Second note on the proposed field test of prestressed concrete beam at Cobourg, Ont.

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No. 150

TECHNICAL NOTE

NOT FOR PUBLICATION FOR INTERNAL USE

PREPARED BY L. J. Marcon CHECKED BY W.R. Schriever APPROVED BY R.F. Legget

PREPARED FOR DATE 28 April 1953

SUBJECT

Second Note on the Proposed Field Test of Prestressed Concrete Beam at Cobourg, Ont.

I Introduction

In the first Technical Note No. 131 titled "Proposed Field Test of Prestressed Reinforced Concrete Beam at Cobourg, Ontario" the reasons for the test, details of the beams, design loads, possible test methods, loading schedule and instrumentation were explained.

The first Technical Note was circulated to all those known to be interested in the test and to friends of the Division to inform them of the test, and to solicit critical comments and suggestions from them.

Since then a great number of comments have been received by letter and in many discussions particularly with the Research Staff of the Hydro-Electric Power Commission of Ontario (the "Hydro") and of the Structures Section of the Division of Mechanical Engineering of the National Research Council. The generous response to the first Technical Note has been a great encouragement to the staff of this Division. Appreciation for this assistance is here gratefully recorded.

The purpose of this second Technical Note is to present a final proposal for the method oftesting in order to obtain agreement with the proposal from those concerned. Copies will be sent to those who received the first Technical Note; any further comments will be greatly appreciated. Since the detailed planning of the test has been developed jointly by the Hydro research staff and the staff of the Division of Building Research, this Note represents their combined conclusions, taking into consideration the fact that the test is not a straight forward research operation but an attempt to get as much as possible out of a large field test with the staff and facilities available.

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The respective staffs have undertaken different parts of the investigations herein summarized but it does not seem necessary to attempt to separate individual contributions in this Note.

II Possible Test Methods

In accordance with the majority of comments received after distribution of the first Note, it was decided to load one beam in its normal vertical working position. After consultation with the Hydro staff it was decided to use a reaction beam fabricated from standard Bailey Bridge parts. The test frame arrangement is shown in drawing BR 439.

Opinions varied over the method of applying the loads to the beam. Some recommended that the loads be applied by yokes to the purlin seats because in prestressed concrete secondary stresses are of considerable importance. Therefore it originally seemed desirable to test the beam in such a way as to make the combination of stresses the same as in actual practice. It is now thought, however, that in view of the large amount of money and time being spent on the test, loads should be applied on the top of the beam since one of the twenty-two purlin seats might fail before the beam proper due for instance to variations in workmanship. On failure, a purlin seat would damage the lower flange and/or the web of the beam, thus giving a much earlier beam failure. There is obviously more to be gained by the knowledge of the actual carrying capacity of the prestressed concrete beam than the carrying capacity of the concrete seat. In order to complete the test, separate loading tests upon specimen seats will therefore be undertaken on sections of the broken beam obtained after the beam has been loaded to destruction. These tests can be done in Cobourg immediately after the loading test on the beam or in a laboratory with a standard testing machine.

III Details of Beams

Since the writing of Technical Note 131, more details of the beam have been received and are shown on drawing BR 438.

IV Design Loads and Computed Test Loads

A more accurate design load figure has been received from the designer of the beam, it is now 16,100 lb. per purlin instead of the original 17,730 lb.

In order to decide on the sizes of various items of equipment it was necessary to compute the estimated maximum loads at which the beam would fail. A theoretical stress analysis of the beam was made as the original design calculations were not available.

The calculations were based on the following assumptions: A maximum concrete strength of 7,000 p.s.i. and a maximum steel strength of 220,000 p.s.i. For both spans equally loaded the maximum loads at the first partial failure (which will probably occur at the haunch) is 43.3 kips per purlin seat (reaction at haunch 324 kips). The actual total collapse of the beam may occur at any point after this loading has been reached, the exact load depending on the type of failure at the haunch. In any case the maximum loading which the beam could possibly sustain is an estimated purlin loading of 56.7 kips.

For the condition where one span is loaded with live load and the other with the dead load only, the corresponding purlin point loads are 50.6 kips and 77.4 kips. In this case, however, the point of first failure will be at the centre of the loaded span.

V Loading Schedule

The following loading schedule has been drawn up. After each load has been removed deflection readings will be taken at various time intervals to check on any possible creep.

