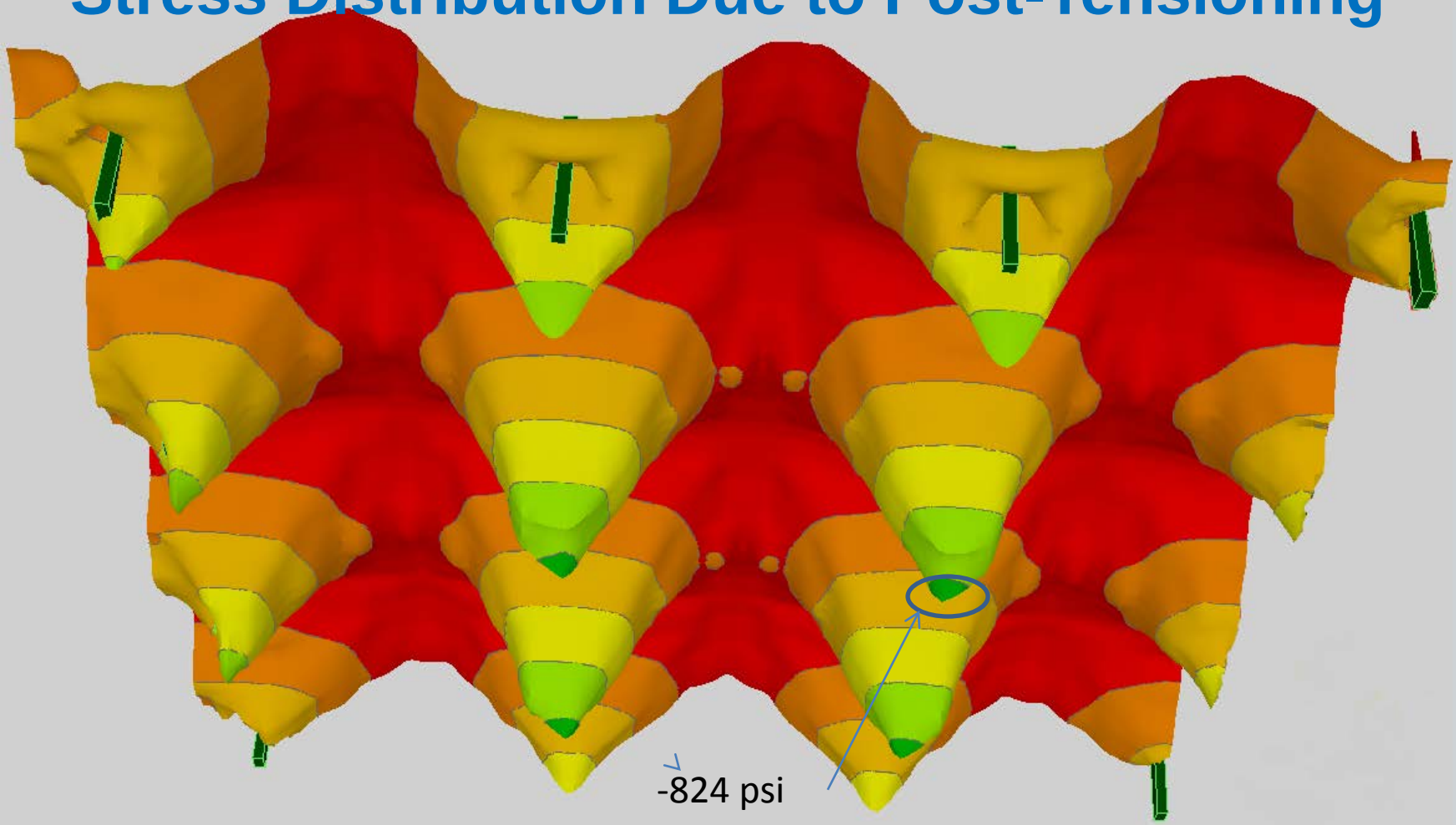
Structural Considerations

- Initial service stresses
- Service stresses
- Deflections
- Strength

Stress Distribution Due to Uniform Loads

