

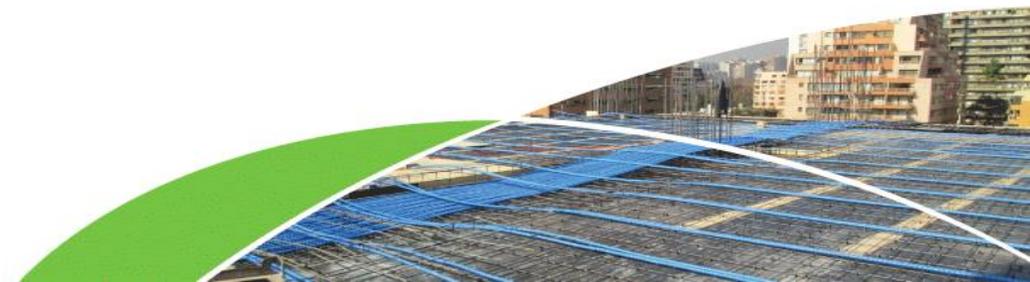
EDIFICIOS CON ENTREPISOS DE HORMIGÓN POST-TENSADO

Ing. Miguel Sebastián Morales

Master of Science in Structural Engineering

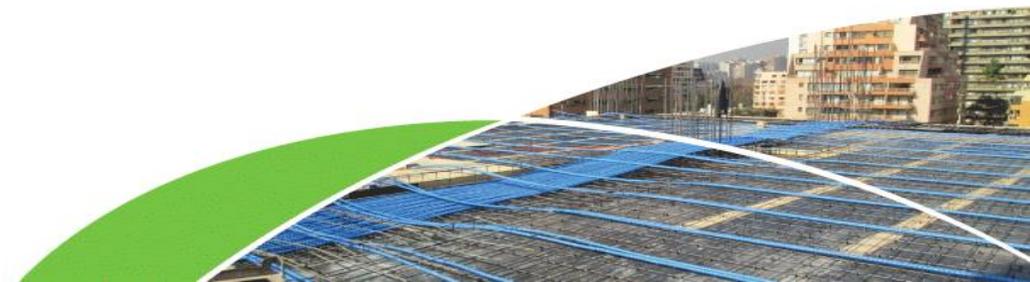
Lugar: Cámara de la Construcción de Guayaquil

Fecha: 6 de Julio de 2017



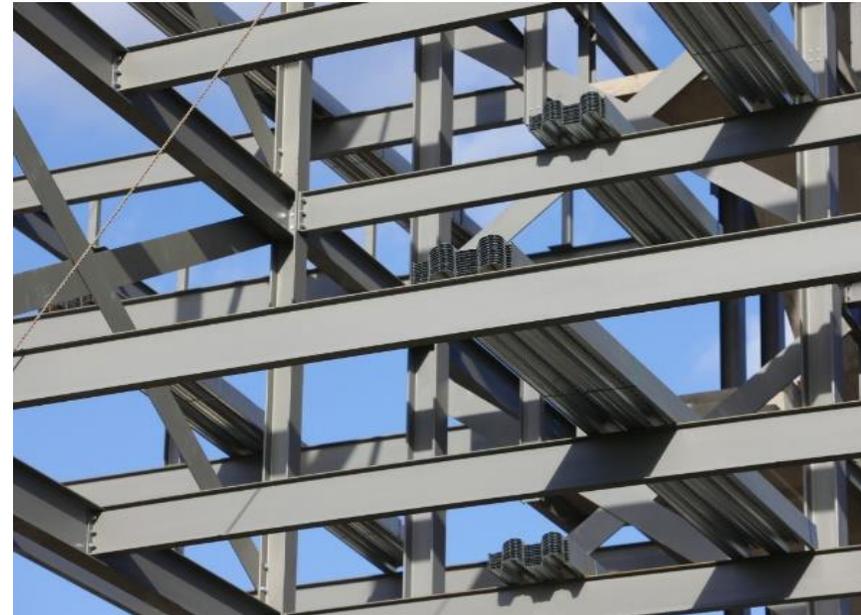
EDIFICIOS CON HORMIGÓN POST-TENSADO

1. Introducción
2. Resumen histórico
3. Principios básicos del funcionamiento
4. Aplicaciones y Ejemplos
5. Ventajas económicas y arquitectónicas
6. Análisis y Diseño estructural
7. Sismoresistencia
8. Procesos constructivos y nuevos retos en el Ecuador
9. Limitaciones superadas en el Ecuador
10. Materiales

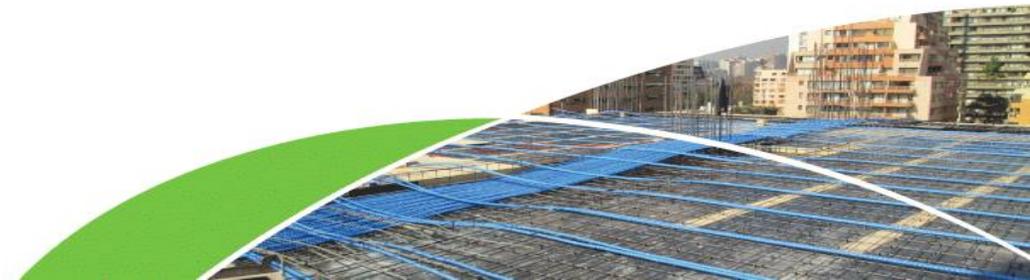


Introducción

- La construcción de entrepisos en Ecuador

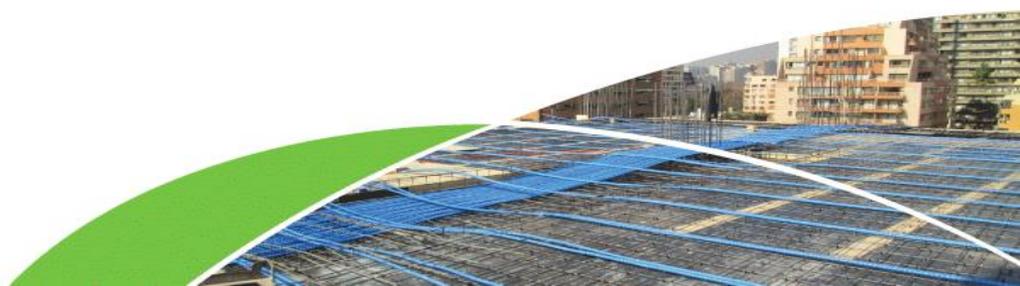
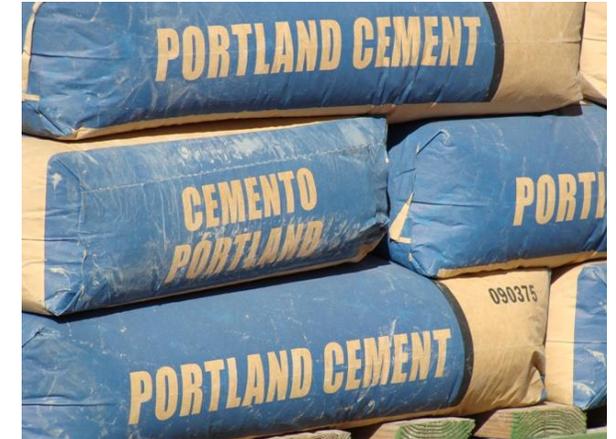
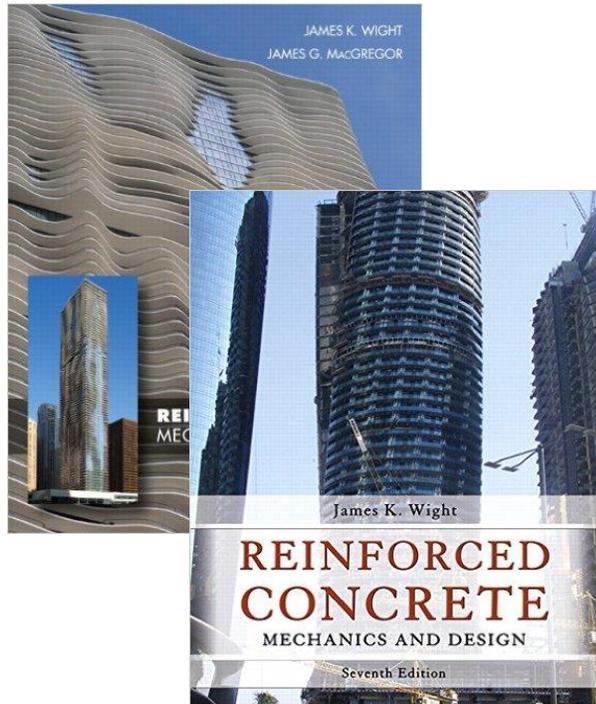


¿Son totalmente económicas?



INTRODUCCIÓN

- SISTEMAS DE ENTREPISO DE HORMIGÓN ARMADO



HORMIGÓN ARMADO

- ¿Desventaja?



HORMIGÓN ARMADO

- Sólo una parte de la sección es efectiva.

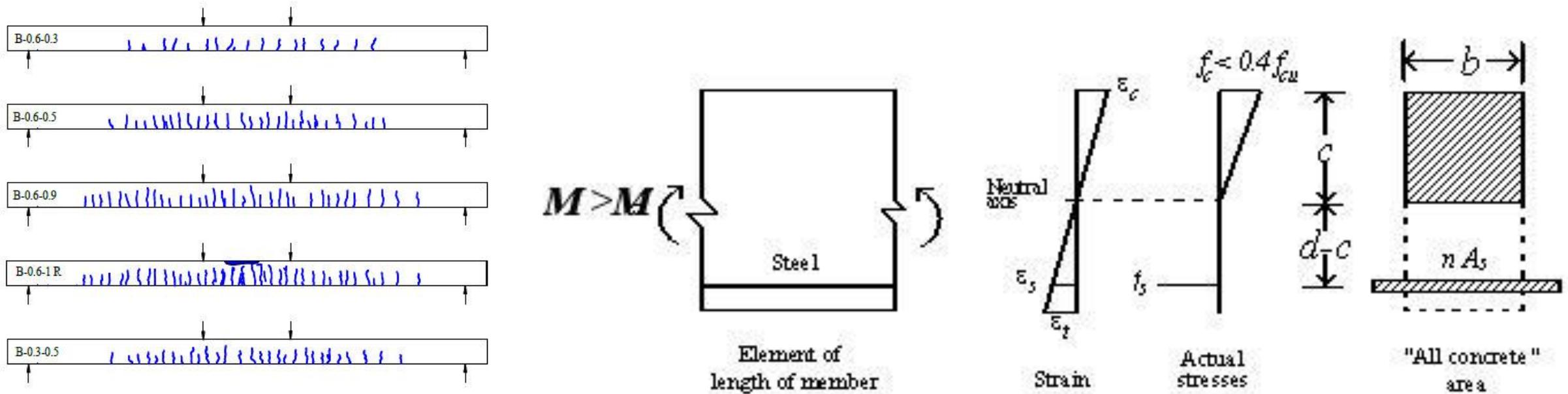
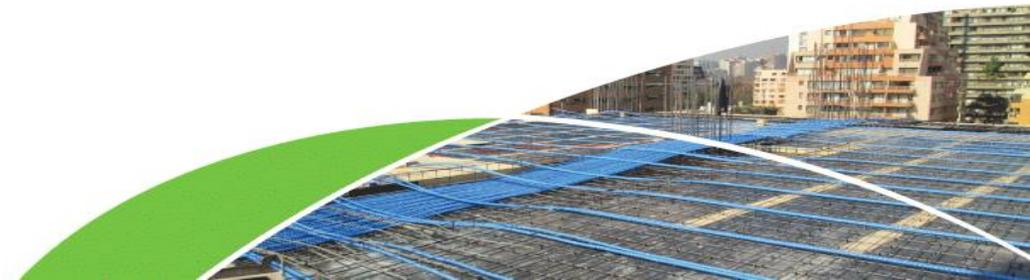
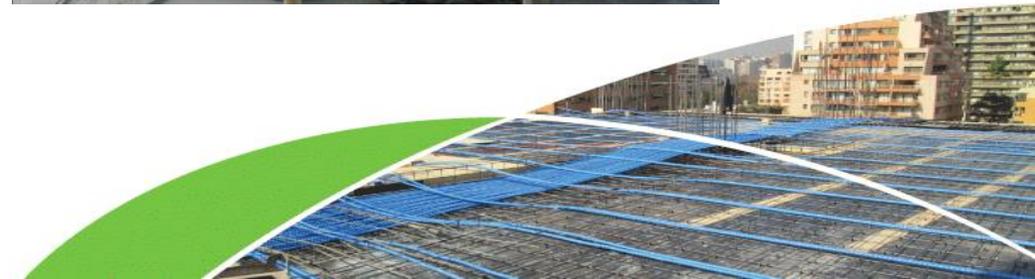
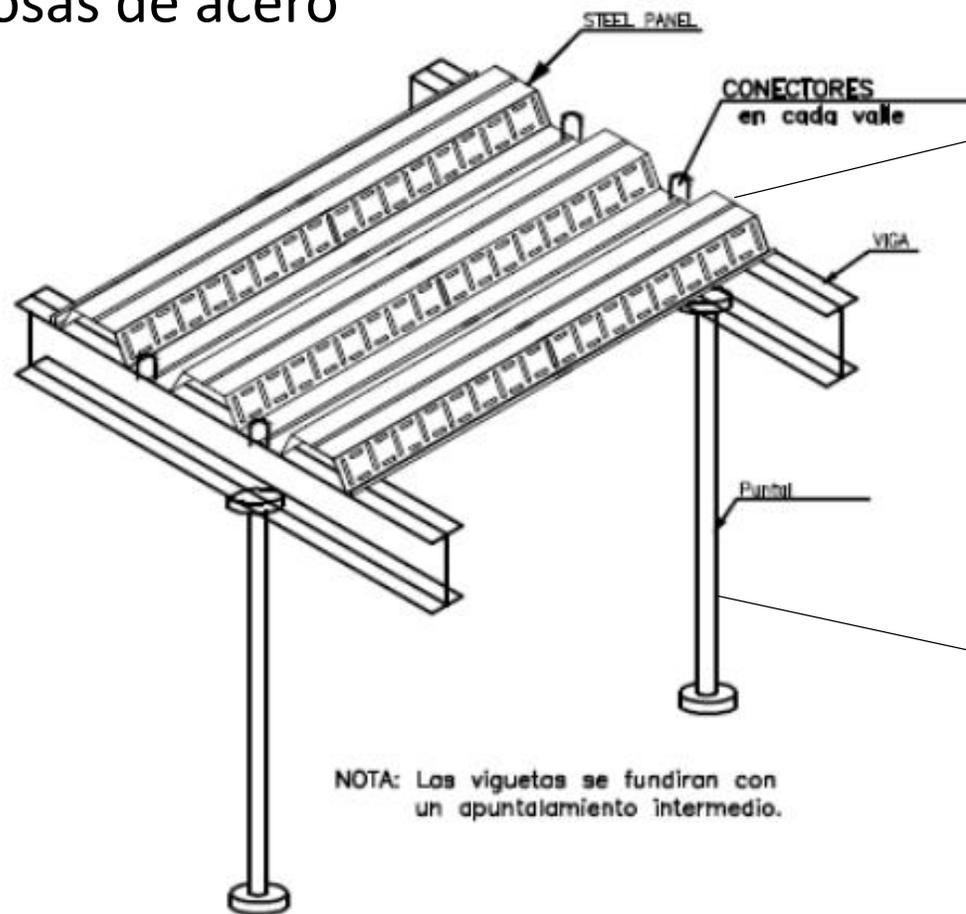


Figure 5: Crack patterns of the damaged beams due to preloading and before strengthening.



ACERO ESTRUCTURAL

- Losas de acero



ACERO ESTRUCTURAL

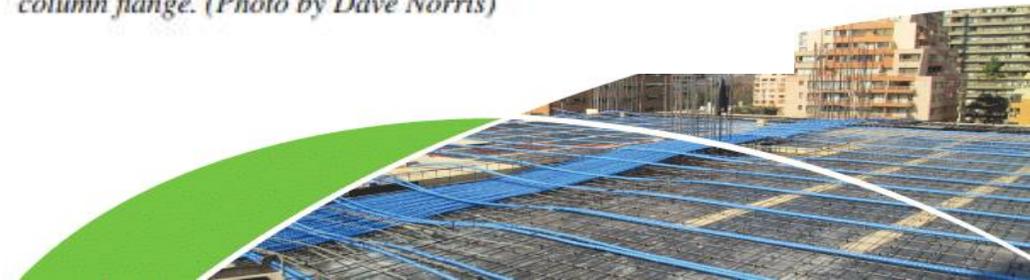
- Soldadura y Conexiones



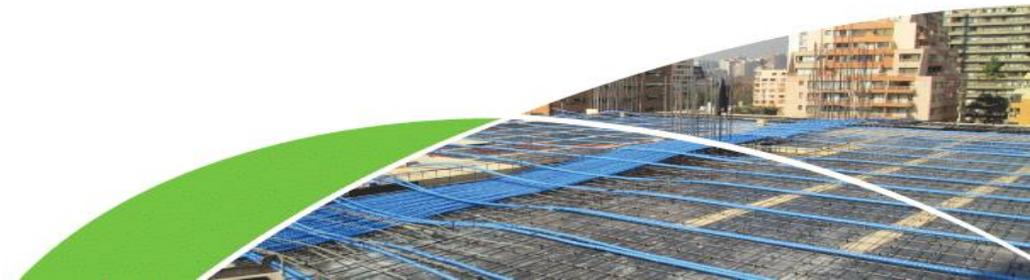
Fig. 6-2. Fracture of beam flange at CJP groove weld of beam flange to column flange. (Photo by Dave Norris)



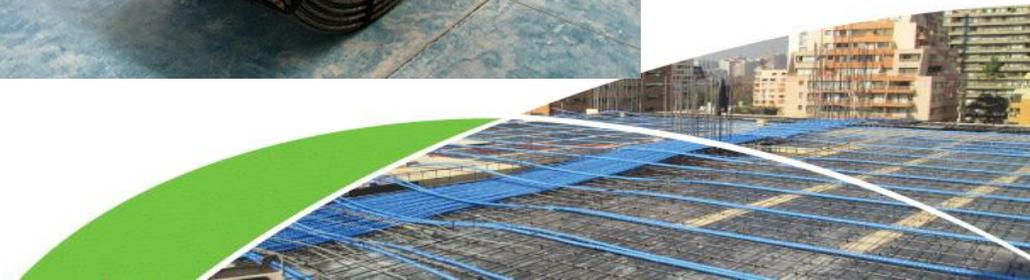
Fig. 6-3. Fracture involving divot of steel being withdrawn from column flange. (Photo by Dave Norris)



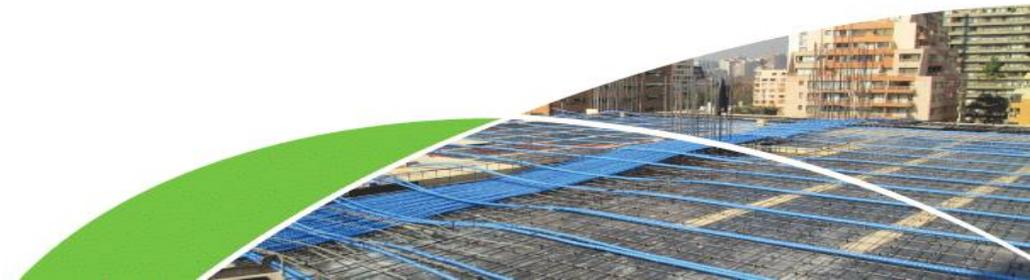
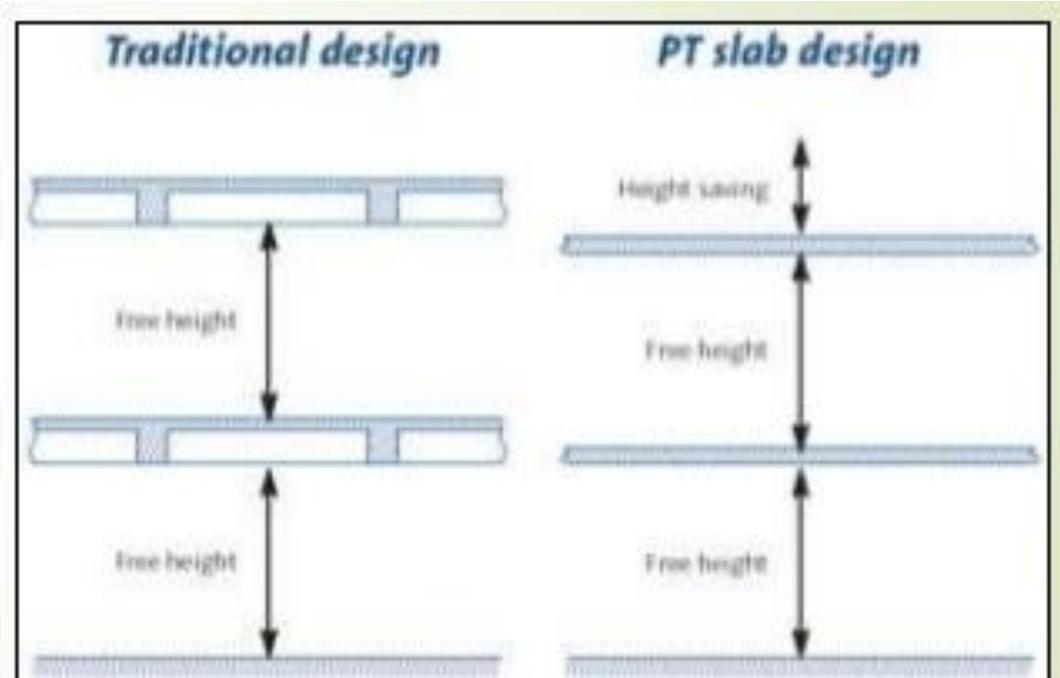
¿Y el sistema de entrepiso que se utiliza en otros países?



