Vägverket

Swedish National Road Administration

In short:

- •Ca 6500 employees
- •Owns and maintains the national road network
- •Close to 15000 bridges
- •Total volume of work ca 2,5 billion €

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Main field of interests are concrete structures, fiber technology and foundations.

Källösund bridge

A case studie of instrumentation and monitoring of an existing bridge on the Swedish west coast.

The purpose of monitoring was to allow heavy traffic while waiting for strengthening measures to be carried out.

Aknowledgements

The bridge is owned by **Vägverket**, in English known as:
Swedish National Road Administration (SNRA)

Expert knowledge as well as design, installation and follow up of instrumentation and monitoring has been provided by:

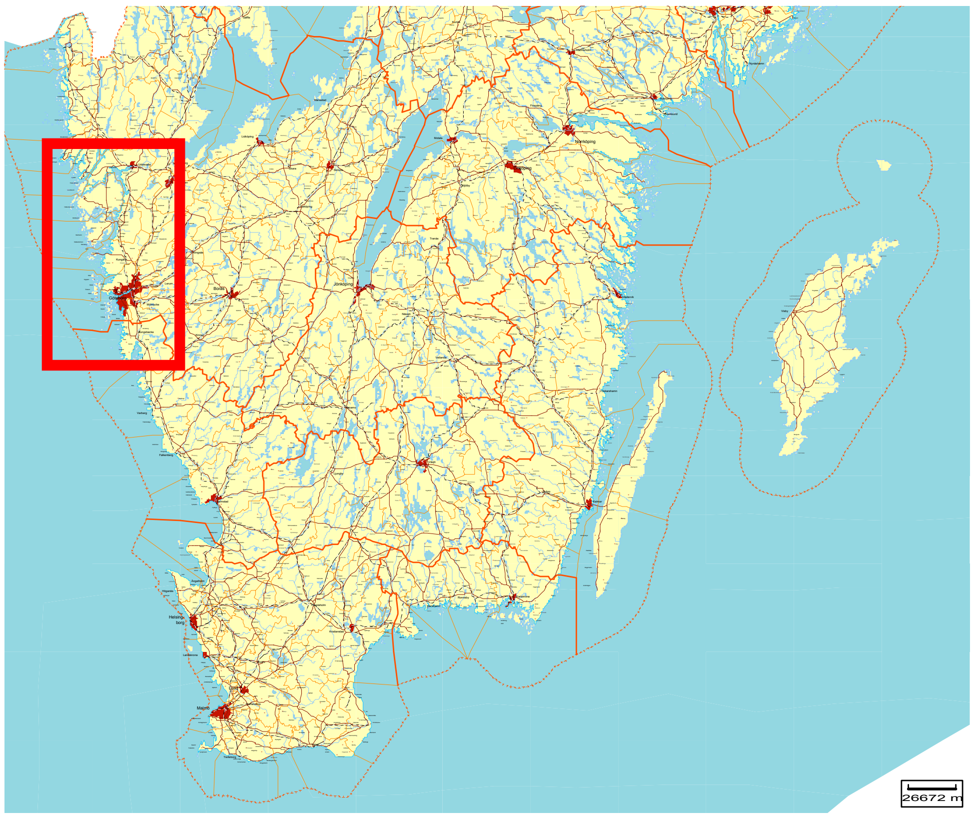
NGI, Norwegian Geotechnical Institute, Oslo

