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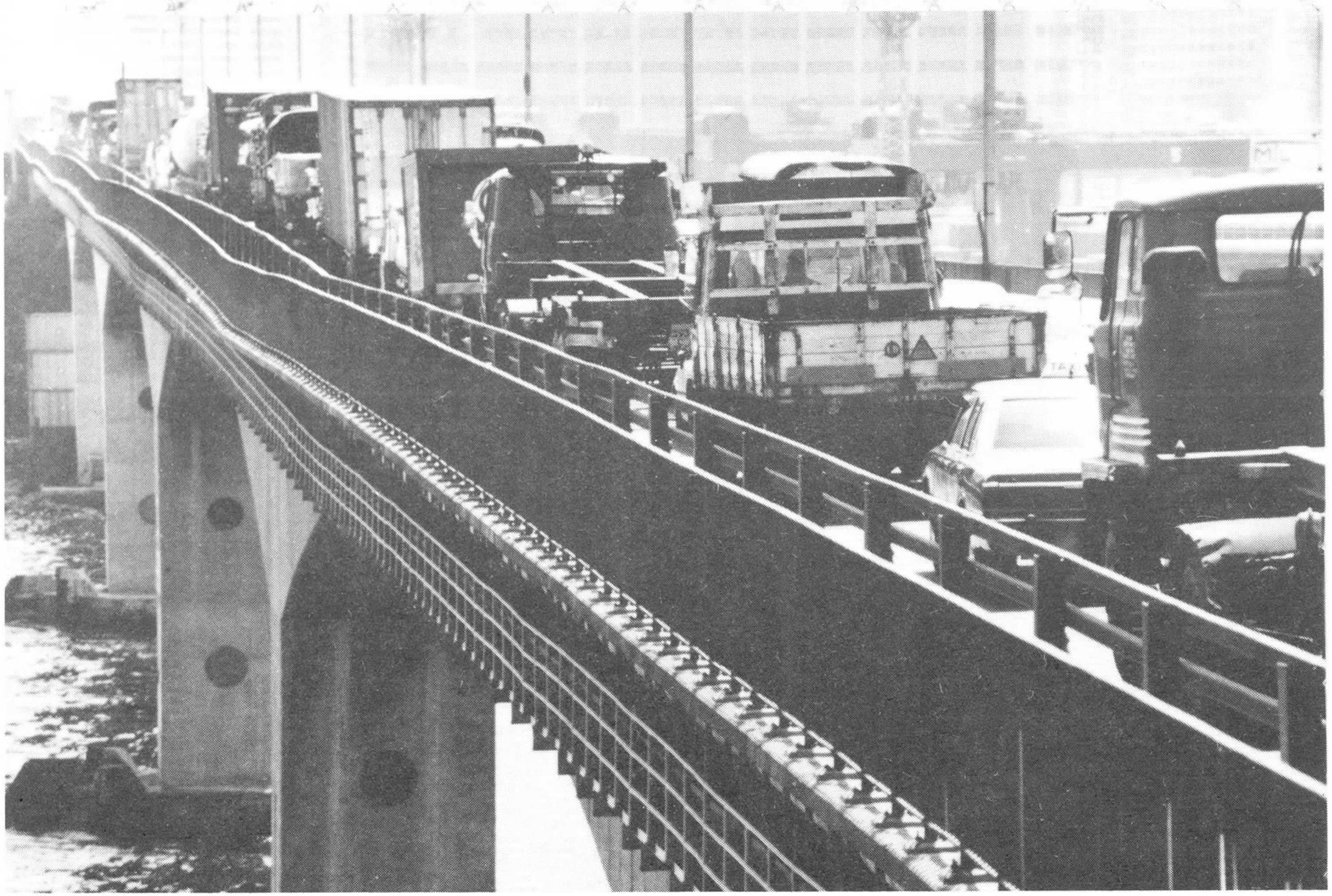
TSING YI SOUTH BRIDGE ASSESSMENT