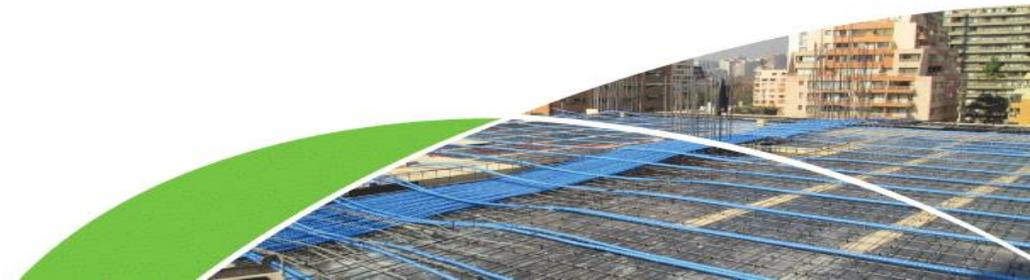
Hormigón Presforzado (Post-Tensado)



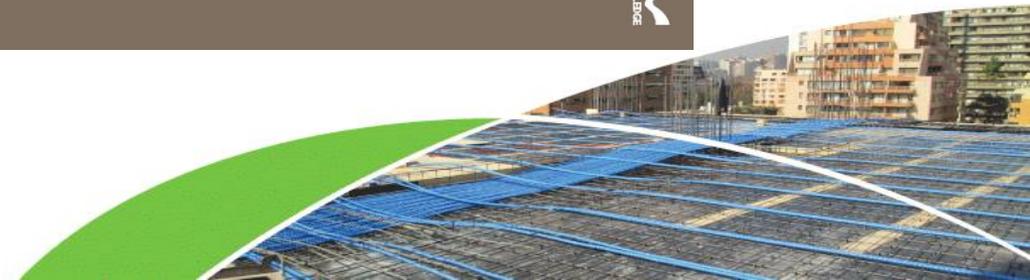
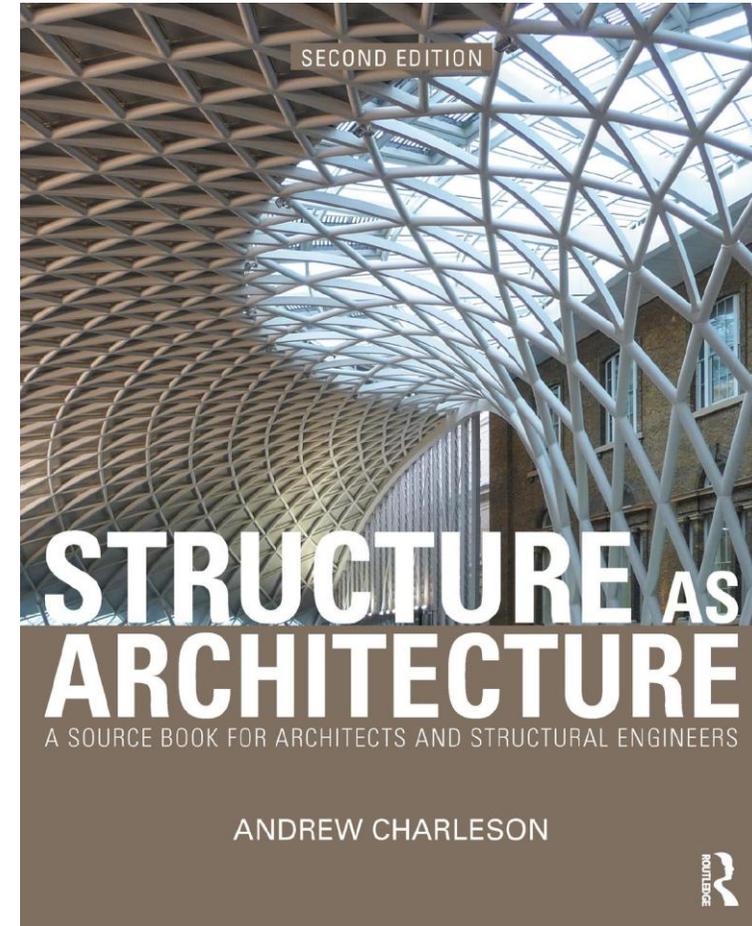
Menores Secciones



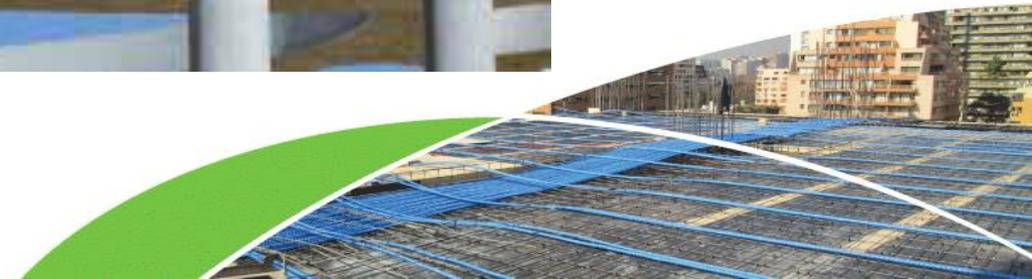
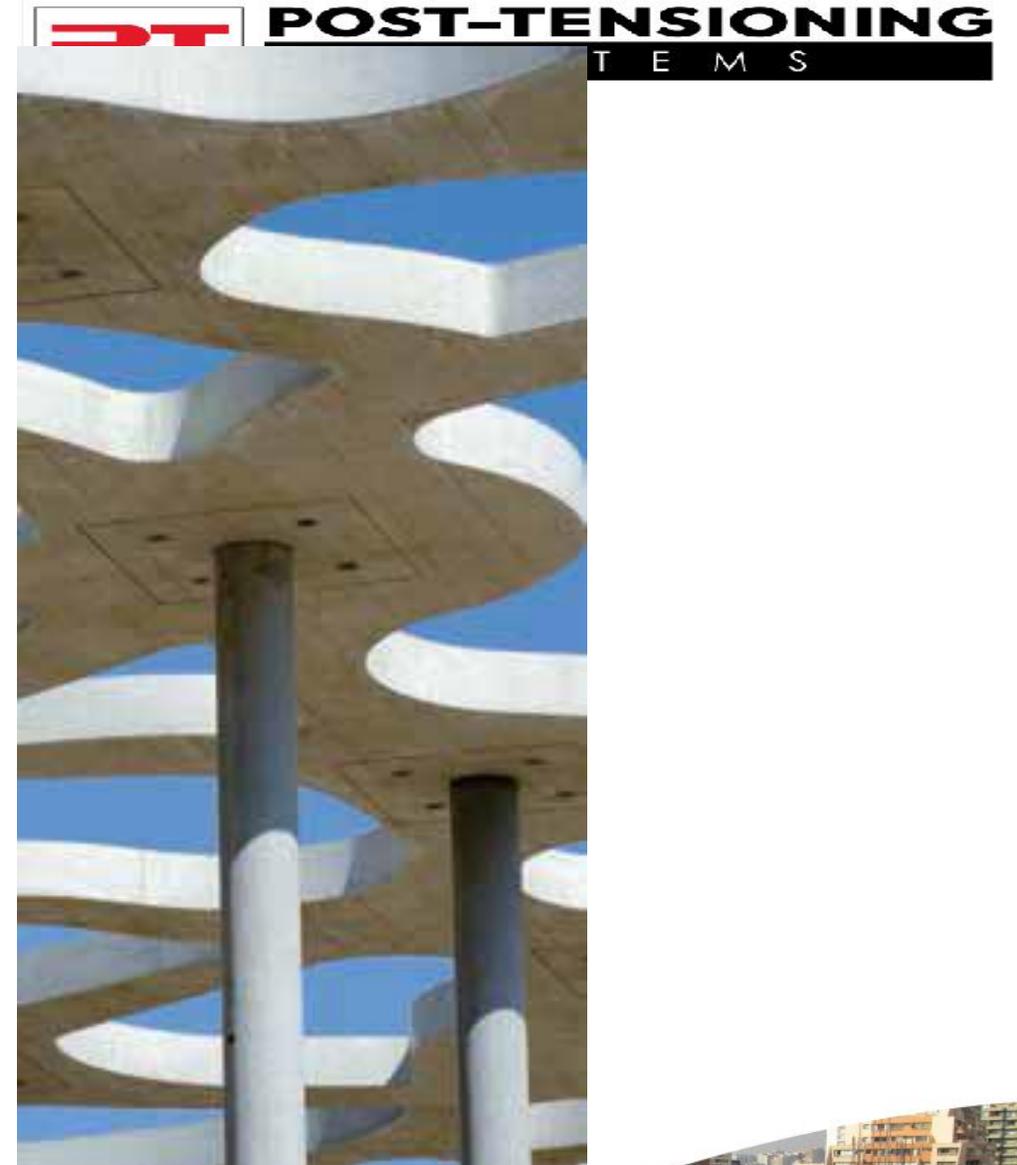
Luces Mayores



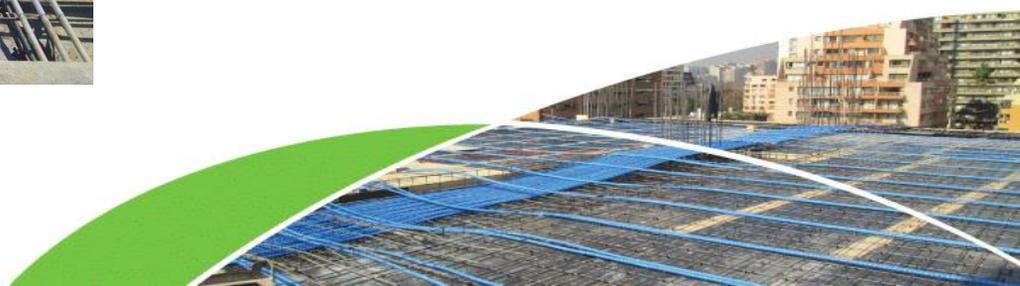
Ventajas arquitectónicas



Formas Irregulares



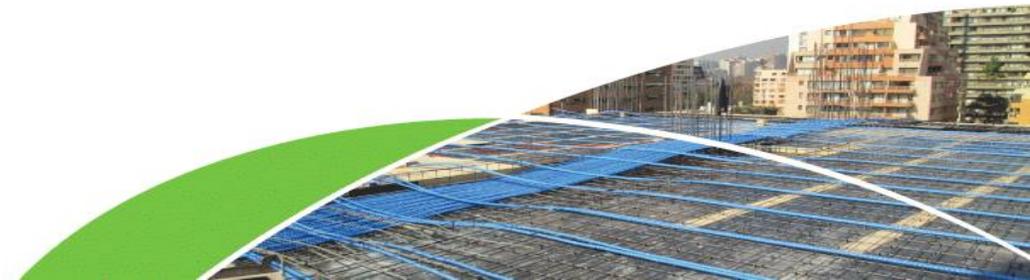
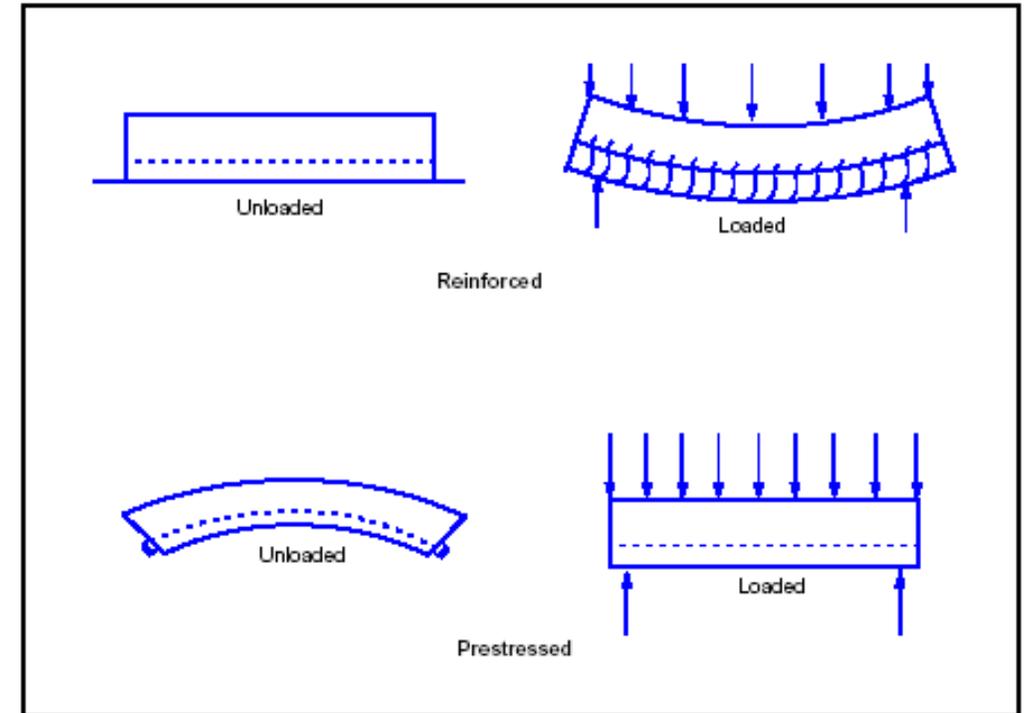
Menor tiempo de construcción



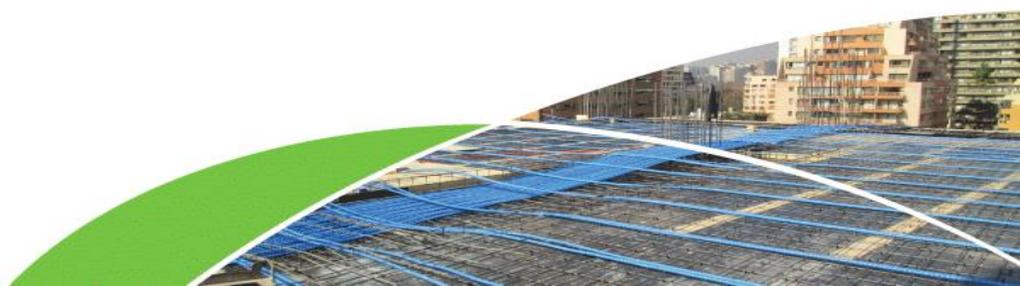
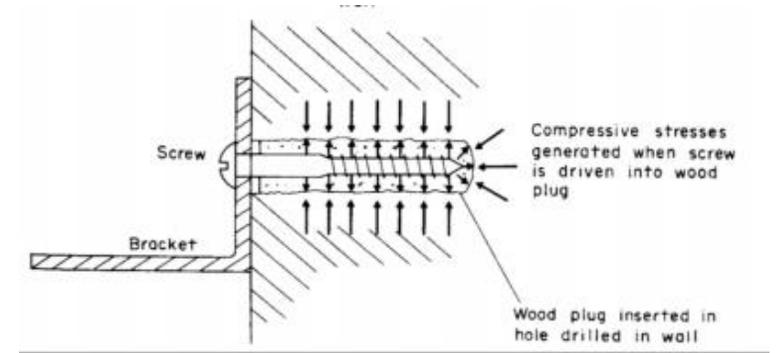
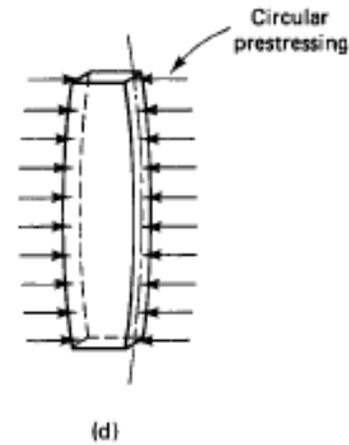
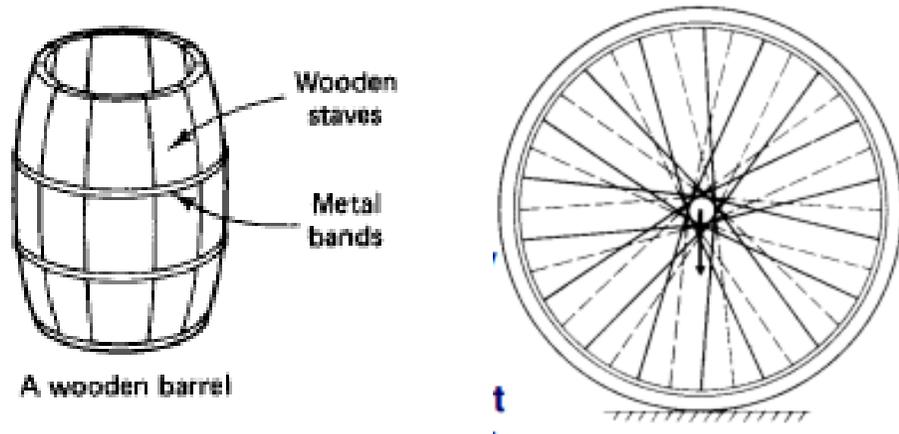
¿Que es el hormigón Post-Tensado?

“Un elemento preesforzado puede ser definido como un elemento en el cuál se han introducido esfuerzos internos de tal magnitud y manera que los esfuerzos producidos por cargas actuantes son contrarrestados a un grado deseado.”