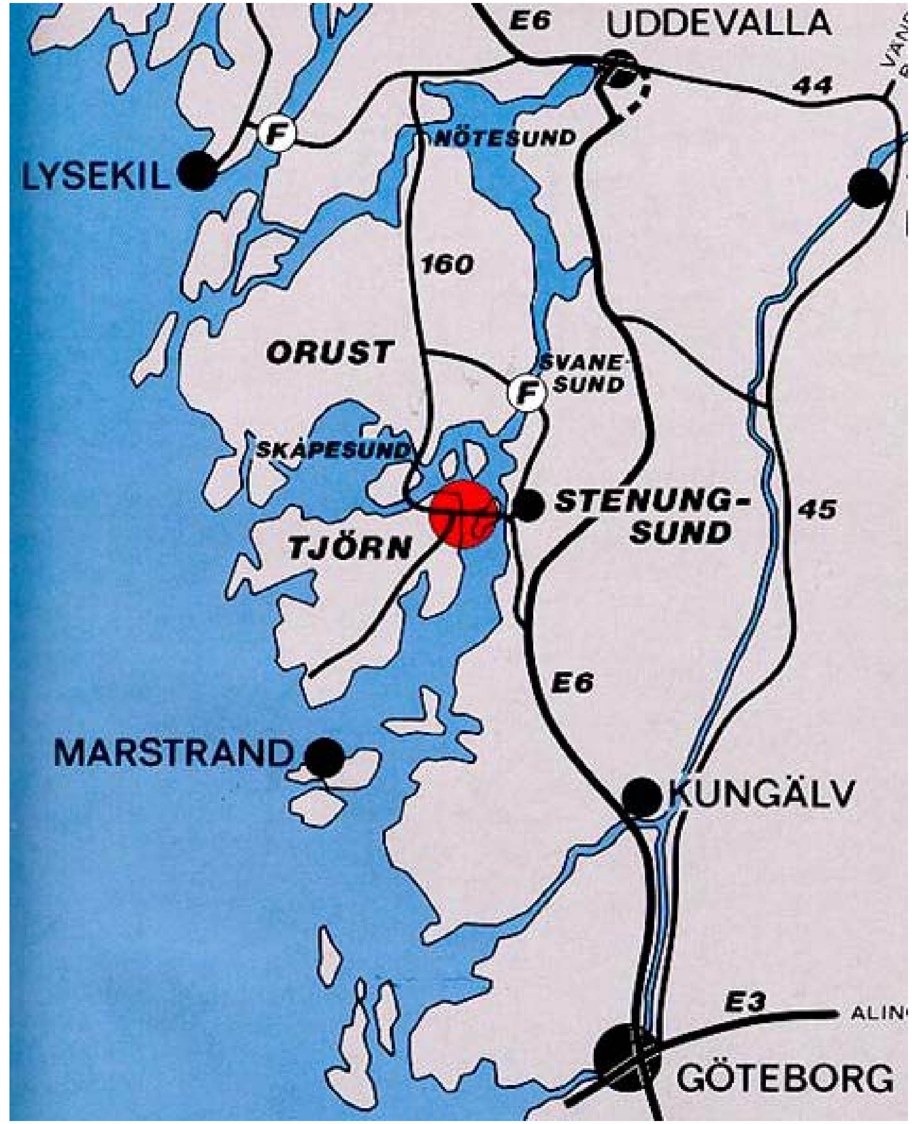
Assessment and strengthening design has been done by:

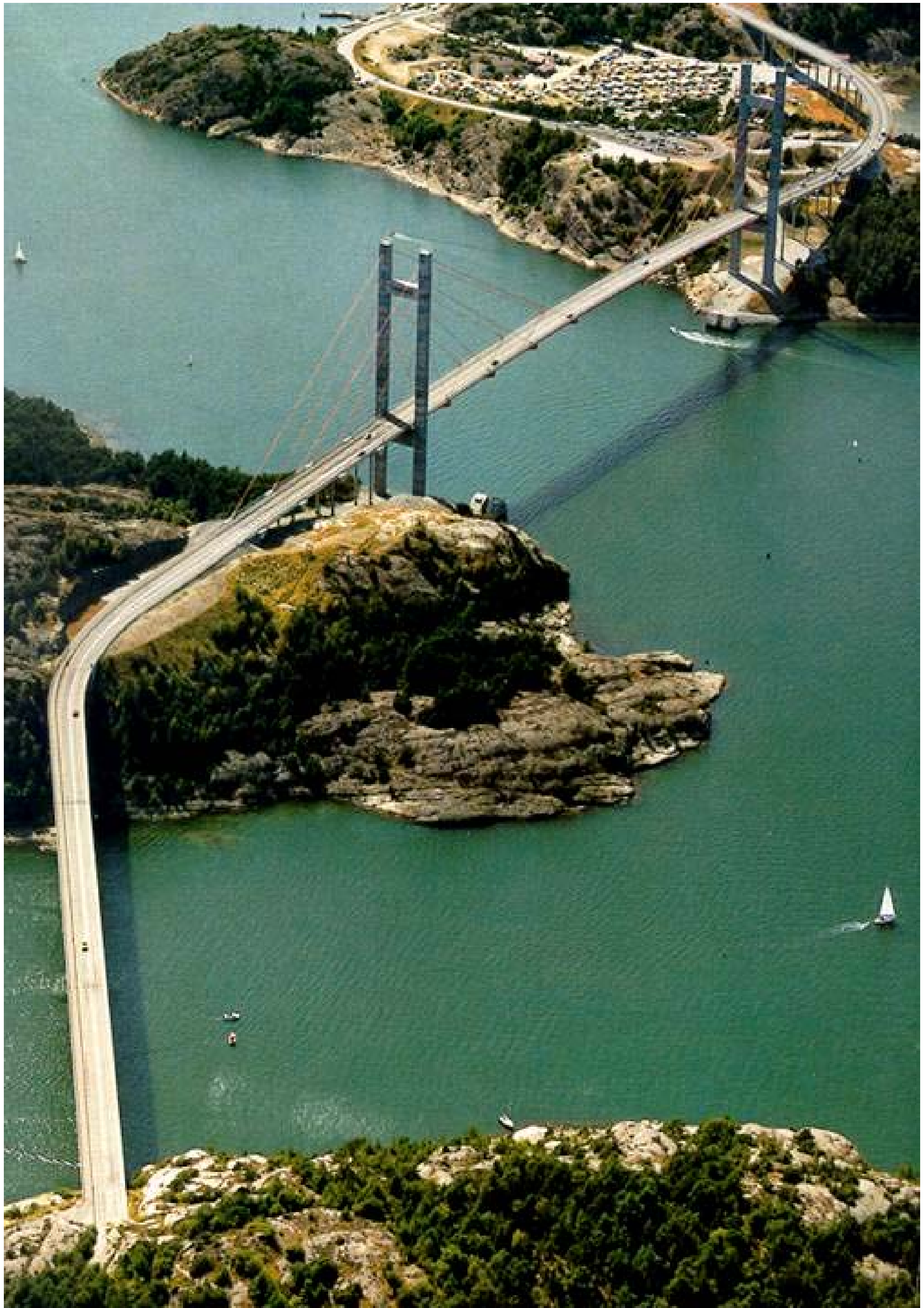
FB Engineering AB, Gothenburg

Källösund bridge

And where are we?







The tragedy

The bridge in the background is Tjörn bridge which was built after a disaster in January 1980.

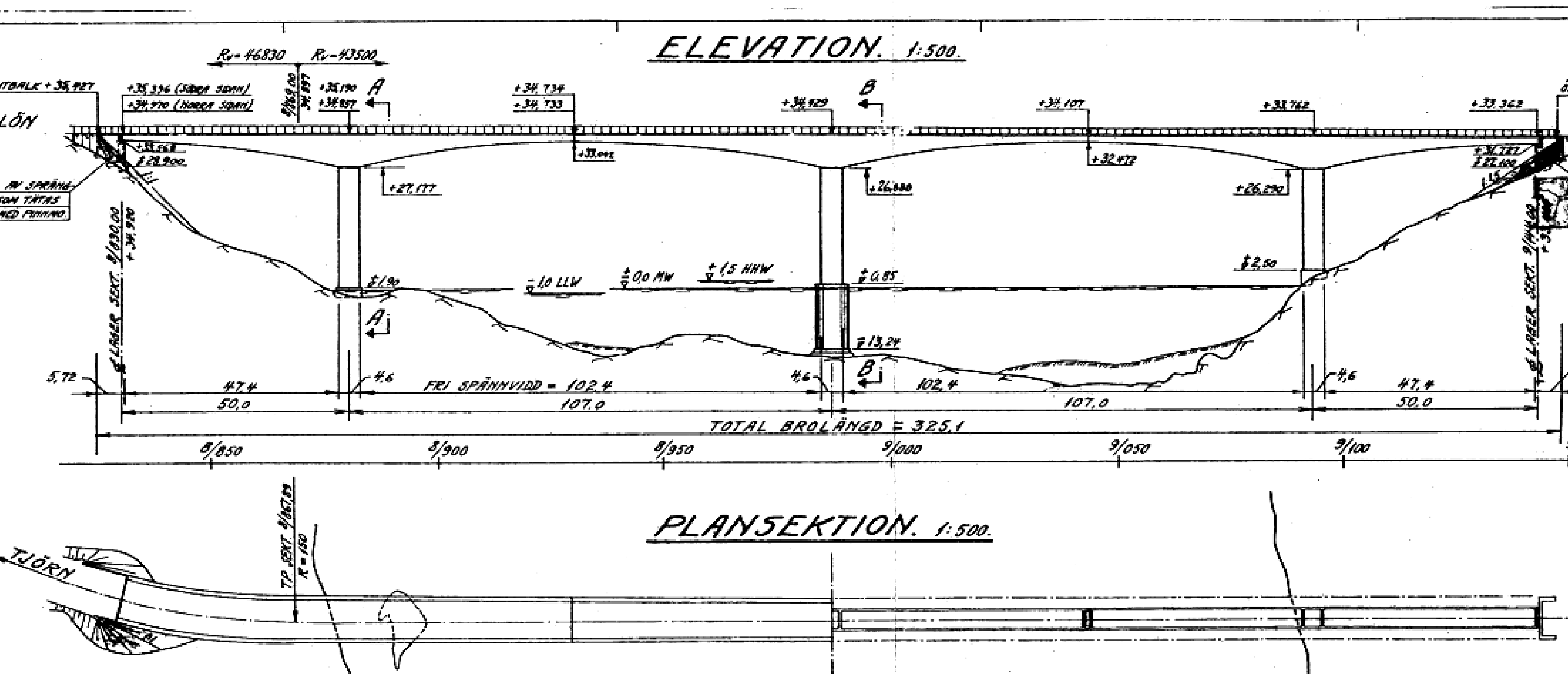
Eight people were killed as they drove of the bridge and into the water below.

