Stress Measurements in Concrete

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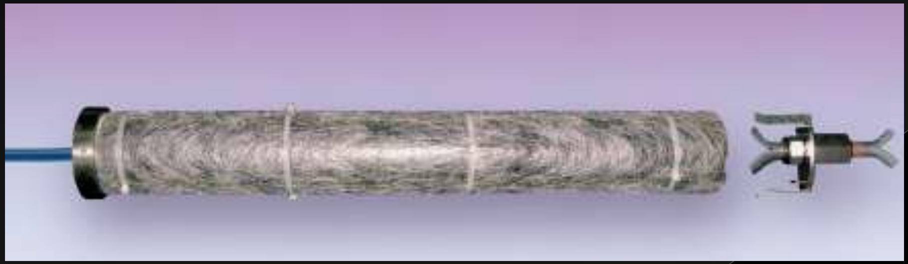
Conventional methods of measuring stress in concrete suffer from certain drawbacks

- 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

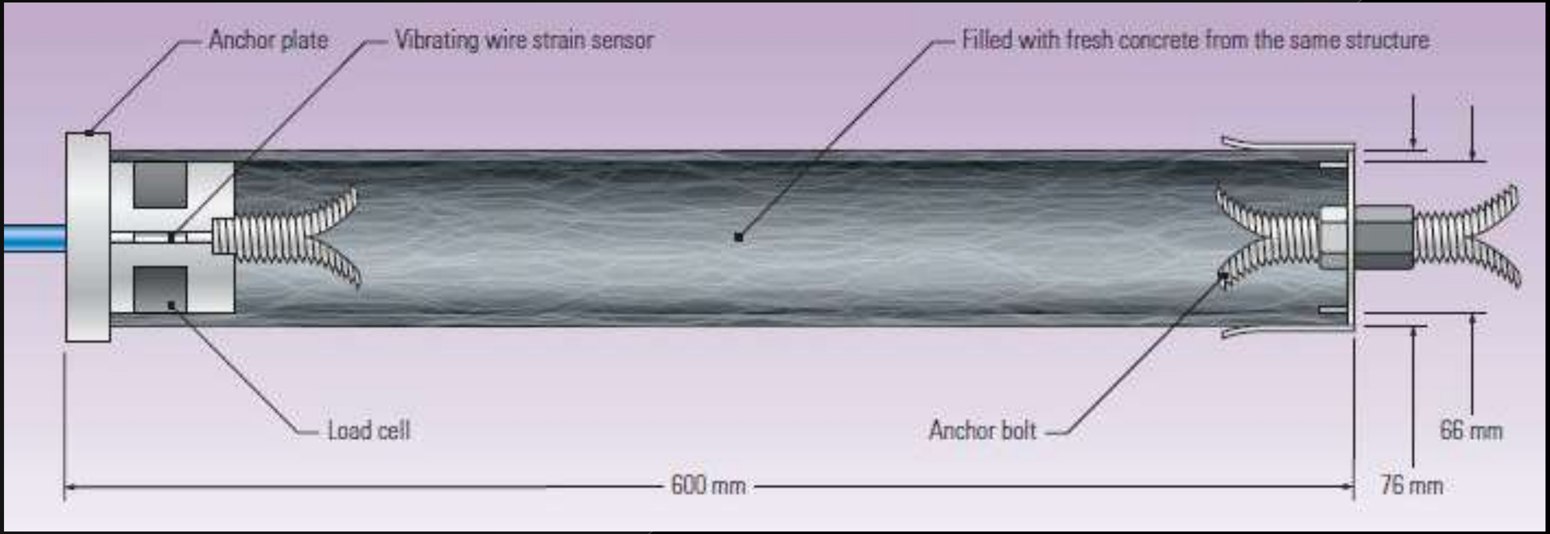
- Most of these problems can be overcome using hydraulic flatjack type stress cells; however, these are subject to
  - a strong temperature dependence
  - de-coupling from the surrounding concrete
  - requirie re-inflation after curing

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

Theory

$$\frac{\sigma_m}{\sigma_C} = \frac{2{,}12 \cdot l_L + l_C}{l_C + l_L \dfrac{E_C(t)}{E_L \cdot}\left(1{,}12 + \dfrac{A_C}{A_L}\right)\left(\dfrac{1}{1+\varphi}\right)}$$