Loading Schedule:

	Loading to	Increment	Remarks
(1)	Roof Dead Load (7,780 lb./purlin)	2,000 lb./ purlin	
(2)	Dead Load and Live Load (7,780 + 8,320 lb./ purlin)	4,000 and 2,000 lb./ purlin	
(3)	Repeat (2) as a check	4,000 and 2,000 lb./ purlin	
(4)	Dead Load and 1-1/2 Live Load	1/2 Live Load and 2,000 lb./purlin	Nat. Bldg. Code requirement (75% deflection recovery in 24 ~~lb.~~ hr.)
(5)	Repeat (4) if necessary		
(6)	Span A: Dead Load and Live Load Span B: Dead Load	1/2 Live Load	Asymmetric Loading
(7)	Span A: Dead Load Span B: Dead Load and 1-1/2 Live Load	1/2 Live Load	Asymmetric Loading

	Loading to	Increment	Remarks
(8)	Span A: Dead Load and 2 Live Load Span B: Dead Load	1/2 Live Load	Asymmetric Loading
(9)	Span A: Dead Load Span B: Dead Load and 2-1/2 Live Load	1/2 Live Load	Asymmetric Loading
(10)	Dead Load and 2-1/2 Live Load Hold for 30 days	1/2 Live Load	Sustained Load Test
(11)	Dead Load and 1 Live Load	1/2 Live Load	Check against (2) and (3)
(12)	Dead Load and Failure Load	1/2 Live Load and smaller	Test to failure

VI <u>Instrumentation</u>

(a) <u>Loads</u>: An accuracy of approximately 2 per cent is regarded as desirable for proper evaluation of the test results. Two methods of measuring the loads applied at each purlin point were considered, namely by pressure gauges attached to the hydraulic jacks and by "load cells" using electric strain gauges. It is hoped that, in order to simplify the test, it will be possible to obtain the desired accuracy without using the additional load cells. As soon as the jacks and pressure gauges have been delivered to the Division they will be separately calibrated on a testing machine. The effect of friction in the glands of the jack is included in the calibration and is partly responsible for the observed hysteresis effect. In the case of an operator over-shooting the required pressure during a test, it will be necessary for him to lower the pressure to a figure slightly below the required pressure and raise it again to ensure that the jack effort will always correspond to that shown by the same calibration curve.

Load cells using electric strain gauges will be placed under the ends and the centre of the beam to measure the reactions and also to serve as a check on the overall jacking load. The load cells will also be calibrated in advance.

(b) <u>Deflections</u>: Deflections will be recorded at each purlin point and at both ends, thus giving a total of 13 points from which a very good load deflection curve can be plotted. The initial deflections of the beam will be measured by the use of 1" dial indicators. Gauge blocks will be used to extend the range of dial indicators.

As a further check on deflections, and especially to measure larger deflections near failure, piano wires attached to the beam and coming together at a "deflection board" will be used. This system is successfully used by Structures Laboratories at National Research Council in their loading tests of airplane structures and involves the use of a length of piano wire (0.010 in. in diameter) attached to the structure at each point where a deflection measurement is required. The wire is then led over a system of pulleys to a vertical deflection board. Each wire is placed under a tension of approximately one pound by suspending a brass weight from its free end so that the weight hangs from the pulley above just clear of the face of the deflection board.

Any vertical displacement of the point of attachment is instantaneously and directly indicated by a similar displacement of the corresponding brass weight. In order to record the displacement, a sheet of paper is fastened on the board and the position of the weights marked with a pencil. The important advantages of this method are that any progressive deflection under load can be detected immediately and that remote measurement is possible.

Further readings on deflections will be made by a precise optical levelling instrument at the ends and centre of the beam to check on any settling.

To check on any possible tipping of the beam dial indicators will be placed at two opposite edges of the beam and any difference in readings will indicate tipping. This will be done at the ends and the centre of the beam. In addition spirit levels will be used to check any tipping at the mid span locations.