Källösund bridge

Free cantilever bridge
Span 50 + 107 + 107 + 50 m

Built 1960
Traffic 15000 / 24 h

Original drawing



Mid span joints

Added public walkway on one side

PROBLEM 1:

Long term creep has led to a sagging bending moment close to the abutments.

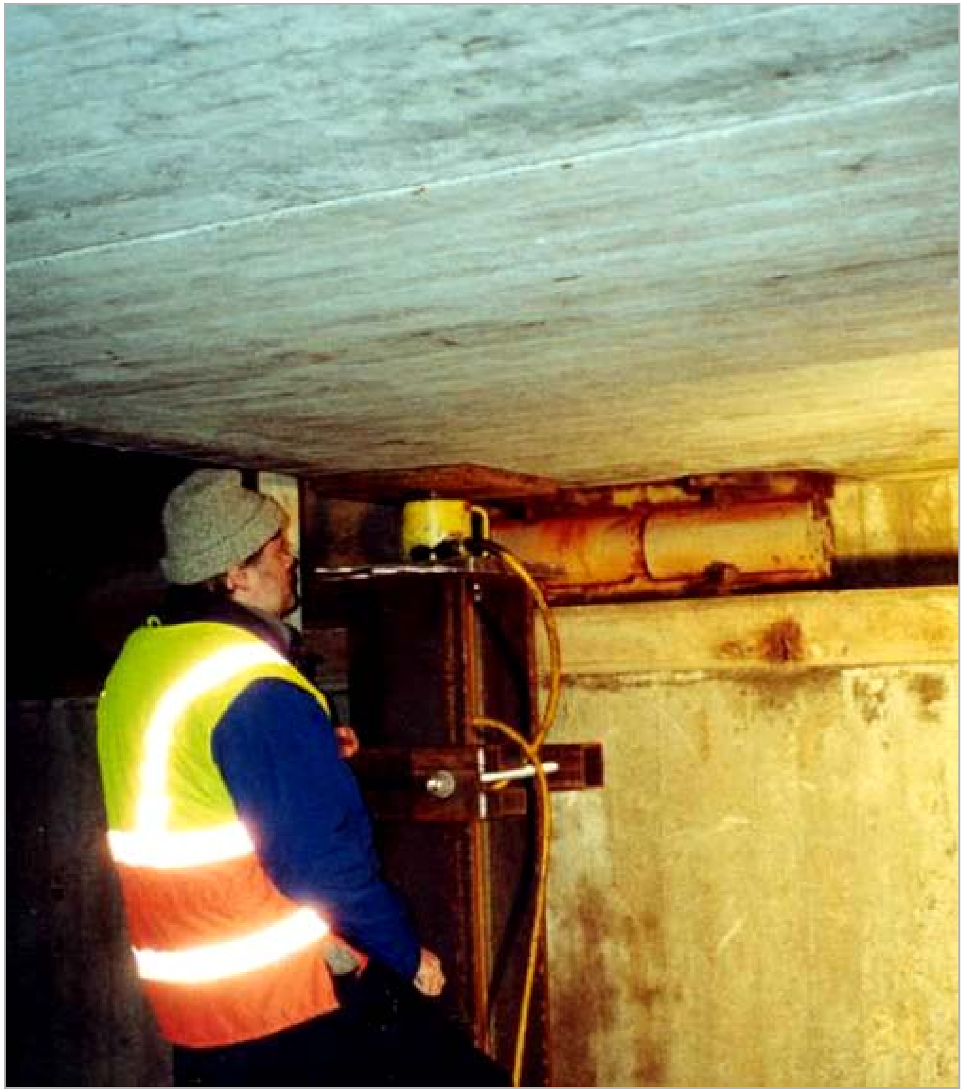
- Not foreseen in the design
- Very small bearing capacity for sagging moment
- Drilled cores from the casting joints in the bottom flange separated in two pieces when taken up of the hole
- Considered to be an urgent matter → Monitoring!