σ_m σ_c = measured stress, real stress,

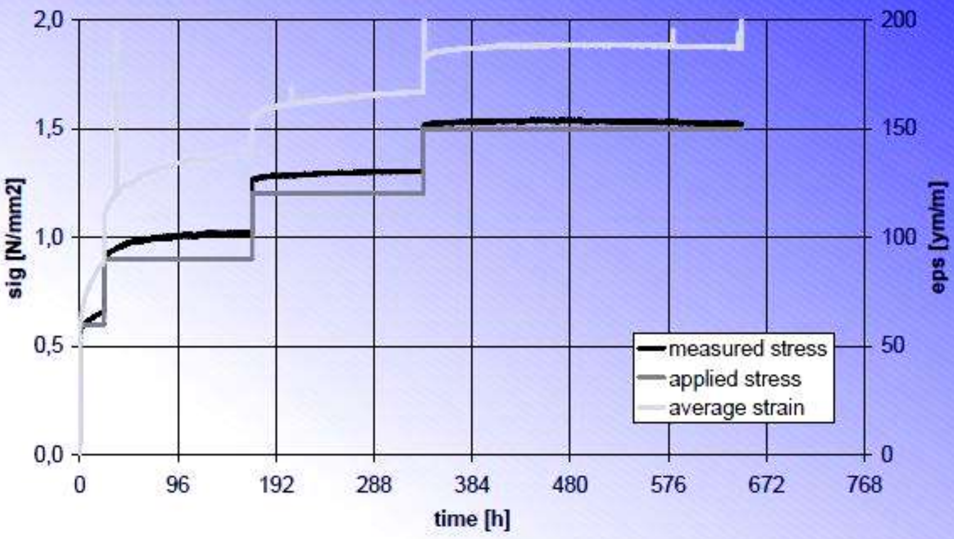
E_c E_L = young's-modulus of concrete, young's-modulus of load-cell,

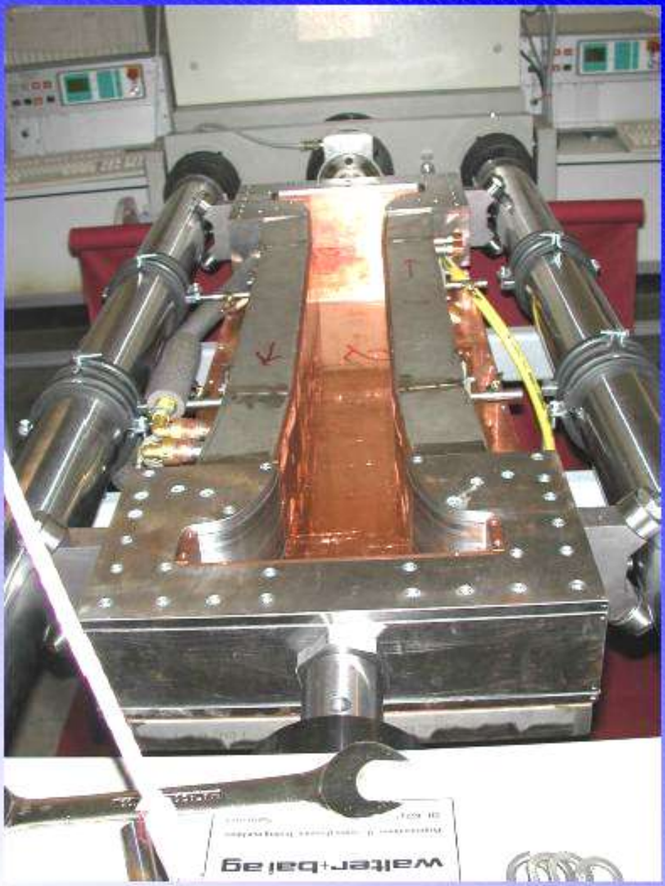
A_L, A_C = cross sectional area of active load-cell part, cross sectional area of concrete prism

l_L, l_C = length of active load cell part, length of concrete prism

φ = creep coefficient.

Testing





Validation of Tension Stresses
for young Concrete
in the horizontal Testing Frame

Specifications

Standard Range	130MPa
Resolution	40kPa
Accuracy [1]	+/-0.1% FS
Temperature Range	-20C - +80C
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

Application…
RCC dam - Vietnam

References

Concrete Stress Measurement – Device and Applications

Dr.-Ing. M. Laube, Dipl.-Ing. T. Rusack (MPA Braunschweig)

A SUITABLE STRESSMETER FOR MONITORING THERMAL STRESSES IN MASS CONCRETE

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References

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Untersuchungsbericht

Dokumentennummer: 7002/2763 – 5 – Ru vom 16.02.2005

Dieser Bericht ersetzt 7002/2763 – 4 – Ru vom 24.08.2004. Diese Berichtsfassung ist der Abschlussbericht.

Auftraggeber: Arge Lehrter Bahnhof Los 1.4
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MATERIALPRÜFANSTALT FÜR DAS BAUWESEN
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Untersuchungsbericht

Dokumentennummer: (7004/4795) – 2 – Ru vom 08.02.2006

Dieser Bericht ersetzt 7004/4795 – 1 – Ru vom 29.07.2005 zum selben Auftrag.