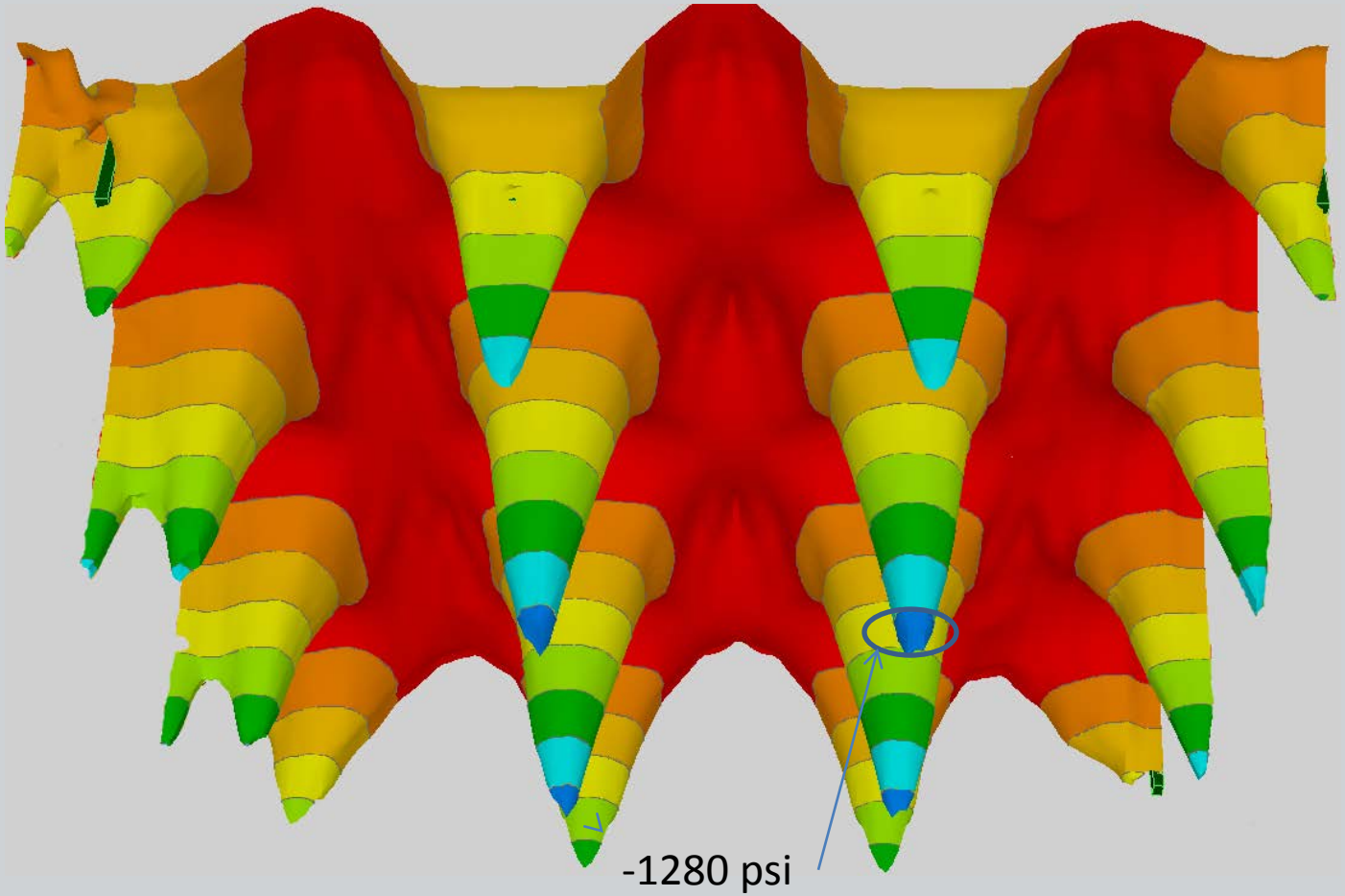


Stress Distribution Due to Post-Tensioning



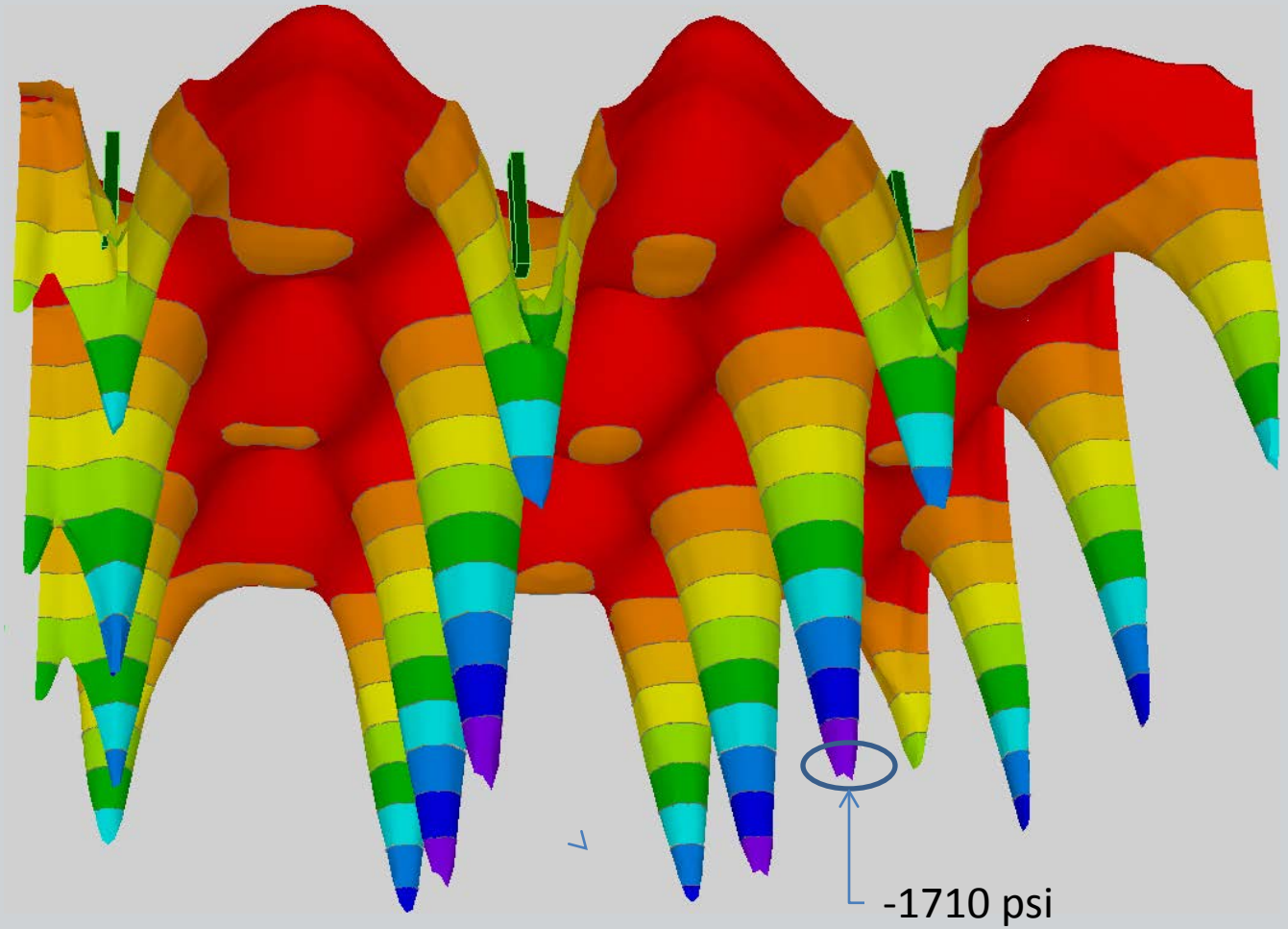
Distributed/Distributed Tendon Layout

Stress Distribution Due to Post-Tensioning