Reason for the sagging moment

The bridge was built with the free cantilever method and then the ends were placed on the abutments. This gives the following chain of events.

- Stress dependent creep will try to lower the free ends
- The abutment will restrain this deformation
- As a result a sagging moment occurs in the outer parts of the cantilevers

Measuring of self weight reaction at the bridge end to calibrate the creep assumptions



PROBLEM 2:

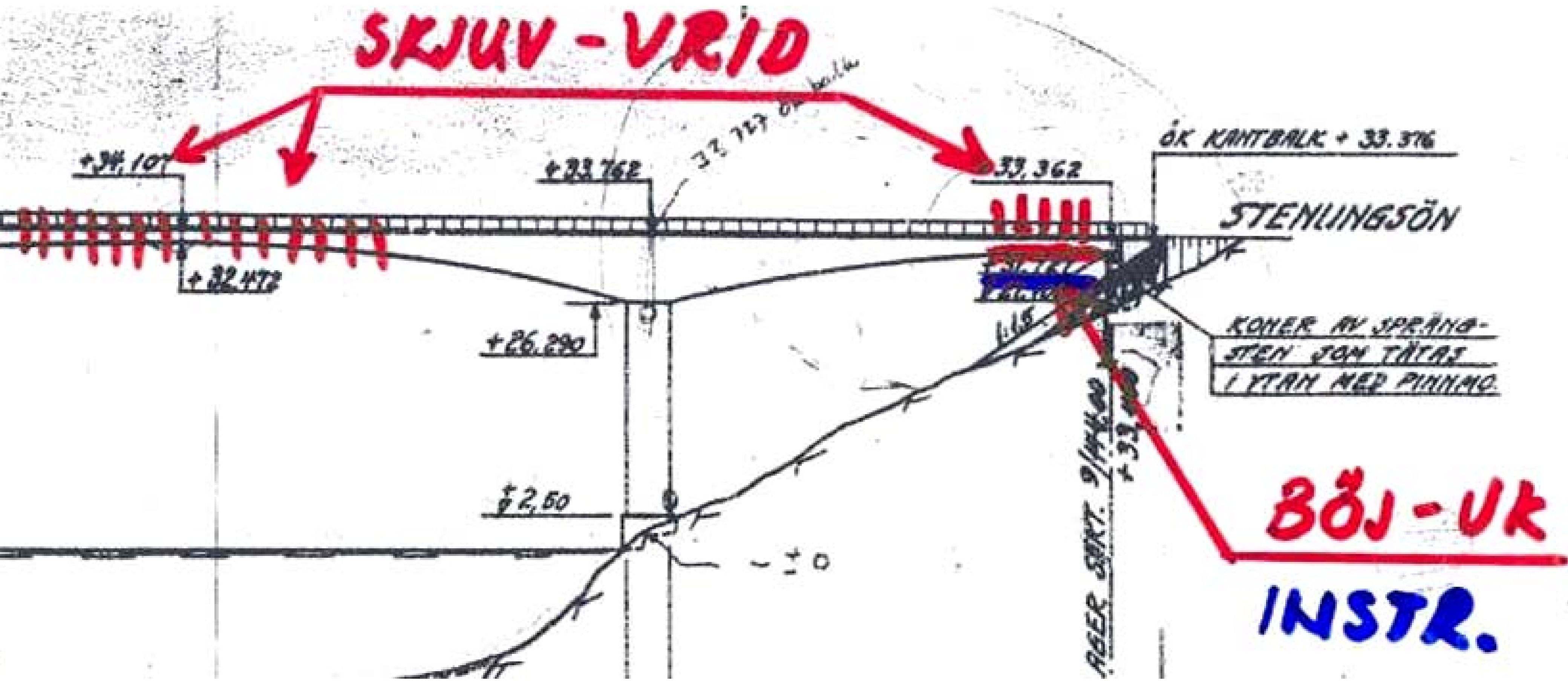
The shear reinforcement in the webs is not up to our modern design codes.

