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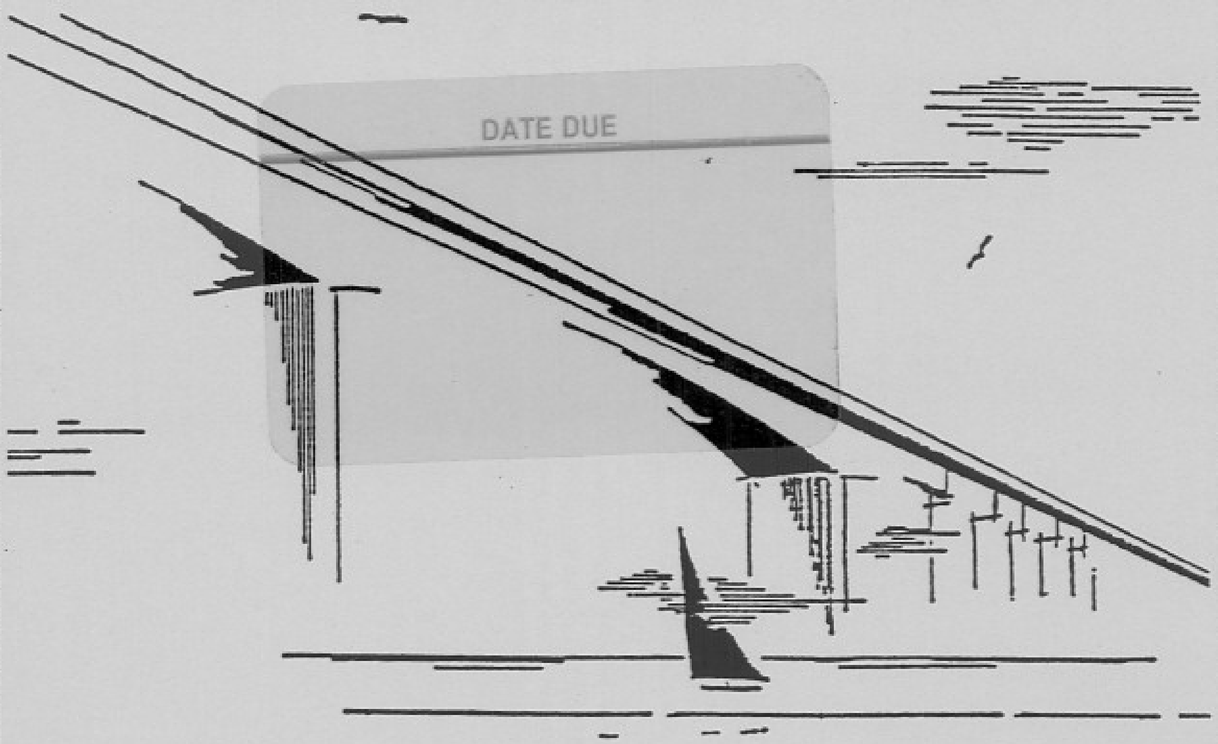

TRANSVERSE PRESTRESSING AND LONGITUDINAL CRACKING IN POST-TENSIONED DECKS

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BY

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1. Introduction

MTO practice requires transverse prestressing along the full length at the top of cast-in-place post-tensioned bridges of circular void and solid cross-section. Typical cross-sections of these structures are shown in Figure 1. Very few structures have transverse prestressing along the bottom of the deck. The top transverse prestressing is used to prevent longitudinal cracking due to shrinkage and the Poisson's effect of the longitudinal post-tensioning forces. In a number of existing post-tensioned bridges longitudinal cracks have been observed along the bottom of the deck. This study was undertaken to determine the need for transverse prestressing along the soffit of post-tensioned decks. The report summarizes the findings of this study and makes recommendations regarding transverse prestressing of the soffit of post-tensioned decks of either a solid cross-section or of a circular void cross-section.

2. Data Collection

Data regarding longitudinal cracks in post-tensioned decks was gathered by reviewing the condition surveys for a number of post-tensioned decks and by field inspection where no condition survey was available or incomplete. The study was limited to structures in Central Region. A total of 46 structures were reviewed for the study including the following: 16 bridges with circular voids without transverse prestressing, 10 with circular voids with transverse prestressing, 10 with solid sections without transverse prestressing and 10 solid sections with transverse prestressing.

The crack data recorded for each structure is given in Figure 2, Section A. In addition to the soffit crack data it was decided to record the data for the deck surface of any exposed post-tensioned decks. The data for Section A of Figure 2 was taken from the deck surface and soffit deterioration drawings included with the condition surveys or was obtained by field inspection. The "Extent of Longitudinal Cracks" referred to in Figure 2 A. is a qualitative measure that was devised to give an indication of the degree of cracking in the deck. The extent of cracking is indicated by such terms as "no cracking", "minor cracking", "moderate cracking" and "severe cracking". Severe cracking for circular void structures is indicative of a deck with longitudinal cracks along the entire length of voids at the top or bottom of the voids. In the case of solid section decks, severe cracking is indicative of longitudinal cracks running the full length of a span and these cracks are usually concentrated in the centre of the width of the section. Photographs showing examples of severe cracking are given in Figure 3. Minor cracking is indicative of a deck with a few random longitudinal cracks . In circular void structures, these cracks may or may not follow the bottom or top of voids. A deck with moderate cracking has a number of shorter length longitudinal cracks few of which extend the full length of a span. These cracks follow the bottom or top of voids in circular void structures. The total length of longitudinal cracking was available from each condition survey for both the top and bottom of the deck but was not obtainable from field observations. The data collected for each structure was input into a dBASE IV file. The drawings for each structure were also reviewed in order to identify some factors which may affect the tendency to crack or the extent of cracking. A draft report by Sadler [1] identified the following factors which affect the need for transverse prestressing. These are:

1. transverse shrinkage stresses
2. the uniformity of cross section across deck width
3. the uniformity of the substructure support system
4. the magnitude of longitudinal stresses due to p/s
5. edge distance and spacing of longitudinal tendons
6. stressing sequence of tendons
7. stress distribution at ends of deck.

