BOND CHARACTERISTICS OF AN SCC MIX FOR KANSAS PRESTRESSED CONCRETE BRIDGE GIRDERS

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ABSTRACT

Results from tests used to determine the material and bond characteristics of a proposed SCC mix for bridge girders in the state of Kansas are presented. Eleven full-scale, pretensioned SCC flexural specimens were tested to evaluate the transfer and development lengths. These specimens were single-strand specimens that included specimens designed to evaluate the so-called "top-strand" effect. These top-strand specimens, with more than twenty inches of concrete below the strand, were tested to evaluate the current AASHTO requirement of a thirty percent increase in the development length when more than the twelve inches of concrete is cast below the strand. Prior to casting the beams, the prestressing strand was pre-qualified using the Large Block Pullout Test procedure.

Strand end-slip measurements, used to estimate the transfer lengths, indicated that the proposed SCC mix meets the ACI and AASHTO requirements. In addition, flexural tests on the same specimens, confirmed that the SCC mix also meets the current code requirements for development length. Furthermore, the test results indicated that a thirty percent increase in development length was not necessary to achieve full tensile capacity of the strand in the "top-strand" specimens.

Keywords: Development length, Prestressed concrete, Self-consolidating concrete, Transfer length.

INTRODUCTION

Self-Consolidating Concrete (SCC) has rapidly become a widely used material in the construction industry. SCC is defined as "a highly workable concrete that can flow through densely reinforced or geometrically complex structural elements under its own weight and adequately fill voids without segregation or excessive bleeding without need for vibration.[1]"

The Interim Guidelines for the use of Self-Consolidating Concrete in PCI Member Plants[1] recommend that "strand bond tests shall be run with new SCC mixes to verify that the bond with SCC is equivalent or better than a conventional concrete of similar design when using similar strand." Furthermore, these guidelines state that "this can be done using a flexural development length test or by direct load testing." Since SCC does not require any external vibration during placement, there has been concern by some design engineers about the ability to achieve adequate bond between the SCC and the prestressing strand.

PROBLEM STATEMENT

The Kansas Department of Transportation (KDOT) would like to use SCC in pretensioned bridge members to enhance aesthetics and improve consolidation in congested areas. Kansas precasters want to use this type of concrete for a variety of reasons. A drawback with conventional concrete is that in hard-to-vibrate areas, such as the flange of inverted T-shape members, air becomes trapped at the surface of the form producing "bug" holes, Figure 1. SCC will help ensure proper consolidation and a smooth finish on these surfaces.

Fig. 1 "Bug" holes in bottom flange of IT

Before allowing the use of SCC in state bridge girders KDOT wanted to investigate the bond and flexural characteristics of an SCC mix proposed by the local precaster. Since SCC is placed without external vibration, KDOT was concerned that the bond between the SCC and strand may not be as strong as that achieved with a conventional concrete mix. Moreover, at the time of this study, information about the transfer and development length of prestressing steel in SCC and the applicability of the American Concrete Institute (ACI) and American Association of State Highway Transportation Officials (AASHTO) equations to these members, were essentially absent from the literature.

Transfer length is the distance required to transfer the fully effective prestressing force from the strand to the concrete. Development length is the bond length required to anchor the strand as it resists external loads on a member.[2] As external loads are applied to a flexural member, the member resists the increased moment demand through increased internal tensile and compressive forces. The increased tension in the strand is achieved through anchorage to the surrounding concrete.[3]

Current ACI[4] and AASHTO[5] design requirements do not address the use of SCC in prestressing applications. The ACI code expressions for transfer and development lengths are based on tests performed with conventional concrete and are shown below.

Transfer length (L_{tr}):

$$L_{tr} = f_{se} d_b / 3 \tag{1}$$

Development length (L_{dev}):

$$L_{dev} = f_{se} d_b / 3 + (f_{ps} - f_{se}) d_b \tag{2}$$

where

d_b = diameter of strand (in.)
f_{se} = effective stress is prestressing strand after allowance of prestress losses (ksi)
f_{ps} = stress in prestressing strand at calculated ultimate capacity of section (ksi)

The AASHTO specifications are similar but require an additional 1.6 multiplier to equation 2 for precast, prestressed beams.

BACKGROUND

KDOT funded an initial investigation in which Large Block Pullout Tests[6] (LBPTs) were performed at Kansas State University (KSU) using both the standard mix recommended by Logan[6] and the proposed SCC mix. The results with SCC had both lower first-slip and ultimate load values compared to those values when conventional concrete was used, Tables 1 and 2. Both of the LBPTs used strand from the same un-weathered reel and which had exhibited satisfactory bond performance in flexural beam tests.