- Torsion from public walkway was not foreseen in the design
- Very small amount of stirrups
- Webs will be strengthened with CFRP.

Need for strengthening

--- Bending

III Shear



Preliminary solution

To maintain access for heavy vehicles it was decided to monitor the sections with low bending capacity.

Note that the bridge has extra capacity if a redistribution of bending moments is allowed.

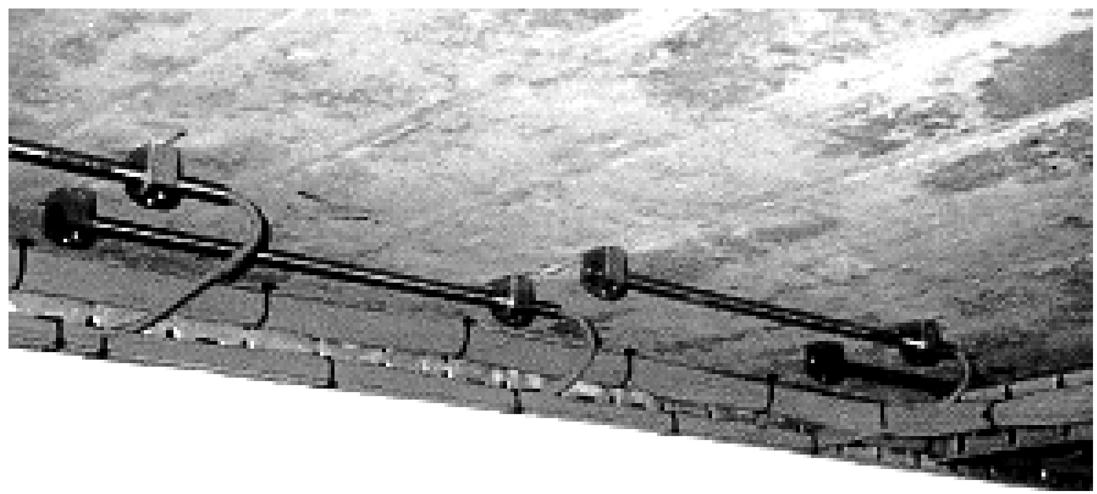
Instrumentation

In areas with unsufficient bearing capacity for sagging moments strain gauges were installed along the lower corners of the beam.

The strain gauges were checked and calibrated with a load test.

System layout

A chain of overlapping 300 mm long strain gauges were placed along each corner



Inside the bridge all sensors are connected via this cabinet

Load test of instrumentation

- A load test was carried out to verify the assessment calculations.
- As load a 70 ton truck was used.
- Due to traffic considerations the load test was done at night. *(Well, there was an attempt….)*
- The test showed a fine correlation between calculated and measured strains.