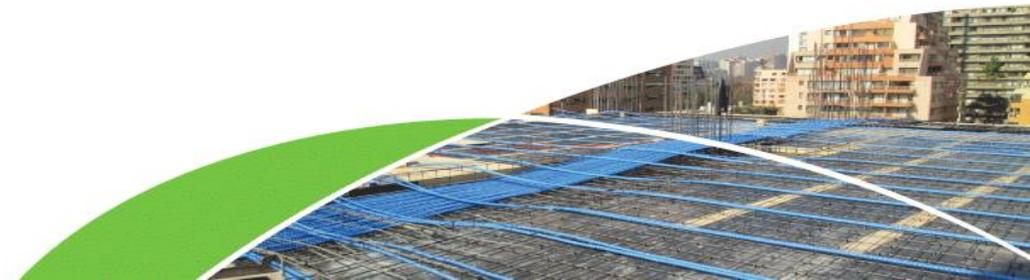
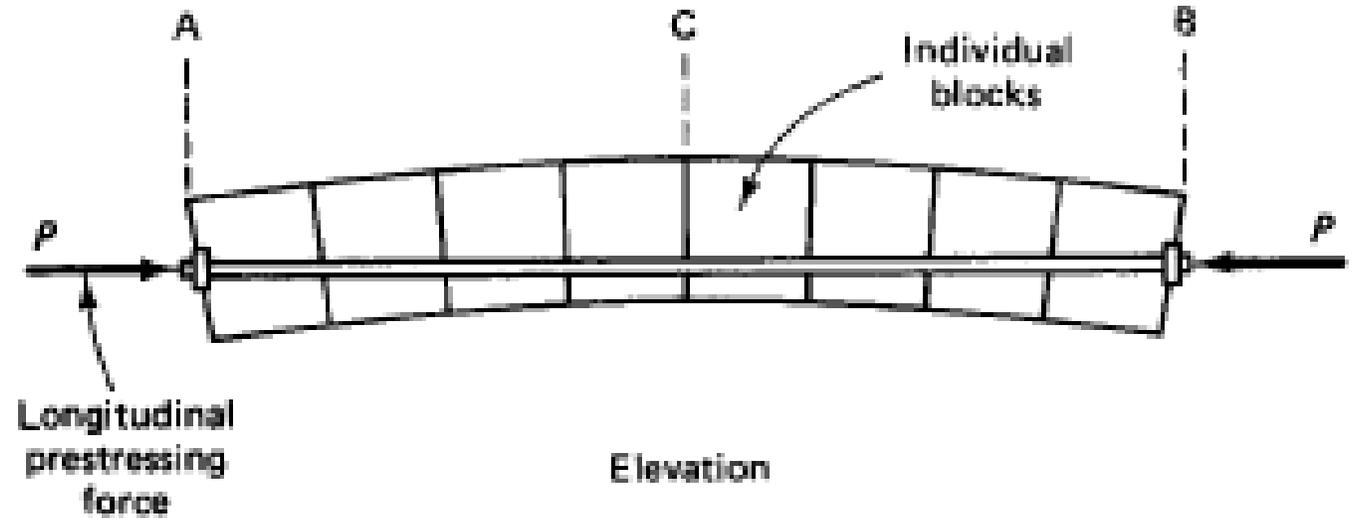
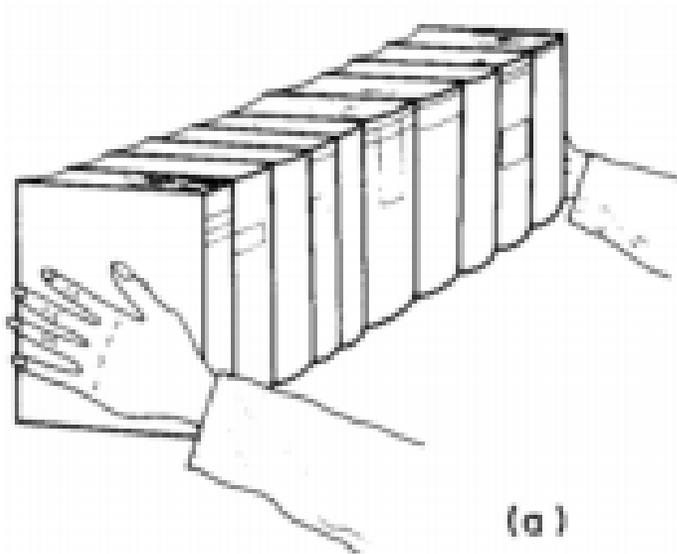
(Nawy,2009)



Elementos preesforzados

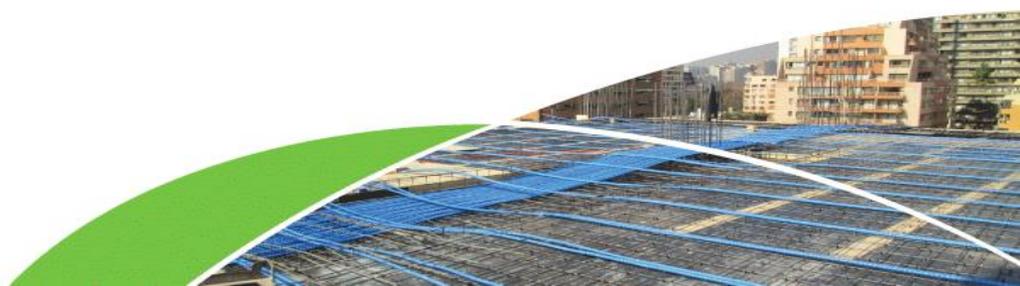
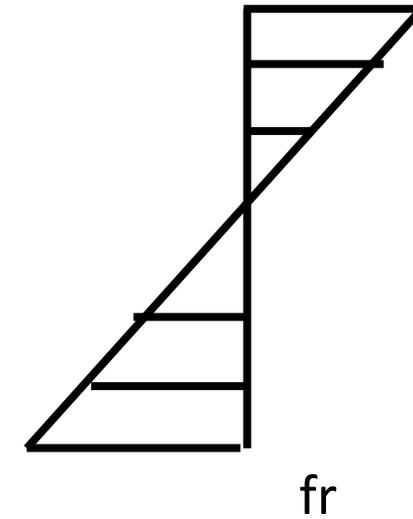


Elementos preesforzados

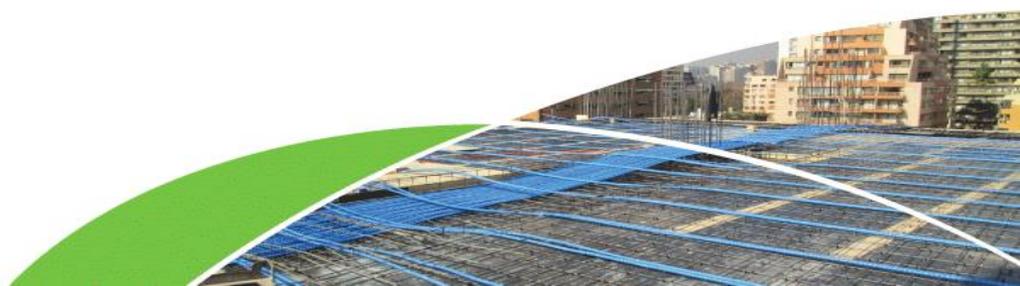
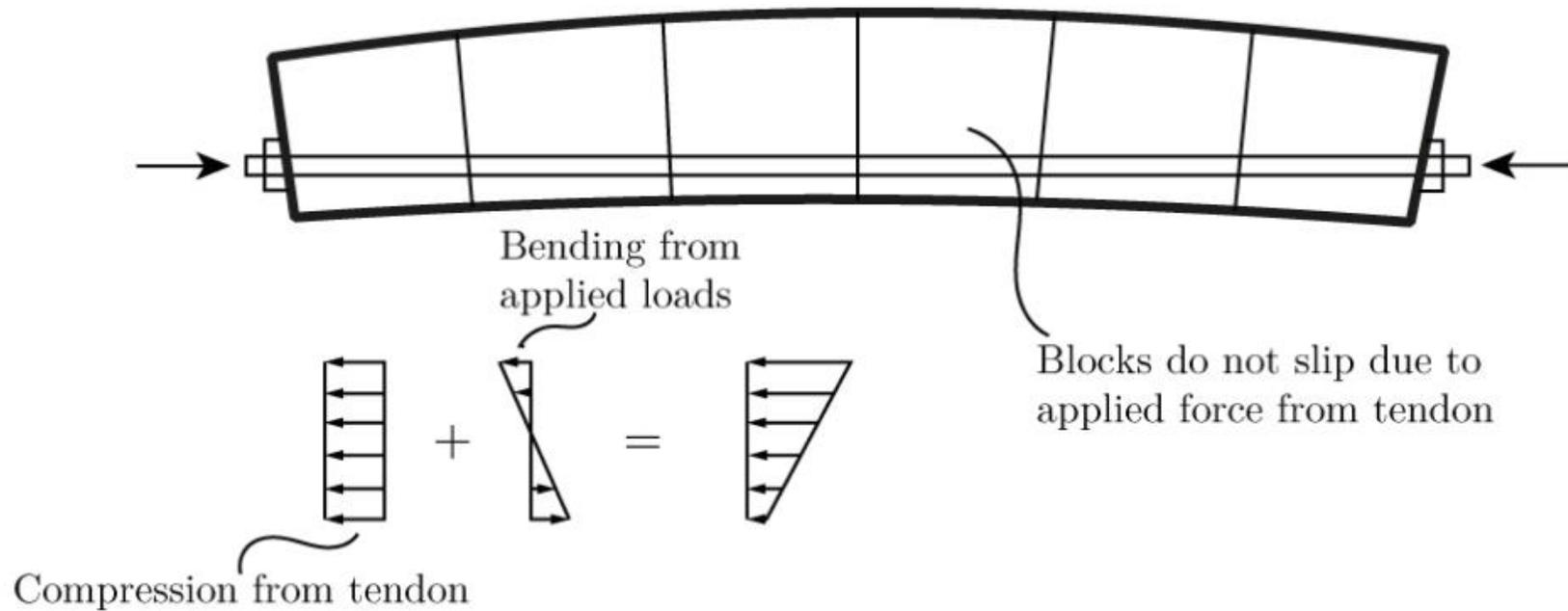


Principios básicos de funcionamiento

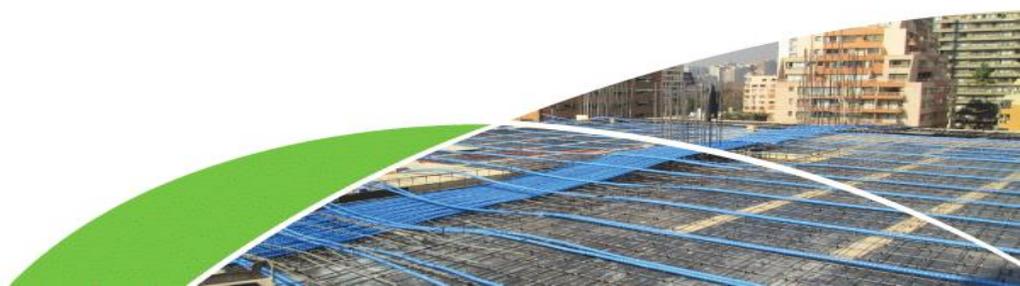
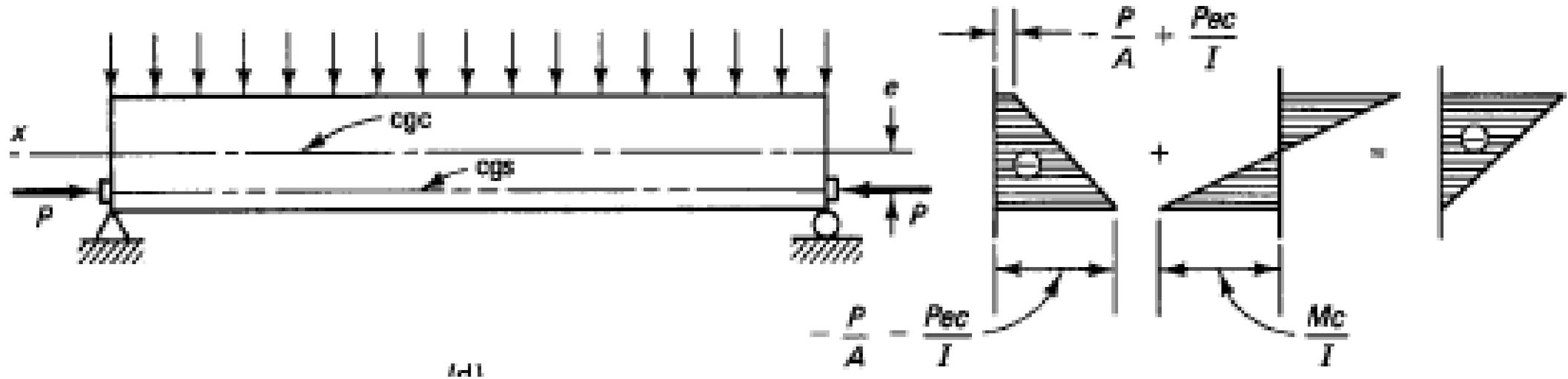
- Funcionamiento de Hormigón Armado



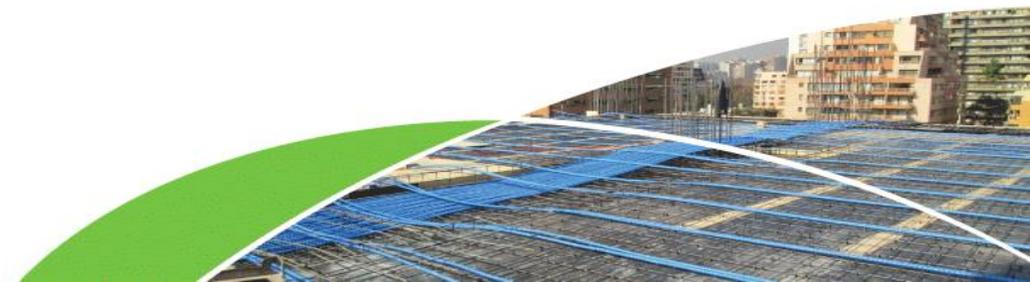
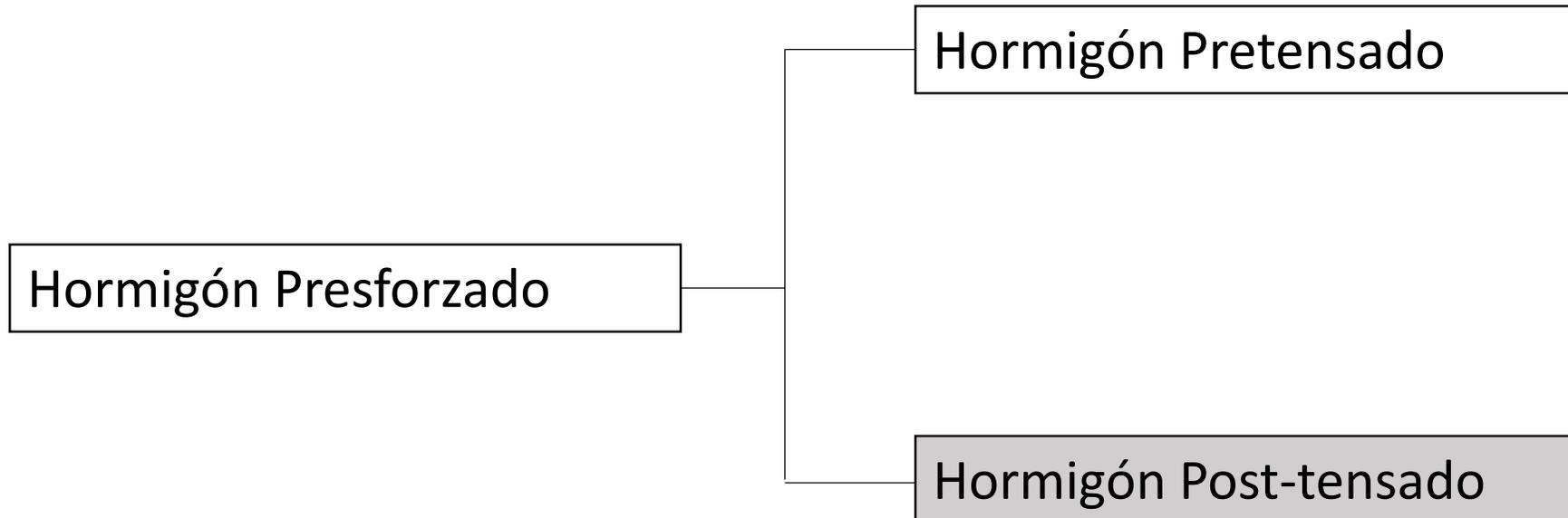
Principios básicos de funcionamiento



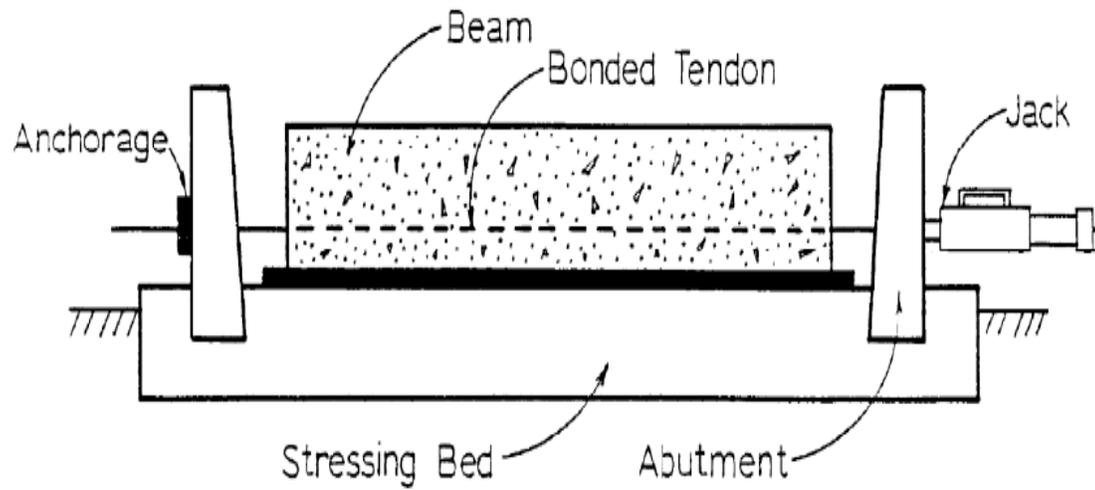
Principios básicos de funcionamiento



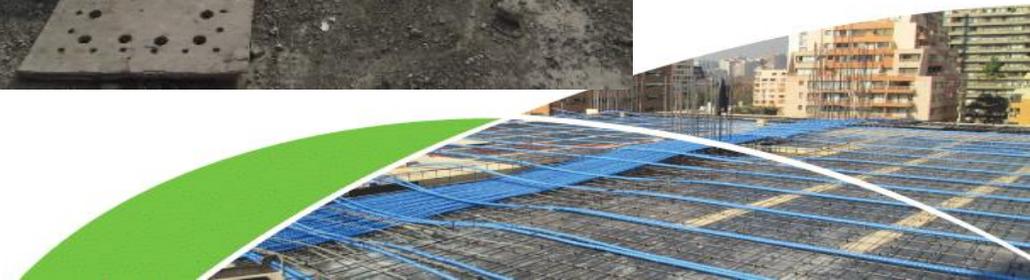
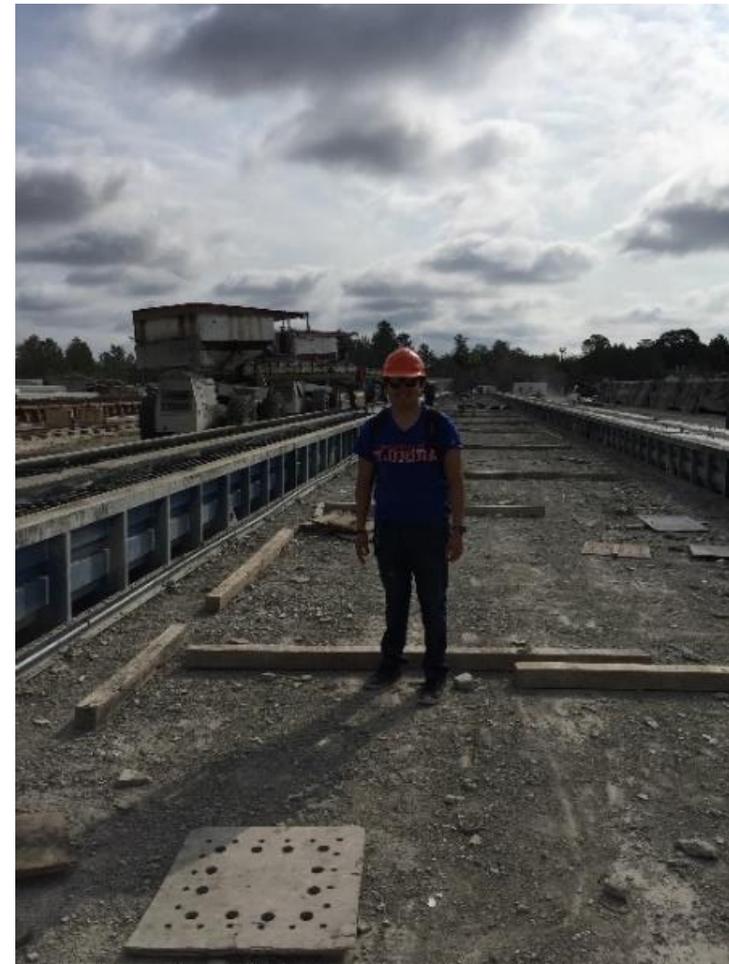
¿Como se divide el Hormigón presforzado?