The first 5 items above were included in this study. The stressing sequence varies from structure to structure and is difficult to quantify for this type of study. The stress distribution at the ends was not included because the end portions of the deck end spans are heavily transversely prestressed and these end portions are usually sufficient to disperse the concentrated prestress forces at the ends. The various items recorded from the tracings are given in Figure 2 B. The section uniformity affects stress concentration due to shear lag which leads to higher longitudinal stresses and higher transverse stresses through the Poisson effect. The section uniformity also affects the placement of longitudinal tendons uniformly across the width of the deck to counteract any higher stresses due to shear lag. The substructure uniformity has a similar effect as the section uniformity in that a structure supported on a single column will have stress concentrations due to shear lag near the support whereas a structure supported uniformly across its width will not have such a problem. However a uniform substructure could also lead to longitudinal cracks in that it resists the transverse shrinkage of the deck resulting in transverse tensile stresses which cause longitudinal cracks. This would be more significant in decks with small span to width ratios where the influence of the substructure would be felt further along the length of the span. The average level of prestress was calculated for each structure by assuming an effective prestress force after losses of 60% of the total ultimate cable force and dividing this by the net cross-sectional area of the deck. The average net area of the voided section was used for structures of circular void cross-section. If the average level of longitudinal prestress is too high, higher transverse stresses are created which can lead to longitudinal crack formation. This prestress level is more significant in structures with circular voids where the section over and below the voids is quite thin and stress concentrations are present.

The drawing data was recorded on a sheet as shown in Figure 2 and then input into the dBASE IV file. Some ratios were calculated using the dBASE IV file. These ratios included the deck width to maximum cross-section depth, the maximum span to deck width (aspect ratio) and the void diameter to maximum section depth. These ratios were identified in the paper by Sadler [1]. The void dia./depth ratio indicates the reduction in effective cross-section which occurs due to the voids which will influence the tendency for cracks to occur due to shrinkage and the Poisson effect. Another ratio that was calculated was the proportion of the cross-section in which no longitudinal cables are distributed. This last ratio was obtained by dividing twice the edge distance to the outside cables by the deck width and it indicates the uniformity of the longitudinal prestressing across the width of the section. The dBASE IV data was used to identify any correlation between longitudinal cracking and any of the factors listed above.

3. Summary and Discussion of Findings

The data collected is given in Appendix A and is summarized and discussed below.

3.1 Circular Voided Decks without Transverse Prestressing

The data for the 16 structures in this group was obtained from condition surveys only. A summary of the major findings is given in Table 1. Eight of the structures had moderate to severe longitudinal cracking of the soffit with the remainder having none or only minor cracking of the soffit. Six of the structures with longitudinal soffit cracks had an average level of prestress of 5.5 MPa or more. Six of the 8 structures with little or no soffit cracks had moderate or severe cracks in the deck surface and 4 of these structures had an average level of prestress above 5.5 MPa. Therefore a total of 14 structures had either top or bottom longitudinal cracks of a moderate to severe nature and of these, 10 had an average level of prestress of 5.5 MPa or more. Of these 10 structures, 6 were uniformly supported and 9 had aspect ratios greater than 2, so that the effect of transverse shrinkage was not as significant as if the aspect ratio were less than 2. The 2 structures with no cracking or minor cracking had an average level of prestress below 5.5 MPa. The 4 structures with longitudinal cracks but an average prestress level below 5.5 MPa had aspect ratios of less than 2 and were uniformly supported across their section widths at the piers. Hence in these cases, transverse shrinkage was probably the predominate cause of longitudinal cracks instead of a high level of prestress in these 4 structures. Incidently, 2 of these structures had a uniform distribution of prestress throughout the section. A structure in which the longitudinal prestress cables are located within 80% or more of the width of the cross-section was considered to have a uniform distribution of prestressing cables. It is difficult to say what effect the section uniformity had on the crack formation. Eight of the 9 structures with uniform cross-section had moderate to severe cracking but other more significant factors such as a high level of prestress were present. The void dia./depth ratio was quite consistent at around 0.7 for all the structures examined so no comments can be made regarding this factor.

Therefore for this group of structures, the data collected shows that the level of prestress is the primary cause of longitudinal cracks. The data indicates that a value around 5.5 MPa is the critical level. An MTO research study by Csagoly and Holowka [2] on cracking of voided post-tensioned decks found that 4.1 MPa was the critical level. The 2nd edition of the Ontario Highway Bridge Design Code (OHBDC) [3] and the Structural Manual [4] previously limited the average level of prestress to 5.5 MPa (0.16 x 35 MPa) for circular voided decks. The 3rd edition of the OHBDC has increased this limit to 6.5 MPa (0.16 x 40 MPa) [5]. The level has been increased due to higher strengths in the order of 40 MPa which have been routinely achieved for 35 MPa concrete mixes in the past. The combination of aspect ratio and sub-structure uniformity also appear to contribute to longitudinal cracking as well. The data showed that structures with aspect ratios less than 2 and which were supported uniformly across their widths tended to have longitudinal cracking problems. It is thought that the restraint provided by the substructure against shrinkage in the transverse direction is one factor contributing to these longitudinal cracks. The other factors considered such as section and prestress uniformity may contribute in a secondary way by accentuating the primary causes such as a high level of prestress.