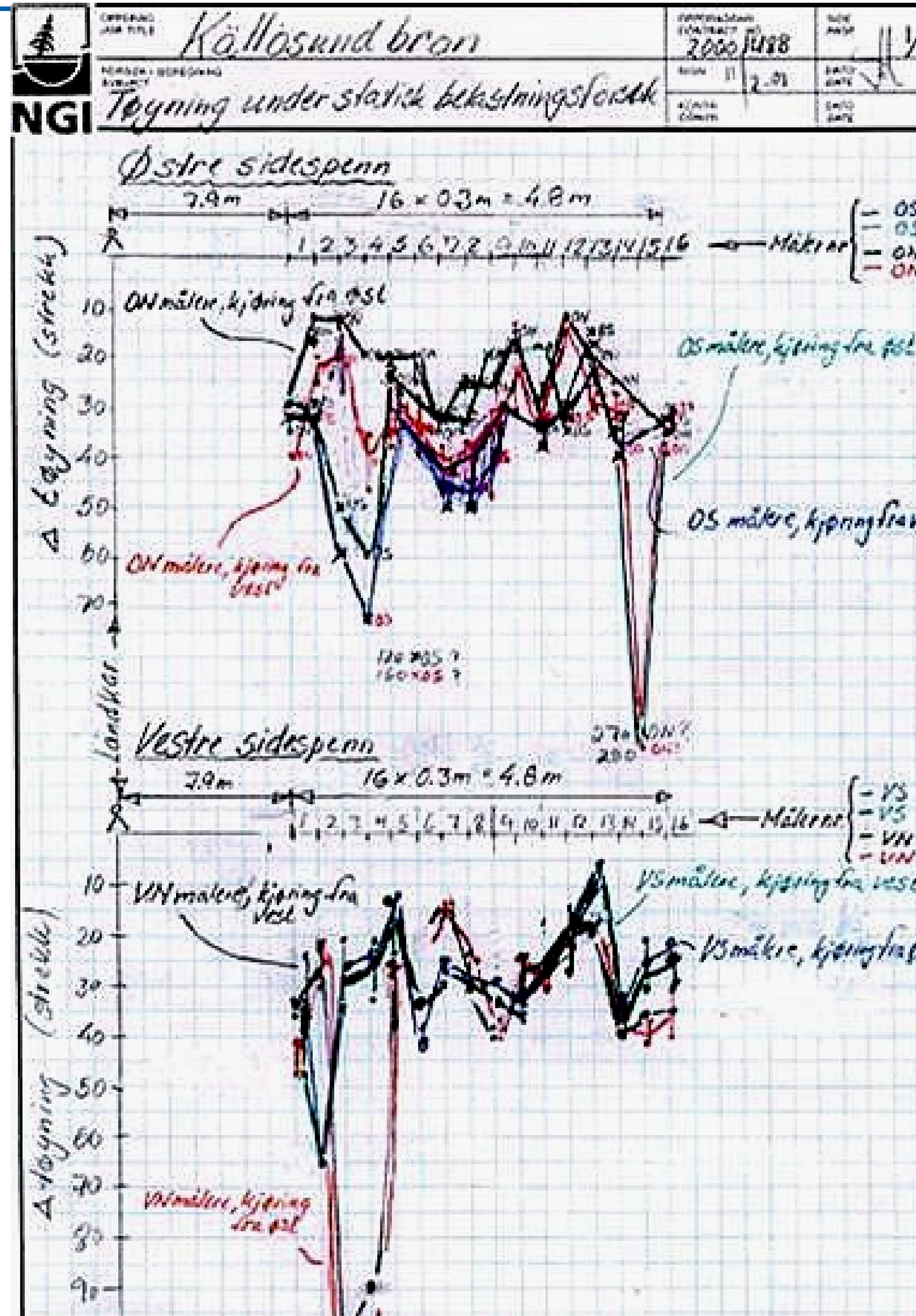
Load test of instrumentation

Load test results

Calculated strain was 50 microstrain for ”cracked” concrete

The test showed a mean value of 40 microstrain

Peak values of up to 280 microstrain were registered at casting joints that had been found to be cracked



