Stress Measurements in Concrete

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Conventional methods of measuring stress in concrete suffer from certain drawbacks

- Embedment strain gages can measure strains but conversion to stress is difficult
  - changing modulus over time
  - shrinking + swelling due to varying moisture contents
  - creep under sustained loads
Conventional methods of measuring stress in concrete suffer from certain drawbacks.

- Most of these problems can be overcome using hydraulic flatjack type stress cells; however, these are subject to:
  - a strong temperature dependence
  - de-coupling from the surrounding concrete
  - require re-inflation after curing
Conventional methods of measuring stress in concrete suffer from certain drawbacks

- By making a stressmeter, in effect, out of concrete, these issues are circumvented in a creative manner...
- Developed in conjunction with the MPA Braunschweig, Germany
- Variation of the Toyoko Elmes Concrete Effective Stress Meter, Japan
Model 4370 Concrete Stressmeter

- Comprises
  - small vibrating wire load cell
  - in series with a cylinder of concrete
- The concrete cylinder has same properties as surrounding concrete but is de-bonded from it by a
  - smooth-walled, porous plastic tube
  - and Tyvec wrap
- It is coupled, at its ends, to the surrounding concrete by
  - a flange and a split anchor
Operating principle

- The vibrating wire load cell measures load imposed on inner concrete cylinder by stresses in surrounding concrete.
- This load, divided by the cross sectional area of the inner cylinder, gives the stress in the concrete.
- Variations in moisture content in the surrounding concrete are felt also by the inner concrete ... so shrinkage & swelling are same inside and out ... so no net change in the load cell readout.
  - ... not strictly true due to short length of metal load cell, which behaves differently.
  - but effect is kept small by large difference in relative lengths of the concrete cylinder versus load cell.
\[
\frac{\sigma_m}{\sigma_C} = \frac{2.12 \cdot I_L + I_C}{I_C + I_L \frac{E_c(t)}{E_L} \left(1.12 + \frac{A_c}{A_L}\right)\left(\frac{1}{1+\varphi}\right)}
\]

\( \sigma_m, \sigma_c \) = measured stress, real stress,

\( E_c, E_L \) = young's-modulus of concrete, young’s-modulus of load-cell,

\( A_L, A_c \) = cross sectional area of active load-cell part,

cross sectional area of concrete prism

\( I_L, I_C \) = length of active load cell part, length of concrete prism

\( \varphi \) = creep coefficient.
Validation of Tension Stresses for young Concrete in the horizontal Testing Frame
Specifications

Standard Range: 130MPa
Resolution: 40kPa
Accuracy: +/-0.1% FS
Temperature Range: -20°C - +80°C
Length x Dia.: 600 x 76mm (ID = 66mm)

¹ Load cell accuracy
Application…
Mass Concrete Germany
Application Redzinski Bridge
Wroscaw, Poland
Application Redzinski Bridge Pier Wroscaw, Poland
Application…

RCC Dam - Vietnam
Application…
RCC Dam - Vietnam
Concrete Stress Measurement – Device and Applications

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A SUITABLE STRESSMETER FOR MONITORING THERMAL STRESSES IN MASS CONCRETE

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References
Model 4370 Concrete Stressmeter
(developed in conjunction with the MPA Braunschweig, Germany)