OFFICE MEMORANDUM

MICHIGAN
STATE HIGHWAY DEPARTMENT

May 14, 1965

To: W. W. McLaughlin
Testing & Research Engineer

From: E. A. Finney

Subject: Survey of Substructures on Edsel Ford Freeway. Research Project 63 B-69(4). Research Report No. R-510.

Some time ago you made a verbal request to me for a survey of bridge structures on the Edsel Ford Freeway to determine the extent that air entrainment was involved in construction of the piers. At the time, considerable concern had developed within the Department over pier spalling on that section of highway.

The results of a survey by Onto Lindy have been summarized in Table 1, which also presents pertinent construction data obtained from Department records. The bridges surveyed are presented in order of percent of total piers cracked or spalled. Of the 30 projects listed, 9 showed no pier cracking or spalling. The number of spalled or cracked piers on the remaining 21 projects varied from 3 to 80 percent. There seems to be no definite correlation between degree of deterioration and the construction factors listed. Only one of the structures (C&O RR: X01 of 82023) appears to have been constructed without air entrainment. Fig. 1 shows typical pier conditions encountered in the survey.

In the period between October and December 1964, field surveys were made by S. W. Curtiss of Wayne County Road Commission and by Bridge Project Engineers Richard W. Dambrun and Fred Pittman. Results of these surveys have been presented to J. F. Oravec, Maintenance Operations Engineer. Copies of these reports and related correspondence have been appended to this report for the record and future reference.

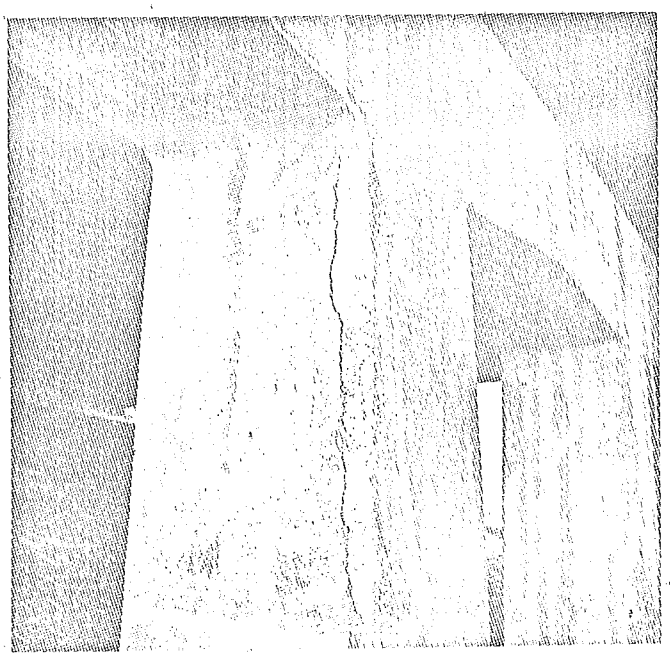
OFFICE OF TESTING AND RESEARCH

E. A. Finney

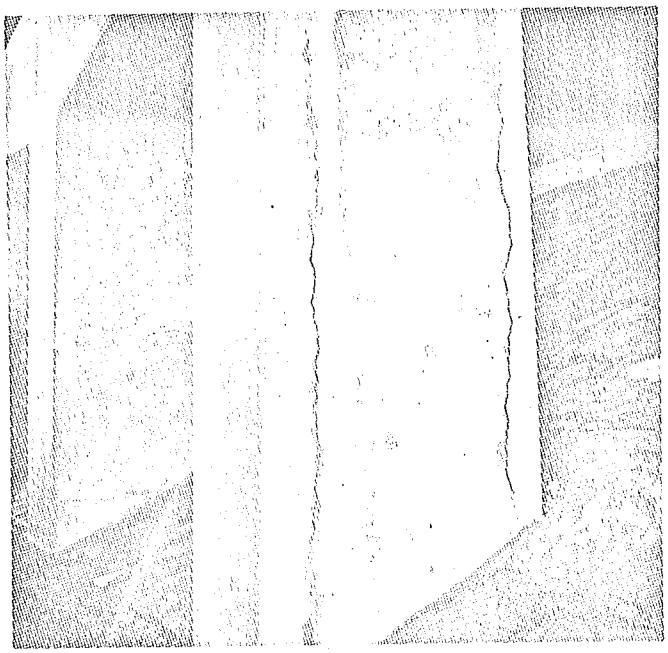
E. A. Finney, Director
Research Laboratory Division

