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Load Variations in Bridge Falsework

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Construction Method

It was necessary to construct the concrete box girder section on a multitude of tubular steel members using a proprietary frame system because of the complex geometry of the bridge and the heavy loads to be carried. The four spans are unequal, the bridge has a reverse curve on plan and it is on a vertical curve. The east abutment is adjacent to a disused railway tunnel whilst the west abutment is on the top of a steeply inclined schist slope which has a river at its foot. In the more heavily loaded areas there were 26 lines of tubular supports, many of which were expected to receive safe maximum working loads.

The box construction, up to 6.3 m overall depth, was constructed in 10 m lengths of bottom slab, walls and then road deck. After the first span and a quarter had been concreted and had matured, it was post-tensioned using a stressing gap whilst concreting continued westwards. The gap was then filled. This procedure was followed for three spans.

Design of Falsework

The falsework supports were designed to withstand the dead load of the concrete work plus the imposed loadings during construction immediately above, together with the distributed wind load from wind speeds of 46 m per second with reduction factors. The wind load calculations based on the Code for permanent structures gave unrealistic answers and questioning led to evaluation of a more relevant design approach to wind loads on multi-tubular frameworks.

The bridge designer was involved in the assessment of likely vertical movements of the bridge as post tensioning was carried out. Whilst the first two operations were predicted to give small acceptable movements, the third span cantilever was predicted to rise by 55 mm and the rotation about the adjacent pier would increase the load in the Falsework east of it. The difficulty of assessing the magnitude of this increase and the risk to the safety of the Falsework for use here or elsewhere led to the use of load-measuring gauges to monitor the load history in the more critical area.

Load History

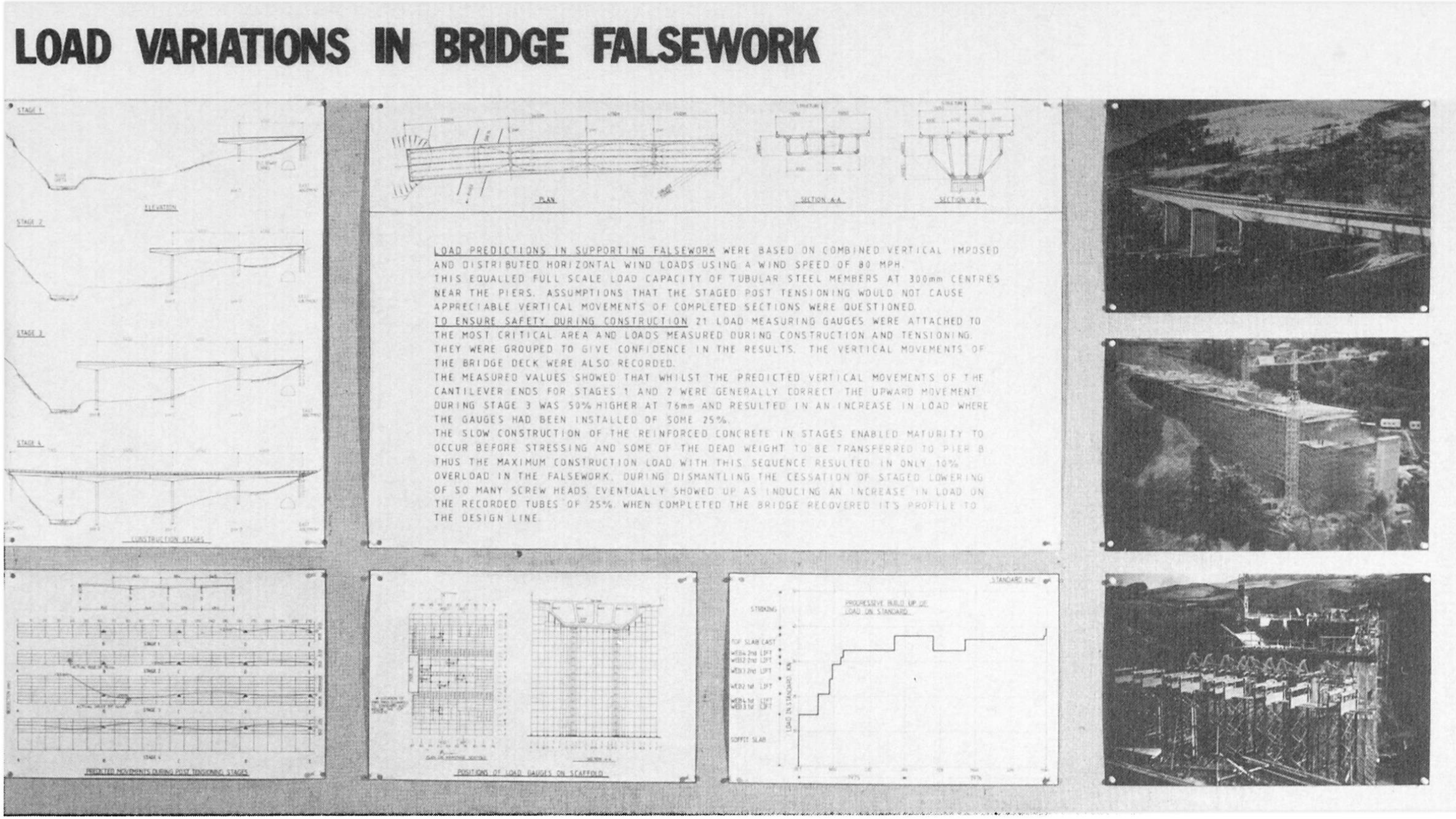
As concrete construction progressed the loads in the Falsework increased and approached the design values. As the concrete matured and particularly after a span was completed, the loads dropped in the Falsework as some 20% was transferred to the piers.