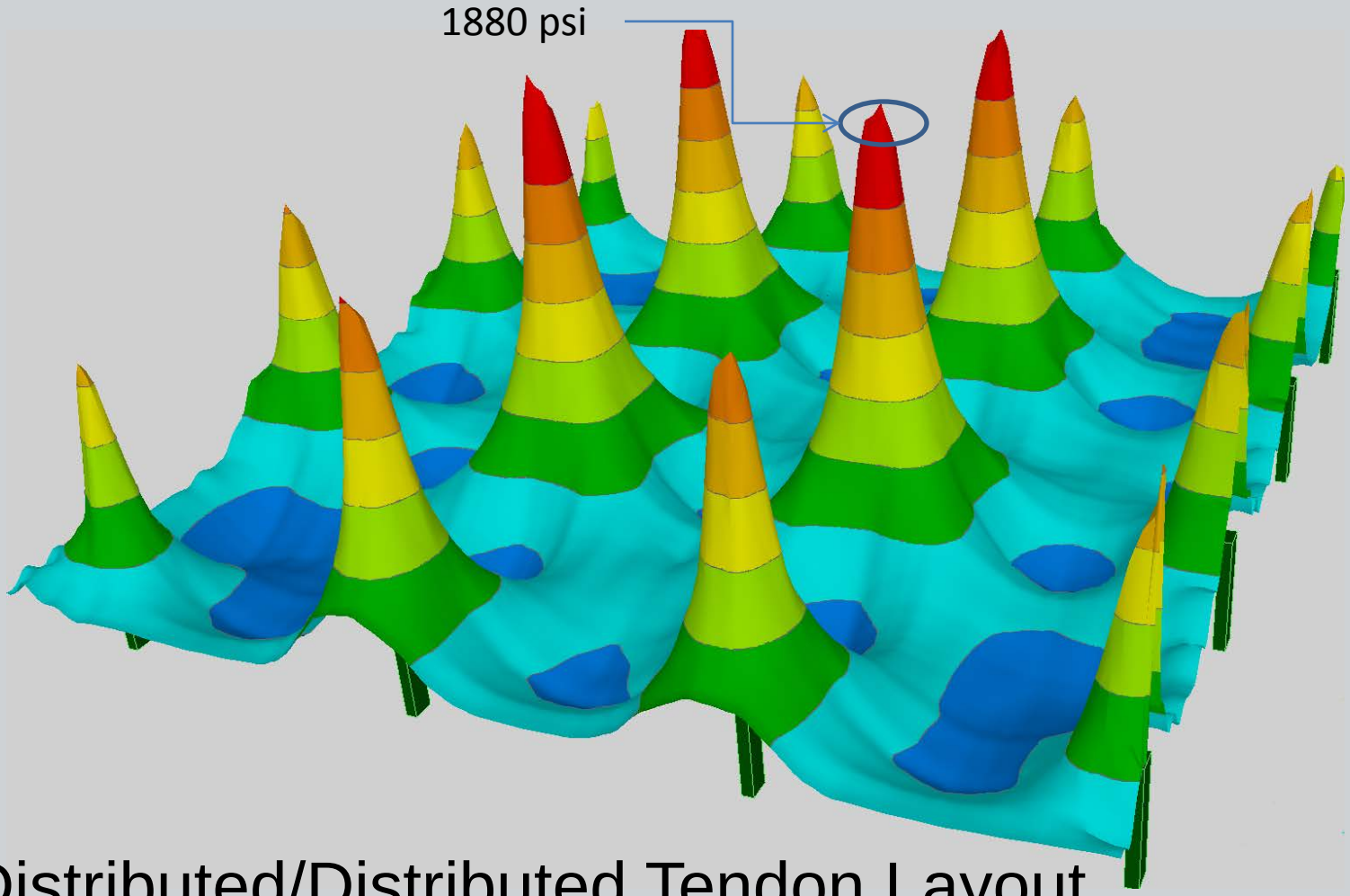
Banded/Distributed Tendon Layout

Stress Distribution Due to Post-Tensioning



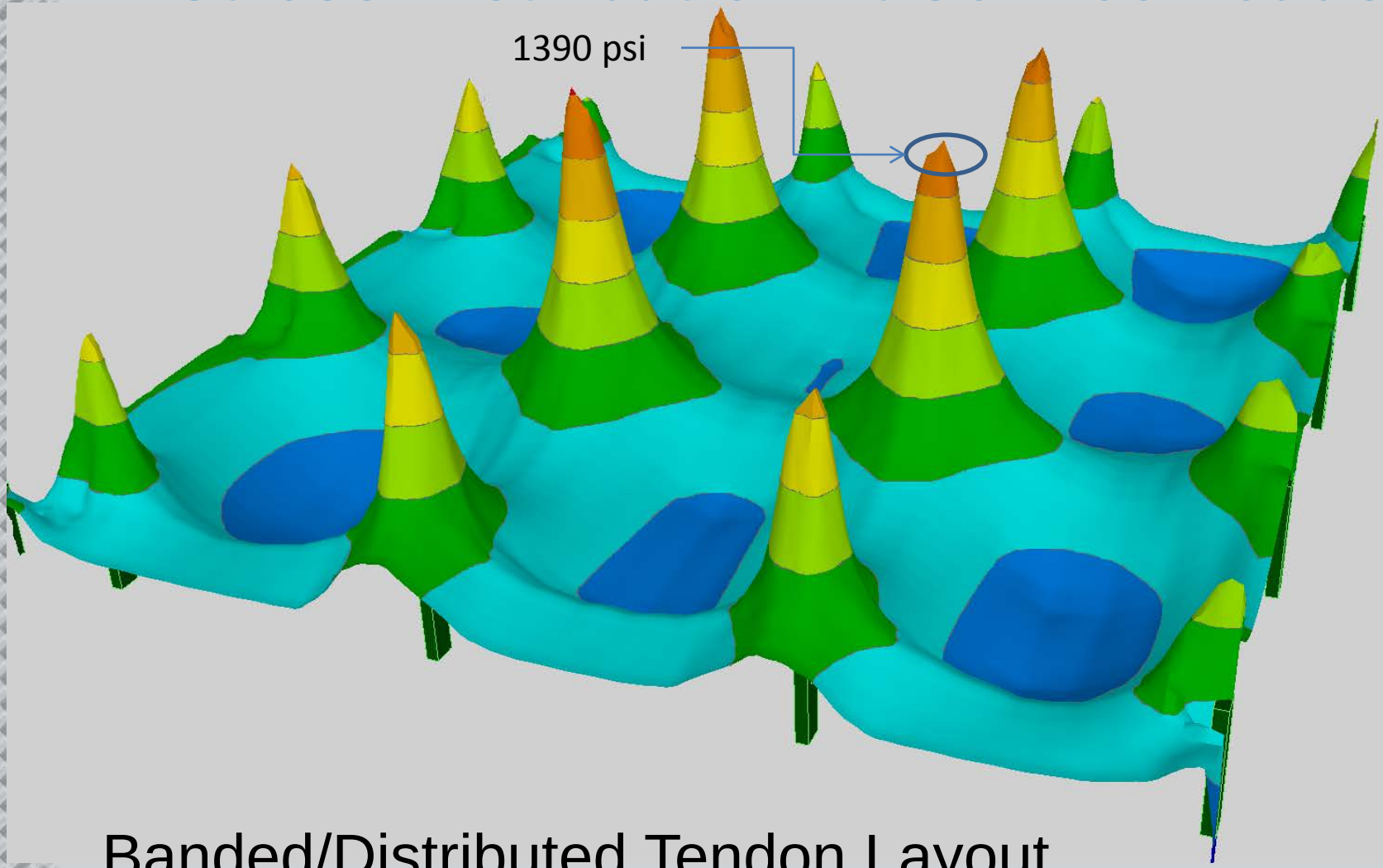