Tsing Yi South Bridge Assessment

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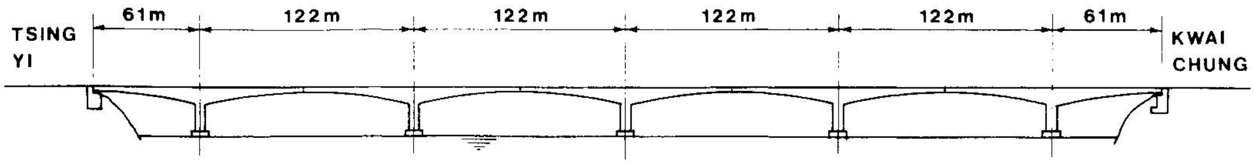
Opened to traffic in 1974, Tsing Yi South Bridge currently provides the only means of access from the mainland to the island of Tsing Yi. It was constructed by a private consortium, principally to provide access to a power station and to carry six 132 kV circuits from it to Kowloon, and upon completion was handed over to Government to operate. Since the bridge was completed, extensive development has occurred on the island, including a rapidly expanding new town. The bridge, which was built by the balanced cantilever method, is made up of five structurally independent prestressed concrete 'T' units, resulting in four main spans of 122 metres and two side spans of 61 metres, see Figure 1.



ELEVATION

Figure 1

When the expansion joints between cantilevers were replaced in 1981, it was found that the tips had deflected by nearly 200mm from their original positions and that these deflections were continuing. The deflections can be clearly seen in the poster. Concern was expressed about the service life of the bridge; this was hightened by the relatively few available construction records, together with presence within the superstructure box of the 132Kv electricity circuits. A programme of regular levelling was therefore instituted and in 1983 a thorough assessment of the structure was commissioned.

At the outset of the assessment a visual inspection was undertaken of all accessible areas of the bridge. This included removal of sections of the surfacing to examine the top flange together with underwater inspection of the piers. Simultaneously all available construction and design records were collected and personnel concerned with its construction contacted.

The visual inspection did not reveal any signs of deterioration and the available records suggested that all units were of a common design and had been constructed in a similar manner. In order to formulate a view on the condition of the bridge as quickly as possible it was therefore decided to concentrate the initial assessment on two adjacent cantilevers.

Bamboo scaffolding was erected inside the chosen cantilevers to allow a more detailed visual inspection of the top flange and to facilitate other inspection activities. Cores were extracted from the webs and top flange and tested to establish compressive strength, 'E' values and the chemical composition of the concrete. The parameters derived from these cores were used in the analysis. The chemical tests did not indicate the presence of any potentially harmful substances.

Next, vibrating wire strain gauges were attached to the concrete surface at three cross-sections on each of the two cantilevers and a series of load tests were carried out. In these tests four fully laden bulk cement carriers were parked on the deck in various patterns and readings of the strain gauges were taken. The deck was also levelled. Upon removal of each test loading the superstructure quickly rebounded to its original level. The results of analyses of the bridge under the various loading patterns agreed well with the test readings, and it was concluded that the bridge was behaving elastically. Typical results are shown in Figure 2.