EAF:nl

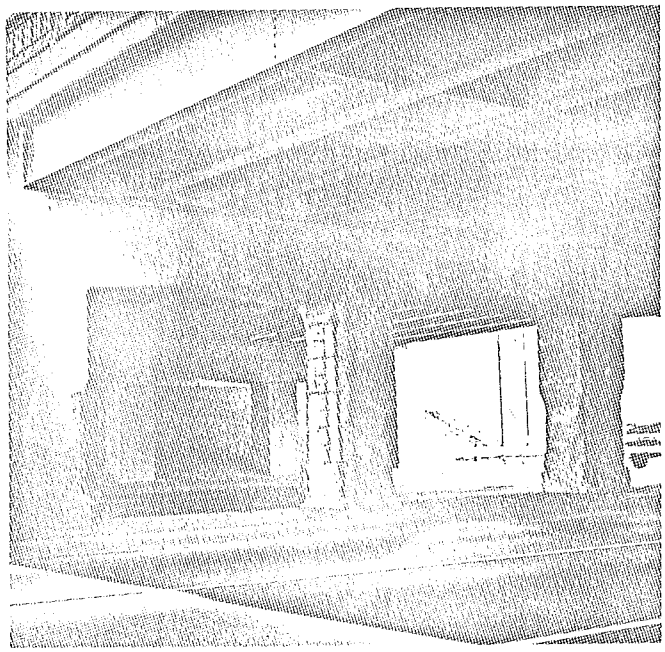
Attachment



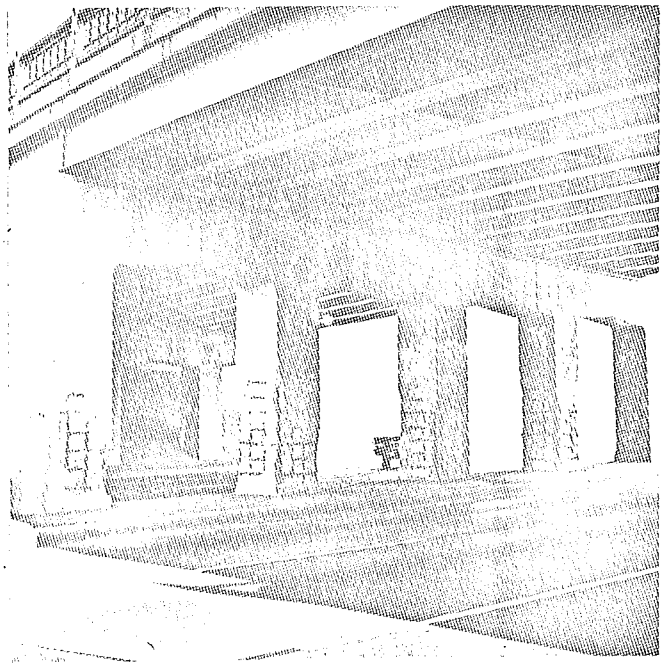
Central (S04 of 82023)



Wesson (S08 of 82023)



Martin (S06 of 82023)



Junction (S09 of 82023)

Figure 1. Typical conditions of bridge piers encountered in survey; cracking at pier corners shown upper left and right, and spalling of pier surfaces lower left and right.

