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Department of Civil Engineering

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TEST RESULTS ON THE DYNAMIC TESTING OF EXPANSION
TYPE CONCRETE ANCHORS

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By: Barry Barror
Roger Rice
Roy M. Stephen

Report to WESTINGHOUSE HANFORD COMPANY

MASTER

DECEMBER 1974

STRUCTURAL ENGINEERING LABORATORY
UNIVERSITY OF CALIFORNIA
BERKELEY, CALIFORNIA

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COLLEGE OF ENGINEERING
DEPARTMENT OF CIVIL ENGINEERING
DIVISION OF STRUCTURAL ENGINEERING
AND STRUCTURAL MECHANICS

BERKELEY, CALIFORNIA 94720

December 11, 1974

Westinghouse Hanford Company
P. O. Box 1970
Richland, WA. 99352

Attention: Mr. G. C. Peterson IN4/337

Gentlemen:

Transmitted herein is a report entitled, "Test Results on the Dynamic Testing of Expansion Type Concrete Anchors."

This test program was conducted at the University of California, Berkeley, under an Industrial Service Program, PROJECT S-69835.

I trust that you will find the report and results satisfactory.

Sincerely yours,

D. Pirtz
Professor of Civil Engineering

RMS:jm

cc:

K. W. McMilliam

WESTINGHOUSE HANFORD COMPANY
RICHLAND, WASHINGTON

TEST RESULTS ON THE DYNAMIC TESTING OF EXPANSION
TYPE CONCRETE ANCHORS

By

Barry Barron
Roger Rice
Roy M. Stephen

OBJECTIVE

The purpose of these tests were to determine the structural response, yield and ultimate capacity of various types of commercially available expansion type anchors when subjected to dynamic loadings similar to those encountered in: (a) steady-state machine vibrations, and (b) earthquakes. The specimens were subjected to tension, shear, and combined shear-tension loads.

DESCRIPTION OF TEST SPECIMENS

The anchors were set in precast concrete blocks measuring 15 in. by 15 in. 12 in., with #2 spiral reinforcement. Figures 1, 2 and 3 show the tension, shear and combined specimens. The concrete used was of three types:

- C - FFTF Regular Concrete 4000 psi mix.
- M - FFTF Magnetite Concrete 5000 psi mix.
- SS - FFTF Steel Shot Concrete 5000 psi mix.

In all cases a 1 1/4-in. threaded bolt with a 4 in. by 4 in. steel plate was cast into the concrete such that the threads projected from the specimen.

Shell, sleeve, and stud-type anchors in sizes of 5/8, 3/4, and 1-inch diameter, as shown in Figure 4, were tested. Table I lists the size, type, manufacturer, and code for each of the anchors tested. All anchors were installed according to the manufacturer's specifications and aligned with respect to the upper cast-in bolt. In some cases eccentricities were noted,

however, these were generally less than 1/4 inch. Embedment depths varied from specimen to specimen as shown on the X-Y plots in the Appendix of this report.

For each test specimen a standard 6 x 12 in.-control cylinder was cast from the same batch of concrete to determine the concrete strength on the day of testing. The control cylinders and specimens were cured in moist sawdust for 14 days.

TESTING EQUIPMENT

Testing was conducted using the 500 kip MTS Dynamic Test Frame in Davis Hall, University of California, Berkeley.

TEST ARRANGEMENT

The specimens were installed in the test frame as shown in Figure 5. Two linear transformers (LVDT's) were mounted under the specimen, as noted in the figure, on opposite sides of the expansion anchor to measure the relative movement between the anchor and the test specimen. Two Honeywell X-Y recorders were used in the testing. One, to measure load versus overall (or ram) displacement, and the other to measure load versus the average of the LVDT's displacement. A Tektronix 56A storage oscilloscope was used to monitor the MTS load range values during dynamic testing. This test equipment along with the MTS control console and function generator is shown in Figure 6.

TEST PROCEDURE AND LOADING SEQUENCE

For the static tests the specimens were installed and the load applied at a rate of approximately 5 kips per minute until failure occurred.

For the dynamic tests the specimens were subjected to an initial load of 20 percent of the average static test values (S'), cycled for 2000 cycles

each at 5, 10, and 15 cycles per second. Displacement readings were made at each interval. At the end of the 6000 cycles the frequency was maintained at 10 cycles per second and the load was increased by 10 percent of S' every 600 cycles up to 50 percent of S' . At this point (7800 accumulated cycles) the load was raised to 60 percent S' and the specimen cycled until 100,000 cycles. At 100,000 cycles the load was increased 2000 pounds every 2000 cycles until failure occurred. Table II outlines the loading sequence used. In many cases, due either to the high loads or large displacements, it was not possible to maintain frequencies above 5 cycles per second. In this case the maximum possible frequency was used and was noted on the X-Y plots.

For the long-term fatigue tests the specimens were loaded to 20 percent of S' for 2,000,000 cycles at 10 cycles per second (frequencies varied on certain specimens as noted above, see X-Y plots for actual frequencies). In the case where the specimen survived 2,000,000 cycles, the load was then increased by 2000 pounds every 2000 cycles until failure occurred.

The minimum load for all dynamic and fatigue tests varied between 500 and 1200 pounds.

RESULTS

The results are tabulated in Table III according to size, anchor type, and type of specimen for easy reference. The table lists from left to right: specimen number, type of concrete, strength of concrete on test date, type of anchor (see Table I), type of test performed, type of specimen, yield load, displacement at yield load, number of cycles at yield load, ultimate load, total number of cycles, and a brief comment on the mode of failure. For dynamic and fatigue tests the yield and ultimate loads are listed as the same.

Table IV is a bar graph showing the ultimate loads of all the specimens tested, grouped according to size and anchor type. Figure 7 shows the typical failure mode for each type of specimen tested.

The X-Y plots are attached as Appendix 1 and are grouped by specimen number. Appendix 2 is a tabulation of the data by bolt type and Appendix 3 is a tabulation of the data by test type.

TABLE 1. TYPES OF ANCHOR BOLTS TESTED

Anchor Type/Size	Code	Manufacturer
Hilti Shell Type 5/8" stud, 27/32" shell	LA-5	Hilti Fastening Systems Stamford, Connecticut
Hilti Shell Type 3/4" stud, 1" shell	LA-6	
Hilti Stud Type 5/8" dia. stud	SH-5	
Hilti Kwik-bolt Stud 3/4" dia. stud	SH-6	
Hilti Kwik-bolt Stud 1" dia. stud	SH-8	
Molly Parabolt Stud 5/8" dia. stud	SB-5	USM Corporation Shelton, Connecticut
Molly Parabolt Stud 3/4" dia. stud	SB-6	
Molly Parabolt Stud 1" dia. stud	SB-8	
Phillips Red-head Sleeve 1/2" dia. stud, 5/8" dia. sleeve	LB-5	Phillips Drill Company Inc. Michigan City, Indiana
Phillips Red Head Sleeve 5/8" dia. stud, 3/4" dia. sleeve	LB-6	
Rawl Stud Anchor 5/8" dia. stud	SA-5	The Rawlplug Company New Rochelle, New York
Rawl Stud Anchor 3/4" dia. stud	SA-6	
Rawl Stud Anchor 1" dia. stud	SA-8	
Weij-it Stud Anchor 5/8" dia. stud	SC-5	Weij-it Corporation Broomfield, Colorado
Weij-it Stud Anchor 3/4" dia. stud	SC-6	
Weij-it Stud Anchor 1" dia. stud	SC-8	

TABLE 2. DYNAMIC LOAD SEQUENCE

Test Period	Max. Load	Cycle/Second	Total Cycles
1	.2S'	5	2000
2	.2S'	10	4000
3	.2S'	15	6000
4	.3S'	10	6600
5	.4S'	10	7200
6	.5S'	10	7800
7	.6S'	10	100,000
8	.6S' + 2000#	10	102,000
9	.6S' + 4000#	10	104,000
i	.6S' + (i-7)2000#	10	100,000 + (i-7)2000

TABLE 3. RESULTS OF ANCHOR TEST PROGRAM

TABLE OF DATA SORTED BY BOLT DIAMETER AND TEST TYPE IN THAT ORDER

5/8 INCH BOLTS TESTED IN TENSION

SPEC NUMB	CONC TYPE	FIC KSI	BOLT TYPE	TEST TYPE		P1 KIP	D1 IN	CYCLE KC	PU KIP	DU IN	CYCLE KC	FAILURE MODE
11	REG	5.60	LB-5	STAT	T	12.0	.25	--	13.0	.40	--	BOLT FAILED
112	REG	7.49	LA-5	DYN	T	6.6	.08	7.8	10.0	.22	102	CONC FAILED
100	REG	6.20	LA-5	DYN	T	7.8	.06	7.8	10.6	.14	101	CONC FAILED
14	REG	4.50	LB-5	DYN	T	11.0	.20	10.2	11.0	.45	11.7	BOLT FAILED
202	REG	4.40	LB-5	DYN	T	6.8	.15	22.0	6.8	.20	71	BOLT FAILED
201	REG	6.10	LB-5	FAT	T	2.6	.25	3.0	2.6	.35	504	BOLT FAILED
205	REG	5.50	LB-5	FAT	T	2.6	.02	2000	2.6	.02	2000	BOLT FAILED
105	REG	6.54	SB-5	STAT	T	8.0	.20	--	14.4	.40	--	PULLOUT
203	REG	6.20	SB-5	STAT	T	11.6	.35	--	11.6	.80	--	PULLOUT
89	REG	6.86	SC-5	DYN	T	5.5	.07	7.8	10.7	.20	102	PULLOUT
85	REG	6.55	SC-5	DYN	T	5.5	.05	7.8	12.6	.20	101	PULLOUT
37	REG	5.50	SA-5	DYN	T	8.6	.22	7.8	18.6	.60	110	PULLOUT
114	REG	6.86	SA-5	DYN	T	8.6	.50	7.8	12.6	1.0	102	CONC FAILED
5	REG	6.30	SB-5	DYN	T	7.0	.45	7.8	16.0	.68	112	PULLOUT
1	REG	6.60	SB-5	DYN	T	7.0	.07	7.8	12.0	.45	102	PULLOUT

TABLE 3. CONTINUED

TABLE OF DATA SORTED BY BOLT DIAMETER AND TEST TYPE IN THAT ORDER (CONT.)

5/8 INCH BOLTS TESTED IN SHEAR

SPEC NUMB	CONC TYPE	F/C KSI	BOLT TYPE	TEST TYPE	P1 KIP	D1 IN	CYCLE KC	PU KIP	DU IN	CYCLE KC	FAILURE MODE	
210	REG	4.90	LB-5	STAT	V	19.0	.45	--	20.0	.70	--	BOLT SHEARED
16	REG	5.00	LB-5	STAT	V	17.0	.20	--	24.0	.70	--	BOLT SHEARED
C2-12	REG	6.87	LB-5	STAT	V	16.0	.30	--	17.2	.40	--	BOLT SHEARED
C2-14	REG	6.22	LA-5	DYN	V	9.6	.15	7.8	9.6	.30	51.0	BOLT SHEARED
C2-15	REG	6.52	LA-5	DYN	V	9.6	.15	7.8	9.6	.25	39.0	BOLT SHEARED
207	REG	4.50	LB-5	DYN	V	14.4	.20	7.8	14.4	.40	31.6	BOLT SHEARED
12	REG	5.50	LB-5	DYN	V	14.4	.35	7.8	14.4	.65	32.0	BOLT SHEARED
206	REG	5.80	LB-5	FAT	V	4.6	.07	.60	26.5		2000	BOLT SHEARED
72	REG	7.17	LB-5	FAT	V	4.6	.05	7.8	26.6	1.0	2000	BOLT SHEARED
208	REG	6.20	SB-5	STAT	V	28.0	.15	--	33.0	.45	--	BOLT SHEARED
C2-13	REG	5.90	SB-5	STAT	V	16.0	.10	--	21.0	.17	--	BOLT SHEARED
7	REG	6.40	SB-5	DYN	V	20.0	.10	7.8	20.0	.20	9.2	BOLT SHEARED
8	REG	---	SB-5	DYN	V	18.0	.22	7.8	18.0	--	10.2	BOLT SHEARED
C2-10	REG	6.40	SC-5	DYN	V	14.4	.15	7.8	14.4	.23	33.9	BOLT SHEARED
C2-11	REG	6.64	SC-5	DYN	V	14.4	.25	7.8	14.4	.75	23.0	BOLT SHEARED
209	REG	7.16	SA-5	DYN	V	19.2	.17	7.8	19.2	.45	17.9	BOLT SHEARED
C2-9	REG	6.77	SA-5	DYN	V	19.2	.30	7.8	19.2	.35	8.0	BOLT SHEARED

TABLE 3. CONTINUED

TABLE OF DATA SORTED BY BOLT DIAMETER AND TEST TYPE IN THAT ORDER (CONT.)

5/8 INCH BOLTS TESTED IN COMBINED TENSION AND SHEAR

SPEC NUMB	CONC TYPE	FIC KSI	BOLT TYPE	TEST TYPE	P1 KIP	D1 IN	CYCLE KC	PU KIP	DU IN	CYCLE KC	FAILURE MODE	
39	REG	6.11	LA-5	STAT	C	4.0	.10	--	11.2	.95	--	BOLT FAILED
21	REG	5.80	LB-5	STAT	C	6.4	.15	--	11.8	1.0	--	PULLOUT
46	REG	5.30	LB-5	STAT	C	8.0	.30	--	11.4	1.1	--	PULLOUT
43	REG	5.70	LB-5	DYN	C	7.0	.05	7.2	7.0	.46	41	PULLOUT
33	REG	5.00	LB-5	DYN	C	7.2	.15	7.8	7.2	.40	16.5	BOLT SHEARED
44	REG	6.61	LA-5	DYN	C	6.6	.07	7.8	6.6	.07	7.8	PULLOUT
34	REG	5.92	LA-5	DYN	C	6.6	.07	7.8	6.6	.07	7.8	PULLOUT
35	REG	4.90	SB-5	STAT	C	11.6	.07	--	11.6	.10	--	CONC FAILED
25	REG	--	SB-5	STAT	C	6.8	.12	--	10.6	.43	--	CONC FAILED
10	REG	5.80	SB-5	DYN	C	6.6	.07	7.8	6.6	--	17.9	BOLT SHEARED
45	REG	6.10	SB-5	DYN	C	6.6	.10	7.8	9.6	.35	102	BOLT SHEARED
18	REG	6.70	SC-5	DYN	C	6.6	.27	7.8	6.6	--	28.0	PULLOUT
4	REG	6.20	SC-5	DYN	C	6.6	.05	7.8	6.6	.07	15.6	PULLOUT
24	REG	6.50	SA-5	DYN	C	6.6	.09	7.8	6.6	.10	22.0	PULLOUT
36	REG	6.30	SA-5	DYN	C	6.6	.15	7.8	6.6	.45	37.0	PULLOUT

TABLE 3. CONTINUED

TABLE OF DATA SORTED BY BOLT DIAMETER AND TEST TYPE IN THAT ORDER (CONT.)

