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Summary of a report of the failure of falsework at the Birling Road Overbridge, Kent 1971

General

At approximately 1500 hours on Monday 22 March 1971 the falsework to the Birling Road Overbridge collapsed as the deck concrete was being poured. The bridge was part of a contract to provide a by-pass around Ditton on the A20 in Kent.

One man was killed [Victor Bernard Woodger (25)], five men were seriously injured and twelve others slightly injured.

Description of the project

The Birling Road Overbridge was a post-tensioned concrete bridge, consisting of three spans. The approach spans were of about 46 ft and the main span of 138 ft, all lying in a roughly north-south direction. The bridge was curved on plan and had a crossfall of one in fifteen. The underside of the deck was approximately 18 ft above ground level. The deck was 4 ft 6 in deep and contained void formers. A sketch of the bridge is in Figure 1.

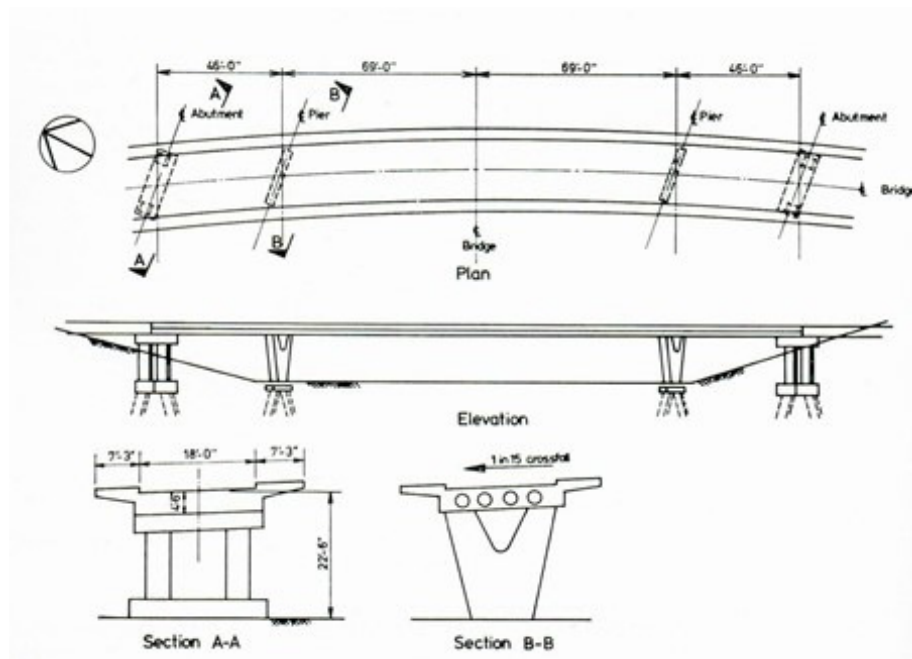


Figure 1 – Sketch of the bridge

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Foundations

Preparations for the construction of the bridge started early in 1970 with the replacement of peaty ground which lay above firm gravel. This entailed excavation to a depth of about 9 ft and replacement with compacted Folkestone sand.

Piling for abutments and piers took place in June 1970 and the construction of the abutments and piers was completed during November.

Falsework and formwork

A 'birdcage' type of falsework employing conventional 2 in diameter scaffold tubes and couplers, was erected on sleeper foundations. A gap was left to enable construction traffic to pass through the structure. The original intention was for this gap to be bridged by steel beams but it was finally decided to fill the gap with shoring frames. Some jacking was done to provide the correct soffit profile.

Formwork consisted basically of $\frac{3}{4}$ in plywood on 6 in x 3 in bearers at approximately 1 ft centres. These in turn were carried by double 9 in x 3 in timbers supported in the forkheads. The walkway areas of the bridge were cantilevered from the main deck and the shuttering for these was somewhat different.

The collapse

The concreting operation began at 0100 hours on the morning of 22 March at the south end and shortly afterwards work started at the north end. Both operations continued until 1500 hours when the collapse occurred. At this stage there remained a gap of about 37 ft between the two advancing faces of concrete. The south face was more advanced than the north and had reached the centre of the main span. Concrete was deposited by two pumps, one at each end of the bridge.

Witnesses both on and off the bridge described the collapse as starting with a sharp noise. All suggested the collapse started at the north end close to the pier and progressed in a wave across the span to the south end.

The main span collapsed entirely but the side spans remained more or less intact.

Matters arising from the investigations

There was no evidence to suggest that movement of the piers and abutments to the permanent works occurred.

Some areas of fill were more compact than others due to the movement of heavy traffic along the line of the future carriageway.