Table 1 LBPTs conducted with SCC

SCC Block with Control Strand		
Specimen	**Max Load (kips)**	**Load at 1st Slip (kips)**
#1	21.8	11.8
#2	21.4	12.5
#3	19.7	12.4
#4	27.5	10.7
#5	23.2	12.7
#6	21.4	10.7
Average	**22.5**	**11.8**

Table 2 LBPTs conducted with control mix

Control Mix with Control Strand		
Specimen	**Max Load (kips)**	**Load at 1st Slip (kips)**
#1	42.0	28.2
#2	41.7	27.8
#3	40.4	27.3
#4	36.5	24.9
#5	36.9	24.2
#6	39.9	25.0
Average	**39.5**	**26.2**

TEST PROGRAM

Based on these early findings it was then determined that full-scale development length girder tests were necessary to further investigate the bond between SCC and the prestressing strand. Therefore, KDOT funded an experimental program to evaluate the flexural performance of pretensioned concrete members with the proposed SCC mix.

MATERIAL PROPERTIES

Large Block Pullout Tests

Prior to casting any flexural test specimens, the prestressing strand that would be used for all test girder specimens was pre-qualified using the LBPTs. Standard LBPT procedures, as stipulated by Logan[6], were followed while performing these tests. These strand qualification tests were performed with the standard mix proposed by Logan[6] and not with SCC. The average first-observed slip was 21.6 kips and the average ultimate was 39.6 kips. The values are both above the minimum values recommended by Logan[6] of 16 kips and 36 kips, respectively. Thus, the strand reel was deemed acceptable for use in this study. This reel was then covered to prevent weathering and used for all flexural beams reported herein.

Mix Design

Casting of test specimens was performed at Prestressed Concrete Inc, in Newton, Kansas (PCIN), which is a PCI certified plant that produces bridge members. PCIN developed their proposed SCC mix design with the help of their admixture supplier. The SCC mix used in this study along with the conventional concrete mix that this plant uses is presented in Table 3. It should be noted that, both mixes use a ¾-inch maximum aggregate size and have a 0.30 and 0.41 water-to-cementicious materials ratio for the SCC and the conventional concrete mix, respectively. Also note that a different high range water reducer is used for the SCC and conventional concrete mix.

Table 3 SCC and Conventional Concrete Mix Design

	SCC	**Conventional**
Materials	**Quantity per yd^3**	**Quantity per yd^3**
Cement (Type III)	750 lbs	650 lbs
Fine Aggregate(MA1 Sand)	1500 lbs	1480 lbs
Coarse Aggregate (CA-6, 1" - # 67)	1360 lbs	1457 lbs
Air Entrainment	5 oz	6 oz
High Range Water Reducer	70 oz	26 oz
Viscosity Modifying Agent	0 oz	0 oz
Water	27 gal	31.6 gal
W/C ratio	0.30	0.41

Fresh Concrete Evaluation

During the casting of the specimens, the SCC mix was tested to determine its rheological properties. At the time of casting, there were no existing ASTM standards for testing SCC, but the PCI Interim Guidelines[1] document many test methods to evaluate the plastic properties of SCC for production qualifications. In this study, Inverted Slump Flow, Figure 2, VSI, J-Ring, Figure 3, and L-Box, Figure 4, tests were all performed on the concrete during casting. The Inverted Slump Flow measures the flow separation resistance, stability/settlement resistance, air migration, and relative viscosity. The J-Ring and L-Box are both tests that measure the passing ability and blocking resistance of the SCC mix.

Fig. 2 Spread Test for SCC

Fig. 3 J-Ring test for SCC

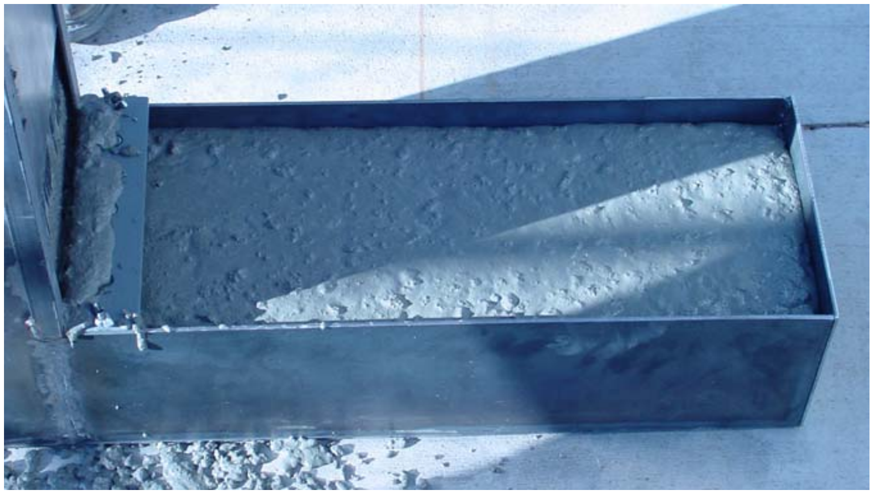

Fig. 4 L-Box test for SCC

Hardened Concrete Properties

The compressive strength and modulus of elasticity of the concrete were measured for future use in analytical computations. Standard ASTM procedures were followed for compressive strength and modulus of elasticity testing. In addition to measuring one-day (release) strengths; compressive strengths were determined just prior to loading the flexural specimens to failure. A set of three 4 x 8 in. cylinders were tested for each flexural specimen and the average values were recorded.