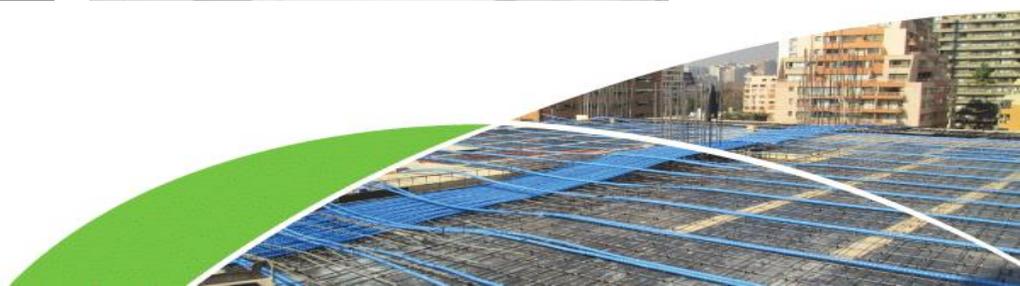
Hormigón Pretensado



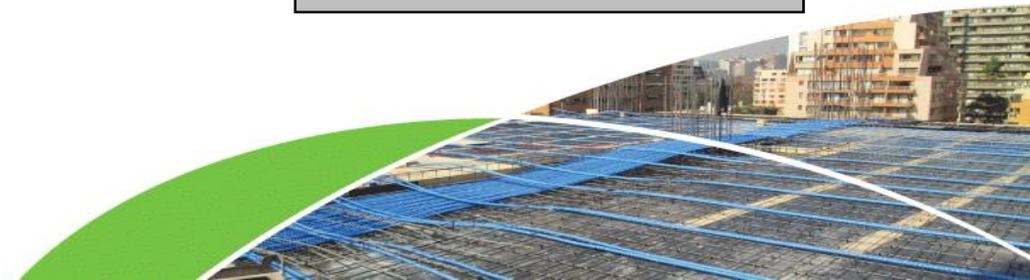
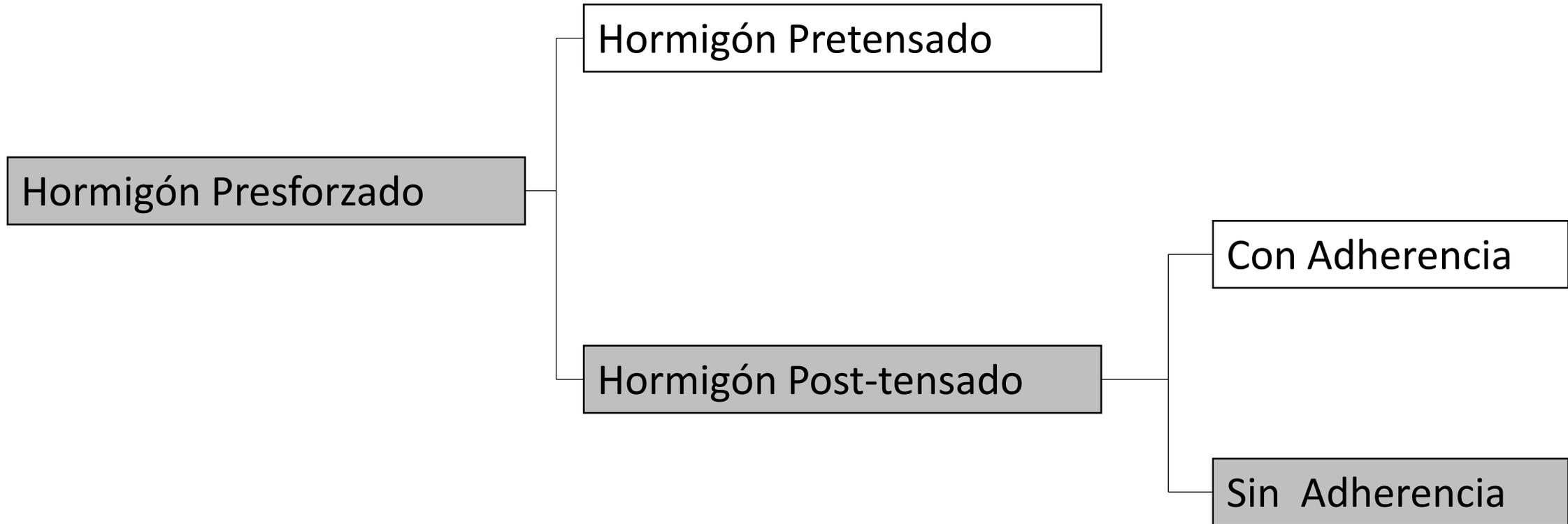
Hormigón pretensado



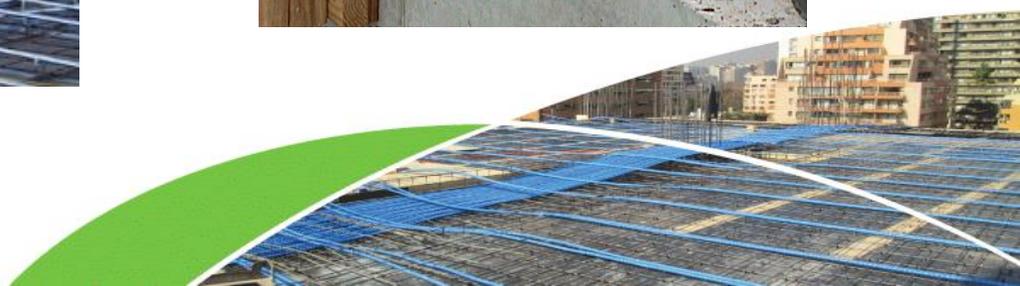
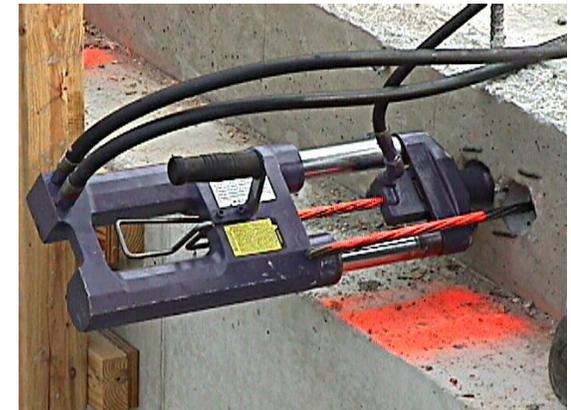
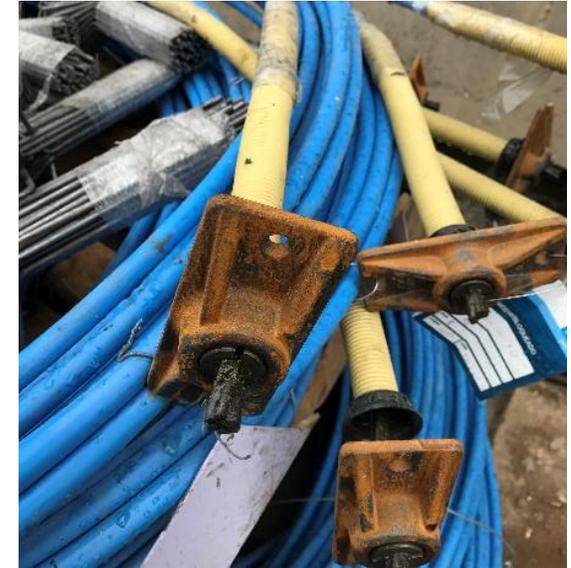
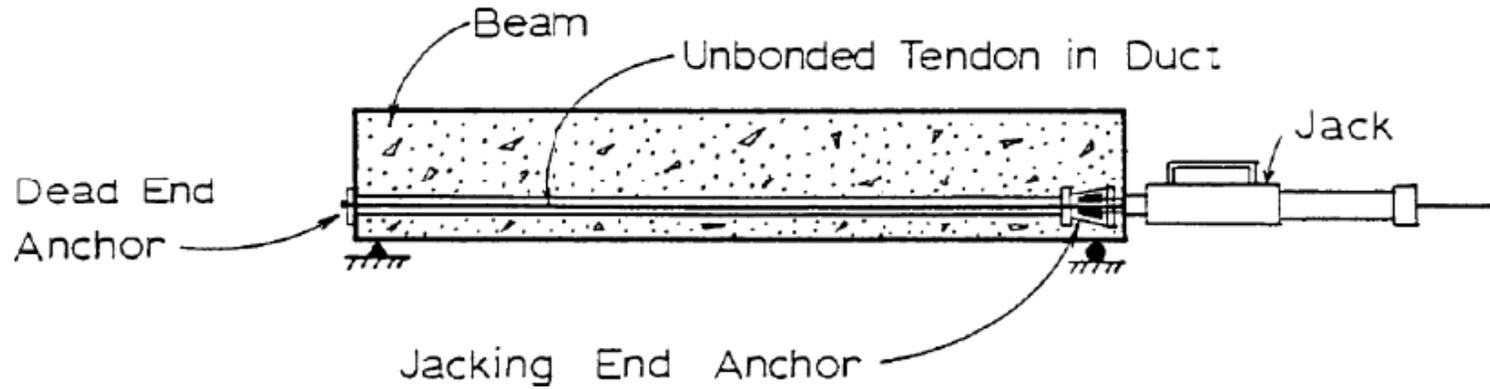
Hormigón pretensado



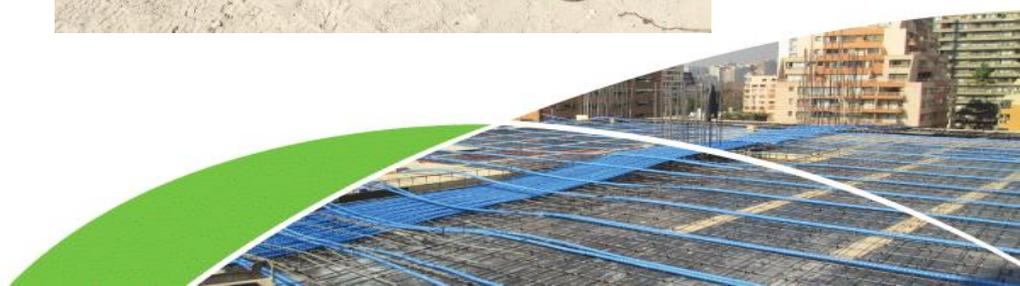
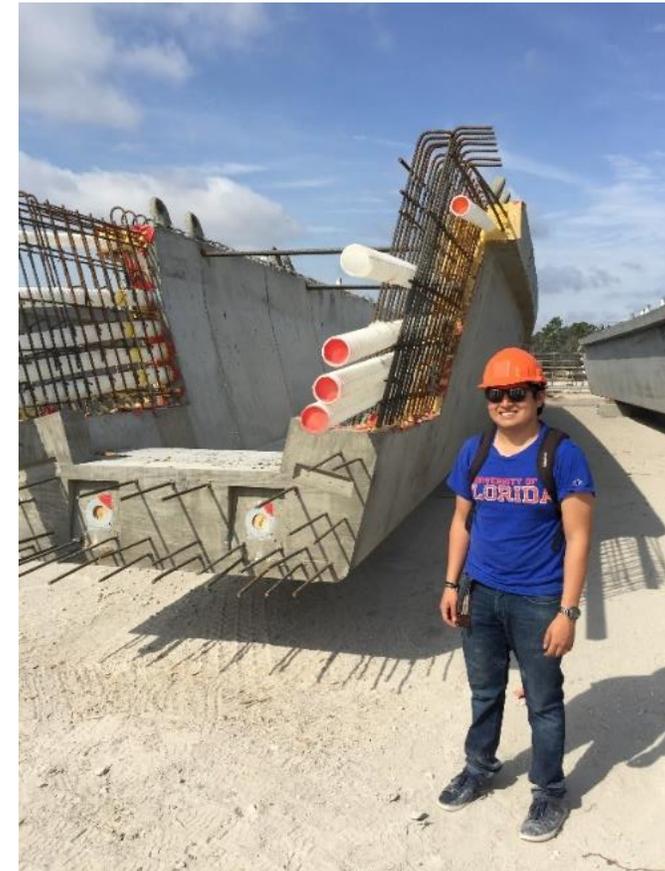
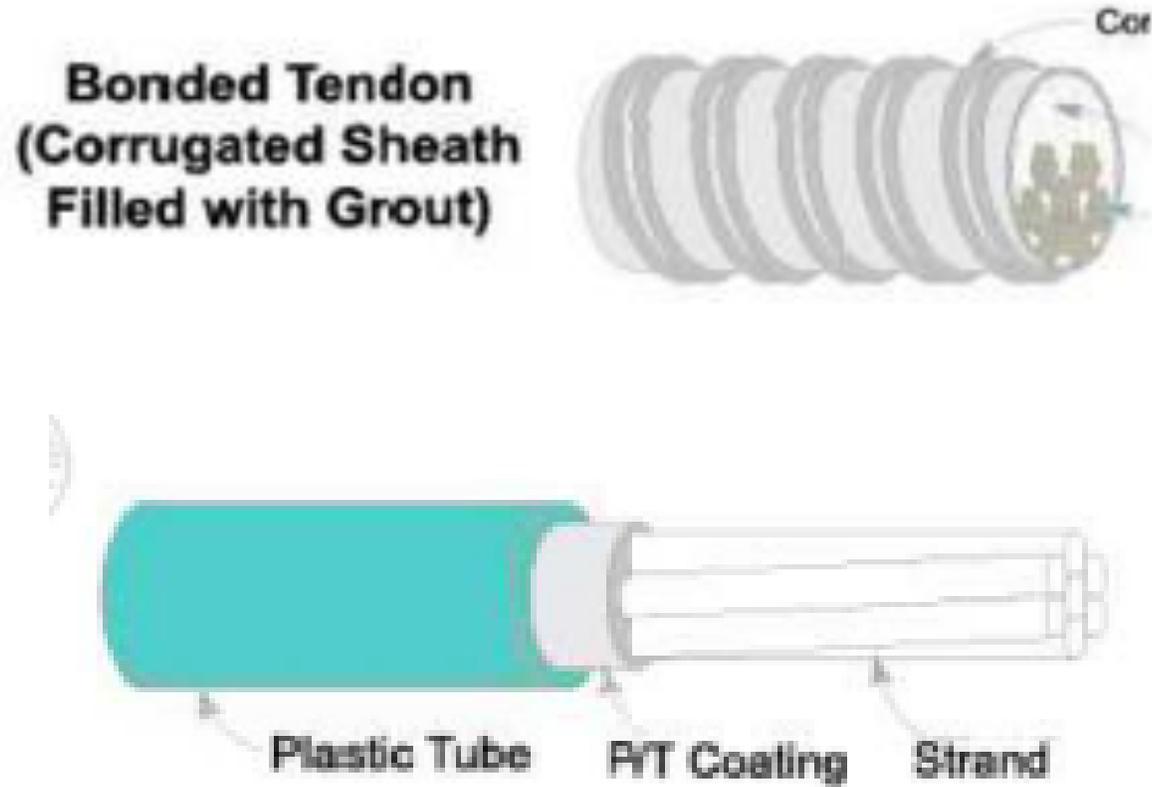
¿Como se divide el Hormigón presforzado?



Hormigón post-tensado

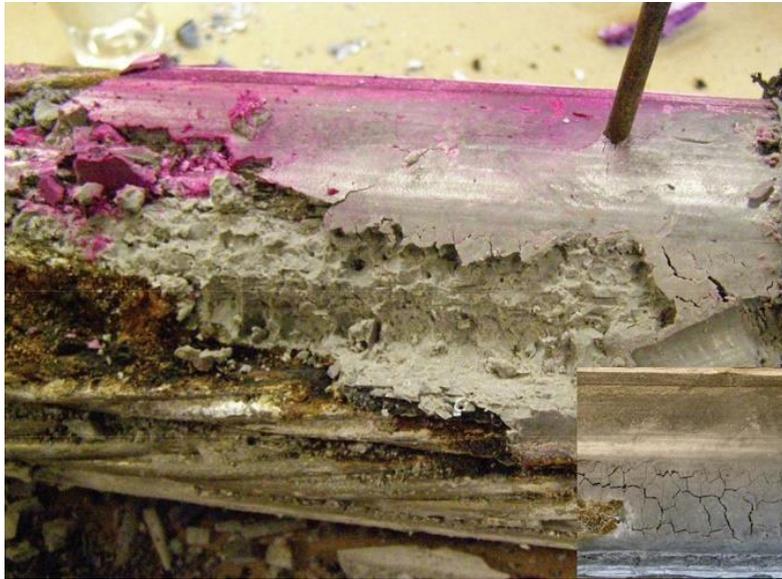


Hormigón post-tensado

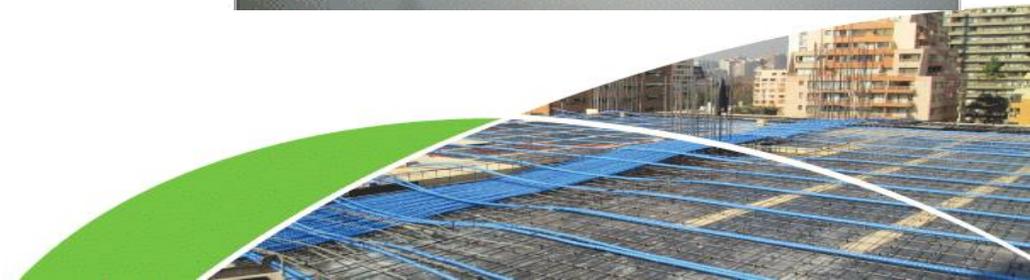


¿Problemas en Estados Unidos ?

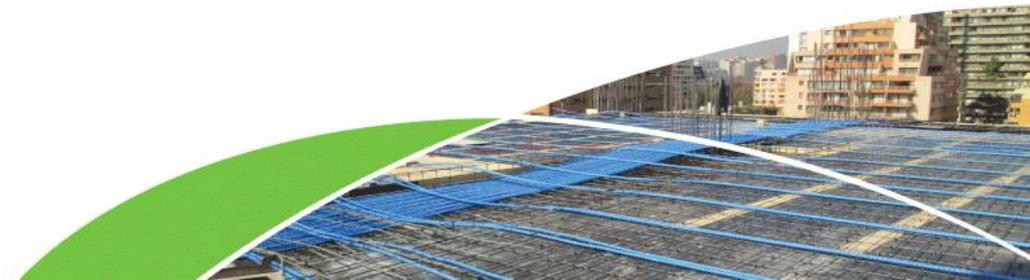
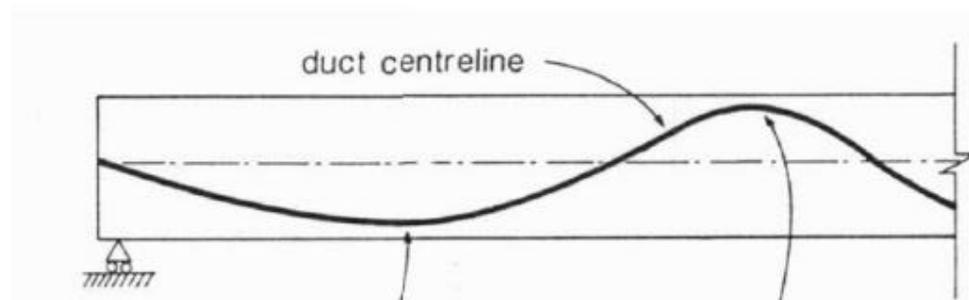
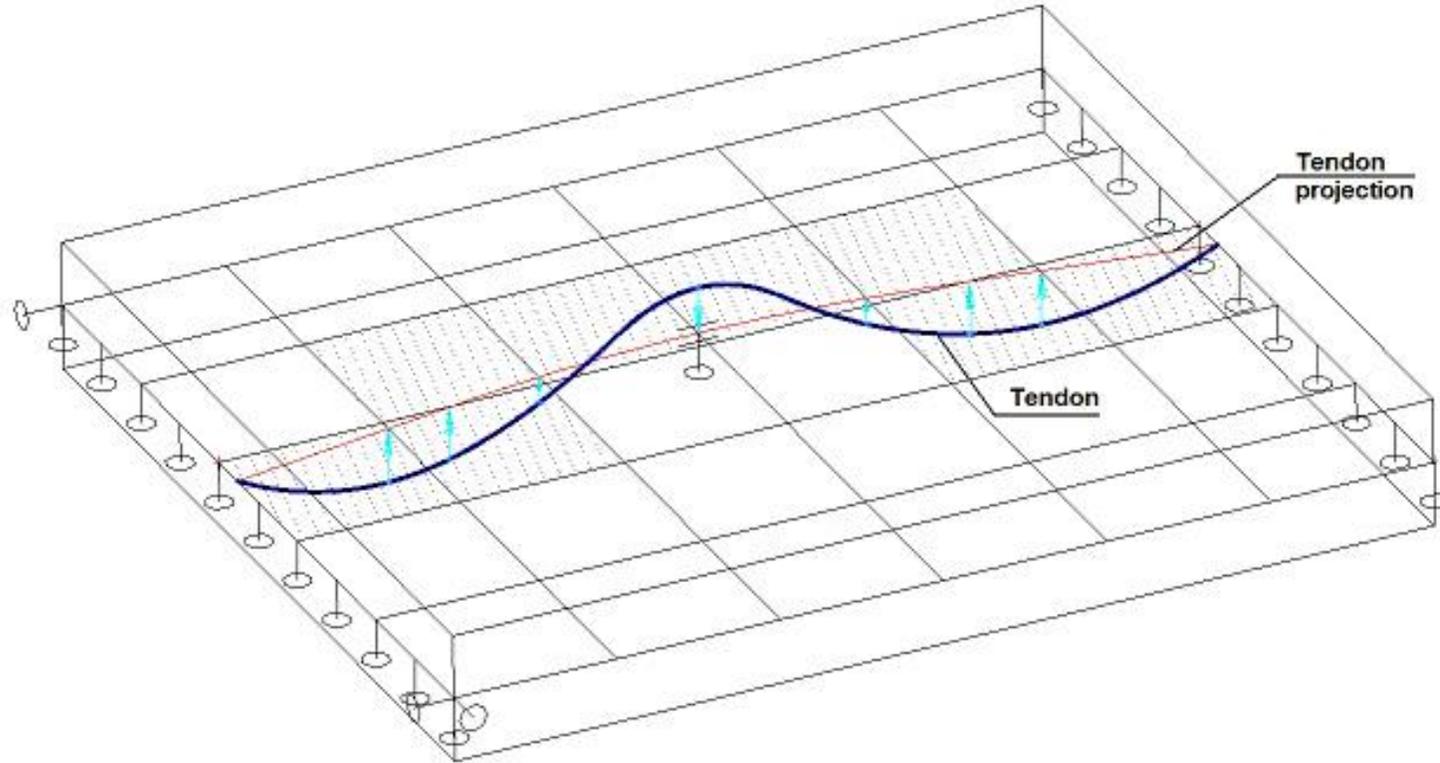
- SOFT GROUT