TABLE 1

SUMMARY OF CONSTRUCTION DATA FOR STRUCTURES SURVEYED

Listed by Percent of Pier Columns Cracked or Spalled

Structure Number	Location	Year	Percent of Total Pier Cols. Cracked or Spalled	Chart Number	Cement Brand	Air Entraining Agent Added*	Contractor	Fine Aggregate Producer	Coarse Aggregate Producer	Transit Mix	Curing Period + or - 40 F
S05 of 82023	Cecil	1950	80	49-MV-505	Peerless A. E.	some	Darin & Armstrong	Oaks Gravel Co.	Inland Lime & Stone	no	-
S04 of 82023	Central	1950	73	49-MV-90	Wyandotte A. E.	some	Louis Garavaglia	American Aggregate	American Aggregate	yes	+
				49-MV-43	Wyandotte A. E.	some	Louis Garavaglia	American Aggregate	Inland Lime & Stone	yes	+
S06 of 82023	Martin	1949	73	49-MV-43	Wyandotte A. E.	none	Louis Garavaglia	American Aggregate	Inland Lime & Stone	yes	+
S36 of 82022	Wyoming	1949	56	48-MV-151	Peerless A. E.	some	L. A. Davidson	American Aggregate	Inland Lime & Stone	no	+
S09 of 82023	Junction	1950	53	50-MV-39	Peerless A. E.	some	Louis Garavaglia	Whittaker & Gooding	Inland Lime & Stone	no**	+
S10 of 82023	30th	1951	50	50-MV-281	Wyandotte A. E.	some	Louis Garavaglia	American Aggregate	American Aggregate	yes	+
				50-MV-280	Wyandotte A. E.	some	Louis Garavaglia	American Aggregate	Inland Lime & Stone	yes	+
S08 of 82023	Wesson	1951	47	50-MV-130	Wyandotte A. E.	some	Louis Garavaglia	American Aggregate	American Aggregate	yes	+
				50-MV-132	Wyandotte A. E.	some	Louis Garavaglia	American Aggregate	Inland Lime & Stone	yes	+
S01 of 82023	Saxon	1950	42	48-MV-151	Peerless A. E.	all	L. A. Davidson	American Aggregate	Inland Lime & Stone	no	+
S18 of 82023	Linwood	1953	40	52-MV-265	Peerless A. E.	some	L. A. Davidson	Walker S & G	Drummond Dolomite	yes	+
X02 of 82023	NYC & GTW RR	1955	36	54-MV-55	Peerless A. E.	some	L. A. Davidson	Walker S & G	Inland Lime & Stone	yes	+ -
X01 of 82023	C & O RR	1948	33	47-MV-397	Peerless Reg.	none	Jutton-Kelley	American Aggregate	Inland Lime & Stone	no	+ -
S13 of 82023	W. Grand	1953	23	Temp.	Peerless Reg.	all	Darin & Armstrong	Lyle J. Walker	Inland Lime & Stone	yes	+
				52-MV-339	Peerless Reg.	all	Darin & Armstrong	Lyle J. Walker	Inland Lime & Stone	yes	+
X03 of 82023	NYC RR	1954	20	53-MV-45	Huron A. E.	all	F. C. Atlewed	American Aggregate	Inland Lime & Stone	no	+
S03 of 82023	Loryo	1949	17	48-MV-240	Peerless A. E.	some	Darin & Armstrong	Heichman & VanEvery	Inland Lime & Stone	yes	+ -
S17 of 82023	G. River	1954	17	53-MV-133	Peerless A. E.	all	L. A. Davidson	Walker S & G	Inland Lime & Stone	yes	+
S11 of 82023	Warren	1953	14	51-MV-297	Wyandotte A. E.	some	Louis Garavaglia	American Aggregate	Inland Lime & Stone	yes	+ -