TRANSFER LENGTH MEASUREMENTS

Mast's strand slip theory as presented by Logan[6] was used to determine the transfer length of the girders experimentally. End-slip values were obtained by measuring the distance that the strand slipped into the beam at the ends. Prior to detensioning, a mark was made on the strand with a saw blade at a distance approximately one inch from the specimen end. A steel block having a width of exactly 0.500 inches was then held against the concrete at the strand location. The distance between this machined block and the mark on the strand was then measured using a digital caliper having a precision of 0.001 inches. This value was then used as the baseline for measurements taken after detensioning to determine the amount of end-slip that occurred. Subsequent measurements were taken up to the time of testing of the specimen. The following equations were used to determine the implied transfer length values from the end-slip measurement data.

$$\Delta = {avg\ f_{si} L_{tr}} / {E_{ps}}$$

where

$\Delta =$ end slip (in.)

$=$ measured length between steel block and strand minus elastic shortening between the mark on the strand and specimen end

$avg\ f_{si} =$ average initial strand stress over the tranfer length after release of prestress (ksi)

$L_{tr} =$ transfer length (in.)

$E_{ps} =$ elastic modulus of strand (ksi)

Assuming straight line variation in the strand stress from zero at the end of the beam to full prestress;

$$\Delta = {0.5 f_{si} L_{tr}} / {E_{ps}}$$

Thus :

$$L_{tr} = {\Delta E_{ps}} / {\left(0.5 f_{si}\right)}$$

FLEXURAL SPECIMEN TYPES

Single-Strand Development Length Specimens

Twelve single-strand development length specimens with different embedment lengths were fabricated and tested in this investigation. However, due to a handling error with one of the specimens only eleven were tested to failure. The single-strand specimens were used to evaluate two different embedment lengths. Two different cross-sections were utilized in order to evaluate the so-called "top strand" effect, having 12 in. or more of concrete cast below the reinforcement. ACI requires a 1.3 multiplier on development length for "horizontal reinforcement so placed that more than 12 in. of fresh concrete is cast in the member below the development length or splice," (ACI 12.2.4). AASHTO uses a similar 1.3 multiplier for strand development length when using an Alternate Development Length Equation (AASHTO 5.11.4.2-2).

The first cross-section cast was the standard 8 x 12 in. section that was used by Peterman et al.[7]. The nomenclature used for these specimens was **S**ingle-**S**trand **B**eams (SSB). This section contained a single prestressing strand at a depth d_p of 10 in., Figure 5. The section chosen was slightly larger than the 6.5 inch wide tested by Logan[6] in order to provide an increased shear capacity. This was desirable since these specimens did not have any shear reinforcement. Refer to the Appendix for shear capacity calculations and other sample calculations.

Specimens with the second single-strand cross-section used to evaluate the "top-strand" effect, are denoted **T**op-**S**trand **B**eams (TSB). These specimens had a width of 8 in. and an overall height of 24 in., Figure 6. The strand in these specimens was located 22 in. from the bottom, and thus greatly exceeded the 12 in. height requiring a 1.3 multiplier for development length by AASHTO. At the center portion of these specimens, however, the strand height was only 12 in. At mid-span, a Styrofoam blockout was used to reduce the height from 24 in. to 12 in., Figure 7. These specimens were inverted prior to testing. Note at mid-span, which is the critical section; these specimens had an identical cross-section to the SSB specimens. Therefore, direct comparisons between results are possible.