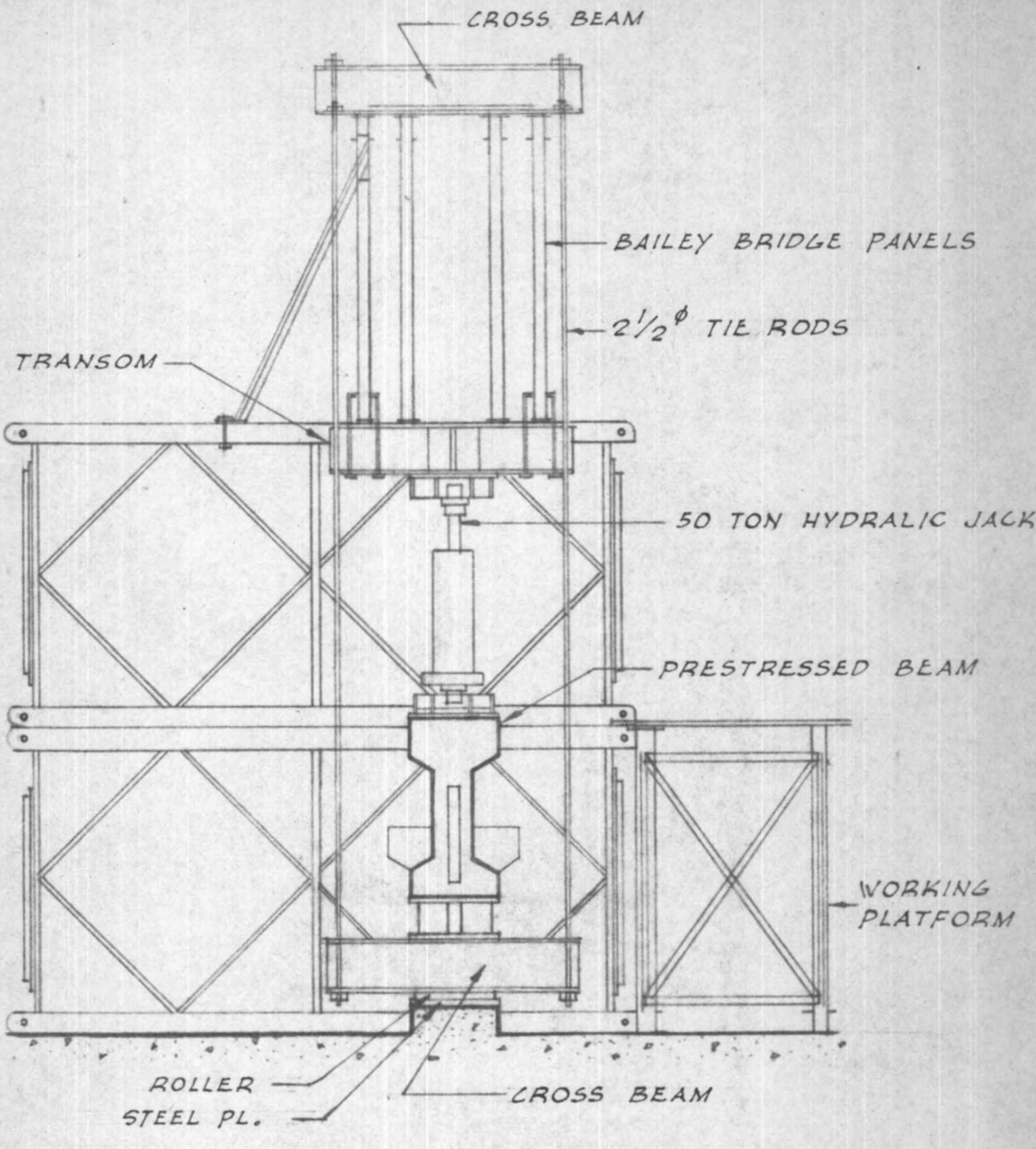
(c) Strain Measurements: Only one half of the beam will be gauged for stress measurements.

STEEL:- Strains in the prestressing wires will be measured by electric strain gauges. Six of each group of 24 wires will be gauged. Strain gauges will be placed on steel near mid span.

CONCRETE:- Concrete strains will be measured during post-tensioning operations and also during the test by electric strain gauges attached to the girder.

In view of the fact that the beam was made under normal field conditions and not under conditions which could be called "controlled conditions" from a research point of view, it is not considered that the project warranted the extensive instrumentation required for complete strain measurements. The Division, however, will attempt to proceed with a limited program of strain measurements, partly in order to gain experience in this type of work and partly to increase the value of the load and deflection measurements.

It is intended to measure strains in the prestressing wires by electric resistance wire strain gauges in six of each of the two 24 wire groups near the middle of the beam. If time and staff permit concrete strains will be measured also by electric resistance wire strain gauges and possibly by mechanical extensometer.



SECTION A-A

BR 439 - B

MAY 20, 1953 BY A.B.