S12 of 82023	Scotten	1953	12	52-MV-245	Wyandotte Reg.	all	Louis Garavaglia	American Aggregate	Drummond Dolomite	yes	+ -
				51-MV-297	Wyandotte A. E.	all	Louis Garavaglia	American Aggregate	Inland Lime & Stone	yes	+ -
				52-MV-458	Wyandotte Reg.	all	Louis Garavaglia	American Aggregate	Inland Lime & Stone	yes	+ -
S21 of 82023	Trumbull	1954	11	53-MV-349	Peerless A. E.	some	W. J. Storen	American Aggregate	Inland Lime & Stone	yes	+
S16 of 82023	Maybury-Grand	1954	7	52-MV-160	Peerless A. E.	all	L. A. Davidson	Lyle J. Walker	Inland Lime & Stone	yes	+
				52-MV-212	Peerless A. E.	some	L. A. Davidson	Lyle J. Walker	Drummond Dolomite	yes	+
				52-MV-233	Peerless A. E.	some	L. A. Davidson	Lyle J. Walker	Drummond Dolomite	yes	+
				52-MV-264	Peerless A. E.	some	L. A. Davidson	Lyle J. Walker	Drummond Dolomite	yes	+
S07 of 82023	Livernois	1950	4	48-MV-454	Peerless A. E.	some	Louis Garavaglia	Whittaker & Gooding	Inland Lime & Stone	no	-
S14 of 82023	W. Grand	1953	3	Temp.	Peerless Reg.	all	Darin & Armstrong	Lyle J. Walker	Inland Lime & Stone	yes	+
				52-MV-339	Peerless Reg.	all	Darin & Armstrong	Lyle J. Walker	Inland Lime & Stone	yes	+
S02 of 82023	Addison	1949	0	49-MV-32	Peerless Reg.	some	Darin & Armstrong	Heichman & VanEvery	Inland Lime & Stone	no	+
P01 of 82023	Trenton	1951	0	51-MV-147	Peerless Reg.	all	Plozai, Inc.	Const. Agg. Corp.	Inland Lime & Stone	yes	+
P02 of 82023	Lumley	1952	0	50-MV-23	Wyandotte A. E.	some	Jutton-Kelley	American Aggregate	American Aggregate	yes	+
				51-MV-25	Wyandotte A. E.	some	Jutton-Kelley	American Aggregate	Inland Lime & Stone	yes	+
P03 of 82023	Tarnow	1952	0	51-MV-25	Wyandotte A. E.	all	Jarvick Const. Co.	American Aggregate	Inland Lime & Stone	yes	+
P04 of 82023	Roosevelt	1953	0	52-MV-459	Wyandotte Reg.	all	Sugden & Sivier	American Aggregate	Inland Lime & Stone	yes	+
				53-MV-203	Wyandotte Reg.	all	Sugden & Sivier	American Aggregate	Inland Lime & Stone	yes	+
S15 of 82023	24th	1953	0	52-MV-163	Peerless A. E.	some	L. A. Davidson	Lyle J. Walker	Inland Lime & Stone	yes	+
				52-MV-404	Peerless A. E.	some	L. A. Davidson	Lyle J. Walker	Inland Lime & Stone	yes	+
				52-MV-403	Peerless A. E.	some	L. A. Davidson	Lyle J. Walker	Inland Lime & Stone	yes	+
S19 of 82023	14th	1953	0	52-MV-458	Wyandotte Reg.	all	Louis Garavaglia	American Aggregate	Inland Lime & Stone	yes	+ -
S20 of 82023	12th	1953	0	52-MV-364	Peerless A. E.	all	W. J. Storen	American Aggregate	Inland Lime & Stone	no**	+
P05 of 82023	Brooklyn	1955	0	54-MV-119	Peerless A. E.	all	Sugden & Sivier	American Aggregate	Drummond Dolomite	yes	+