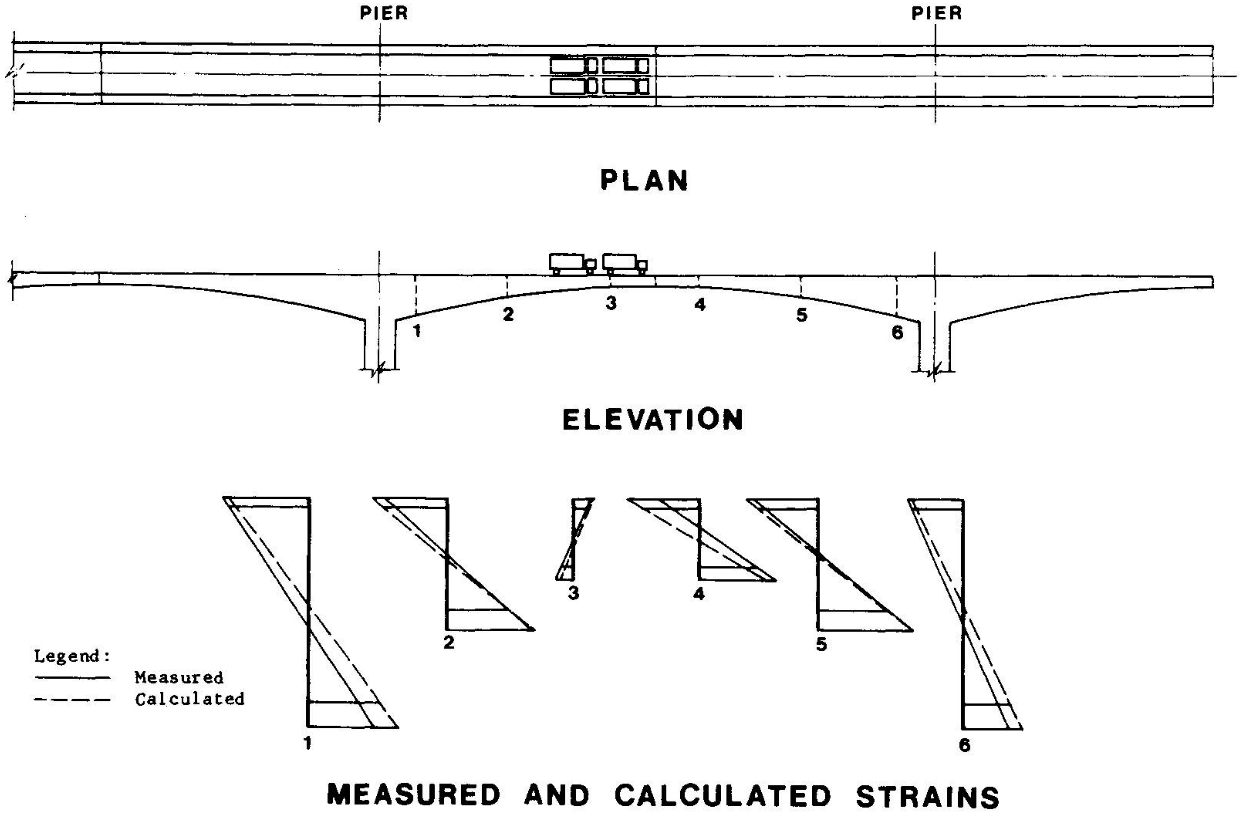


Figure 2

Traffic counts and strain gauge readings were checked against elastic analysis to determine the approximate live loading on the structure. Published annual traffic counts were then used to deduce the rate of increase in loading since the opening of the bridge.

In order to establish that all the design prestressing tendons were present, and also to check on their condition a radiograhic inspection was carried out using a Cobalt 60, 30 currie source. Radiographic plates were taken at sections across the top flange at five metre centres. However, where necessary additional plates were taken at intermediate locations. From this inspection it was concluded that all the design prestressing tendons were present but that approximately ten per cent were either partially or completely ungrouted. No signs of deterioration of either tendons or ducts were detected. A section of a typical plate showing grouted and ungrouted ducts is shown in Figure 3.

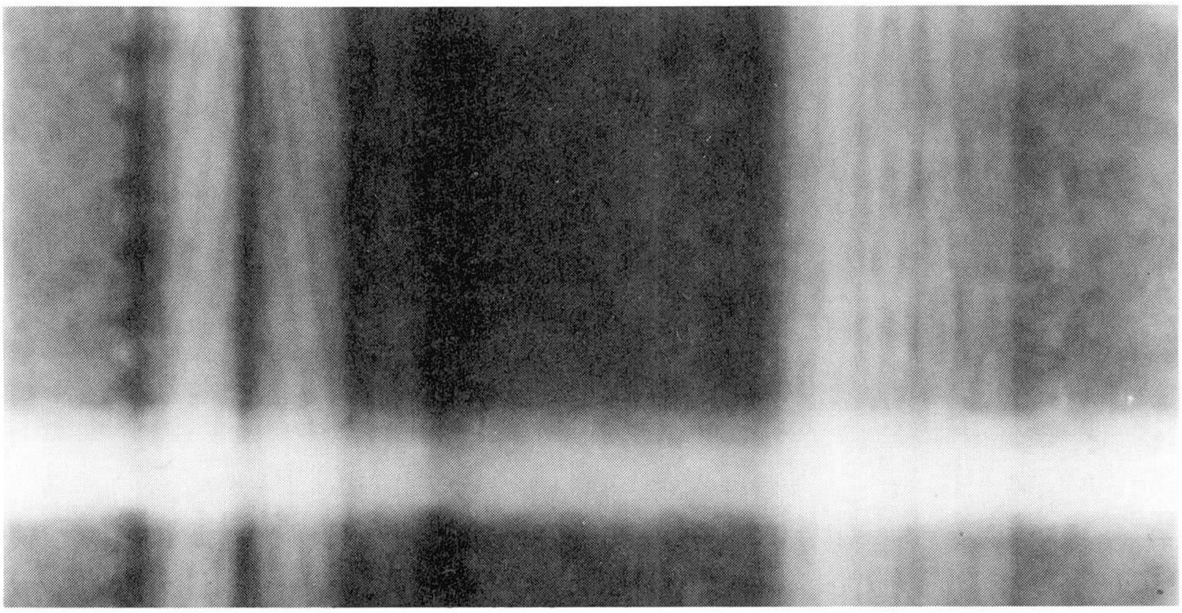


Figure 3

Throughout the period of assessement the bridge was monitored to ensure that no unexpected or sudden deterioration occurred. This monitoring continued for approximately two years and was held once a month over a twenty-four hour period. At regular intervals during the sessions the superstructure was levelled; the strain gauges read; temperature readings taken of the concrete surface, the high-voltage electricity cables and the surrounding air; and details obtained of the power loading through the cables.