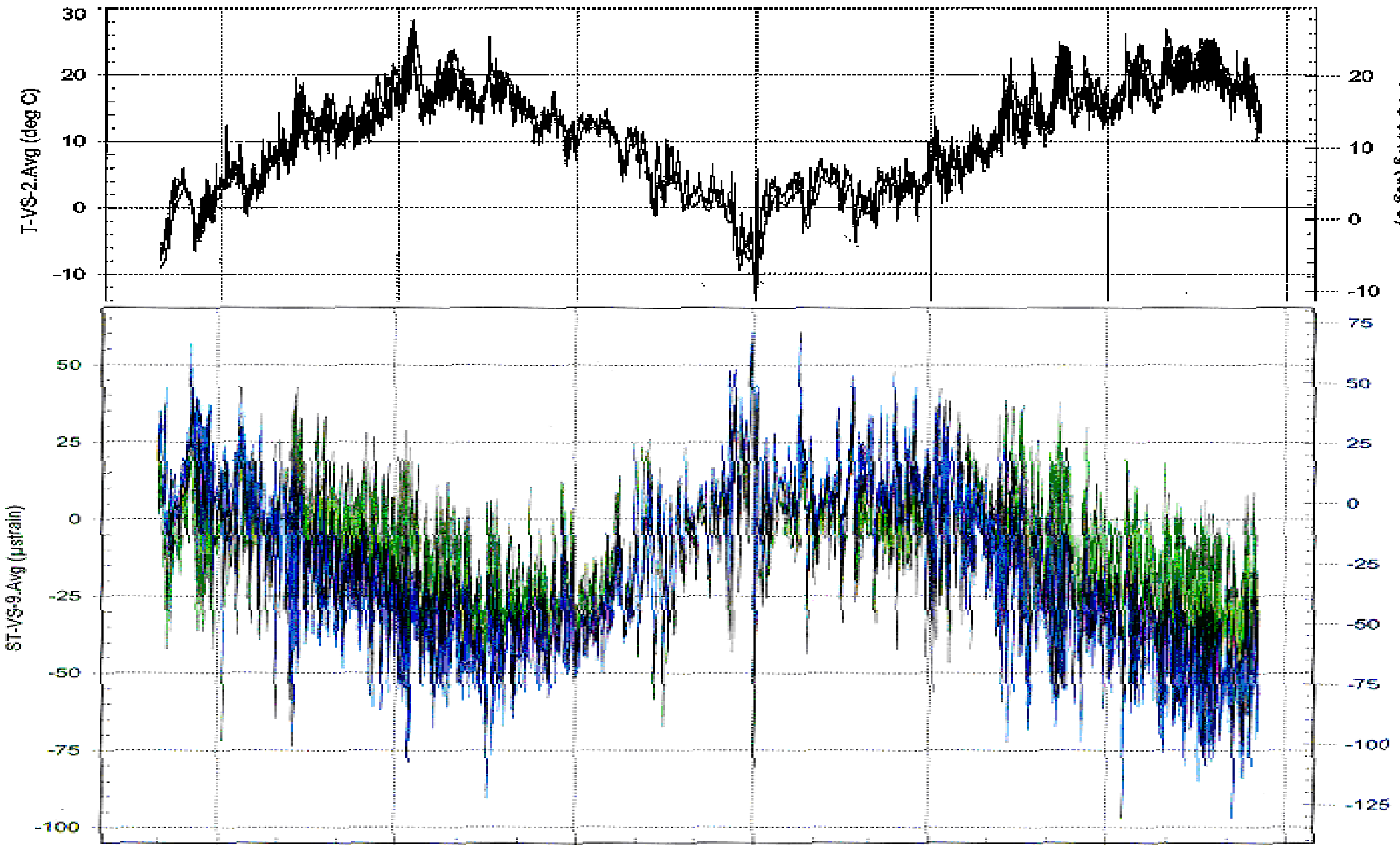
Temperature

Temperature is measured to allow corrections of the measured strains.

A good correlation has been found between temperature and strains measured during 18 months. Note the delay from surface temperature to mean temperature.

Temperature →

Strain →



Monitoring solution

The strain gauges are automatically monitored with 3 min. intervals.

An alarm limit of 300 microstrain corresponds to a crack width of 0.1 mm within a 300 mm long gauge.

If 300 microstrain is recorded an alarm automatically goes to the ”Traffic Information Centre” (TIC) at the regional office of SNRA in Gothenburg.

TIC is manned around the clock and will alert the bridge engineer in case of an alarm.

Monitoring period

Monitoring began in December 2000.

10 out of a totally installed 72 gauges has been reported faulty.

Strengthening will be done during summer 2004.

→ Total running time 3.5 years.

Intrumentation might be used to verify the statical behaviour of the strengthening, but the present gauges have to be removed as they are in the way.

Conclusions

With monitoring heavy traffic can be allowed even when calculated bearing capacity is insufficient.

The load test and traffic during the monitoring shows that the cracks in the bottom flange open under load but close again.