* "All," "some," or "none" of the pours had air-entraining agent added.

** Wet batched from nearby site.

APPENDIX

PREVIOUS CORRESPONDENCE AND FIELD SURVEYS OF PIER COLUMNS ON EDSEL FORD FREEWAY

1. Warren F. Cox to J. F. Oravec - October 12, 1964.

"I am attaching a letter which is addressed to Mr. A. J. Sinelli, District Bridge Engineer. Because of his concern in this matter, he suggested this letter so that he may call this to the attention of the Bridge Construction Office in Lansing.

"I know you are familiar with this problem so that no further explanation is necessary, but I will add that in a recent budget discussion with S. W. Curtiss, we are finding that the pier column failure will be a major problem in our budgeting in the very near future. In addition to this we are very concerned about the rapid pattern that is presently developing.

"If you require additional information, I will be happy to supply it."

2. Warren F. Cox to A. J. Sinelli - October 12, 1964.

"Concrete failures of the surfaces of pier columns has become a major concern on the Detroit expressways. Failures develop from vertical cracks occurring in line with the corner vertical reinforcing bars. These cracks occurring on opposite sides of the pier eventually result in a failure plane across the entire pier parallel to the adjacent face and to the depth of the reinforcing steel. The median piers from Michigan to the interchange on the Edsel Ford Expressway exhibit this failure to the greatest degree, although it is becoming evident now on the south section of the John Lodge. This pattern of failure is related to the structure age.

"Currently we plan maintenance on three structures which include Michigan Avenue and Martin Avenue on the Edsel Ford. Six more structures must be reserved until we have funds available. They are all on the Edsel Ford in the critical areas above described. Other piers in this area show the cracks which are signs of eventual complete failure.

"Due to the fact a number of structures constructed fourteen to sixteen years ago have developed failures, or the signs of failure, we in maintenance feel that a serious pattern may be developing. From our previous discussions I know you are interested in this matter and I am using this letter to further call your attention to the problem."

3. J. F. Oravec to N. C. Jones - November 10, 1964.

"Attached please find a copy of a letter from W. Cox to A. J. Sinelli dated October 12, 1964 and a copy of a letter from W. Cox to me dated October 12, 1964. Both of these letters bring to our attention the concrete failures of the surfaces of pier columns in the Detroit area.

"In a discussion with L. M. Kukielka, he pointed out that the (1) failures are more severe in the median areas, (2) the failures are in the areas where salt spray is more likely to reach the pier column, (3) the more serious cracking is occurring at the corners of the pier columns, and (4) these structures are approximately 15 years old.

"I am calling this to your attention with the hope that we may jointly take a look at this problem. We in Maintenance could continue to make these repairs as has been done in the past without any further help or consultation. However I feel that we should take whatever steps are necessary to prevent the reoccurrance of this problem after we have made the necessary repairs. Also there may be something that we could do from the Design standpoint to prevent the occurrence on bridges that are about to be constructed.

"From the standpoint of maintenance it may be that an additional covering of concrete over the steel may be warranted. The additional volume of concrete is insignificant to the total cost of making the repairs. The work of chipping the concrete, cleaning the steel and forming is the major expense and the volume of concrete used would add very little to the cost. There may be other solutions that you may want to recommend.

"It is my hope that we can arrange a meeting on this subject sometime in the future. Before we have such a meeting I have asked Mr. L. M. Kukielka to make a survey and itemize for us the locations where this type of failure is most prevalent. As soon as he has provided me with this information I will contact you."

4. Warren F. Cox to J. F. Oravec - November 30, 1964.

"In your memo of November 10 to Mr. Jones regarding a meeting to inspect surface concrete failures of pier columns on the Metropolitan Detroit Freeways, you refer to a survey to be made by this office which will help to localize this type of failure.

"I have conducted this survey by two methods. The first was submitted to this office by Mr. S. W. Curtiss of Wayne County Road Commission, and gives a detailed description of two structures which are presently being repaired under maintenance. These descriptions detail the location of disintegration in relation to the specific structures mentioned.

"A second survey which was conducted by bridge project engineers Richard W. Dambrun and Fred Pittman illustrates the extent of this type of failure within the section of the Edsel Ford Freeway from Wyoming to the Lodge Interchange. This survey does not detail the location of the failures with relation to each individual structure, but, rather outlines the limits to which this type of failure has progressed on an entire section of Freeway.

"Should any explanation of these reports be necessary, I would be happy to furnish you with any additional information."