3/4 INCH BOLTS TESTED IN TENSION

SPEC NUMB	CONC TYPE	FIC KSI	BOLT TYPE	TEST TYPE	P1 KIP	D1 IN	CYCLE KC	PU KIP	DU IN	CYCLE KC	FAILURE MODE	
106	REG	7.16	LB-6	STAT	T	14.8	.78	--	15.4	.98	--	PULLOUT
99	REG	6.91	LB-6	STAT	T	--	--	9.4	--	--	--	PULLOUT
87	REG	5.51	LB-6	DYN	T	7.8	.15	7.8	15.6	1.01	103	PULLOUT
86	REG	7.24	LB-6	DYN	T	7.8	.80	7.8	9.7	.96	9.7	PULLOUT
13	REG	6.08	LB-6	FAT	T	2.6	.02	1.0	4.2	.03	2000	BOLT FAILED
94	REG	6.38	LB-6	FAT	T	2.6	.05	1.0	2.6	.15	535	BOLT FAILED
121	MAG	6.17	LB-6	STAT	T	--	--	16.6	--	--	--	PULLOUT
128	MAG	6.20	LB-6	STAT	T	3.7	.01	--	5.6	--	--	PULLOUT
127	MAG	6.17	LB-6	DYN	T	7.0	1.0	7.8	13.0	1.26	107.8	CONC FAILED
130	MAG	6.15	LB-6	DYN	T	7.0	.46	7.8	12.5	.76	102	CONC FAILED
132	SS	6.27	LB-6	STAT	T	2.8	.02	--	4.0	--	--	PULLOUT
134	SS	6.29	LB-6	STAT	T	4.8	.38	--	7.2	1.05	--	PULLOUT
137	SS	6.20	LB-6	DYN	T	3.4	.38	7.8	6.4	.97	110	PULLOUT
136	SS	6.24	LB-6	DYN	T	--	--	--	2.2	.83	6.8	PULLOUT
110	REG	7.49	SB-6	STAT	T	5.0	.10	--	17.3	.50	--	PULLOUT
109	REG	7.44	SA-6	STAT	T	6.0	.20	--	22.0	.50	--	PULLOUT
115	REG	6.86	SA-6	DYN	T	10.0	.25	7.8	18.2	.45	105	PULLOUT
120	REG	7.12	SA-6	DYN	T	10.0	.18	7.8	21.8	.45	108	CONC FAILED
204	REG	--	SA-6	FAT	T	4.0	.01	--	4.0	.03	386	BOLT SHEARED
73	REG	--		FAT	T							
123	MAG	6.93	SB-6	STAT	T	8.0	.04	--	14.2	.15	--	CONC FAILED
116	MAG	7.05	SA-6	STAT	T	8.0	.05	--	25.5	.42	--	CONC FAILED
129	MAG	6.78	SB-6	DYN	T	13.6	.10	7.8	15.7	.42	100	BOLT FAILED
122	MAG	7.07	SA-6	DYN	T	13.6	.18	7.8	13.6	.26	94	BOLT FAILED

TABLE 3. CONTINUED

TABLE OF DATA SORTED BY BOLT DIAMETER AND TEST TYPE IN THAT ORDER (CONT.)

3/4 INCH BOLTS TESTED IN TENSION CONT.

SPEC NUMB	CONC TYPE	F•C KSI	BOLT TYPE	TEST TYPE	P1 KIP	D1 IN	CYCLE KC	PU KIP	DU IN	CYCLE KC	FAILURE MODE	
139	SS	6.50	SA-6	STAT	T	12.0	.30	--	15.6	.60	--	PULLOUT
138	SS	7.38	SB-6	STAT	T	6.0	.40	--	7.6	.60	--	PULLOUT
131	SS	7.33	SA-6	DYN	T	9.6	.21	7.8	13.6	.30	101	PULLOUT
140	SS	7.58	SA-6	DYN	T	8.4	.27	7.8	14.4	.40	102	PULLOUT
133	SS	7.61	SB-6	FAT	T	3.2	.05	--	3.2	.70	1440	BOLT FAILED

TABLE 3. CONTINUED

TABLE OF DATA SORTED BY BOLT DIAMETER AND TEST TYPE IN THAT ORDER (CONT.)

3/4 INCH BOLTS TESTED IN SHEAR

SPEC NUMB	CONC TYPE	FIC KSI	BOLT TYPE	TEST TYPE		P1 KIP	D1 IN	CYCLE KC	PU KIP	DU IN	CYCLE KC	FAILURE MODE
77	REG	6.78	LB-6	STAT	V	21.5	.30	--	29.2	.85	--	BOLT FAILED
76	REG	6.67	LB-6	STAT	V	28.0	.40	--	31.6	.65	--	BOLT FAILED
75	REG	7.35	LB-6	DYN	V	17.8	.27	7.8	17.8	.80	27.5	BOLT FAILED
78	REG	6.54	LB-6	DYN	V	17.8	1.10	7.8	17.8	--	19.8	BOLT FAILED
63	MAG	6.54	LB-6	STAT	V	23.0	.34	--	32.4	--	--	BOLT FAILED
65	MAG	6.57	LB-6	STAT	V	25.0	.40	--	28.2	.90	--	BOLT FAILED
66	MAG	6.48	LB-6	DYN	V	17.4	.25	7.8	17.4	.55	39.6	BOLT FAILED
64	MAG	6.70	LB-6	DYNV	V	17.4	.27	7.8	17.4	1.25	26.9	BOLT FAILED
69	SS	6.40	LB-6	STAT	V	18.8	.17	--	22.0	1.20	--	PULLOUT
68	SS	6.96	LB-6	STAT	V	26.0	.40	--	28.0	.60	--	PULLOUT
70	SS	5.16	LB-6	DYN	V	10.8	.22	7.8	10.8	--	34	PULLOUT
71	SS	6.43	LB-6	DYN	V	16.8	1.10	7.8	10.8	--	7.8	PULLOUT
C2-1	REG	5.87	SH-6	STAT	V	30.1	.23	--	32.8	.30	--	BOLT SHEARED
C2-2	REG	6.10	SA-6	STAT	V	30.3	.15	--	34.0	.20	--	BOLT SHEARED
C2-3	REG	6.38	SB-6	DYN	V	20.1	.13	7.8	23.4	.25	101	BOLT SHEARED
C2-4	REG	6.68	SA-6	DYN	V	20.1	.20	7.8	20.1	.25	18.7	BOLT SHEARED
M2-2	MAG	5.81	SA-6	STAT	V	38.0	.25	--	42.0	.33	--	CONC FAILED
M2-1	MAG	6.08	SH-6	STAT	V	34.0	.30	--	37.8	.70	--	BOLT FAILED
M2-4	MAG	5.87	SH-6	DYN	V	24.0	.30	7.8	24.0	.80	8.1	BOLT FAILED
M2-3	MAG	5.49	SB-6	DYN	V	24.0	.20	7.8	24.0	.25	8.1	BOLT FAILED
S2-1	SS	7.30	SA-6	STAT	V	24.0	.20	--	32.0	.30	--	CONC FAILED
S2-2	SS	6.84	SH-6	STAT	V	20.0	.15	--	26.0	.22	--	CONC FAILED
S2-3	SS	7.44	SB-6	DYN	V	18.4	.20	7.8	18.4	.40	36.4	PULLOUT
S2-4	SS	7.10	SA-6	DYN	V	18.0	.10	7.8	26.3	.19	103	CONC FAILED
S2-5	SS	7.23	SA-6	FAT	V	5.8	.05	--	5.8	.12	1500	FAILED STAT

TABLE 3. CONTINUED

TABLE OF DATA SORTED BY BOLT DIAMETER AND TEST TYPE IN THAT ORDER (CONT.)

3/4 INCH BOLTS TESTED IN COMBINED TENSION AND SHEAR

SPEC NUMB	CONC TYPE	F.C KSI	BOLT TYPE	TEST TYPE		P1 KIP	D1 IN	CYCLE KC	PU KIP	DU IN	CYCLE KC	FAILURE MODE
81	REG	7.10	LA-6	STAT	C	9.0	.40	--	13.3	.55	--	PULLOUT
27	REG	7.12	LA-6	STAT	C	11.0	.14	--	12.0	.16	--	CONC FAILED
26	REG	--	LB-6	STAT	C	6.0	.15	--	10.4	--	--	CONC FAILED
30	REG	5.85	LB-6	STAT	C	8.4	.19	--	14.4	1.35	--	CONC FAILED
28	REG	6.43	LB-6	DYN	C	7.2	.54	7.8	7.2	--	39.5	BOLT SHEARED
32	REG	7.01	LB-6	DYN	C	7.2	.32	7.8	7.2	--	63.3	BOLT SHEARED
54	MAG	8.14	LB-6	STAT	C	5.8	.08	--	15.4	--	--	CONC FAILED
51	MAG	8.07	LB-6	STAT	C	7.2	.09	--	14.2	.93	--	CONC FAILED
56	MAG	8.07	LB-6	DYN	C	6.4	.07	7.8	6.4	--	67	PULLOUT
53	MAG	7.90	LB-6	DYN	C	6.4	.09	7.8	6.2	--	95.5	BOLT SHEARED
61	SS	7.65	LB-6	STAT	C	9.6	.11	--	11.2	.94	--	CONC FAILED
215	SS	6.38	LB-6	STAT	C	8.6	.12	--	11.2	.41	--	CONC FAILED
214	SS	8.77	LB-6	DYN	C	6.3	.11	7.8	6.25	--	44.6	STUD SHEARED
216	SS	6.86	LB-6	DYN	C	6.4	.14	7.8	6.40	--	7.9	PULLOUT
80	REG	7.17	SB-6	STAT	C	9.0	.20	--	13.0	.30	--	PULLOUT
83	REG	6.86	SA-6	DYN	C	6.5	.25	7.8	13.2	.50	107	PULLOUT
31	REG	6.71	SB-6	DYN	C	6.5	.50	7.8	11.8	1.0	102	PULLOUT
50	REG	6.22	SA-6	FAT	C	2.6	.01	--	10.3	.29	2005	CONC FAILED
55	MAG	--	SA-6	STAT	C	8.0	.15	--	11.4	.20	--	CONC FAILED
52	MAG	--	SB-6	STAT	C	12.0	.02	--	15.4	.23	--	CONC FAILED
58	MAG	--	SB-6	DYN	C	8.0	.20	7.8	14.6	.24	104	CONC FAILED
59	MAG	8.62	SA-6	DYN	C	8.2	.04	7.8	12.0	.08	102	CONC FAILED
62	SS	7.90	SB-6	STAT	C	6.0	.08	--	10.4	.17	--	BOLT FAILED
213	SS	8.14	SA-6	DYN	C	6.0	.20	7.8	10.0	.43	71.8	BOLT FAILED
219	SS	8.53	SA-6	DYN	C	6.1	.17	7.8	6.1	.26	84.0	BOLT FAILED
217	SS	8.09	SA-6	FAT	C	2.0	.02	--	6.0	.35	2006	BOLT SHEARED

TABLE 3. CONTINUED

TABLE OF DATA SORTED BY BOLT DIAMETER AND TEST TYPE IN THAT ORDER (CONT.)

1 INCH BOLTS TESTED IN TENSION

SPEC NUMB	CONC TYPE	F/C KSI	BOLT TYPE	TEST TYPE	P1 KIP	D1 IN	CYCLE KC	PU KIP	DU IN	CYCLE KC	FAILURE MODE
68	REG	6.96	SA-8	STAT T	24.0	.50	--	26.4	.60	--	CONC FAILED
113	REG	6.13	SB-8	STAT T	16.0	1.0	--	22.5	1.20	--	CONC FAILED
107	REG	7.00	SB-8	DYN T	15.8	.65	7.8	20.8	.85	101	CONC FAILED
91	REG	5.69	SA-8	DYN T	16.0	.10	7.8	26.0	.33	103	CONC FAILED

1 INCH BOLTS TESTED IN SHEAR

SPEC NUMB	CONC TYPE	F/C KSI	BOLT TYPE	TEST TYPE	P1 KIP	D1 IN	CYCLE KC	PU KIP	DU IN	CYCLE KC	FAILURE MODE
C2-5	REG	6.66	SA-8	STAT V	28.0	.1		34.5	.50	--	CONC FAILED
C2-6	REG	7.14	SA-8	STAT V	28.0	.1		36.4	.50	--	CONC FAILED
C2-7	REG	6.36	SA-8	DYN V	21.8	.25	7.8	38.0	.50	76	BOLT FAILED
C2-8	REG	6.10	SA-8	DYN V	21.8	.10	7.8	31.0	.25	106	CONC FAILED

1 INCH BOLTS TESTED IN COMBINED TENSION AND SHEAR

SPEC NUMB	CONC TYPE	F/C KSI	BOLT TYPE	TEST TYPE	P1 KIP	D1 IN	CYCLE KC	PU KIP	DU IN	CYCLE KC	FAILURE MODE
17	REG	6.02	SB-8	STAT C	10.0	.20	--	13.0	.25	--	CONC FAILED
23	REG	7.14	SA-8	STAT C	10.0	.20	--	12.6	.25	--	CONC FAILED
29	REG	6.52	SA-8	DYN C	8.0	.14	7.8	8.0	.34	74	CONC FAILED
20	REG	6.77	SA-8	DYN C	8.0	.36	7.8	11.6	.57	102	CONC FAILED

TABLE IV. COMPARATIVE BAR CHART FOR EXPANSION ANCHORS.

EXPLANATION

Each bar on the chart represents one test, with the length of the bar representing the ultimate load. In the case of the shear test where two bolts are used the plotted value is taken as one half the ultimate total load. Lines without a KC (kilo cycle) notation above them are static, all others are dynamic. The KC notation refers to the number of cycles (in thousands) that the specimen sustained.

At the top of the page directly above the bar is listed the type (tension, shear, or combined) test, and the diameter of the bolt used in that test. Note at the bottom of the page the type of bolt (sleeve, shell or stud) and type of concrete (regular, magnite or steel shot) used in the test.

In most cases the short bars (4 kips or less) represent long term fatigue tests, where the specimen was loaded with a low load and failed due to eccentricity in the load and or premature metal fatigue due to an imperfection in the bolt.

The small "w" at the bottom of some bars represents a Wej-it standard bolt, which is slightly differently from the other manufactures stud anchors.

Specimen #'s 73 and 121 are not included in this chart due to insufficient data; all other specimens are included.