3.2 Circular Voided Decks with Transverse Prestressing

Data for 9 of the 10 structures in this group was obtained from field inspection. A summary of the major findings is given in Table 2. Seven structures had moderate to severe cracking of the soffit and 6 of these 7 had an average level of prestress of 5.5 MPa or more and were uniformly supported with only 1 having an aspect ratio less than 2. The one structure which had moderate cracking with a level of prestress below 5.5 MPa, had a span/width ratio close to 2 and it was uniformly supported. This one case may be a borderline case and may explain the moderate level of cracking. Two of the 3 structures which had no longitudinal cracking of the soffit had an average level of prestress above 5.5 MPa. These 2 structures also had aspect ratios above 2.5 and they were not uniformly supported across the width of the cross-section. Consequently the effect of transverse shrinkage should have been minimized and the level of prestress should have been the main source of longitudinal cracks. Since these 2 structures do not fit the level of prestress criteria, other factors, such as the actual strength of concrete achieved during the pour or the level of prestress losses, may explain the absence of cracks. A higher strength concrete would mean a higher tensile strength which would allow a higher level of prestress before cracks form due to the Poisson effect. Higher prestress losses would mean that the effective prestress forces are less than the assumed 0.6fpu which would result in lower levels of prestress, perhaps below 5.5 MPa.

In a majority of the cases for this group of structures, the data shows that the level of prestress is the most important factor. The other factors of cross-section uniformity and void dia./depth ratio were consistent among all the structures surveyed, so no comments can be made regarding the influence of these factors for this group of structures.

3.3 Solid Section Decks without Transverse Prestressing

The data for 5 of the 10 structures examined was taken from condition surveys and the remainder from field inspection. A summary of the major findings is given in Table 3. Five of the 10 structures had severe longitudinal cracking of the soffit and one of the structures had moderate cracking in the deck surface. All 6 structures had width/depth ratios of 25 or more, aspect ratios less than 1.6 and all were uniformly supported across the width of the cross-section. The 4 structures which showed little or no cracking of the deck or soffit had width to depth ratios of 18 or less with 3 structures having aspect ratios of 2 or more and 2 structures were non-uniformly supported. It is interesting that the 2 structures which had a non-uniform distribution of prestress did not show any signs of longitudinal cracks in both the deck surface and soffit even though they were supported on non-uniform sub-structures. Hence the shear lag effect due to non-uniform support conditions was not sufficient to induce cracks. The average level of prestress did not appear to have an influence as the structures with severe longitudinal cracks did not have average prestress levels different from those without cracks. All structures had uniform cross-sections and no comments can be made regarding this factor for this group of structures.

It is postulated that in this case, the main source of cracking is the restraint against transverse shrinkage provided by the uniform sub-structure. The effect is pronounced when the deck is relatively thin compared to its width (width/depth ratios greater than 25) and the aspect ratio is low (less than 1.6). The Structural Manual [4] requires that a refined method of analysis be carried out when the aspect ratio is 1.5 or less. Failure to do a refined analysis which would be reflected in the detailing could be an additional factor contributing to crack formation.

3.4 Solid Section Decks with Transverse Prestressing

All data gathered for these structures was from field observations. A summary of the main findings is given in Table 4. Four of the 10 structures had moderate or severe cracking of the soffit and 2 of these had width to depth ratios of 25 or more and 3 had aspect ratios less than 1.6. All four were uniformly supported across their widths. One structure had moderate cracking but had a width to depth ratio of approximately 14 and an aspect ratio of almost 2. Only 1 of the 4 structures with longitudinal cracking had a non-uniform distribution of longitudinal prestressing. As for the solid sections without transverse prestressing, the average longitudinal prestress does not appear to have an influence on longitudinal crack formation. All structures had uniform cross-sections so no comments can be made regarding this factor for this group of structures. The use of transverse prestressing did not seem to aggravate the cracking in the soffit as the proportion of structures with soffit cracks in this group of structures was not higher than the proportion for the solid decks without transverse prestressing. It appears that similar factors as indicated in section 3.3 above influenced longitudinal cracking in this group of structures.

4. Recommendations and Suggestions for Future Research

Based on the above findings the following recommendations are made for the groups of structures studied above:

4.1 Circular Voided Decks

1. The average level of effective longitudinal prestress can result in longitudinal cracks if it is too high. The study found that a level of 5.5 MPa was the maximum that could be tolerated for 35 MPa concrete. Higher average prestress could be allowed for higher strength concretes with the limit tied to the strength of concrete. The expression 0.16xfc' used in the 2nd edition of the OHBDC [3] seems appropriate.

2. The combination of an aspect ratio of 2 or less coupled with uniform support conditions across the width of the deck can result in longitudinal cracks due to transverse shrinkage of the deck. This should be considered during the design phase and measures taken to alleviate or avoid this situation. For example transverse prestressing of the deck may be used. If transverse prestressing is placed in the top of the deck, the effect on the transverse stresses in the bottom should be considered. The use of bearings which will accommodate the transverse shrinkage could be considered as well. Changing the support configuration so that the entire width of the deck is not restrained or changing the aspect ratio so that it is greater than 2 could also be considered during the design phase.

3. A number of circular voided decks which had no transverse prestressing did exhibit extensive cracking, even at lower levels of average prestress. Hence there is some benefit in maintaining the requirement of nominal transverse prestressing in the top slab especially for structures mentioned in 2. above.

4. One method of controlling longitudinal cracks in the soffit is to place transverse prestressing in the bottom of the deck below the voids. This however may be difficult to implement in all cases in that there may not be sufficient room to accommodate the anchors for the top and bottom transverse prestressing. In addition, adding transverse prestressing to the soffit would counteract somewhat the transverse prestressing in the top slab making it less effective and possibly resulting in more deterioration of the deck surface which is more serious than deterioration of the soffit from a durability point of view.