5. Warren Cox to J. F. Oravec - November 30, 1964 (survey data by Richard Dambrun and Fred Pittman).

COLUMN CONDITION SURVEY
STRUCTURES ON I 94: WYOMING TO LODGE INTERCHANGE

Structure No.	Location	Year	Median Piers		Outside Piers		Totals	
			Cracked	Spalled	Cracked	Spalled	Cols.	Pier
S36 of 82022	Wyoming	1949	1	1	7	1	18	3
S01 of 82023	Weir	1950	3	0	2	0	12	3
S02 of 82023	Addison	1949	0	0	-	-	5	1
P01 of 82023	Trenton	1951	0	0	0	0	4	2
S03 of 82023	Lonyo	1949	1	0	-	-	6	1
P02 of 82023	Lumley	1952	0	0	0	0	4	2
S04 of 82023	Central	1950	1	3	7	0	15	3
P03 of 82023	Tarnow	1952	0	0	0	0	6	2
S05 of 82023	Cecil	1950	1	4	7	0	15	3*
S06 of 82023	Martin	1949	0	5	5	1	15	3
S07 of 82023	Livernois	1950	0	0	1	0	24	3
X01 of 82023	C & O RR	1948	2	2	2	0	18	3
S08 of 82023	Wesson	1951	0	3	4	0	15	3
S09 of 82023	Junction	1950	0	5	3	0	15	3
S10 of 82023	30th	1951	3	0	6	0	18	3
S11 of 82023	Warren	1953	0	0	7	0	49	7
S12 of 82023	Scotten	1953	1	1	1	0	25	5*
S13 of 82023	W. Grand	1953	1	1	3	1	25	7*
S14 of 82023	W. Grand	1953	0	0	0	1	25	7*
P04 of 82023	Roosvelt	1953	0	0	0	0	6	3
S15 of 82023	24th	1953	0	0	0	0	15	3
S16 of 82023	Maybury G.	1954	0	1	0	0	15	3*
S17 of 82023	G. River	1954	4	0	0	0	24	3*
S18 of 82023	Linwood	1953	2	0	2	1	12	3*
S19 of 82023	14th	1953	0	0	0	0	18	3
X02 of 82023	GTW RR LS & MS RR	1955	0	5	0	0	14	2
S20 of 82023	12th	1953	0	0	-	-	5	1
X03 of 82023	NYC RR	1954	0	2	-	-	10	1*
S21 of 82023	Trumbull	1054	0	2	0	0	18	3
P05 of 82023	Brooklyn	1955	0	0	0	0	8	4

* Cap beam or beams cracked or wall cracked.
NOTE: Decks leak over all piers.

6. S. W. Curtiss to L. M. Kukielka - November 19, 1964 (results of survey by S. W. Curtiss).

SHD File No. S34 of 82022 - County Job No. 727, Michigan Avenue, I 94

SHD File No. S32 of 82022 - County Job No. 729, Eastbound Michigan Ramp, I 94

SHD File No. S06 of 82023 - County Job No. 740, Martin Avenue, Edsel Ford Freeway

"As per your request, a comprehensive survey has been made on the extent of repairs made at S34 of 82022 and S32 of 82022 and the apparent condition of the piers at S06 of 82023.

"The repairs made at S34 of 82022 are as follows:

"This is a two-span structure. All disintegration has been at the pier which is in a narrow median island. There are 16 columns in the pier. Numbering is from the west.

Column No.	Location	Area of Repair
2	Northeast corner	From 1' to 4' above grade
7	South side	8' to 9'
	Southeast corner	3' to 9'
9	South side	3' to 9'
	North side	0' to 9'
	West side	7' to 9'
	East side	7' to 9'
10	South side	4' to 9'
	Southwest corner	0' to 9'
	Southeast corner	0' to 9'
	North side	4' to 9'
	Northwest corner	0' to 9'
11	South side	1' to 9'
	East side	0' to 3'
	North side	9' to 9'
	West side	0' to 4'
12	South side	0' to 9'
	North side	0' to 4'
	Northeast corner	0' to 9'
13	South side	0' to 4'
	Southwest corner	0' to 9'

6. (Cont.)