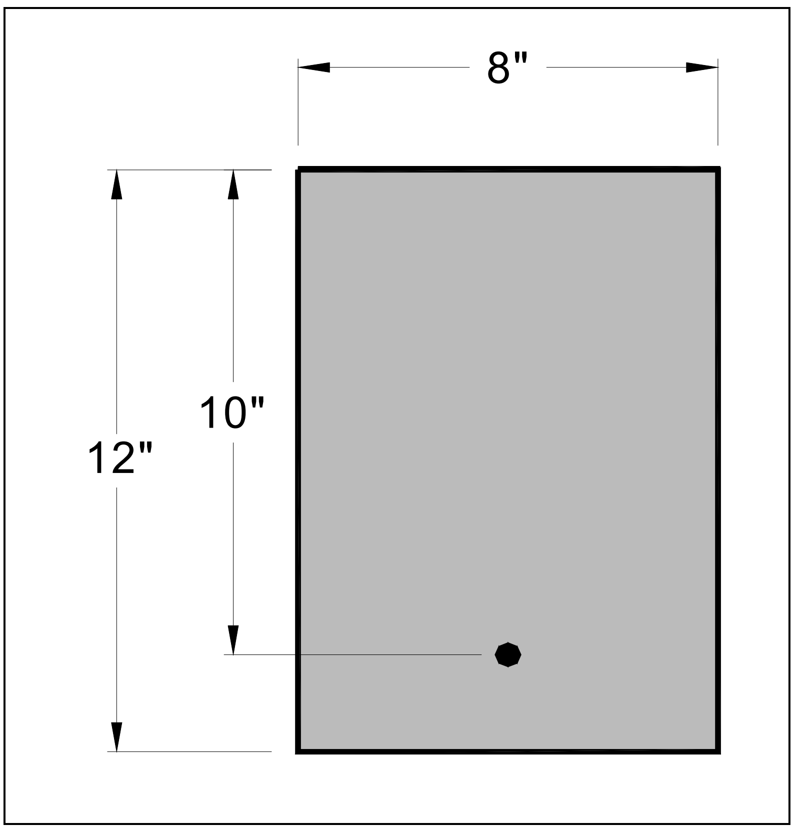

Fig. 5 Cross section of bottom strand girders

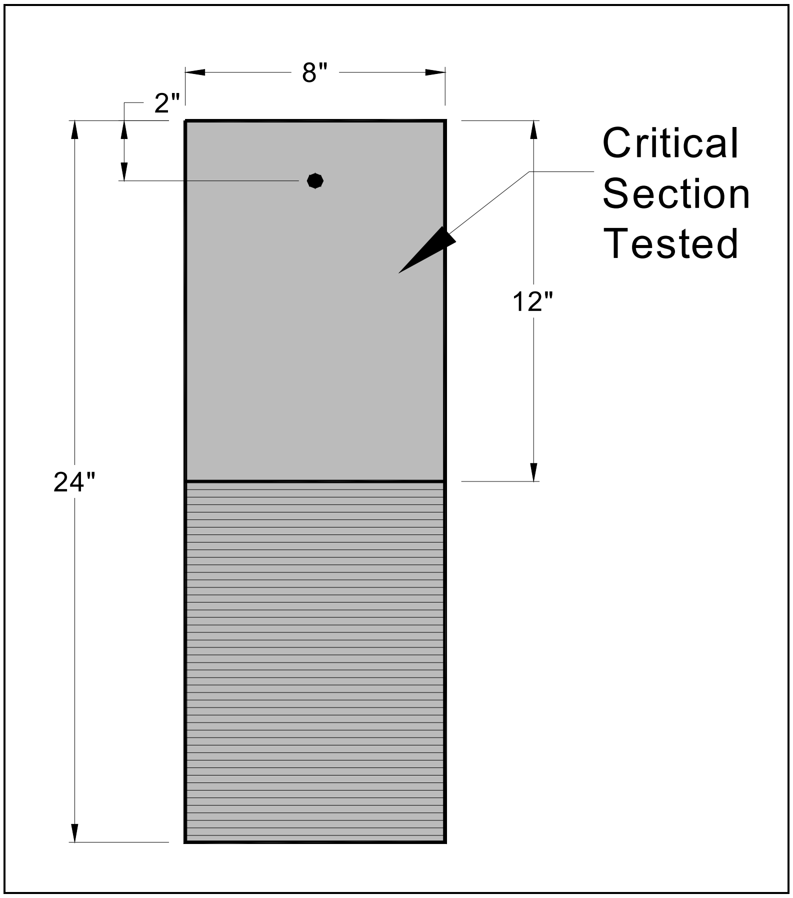

Fig. 6 Cross section of top strand girders

Fig. 7 Blockouts for top strand beams

Embedment Lengths

At the outset of this experimental program the researchers decided to evaluate two different embedment lengths. Crack formers, Figure 8, were cast at the embedment length to insure that during loading the first cracks would open at his location. The first set of specimens was tested at an embedment length equal to 100% of the calculated development length (l_{dev}). The second set of specimens was tested at either 80% l_{dev} or 120% l_{dev}, depending on the results obtained from the 100% l_{dev} specimen tests. The second set of specimens was specifically designed to allow for testing at either embedment length as explained below.

If the 100% l_{dev} specimens failed (by flexure) at a moment greater than or equal to the calculated nominal moment capacity, M_n, then the second set of specimens would be tested at an embedment length equal to 80% l_{dev}. However, if the 100% l_{dev} specimens failed (by bond) at a moment less than the calculated nominal moment capacity, M_n, then the second set of specimens would be tested at an embedment length equal to 120% l_{dev}. Since all of the 100% l_{dev} specimens failed by flexure (as later discussed in results section of this manuscript), the second set of specimens were tested at an embedment length equal to 80% l_{dev}.

The different embedment length testing of the second set of specimens was made possible by utilizing four crack formers per beam, Figure 9. As shown in this figure, the 80% l_{dev} tests required the use of the spreader beam with loading points directly above the outer-most crack former.