5. Further study of the problem of longitudinal cracking in circular voided decks is needed. A larger sample of structures than investigated in this study would be useful in confirming the above findings. A parametric study utilizing the finite element method would also provide further data to confirm the above findings as well as aid in investigating some of the other factors which were mentioned in the study, but for which insufficient data was available. The section uniformity and prestressing uniformity are two factors which could be studied in this way.

4.2 Solid Section Decks

1. In the case of solid section decks, the aspect ratio coupled with the uniformity of the substructure appeared to have the most influence on the tendency for longitudinal cracks to develop. Uniform support conditions across the width of the deck restrain the deck from shrinking transversely, resulting in transverse tensile stresses and hence longitudinal cracks. In addition at an aspect ratio of 1.6 or less, the assumption of the deck acting as a beam may not be correct and therefore a more refined analysis should be carried out as recommended currently in the Structural Manual [4]. At the very minimum nominal transverse prestressing should be used when the aspect ratio is 1.6 or less especially if the supports do not allow or limit transverse movement. Any structures with an aspect ratio greater than 1.6 and a non-uniform sub-structure would not be as susceptible to cracking and therefore may not need nominal transverse prestressing.

2. The usual practice for solid decks is to place nominal transverse prestressing in the top. An alternative which has been proposed by Sadler [1] is to place the nominal transverse prestressing in solid decks in the centre. This would result in the same number of cables as if they were placed in the top but the prestressing would benefit both the surface and the soffit of the deck.

3. Similar to recommendation 5 above for circular voided decks, additional structures should be surveyed and a parametric study utilizing the finite element method should be carried out for solid section decks as well.

References:

1. Sadler, C., *Guidelines for Determining the Need for Transverse Prestressing in Bridge Decks*, Draft Report Presented for Discussion, Ministry Of Transportation of Ontario, Procedures Section, Structural Office, Downsview, Ontario, Canada, 1992.

2. Csagoly, P. and Holowka, M., *Cracking of Voided Post-tensioned Concrete Bridge Decks,* RR193, Ministry of Transportation of Ontario, Downsview, Ontario, Canada, 1975.

3. *Ontario Highway Bridge Design Code,* 2nd Edition, Ministry of Transportation of Ontario, Downsview, Ontario, Canada, 1983.

4. *Structural Manual,* Ministry of Transportation of Ontario, Downsview, Ontario, Canada, 1980.

5. *Ontario Highway Bridge Design Code,* 3rd Edition, Ministry of Transportation of Ontario, Downsview, Ontario, Canada, 1991.

Table 1 - Factors Influencing Longitudinal Crack Severity in Circular Voided Decks without Transverse Prestressing

Location of Cracks	Crack Severity	Average Prestress (MPa)	No. of Structures	Uniform Sub-Struct.	Span/Width Ratio < 2
Top	Moderate to Severe	>/= 5.5	4	1	1
		< 5.5	2	2	2
Bottom	Moderate to Severe	>/= 5.5	6	5	0
		< 5.5	2	2	2

Table 2 - Factors Influencing Longitudinal Crack Severity in Circular Voided Decks with Transverse Prestressing

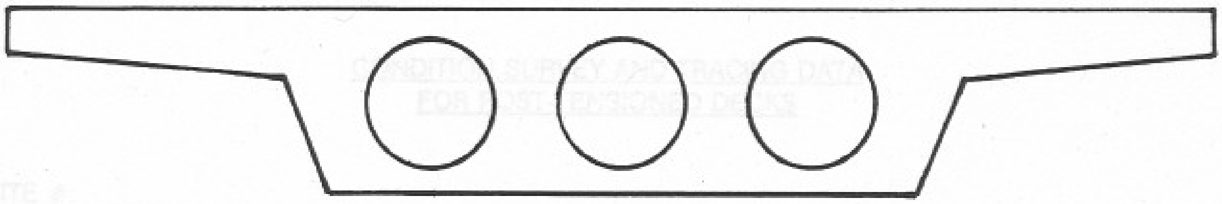
Location of Cracks	Crack Severity	Average Prestress (MPa)	No. of Structures	Uniform Sub-Struct.	Span/Width Ratio < 2
Bottom	Moderate to Severe	>/= 5.5	6	6	1
		< 5.5	1	1	1

Table 3 - Factors Influencing Longitudinal Crack Severity in Solid Section Decks without Transverse Prestressing

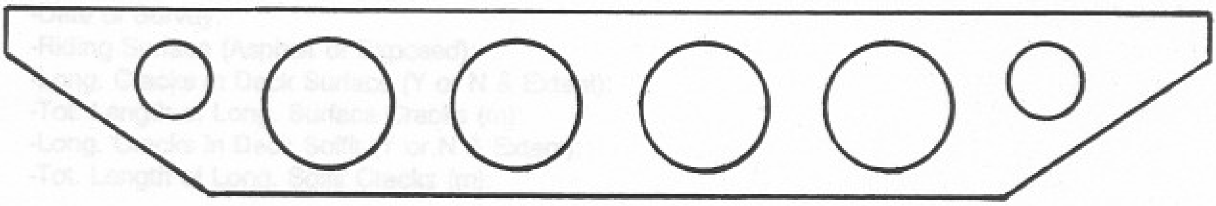
Location of Cracks	Crack Severity	No. of Structures	Uniform Sub-Struct.	Width/Depth Ratio > 25	Span/Width Ratio < 1.6
Top	Moderate to Severe	1	1	1	1
Bottom	Moderate to Severe	5	5	5	5

Table 4 - Factors Influencing Longitudinal Crack Severity in Solid Section Decks with Transverse Prestressing

Location of Cracks	Crack Severity	No. of Structures	Uniform Sub-Struct.	Width/Depth Ratio > 25	Span/Width Ratio < 1.6
Bottom	Moderate to Severe	4	4	2	3