Banded/Banded Tendon Layout

Stress Distribution At Service Loads



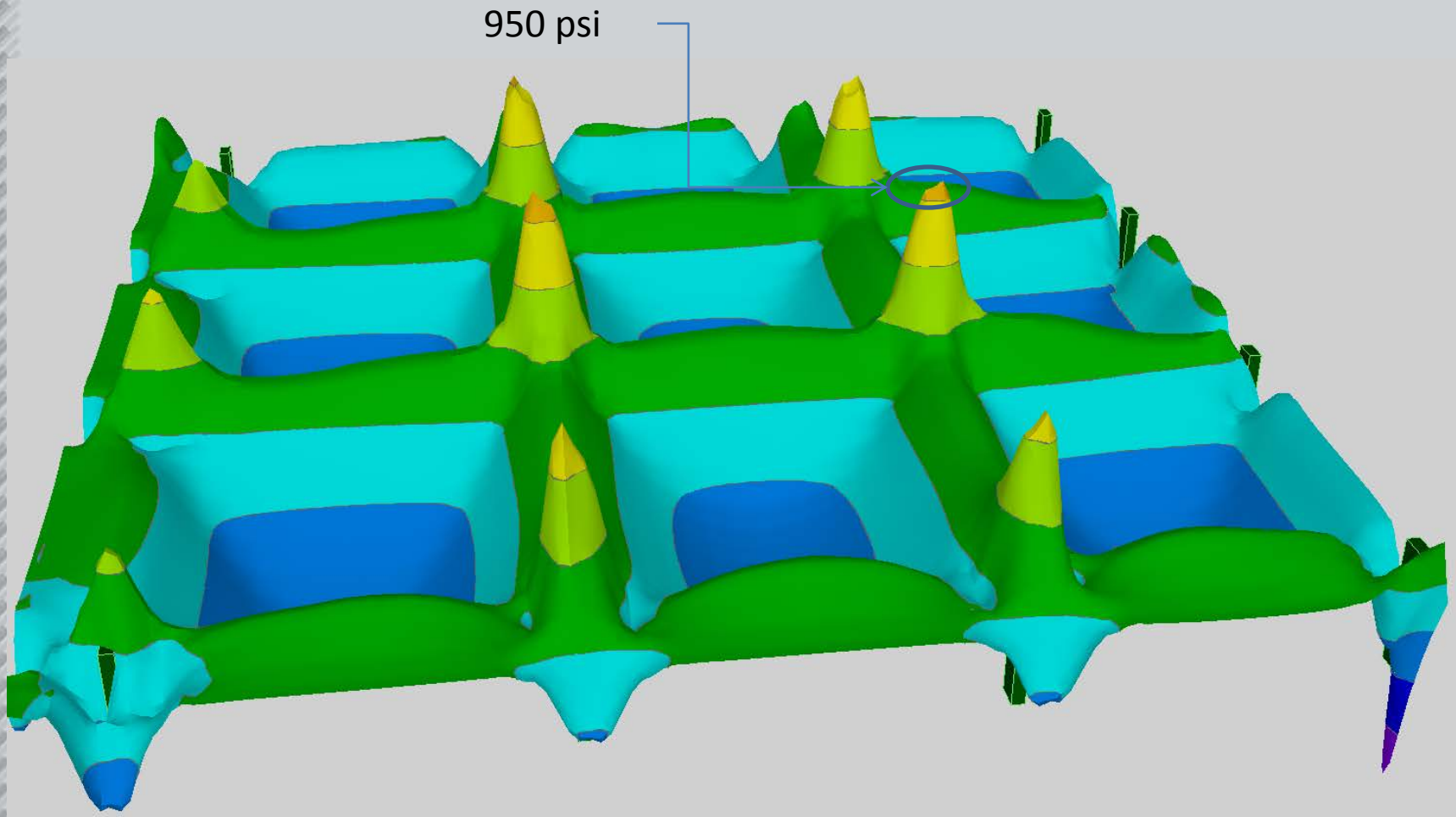
Distributed/Distributed Tendon Layout

Stress Distribution At Service Loads