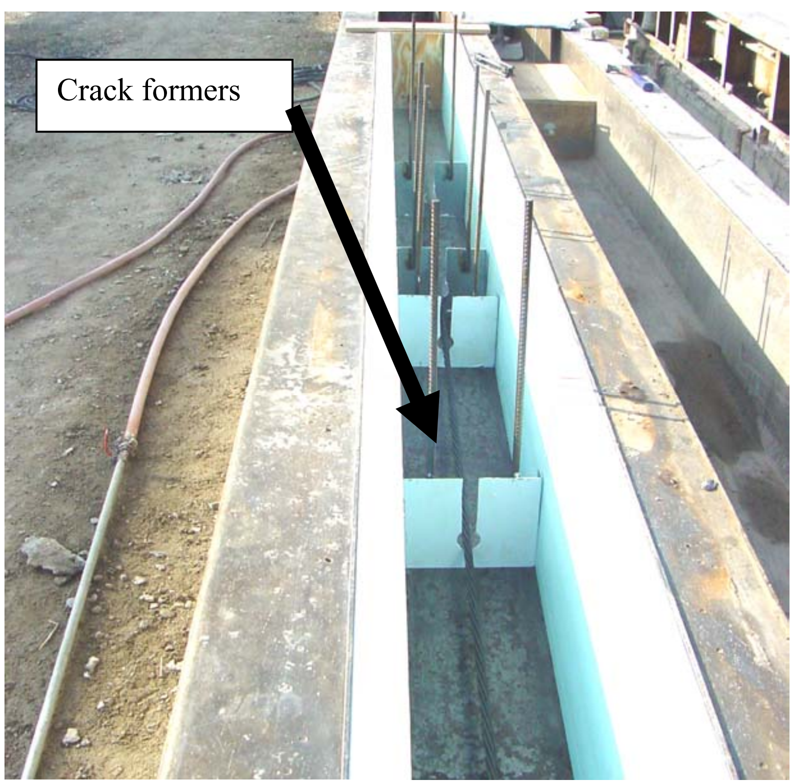

Fig. 8 Crack formers

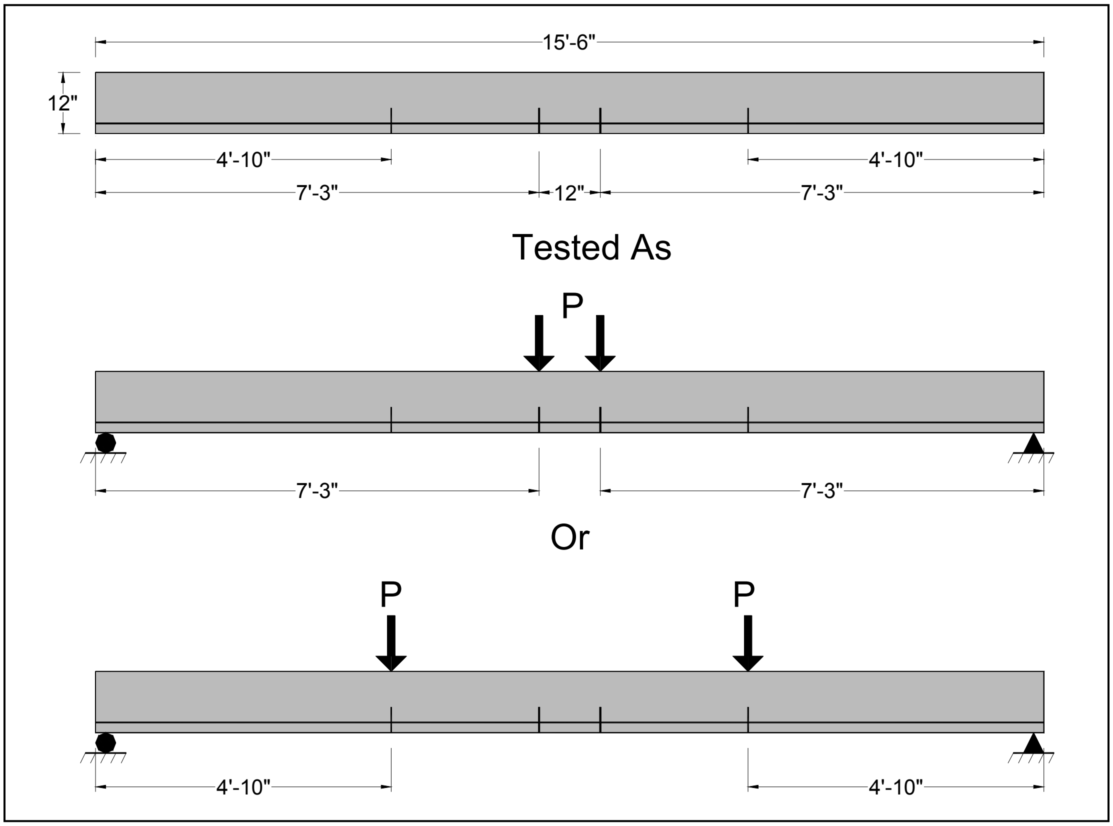

Fig. 9 Test setup for 4'-10" embedment length for bottom strand beams

LOADING CONDITIONS

Three types of loading rate conditions were used for evaluating the different embedment lengths. The first loading condition was designated as the SLOW test and was targeted to take about ten hours. During a SLOW test, the specimen was loaded at 100 lbs/min until cracking. Then the loading rate was reduced to 10 lbs/min until failure. This slow loading rate was used in order to accurately measure the amount of strand slip, if any, occurring prior to failure. For the second loading condition, designated as 76.5 % M_n, the specimen was loaded at 100 lbs/min up to 76.5% of nominal capacity of the specimen, then this load was maintained for twenty-four hours. This load condition was modeled after ACI 20.3.2 for the testing and evaluation of existing structures. If the specimen successfully withstood the load for 24 hours, it was then loaded at 10 lbs/min to failure. The final loading condition, designated as 100% M_n, was similar to the 76.5% M_n procedure, except that load was maintained at 100% M_n for 24 hours. Table 4 shows the loading condition of each specimen tested along with the corresponding development length.