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Model 4370 Concrete Stressmeter

(developed in conjunction with the MPA Braunschweig, Germany)

Model 4370

Concrete Stressmeter

Applications
The Model 4370 Concrete Stressmeter is designed to measure tensile and compressive stresses in…

- Mass concrete

• Model 4370 installation

• Model 4370 Concrete Stressmeter

Operating Principle
In essence, the Model 4370 Concrete Stressmeter comprises a short vibrating wire load cell in series with a longer cylinder of concrete. This concrete cylinder has the same properties as the surrounding concrete but is de-bonded from it by means of a smooth-walled, porous plastic tube. It's coupled at its ends to the surrounding concrete by means of two flanges equipped with sections of split rebar to provide a better grip. The vibrating wire load cell measures the load imposed on the inner concrete cylinder by stresses in the surrounding concrete. This load, when divided by the cross sectional area of the inner cylinder, gives the stress in the surrounding concrete.

Advantages and Limitations
The Model 4370 is designed to more accurately measure stresses in concrete over more conventional methods, which have some disadvantages: strain gages can measure strains but the conversion of strains to stress is made difficult due to change of elastic modulus with time, shrinkage and swelling caused by varying moisture content and creep under sustained loads.

The Model 4370 is designed to overcome these problems by making a stressmeter out of concrete. The resultant stressmeter has the same properties of shrinkage/swelling, modulus variation, temperature dependence, and creep potential as the surrounding concrete.

The moisture content of the surrounding concrete and the inner concrete are practically identical. Hence, the readout of the load cell is not affected so that shrinkage and swelling are the same both inside and out, leading to no net change in the load cell readout.

The presence of the load cell introduces a small measurement error, i.e. the modulus of the stressmeter can be slightly higher or lower than the surrounding concrete.

Special procedures and equipment may be required for installation in RCC (Roller Compacted Concrete).

A thermistor is included inside the cell for the measurement of temperatures.

The Model 4370 is suitable for the assessment of tensile stresses, which can occur while the concrete is in the hardening phase.

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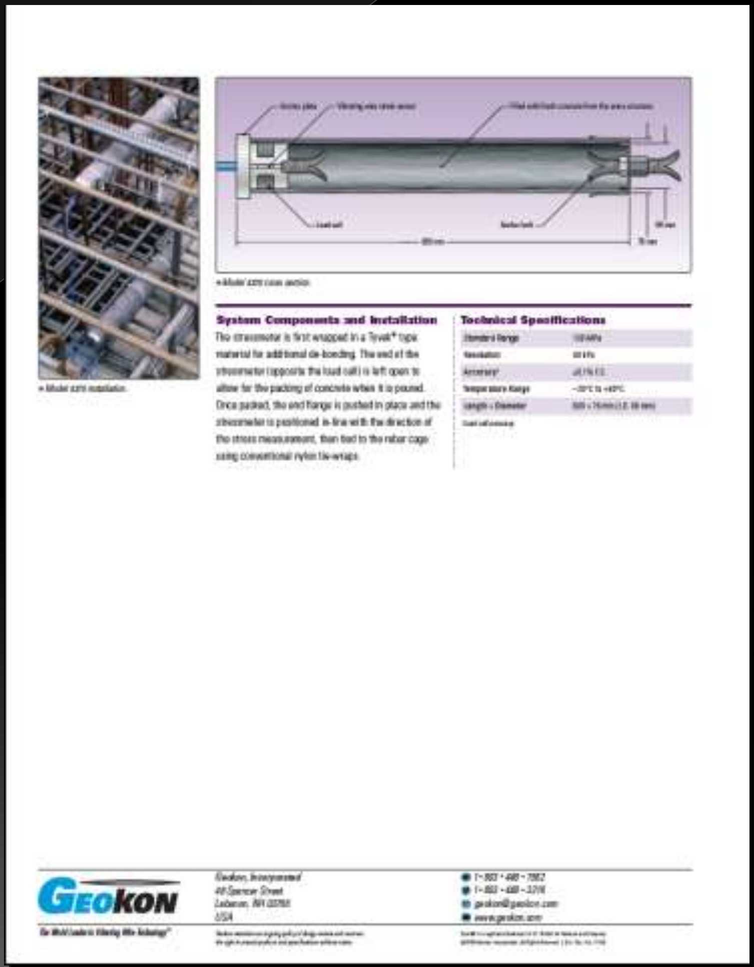
Geotechnical Instrumentation



• Model 4370 installation

• Model 4370 cross section

System Components and Installation
The stressmeter is first wrapped in a Tyvek® type material for additional de-bonding. The end of the stressmeter (opposite the load cell) is left open to allow for the packing of concrete when it is poured. Once packed, the end flange is pushed in place and the stressmeter is positioned in-line with the direction of the stress measurement, then tied to the rebar cage using conventional nylon tie-wraps.

Technical Specifications

Standard Range	[illegible]
Resolution	[illegible]
Accuracy	[illegible]
Temperature Range	−20°C to +60°C
Length × Diameter	[illegible]

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