During post tensioning the third cantilever end rose by 76 mm and the adjacent span moved 14 mm downwards. The loads on the measured members rose by 25% from their previous values.

Subsequently, during removal of the Falsework the loads in some of the members which were the last to be fully relieved of load increased by a further 25%.

Summary

The measurements of the load history in the Falsework have shown the significance of post tensioning movements on supporting temporary works and the need to assess them. Monitoring of this kind is not only of value to future designs but enables safe control of Falsework to be demonstrated as the work proceeds.


LOAD VARIATIONS IN BRIDGE FALSEWORK
STAGE 1
ELEVATION
STAGE 2
STAGE 3
STAGE 4
CONSTRUCTION STAGES
PLAN
SECTION A-A
SECTION B-B
LOAD PREDICTIONS IN SUPPORTING FALSEWORK WERE BASED ON COMBINED VERTICAL IMPOSED AND DISTRIBUTED HORIZONTAL WIND LOADS USING A WIND SPEED OF 80 MPH.
THIS EQUALLED FULL SCALE LOAD CAPACITY OF TUBULAR STEEL MEMBERS AT 300mm CENTRES NEAR THE PIERS. ASSUMPTIONS THAT THE STAGED POST TENSIONING WOULD NOT CAUSE APPRECIABLE VERTICAL MOVEMENTS OF COMPLETED SECTIONS WERE QUESTIONED.
TO ENSURE SAFETY DURING CONSTRUCTION 21 LOAD MEASURING GAUGES WERE ATTACHED TO THE MOST CRITICAL AREA AND LOADS MEASURED DURING CONSTRUCTION AND TENSIONING. THEY WERE GROUPED TO GIVE CONFIDENCE IN THE RESULTS. THE VERTICAL MOVEMENTS OF THE BRIDGE DECK WERE ALSO RECORDED.
THE MEASURED VALUES SHOWED THAT WHILST THE PREDICTED VERTICAL MOVEMENTS OF THE CANTILEVER ENDS FOR STAGES 1 AND 2 WERE GENERALLY CORRECT THE UPWARD MOVEMENT DURING STAGE 3 WAS 50% HIGHER AT 76mm AND RESULTED IN AN INCREASE IN LOAD WHERE THE GAUGES HAD BEEN INSTALLED OF SOME 25%.
THE SLOW CONSTRUCTION OF THE REINFORCED CONCRETE IN STAGES ENABLED MATURITY TO OCCUR BEFORE STRESSING AND SOME OF THE DEAD WEIGHT TO BE TRANSFERRED TO PIER B THUS THE MAXIMUM CONSTRUCTION LOAD WITH THIS SEQUENCE RESULTED IN ONLY 10% OVERLOAD IN THE FALSEWORK. DURING DISMANTLING THE CESSATION OF STAGED LOWERING OF SO MANY SCREW HEADS EVENTUALLY SHOWED UP AS INDUCING AN INCREASE IN LOAD ON THE RECORDED TUBES OF 25%. WHEN COMPLETED THE BRIDGE RECOVERED IT'S PROFILE TO THE DESIGN LINE.
PREDICTED MOVEMENTS DURING POST TENSIONING STAGES
POSITIONS OF LOAD GAUGES ON SCAFFOLD
PROGRESSIVE BUILD UP OF LOAD ON STANDARD
STRIKING
TOP SLAB CAST
SOFFIT SLAB