COMPARATIVE BAR CHART FOR EXPANSION ANCHORS

5/8" BOLTS

COMPARATIVE BAR CHART FOR EXPANSION ANCHORS

3/4" INCH BOLTS

COMPARATIVE BAR CHART FOR EXPANSION ANCHORS CONTINUED

3/4" BOLTS CONTINUED

1" BOLTS

SHEAR

COMBINED

TENSION

SHEAR

COMBINED

20-

18-

16-

ULTIMATE LOAD IN KIPS

14-

12-

10-

8-

6-

4-

2-

SLEEVE

SHELL

STUD

SLEEVE

STUD

REG

MAG

REG

SS

ULTIMATE LOAD IN KIPS
(NOTE CHANGE IN SCALE)

28

24

20

16

12

8

4

103

101

106

76

74

102

STUD

REG

Fig. 1. TENSION TEST SPECIMEN

Fig. 2. SHEAR TEST SPECIMEN

Fig. 3. COMBINED TEST SPECIMEN

Fig. 4. TYPICAL SLEEVE, STUD AND SHELL TYPE ANCHOR

TENSION TEST SET-UP

SHEAR TEST SET-UP

Fig. 5. TYPICAL TEST ARRANGEMENT

Fig. 6. ARRANGEMENT OF TEST EQUIPMENT

TENSION - PULL OUT

SHEAR

COMBINED - CONCRETE FAILURE

Fig. 7. TYPICAL FAILURE MODES FOR EACH TYPE OF SPECIMEN

APPENDIX 1

WESTINGHOUSE
 REG CONCRETE
 PARABOL STUD TYPE
 5/8" DIA. STUD
 SPECIMEN # 1
 DYNAMIC TENSION TEST
 7-31-74

47 0860

K-E INSTRUMENTS
 LOAD - KIPS

47 0560

LOAD - KIPS

47 0860

K&E TEST ENGINEERING, INC.
NEWTON, MASSACHUSETTS 02459
LOAD - KIPS

47 0860

WEASTINGHOUSE
REG. CONCRETE
PARABOLIC STUD TYPE
5/8" DIA. STUD
SPECIMEN #5
DYNAMIC TENSION TEST
7-30-74

LOAD - KIPS

47 0860

K-E 4X2011MCM-1 AIN HES
REPT. 8-13-74

WESTINGHOUSE
REG. CONCRETE
WET - IT
3/8" DIA. STUD
SPECIMEN # 4
DYNAMIC COMBINED
8-13-79

47 0860

K-E

470°60

K-E
LOAD - KIPS

47 0550

K-E 5.8 X 10¹² INCHES
4040-KIPS

WESTINGHOUSE
REG. CONCRETE
PARABOLIC STUD TYPE
5/8" DIA. STUD
SPECIMEN # 8
DYNAMIC SHEAR TEST
8-2-74

47 0860

LOAD - KIPS

36
32
28
24
20
16
12
8
4

47 0360

REINFORCED CONCRETE
LOAD - KIIPS

(

WESTINGHOUSE
REG CONCRETE
PARABOLIC STUD TYPE
5/8" DIA. STUD
SPECIMEN #8
8-2-74
DYNAMIC SHEAR TEST

47 0360

1000 LBS

18

16

14

12

10

8

6

4

2

.05

.10

.15

.20

.25

.30

.35

.40

.45

.50

.55

.60

.65

.70

OVERALL DISPLACEMENT (in)

WESTINGHOUSE
REG CONCRETE
PARALLEL STUD TYPE
5/8" DIA. STUD
SPECIMEN # 10
DYNAMIC COMBINED
8-9-74

SPECIMEN BROKE AT 17,000 cycles
MAX LOAD 6600[±]

470860

14-E (1) TOLL NUMBER 14-E-145

LOAD - KIPS

7-19-74

MAX. LOAD 13 kips

WESTINGHOUSE
REG. CONCRETE
PHILLIPS SLEEVE TYPE ANCHOR
5/8" DIA. SLEEVE
1/2" DIA. STUD
SPECIMEN NO 11
TENSION TEST

1-2 5X310 INCH 47 0000
10 15 20 25 30 35 40 45 50
LOAD KIPS

LVDT'S (DISPLACEMENT OF BOLT, IN)

7-19-74

MAX LOAD 13 kips

WESTINGHOUSE
REG. CONCRETE
PHILLIPS SLEEVE TYPE ANCHOR
5/8" DIA. SLEEVE
1/2" DIA. STUD
SPEC. # 11
TENSION TEST

K-E 853115 NCH 47.0400
FALL & REBAR

LOAD - KIIPS

OVERALL DISPLACEMENT (in.)

47 0360

KIPES TO 12 INCHES

LOAD - KIPS

470860

LOAD - KIPS

K-E 18570-1 INCHES

18
16
14
12
10
8
6
4
2

WESTINGHOUSE
REG CONCRETE
PHILLIPS SLEEVES
5/8" DIA SLEEVE
1/2" DIA STUD
SPECIMEN #13
LONG-TERM TENSION
FATIGUE
8-29-74

LOAD-KIPS

47 0860

WESTINGHOUSE
REG. CONCRETE
PHILLIPS SLEEVES TYPE
5/8" DIA SLEEVE
1/2" DIA STUD
SPECIMEN # 13
LONG-TERM TENSION
FATIGUE
8-29-74

47 0860

LOAD-KIPS

7-19-74

WESTINGHOUSE
REG. CONCRETE
PHILLIPS SLEEVE PIPE
5/8" DIA. SLEEVE
1/2" DIA. STUD
SPECIMEN # 14
DYNAMIC TEST

TENSILE FAILURE
IN STUD @ 11745 cycles
MAX LOAD 11,000*

LOAD - KIPS

K&E B&B TO INCH 47 0880
IN 1/4 INCHES
BY F&B & B&B CO.

LOAD - KIPS CS60

K-E SYSTEM INCHES IN. CHS
NET WEIGHT 2000 LBS

WESTINGHOUSE
REGULAR CONCRETE
PHILLIPS SLEEVE TYPE
5' DIA. SLEEVE
1/2" DIA. STUD
STATIC SHEAR TEST
SPECIMEN # 16
7-21-74

MAX LOAD 24.4^k

OVERALL DISPLACEMENT (IN.)

47 0560

LOAD - KIPS

K-E STRAINING SYSTEM
NOTED FOR NO. 16

47 0780

K-LOAD (KIPS)

47 0780

LOAD (KIPS)

5 1/2" embedment

WESTINGHOUSE
REG. CONCRETE
SPECIMEN #17
PARABOLT 1" STUD
STATIC TENSION
9-17-79 COMBINED

18
16
14
12
10
8
6
4
2

OVERALL (IN.)

47 0360

K-E 315 TO LINGCHU 11 INCHES
FLUID-SEWAGE BRIDGE

47 0560

KSI 1000 LBS. PER INCH SQUARE
STRESS & COMBINED STRESS

18

16

14

12

10

8

6

4

2

WESTINGHOUSE
REG. CONCRETE
WEJ-17
5/8" DIA. STUD
SPECIMEN # 18
DYNAMIC COMBINED
8-13-74

47 0780

K/S TOTAL N M... XMS

4 1/2" shallow embedment

Westinghouse
Ray Concrete
Specimen #20
Rawl P. stud
Dynamic Combined
9-18-74

Westinghouse
Reg Concrete
Specimen #20
Rawl 1" stud
Dynamic combined
9-18-74

Max load 11.6K
102,000 total cycles.

CONCRETE
FAILED

7-22-74

WESTINGHOUSE
REG. CONCRETE
PHILLIPS SLEEVE ANCHOR
5/8" DIA. SLEEVE
1/2" DIA. STUD
SPECIMEN # 21
COMBINED STATIC TEST

LOAD - KIPS

K-2 SYSTEM 470300
DISPLACEMENT IN.

MAX LOAD 11,800*

Plot x 1/2 scale

LVDT'S (DISPLACEMENT IN.)

47 0780

RELOAD (KIPS)

4 1/2" embedment

WESTINGHOUSE
REG. CONCRETE
RAWL 1" STUD
SPECIMEN #23
STATIC TENSION
9-17-79 COMBINED

Max load 12.6 k

Concrete Failed

470730

LOAD (KIPS)

47 0960

K/E ANY FOLLOWS IN INCHES
LOAD - KIPS

47 0560

LOAD - KIIPS

18

16

14

12

10

8

6

4

2

470560

KIP LOAD - KIPS

WESTINGHOUSE
REG. CONCRETE
PARABOLY STUD TYPE
5/8" DIA STUD
SPECIMEN # 25
STATIC COMBINED TEST
8-2-74

47 0360

K-E
LOAD - KIPS

18

16

14

12

10

8

6

4

2

WESTINGHOUSE
REG CONCRETE
PARABOLIC STAD TYPE
5/8" DIA STUD
SPECIMEN # 25
STATIC COMBINED
8-2-77

MAX LOAD 10.6 K

LOAD'S DISPLACEMENT (IN.)

.05 .10 .15 .20 .25 .30 .35 .40 .45 .50 .55 .60 .65 .70

WESTINGHOUSE
REG. CONCRETE
TYPICAL (PHILLIPS) SLEEVE TBA
3/4" DIA SLEEVE
5/8" DIA. STUD
SPECIMEN # 26
STATIC COMBINED
8-17-74

47 0560

LOAD - KIPS

OVERALL DISPLACEMENT (in)

47 0360

LOAD - KIPS

WESTINGHOUSE
REG. CONCRETE
TYPICAL (PHILLIPS) SLEEVE TYPE
3/4" DIA. SLEEVE
5/8" DIA. STUD
SPECIMEN # 26
STATIC COMBINED
8-14-74

47 0760

K&E 11.5 IN TO THE INCHES OF INCHES
RESISTANCE AT 1000 PSI

LOAD (KIPS)

47 0780

LOAD = K/PS

[illegible]

47-0860

WESTINGHOUSE

LOAD (KIPS)

U. LOAD (KIPS)

47 0'80

470360

KE (ASTRO) INCHES

47 0360

K&E STATO LINEAR
MODEL 8000000

LOAD
KIPS

USE 1/8" TO 1/4" INCHES

47 0790

WESTINGHOUSE
RE6 CONCRETE
DARABOLT ~~TYPE~~
3/4" DIA STUD
SPECIMEN #31
DYNAMIC COMBINED
912-74

Failure at 102.032 cycles
Max load 118*

47 0360

16Z 4X 7012 INCHES IN DIAMETER
NUMBERED TO MATCH

47 OS60

K&S 113 0 1/2 INCHES

470560

K-E 211.01 V.M.T.
LOAD - KIPS

18

16

14

12

10

8

6

4

2

0

47 0560

K-E 31173
LOAD - KIIPS

WESTINGHOUSE
REG. CONCRETE
PHILLIPS SLEEVE TYPE
5/8" DIA. SLEEVE
1/2" DIA. STD
SPECIMEN #33
DYNAMIC COMBINED TEST
7-29-74

470350

LOAD
KIPS

K-E
KIP TO INCHES IN 4'S
MULTIPLIED BY 1000

47 0560

LOAD
Kips

WESTINGHOUSE
REG. CONCRETE
HILTI SHELL TYPE
5/8" DIA. SHELL
SPECIMEN #39
DYNAMIC COMBINED
8-17-74

470860

K-E 3.5 TO 2.2 INCHES
ALUMINUM WIRE

WESTINGHOUSE
REG. CONCRETE
PARABOL STUD TIES
5/8" DIA. STUD
SPECIMEN #35
STATIC COMBINED
8-2-74

470560

WESTINGHOUSE
RESEARCH & DEVELOPMENT
DIVISION

WESTINGHOUSE
REB. CONCRETE
PARABOLT STUD TYPE
3/8" DIA. STUD
SPECIMEN #35
STATIC COMBINED
8-2-74

47 0360

KIP LOAD - KIPS

47 0960

KIP (K) 1000 LBS

LOAD-KIPS

18

16

14

12

10

8

6

4

2

WESTINGHOUSE
REB CONCRETE
RAWL STUD TYPE
5/8" DIA. STUD
SPECIMEN #36
DYNAMIC COMBINED
8-13-74

Total Cycles
37,400
MAX LOAD 6650 #

[illegible]

47 0660

K2 384012 INCHES 25. N HBS

LOAD (KIPS)

47 0780

LOADS IN KILOPS

47 0780

LOAD - KIPS

WESTINGHOUSE
REG CONCRETE
HILTI SHELL TYPE
5/8" DIA STUD
27/32" DIA SHELL
SPECIMEN #39
STATIC DYNAMIC COMBINED
9-13-74

Bolt supplied by UC failed

MAX LOAD 11.2 K

47 0860

LOAD - KIPS

47 0860

LOAD - KIIPS

18

16

14

12

10

8

6

4

2

.05

.10

.15

.20

.25

.30

.35

.40

.45

.50

.55

.60

.65

.70

OVERALL DISPLACEMENT (IN)

WESTINGHOUSE
REG. CONCRETE
PARALLEL STUD. TIES
5/8" DIA. STUD.
SPECIMEN # 95
DYNAMIC COMBINED
8-12-74

MAX. LOAD 9666 lb
102,000 total cycles

6000, 6600
8400
14000, 25,000
100,000, 101,000
30,000, 50,000

47 0650

K-E EXACTO-ENERGY SYSTEM
LOAD - KIPS

47 0860

K-E 341011 UNCLAS
RECEIVED 10-10-79

WESTINGHOUSE
REG. CONCRETE
HILL SHELL TYPE
50" DIA TANK
SPECIMEN # 44
DYNAMIC COMBINED
8-13-79

47 0860

H-E 1.5 TO 1.2 INCH AND 1.5 INCHES
REPAIR & OVER CO. 10-1-74

47 0860

LOAD (KIPS)

WESTINGHOUSE
REG CONCRETE
PHILLIPS SLEEVE TYPE
5/8" DIA SLEEVE
1/2" DIA STUD
SPECIMEN NO 46
COMBINED TEST
7/22/74

47 0860

K-E
LOAD - KIPS

47 0560

KIP LOAD - KIIPS

18

16

14

12

10

8

6

4

2

WESTINGHOUSE
REG. CONCRETE
PARABOL STUD TYPE
5/8" DIA STUD
SPECIMEN # 47
DYNAMIC COMBINED
8-9-74

Machine responded too fast
specimen failed.
MAX LOAD - 9.6 K

LYDT'S DISPLACEMENT (IN)

47 0860

K-E 11-10-74

47 0860

16-2 1/2 TO 1 1/2 IN. DIA. STUDS
ADAPTED FROM FIG. 10-1-1

WESTINGHOUSE
REGULAR CONCRETE
TYPICAL (RAWL) STUD
3/4" DIA STUD
SPECIMEN # 50
LONG-TERM COMBINED FATIGUE
10-21-74

WESTINGHOUSE
MAGNETITE CONCRETE
TYPICAL (PHILIPS) SLEEVE
5/8" DIA STUD 3/4" SLEEVE
SPECIMEN # 51
STATIC COMBINED
3 1/2" IMBEDMENT
8-16-74

470860
KIPS

3/8" TO 1/2" INCH DIA STUDS
ADJUSTED & CALIBRATED

47 0700

NET LOAD (KIPS)

1 1/2" normal embedment

WESTINGHOUSE
MAGNETITE
TYPICAL (PARABOLT) STUD TYPE
3/8" DIA STUD
SPECIMEN #52
STATIC COMBINED
9-19-74

15.4 K MAX LOAD

LOAD (IN.)

47 0700

KIPS LOAD (KIPS)

1 1/2" normal embedment

WESTINGHOUSE
MAGNETITE
TYPICAL (PARABOL) STUD TYPE
3/4" DIA STUD
SPECIMEN # 52
STATIC COMBINED
9-19-79

47 0350

K LOAD - KIPS

LOAD - KIPS

WESTINGHOUSE
MAGNETITE CONCRETE
TYPICAL PHILLIPS SCREWS
3/4" DIA SCREWS
5/8" DIA STUD
SPECIMEN # 53
DYNAMIC COMBUSTION
8-22-74

35,450 total cycles
MAX LOAD 6200^{lbs}

OVERALL DIMENSION (in.)

47 0860

Kips

KIP
STRESSING
NUMBER OF
STRESSING

16

14

12

10

8

6

4

2

0

.10

.20

.30

.40

.50

.60

.70

.80

.90

1.00

1.10

1.20

1.30

1.40

Overall

WESTINGHOUSE
MAGNETITE CONCRETE
TYPICAL FAILURE SLURRY
3/4" DIA SLEEVE
5/8" DIA STUD
SPECIMEN # 52
STATIC COMBINED
8-16-74

MAX LOAD 15.4 K

470860

Kys

K-E EASTON ENGINEERING CO. INC.
NEW JERSEY

47 0700

LOAD (KIP)

3 1/2" shallow embedment

WESTINGHOUSE
MAGNETIC CONCRETE
TYPICAL STUD TYPE (PALLAD)
3" DIA STUD
SPECIMEN #55
STATIC COMBINED
9-19-79

36
32
28
24
20
16
12
8
4

11.9 K MAX LOAD

.05 .10 .15 .20 .25 .30 .35 .40 .45 .50 .55 .60 .65 .70

OVERALL (IN)

LOAD (KIPS)

47 0700

36

32

28

24

20

16

12

8

4

3 1/2 shallow embedment

WESTINGHOUSE
MAGNETIC CONCRETE
TYPICAL STUD TYPE (ASTM)
2 1/4" DIA. STUD
SPECIMEN #55
STATIC COMBINED

9-19-79

11.4 K MAX LOAD

LVDT'S (IN.)