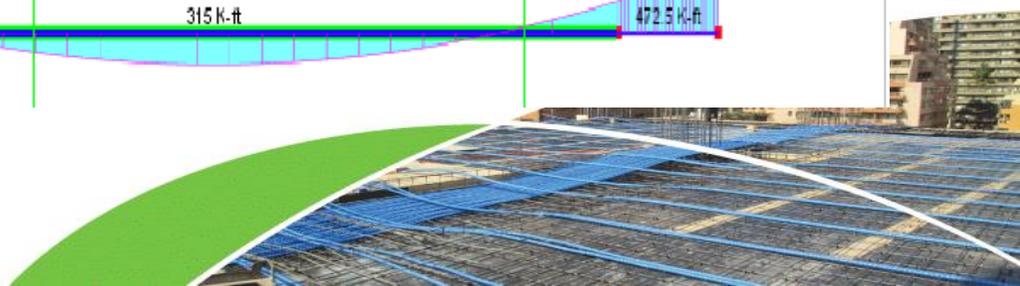
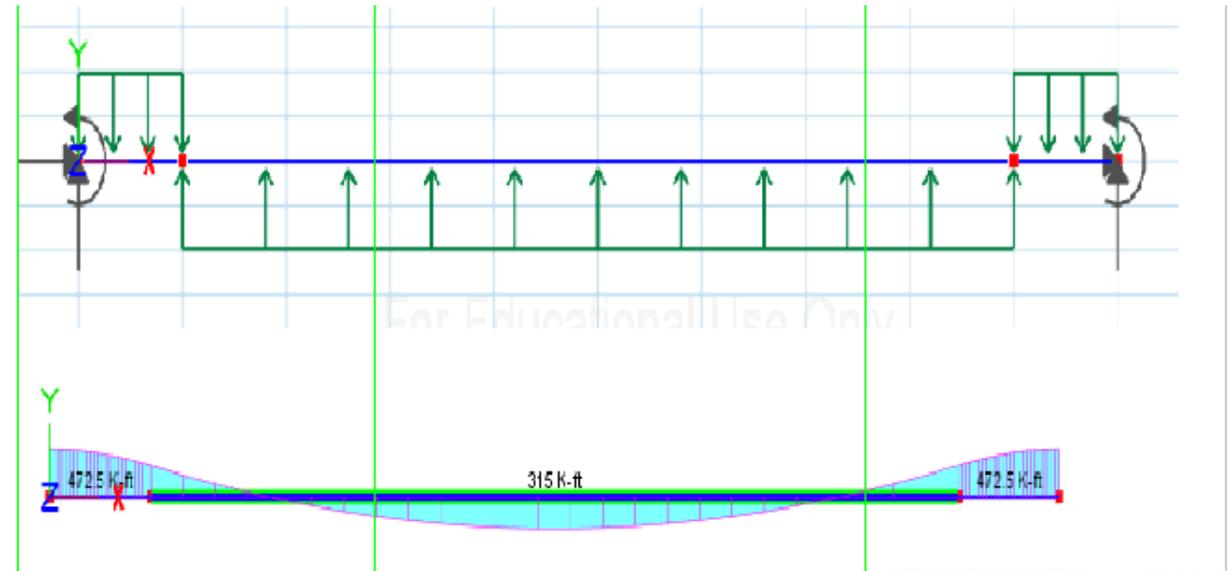
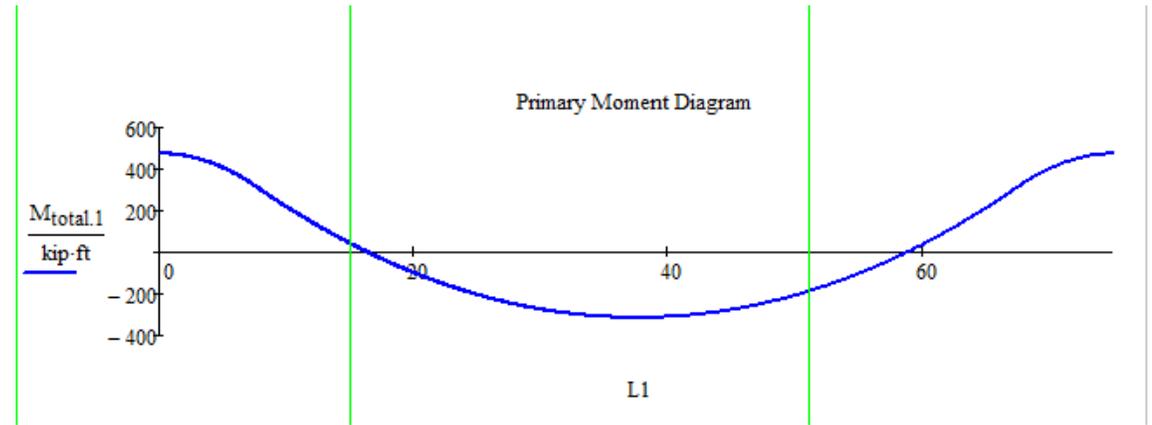
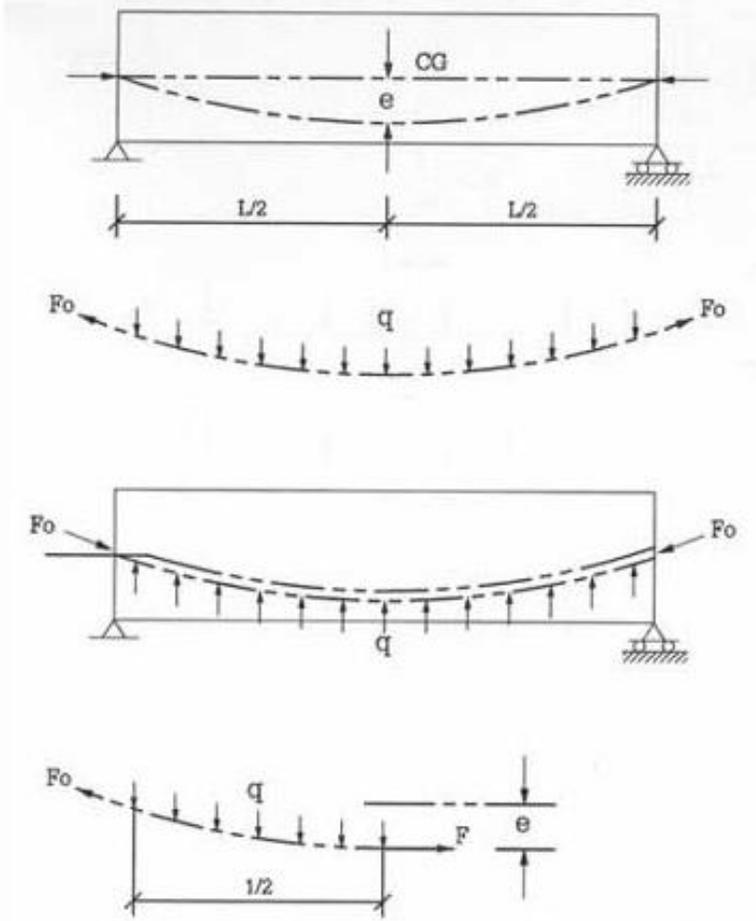
PT



¡El cable por los lugares que se necesita!



Balaceo de cargas



Aplicaciones



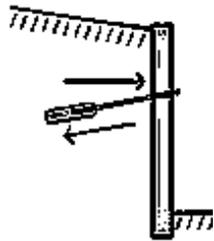
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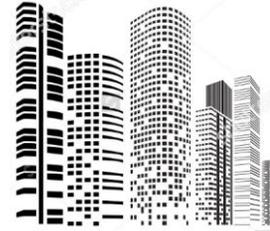
Tanques



Anillos de Cúpulas



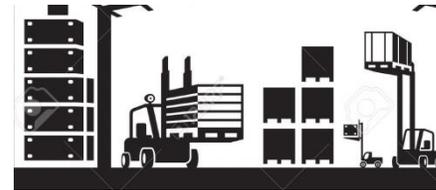
Muros de
estabilización de
taludes



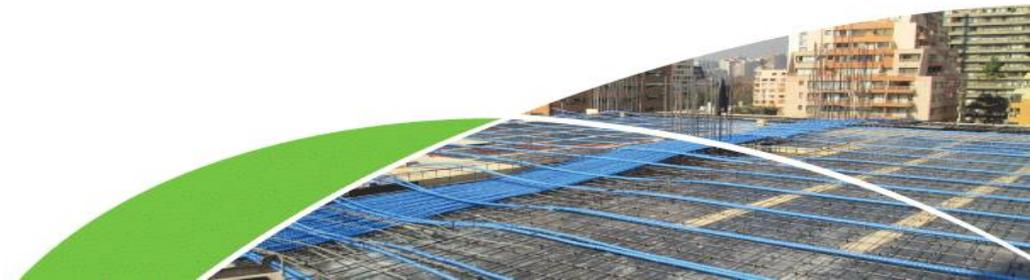
Edificios



Losa de
Cimentación

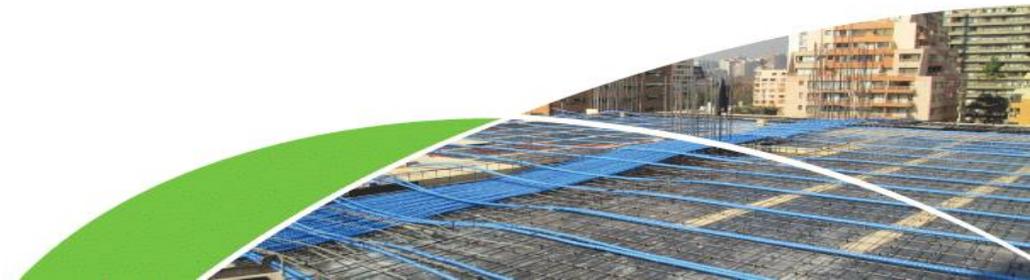


Pisos Industriales

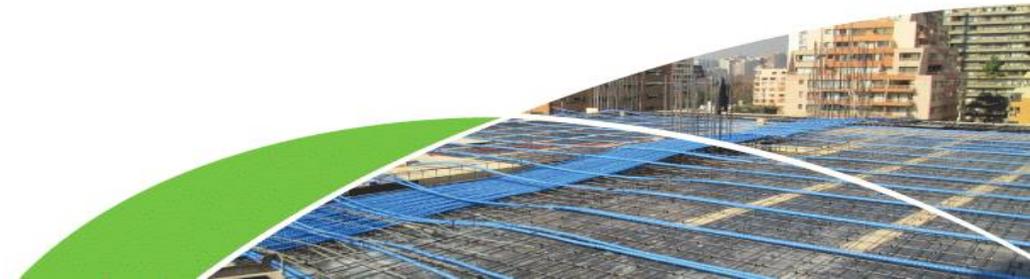
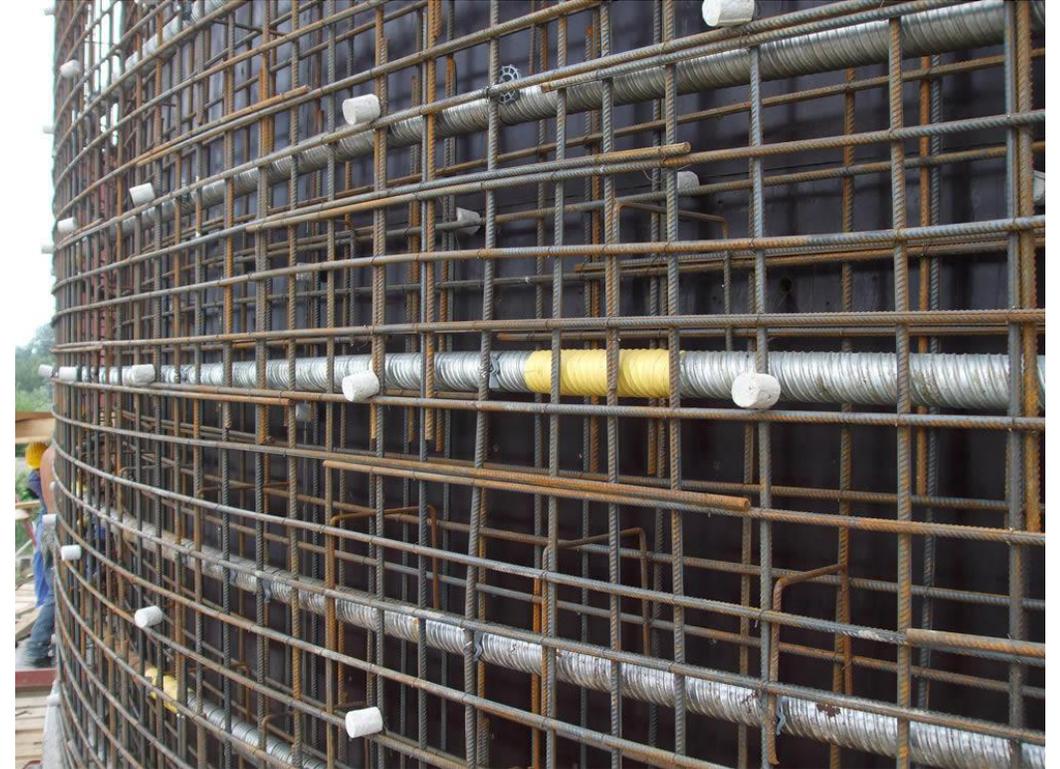


Puentes

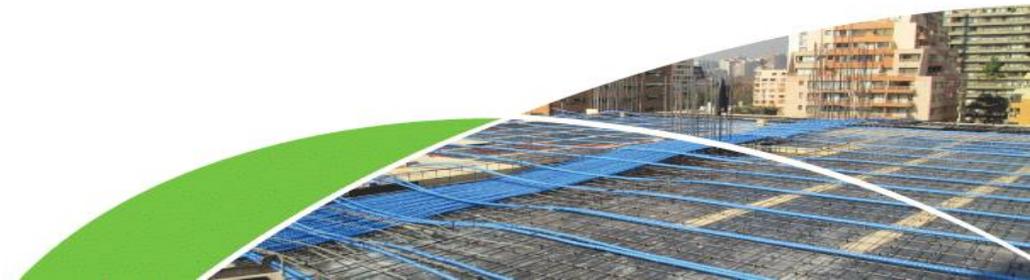
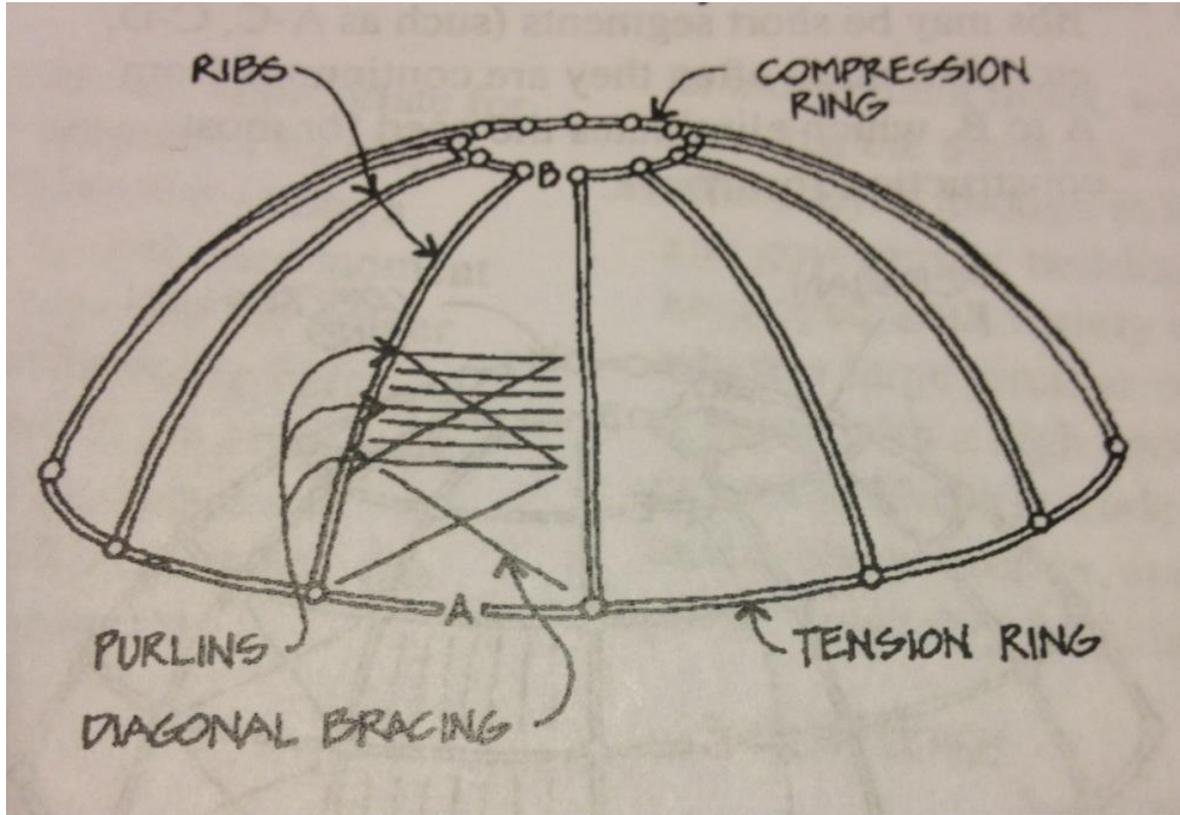
- Acosta Bridge, Jacksonville



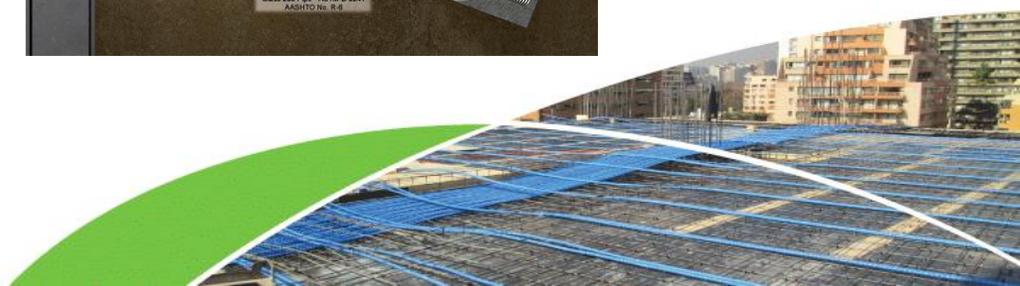
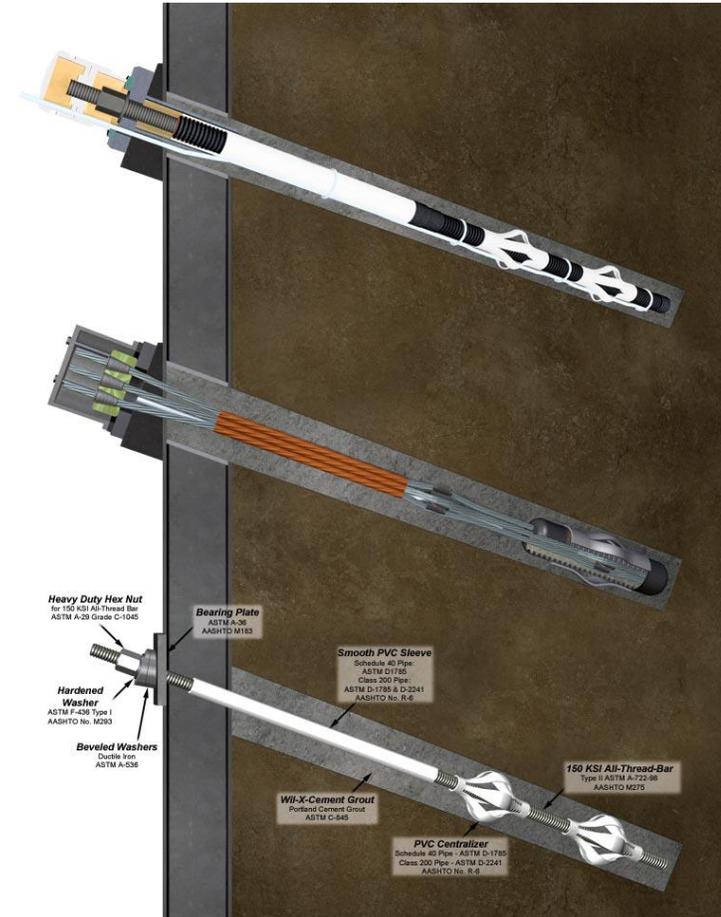
Tanques



