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PRESTRESS LOSS AND CREEP CAMBER IN A HIGHWAY BRIDGE WITH REINFORCED CONCRETE SLAB ON PRETENSIONED PRESTRESSED CONCRETE BEAMS

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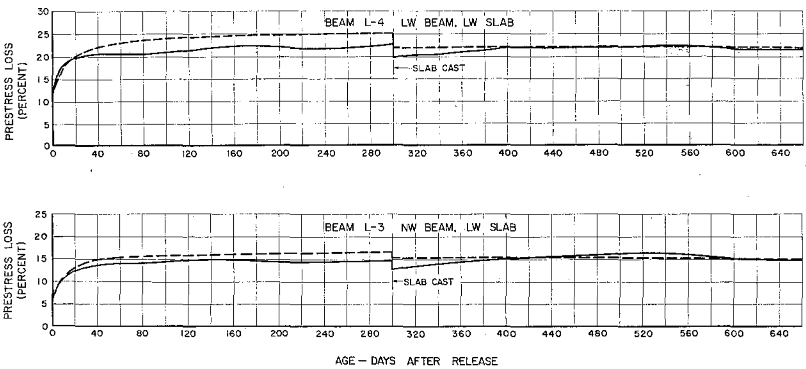

Midspan deflection of bridge beams.

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Prestress Loss and Creep Camber in a Highway Bridge With Reinforced Concrete Slab on Pretensioned Prestressed Concrete Beams

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Time dependent camber and prestress losses are among the matters of primary concern to the designer of prestressed concrete structures. Simple span bridges made up of prestressed concrete beams and cast-in-place reinforced decks are widely used on Texas highways. Such a bridge is the subject of the study described briefly here.

The eight-lane bridge had four prestressed concrete simple beam spans of 40, 56, 56, and 56 ft. and a cast-in-place reinforced concrete deck. It was designed by the Bridge Division of the Texas Highway Department and was constructed on IH 610 over South Park Boulevard in Houston, Texas in 1967. The prestressed beams were fabricated and stored in the yard in Houston approximately 10 months before the bridge was built.

Slab and beam elements were made of either normal weight or lightweight concrete as shown in Table I. The lightweight concrete used natural sand fines and expanded shale (Featherlite) coarse aggregate. The normal weight concrete used sand fines and crushed stone coarse aggregate. Seven sacks of Type III cement per c.y. were used for all beams except those for span R-2 where a 7½-sack mix was used.

The slab used similar aggregates and a 5-sack mix in the NW slab and 5½ sacks in the LW slab. The air content was nominally 5% for NW and 8% for LW, both determined from pressure meter measurements.

During the test of almost two years duration, air temperatures varied from about 100°F to about 50°F, and the variation in relative humidities was from about 90% to about 60%. These figures represent 10-day averages; day and hourly variations covered wider ranges in both temperature and relative humidity.

Strains were measured from gages embedded in selected beams at ends, ¼ span, and midspan stations near top and bottom surfaces and at mid-depth. A 10-inch mechanical gage was used for that purpose.

Elevations read with a precise level from points at ends, ¼ span, and midspan stations were taken from some of the beams.

Time functions of shrinkage and creep were developed from the strain data and were used in predicting beam camber and prestress loss. A step-by-step procedure using discrete time intervals was used in a computer program in those predictions. Figure 1 shows the measured camber as a solid line and the predicted camber as a dashed line. Prestress losses computed from beam strains are shown on the front page in a similar way. The information shown in the figures is typical of similar information developed from other beams in the bridge.

Table II gives further information on prestress losses. Relaxation of the steel strands is not included in prestress losses given in this report;

TABLE I. BEAM AND CAMBER DATA

Beam Mark	Beam Span	Concrete Beam	Concrete Slab	Cure	At Release: Age (Days)	At Release: Midspan Stresses Top (psi)	At Release: Midspan Stresses Bot. (psi)	At Release: Midspan Camber Upward (ins)	Midspan Camber 300-Day Age (ins)	Elastic Downward Defl. Under Slab DL (ins)	Camber Beam & Slab at 640-Day Bm. Age
L-1	40	LW	LW	Steam	2	−80	1460	0.40	0.72	−0.10	0.46
R-1	40	LW	LW	Wet Mat	3	−60	1400	0.33	0.53	−0.15	0.38
L-2	56	LW	NW			160	2830	NO DATA			
R-2	56	LW	LW	Steam	1	−130	2520	1.30	2.06		1.20
L-3	56	NW	LW	Wet Mat	2	80	2730	.62	1.10	−0.26	0.58
R-3	56	NW	LW	Steam	2	80	2730	.64	1.17	−0.23	0.60
L-4	56	LW	LW	Steam	1	−130	2520	1.32	2.11	−0.54	1.46
R-4	56	LW	NW	Steam & Wet Mat	7	180	2790	1.12	1.73	−0.67	0.72

Slab was placed at approximately 300-day beam age.