.05 .10 .15 .20 .25 .30 .35 .40 .45 .50 .55 .60 .65 .70

47 0560

K-E
3 X 5 TO 2 X 4 IN. 4
MA TILL & EMB CO 4 X 4
1818

47 0700

LOAD (KIPS)

47 0700

WELDED (S)

47 0700

LOAD-KIPS

WAD-KIPS

3 1/2" shallow embedment

WESTINGHOUSE
MAGNETITE CONCRETE
TYPICAL (RAWL) STUD TYPE
3/4" DIA STUD
SPECIMEN # 59
DYNAMIC COMBINED
9-23-74

47 0860

LOAD - KIPS

47 0860

LOAD KIPS

47 0700

LOADS IN KIIPS

18

16

14

12

10

8

6

4

2

0

4 1/2" embedment

Max load 10.4K
Concrete Failure

WESTINGHOUSE
STEEL SHOT CONCRETE
TYPICAL (PARABOLT) STUD TYPE
3/4" DIA STUD
SPECIMEN #62
STATIC COMBINED
10-4-74

OVERALL DISPLACEMENT (IN.)

47 0860

LOAD (KIPS)

47 0860

LOAD IN KIPS

470860

K-S STAYS, NIMICA, MEMPHIS
ROUTE 4, 38110, TENN.36
32
28
24
20
16
12
8
4

LOADS (IN)

WESTINGHOUSE
 MAGNETIC CONCRETE
 PHILLIPS TYPE
 3/4" DIA SLEEVES
 5/8" DIA STUDS
 8-31-74
 DYNAMIC SHEAR
 SPECIMEN #64

47 0360

Kips

WESTINGHOUSE
 MAGNETIC CONCRETE
 PHILLIPS TYPE
 3/4" DIA SLEEVES
 5/8" DIA STUDS
 8-31-74
 DYNAMIC SHEAR
 SPECIMEN #64

47 0860

LOAD = KIIPS: 0.15 INCHES
PER KIIP

WESTINGHOUSE
MAGNETIC CONCRETE
PHILLIPS SLEEVE TYPE
3/4" DIA SLEEVE
5/8" DIA STUD
SPECIMEN # 65
STATIC SHEAR
8-31-74

47 0360

LOAD KIPS

36

32

28

24

20

16

12

8

4

 $3\frac{1}{2}$ " shallow imbedment

WESTINGHOUSE
MAGNETITE CONCRETE
PHILLIPS SLEEVE TYPE
 $3\frac{1}{4}$ " DIA SKEWES
 $5\frac{1}{2}$ " DIA STUD
SPECIMEN # 66
DYNAMIC SHEAR
9-2-74

47 0860

LOAD-KIPS

36

32

28

24

20

16

12

8

4

 $3\frac{1}{2}$ " shallow imbedment

WESTINGHOUSE
MAGNETITE CONCRETE
PHILLIPS SLEEVE PIPE
 $3\frac{1}{4}$ " DIA SLEEVE
 $5/8$ " DIA STUD
SPECIMEN # 66
DYNAMIC SHEAR
B-2-74

FAILURE AT 39,650 cycles
MAX LOAD 18.2

LVDT'S DISPLACEMENT (in)

470860

LOAD: KIPS

36
32
28
24
20
16
12
8
4

MAX LOAD 28.0 K

WESTINGHOUSE
STEEL SHOT CONCRETE
PHILLIPS SLEEVE TYPE
5/8" DIA SLEEVE
5/8" DIA STUD
SPECIMEN # 68
STATIC SHEAR
8-27-74

OVERALL DISPLACEMENT (IN)

WESTINGHOUSE
STEEL SHOT CONCRETE
MILLERS SLEEVE TYPE
3/4" DIA SLEEVE
5/8" DIA STUD
SPECIMON # 68
STATIC SHEAR
8-27-74

47 0860

LOAD, KIPS

36
32
28
24
20
16
12
8
4

MAX LOAD 28.0*

LVDT'S DISPLACEMENT (IN)

.10 .20 .30 .40 .50 .60 .70 .80 .90 1.0 1.1 1.2 1.3 1.4

WESTINGHOUSE
STEEL SHOT CONCRETE
PHILLIPS SLEEVE TYPE
3/4" DIA SLEEVE
5/8" DIA STUD
SPECIMEN # 69
STATIC SHEAR
8-27-74

47 0860

LOAD-KIPS

WESTINGHOUSE
STEEL SHOT CONCRETE
PHILLIPS SLEEVE TYPE
3/4" DIA SLEEVE
5/8" DIA STUD
SPECIMEN # 69
STATIC SHEAR
8-27-74

47 0860

LOAD - KIPS

WESTINGHOUSE
STEEL SHOT CONCRETE
PHILLIPS SLEEVE TYPE
3/4" DIA. SLEEVE
5/8" DIA. STUD
SPECIMEN # 70
DYNAMIC SHEAR
8-27-74

470930

K-E TEST INSTRUMENTS
NEWPORT NEWS
LOAD - KIPS

WESTINGHOUSE
 STEEL SHOT CONCRETE
 PHILLIPS SLEEVE TYPE
 3/4" DIA. SLEEVE
 5/8" DIA. STUD
 SPECIMEN # 70
 DYNAMIC SHEAR
 8-27-74

470560

LOAD - KIPS

KIP INCHES

WESTINGHOUSE
 STEEL SHOT CONCRETE
 PHILLIPS SLEEVE TYPE
 3/4" DIA. SLEEVE
 5/8" DIA. STUD
 SPECIMEN # 71
 DYNAMIC SHEAR
 8-27-74

LOAD - KIPS

47 0850

36

32

28

24

20

16

12

8

4

0

0

0

0

2000, 4000, 6000

6600

7200

7800 cycles

Total Cycles
 7837
 max load 16.8 K

OVERALL

WESTINGHOUSE
STEEL SHOT CONCRETE
PHILLIPS SLEEVE TYPE
3/4" DIA. SLEEVE
5/8" DIA. STUD
SPECIMEN #71
DYNAMIC SHEAR
8-27-74

47 0860

LOAD - KIPS.

47 0860

K-E STATIONING: 1000

LOAD - KIPS

18

16

14

12

10

8

6

4

2

0

.0

.20

.40

.60

.80

1.00

1.20

1.40

LYDT'S DISPLACEMENT (IN.)

0

2

4

6

8

10

12

14

16

18

20

22

24

26

28

30

32

34

36

38

40

42

44

46

48

50

52

54

56

58

60

62

64

66

68

70

72

74

76

78

80

82

84

86

88

90

92

94

96

98

100

102

104

106

108

110

112

114

116

118

120

122

124

126

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658

660

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664

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668

670

672

674

676

678

680

682

684

686

688

690

692

694

696

698

700

702

704

706

70

LOAD - KIPS

7

8

9

10

11

12

13

14

15

16

17

18

19

20

21

22

23

24

25

26

27

28

29

30

31

32

33

34

35

MAX LOAD 26.6k
2,010,000 cycles

WESTINGHOUSE
REG. CONCRETE
PHILLIPS SLEEVE TYPE
50" O.A. SCABE
1/2" O.A. STUD
SPECIMEN #72
FATIGUE SHEAR
9-2-74

47 0860

WESTINGHOUSE
REGULAR CONCRETE
TYPICAL (RAWL) STUD
1/2" DIA. STUD
SPECIMEN # 73
LONG TERM SHEAR FATIGUE
10-28-74

WESTINGHOUSE
 REGULAR CONCRETE
 TYPICAL (RAWL) STUD
 1/2" DIA. STUD
 SPECIMEN # 73
 LONG TERM SHEAR FATIGUE

10-28-74

470860

K&E 31A TO 12 INCHES MAXIMUM
 NEPTUN & SON CO. NEWARK, NJ

WESTINGHOUSE
REG CONCRETE
PHILLIPS SLEEVE TYPE
3/4" DIA SLEEVE
3/8" DIA STUD
SPECIMEN #75
DYNAMIC-SHEAR
9-2-74

KE STATISTICAL CONSULTANTS
RESEARCH & ENGINEERING

47 0860

KIP TO TONS
LOAD - KIPS36
32
28
24
20
16
12
8
4

WESTINGHOUSE
REG. CONCRETE
PHILLIPS SLEEVE TYPE
3/4" DIA. SLEEVE
5/8" DIA. STUD
SPECIMEN DWD 75
DYNAMIC SHEAR
9-2-74

47 0860

LOAD - KIPS

36

32

28

24

20

16

12

8

4

MAX LOAD 31.6K

LVOT'S DISPLACEMENT (IN)

WESTINGHOUSE
REG. CONCRETE
PHILLIPS SLEEVE TYPE
3/4" DIA SLEEVE
5/8" DIA STUD
SPECIMEN # 76
STATIC SHEAR
9-2-74

WESTINGHOUSE
REG. CONCRETE
PHILIPS SLEEVE TYPE
3/4" DIA SLEEVE
5/8" DIA STUD
SPECIMEN # 77
STATIC SHEAR
9-2-74

MAX LOAD 29.2K

47 0860

KDAD-KIPS

36

32

28

24

20

16

12

8

4

.10

.20

.30

.40

.50

.60

.70

.80

.90

1.0

1.1

1.2

1.3

1.4

OVERALL DISPLACEMENT (IN)

WESTINGHOUSE
REG. CONCRETE
PHILLIPS SLEEVE TYPE
3/4" DIA SLEEVE
5/8" DIA STUD
SPECIMEN # 77
STATIC SHEAR
9-2-74

47 0860

LOAD-KIPS

36

32

28

24

20

16

12

8

4

0

MAX LOAD 25.2*

LVDT'S DISPLACEMENT (IN.)

.10

.20

.30

.40

.50

.60

.70

.80

.90

1.0

1.1

1.2

1.3

1.4

47 0860

LOAD - KIIPS

36
32
28
24
20
16
12
8
4
0

AVOT'S DISPLACEMENT (IN)

WESTINGHOUSE
REG. CONCRETE
PHILLIPS SLEEVE TYPE
3/4" DIA SLEEVE
5/8" DIA STUD
SPECIMEN # 78
DYNAMIC SHEAR
9-2-74

Failure 17800
Max Load 18.4"

WESTINGHOUSE
 REG. CONCRETE
 PHILLIPS SLEEVE TYPE
 3/4" DIA SLEEVE TYPE
 1/8" DIA STUD
 SPECIMEN #78
 DYNAMIC SHEAR
 9-2-74

Max Load 184 K
 Failure 19200

470860

LOAD - KIIPS

47 0780

K/E 10 X 10 TO THE INCHES
ALL PLS. SHOWN CO. AND DATE

LOAD (KIPS)

47 0780

KCE DATA CENTER
UNIVERSITY MICROFILMS

LOAD (KIPS.)

47 0780

NEW INSTRUMENTATION WORK
RECEIVED 10/10/74

NESTINGHOUSE
REG. CONCRETE
HILTI STUD TYPE
3/4" DIA. STUD
SPECIMEN # 100 81
9/12/74
STATIC COMBINED
DO

concrete cracked then stud pulled out

max load 13.3k

LOAD (KIPS)

OVERALL DISPLACEMENT (IN.)

470780

K&Z DATA TO THE NATIONAL BUREAU OF STANDARDS

LOAD (KIPS)

36

32

28

24

20

16

12

8

4

WESTINGHOUSE
 REG. CONCRETE
 RAIL STUD TYPE
 3/4" DIA. STUD
 SPECIMEN # B3
 DYNAMIC COMBINED
 9/12/72

Concrete failed then stud
 pulled out

max load 13.2 kips

107,800 cpsi

47 0780

KG IS 2.2 TO THE INCHES
 RECALCULATED TO THE INCHES

47 0780

NO. 10 IN THE INCHES & IN THE
PERCENTAGE OF THE TOTAL

LOAD (KIPS)

47 0860

WEIGHT KIPS

18

16

14

12

10

8

6

4

2

0

470860

LOAD KIPS

18

16

14

12

10

8

6

4

2

3/4" shallow embedment

Stud failed

101,865 cycles

max load 18.66 kip

WESTINGHOUSE
REG-CONCRETE
WET-6T STUD TYPE
5/8" DIA STUD
SPECIMEN # 85
DYNAMIC TENSION
7-H-79

OVERALL DISPLACEMENT (in.)

47 0860

LOAD-KIPS

47 0860

LOAD - KIPS

470860

KIP-LOADS

47 0860

K-E RATIO 2 INCHES
REINFORCING BARS

47 0780

LOAD (KIPS)

47 0780

LOAD (KIPS)

4 1/2" normal embedment

WESTINGHOUSE
REG. CONCRETE
WEJ-IT STUD TYPE
3/8" O.T.A. STUD
SPECIMEN # 89
DYNAMIC TENSION
9-10-74

47 0860

LOAD - KIIPS

47 0780

K-2 11.5 IN TO THE INCHES IN INCHES

470780

KIP INCHES TO THE INCHES AND INCHES

36

32

28

24

20

16

12

8

4

47 0960

K&E ANALYSIS REPORT NUMBER 47 0960

LOAD (KIPS)

10
8
6
4
2
0

LOAD - KIIPS

LOAD - KIIPS

18

16

14

12

15

8

6

4

2

1

• 2

10

12

20

25

30

3.

• 40

5

• 5

5

•

• 6

•

LVDT DISPLACEMENT (in)

WESTINGHOUSE
REG. CONCRETE
PHILLIPS SLEEVE TYPE
3/8" DIA SLEEVE
1/2" DIA STUD
SPECIMEN # 9A
LONG-TERM TENSION
FATIGUE
8-28-74

535,450 TOTAL CYCLES
MAX LOAD 2600 LBS
STUD SHERRED

49,000, 75,100 96,000

47 0860

K&E TEST TO 13 INCHES 3 INCHES
HARPER & STUB CO. and K&E

WESTINGHOUSE
REGULAR CONCRETE
TYPICAL PHILLIPS SLEEVE TYPE
3/4" DIA. SLEEVE
5/8" DIA. STUD
SPECIMEN # 99
STATIC TENSION
8/22/74

LOAD (KIPS)

47 0860

K-E 5.5 TO 1.2 INCH DIA. STUDS
REINFORCED CONCRETE

LOAD (KIPS)

18

16

14

12

10

8

6

4

2

.05

.10

.15

.20

.25

.30

.35

.40

.45

.50

.55

.60

.65

.70

L.V.D.T'S DISPLACEMENT (IN.)

L.V.D.T'S PEAKED OUT
EARLY
MAX LOAD 9.4K

WESTINGHOUSE
REGULAR CONCRETE
TYPICAL PHILLIPS SLEEVE TYPE
3/4" DIA. SLEEVE
3/8" DIA. STUD
SPECIMEN # 99
STATIC TENSION
8/22/74

47 0780

K&S 1.5-72 150 1000 1000 1000

47 0780

3-K-5
IN ORDER TO GET THE INFORMATION
FROM THE OFFICE OF THE ATTORNEY
GENERAL

WESTINGHOUSE
REG CONCRETE
TYPICAL STUD TYPE (RAW)
3/4" STUD DIA
SPECIMEN # 102
DYNAMIC TENSION
9-11-74

4 1/2" normal embedment

Max load 18.2^k

MISTAKE

47 0860

LOAD-KIPS

ANV'S DISPLACEMENT (IN.)