Table 4 Loading conditions for beams testes

	Beam	Embedment Length	Loading Condition
Bottom Strand	SSB A	6'-1"	76.5% M_n
	SSB C	6'-1"	SLOW
	SSB D	4-10"	100% M_n
	SSB E	4-10"	SLOW
	SSB F	4-10"	76.5% M_n
Top Strand	TSB A	4'-10"	76.5% M_n
	TSB B	4'-10"	100% M_n
	TSB C	4'-10"	SLOW
	TSB D	6'-1"	100% M_n
	TSB E	6'-1"	76.5% M_n
	TSB F	6'-1"	SLOW

TEST SETUP

All specimens were tested using a 22-kip MTS servo-controlled actuator in the KSU Civil Engineering Department Mechanics of Materials Laboratory. Data was collected for load, mid-span deflection, strand end-slip, and tension face crack opening. End slip readings were monitored by using an LVDT. Figure 10 shows the test frame setup that was used to load all specimens. A spreader beam with rollers was used to apply point loads directly above the crack formers. Roller connections were used to apply the point load at these locations.

Fig. 10 Beam setup

RESULTS

TRANSFER LENGTH

As described earlier, end-slip measurements were used to estimate the transfer length of each girder. In these calculations, f_{si} was assumed to be 196.2 ksi for all single strand specimens. For all bottom strand beams, none had a longer implied transfer length (21-day) than assumed by the ACI code. The average implied transfer length was 21 in. for the SSB specimens and 32 in. for the TSB specimens. Figure 11 presents the range and average implied transfer lengths for all the specimens tested, along with the ACI code assumptions.

FLEXURAL TEST RESULTS

Flexural failure by strand rupture was the failure mode of all specimens tested in this study. In each case, the experimental moment exceeded the calculated nominal moment capacities by 10%- 20%, Table 5. In Table 5 the spread column refers to the test referred to in Figure 2. Furthermore, the maximum end-slip recorded for all specimens during testing was less than 0.01 in.