Timber sleepers had been bedded using sledge hammers.



The day after the collapse it was noted that there was evidence of a very high water table in the area of the bridge. Ponds could be seen either side of the span. The immediate top surface of the sand close to the bridge was moist.

Rainfall records obtained for the period 1 November 1970 to 22 March 1971 showed a total of 52.6 mm of rain in December, 63.6 mm in January, 17.3 mm in February and 54.2 mm up to 22 March. During the period 14-22 March a total of 41 mm was recorded and the heaviest rainfall of the three month period occurred on 17 March (14.6 mm). There was no rain on the day of the collapse.

On 22 March in the period of 0600 hours to 1500 hours the maximum wind speed recorded as 21 knots with an average of 17.7 knots for the period.

It was suggested that there had been a spring in the area of the north abutment for some time.

There is evidence to show that after the rain on 17 March the ground was waterlogged and erosion of the ground beneath some sleepers had occurred. Concrete was placed under some sleepers on 19 March.

The nature of the filled ground and its load bearing capacity was a subject for investigation. It was calculated that a symmetrically loaded sleeper would impose a load of about 1.8 tons per sq ft on the ground, but sleepers which were not symmetrically loaded were observed and calculations showed that in at least one instance pressures of 3 tons per sq ft could be expected.

Sleepers in the region of the north pier were examined and it was obvious that some were more deeply embedded in the sand than others. This suggested that settlement had occurred but not on a large scale.

There was difficulty in establishing whether final working drawings of the falsework provided at Birling Road ever existed. It was obvious that the structure which remained standing, that is the side spans, was not in accordance with a preliminary drawing produced. Enquiries suggested that the scaffolders used this drawing to obtain broad guidance.

No evidence could be found of swivel couplers having been used. The fact that the bridge was curved and skewed on plan meant that the angle between the transverse and longitudinal horizontal members was not 90°. The significance of this is that transverse bracing connected to the longitudinal members would not necessarily be in the same place as the rows of standards across the width of the bridge and could not be connected to them. An examination of the side spans confirmed that bracing in those areas was somewhat haphazard and that few connections were possible close to standards or at each lift because of the geometry.



The drawing previously referred to showed all bracings on the line of the standards. The drawing also specified the use of chairs with right angle couplers. No chairs were found on site.

Investigations showed that the bracing system was not uniform throughout the span and that connections were made at levels which meant that some bracings were unrestrained for relatively long distances.

From examination of the wreckage of the main span it was clear that the majority of standards had all failed in one direction and that the mode of failure was in a single curve from top to bottom. This suggested that the actual effective length of the standards in the collapse condition was not related to the distance between intermediate horizontal members. There was very little evidence of contraflexure between these members, i.e. between nodes.

Calculations had not been obtained for the falsework prior to the collapse.

The preliminary drawing gave an indication of design loads but a copy of the original calculations was not available.

Calculations to BS 449, assuming standards to be loaded concentrically and with an effective height between restraints of six feet, showed that there was a slight overstress but not sufficient to cause failure.

With the same restraint conditions but with a simple eccentricity applied at the forkhead and the resulting moment transferred into the vertical standard and the horizontal members according to their relative stiffnesses, a factor for combined bending and axial stress of 1.24 was obtained. (The appropriate factor recommended in BS 449 is unity).

The condition of an effective length based on the total height of the standard acting in single curvature and concentrically loaded, showed that the standard would fail. Similarly the assumption of full fixity at top and bottom again showed that the standard would fail.

Enquiries established that the falsework had been inspected in the week prior to the pour. As a result some additional bracings and standards were added.

A pile of unused bracing units were discovered in the wreckage. These were surplus to requirements. It was observed that in places the erection of the units was not in strict accordance with recommendations in respect of bracing and that in order to make up differences in height across the width of the bridge (due to crossfall), ordinary mild steel scaffold tubes had been coupled (with single couplers) to the tops of the towers.



An attempt had been made to connect together adjacent towers but it was difficult to establish the extent of this tying.

Some additional falsework supports below the cantilever at the side of the bridge had been fixed with the prime purpose of varying working platforms. It was connected to the rest of the falsework. Additional standards in the side span at the north end were added again connecting to the falsework. Scaffolds were also provided at the extreme ends of the bridge.

Calculations on the timber members comprising the formwork showed them to be stressed between 500 and 700 lb per sq in.

An absence of wedges in the forkheads was noted despite the obvious crossfall.

Concrete consolidation was by the use of six shutter vibrators in addition to poker vibrators. Three men did the job and at the time of the collapse were in the centre of the span and under the middle of the deck moving the vibrators.