47 0860

LOAD - KIPS

470860

K&E 5 X 5 TO 12 INCHES X 11 INCHES
REINFORCING & CONCRETE LAB

LOAD (KIP/IN)

47 0860

K&E 5 X 5 TO 12 INCHES
ALUMINUM CO. AND .11

LOAD (KIPS)

10

8

6

4

2

0

0

0

0

0

0

0

0

0

0

.10

.20

.30

.40

.50

.60

.70

.80

.90

1.0

1.1

1.2

1.3

1.4

LVDT DISPLACEMENT (IN.)

MAX LOAD 14.4K

WESTINGHOUSE
REGULAR CONCRETE
PARABOLT STUD TYPE
5/8" DIA. STUD
SPECIMEN A 105
STATIC TENSION
9/6/74

47 0860

LOAD IN KIIPS

47 0860

K&E 5.5 TO 12 INCH AND 1/2 IN. DIA.
HEAVY DUTY LOAD CELL

18

16

14

12

10

8

6

4

2

0

MAX LOAD 15.5 K

LVDT DISPLACEMENT (IN.)

WESTINGHOUSE
REG. CONCRETE
PHILLIPS SLEEVE TYPE
3/4" DIA SLEEVE
3/8" DIA STUD
SPECIMEN Q/06
STATIC TENSION
8-22-74

47 0780

KSE 10.5 IN TO THE INCHES
STUD BOLT 1" DIA

47 0780

K-E 10.8 IS TO THE INCHES IN THE
PLATE OF CONCRETE

36

32

28

24

20

16

12

8

4

4 1/2" embedment

WESTINGHOUSE
REG. CONCRETE
SPECIMEN # 107
PARABOLT 1" STUD
DYNAMIC TENSION
9/17/74

Failure at 101,475 cycles
Max Load 20.8 k

470860

K&E
LOAD (KIPS)K&E
LOAD (KIPS)

47 0560

WESTINGHOUSE
REG. CONCRETE
RAIL STUD TYPE
24" STUD TYPE
SPECIMEN # 109
STATIC TENSION
9/11/74

LOAD (KIPS)

470860

K-E 2837013 IN. HALL'S, N.Y.C.

LOAD (KIIPS)

470860

K&E
TESTING
EQUIPMENT & SUPPLY CO. - CHICAGO, ILL.

LOAD (KIPS)

47 0780

K·S
EX. 0.10 TH. NCM-1
EX. 0.10 TH. NCM-1

LOAD (KIPS)

47 0780

K&E HAS 1000 THE DEPARTMENT OF THE ARMY
RESEARCH AND ENGINEERING

LOAD (KIPS)

1000 cycles

100,000

101,000

102,000

Failure at 102,400 cycles
Max Load 10.0K

LVDT'S DISPLACEMENT (IN.)

WESTINGHOUSE
REG. CONCRETE #112
WILT' SHELL-TYPE
3/8" DIA. STUD
27/32" DIA. SHELL
SPECIMEN NO. 112
DYNAMIC TENSION
9/13/74

47 0780

KIP
RELATIONS OF 1000 LBS

36

32

28

24

20

16

12

8

4

WESTINGHOUSE
PARABOLT 1" STUD
SPECIMEN #113
STATIC TENSION
7-16-79
REG. CONCRETE

Concrete failure
max load = 22.5 Kip

bolt was not set before testing

OVERALL DISPLACEMENT

.10

.20

.30

.40

.50

.60

.70

.80

.90

1.0

1.1

1.2

1.3

1.4

WESTINGHOUSE
PARABOLT 1" STUD
SPECIMEN #113
STATIC TENSION
9-16-79
REG. CONCRETE

47 0780

1625
1620
1625
1630
1635
1640
1645
1650
1655
1660
1665
1670
1675
1680
1685
1690
1695
1700
1705
1710
1715
1720
1725
1730
1735
1740
1745
1750
1755
1760
1765
1770
1775
1780
1785
1790
1795
1800
1805
1810
1815
1820
1825
1830
1835
1840
1845
1850
1855
1860
1865
1870
1875
1880
1885
1890
1895
1900
1905
1910
1915
1920
1925
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000

47 0860

LOAD-KIPS

47 0360

LOAD IN KIIPS

47 0860

LOAD-KIPS

47 0780

LOAD IN KILOPS

47 0780

LOAD (KIPS)

3 1/2" shallow embedment

WESTINGHOUSE
REG. CONCRETE
PAUL STUD TYPE
3/4" DIA STUD
SPECIMEN # 120
DYNAMIL TENSION
9-11-79

47 0780

LOAD (KIP)

47 0860

WE 5.5 TO 1.2 INCHES IN DIA
AT 100 PSI AND 1000 PSI

LOAD (KIPS)

3

2

1

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

.10

.20

.30

.40

.50

.60

.70

.80

.90

1.0

1.1

1.2

1.3

1.4

LVDT'S DISPLACEMENT (IN.)

MAX LOAD 16.6K

WESTINGHOUSE
MAGNETITE CONCRETE
PHILLIPS SLEEVE TYPE
3/4" DIA. SLEEVE
5/8" DIA. STUD
SPECIMEN # 121
STATIC TENSION
8/23/74

47 0860

47 0700

LOAD: KIPS

WESTINGHOUSE
MAGNETITE CONCRETE
TYPICAL (RAWL) STUD TYPE
3/4" DIA STUD
SPECIMEN # 122
DYNAMIC TENSION
9-23-74

3 1/2" shallow embedment

47 0700

LOAD - KIIPS

18
16
14
12
10
8
6
4
2

3 cycles 2000, 7000

6000

6600

7100

7600

0 10,000
0 20,000
0 30,000
0 40,000

Failure at 94,400 cycles
Max load 13.4 k
Stud Sheared off

OVERALL DISPLACEMENT (in.)

.05 .10 .15 .20 .25 .30 .35 .40 .45 .50 .55 .60 .65 .70

3 1/2" shallow embedment

WESTINGHOUSE
MAGNETITE CONCRETE
TYPICAL STUD TYPE (PARABOL)
3/4" DIA STUD
SPECIMEN # 123
STATIC TENSION

9-23-74

47 0700

LOAD: KIIPS

3 1/2" shallow embedment

WESTINGHOUSE
MAGNETITE CONCRETE
TYPICAL STUD TYPE (PARABOL)
3/4" DIA STUD
SPECIMEN # 123
STATIC TENSION
9-23-74

47 0700

LOAD = KIPS

36

32

28

24

20

16

12

8

4

.05

.10

.15

.20

.25

.30

.35

.40

.45

.50

.55

.60

.65

.70

OVERALL DISPLACEMENT (in)

Max load 19.2 K
Concrete Failed

4 1/2" normal embedment

WESTINGHOUSE
MAGNETITE CONCRETE
TYPICAL (RAW) STUD TYPE
3/4" DIA STUD
SPECIMEN # 126
STATIC TENSION
9-23-74

MAX. LOAD @ 25.5 KIPS
Concrete Failure

47 0700

LOAD-KIPS

36

32

28

24

20

16

12

8

4

.05

.10

.15

.20

.25

.30

.35

.40

.45

.50

.55

.60

.65

.70

OVERALL DISPLACEMENT (IN)

4 1/2" normal embedment

WESTINGHOUSE
MAGNETITE CONCRETE
TYPICAL (RAWL) STUD TYPE
3/4" DIA STUD
SPECIMEN #126
STATIC TENSION
9-23-74

47 0700

LOAD--KIPS

MAX. LOAD @ 25.5 KIPS
Concrete Failure

470560

LOAD-KIPS

18

16

14

12

10

8

6

4

2

0

47 0860

LOAD - KIPS

18

16

14

12

10

8

6

4

2

0

WESTINGHOUSE
MAGNETITE CONCRETE
PHILLIPS SLEEVE TYPE
3/4" DIA SLEEVE
5/8" DIA STUD
SPECIMEN #128
STATIC TENSION
8-29-74

MAX. LOAD 5.6 K

OVERALL DISPLACEMENT (IN)

1.4

1.3

1.2

1.1

1.0

.90

.80

.70

.60

.50

.40

.30

.20

.10

47 0860

LOAD IN KIIPS

47 0700

NEW LOAD (KIPS)

18
16
14
12
10
8
6
4
2

47 0860

K-E STATISTICAL ANALYSIS
RESEARCH DIVISION

LOAD (KIPS)

WESTINGHOUSE
MAGNETITE CONCRETE
PHILLIPS SLEEVE TYPE
3/4" DIA. SLEEVE
5/8" DIA. STUD
SPECIMEN # 130
DYNAMIC TENSION
8/26/74

3 1/2" embedment

Went to 10hz at 50,000 cycles

Failure 102,984 cycles
12.8 kip

47 0860

K-E 1310 12 INCHES 1/2 INCHES
K-E 1310 12 INCHES 1/2 INCHES

LOAD (KIP)

47 0860

LOADS: KIPS

47 0860

LOAD - KIPS

Page #1

at 622,000 cycle, change in displacement
Scale See Page #2

Westinghouse
Steel Shot Concrete
Parabolt 3/4" stud type
Specimen #133
Long term fatigue tensile
10-16-74

47 0860

Kips

K-E
K-E TOTAL LENGTH 4.1 INCHES
REINFORCING BAR CO. 60K 1014

Page #2 - Continuation
2 x Displacement Scale

WESTINGHOUSE
STEEL SHOT REINFORCED CONCRETE
TYPICAL (PARABOLIC) STUD
3/4" DIA STUD
SPECIMEN #133
LONG-TERM TENSION FATIGUE
10-17-74

Transfer at 622,000 cycles

Total Cycles
1,441,000

622,000 cycles

1,031,000
1,220,000

47 0560

LOAD (KIPS)

18
16
14
12
10
8
6
4
2

.10 .20 .30 .40 .50 .60 .70 .80 .90 1.0 1.1 1.2 1.3 1.4
LVDT'S DISPLACEMENT (IN)

Page #1
 at 622,000 cycles change in displacement
 Scale, See Page 2

Westinghouse
 Steel shot concrete
 Parabolt 7/8" stud type
 Specimen #133
 Long term fatigue tension
 10-16-74

47 0860

K-E 315 TO 1 INCHES IN INCHES
 K-E 315 TO 1 INCHES IN INCHES

18

16

14

12

10

8

6

4

2

.05

.10

.15

.20

.25

.30

.35

.40

.45

.50

.55

.60

.65

.70

OVERALL (N)

1000

1500

118,000

121,000

151,000

164,000

175,000

184,000

192,000

197,000

197,000

197,000

1,622,000

1

47 0860

LOAD: SCALE: (KIPS)

Page #2

$\frac{2}{3}$ 2X DISPLACEMENT SCALE
Continuation

transfer at 622,000 cycles

WESTINGHOUSE
~~STEEL~~ ~~REINFORCED~~ CONCRETE
TYPICAL (PARABOL) STUD
5/4" DIA STUD
SPECIMEN #133
LONG-TERM TENSION FATIGUE
10-17-74

Total Cycles 1,441,000
Stud sheared

1,031,000
1,220,000
1,441,000 cycles

OVERALL DISPLACEMENT (in.)

47 0860

K&E ELECTRONICS, INC.
REPAIRS & CALIBRATION

LOAD (KIPS)

47 0860

K&E SYSTEMS
MINIATURE
MODEL 8000 0.00001

LOAD (KIPS)

WESTINGHOUSE
STEEL SHOT CONCRETE
PHILLIPS SLEEVE TYPE
3/4" DIA SLEEVE
5/8" DIA STUD
SPECIMEN # 136
DYNAMIC TENSION
8-27-74

LOADS: KIPS: 1.00

47 0860

K-E 3/4" DIA. STUD - 1/2" DIA. STUD
NUMBER 136 - 1/2" DIA. STUD

3 1/2" shallow imbedment

WESTINGHOUSE
STEEL SHOT CONCRETE
PHILLIPS SLEEVE TYPE
3/4" DIA. SLEEVE
5/8" DIA. STUD
SPECIMEN # 136
DYNAMIC TENSION
9/27/74

LOAD (KIPS)

2000, 4000, 6000

1 cycle

6600

FAILURE @ 6830 cycle
Max Load 2240*

OVERALL DISPLACEMENT (IN.)

47 0860

K&E 581012 NCM 3.5 IN. H.S.

(

6040 (X100)

WESTINGHOUSE
STEEL SHOT CONCRETE
PILINGS SCOUR TYPE
36" DIA. STEEL
5/8" DIA STUD
SPC CMEN #137
DYNAMIC TENSION
8-26-79

47 0700

LOAD - KIPS

47 0700

LOAD (KIPS)

4 1/2" embedment

WESTINGHOUSE
STEEL SHOT CONCRETE
TYPICAL (RAWL) STUD TYPE
3/4" DIA STUD
SPECIMEN # 139
STATIC TENSION
10-3-74

47 0700

LOAD IN KILOPS

Max load 15.6K
Bolt Pullout

4 1/2" embedment

WESTINGHOUSE
STEEL SHOT CONCRETE
TYPICAL (RAW) STUD TYPE
3/4" DIA STUD
SPECIMEN # 139
STATIC TENSION
10-3-74

Max load 15.6 K
Stud Pulled out

47 0700

LOAD-KIPS

26

32

28

24

20

16

12

8

4

.05

.10

.15

.20

.25

.30

.35

.40

.45

.50

.55

.60

.65

.70

OVERALL DISPLACEMENT (in)

47 0700

K/E 10 X 10 TO THE INCHES
KEPSEL & ENTRA TO THE INCHES

WESTINGHOUSE
STEEL SHOT CONCRETE
TYPICAL (RAWL) STUD TYPE
3/4" DIA STUD.
SPECIMEN # 140
DYNAMIC TENSION
10-4-74

47 0700

K/E
X 3.0 TO THE N. H. A. 1.1 M. H. S.
ALPHAL 8.514 C. 3.0 M. 4.1

Max load 14.4^k

Total Cycles
102,722 Stud Pullout

LVDT DISPLACEMENT (IN)

47 0860

KIPS

47 0860

470860

K-E S&S TO 2 INCHES 1/2 IN

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WESTINGHOUSE
 REG. CONCRETE
 PHILLIPS SLEEVE TYPE
 5/8" DIA SLEEVE
 1/2" DIA STUD 202
 SPECIMEN NO 202
 DYNAMIC TENSION
 7/22/74

47 0860

LOAD (KIPS)

K-E EAST TO LINE 1 - 1000 LBS

300 cycle
 6000 cycles

500 cycle

500 cycle

500 cycle

500 cycle

500 cycle

MAX LOAD 6.8 K
 71,100 cycles total

LVDT'S DISPLACEMENT (IN.)

47 0860

K-E INSTRUMENTS
LOAD - KIPS

WESTINGHOUSE
RES. CONCRETE
PARABOLIC STUD TYPE
5" DIA STUD
SPECIMEN # 203
STATIC TENSION
7-29-74

47 0860

K-E TEST STATION, W. FALLS, N.J.
LOAD - KIPS

18
16
14
12
10
8
6
4
2

MAX LOAD 11.6 KIPS

LVDT DISPLACEMENT (IN.)