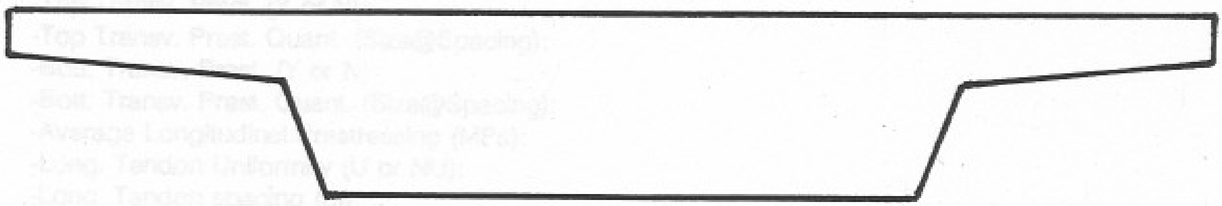


Non-Uniform Cross-section

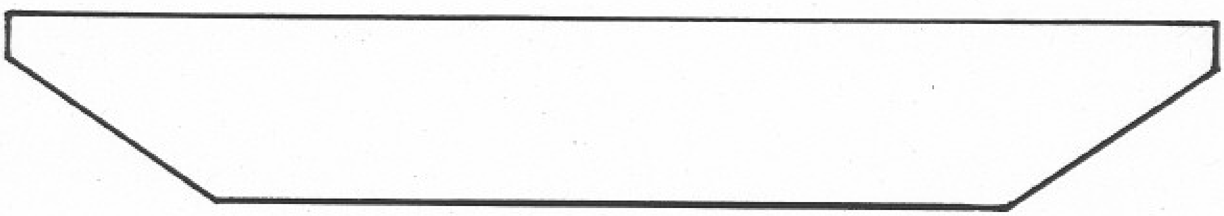


Uniform Cross-section

a.) Circular Void Cross-sections



Non-Uniform Cross-section



Uniform Cross-section

b.) Solid Cross-sections

Figure 1 - Typical Cross-Sections of Post-tensioned Decks Studied

CONDITION SURVEY AND TRACING DATA FOR POST-TENSIONED DECKS

SITE #:________

A.) Condition Survey Data

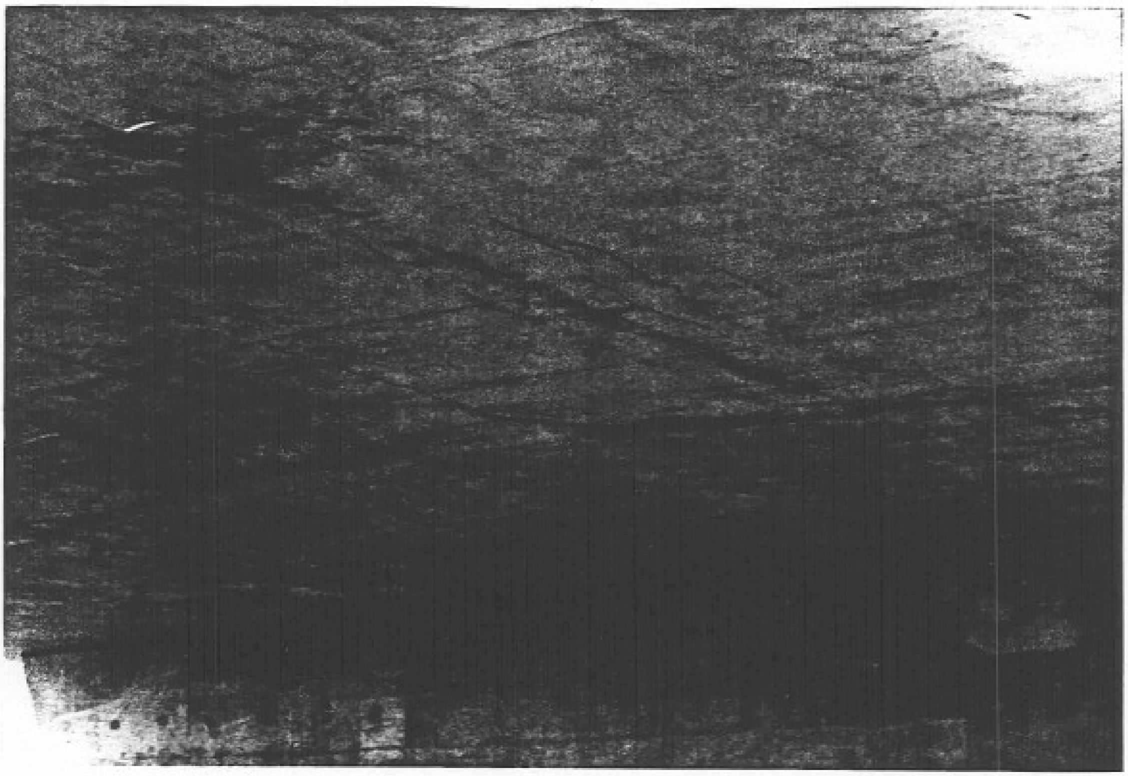
-Date Constructed:
-Date of Survey:
-Riding Surface (Asphalt or Exposed):
-Long. Cracks in Deck Surface (Y or N & Extent):
-Tot. Length of Long. Surface Cracks (m):
-Long. Cracks in Deck Soffit (Y or N & Extent):
-Tot. Length of Long. Soffit Cracks (m):