The vibrators were clamped to the 6 in x 3 in timbers under the soffit.

There is evidence of movement of the shutters (or the falsework) on two occasions during the pour. Witnesses reported a slight movement of the deck at about 5.0 a.m. This was not reported to any of the engineers present.

About an hour before the collapse it was noticed that small pavement shutters on the east side of the bridge were beginning to lean over, the bottom spreading towards the centre of the bridge. This was investigated and apparently rectified by the carpenters.

Source:

Final report of the Advisory Committee on Falsework – Appendix 1, Case Studies, pp 103 to 107 - June 1975, HMSO, ISBN 0 11 880347 6 (“The Bragg Report”)

Aerial view of the devastation at Birling Road Overbridge
Ditton, Kent, March 1971 (p17)



The Press and Journal, Tuesday, March 23, 1971

One dead, 14 hurt as bridge crashes

A WORKMAN was killed and another man was missing and at least 14 men were injured when a bridge being built at Leybourne, Kent, for the Maidstone motorway by-pass extension collapsed yesterday afternoon.

At least 16 workmen were injured. Fleets of ambulances were summoned to take casualties to the West Kent hospital in Maidstone and the Medway Accident Centre at Gillingham.

As dusk fell workmen were digging desperately to remove tons of rubble believed to be covering the missing man.

After the bridge collapsed with a tremendous roar, raising clouds of dust visible for miles, police and firemen joined workmen in frantic efforts to haul scaffolding and rubble off the casualties.

'CHAOS'

An ambulance man described the scene as "absolute chaos."

He said that scaffolding and concrete were strewn right across the highway with injured men—some of them partly buried—lying everywhere.

Some of the injured were treated on the spot before being sent to hospital.

The dead man was later named as 25-year-old Mr Victor Woodger, of Snodland.

The bridge was being built over an unopened section of the Maidstone By-pass. Work was just past the half-way stage.

Evening Chronicle, Tuesday, March 23, 1971

Bridge checks after collapse

A DOZEN motorway bridges being built on the new Maidstone, Kent, bypass are to be examined for possible flaws, after yesterday's bridge crash at Leybourne, near Maidstone, in which one man died and 14 others were hurt.

This decision was made today by Costain, the bridge builders.

"We have no reason to believe that any of the other bridges will be suspect. But after what happened yesterday we feel it

would be wise to inspect them," said Mr. Gordon Morris, a Costain official.

Work on the disaster bridge stopped today and workmen were told not to move any rubble while investigations went on.

The man who was killed was under the bridge when it collapsed. Only a few minutes before, at least eight men had been standing close to the same spot.

The official inquiry is being held by the South Eastern Road Construction unit of the Department of the Environment.

The contractors are holding their own inquiry.

The Birmingham Post, Tuesday, March 23, 1971



Rescue work goes on amid tons of concrete and twisted girders after a motorway bridge being built over an unopened part of the Maidstone by-pass, collapsed yesterday. One man was killed.

One killed, 14 hurt in bridge collapse

A man was killed and 14 others injured yesterday when a motorway bridge being built at Leybourne, near Maidstone, Kent, crashed and buried workmen in the rubble.

Kent police last night named the dead man as Mr. Victor Woodger, aged 25, of Snodland, Kent.

Firemen, police and contractors hauled concrete and scaffolding off the trapped men. The injured were taken to West Kent General Hospital Maidstone, and the Medway Accident Centre, Gillingham.

The bridge was being built over an unopened part of the Maidstone bypass at Birling Road, and 40 men were working on it when it fell.

Cause unknown

The contractors, Costain Civil Engineering Ltd., said that the cause of the collapse was not known.

The bridge was one of 16 in a £4,400,000 contract for 6½ miles of dual carriageway on the A20 (M), between Coldharbour, Kent, and Wrotham Heath.

Work started early last year and will be completed next year.

Later, a Costain spokesman said: "The structure was of pre-stressed concrete, containing 800 cubic yards of concrete. There will be a full investigation. We already have our own experts on the site."

The Courier, March 26, 1971

MAN DIES AS BRIDGE COLLAPSES

AN inquest on a man who died when a motorway bridge at Leybourne, Maidstone, collapsed on Monday, is being opened in Tonbridge today (Friday).

Forty workmen escaped death when the bridge crashed on to the road below and 14 were injured. There was no warning of the disaster. The 100ft-long bridge cracked in the middle and a second or two later collapsed in a tangle of metal and concrete on the road 40ft. below.

The dead man is Mr. Victor Woodger, aged 25, of Fairview Caravan Site, Snodland. Among the injured was Mr. Rowen Amidjar of Old Road, East Peckham.