.10 .20 .30 .40 .50 .60 .70 .80 .90 1.00

47 0860

LOADS KIPS

470860

LOAD: KIIPS

18

16

14

12

10

8

6

4

2

0

4 1/2" embedment

WESTINGHOUSE
REGULAR CONCRETE
TYPICAL (RAWL) STUD TYPE
3/4" DIA STUD
SPECIMEN # 204
LONG-TERM TENSILE
FATIGUE
10-15-74

Total Cycles

38,500

Stud broke Prematurely

Max load 9000 #

3 cycles

12000 - 265,000

OVERALL DISPLACEMENT (IN)

WESTINGHOUSE
REG CONCRETE
PHILLIPS SLEEVE TYPE
3" DIA SLEEVE
1" DIA STUD
SPECIMEN # 205
LONG TERM FATIGUE
TENSION
8-6-74

47 0860

5 x 7 1/2 x 2 1/2 INCHES 357

5813-KIPS

47 0860
↑
KIPS

K/S 1/16 INCHES IN HOLES
NEUTRAL AXIS TO TENSILE

470860

↑ KIPS

K-E 3/4" DIA. 12 INCHES LONG
NUCLEI ENCASED

PAGE 2

47 0860

K-E 4.5 TO 12 IN. P.C. 1.5 IN. INCHES
REINFORCED CONCRETE

47 0860

K-E S&T OIL COMPANY
KUPIL & SELLER CO. AND SONS

2 4 6 8 10 12 14 16 18

47 0850

K-E 3.5 TO 12 INCHES
REPAIR & REPAIR CO. WASH. D.C.
LOAD - KIPS

Westinghouse
Regular Concrete
Parabolt stud type
5/8" Dia. Stud
Specimen #208
Static Shear
8-1-74

47 0700

[illegible]

47 0700

K-E 15.5 IN TO THE INCH IN 4 IN INCHES
LOAD (KIPS)

WESTINGHOUSE
REG. CONCRETE
SPECIMEN NO. 209
5/8" RAIL STUD
DYNAMIC SHEAR
9/27/74

47 0860

K-E 3.65 TO 1.2 INCH 3.15 TO .7 INCH
RUFFEL & ENER CO. MADE IN U.S.A.

47 0860

K-E 5 X 5 TO 1.2 INCHES
REINFORCING STEEL & STUDS

LOAD - KIPS

47 0700

LOADS KILOGRAMS

WESTINGHOUSE
TYPICAL (RAWL) STUD
3/4" DIA STUD
STEEL SHOT CONCRETE
SPECIMEN #213
DYNAMIC COMBINED
10-9-78

47 0860

KZ 040-2175

47 0860

LOADS - KIIPS

47 0860

KIP LOAD (KIPS)

18

16

14

12

10

8

6

4

2

0

.10

.20

.30

.40

.50

.60

.70

.80

.90

1.0

1.1

1.2

1.3

1.4

OVERALL DISPLACEMENT (IN.)

WESTINGHOUSE
STEEL SHOT CONCRETE
TYPICAL PHILLIPS SLEEVE TYPE
3/4" DIA SLEEVE
5/8" DIA STUD
SPECIMEN # 215
STATIC COMBINED
8-15-74

MAX LOAD 11.2 K

470860

K-LOAD - KIPS

WESTINGHOUSE
STEEL SHOT CONCRETE
TYPICAL PHILLIPS SLEEVES
3/4" DIA SLEEVE
5/8" DIA STUD
SPECIMEN # 216
DYNAMIC COMBINED
8-16-74

47 0860

LOAD = KIIPS

18

16

14

12

10

8

6

4

2

47 0860

LOAD (KIPS)

10-24-74

2,006,100

STUD SHEARED

(5/11/2017)

47 0860

WELDED (KIP)

47 0700

LOAD - KIIPS

47 0700

LOAD-KIPS

LOAD - KIIPS

470700

4 1/2" normal embedment

WESTINGHOUSE
REGULAR CONCRETE
TYPICAL (HILTI) STUD TYPE
3/4" DIA STUD
SPECIMEN #C-2-#1
STATIC SHEAR
9-23-74

Max load 32.8 k
Concrete Failed

47 0700

LOAD - KIIPS

47 0700

LOADS IN KILOPS

LOAD-KIPS

470700

47 0700

LOAD-KIPS

3 1/2" shallow embedment

WESTINGHOUSE
REGULAR CONCRETE
TYPICAL (RAWL) STUD TYPE
3/4" DIA. STUD
SPECIMEN #C2-#4
DYNAMIC SHEAR
9-25-74

Failure at 18,700 cycles
Max load 26.0 k
Stud Sheared

47 0860

LOAD-KIPS

LYDT'S DISPLACEMENT (in)

47 0860

K-E
SIXTENTH INCHES
HUNDREDS OF POUNDS

47 0860

KIP LOAD (KIPS)

36

32

28

24

20

16

12

8

4

$4\frac{1}{2}''$ embedment

Max Load 34.4 K
Concrete Failed

WESTINGHOUSE
REG. CONCRETE
TYPICAL (RAW) STUD TYPE
1" DIA. STUD
SPECIMEN #C2-#6
9-25-79
STATIC SHEAR

1" 2"

OVERALL (IN.)

LODGE (Rios)

47 0860

LOAD (KIPS)

36

32

28

24

20

16

12

8

4

5 1/2" embedment

max load 38 kips
 76,800 cycles at 21.8 kips
 then deflection became too
 great for MTS to follow
 the load. Specimen was
 than failed statically
Stud sheared!

WESTINGHOUSE
 REB. CONCRETE
 TYPICAL (RAW) STUD TYPE
 SPECIMEN #12-7
 1" DIA. STUD
 DYNAMIC SHEAR
 9-25-74

77,000

OVERALL (IN.)

.70

47 0860

LOAD (KIPS)

470860

K-E 5/8" x 1 1/2" x 1 1/2" x 1 1/2" INCHES
GEORGE & EDGAR CO. BOSTON, MASS.

36
32
28
24
20
16
12
8
4

Max load 30.4^k

LOAD'S IN

Block began to crack
around top cast in
anchor. Test stopped
at 102,500 cycles.

Westinghouse
Reg Concrete
Specimen C248
Bar 14 Stud
DYNAMIC SHEAR
9-26-78

Westinghouse
Reg Concrete
Specimen #C2-8
Rawl 1" Stud
DYNAMIC SHEAR
9-26-74

47 0700

LOAD - KIPS

47 0700

LOAD-KIPS

47 0700

LOAD - KIIPS

47 0700

LOAD-KIPS

WESTINGHOUSE
REGULAR CONCRETE
WEJ-IT STUD TYPE
3/8" DIA STUD
SPECIMEN #C2 //
DYNAMIC SHEAR

9-28-74

3 1/2" embedment

47 0700

LOAD - KIPS

18
16
14
12
10
8
6
4
2

Failure at 23,000 cycles
Max load 14.9 KIPS
Stud Sheared

4 1/2" embedment

WESTINGHOUSE
REGULAR CONCRETE
PHILLIPS SLEEVE TYPE
3/8" DIA SLEEVE
1/2" DIA STUD
SPECIMEN #G2 #12
STATIC SHEAR
9-28-74

47 0700

LOAD-KIPS

36

32

28

24

20

16

12

8

4

.05

.10

.15

.20

.25

.30

.35

.40

.45

.50

.55

.60

.65

.70

OVERALL DISPLACEMENT (IN.)

Max load 17.2 k
Stud Sheared

Westinghouse
Reg. Concrete
Phillips 5/8" sleeve type
1/2" stud
Static Shear
9-28-74
specimen C-2#12

47 0700
Kips
K-E
10.5 IN. TO THE CENTER OF THE STUDS
10.5 IN. TO THE CENTER OF THE STUDS

470700

LOAD-KIPS

47 0700

LOAD-KIPS

47 0700

LOAD - KIPS

18

16

14

12

10

8

6

4

2

0

-2

-4

-6

-8

-10

-12

-14

-16

-18

-20

-22

-24

-26

-28

-30

-32

-34

-36

-38

-40

-42

-44

-46

-48

-50

-52

-54

-56

-58

-60

-62

-64

-66

-68

-70

-72

-74

-76

-78

-80

-82

-84

-86

-88

-90

-92

-94

-96

-98

-100

-102

-104

-106

-108

-110

-112

-114

-116

-118

-120

-122

-124

-126

-128

-130

-132

-134

-136

-138

-140

-142

-144

-146

-148

-150

-152

-154

-156

-158

-160

-162

-164

-166

-168

-170

-172

-174

-176

-178

-180

-182

-184

-186

-188

-190

-192

-194

-196

-198

-200

-202

-204

-206

-208

-210

-212

-214

-216

-218

-220

-222

-224

-226

-228

-230

-232

-234

-236

-238

-240

-242

-244

-246

-248

-250

-252

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-256

-258

-260

-262

-264

-266

-268

-270

-272

-274

-276

-278

-280

-282

-284

-286

-288

-290

-292

-294

-296

-298

-300

-302

-304

-306

-308

-310

-312

-314

-316

-318

-320

-322

-324

-326

-328

-330

-332

-334

-336

-338

-340

-342

-344

-346

-348

-350

-352

-354

-356

-358

-360

-362

-364

-366

-368

-370

-372

-374

-376

-378

-380

-382

-384

-386

-388

-390

-392

-394

-396

-398

-400

-402

-404

-406

-408

-410

-412

-414

-416

-418

-420

-422

-424

-426

-428

-430

-432

-434

-436

-438

-440

-442

-444

-446

-448

-450

-452

-454

-456

-458

-460

-462

-464

-466

-468

-470

-472

-474

-476

-478

-480

-482

-484

-486

-488

-490

-492

-494

-496

-498

-500

-502

-504

-506

-508

-510

-512

-514

-516

-518

-520

-522

-524

-526

-528

-530

-532

-534

-536

-538

-540

-542

-544

-546

-548

-550

-552

-554

-556

-558

-560

-562

-564

-566

-568

-570

47 0700

Kips

K/E 10 X 10 TO THE INCHES
NEEDED UNDER 10" MAX BAR

47 0700

Kips

10 X 10 TO THE INCHES X 15 INCHES
NEUPPEL & BONES CO. NEW YORK

K-2

18

16

14

12

10

8

6

4

2

SHEARED BOLT AT 39,800 CYC.
Max load 9.6 K

LVDT'S IN

WESTINGHOUSE
Reg Concrete
5/8" inner dia.
2 7/32" outer dia.
HILTI SHELL TYPE
SPECIMEN #C2-15
DYNAMIC SHEAR
10-2-74

47 0700

LOAD - KIPS

36

32

28

24

20

16

12

8

4

.05

.10

.15

.20

.25

.30

.35

.40

.45

.50

.55

.60

.65

.70

LVOTS DISPLACEMENT (in)

MAX LOAD 37.8 K

STUD
SHEAREDWESTINGHOUSE
MAGNETITE CONCRETE
TYPICAL STUD TYPE (HILTI)
3/4" DIA STUD
SPECIMEN # M-2-1
STATIC SHEAR

9-18-74

WESTINGHOUSE
MAGNETITE CONCRETE
TYPICAL STUD TYPE (HILN)
3/4" DIA STUD
SPECIMEN # M-2-1
STATIC SHEAR
9-18-74

Max load 37.8^k
Stud Sheared

47 0700

LOAD-KIPS

WESTINGHOUSE
MAGNETITE CONCRETE
TYPICAL STUDTYPE (RAWL)
3/4" DIA STUD
SPECIMEN # M-2-#2
STATIC SHEAR
9-18-74

47 0700

LOAD-KIPS
DISPLACEMENT INCHES

36

32

28

24

20

16

12

8

4

.05
10.10
20.15
30.20
40.25
50.30
60.35
70.40
80.45
90.50
100.55
110.60
120.65
130.70
140

OVERALL DISPLACEMENT (IN)

WESTINGHOUSE
MAGNETITE CONCRETE
TYPICAL STUD TYPE
RAWL STUD; $\frac{3}{4}$ " DIA STUD
SPECIMEN M-2-#2
STATIC SHEAR
9-18-74

CHANGE TO THREE LOAD SCHE

Max load 42.0k

Concrete Failed

47 0700

K/E 10.10 TO THE INCHES
NEUTRAL FIBER CO. 1000000

36

32

28

24

20

16

12

8

4

WESTINGHOUSE
MAGNETITE CONCRETE
TYPICAL STUD TYPE (PARABOL)
3/4" DIA STUD
SPECIMEN #M-2-#3
DYNAMIC SHEAR
9-19-74

47 0700

1000 TO 1000 INCHES
ALONG A BASE UP THE WALL

47 0700

LOAD-KIPS

36

32

28

24

20

16

12

8

4

0

.05

.10

.15

.20

.25

.30

.35

.40

.45

.50

.55

.60

.65

.70

.75

.80

.85

.90

.95

1.00

OVERALL DISPLACEMENT (IN)

WESTINGHOUSE
MAGNETITE CONCRETE
TYPICAL (HILT) STUD TYPE
3/4" DIA STUD
SPECIMEN #M-2-4
DYNAMIC SHEAR

9-19-74

3 cycles from 4000-6000 @ 25' - Fund 10 cps

3000

6000

3500

Failure at 8180 cycles
Max load 24.8"

8000

47 0700

LOAD - KIIPS

36

32

28

24

20

16

12

8

4

47 0700

LOAD (KIPS)

47 0700

LOAD + KIPS

47 0700

LOADS KIPS

36

32

28

24

20

16

12

8

4

3 1/2" embedment

WESTINGHOUSE
STEEL SHOT CONCRETE
TYPICAL (HILTI) STUD
3/4" DIA STUD
SPECIMEN MS2 #2
STATIC SHEAR
10-10-74

Max load 26.0 K
Concrete Failed

STUD'S DISPLACEMENT (IN)

47 0700

LOADS KIPS

LOAD IN KILOPS

47 0700

47 0700

LOAD: KIIPS

$\frac{1}{2}$ " actual embedment

WESTINGHOUSE
STEEL SHOT CONCRETE
RAWL STUD
 $\frac{3}{4}$ " DIAMETER
SPECIMEN S2#4
DYNAMIC SHEAR
10-11-74

(KIPS)

K-E 10 X 10 TO THE INCHES 0.1 INCHES
ALUMINUM STUD CO. 10-11-74

36

32

28

24

20

16

12

8

4

.10

.20

.30

.40

.50

.60

.70
LVDT's

.80

.90

1.0

1.1

1.2

1.3

1.4

WESTINGHOUSE
STEEL SHOT CONCRETE
RAWL STUD
3/4" DIAMETER
SPECIMEN S2 #4
DYNAMIC SHEAR
10-11-74

Block began to crack
around top cast in
anchor at 103,350 cycles
max load = 26.3 kips

47 0860

LOAD - KIPS

4 1/2" embedment

WESTINGHOUSE
STEEL SHOT CONCRETE
TYPICAL (RAW) STUD TYPE
3/4" DIA STUD
SPECIMEN #S2- #5
LONG-TERM SHEAR FATIGUE
10/21/74

18
16
14
12
10
8
6
4
2.05 .10 .15 .20 .25 .30 .35 .40 .45 .50 .55 .60 .65 .70
OVERALL DISPLACEMENT (IN)2X
LOAD
SCALE

4 cycles
16,000 87,000
15,000 87,000
14,000 87,000
13,000 87,000
12,000 87,000
11,000 87,000
10,000 87,000
9,000 87,000
8,000 87,000
7,000 87,000
6,000 87,000
5,000 87,000
4,000 87,000
3,000 87,000
2,000 87,000
1,000 87,000
0 87,000

150,000
100,000
50,000

4 1/2' embedment.