B.) Bridge Data Obtained From Drawings

-Cross-Section Type (Cir.,Rec.,Solid):
-Section Uniformity (Uniform or Non-uniform):
-Deck Width (m):
-Section Depth (m):
-Top Transv. Prest. (Y or N):
-Top Transv. Prest. Quant. (Size@Spacing):
-Bott. Transv. Prest. (Y or N):
-Bott. Transv. Prest. Quant. (Size@Spacing):
-Average Longitudinal Prestressing (MPa):
-Long. Tendon Uniformity (U or NU):
-Long. Tendon spacing (m):
-Dist. of Tendon from Ext. Edge (m):
-Max. Span (m):
-Min. Span (m):
-Sub-Structure Uniformity Transv. to Deck (U or NU):

Figure 2 - Data Input Sheets

a.) Circular Void Cross-section



b.) Solid Cross-section

Figure 3 - Severe Longitudinal Cracking in Soffits

APPENDIX A

Data Collected

SURVEY OF LONGITUDINAL CRACKING IN POST-TENSIONED DECKS

SITE #	STRUCTURE NAME	DECK SYSTEM	DATE CON.	COND. SURV. DATE	DECK SURF.	TOP TRAN. PRST.	TOP TRAN. PRESTR. QUANTITY	LONG. CRACKS IN TOP	TOP CRACK SEVERITY	BOT. TRAN. PRST.	LONG. CRACKS IN BOT.	BOT. CRACK SEVERITY	SECTION UNIFORMTY	DECK WIDTH (m)	SECT. DEPTH (m)	VOID DIA. (m)	AVERAGE LN.PRS. (MPa)	CONC. STR. (MPa)	LONG.TEN. UNIFORMTY	TEN. SPAC. (m)	LN.TEN. ED.DIS. (m)	MAX. SPAN (m)	MIN. SPAN (m)	SUBSTRUC. UNIFORMTY	SPAN/ DEPTH	SPAN/ WIDTH	WIDTH/ DEPTH	VOID DIA./ DEPTH	2xEI DI /WI
34-201	ST DAVIDS RD INTERCH-BR NO 5	CirVd	1969	1990	Exp	No		Yes	Minor	No	Yes	Minor	Non-Unfrm	14.34	0.762	0.475	4.600	35.0	Non-Unfrm	1.000	2.400	23.8	12.8	Uniform	31.234	1.660	18.819	0.623	0.3
37-713	RAMP E-S OVER 27 BR. # 3	CirVd	1968	1989	Exp	No		Yes	Severe	No	Yes	Minor	Uniform	9.80	1.000	0.682	8.600	35.0	Non-Unfrm	1.320	3.000	29.9	29.9	Non-Unfrm	29.900	3.051	9.800	0.682	0.6
37-717	BR.#7-TURNING ROADWAY E-N	CirVd	1969	1984	Exp	No		Yes	Severe	No	Yes	Minor	Uniform	11.28	1.220	0.940	8.600	35.0	Non-Unfrm	1.550	1.900	39.6	27.4	Non-Unfrm	32.459	3.511	9.246	0.770	0.3
37-814	RAMP S-E 401 OVER HWY 27S LINE	CirVd	1969	1982	Exp	No		Yes	Severe	No	Yes	Minor	Uniform	16.45	0.914	0.685	4.400	35.0	Non-Unfrm	1.070	2.640	30.5	19.8	Uniform	33.370	1.854	17.998	0.749	0.3
37-822	RENFORTH DR.OVER401(E.STRUCT)	CirVd	1968	1986	Exp	No		Yes	Severe	No	Yes	Minor	Uniform	12.34	1.270	0.940	8.900	35.0	Non-Unfrm	1.520	1.710	38.1	28.9	Non-Unfrm	30.000	3.088	9.717	0.740	0.2
21-338	HWY #28 OVERPASS...............	CirVd	1966	1980	Exp	No		Yes	Severe	No	Yes	Moderate	Uniform	14.90	0.622	0.356	4.500	35.0	Uniform	0.813	1.220	20.0	10.0	Uniform	32.154	1.342	23.955	0.572	0.1
37-217	MCCOWAN ROAD UNDERPASS SBL	CirVd	1968	1990	Exp	No		Yes	Severe	No	Yes	Moderate	Uniform	17.20	1.320	1.040	8.400	35.0	Non-Unfrm	1.600	2.800	45.1	36.0	Uniform	34.167	2.622	13.030	0.788	0.3
37-803	HWY 427 SB OVER EGLINTON AVE.#3	CirVd	1968	1988	Exp	No		Yes	Moderate	No	No	None	Uniform	16.92	1.220	0.940	7.000	35.0	Non-Unfrm	1.550	3.200	30.5	18.3	Uniform	25.000	1.803	13.869	0.770	0.3
37-804	RAMP E-S HWY 401 OVER EGLINTON	CirVd	1968	1988	Exp	No		No	None	No	No	None	Uniform	16.92	0.910	0.635	3.700	35.0	Uniform	1.070	0.920	21.3	15.2	Non-Unfrm	23.407	1.259	18.593	0.698	0.1
37-812	RAMP S-E 401 OVER EGLINTON AVE	CirVd	1969	1982	Exp	No		Yes	Severe	No	No	None	Uniform	16.46	0.914	0.685	4.500	35.0	Non-Unfrm	1.070	2.770	25.9	14.6	Uniform	28.337	1.574	18.009	0.749	0.3
37-210	VICTORIA PARK AVE U/P (NBL)	CirVd	1966	1990	Exp	No		Yes	Severe	No	Yes	Severe	Non-Unfrm	21.50	1.220	0.937	7.900	35.0	Non-Unfrm	1.750	4.600	43.4	38.7	Uniform	35.574	2.019	17.623	0.768	0.4