Banded/Distributed Tendon Layout

Stress Distribution At Service Loads

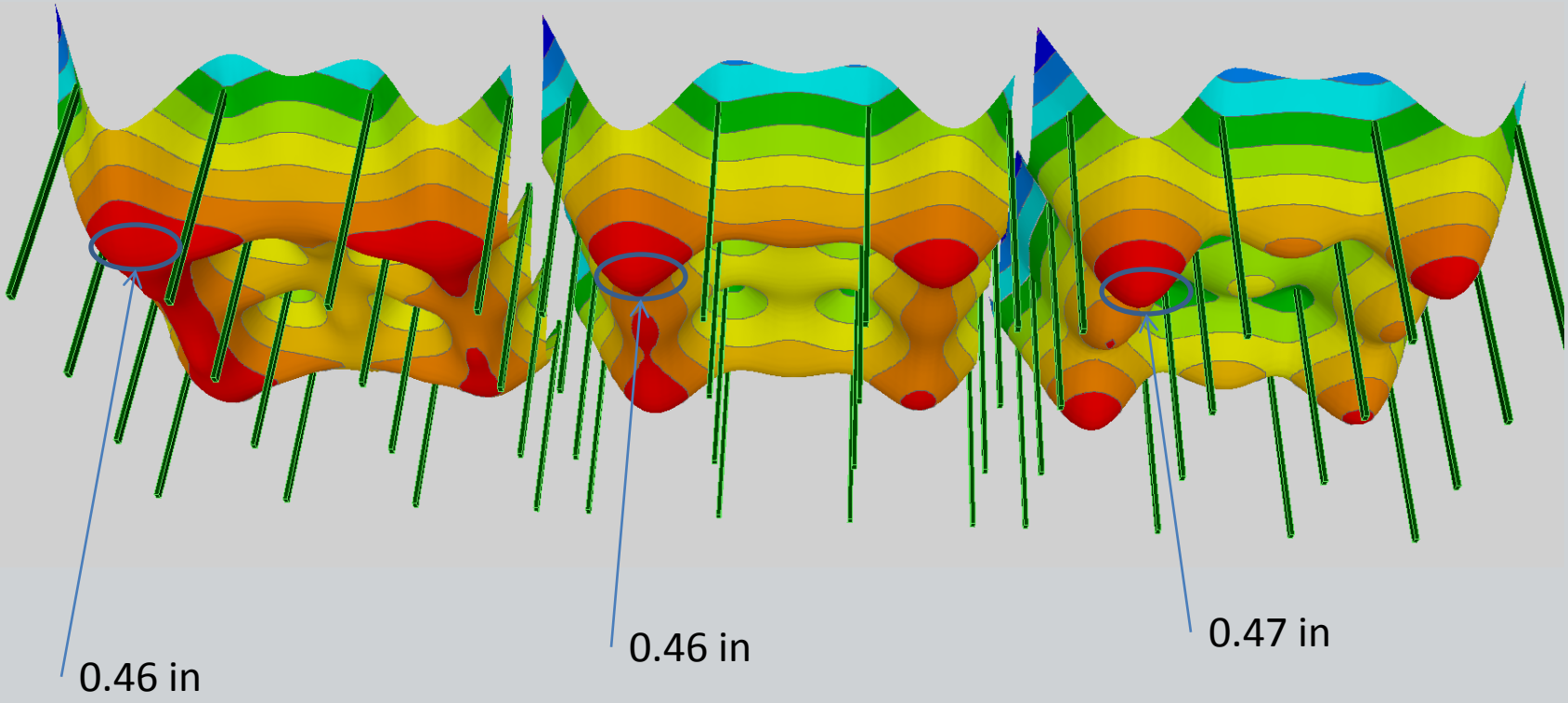


Banded/Banded Tendon Layout

Peak Stress Distribution Summary

	Service Loads				Initial Service Loads (Transfer)			
Tendon Layout Type	Max Top Stress (psi)	Min Top Stress (psi)	Max Bot Stress (psi)	Min Bot Stress (psi)	Max Top Stress (psi)	Min Top Stress (psi)	Max Bot Stress (psi)	Min Bot Stress (psi)
Dist./Dist.	1880	-520	420	-2000	830	-520	170	-1120
Band/Dist.	1390	-550	460	-1600	220	-280	0	-600
Band/Band	950	-650	490	-1220	150	-460	300	-540