WESTINGHOUSE
STEEL SHOT CONCRETE
TYPICAL (RAWL) STUD TYPE
3/4" DIA STUD
SPECIMEN #S2-#5
LONG-TERM SHEAR FATIGUE
10/31/74

APPENDIX 2

TABLE OF DATA SORTED BY BOLT TYPE, BOLT DIAMETER, AND TYPE TEST, IN THAT ORDER

5/8 INCH SLEEVE TYPE BOLTS

SPEC NUMB	CONC TYPE	F _{IC} KSI	BOLT TYPE	TEST TYPE	P1 KIP	D1 IN	DELTA KC	PJ KIP	DU IN	DELTA KC	FAILURE MODE	
11	REG	5.60	LB-5	STAT	T	12.0	.25	--	13.0	.40	--	BOLT FAILED
14	REG	4.50	LB-5	DYN	T	11.0	.20	10.2	11.0	.45	11.7	BOLT FAILED
202	REG	4.40	LB-5	DYN	T	6.8	.15	22.0	6.8	.20	71	BOLT FAILED
201	REG	6.10	LB-5	FAT	T	2.6	.25	3.0	2.6	.35	504	BOLT FAILED
205	REG	5.50	LB-5	FAT	T	2.6	.02	2000	2.6	.02	2000	BOLT FAILED
210	REG	4.90	LB-5	STAT	V	19.0	.45	--	20.0	.70	--	BOLT SHEARED
16	REG	5.00	LB-5	STAT	V	17.0	.20	--	24.0	.70	--	BOLT SHEARED
C2-12	REG	6.87	LB-5	STAT	V	16.0	.30	--	17.2	.40	--	BOLT SHEARED
207	REG	4.50	LB-5	DYN	V	14.4	.20	7.8	14.4	.40	31.6	BOLT SHEARED
12	REG	5.50	LB-5	DYN	V	14.4	.35	7.8	14.4	.65	32.0	BOLT SHEARED
206	REG	5.80	LB-5	FAT	V	4.6	.07	.60	26.5		2000	BOLT SHEARED
72	REG	7.17	LB-5	FAT	V	4.6	.05	7.8	26.6	1.0	2000	BOLT SHEARED
21	REG	5.80	LB-5	STAT	C	6.4	.15	--	11.8	1.0	--	PULLOUT
46	REG	5.30	LB-5	STAT	C	8.0	.30	--	11.4	1.1	--	PULLOUT
3	REG	5.70	LB-5	DYN	C	7.0	.05	7.2	7.0	.46	41	PULLOUT
33	REG	5.00	LB-5	DYN	C	7.2	.15	7.8	7.2	.40	16.5	BOLT SHEARED

TABLE OF DATA SORTED BY BOLT TYPE, BOLT DIA., AND TYPE TEST. CONT.

3/4 INCH SLEEVE TYPE BOLTS

SPEC NUMB	CONC TYPE	FIC KSI	BOLT TYPE	TEST TYPE		P1 KIP	D1 IN	DELTA KC	PU KIP	DU IN	DELTA KC	FAILURE MODE
106	REG	7.15	LB-6	STAT	T	14.8	.78	--	15.4	.98	--	PULLOUT
99	REG	6.91	LB-6	STAT	T	--	--	--	9.4	--	--	PULLOUT
87	REG	5.51	LB-6	DYN	T	7.8	.15	7.8	15.6	1.01	103	PULLOUT
86	REG	7.24	LB-6	DYN	T	7.8	.80	7.8	9.7	.96	9.7	PULLOUT
13	REG	6.08	LB-6	FAT	T	2.6	.02	1.0	4.2	.03	2000	BOLT FAILED
94	REG	6.38	LB-6	FAT	T	2.6	.05	1.0	2.6	.15	535	BOLT FAILED
121	MAG	6.17	LB-6	STAT	T	--	--	--	16.6	--	--	PULLOUT
125	MAG	6.20	LB-6	STAT	T	3.7	.01	--	5.6	--	--	PULLOUT
127	MAG	6.17	LB-6	DYN	T	7.0	1.0	7.8	13.0	1.26	107.3	CONC FAILED
130	MAG	6.15	LB-6	DYN	T	7.0	.46	7.8	12.5	.76	102	CONC FAILED
132	SS	6.27	LB-6	STAT	T	2.8	.02	--	4.0	--	--	PULLOUT
134	SS	6.29	LB-6	STAT	T	4.8	.38	--	7.2	1.05	--	PULLOUT
137	SS	6.20	LB-6	DYN	T	3.4	.38	7.8	6.4	.97	110	PULLOUT
136	SS	6.24	LB-6	DYN	T	--	--	--	2.2	.83	6.8	PULLOUT
7	REG	6.78	LB-6	STAT	V	21.5	.30	--	29.2	.85	--	BOLT FAILED
76	REG	6.67	LB-6	STAT	V	28.0	.40	--	31.6	.65	--	BOLT FAILED
75	REG	7.35	LB-6	DYN	V	17.8	.27	7.8	17.8	.30	27.5	BOLT FAILED
76	REG	6.54	LB-6	DYN	V	17.8	1.10	7.8	17.8	--	19.8	BOLT FAILED
63	MAG	6.54	LB-6	STAT	V	23.0	.34	--	32.4	--	--	BOLT FAILED
65	MAG	6.57	LB-6	STAT	V	25.0	.40	--	28.2	.90	--	BOLT FAILED
66	MAG	6.48	LB-6	DYN	V	17.4	.25	7.8	17.4	.55	39.6	BOLT FAILED
64	MAG	6.70	LB-6	DYNV	V	17.4	.27	7.8	17.4	1.25	26.9	BOLT FAILED
69	SS	6.40	LB-6	STAT	V	18.8	.17	--	22.0	1.20	--	PULLOUT
65	SS	6.96	LB-6	STAT	V	26.0	.40	--	28.0	.60	--	PULLOUT

TABLE OF DATA SORTED BY BOLT TYPE, BOLT DIA., AND TYPE TEST. CONT.

3/4 INCH SLEEVE TYPE BOLTS CONT.

SPEC NUMB	CONC TYPE	F/C KSI	BOLT TYPE	TEST TYPE		P1 KIP	D1 IN	DELTA KC	PU KIP	DU IN	DELTA KC	FAILURE MODE
70	SS	5.16	LB-6	DYN	V	10.8	.22	7.8	10.8	--	34	PULLOUT
71	SS	6.43	LB-6	DYN	V	16.8	1.10	7.8	10.8	--	7.8	PULLOUT
26	REG	--	LB-6	STAT	C	6.0	.15	--	10.4	--	--	CONC FAILED
30	REG	5.85	LB-6	STAT	C	8.4	.19	--	14.4	1.35	--	CONC FAILED
28	REG	6.43	LB-6	DYN	C	7.2	.54	7.8	7.2	--	39.5	BOLT SHEARED
32	REG	7.01	LB-6	DYN	C	7.2	.32	7.8	7.2	--	63.3	BOLT SHEARED
54	MAG	8.14	LB-6	STAT	C	5.8	.08	--	15.4	--	--	CONC FAILED
51	MAG	8.07	LB-6	STAT	C	7.2	.09	--	14.2	.93	--	CONC FAILED
56	MAG	8.07	LB-6	DYN	C	6.4	.07	7.8	6.4	--	67	PULLOUT
53	MAG	7.90	LB-6	DYN	C	6.4	.09	7.8	6.2	--	95.5	BOLT SHEARED
61	SS	7.65	LB-6	STAT	C	9.6	.11	--	11.2	.94	--	CONC FAILED
215	SS	6.58	LB-6	STAT	C	8.6	.12	--	11.2	.41	--	CONC FAILED
214	SS	8.77	LB-6	DYN	C	6.3	.11	7.8	6.25	--	44.6	STUD SHEARED
216	SS	6.86	LB-6	DYN	C	6.4	.14	7.8	6.40	--	7.9	PULLOUT

TABLE OF DATA SORTED BY BOLT TYPE, BOLT DIA., AND TYPE TEST. CONT.

5/8 INCH STUD TYPE BOLTS

SPEC NUMB	CONC TYPE	F/C KSI	BOLT TYPE	TEST TYPE		P1 KIP	D1 IN	DELTA KC	PU KIP	DU IN	DELTA KC	FAILURE MODE
105	REG	6.54	SB-5	STAT	T	8.0	.20	--	14.4	.40	--	PULLOUT
203	REG	6.20	SB-5	STAT	T	11.6	.35	--	11.6	.80	--	PULLOUT
37	REG	5.50	SA-5	DYN	T	8.6	.22	7.8	18.6	.60	110	PULLOUT
114	REG	6.86	SA-5	DYN	T	8.6	.50	7.8	12.6	1.0	102	CONC FAILED
5	REG	6.30	SB-5	DYN	T	7.0	.45	7.8	16.0	.68	112	PULLOUT
1	REG	6.60	SB-5	DYN	T	7.0	.07	7.8	12.0	.45	102	PULLOUT
89	REG	6.86	SC-5	DYN	T	5.5	.07	7.8	10.7	.20	102	PULLOUT
85	REG	6.55	SC-5	DYN	T	5.5	.05	7.8	12.6	.20	101	PULLOUT
208	REG	6.20	SB-5	STAT	V	28.0	.15	--	33.0	.45	--	BOLT SHEARED
C2-13	REG	5.90	SB-5	STAT	V	16.0	.10	--	21.0	.17	--	BOLT SHEARED
209	REG	7.16	SA-5	DYN	V	19.2	.17	7.8	19.2	.45	17.9	BOLT SHEARED
C2-9	REG	6.77	SA-5	DYN	V	19.2	.30	7.8	19.2	.35	8.0	BOLT SHEARED
7	REG	6.40	SB-5	DYN	V	20.0	.10	7.8	20.0	.20	9.2	BOLT SHEARED
9	REG	--	SB-5	DYN	V	18.0	.22	7.8	18.0	--	10.2	BOLT SHEARED
2-10	REG	6.40	SC-5	DYN	V	14.4	.15	7.8	14.4	.23	33.9	BOLT SHEARED
C2-11	REG	6.64	SC-5	DYN	V	14.4	.25	7.8	14.4	.75	23.0	BOLT SHEARED
35	REG	4.90	SB-5	STAT	C	11.6	.07	--	11.6	.10	--	CONC FAILED
25	REG	--	SB-5	STAT	C	6.8	.12	--	10.6	.43	--	CONC FAILED
24	REG	6.50	SA-5	DYN	C	6.6	.09	7.8	6.6	.10	22.0	PULLOUT
36	REG	6.30	SA-5	DYN	C	6.6	.15	7.8	6.6	.45	37.0	PULLOUT
10	REG	5.80	SB-5	DYN	C	6.6	.07	7.8	6.6	--	17.9	BOLT SHEARED
45	REG	6.10	SB-5	DYN	C	6.6	.10	7.8	9.6	.35	102	BOLT SHEARED
18	REG	6.70	SC-5	DYN	C	6.6	.27	7.8	6.6	--	28.0	PULLOUT
4	REG	6.20	SC-5	DYN	C	6.6	.05	7.8	6.6	.07	15.6	PULLOUT

TABLE OF DATA SORTED BY BOLT TYPE, BOLT DIA., AND TYPE TEST. CONT.

1/4 INCH STUD TYPE BOLTS

SPEC NUMB	CONC TYPE	FIC KSI	BOLT TYPE	TEST TYPE		P1 KIP	D1 IN	DELTA KC	PU KIP	DU IN	DELTA KC	FAILURE MODE
110	REG	7.49	SB-6	STAT	T	5.0	.10	--	17.3	.50	--	PULLOUT
109	REG	7.44	SA-6	STAT	T	6.0	.20	--	22.0	.50	--	PULLOUT
115	REG	6.86	SA-6	DYN	T	10.0	.25	7.8	18.2	.45	105	PULLOUT
120	REG	7.12	SA-6	DYN	T	10.0	.18	7.8	21.8	.45	108	CONC FAILED
204	REG	--	SA-6	FAT	T	4.0	.01	--	4.0	.03	386	BOLT SHEARED
73	REG	--	SA-6	FAT	T							
123	MAG	6.93	SB-6	STAT	T	8.0	.04	--	14.2	.15	--	CONC FAILED
126	MAG	7.05	SA-6	STAT	T	8.0	.05	--	25.5	.42	--	CONC FAILED
129	MAG	6.76	SB-6	DYN	T	13.6	.10	7.8	15.7	.42	100	BOLT FAILED
122	MAG	7.07	SA-6	DYN	T	13.6	.18	7.8	13.6	.26	94	BOLT FAILED
139	SS	6.50	SA-6	STAT	T	12.0	.30	--	15.6	.60	--	PULLOUT
133	SS	7.38	SB-6	STAT	T	6.0	.40	--	7.6	.60	--	PULLOUT
131	SS	7.33	SA-6	DYN	T	9.6	.21	7.8	13.6	.30	101	PULLOUT
140	SS	7.58	SA-6	DYN	T	8.4	.27	7.8	14.4	.40	102	PULLOUT
33	SS	7.61	SB-6	FAT	T	3.2	.05	--	3.2	.70	1440	BOLT FAILED
C2-1	REG	5.87	SH-6	STAT	V	30.1	.23	--	32.8	.30	--	BOLT SHEARED
C2-2	REG	6.10	SA-6	STAT	V	30.3	.15	--	34.0	.20	--	BOLT SHEARED
C2-3	REG	6.38	SB-6	DYN	V	20.1	.13	7.8	23.4	.25	101	BOLT SHEARED
C2-4	REG	6.68	SA-6	DYN	V	20.1	.20	7.8	20.1	.25	18.7	BOLT SHEARED
M2-1	MAG	6.08	SH-6	STAT	V	34.0	.30	--	37.8	.70	--	BOLT FAILED
M2-2	MAG	5.81	SA-6	STAT	V	38.0	.25	--	42.0	.33	--	CONC FAILED
M2-3	MAG	5.49	SB-6	DYN	V	24.0	.20	7.8	24.0	.25	8.1	BOLT FAILED
M2-4	MAG	5.87	SH-6	DYN	V	24.0	.30	7.8	24.0	.80	8.1	BOLT FAILED
S2-1	SS	7.30	SA-6	STAT	V	24.0	.20	--	32.0	.30	--	CONC FAILED

TABLE OF DATA SORTED BY BOLT TYPE, BOLT DIA., AND TYPE TEST. CONT.

3/4 INCH STUD TYPE BOLTS CONT

SPEC NUMB	CONC TYPL	FIC KSI	BOLT TYPE	TEST TYPE	P1 KIP	D1 IN	DELTA KC	PU KIP	DU IN	DELTA KC	FAILURE MODE	
S2-2	SS	6.84	SH-6	STAT	V	20.0	.15	--	26.0	.22	--	CONC FAILED
S2-3	SS	7.44	SB-6	DYN	V	18.4	.20	7.8	18.4	.40	36.4	PULLOUT
S2-4	SS	7.10	SA-6	DYN	V	18.0	.10	7.8	26.3	.19	103	CONC FAILED
S2-5	SS	7.23	SA-6	FAT	V	5.8	.05	--	5.8	.12	1500	FAILED STAT
80	REG	7.17	SE-6	STAT	C	9.0	.20	--	13.0	.30	--	PULLOUT
83	REG	6.86	SA-6	DYN	C	6.5	.25	7.8	13.2	.50	107	PULLOUT
31	REG	6.71	SB-6	DYN	C	6.5	.50	7.8	11.8	1.0	102	PULLOUT
50	REG	6.22	SA-6	FAT	C	2.6	.01	--	10.3	.29	2005	CONC FAILED
55	MAG	--	SA-6	STAT	C	8.0	.15	--	11.4	.20	--	CONC FAILED
52	MAG	--	SB-6	STAT	C	12.0	.02	--	15.4	.23	--	CONC FAILED
55	MAG	--	SB-6	DYN	C	8.0	.20	7.8	14.6	.24	104	CONC FAILED
59	MAG	8.62	SA-6	DYN	C	8.2	.04	7.8	12.0	.08	102	CONC FAILED
62	SS	7.90	SB-6	STAT	C	6.0	.08	--	10.4	.17	--	BOLT FAILED
213	SS	8.14	SA-6	DYN	C	6.0	.20	7.8	10.0	.43	71.8	BOLT FAILED
19	SS	8.53	SA-6	DYN	C	6.1	.17	7.8	6.1	.26	84.0	BOLT FAILED
217	SS	8.09	SA-6	FAT	C	2.0	.02	--	6.0	.35	2006	BOLT SHEARED

TABLE OF DATA SORTED BY BOLT TYPE, BOLT DIA., AND TYPE TEST. CONT.