Column No.	Location	Area of Repair
13 (cont.)	North side	From 0' to 5' above grade
	West side	0' to 2'
	West side	7' to 9'
14	North side	0' to 3'
	Northeast corner	0' to 9'

"The repairs made at S32 of 82022 are as follows:

"This is a five-span structure. All repairs are currently being made on the second pier from the north which is in an island between the westbound ramp and the westbound freeway. There are four columns in the pier. Numbering is from the west:

Column No.	Location	Area of Repair
1	East side	From 0' to 5' above grade
	North side	0' to 2'
2	West side	0' to 2'
	North side	0' to 3'
	East side	0' to 2'
	Southeast corner	0' to 10'
3	Southwest corner	0' to 10'
	East side	0' to 2'
	North side	0' to 3'
4	Northwest corner	3' to 5'
	East side	3' to 5'

"On this structure there is considerable horizontal cracking apparent in the pier columns which is a condition not apparent in other structures."

S06 of 82023 "is a four-span structure. Disintegration has occurred at all three piers, but is most serious at the center pier. There are five columns in each pier. Numbering is from the west:

	Column No.	Location	Area of Disintegration
South Pier	1	Northwest corner	Cracked from 0' to 4' above grade
		Southeast corner	0' to 10'

6. (Cont.)

	Column No.	Location	Area of Disintegration
South Pier (cont.)	2	Northwest corner	Cracked from 0' to 10' above grade
		Southwest corner	1' to 2'
		Southwest corner	8' to 9'
	3	Northwest corner	Cracked & spalled 0' to 5'
		Southwest corner	Cracked & spalled 0' to 3'
	5	Northwest corner	Cracked from 0' to 4'
Center Pier	1	Southest corner	Spalled from 1' to 5' above grade
		Northeast corner	1' to 6'
	2	West side	0' to 10'
		Southeast corner	0' to 5'
		Northeast corner	0' to 7'
	3	Southwest corner	0' to 5'
		Northwest corner	1' to 5'
		Southeast corner	1' to 6'
		Northeast corner	1' to 7'
	4	Northwest corner	0' to 9'
		Northeast corner	0' to 8'
	5	Southwest corner	0' to 10'
		Northwest corner	0' to 9'
		Northeast corner	Disintegrated from 1' to 3'
North Pier	1	Northeast corner	Cracked from 1' to 3' above grade
	2	Southeast corner	1' to 2'
		Northeast corner	1' to 2'
	4	Southeast corner	0' to 3'
		Northeast corner	0' to 2'

7. J. F. Oravec to N. C. Jones and P. A. Nordgren - December 4, 1964.

"This is to confirm our joint inspection of above condition on Friday, December 11, 1964. Joe Badaluco of this office will accompany us and I am sure that District personnel will also be with us.

"We will be in touch next week on starting time, etc."

8. Warren F. Cox to J. F. Oravec - December 14, 1964.

"This will confirm the conclusions and suggestions of the subject meeting held at the Redford District Office.

"Field investigation and discussion reached these conclusions as to the primary causes for the conditions developing on pier columns in the Detroit area:

"1. Areas of porous concrete (honeycomb) located along the corners of the columns.

"2. Reinforcing steel with less than two inches of concrete covering.

"3. The extreme exposure to which the pier columns on the Detroit Freeways are subjected.

"With regard to the repair of these columns on maintenance, the following suggestions were made:

"1. The reinforcing steel which has been exposed to considerable rust should be cleaned within the practical limits determined by the amount of deteriorated concrete removed.

"2. Repaired columns should be sealed with some type of epoxy or penetrating sealer to eliminate as much as possible the moisture which attacks the reinforcing steel and concrete. Joseph Badaluco, because of his position on the deck sealing committee, was to recommend an appropriate sealer for this purpose.

"Suggestions by Bridge Construction to alleviate this condition on future projects included the possibility of making the complete removal of honeycombed areas in pier columns mandatory on construction, thus eliminating the original source of failure.

"Mr. Bruce LaFrance offered to arrange for colored slides which would clearly illustrate to construction forces how honeycomb eventually effects the concrete failures in these columns."