Prestressed Concrete Bridge Members

SPECIAL REPORT ON 3/8 IN. GALVANIZED STRANDS

by

Louis J. Debly

This work has been carried out as a part of an investigation sponsored by the following:

American Steel & Wire Div., U. S. Steel
Concrete Products Company of America
Lehigh University
Pennsylvania State Highway Department
Reinforced Concrete Research Council
John A. Roebling's Sons Corporation
U.S. Bureau of Public Roads

Fritz Engineering Laboratory
Department of Civil Engineering
Lehigh University
Bethlehem, Pennsylvania

June, 1956

(Not for Publication) $2.50
I. INTRODUCTION

The Lehigh Prestressed Concrete Committee at its last meeting, decided to cast and test two beams, containing 3/8 in. galvanized strands manufactured by John A. Roebling's Sons Corporation. The bonding characteristics of the strand was to be investigated with a minimum amount of instrumentation. The beams were to be tested statically with center-point and third-point loadings.

The concrete cylinder strength at release was established at 4000 psi.

The beams are designated as follows: the letter A denotes center-point loading, and the letter B, third-point loading. The casting date follows:

II. DESIGN AND DESCRIPTION OF BEAMS

A. Concrete Mixes

The mix contained 5.7 sacks of "high-early" strength cement per cubic yard and 7 gallons of water to the sack with adjustments for the moisture content of the aggregates.

B. Concrete Properties

At release, 7 days after pouring, the average of 4 cylinders was 5070 psi. At test, 14 days after pouring,
the average of 9 cylinders was 6140 psi. The modulus of rupture was 695 for Beam A-5-10 and 600 psi for Beam B-5-10.

C. Description of Beams

The beams were cast 6 in. wide, 12 in. deep and 12 ft. long. Two strands were placed with centers 2-1/2 in. from the bottom and 2 in. on centers symmetrically in the cross section.

Table I shows the losses in the prestress forces according to BPR Criteria.

Table I - Measured Prestress Forces Based on BPR

<table>
<thead>
<tr>
<th>Beam</th>
<th>Initial Tension in Strands</th>
<th>% of Ult.</th>
<th>Prestress Forces After Losses</th>
<th>% of Ult.</th>
<th>% of Losses</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-5-10</td>
<td>23,500</td>
<td>71.3</td>
<td>20,610</td>
<td>63.6</td>
<td>12.5</td>
</tr>
<tr>
<td>B-5-10</td>
<td>22,800</td>
<td>69.2</td>
<td>19,880</td>
<td>60.2</td>
<td>12.8</td>
</tr>
</tbody>
</table>

Table II shows the concrete stresses in the extreme fibers calculated from the forces given in Table I.

Table II - Concrete Stresses Based on BPR

<table>
<thead>
<tr>
<th>Age at Release</th>
<th>Beam</th>
<th>$f_{ci}$</th>
<th>$f_{bot}$</th>
<th>$f_{top}$</th>
<th>$f_b$</th>
<th>$f_t$</th>
<th>After Losses</th>
<th>$f_{bot}$</th>
<th>$f_{top}$</th>
<th>$f_{ci}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 days</td>
<td>A-5-10</td>
<td>5070</td>
<td>-797</td>
<td>+141</td>
<td>15.7</td>
<td>2.8</td>
<td>-767</td>
<td>+135</td>
<td>15.1</td>
<td>2.7</td>
</tr>
<tr>
<td>7 days</td>
<td>B-5-10</td>
<td>5070</td>
<td>-684</td>
<td>+112</td>
<td>13.5</td>
<td>2.2</td>
<td>-656</td>
<td>+104</td>
<td>12.9</td>
<td>2.1</td>
</tr>
</tbody>
</table>
The calculated ultimate moment based on BPR is 23,400 ft. lbs. Subtracting the dead load moment and dividing by three results in a design load of 2,580 lbs. for center-point loading and 3,860 lbs. total for third-point loading.

III. TESTING PROCEDURE

A. **Jacking**

The strands were tensioned individually by means of a hydraulic jack to approximately 1,650 lbs. The mechanical jacks were then used to tension all four strands simultaneously while measuring the force in the strands by using previously calibrated dynamometers between the strand grips and moveable crosshead of the jacking frame.

B. **Release**

Brackets with two Ames dials (.001 in.) were mounted on each strand to measure the slip. The camber was measured by Ames dials mounted at the center and quarter-points of the beams. The load was released in eight increments with camber and slip readings being taken.

C. **Test**

The instrumentation at test consisted of two Ames dials mounted on each strand to measure slip and an Ames dial to measure center-point deflection.
The load was applied in 500 lb. increments to slightly over observed cracking load. The load was removed and reapplied in 1000 lb. increments to the previous load, then in 500 lb. increments to ultimate.

IV. RESULTS OF TEST

A. Release

Fig. 1 shows the slip as the load was gradually released. The average values from the two strands are plotted for both ends of each beam.

Figs. 2 and 3 show the increase of camber at center-line and quarter-points during and after release.

B. Static Tests

The load deflection curves are shown in Figs. 4 and 5.

Fig. 6 shows a photograph of the beams after testing was completed.
V. SUMMARY

A. Cracking Load

Table III compares the cracking load computed by BPR Criteria with the experimental.

Table III - Cracking Load

<table>
<thead>
<tr>
<th>Beam (B-5-10)</th>
<th>Observed Cracking Load</th>
<th>Computed Cracking Load by BPR</th>
<th>Ratio of Observed to Computed</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-5-10</td>
<td>6200</td>
<td>5770</td>
<td>1.07</td>
</tr>
<tr>
<td>B-5-10</td>
<td>8200</td>
<td>7870</td>
<td>1.04</td>
</tr>
</tbody>
</table>

Table IV compares the computed ultimate to the experimental ultimate. Both beams failed by crushing of the concrete in the top fibers.

Table IV - Ultimate Moments

<table>
<thead>
<tr>
<th>Beam (B-5-10)</th>
<th>Experimental Ultimate Load</th>
<th>Computed Ult. Load by BPR</th>
<th>Ratio of Observed to Computed</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-5-10</td>
<td>344,000 in. lbs</td>
<td>282,000 in. lbs</td>
<td>1.22</td>
</tr>
<tr>
<td>B-5-10</td>
<td>327,000</td>
<td>282,000</td>
<td>1.16</td>
</tr>
</tbody>
</table>
The modulus of elasticity obtained from cylinders is $3.53 \times 10^6$ for both beams at time of testing. The values obtained from the deflections are $4.03 \times 10^6$ for Beam A-5-10 and $3.87 \times 10^6$ for Beam B-5-10. The cracks in Beam B-5-10 (Fig. 6) were quite evenly spaced along the middle third of the beam indicating good bond in that beam. Only four cracks developed in Beam A-5-10 and were quite evenly distributed although they were wider than those in B-5-10. The strands did not slip at ultimate load.
Fig. 1 - Strand Slip
Fig. 2 - Camber During and After Release (A-5-10)
Fig. 3 - Camber During and After Release (B-5-10)
Fig. 4 - Load Deflection Curve (A-5-10)
Fig. 6 - Elevation View of Beams after Applying Ultimate Load