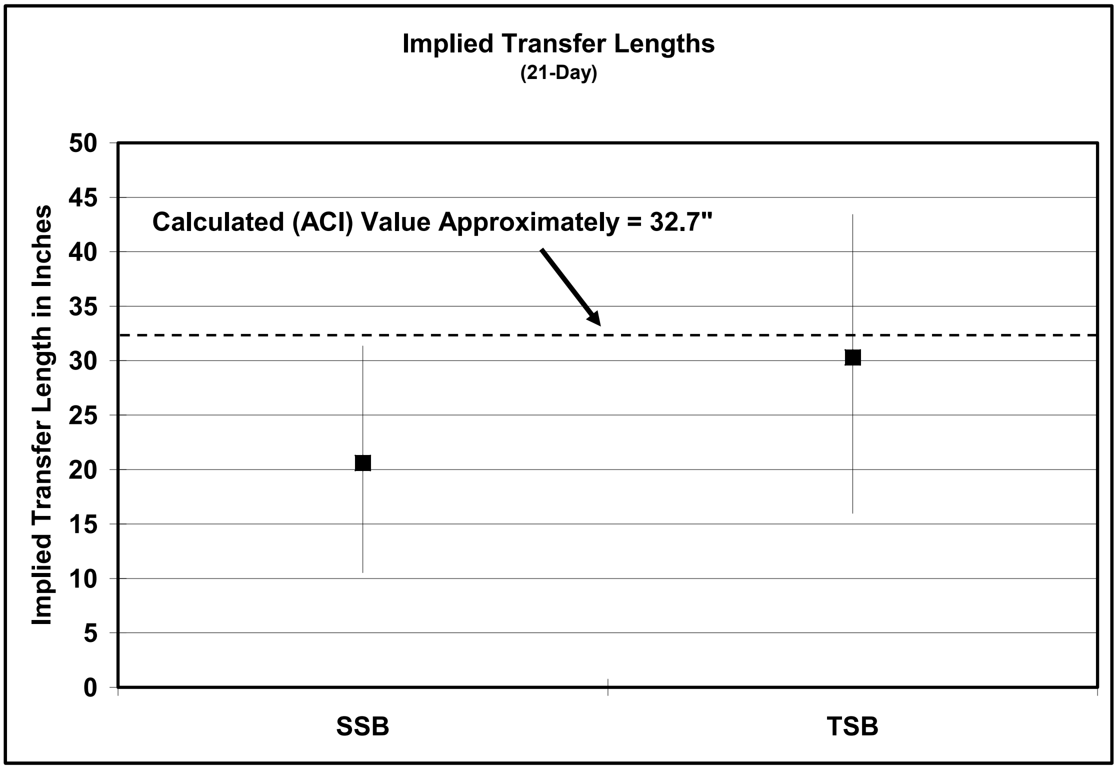

Fig. 11 Transfer Length Results

Table 5 Results of Specimens Tested

	Beam	Spread (in)	% M_n Achieved	Strand Rupture	Strand Slip >0.01"
SSB	A	21	110.9	Yes	No
	C	21	115.4	Yes	No
	D	22	117.2	Yes	No
	E	22	113.3	Yes	No
	F	22	115.7	Yes	No
TSB	A	28	116.2	Yes	No
	B	28	116.4	Yes	No
	C	28	115.3	Yes	No
	D	28	112.6	Yes	No
	E	28	116.6	Yes	No
	F	28	114.0	Yes	No

CONCLUSIONS

1. Transfer lengths estimated from 21-Day strand end-slip measurements were in general accordance with the values assumed by the AASHTO and ACI specifications. The average implied transfer lengths for the top-strand beams were approximately 50% greater than those for the corresponding bottom-strand beams.
2. Flexural tests indicated that the current ACI (and thus also the AASHTO) equations for strand development length were conservative for the SCC mix and specimen geometry used in this study. Moreover, all of the load tests conducted on specimens with an embedment length equal to eighty percent of the ACI development length, including those with more than 12 in. of concrete below the strand, failed in flexure by strand rupture.

REFERENCES

1. Interim Guidelines for the use of Self-Consolidating Concrete in Precast/ Prestressed Concrete Institute Member Plants, First Edition, Chicago, IL, 2003.
2. PCI Design Handbook, Fifth Edition, Precast/Prestressed Concrete Institute, Chicago, IL, 1999.
3. Khayat, K. H., Assaad, J., and Daczko, J., "Comparison of Field-Oriented Test Methods to Assess Dynamic Stability of Self-Consolidating Concrete," ACI Materials Journal, V. 101, No. 2, March-April 2004, pp. 168-176.
4. ACI Committee 318, "Building Code Requirements for Structural Concrete (ACI 318-02) and Commentary (ACI 318R-02)," American Concrete Institute, Farmington Hills, MI, 2002.
5. AASHTO, LRFD Bridge Design Specifications, 3rd Ed., American Association of State Highway and Transportation Officials, Washington, DC, 2004.
6. Logan, Donald R., "Acceptance Criteria for Bond Quality of Strand for Pretensioned Prestressed Concrete Applications," PCI JOURNAL, V.42, No. 2, March-April 1997, pp.52-90.
7. Peterman, R. J., Ramirez, J. A., and Olek, J., "Influence of Flexure-Shear Cracking on Strand Development Length in Prestressed Concrete Members," PCI JOURNAL, V. 45, No. 5, Sept-Oct 2000, pp. 76-94.

APPENDIX

Prestress Losses and Nominal Calculations for SSB specimen
Assume that
$\varepsilon_c = 0.003 \qquad f_c^{'} = 8{,}000\,\text{psi} \qquad f_{pu} = 270\,\text{ksi}$

See Figure 4 for rectangular prestressed concrete beam with following properties:

$b = 8\,\text{in}$ $h = 12\,\text{in}$ $d_p = 10\,\text{in}$

$A = 96\,\text{in}^2$ $I = 1152\,\text{in}^4$ $y_b = 6\,\text{in}$

$e = 4\,\text{in}$ $\beta_1 = 0.85 - [0.05(f_c^{'} - 4,000)/1,000] = 0.65$

$E_{ps} = 28{,}500\,\text{ksi}$ $A_{ps} = 0.153\,\text{in}^2$ $f_{pj} = 0.75*(270) = 202.5\,\text{ksi}$

$P = 202.5*0.153 = 30.983\,\text{kips}$ $E_{ci} = 3{,}600\,\text{ksi}$

$E_c = 5{,}000\,\text{ksi}$ $\text{Self Weight} = 93.33\,\text{lb/ft}$

$L_b = 13.17\,\text{ft}$ $M_{sw} = \dfrac{93.33*(13.17)^2}{8}*12 = 24{,}376\,\text{lb}-\text{in}$

$V/S = 2.33$ $RH = 65\%$

Loss Calculations (Based on PCI Handbook 5th Edition[9])

Elastic Shortening (ES)

$$ES = K_{es} * E_{ps} * f_{cir}/E_{ci}$$

$$f_{cir} = K_{cir}\left[\frac{P}{A} + \frac{P*e^2}{I}\right] - \frac{M_{sw}*e}{I}$$

$$= 0.9\left[\frac{30{,}983}{96} + \frac{30{,}983*4^2}{1152}\right] - \frac{24{,}276*4}{1152}$$