Approximate Secant Modulus of concretes taken at ½ f'_c at release of prestress:

$E_{LW} = 2{,}950{,}000$ psi; $E_{NW} = 6{,}900{,}000$.

At 220-day-age: $E_{LW} = 3{,}220{,}000$ psi; $E_{NW} = 5{,}900{,}000$.

TABLE II. PRESTRESS LOSSES AT MIDSPAN

Beam	Span (ft)	Concrete Bm	Concrete Slab	Midspan (Sta. C) Prestress Loss (% of Pre-release) (Determined from strain measurements): Release (elastic)	Slab Cast (elastic)	Net elastic	Final	Time Dependent*	Ratio of Losses (Time Dependent / Elastic)
L-1	40	LW	LW	7.44	−1.57	5.87	15.93	10.06	1.71
R-1	40	LW	LW	6.01	−1.43	4.58	14.92	10.34	2.26
L-4	56	LW	LW	11.75	−2.97	8.78	21.83	13.05	1.49
R-4	56	LW	NW	10.45	−2.16	8.29	20.84	12.55	1.51
L-3	56	NW	LW	7.46	−1.46	6.00	14.57	8.57	1.43

*Final minus total elastic.

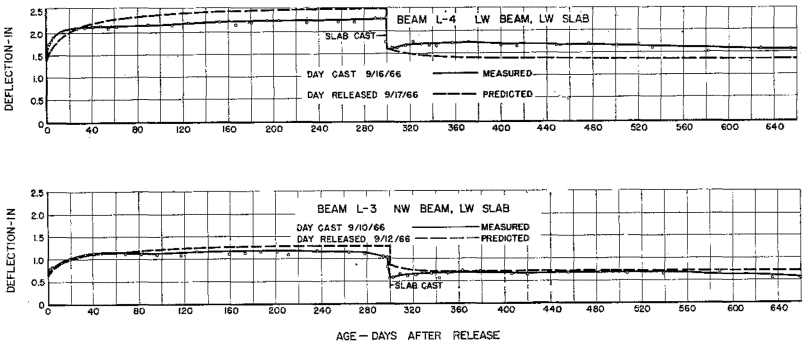

Figure 1. Prestress loss in bridge beams.

it may be accounted for by direct addition of the relaxation loss to the values given here.

Measurements of beam deflections under the dead weight of the plastic slab concrete were one-half to two-thirds of the values computed by theory using secant modulus determined from tests. No good explanation has been found to explain the nonagreement between theory and the field measurements.

Major conclusions drawn from the study are:

1. Time dependent camber and prestress loss due to creep and shrinkage can be closely predicted by the step-by-step method and the digital computer. Accurate creep and shrinkage functions derived from strains measured from concrete under conditions similar to those of the bridge concrete are necessary for good predictions.

2. Most of the time dependent camber and prestress losses developed within 90 days after beam fabrication.

3. Midspan prestress losses in the 56-ft. beams at 10-month age were nominally 14% for NW concrete and 21% for LW concrete beams. At 660-day age, the losses were essentially unchanged. Steel relaxation is not included in these percentages.

4. The elastic changes in camber and prestress losses when the plastic slab was cast were almost offset by time dependent changes in camber and prestress losses occurring after the slab was cast—from 10-month age to 660-day age.

5. Ratios of 10-month camber, just prior to slab casting, to elastic camber at prestress release were: 1.7 for 40-ft. LW beams, 1.6 for 56-ft. LW beams, and 1.8 for 56-ft. NW beams.

6. The ratios of final beam cambers to net elastic cambers (release plus slab casting) were: about 1.6 for the 56-ft. NW beams and 1.9 for the 56-ft. LW beams.

7. The ratios of time dependent prestress losses to the net elastic losses (release plus slab casting) were about 1.5 for both the LW and NW 56-ft. beams. The ratio was higher for the 40-ft. beams.