37-285	SPADINA BR. # 4 RAMP TO 401	CirVd	1963	1991	Asph	No		N/A	N/A	No	Yes	Severe	Non-Unfrm	9.00	1.370	0.937	7.700	35.0	Non-Unfrm	1.300	2.240	47.5	28.0	Non-Unfrm	34.672	5.278	6.569	0.684	0.4
37-305	SPADINA BRIDGE #24	CirVd	1964	1990	Asph	No		N/A	N/A	No	Yes	Severe	Non-Unfrm	12.80	1.370	0.937	6.800	35.0	Non-Unfrm	1.520	2.360	45.7	22.9	Uniform	33.358	3.570	9.343	0.684	0.3
37-311	HWY 400-401 INT BR #5 SBL......	CirVd	1964	1990	Asph	No		N/A	N/A	No	Yes	Severe	Non-Unfrm	17.78	1.270	0.914	5.500	35.0	Non-Unfrm	1.220	2.490	39.0	21.0	Uniform	30.709	2.193	14.000	0.720	0.2
37-311	HWY 400-401 INT RAMP BR #8.....	CirVd	1964	1990	Asph	No		N/A	N/A	No	Yes	Severe	Non-Unfrm	8.99	1.270	0.914	5.500	35.0	Non-Unfrm	1.220	2.490	39.0	29.3	Uniform	30.709	4.338	7.079	0.720	0.5
37-313	HWY 400-401 INT. BR. # 11	CirVd	1963	1990	Asph	No		N/A	N/A	No	Yes	Severe	Uniform	24.08	1.270	0.914	4.300	35.0	Uniform	1.320	2.400	38.1	22.9	Uniform	30.000	1.582	18.961	0.720	0.1
10-281	HWY 403 U/P AT HWY 5	CirVd	1980	9999	Asph	Yes	406@.762m	N/A	N/A	No	Yes	Moderate	Uniform	14.80	1.143	0.838	4.800	35.0	Non-Unfrm	1.450	2.330	30.5	30.5	Uniform	26.684	2.061	12.948	0.733	0.3
24-319	EGLINTON AVE UNDERPASS W.B.L.	CirVd	1979	9999	Asph	Yes	406@.762m	N/A	N/A	No	Yes	Moderate	Uniform	14.91	1.524	1.219	7.900	35.0	Uniform	1.930	1.260	43.9	28.7	Uniform	28.806	2.944	9.783	0.800	0.1
24-439	HWY 403 U'PASS AT MAVIS EBL	CirVd	1980	9999	Asph	Yes	406@.914m	N/A	N/A	No	Yes	Moderate	Uniform	14.26	1.295	0.965	6.100	35.0	Non-Unfrm	1.590	2.740	33.5	33.5	Uniform	25.869	2.349	11.012	0.745	0.3
18-197	MOUNTAIN VIEW RD. U/P	CirVd	1972	1985	Exp	Yes	106@.914m	No	None	No	No	None	Uniform	9.45	0.914	0.631	5.900	35.0	Uniform	1.110	0.990	24.0	23.5	Non-Unfrm	26.258	2.540	10.339	0.690	0.2
24-387	MISSISSAUGA ROAD UPASS/HWY 403	CirVd	1980	9999	Asph	Yes	406@.762m	No	N/A	No	No	None	Uniform	20.42	1.143	0.838	5.000	35.0	Non-Unfrm	1.370	2.670	30.4	30.4	Uniform	26.597	1.489	17.865	0.733	0.2
37-699	VANDORF ROAD UNDERPASS	CirVd	1980	9999	Asph	Yes	406@.762m	N/A	N/A	No	No	None	Uniform	11.58	1.370	1.070	6.400	35.0	Non-Unfrm	1.630	2.540	35.4	35.4	Non-Unfrm	25.839	3.057	8.453	0.781	0.4
10-312	JAMES SNOW PKY BR. AT 401 NBL	CirVd	1981	9999	Asph	Yes	406@.914m	N/A	N/A	No	Yes	Severe	Uniform	15.19	1.397	1.015	6.500	35.0	Non-Unfrm	1.650	2.650	38.1	38.1	Uniform	27.273	2.508	10.873	0.727	0.34
24-384	HWY 403 U/P WINSTON CHURCHILL	CirVd	1980	9999	Asph	Yes	406@.914m	N/A	N/A	No	Yes	Severe	Uniform	14.94	1.295	0.965	5.800	35.0	Non-Unfrm	1.580	2.740	33.5	33.5	Uniform	25.869	2.242	11.537	0.745	0.3
24-385	ERIN MILLS PARKWAY U/P (SBL)	CirVd	1980	9999	Asph	Yes	406@.762m	N/A	N/A	No	Yes	Severe	Uniform	15.24	1.346	1.041	5.400	35.0	Non-Unfrm	1.310	3.370	37.2	37.2	Uniform	27.637	2.441	11.322	0.773	0.44
37-982	HWY 427 U/P AT REXDALE BLVD WBL	CirVd	1979	9999	Asph	Yes	406@.914m	N/A	N/A	No	Yes	Severe	Uniform	20.12	1.295	0.990	6.400	35.0	Non-Unfrm	1.730	2.700	35.1	35.1	Uniform	27.104	1.745	15.537	0.764	0.2
37-295	SPADINA BR #14 U/P	Solid	1967	1992	Asph	No		N/A	N/A	No	Yes	Minor	Uniform	13.72	0.762	0.000	5.400	35.0	Uniform	0.304	0.304	29.4	18.3	Uniform	38.583	2.143	18.005	0.000	0.04
37-296	SPADINA BRIDGE #15	Solid	1967	1992	Asph	No		N/A	N/A	No	Yes	Minor	Uniform	11.18	0.762	0.000	5.400	35.0	Uniform	0.305	0.400	29.4	18.3	Uniform	38.583	2.630	14.672	0.000	0.07
21-32	CANANVILLE CK BR	Solid	1966	1978	Exp	No		Yes	Moderate	No	No	None	Uniform	14.20	0.394	0.000	4.600	35.0	Uniform	0.240	1.130	12.8	8.5	Uniform	32.487	0.901	36.041	0.000	0.15