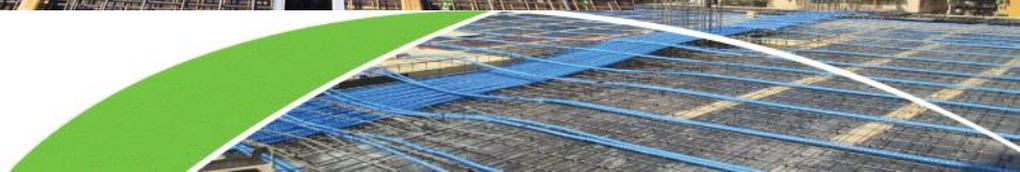
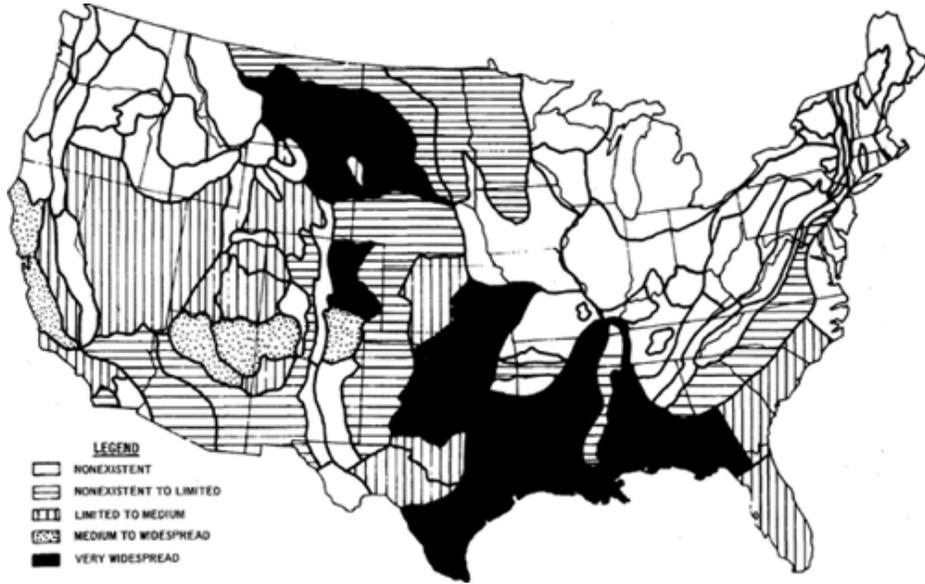
Anillos de Cúpulas



Muros

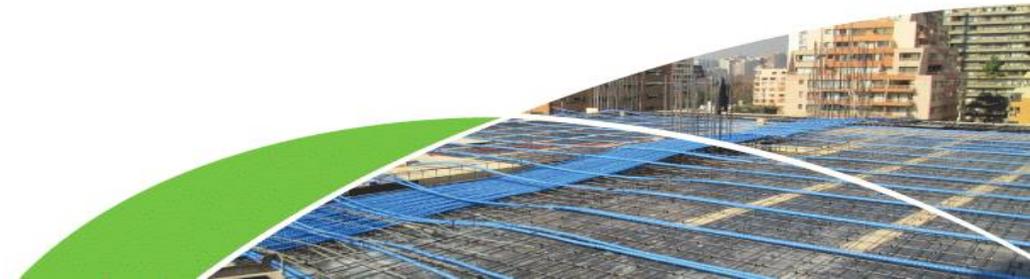


Losas de cimentación

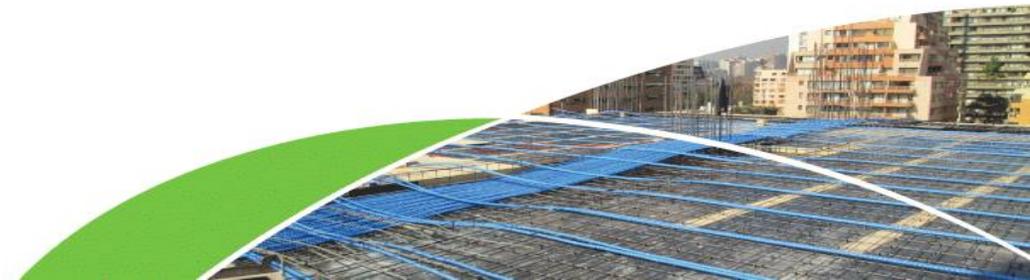


Pisos industriales

- 2000 m2 sin juntas

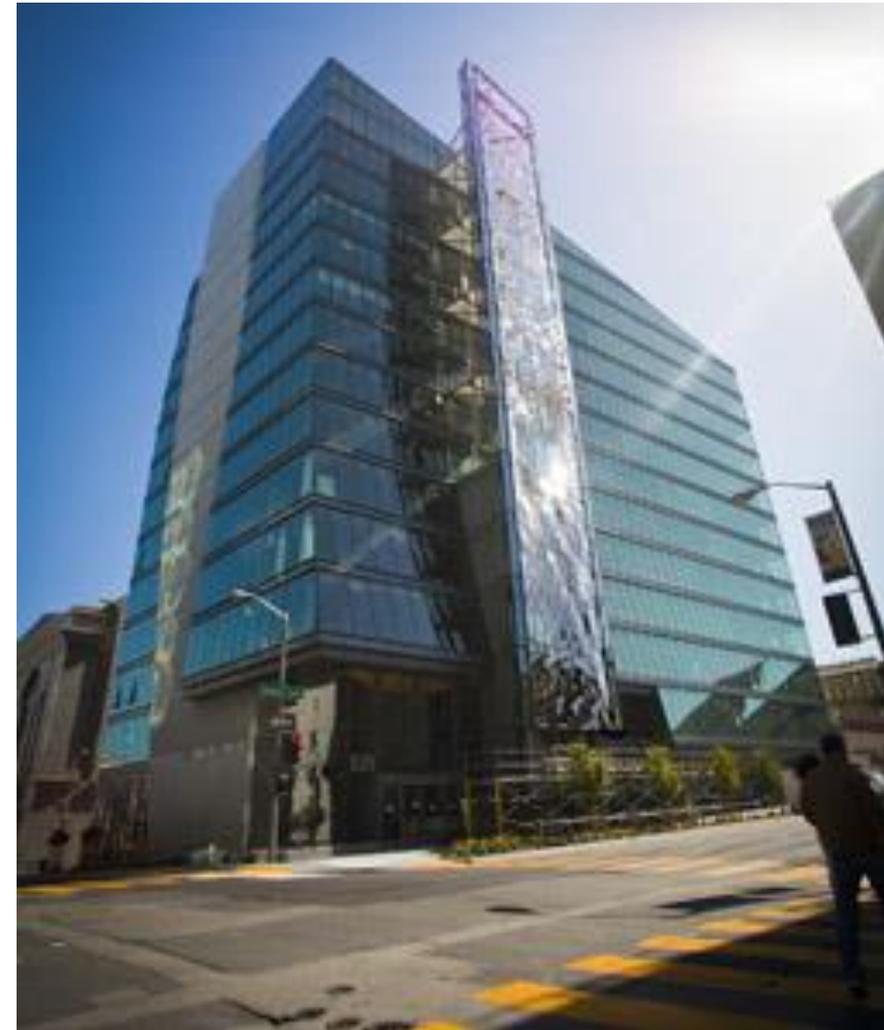


Reforzamiento y Rehabilitación de Estructuras



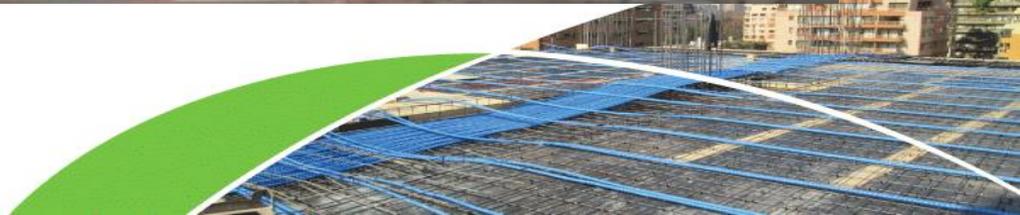
Edificios

- San Francisco Public Utilities Commission Headquarters



Edificios

- Acqua Vista, San Diego CA



Edificios

- Cube Tower, Mexico



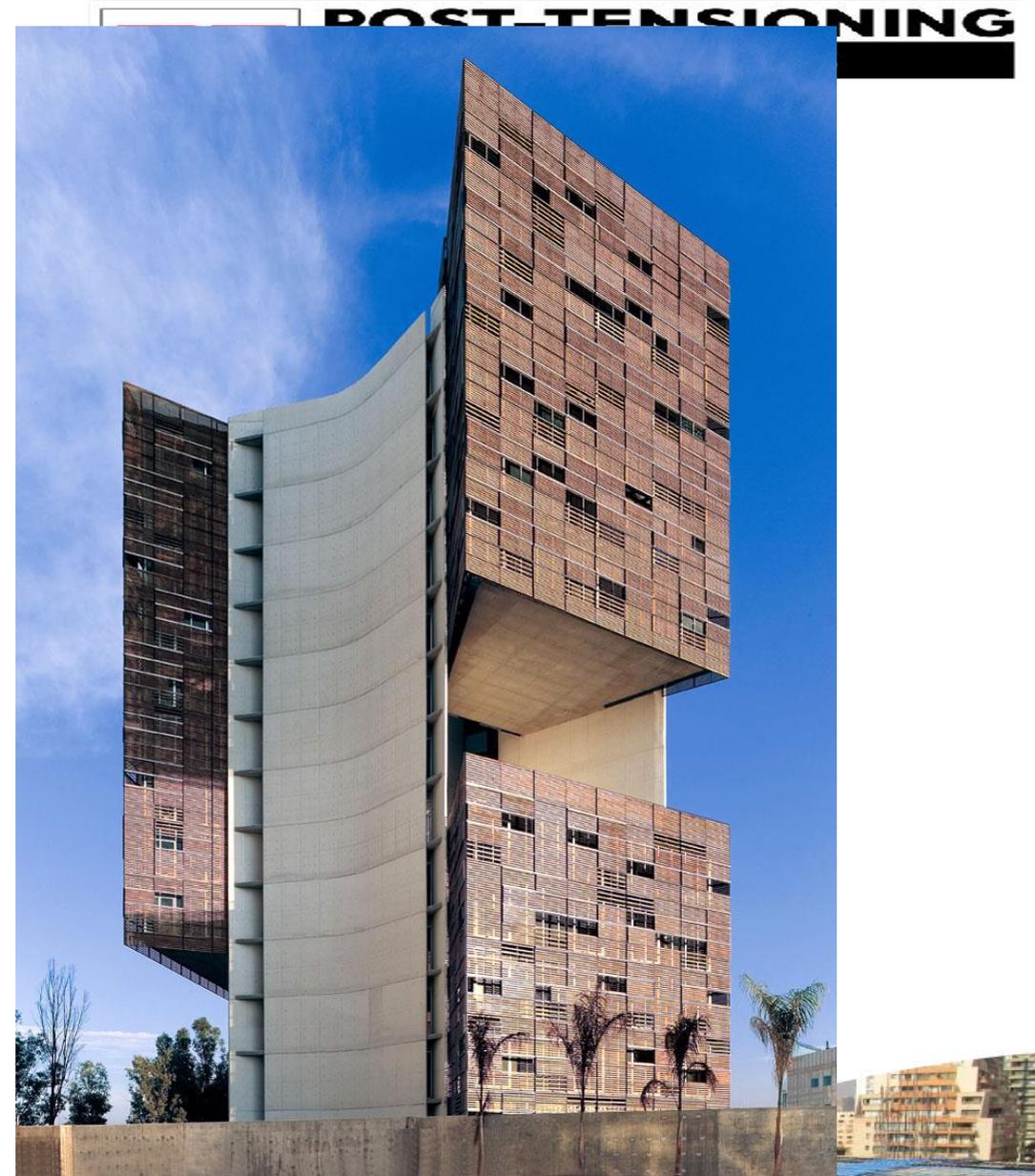
Auspician:



IdealAlambrec

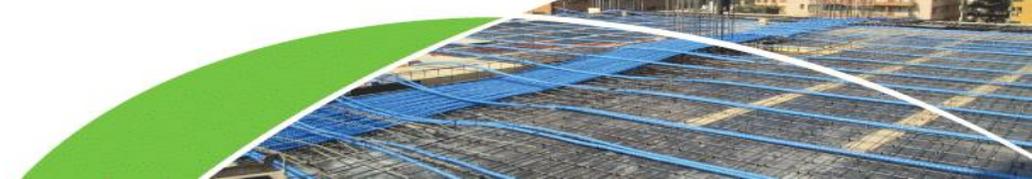


BEKAERT



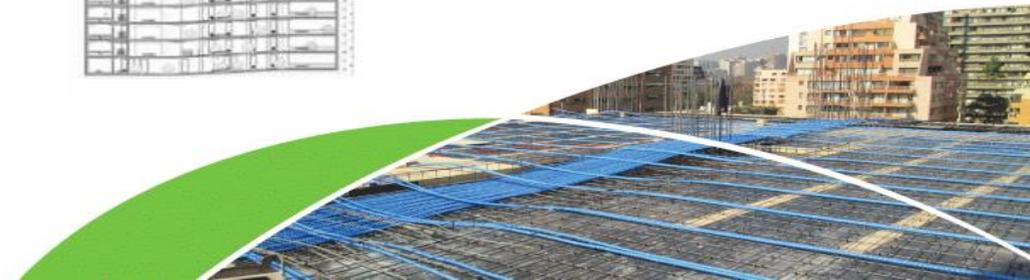
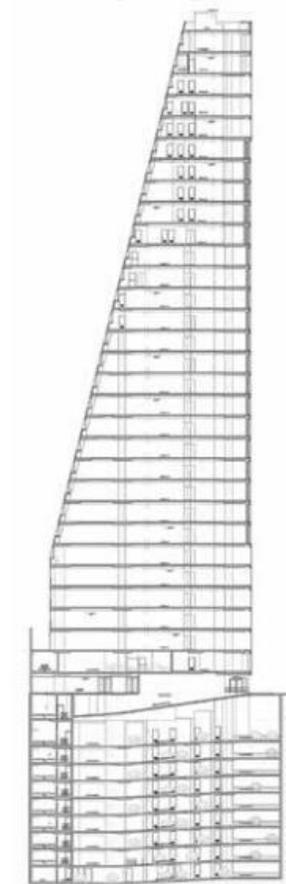
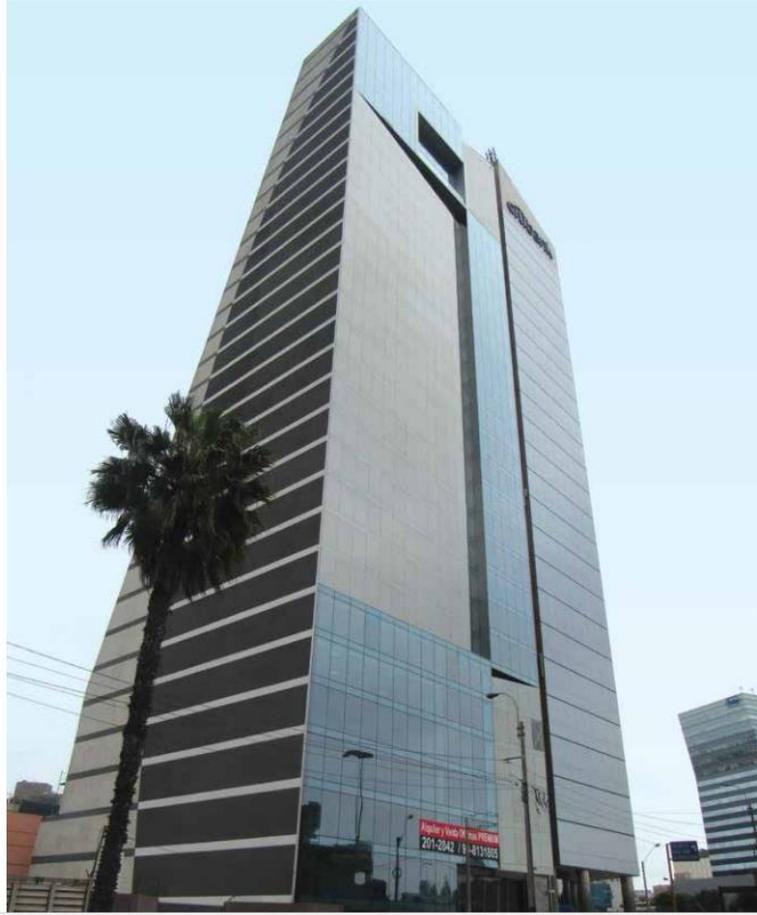
Edificios

- Cube Tower II, Mexico

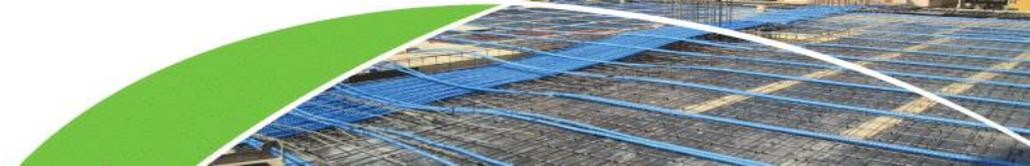


Edificios

- Edificio Torre Barlovento, Perú



Edificios

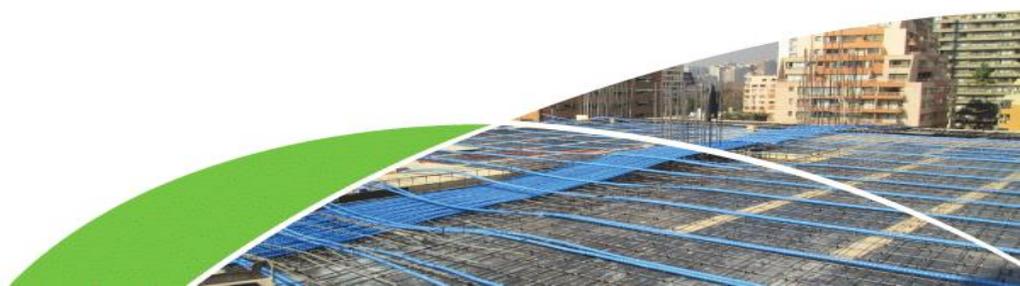


Ventajas económicas en Estados Unidos

- Multistory Hotel in Northern California (Aalami,2014)
- 8m de luz, las cantidades son por piso.
- Comparación de Post tensado y Hormigón Armado

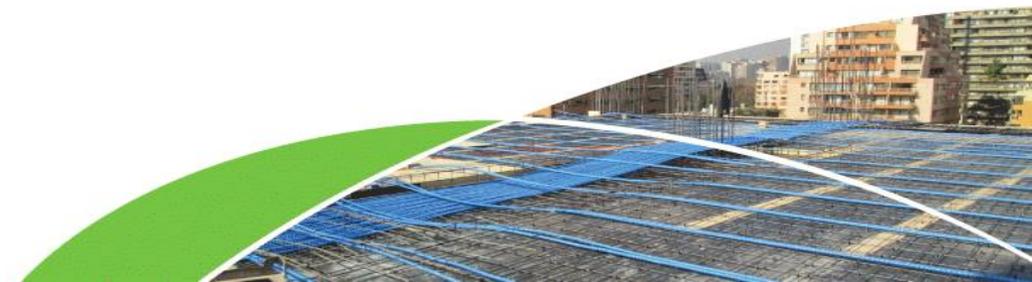
TABLE 2.6.1A-1 Reinforcement Quantities for Floors of a Multistory Hotel (T111)

Concrete	7 in (180 mm)	8.5 in (220 mm)
Rebar	1.3 psf (6.34 Kg/m ²)	5.5 psf (26.85 Kg/m ²)
Post-Tensioning	0.85 psf (4.15 Kg/m ²)	0



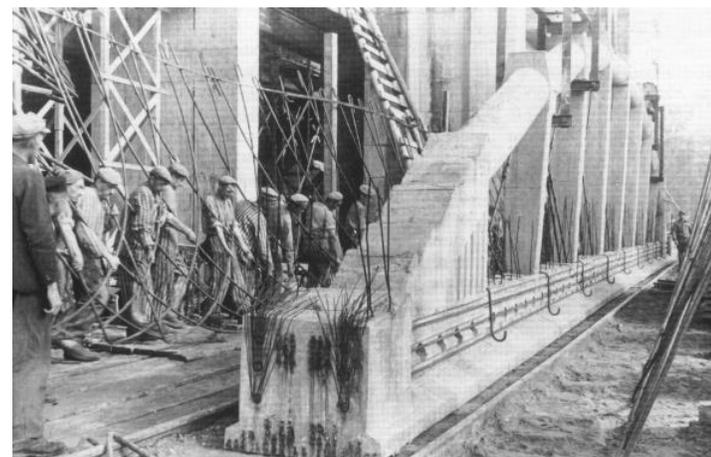
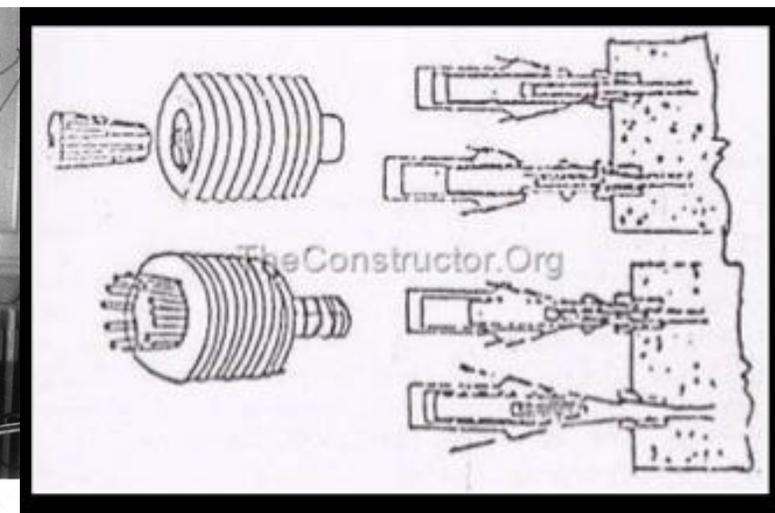
¿Ventajas económicas en Ecuador?