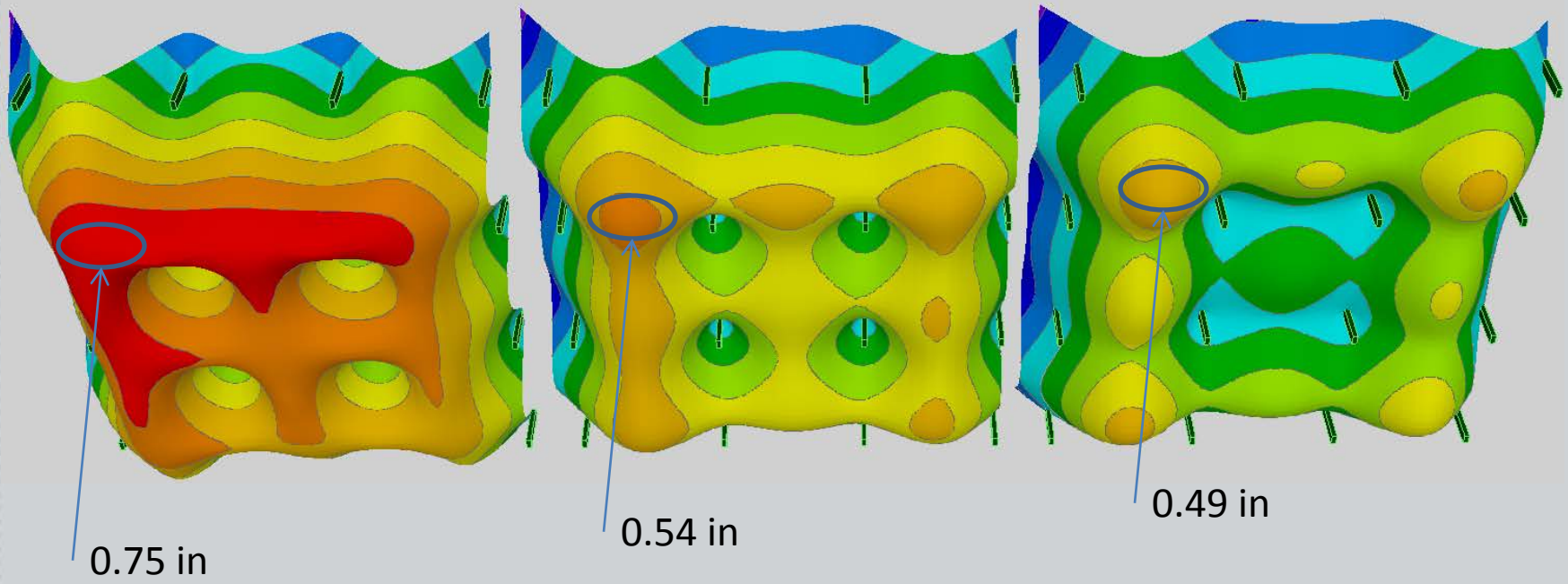
Service Load Deflections



Distributed/Distributed Banded/Distributed Banded/Banded

Linear elastic deflections

Service Load Deflections



Distributed/Distributed Banded/Distributed Banded/Banded

Cracked deflections

Strength Advantages of Dual Banded Tendon Layout

- Flexural strength comparable
- Increased punching shear strength
- Increased flexural moment transfer strength

Conclusions/Recommendations

- Dual banded tendon layouts can provide economic and structural advantages over currently used tendon layouts
- Conduct a series of tests similar to Burns et al.
- Determine minimum rebar requirements
- Change ACI 318 to allow dual banded tendon layout