37-724	HWY #27 RAMP TO Q.E.W. E.B.	Solid	1968	1989	Exp	No		No	None	No	No	None	Uniform	7.77	0.610	0.000	4.500	35.0	Non-Unfrm	0.460	1.830	16.0	11.0	Non-Unfrm	26.230	2.059	12.738	0.000	0.47
37-864	HWY 27 NB S-E OVER EGLINTON...	Solid	1969	1991	Exp	No		No	None	No	No	None	Uniform	7.77	0.610	0.000	3.500	35.0	Non-Unfrm	0.710	1.750	13.7	9.1	Non-Unfrm	22.459	1.763	12.738	0.000	0.45
10-144	NELSON TWP BRIDGE FW 1	Solid	1958	9999	Asph	No		N/A	N/A	No	Yes	Severe	Uniform	15.24	0.610	0.000	1.400	35.0	Uniform	0.381	0.381	24.0	17.0	Uniform	39.344	1.575	24.984	0.000	0.05
23-23	White's Creek Bridge	Solid	1964	9999	Asph	No		N/A	N/A	No	Yes	Severe	Uniform	13.26	0.381	0.000	3.900	35.0	Uniform	0.305	0.305	12.0	10.0	Uniform	31.496	0.905	34.803	0.000	0.04
23-24	Beaverton River Br. on Cty Rd. 15	Solid	1964	9999	Asph	No		N/A	N/A	No	Yes	Severe	Uniform	12.95	0.381	0.000	4.500	35.0	Uniform	0.262	0.300	13.7	11.6	Uniform	35.958	1.058	33.990	0.000	0.04
23-25	Beaverton River Bridge on Hwy 12	Solid	1964	9999	Asph	No		N/A	N/A	No	Yes	Severe	Uniform	16.58	0.381	0.000	4.600	35.0	Uniform	0.270	0.300	13.7	11.6	Uniform	35.958	0.826	43.517	0.000	0.03
37-293	SPADINA BR.#12	Solid	1967	9999	Asph	No		N/A	N/A	No	Yes	Severe	Uniform	19.60	0.762	0.000	4.900	35.0	Uniform	0.340	0.690	29.4	18.3	Uniform	38.583	1.500	25.722	0.000	0.07
24-438	CREDITVEW RD. UNDERPASS	Solid	1980	9999	Asph	Yes	406@.762m	N/A	N/A	No	Yes	Minor	Uniform	16.71	1.020	0.000	5.400	35.0	Uniform	0.530	1.690	29.0	29.0	Uniform	28.431	1.735	16.382	0.000	0.20
10-282	W-N RAMP HWY 403 UNDER E-NS RAMP	Solid	1980	9999	Asph	Yes	406@.914m	N/A	N/A	No	Yes	Moderate	Uniform	11.84	0.838	0.000	4.300	35.0	Uniform	0.560	1.100	23.5	14.0	Uniform	28.043	1.985	14.129	0.000	0.18
24-314	HWY 401 WBC OVER HEART LAKE RD	Solid	1978	9999	Asph	Yes	206@.914m	N/A	N/A	No	Yes	Moderate	Uniform	20.73	0.762	0.000	3.800	35.0	Uniform	0.610	1.530	21.3	10.7	Uniform	27.953	1.027	27.205	0.000	0.14
10-282	W-N RAMP HWY 403/N SERVICE RD	Solid	1980	9999	Asph	Yes	406@.914m	N/A	N/A	No	No	None	Uniform	20.17	0.838	0.000	4.100	35.0	Uniform	0.635	0.930	24.4	15.2	Uniform	29.117	1.210	24.069	0.000	0.09
10-339	Q.E.W SB/HWY #403 E RAMP	Solid	1992	9999	Asph	Yes	406@0.90m	N/A	N/A	No	No	None	Uniform	10.96	0.850	0.000	2.800	35.0	Non-Unfrm	0.900	2.330	20.2	12.0	Uniform	23.765	1.843	12.894	0.000	0.42
24-331	HEART LAKE ROAD OVERPASS	Solid	1978	9999	Asph	Yes	206@.457m	N/A	N/A	No	No	None	Uniform	12.65	0.762	0.000	4.900	35.0	Non-Unfrm	0.457	1.680	21.3	11.6	Uniform	27.953	1.684	16.601	0.000	0.26
24-332	HEART LAKE ROAD OPASS RAMP E-N	Solid	1978	9999	Asph	Yes	206@.457m	N/A	N/A	No	No	None	Uniform	12.65	0.838	0.000	4.700	35.0	Uniform	0.457	1.220	21.3	15.2	Uniform	25.418	1.684	15.095	0.000	0.19
24-465	HWY 403 EBC OVER HEART LAKE RD	Solid	1983	9999	Asph	Yes	206@1.00m	N/A	N/A	No	No	None	Uniform	13.50	0.900	0.000	2.700	35.0	Non-Unfrm	1.000	2.250	22.0	16.0	Uniform	24.444	1.630	15.000	0.000	0.33
10-280	HWY 403 U/P @ BURNHAMTHORPE RD	Solid	1980	9999	Asph	Yes	406@.61m	N/A	N/A.	No	Yes	Severe	Uniform	19.86	0.914	0.000	5.200	35.0	Non-Unfrm	0.610	2.270	25.9	25.9	Uniform	28.337	1.304	21.729	0.000	0.22
24-316	HWY 401 EB OVER HEART LAKE ROAD	Solid	1978	9999	Asph	Yes	206@.914m	N/A	N/A	No	Yes	Severe	Uniform	20.73	0.762	0.000	3.800	35.0	Uniform	0.610	1.530	21.3	10.7	Uniform	27.953	1.027	27.205	0.000	0.14