-Siguiente Sesión- José Hurtado

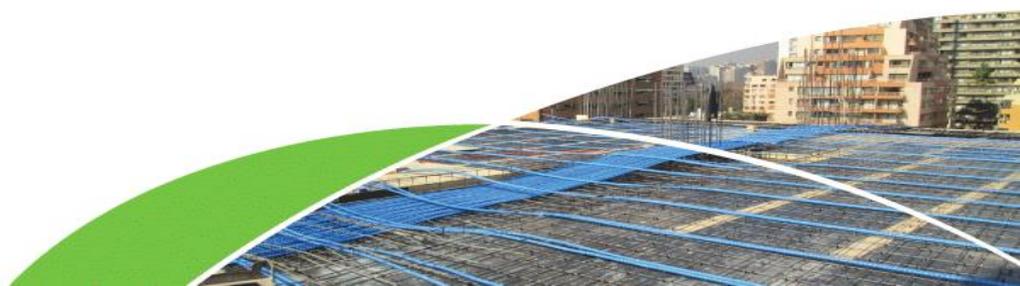
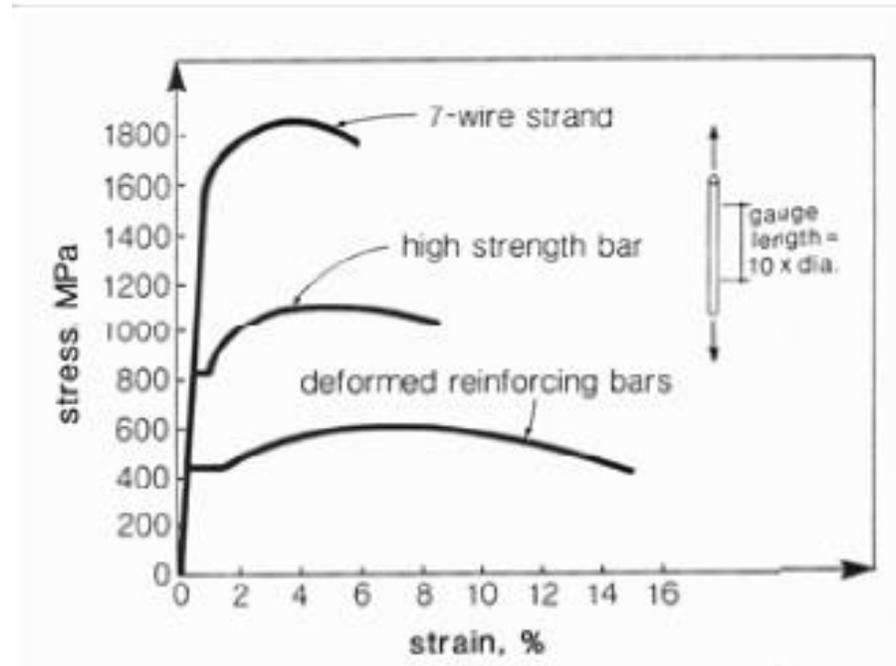


¿Es nuevo este sistema?

- 1872 P.H Jackson. Los primeros intentos.
- 1926-1928 Freyssinet, Utilizó anclajes y acero de alta resistencia.
- II Guerra Mundial, casi no hubo desarrollo
- Post Guerra, Se utilizó para reparar Puentes. Magnel
- Estados Unidos. En los años 50.

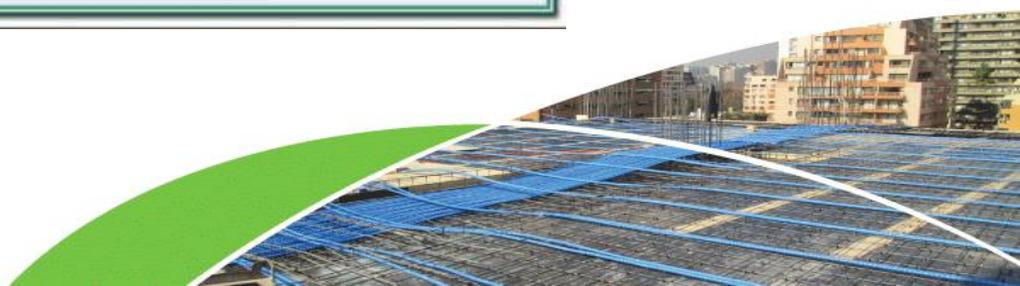
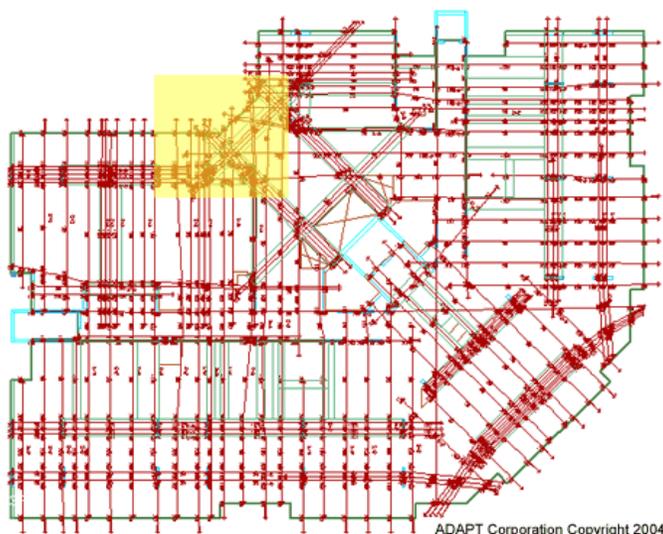


¿Por qué no se desarrollo en sus inicios?



Cálculo Estructural

“Existe resistencia por parte de algunos ingenieros consultores a seleccionar una alternativa post-tensada. Ya que el diseño requiere más tiempo y esfuerzo que el hormigón armado convencional, aunque la alternativa post-tensada sea más económica y con mejor desempeño” (Aalami,2014)



Métodos de Diseño

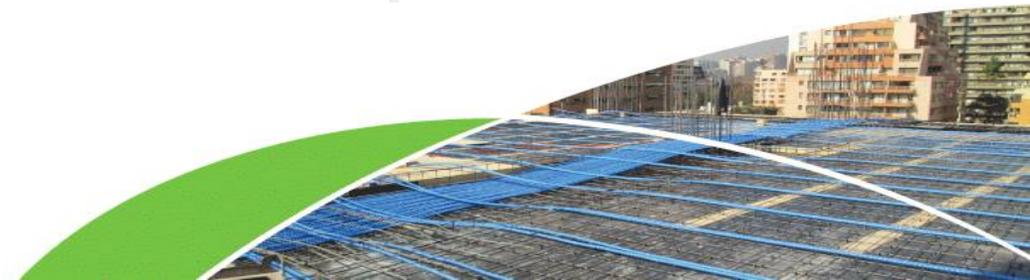
- Pórtico Equivalente.
- Método de Elementos Finitos. (Paquetes Informáticos).



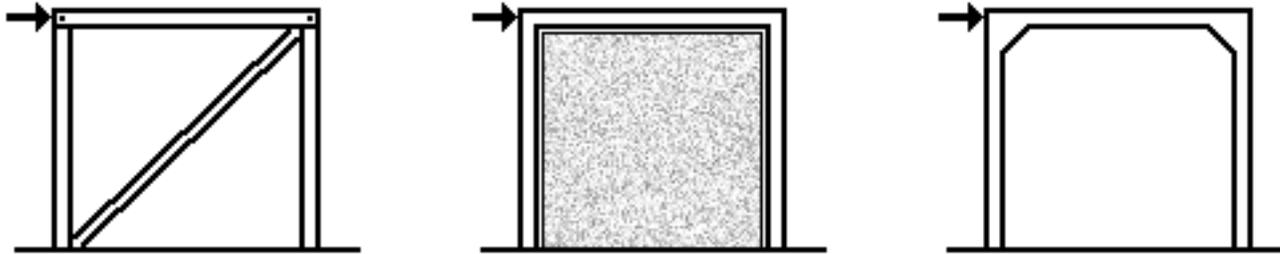
ACI 423.3R-05

**Recommendations for Concrete
Members Prestressed with
Unbonded Tendons**

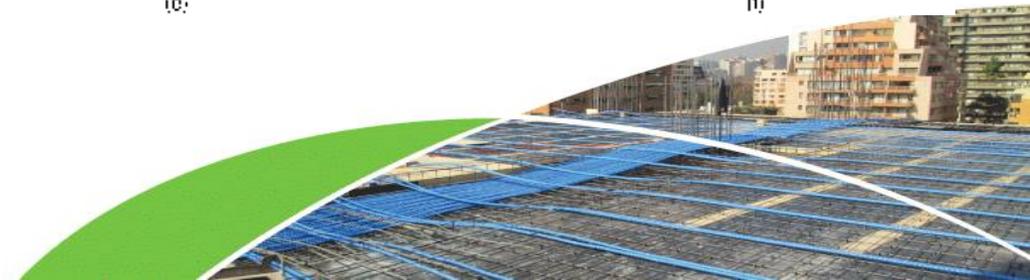
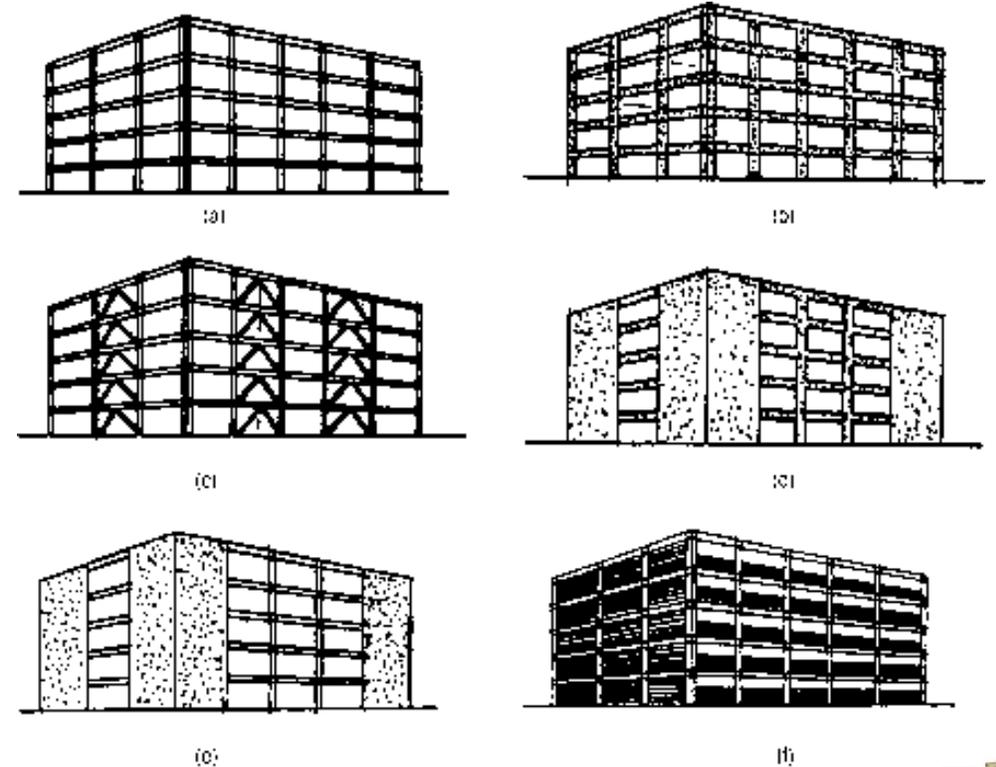
Reported by ACI Committee 423



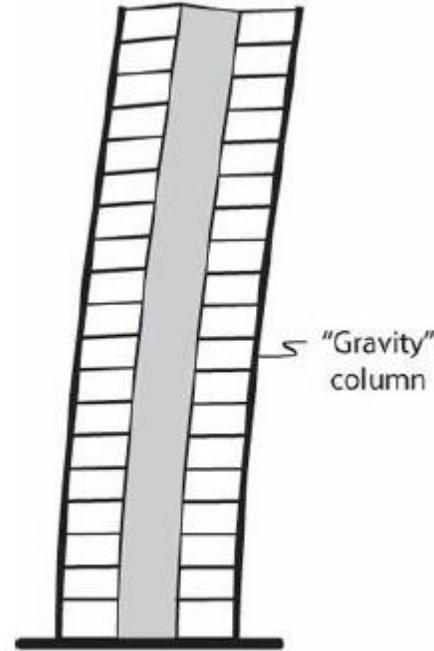
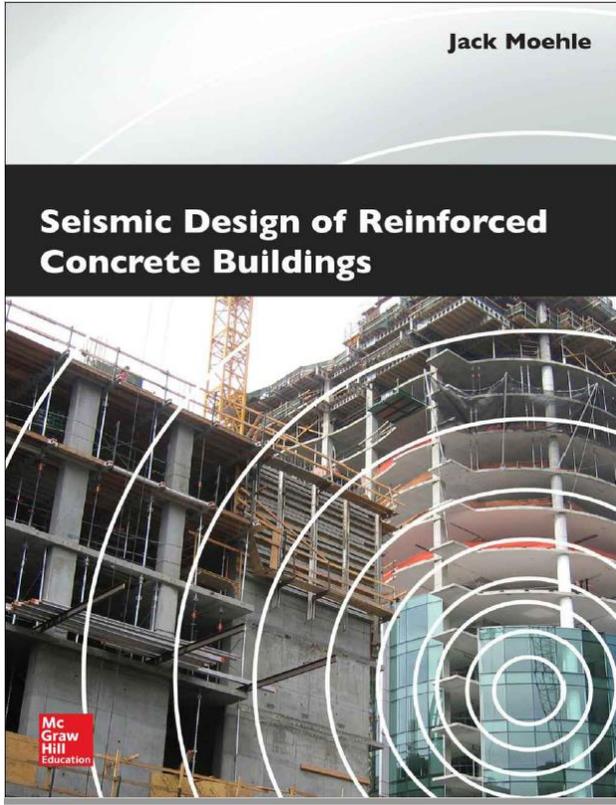
Sistemas resistente a fuerzas laterales



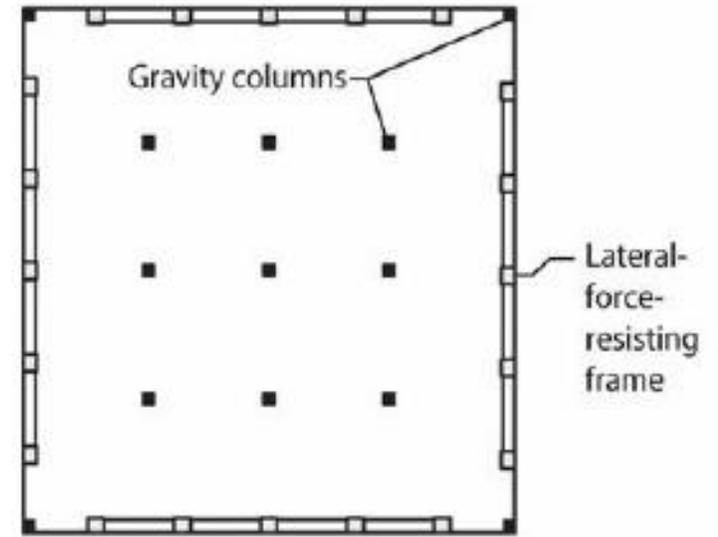
Three basic methods of assuring lateral stability of simple structural assemblies:
diagonal bracing, shear planes, and rigid joints



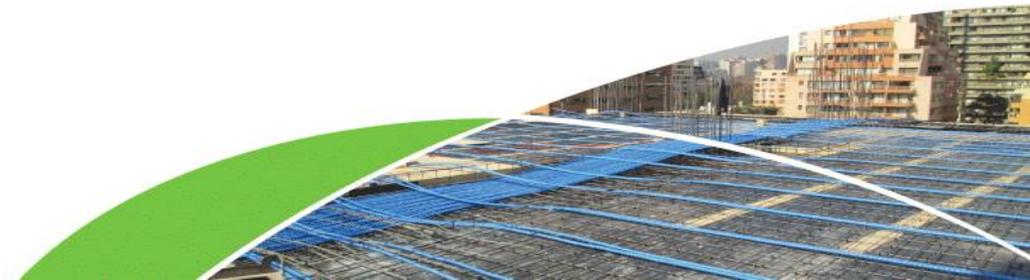
¿Sismoresistencia?



(a) Displacements



(a) Building plan



Elementos que no forman parte del sistema resistente a fuerzas laterales

- ACI 318-14 Capítulo 18.14

18.14—Members not designated as part of the seismic-force-resisting system

18.14.1 Scope

18.14.1.1 This section shall apply to members not designated as part of the seismic-force-resisting system in structures assigned to SDC D, E, and F.

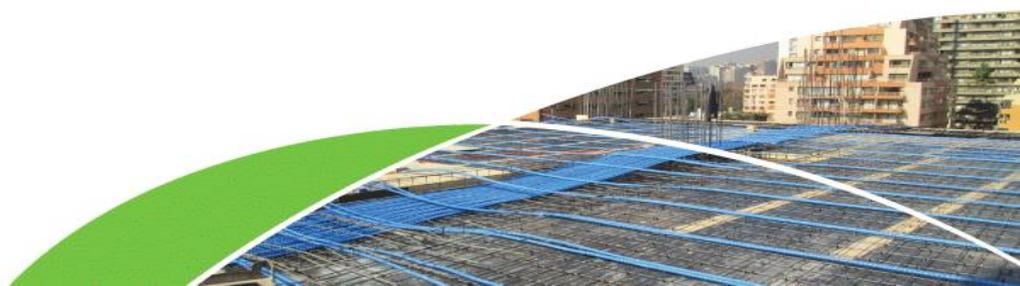
18.14.2 Design actions

18.14.2.1 Members not designated as part of the seismic-force-resisting system shall be evaluated for gravity load combinations of $(1.2D + 1.0L + 0.2S)$ or $0.9D$, whichever is critical, acting simultaneously with the design displacement δ_u . The load factor on the live load, L , shall be permitted to be reduced to 0.5 except for garages, areas occupied as places of public assembly, and all areas where L is greater than 100 lb/ft².