$594\,\text{psi}$

with $K_{cir} = 0.9$ for pretensioned members

$K_{es} = 1.0$ for pretensioned members

$$ES = 1.0*28{,}500*0.594/3600 = 4.70\,\text{ksi}$$

Creep (CR)

$$CR = K_{cr}*(E_p/E_c)*(f_{cir} - f_{cds})$$

with

$$CR = 2.0*(28{,}500/5000)*.594 = 6.77\,\text{ksi}$$

Shrinkage (SH)

$$SH = (8.2x10^{-6})*K_{SH}*E_p*(1 - 0.06*(V/S))*(100 - RH)$$

with

$$SH = (8.2x10^{-6})*1.0*28{,}500*(1 - 0.06*2.33)*(100 - 65) = 7.04\,\text{ksi}$$

Relaxation (RE)

$$RE_L = [K_{RE} - J*(SH + CR + ES)]*C$$

with

$$RE_L = [5.0 - 0.04*(4.7 + 6.77 + 7.04)]*1.0 = 4.26$$

$$RE_i = f_{st}\left\{\left[\log 24t - \log 24t_1\right]/24\right\}*\left[f_{st}/f_{py} - .55\right]$$

$$= 202,500*\left[\log 18\right]/45*\left[202,500/243,000 - .55\right] = 1.60\,\text{ksi}$$

Total Losses

$$f_{si} = f_{pj} - ES - RE_i$$

$$= 202.5 - 4.7 - 1.6 \approx 196\,\text{ksi}$$

$$f_{se} = f_{pj} - ES - CR - SH - RE_L$$

$$= 202.5 - 4.7 - 6.77 - 7.04 - 4.26 \approx 180\,\text{ksi}$$

Calculated Transfer Length (using equation 1)

$$L_{tr} = f_{se} d_b / 3$$

$$196*.5/3 = 32.67\,\text{inches}$$

Experimental Implied Transfer Length (Sample Calculation)

$$\Delta_{end-slip} = .060 - \left(\frac{PL}{AE}\right)_{elastic\,shortening} = .060 - \left(\frac{30.98*1}{.153*28,500}\right) = .055\,\text{inch}$$

$$\mathrm{L_{tr}} = {}^{\Delta E_{ps}}\!\big/_{.5 f_{si}} = {}^{.055*28,500}\!\big/_{.5*196} = 16\,\text{inch}$$

Calculated Development Length (using Equation 2)

$$L_{dev} = f_{se} d_b / 3 + (f_{ps} - f_{se}) d_b$$

$$= 180*.5/3 + \left(268.2 - 180\right)*.5 = 74\,\text{inch}$$

Nominal Capacity using Strain Compatibility

$$P_e = f_{se} * A_{ps} = 180 * 0.153 = 27.54\,\text{kips}$$
$$\varepsilon_1 = f_{se} / E_p = 180/28{,}500 = 0.00623$$
$$\varepsilon_2 = \frac{1}{E_c}\left[\frac{P_e}{A} + \frac{P_e * e^2}{I}\right] = \frac{1}{5000}\left[\frac{27.54}{96} + \frac{27.54 * 4^2}{1152}\right] = .000134$$
$$\text{Assume } f_{ps} = 268.2\,\text{ksi}$$
$$a = \frac{A_{ps} * f_{ps}}{0.85 * f_c^{'} * b} = \frac{0.153 * 268.2}{0.85 * 8 * 8} = 0.754$$
$$c = a / \beta_1 = 0.754 / 0.65 = 1.16$$
$$\varepsilon_3 = \left(\frac{d_p - c}{c}\right) * \varepsilon_c = \left(\frac{10 - 1.16}{1.16}\right) * 0.003 = 0.0229$$
$$\varepsilon_{ps} = \varepsilon_1 + \varepsilon_2 + \varepsilon_3 = 0.00623 + 0.000134 + 0.0229 = 0.0294$$
$$\textit{From Curve in Handbook}$$
$$f_{ps} = 270 - \frac{0.04}{\varepsilon_{ps} - 0.007} = 268.2\,ksi\,(\textit{Equals assumed value})$$
$$M_n = A_{ps} * f_{ps} * \left(d_p - \frac{a}{2}\right) = 0.153 * 268.2 * \left(10 - \frac{.754}{1}\right) = 394.9\,\text{kip-in}$$
$$32.9\,\text{kip-ft}$$

Shear Capacity

$$\textit{Test Span} \quad L_{test} = 12.83\,ft$$
$$\textit{Shear Span} \quad a_{test} = 5.92\,ft$$

$$M_D + M_L = 32.9\,kip - ft$$
$$\frac{(0.0933) * (12.83)^2}{8} + \frac{P_F}{2}(5.92) = 32.9$$
$$P_F = 10.5\,kips$$
$$V_{\max} = 0.0933 * (6) + \frac{10.5}{2} = 5.8\,kips$$
$$V_c = 2 * \sqrt{f_c^{'}} * b * d_p = 2 * \sqrt{8{,}000} * 8 * 10 = 14.3\,kips$$
$$V_c > V_{\max} \quad (\textit{Good})$$