Concurrent with the inspection, analysis of the bridge was carried out in two phases. The first phase covered the construction of the bridge, and the second its long-term behaviour. Level measurements had been taken of the piers and the tips of the cantilevers on 28th November 1974, about one year after structural completion. These measured values were adopted as a check on the first phase of analysis, and as the datum for long term calculations. The calculated levels for the cantilever tips on 28th November 1974 agreed very closely with those measured.

The long-term analysis, which was extended to cover a period of 125 years, investigated the effects of time-dependent loading and losses on the bridge's behaviour. These effects included the build up of live loading, variations in temperature, temperature distributions though the superstructure, concrete creep and shrinkage, and prestressing relaxation. The calculated and measured values in December 1983 were found to be in good agreement, and the calculations indicated that deflections could be expected to increase.

From the assessment it was concluded that:

(i) the bridge was generally constructed in accordance with the design;

(ii) while the servicability life of the bridge had almost been reached, the ultimate strength of the bridge was satisfactory; and,

(iii) the long-term analysis showed that the deflections, and their continuation ten years after completion could be predicted.

Subsequently inspections were extended to the remainder of the bridge and a rehabilitation scheme developed.

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Contributions:
Appraised & Proved by
Ministry of Machine
Building of China &
Hunan Construction Commission
Also Accepted by ASCE.

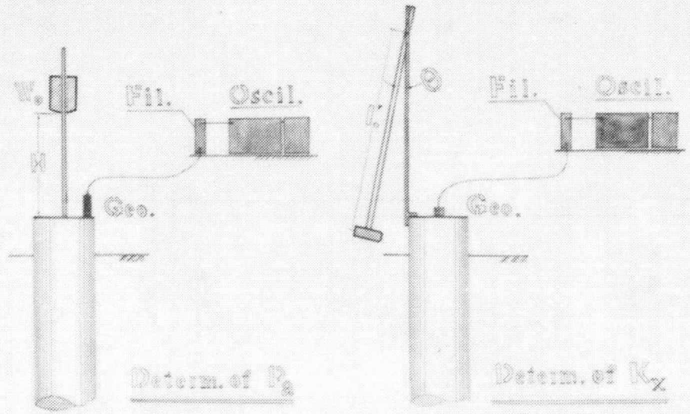
DYNAMIC DETECTIONS OF THE QULITY OF PILES

I. VERTICAL DETECTIONS

1. Determination of the Bearing Capacity of Fricton Piles:

$$P_a = \frac{0.03 f_v^2 (1+e) W_0 \sqrt{H} K_v}{K V_0}$$

2. PROGRAM: Available for Plotting SuperPosed Stress Diagrams of the Cap Beams on Piles with Stochastic Variability.

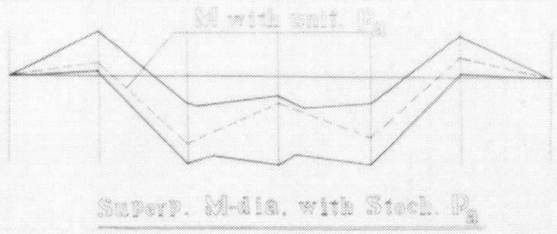


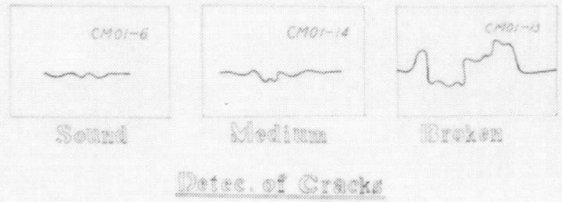
II. HORIZONTAL DETECTIONS

1. Determination of 16 Parameters—— Functions of K_x & β:

$$K_x = 25.29 \frac{f_x^2 W_e (1+e) L' \Theta}{V_0 T} K_h \; ; \; \beta = \sqrt[4]{\frac{K_x}{3 I E I}}$$

2. Detection of the Cracks on the Upper Portion of Piles





III. PRACTICE: Over 3000 Piles

IV. ECONOMY: Save Both Cost & Time 99%

V. LICENCE: No. XC—0010