18.14.5 Slab-column connections

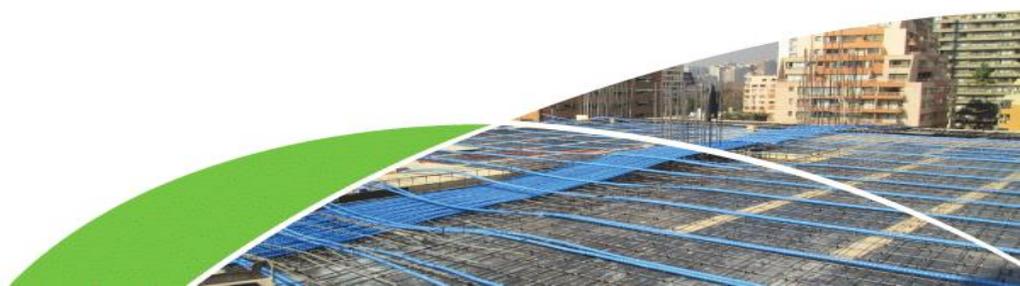
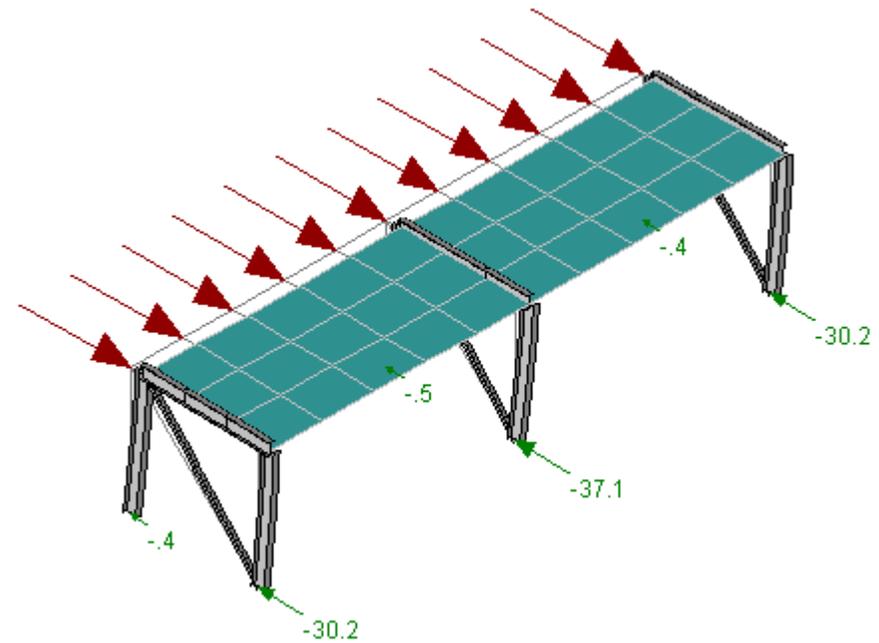
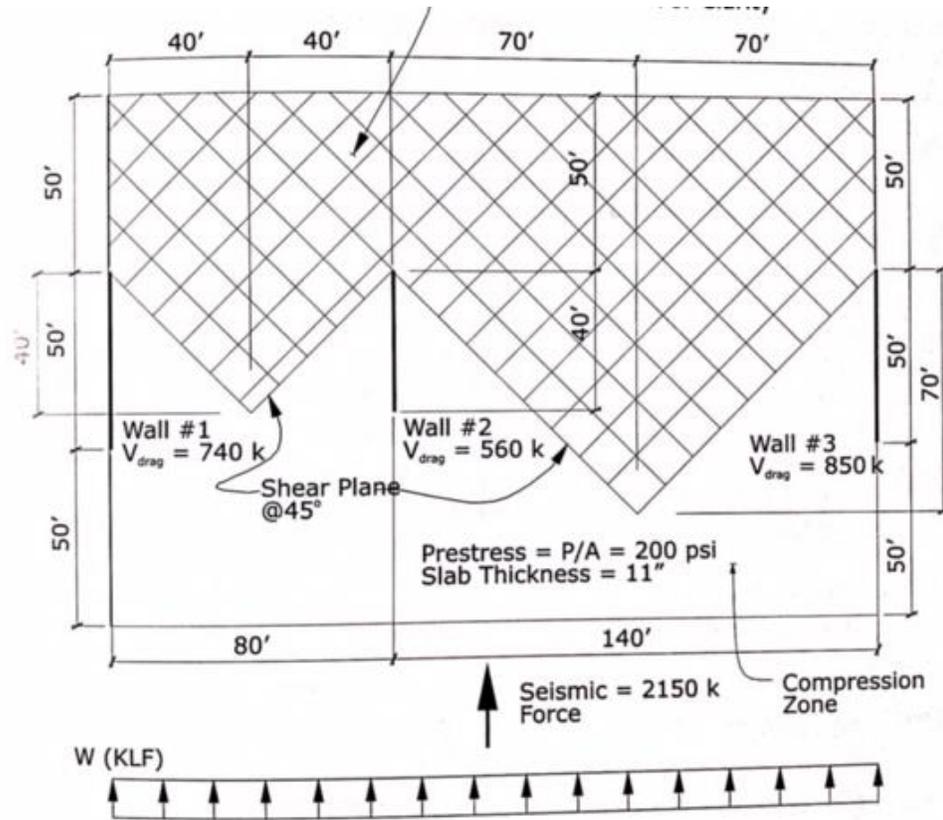
18.14.5.1 For slab-column connections of two-way slabs without beams, slab shear reinforcement satisfying the requirements of 8.7.6 or 8.7.7 shall be provided at any slab critical section defined in 22.6.4.1 if $\Delta_x/h_{sx} \geq 0.035 - (1/20)(v_{ug}/\phi v_c)$. Required slab shear reinforcement shall provide $v_s \geq 3.5\sqrt{f'_c}$ at the slab critical section and shall extend at least four times the slab thickness from the face of the support adjacent to the slab critical section. The shear reinforcement requirements of this provision shall not apply if $\Delta_x/h_{sx} \leq 0.005$.

The value of (Δ_x/h_{sx}) shall be taken as the greater of the values of the adjacent stories above and below the slab-column connection. v_s shall be calculated in accordance with 22.6.5. v_{ug} is the factored shear stress on the slab critical section for two-way action due to gravity loads without moment transfer.



Comportamiento como diafragmas

- ACI 318-14 Capitulo 12



Miembros que no forman parte del sistema resistente

- Como tomarlo en cuenta?

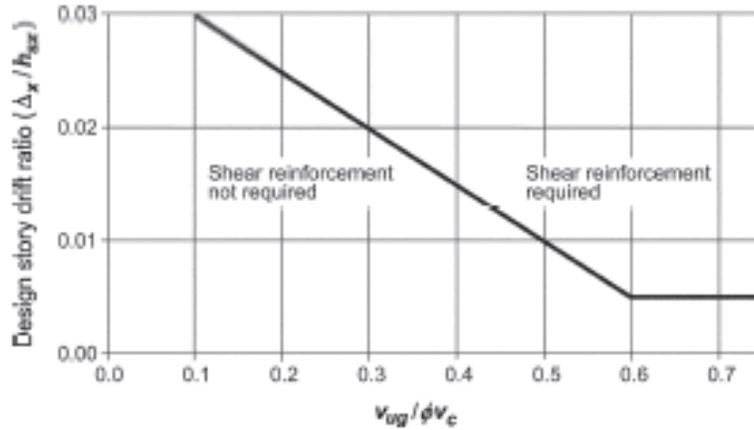
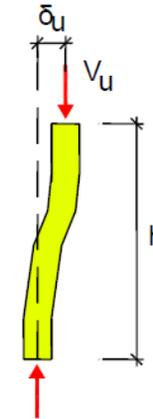


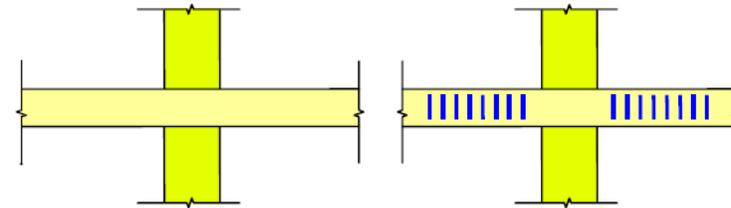
Fig. R18.14.5.1—Illustration of the criterion of 18.14.5.1.

$$\frac{\Delta}{h} \leq \text{larger of } \begin{cases} 0.005 \\ 0.035 - 0.05 \left(\frac{V_u}{\phi V_c} \right) \end{cases}$$

No limit on punching shear ratio if drift ratio is less than 0.005



(a) Displaced column

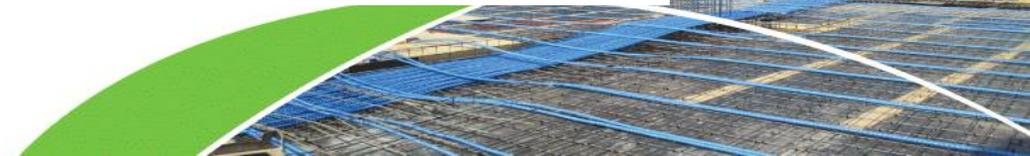


(b) Reinforcement not required

(c) Reinforcement required

$$\frac{\delta_u}{h} < \text{limit}$$

$$\frac{\delta_u}{h} \geq \text{limit}$$



Limitaciones superadas en el Ecuador

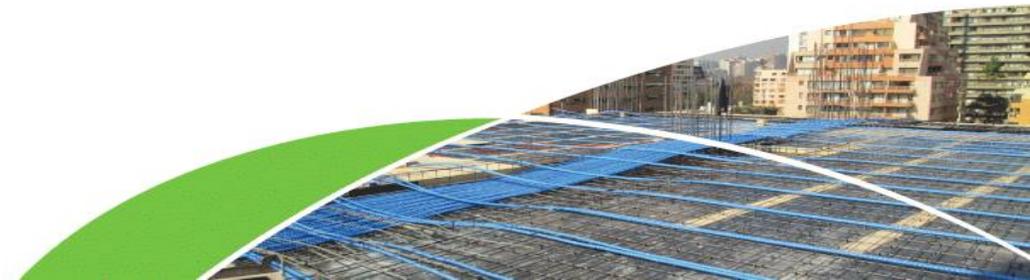
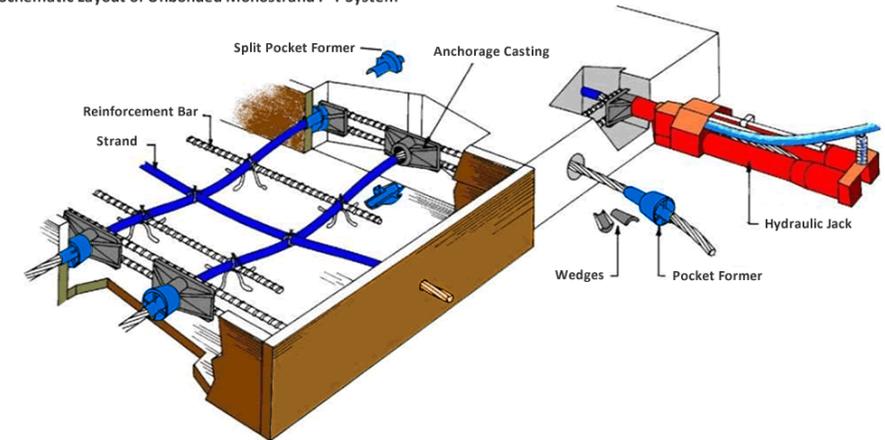
- Profesionales

Materiales

Equipos

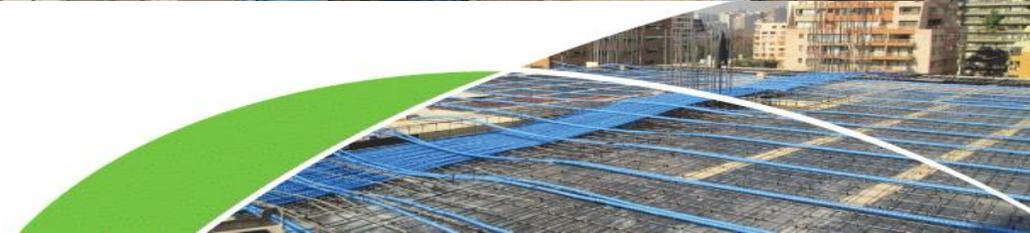
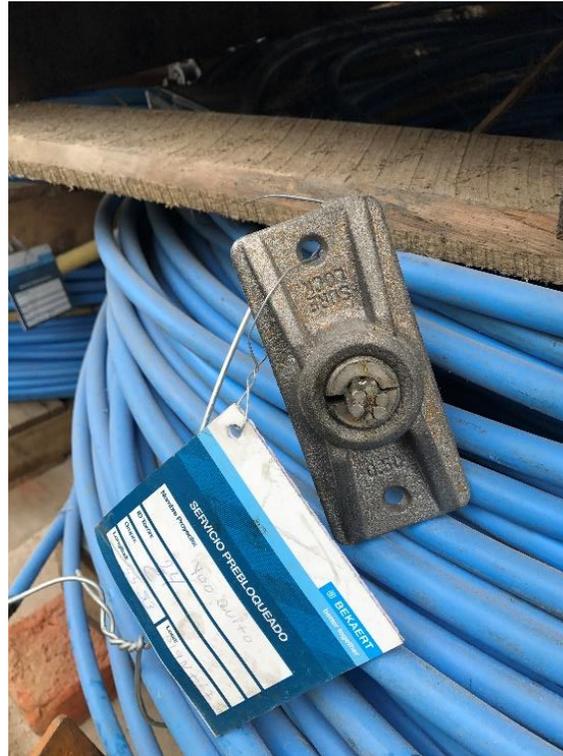


Schematic Layout of Unbonded Monostrand P-T System



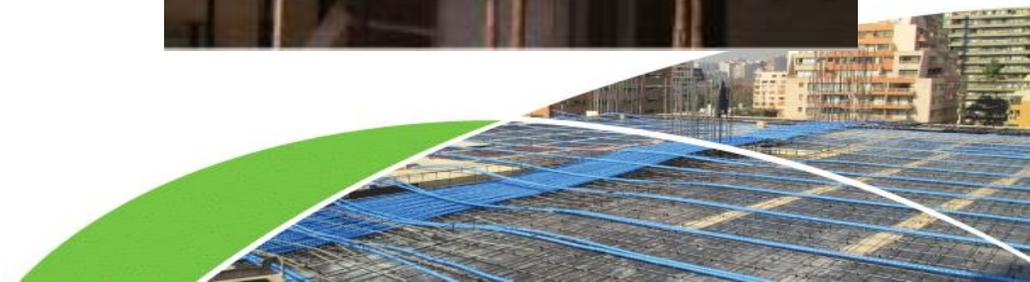
Procesos constructivos

- Materiales de Ideal Alambrec BEKAERT



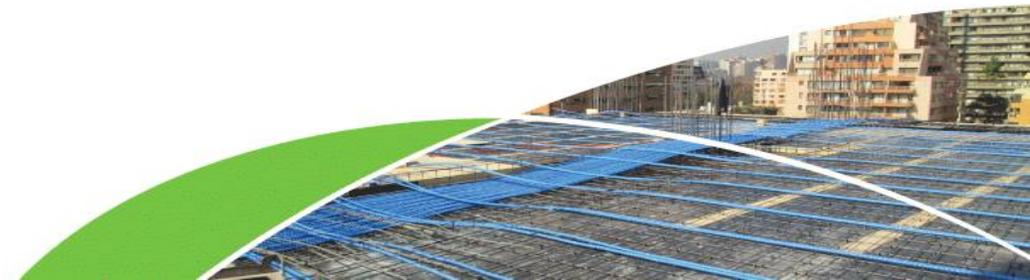
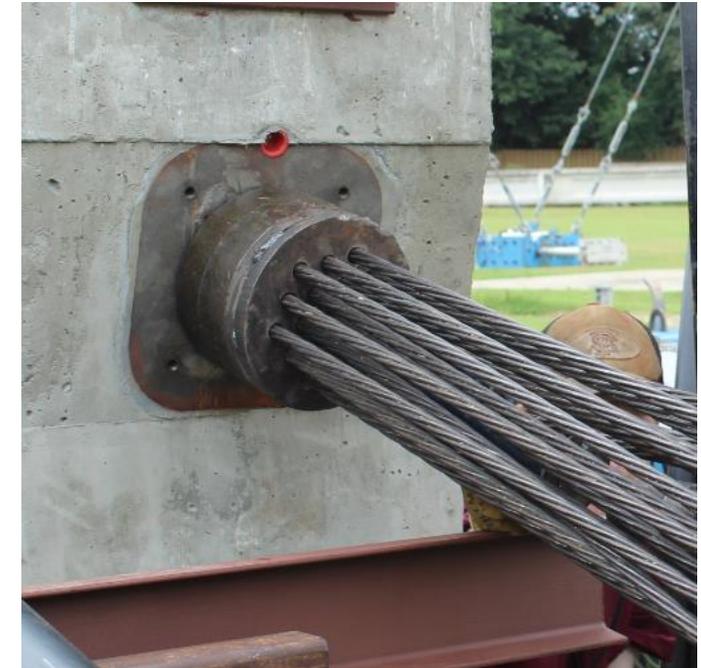
Procesos constructivos

- Colocación de cables en losas



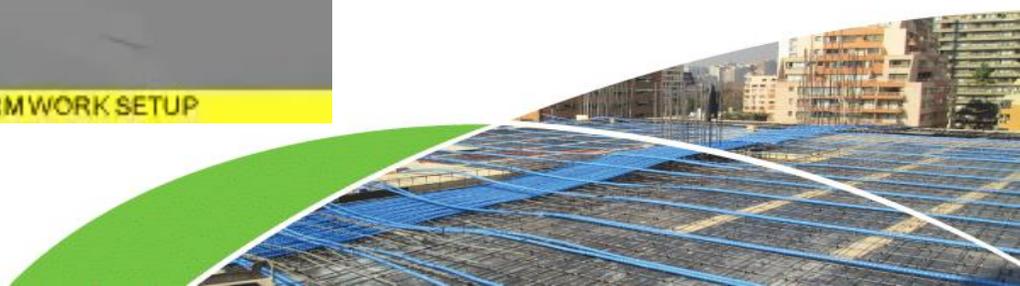
Procesos Constructivos

- Aplicación de la fuerza en cables y posteriormente el cortado de cables.



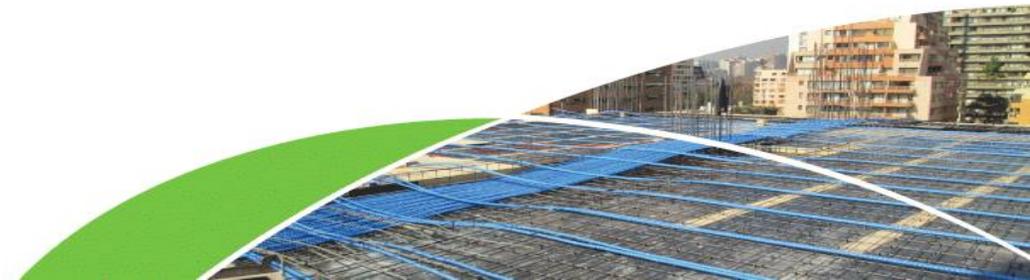


STEP 1 : FORM WORK SETUP



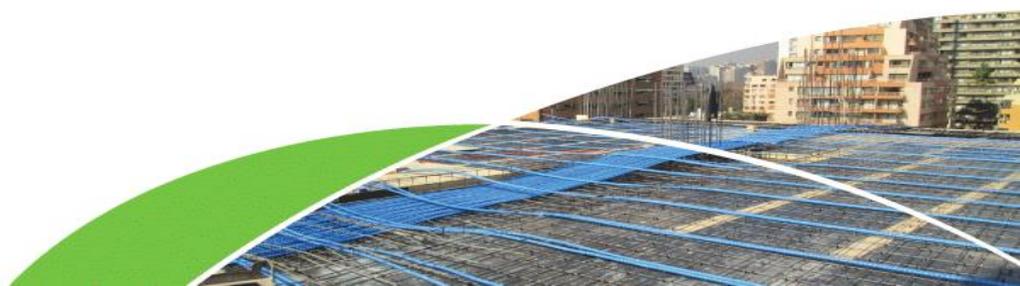
Nuevos retos en el Ecuador

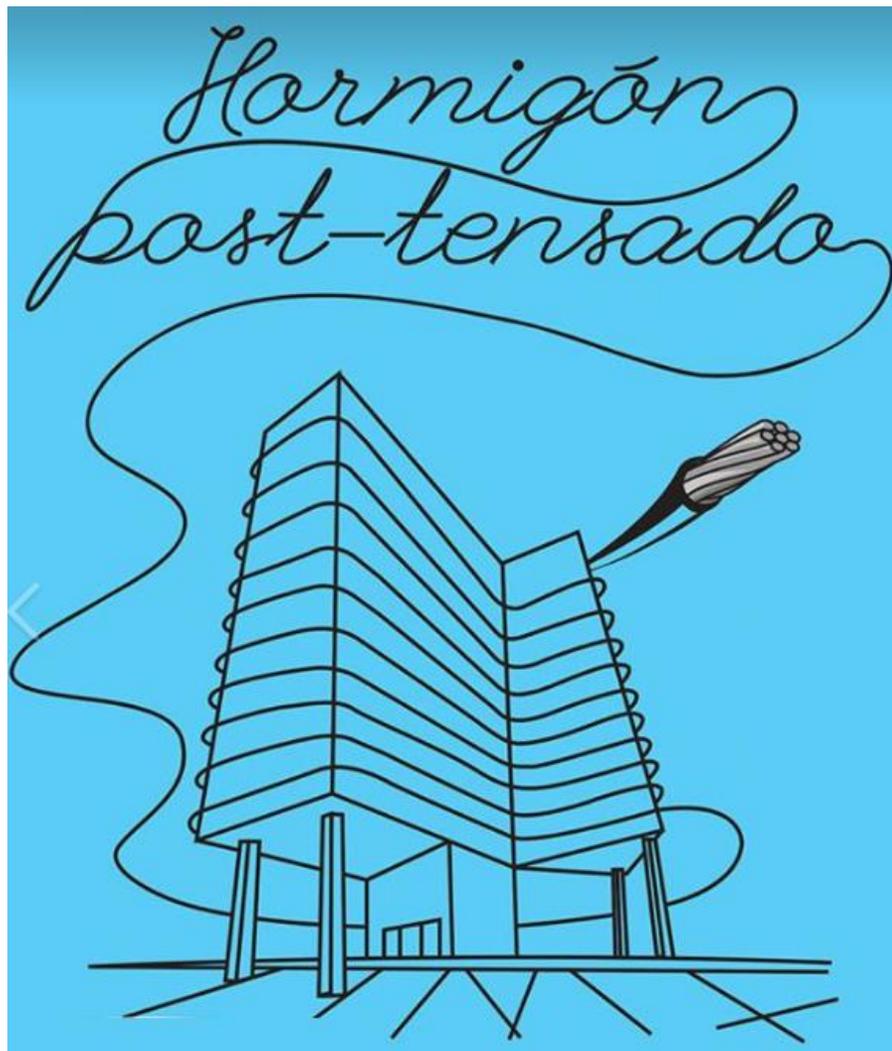
- Viabilidad
- Conocimiento de ventajas
- Capacitación a Profesionales
- Capacitación a Instaladores



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Gracias

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