1 INCH STUD TYPE BOLTS

SPEC NUMB	CONC TYPE	F ¹ C KSI	BOLT TYPE	TEST TYPE		P1 KIP	D1 IN	DELTA KC	PU KIP	DU IN	DELTA KC	FAILURE MODE
88	REG	6.96	SA-8	STAT	T	24.0	.50	--	26.4	.60	--	CONC FAILED
113	REG	6.13	SB-8	STAT	T	16.0	1.0	--	22.5	1.20	--	CONC FAILED
91	REG	5.69	SA-8	DYN	T	16.0	.10	7.8	26.0	.33	103	CONC FAILED
107	REG	7.00	SB-8	DYN	T	15.8	.65	7.8	20.8	.85	101	CONC FAILED
C2-5	REG	6.66	SA-8	STAT	V	28.0	.1		34.5	.50	--	CONC FAILED
C2-6	REG	7.14	SA-8	STAT	V	28.0	.1		36.4	.50	--	
C2-7	REG	6.36	SA-8	DYN	V	21.8	.25	7.8	38.0	.50	76	BOLT FAILED
C2-8	REG	6.10	SA-8	DYN	V	21.8	.10	7.8	31.0	.25	106	CONC FAILED
23	REG	7.14	SA-8	STAT	C	10.0	.20	--	12.6	.25	--	CONC FAILED
17	REG	6.02	SB-8	STAT	C	10.0	.20	--	13.0	.25	--	CONC FAILED
29	REG	6.52	SA-8	DYN	C	6.0	.14	7.8	8.0	.34	74	CONC FAILED
20	REG	6.77	SA-8	DYN	C	8.0	.36	7.8	11.6	.57	102	CONC FAILED

T E OF DATA SORTED BY BOLT TYPE, BOLT DIA., AND TYPE TEST. CONT.

5/8 INCH SHELL ANCHORS

112	REG	7.49	LA-5	DYN	T	6.6	.08	7.8	10.0	.22	102	CONC FAILED
100	REG	6.20	LA-5	DYN	T	7.8	.06	7.8	10.6	.14	101	CONC FAILED
C2-14	REG	6.22	LA-5	DYN	V	9.6	.15	7.8	9.6	.30	51.0	BOLT SHEARED
C2-15	REG	6.52	LA-5	DYN	V	9.6	.15	7.8	9.6	.25	39.0	BOLT SHEARED
39	REG	6.11	LA-5	STAT	C	4.0	.10	--	11.2	.95	--	BOLT FAILED
44	REG	6.61	LA-5	DYN	C	6.6	.07	7.8	6.6	.07	7.8	PULLOUT
34	REG	5.92	LA-5	DYN	C	6.6	.07	7.8	6.6	.07	7.8	PULLOUT

3/4 INCH SHELL ANCHORS

SPEC	CONC	FIC	BOLT	TEST	P1	D1	DELTA	PU	DU	DELTA	FAILURE
NUMB	TYPE	KSI	TYPE	TYPE	KIP	IN	KC	KIP	IN	KC	MODE
27	REG	7.12	LA-6	STAT C	11.0	.14	--	12.0	.16	--	CONC FAILED
81	REG	7.10	LA-6	STAT C	9.0	.40	--	13.3	.55	---	PULLOUT

APPENDIX 3

TABLE OF DATA SORTED BY TEST TYPE AND ULTIMATE LOAD (PU), IN THAT ORDER

TENSION TESTS

SPEC NUMB	CONC TYPE	FIC KSI	BOLT TYPE	TEST TYPE	T	P1 KIP	D1 IN	DELTA KC	PU KIP	DU IN	DELTA KC	FAILURE MODE
88	REG	6.96	SA-8	STAT	T	24.0	.50	--	26.4	.60	--	CONC FAILED
91	REG	5.69	SA-8	DYN	T	16.0	.10	7.8	26.0	.33	103	CONC FAILED
126	MAG	7.05	SA-6	STAT	T	8.0	.05	--	25.5	.42	--	CONC FAILED
113	REG	6.13	SB-8	STAT	T	16.0	1.0	--	22.5	1.20	--	CONC FAILED
109	REG	7.44	SA-6	STAT	T	6.0	.20	--	22.0	.50	--	PULLOUT
120	REG	7.12	SA-6	DYN	T	10.0	.18	7.8	21.8	.45	108	CONC FAILED
37	REG	5.50	SA-5	DYN	T	8.6	.22	7.8	18.6	.60	110	PULLOUT
115	REG	6.86	SA-6	DYN	T	10.0	.25	7.8	18.2	.45	105	PULLOUT
110	REG	7.49	SB-6	STAT	T	5.0	.10	--	17.3	.50	--	PULLOUT
121	MAG	6.17	LB-6	STAT	T	--	--	--	16.6	--	--	PULLOUT
129	MAG	6.78	SB-6	DYN	T	13.6	.10	7.8	15.7	.42	100	BOLT FAILED
67	REG	5.51	LB-6	DYN	T	7.8	.15	7.8	15.6	1.01	103	PULLOUT
139	SS	6.50	SA-6	STAT	T	12.0	.30	--	15.6	.60	--	PULLOUT
106	REG	7.16	LB-6	STAT	T	14.8	.78	--	15.4	.98	--	PULLOUT
10	SS	7.58	SA-6	DYN	T	8.4	.27	7.8	14.4	.40	102	PULLOUT
105	REG	6.54	SB-5	STAT	T	8.0	.20	--	14.4	.40	--	PULLOUT
123	MAG	6.93	SB-6	STAT	T	8.0	.04	--	14.2	.15	--	CONC FAILED
131	SS	7.33	SA-6	DYN	T	9.6	.21	7.8	13.6	.30	101	PULLOUT
122	MAG	7.07	SA-6	DYN	T	13.6	.18	7.8	13.6	.26	94	BOLT FAILED
127	MAG	6.17	LB-6	DYN	T	7.0	1.0	7.8	13.0	1.26	107.8	CONC FAILED
11	REG	5.60	LB-5	STAT	T	12.0	.25	--	13.0	.40	--	BOLT FAILED
114	REG	6.86	SA-5	DYN	T	8.6	.50	7.8	12.6	1.0	102	CONC FAILED
85	REG	6.55	SC-5	DYN	T	5.5	.05	7.8	12.6	.20	101	PULLOUT
130	MAG	6.15	LB-6	DYN	T	7.0	.46	7.8	12.5	.76	102	CONC FAILED

TABLE OF DATA SORTED BY TEST TYPE AND ULTIMATE LOAD (PU), IN THAT ORDER CONT.

PULSION TESTS

CONT.

SPEC NUMB	CONC TYPE	FIC KSI	BOLT TYPE	TEST TYPE		P1 KIP	D1 IN	DELTA KC	PU KIP	DU IN	DELTA KC	FAILURE MODE
1	REG	6.60	SB-5	DYN	T	7.0	.07	7.8	12.0	.45	102	PULLOUT
203	REG	6.20	SB-5	STAT	T	11.6	.35	--	11.6	.80	--	PULLOUT
14	REG	4.50	LB-5	DYN	T	11.0	.20	10.2	11.0	.45	11.7	BOLT FAILED
5	REG	6.30	SB-5	DYN	T	7.0	.45	7.8	16.0	.68	112	PULLOUT
100	REG	6.20	LA-5	DYN	T	7.8	.06	7.8	10.6	.14	101	CONC FAILED
112	REG	7.49	LA-5	DYN	T	6.6	.08	7.8	10.0	.22	102	CONC FAILED
86	REG	7.24	LB-6	DYN	T	7.8	.80	7.8	9.7	.96	9.7	PULLOUT
99	REG	6.91	LB-6	STAT	T	--	--	*	9.4	--	--	PULLOUT
89	REG	6.86	SC-5	DYN	T	5.5	.07	7.8	10.7	.20	102	PULLOUT
138	SS	7.38	SB-6	STAT	T	6.0	.40	--	7.6	.60	--	PULLOUT
134	SS	6.29	LB-6	STAT	T	4.8	.38	--	7.2	1.05	--	PULLOUT
202	REG	4.40	LB-5	DYN	T	6.8	.15	22.0	6.8	.20	71	BOLT FAILED
137	SS	6.20	LB-6	DYN	T	3.4	.38	7.8	6.4	.97	110	PULLOUT
129	MAG	6.20	LB-6	STAT	T	3.7	.01	--	5.6	--	--	PULLOUT
3	REG	6.08	LB-6	FAT	T	2.6	.02	1.0	4.2	.03	2000	BOLT FAILED
204	REG	--	SA-6	FAT	T	4.0	.01	--	4.0	.03	386	BOLT SHEARED
132	SS	6.27	LB-6	STAT	T	2.8	.02	--	4.0	--	--	PULLOUT
133	SS	7.61	SB-6	FAT	T	3.2	.05	--	3.2	.70	1440	BOLT FAILED
107	REG	7.00	SB-8	DYN	T	15.8	.65	7.8	20.8	.85	101	CONC FAILED
205	REG	5.50	LB-5	FAT	T	2.6	.02	2000	2.6	.02	2000	BOLT FAILED
94	REG	6.38	LB-6	FAT	T	2.6	.05	1.0	2.6	.15	535	BOLT FAILED
201	REG	6.10	LB-5	FAT	T	2.6	.25	3.0	2.6	.35	504	BOLT FAILED
136	SS	6.24	LB-6	DYN	T	--	--	--	2.2	.83	6.8	PULLOUT
73	REG	--	SA-6	FAT	T							

TABLE OF DATA SORTED BY TEST TYPE AND ULTIMATE LOAD (PU), IN THAT ORDER CONT.

TESTS

SPEC NO.	CONC TYPE	FIC KSI	BOLT TYPE	TEST TYPE		P1 KIP	D1 IN	DELTA KC	PU KIP	DU IN	DELTA KC	FAILURE MODE
12-2	MAG	5.81	SA-6	STAT	V	38.0	.25	--	42.0	.33	--	CONC FAILED
12-7	REG	6.36	SA-8	DYN	V	21.8	.25	7.8	38.0	.50	76	BOLT FAILED
12-1	MAG	6.08	SH-6	STAT	V	34.0	.30	--	37.8	.70	--	BOLT FAILED
12-5	REG	7.14	SA-8	STAT	V	28.0	.1		36.4	.50	--	
12-3	REG	6.66	SA-8	STAT	V	28.0	.1		34.5	.50	--	CONC FAILED
12-2	REG	6.10	SA-6	STAT	V	30.3	.15	--	34.0	.20	--	BOLT SHEARED
12-3	REG	6.20	SB-5	STAT	V	28.0	.15	--	33.0	.45	--	BOLT SHEARED
12-1	REG	5.87	SH-6	STAT	V	30.1	.23	--	32.8	.30	--	BOLT SHEARED
13	MAG	6.54	LB-6	STAT	V	23.0	.34	--	32.4	--	--	BOLT FAILED
12-1	SS	7.30	SA-6	STAT	V	24.0	.20	--	32.0	.30	--	CONC FAILED
75	REG	6.67	LB-6	STAT	V	28.0	.40	--	31.6	.65	--	BOLT FAILED
12-5	REG	6.10	SA-8	DYN	V	21.8	.10	7.8	31.0	.25	106	CONC FAILED
17	REG	6.78	LB-6	STAT	V	21.5	.30	--	29.2	.85	--	BOLT FAILED
15	MAG	6.57	LB-6	STAT	V	25.0	.40	--	28.2	.90	--	BOLT FAILED
12	SS	6.96	LB-6	STAT	V	26.0	.40	--	28.0	.60	--	PULLOUT
12	REG	7.17	LB-5	FAT	V	4.6	.05	7.8	26.6	1.0	2000	BOLT SHEARED
12-5	REG	5.80	LB-5	FAT	V	4.6	.07	.60	26.5		2000	BOLT SHEARED
12-4	SS	7.10	SA-6	DYN	V	18.0	.10	7.8	26.3	.19	103	CONC FAILED
12-2	SS	6.84	SH-6	STAT	V	20.0	.15	--	26.0	.22	--	CONC FAILED
12-3	MAG	5.49	SB-6	DYN	V	24.0	.20	7.8	24.0	.25	8.1	BOLT FAILED
12-4	MAG	5.87	SH-6	DYN	V	24.0	.30	7.8	24.0	.80	8.1	BOLT FAILED
12	REG	5.00	LB-5	STAT	V	17.0	.20	--	24.0	.70	--	BOLT SHEARED
12-3	REG	6.38	SB-6	DYN	V	20.1	.13	7.8	23.4	.25	101	BOLT SHEARED
12	SS	6.40	LB-6	STAT	V	18.8	.17	--	22.0	1.20	--	PULLOUT
12-13	REG	5.90	SB-5	STAT	V	16.0	.10	--	21.0	.17	--	BOLT SHEARED

TABLE OF DATA SORTED BY TEST TYPE AND ULTIMATE LOAD (PU), IN THAT ORDER CONT.

SHEAR TESTS CONT.

SPEC NUMB	CONC TYPE	F _{IC} KSI	BOLT TYPE	TEST TYPE	P1 KIP	D1 IN	DELTA KC	PU KIP	DU IN	DELTA KC	FAILURE MODE	
C2-4	REG	6.68	SA-6	DYN	V	20.1	.20	7.8	20.1	.25	18.7	BOLT SHEARED
7	REG	6.40	SB-5	DYN	V	20.0	.10	7.8	20.0	.20	9.2	BOLT SHEARED
209	REG	7.16	SA-5	DYN	V	19.2	.17	7.8	19.2	.45	17.9	BOLT SHEARED
C2-9	REG	6.77	SA-5	DYN	V	19.2	.30	7.8	19.2	.35	8.0	BOLT SHEARED
S2-3	SS	7.44	SB-6	DYN	V	18.4	.20	7.8	18.4	.40	36.4	PULLOUT
11	REG	---	SB-5	DYN	V	18.0	.22	7.8	18.0	--	10.2	BOLT SHEARED
13	REG	6.54	LB-6	DYN	V	17.8	1.10	7.8	17.8	--	19.8	BOLT FAILED
65	MAG	6.48	LB-6	DYN	V	17.4	.25	7.8	17.4	.35	39.6	BOLT FAILED
64	MAG	6.70	LB-6	DYNV	V	17.4	.27	7.8	17.4	1.25	26.9	BOLT FAILED
C2-12	REG	6.67	LB-5	STAT	V	16.0	.30	--	17.2	.40	--	BOLT SHEARED
C2-10	REG	6.40	SC-5	DYN	V	14.4	.15	7.8	14.4	.23	33.9	BOLT SHEARED
12	REG	5.50	LB-5	DYN	V	14.4	.35	7.8	14.4	.65	32.0	BOLT SHEARED
207	REG	4.50	LB-5	DYN	V	14.4	.20	7.8	14.4	.40	31.6	BOLT SHEARED
2-11	REG	6.64	SC-5	DYN	V	14.4	.25	7.8	14.4	.75	23.0	BOLT SHEARED
2-14	REG	6.22	LA-5	DYN	V	9.6	.15	7.8	9.6	.30	51.0	BOLT SHEARED
C2-15	REG	6.52	LA-5	DYN	V	9.6	.15	7.8	9.6	.25	39.0	BOLT SHEARED
75	REG	7.35	LB-6	DYN	V	17.8	.27	7.8	17.8	.80	27.5	BOLT FAILED
71	SS	6.45	LB-6	DYN	V	16.8	1.10	7.8	10.8	--	7.8	PULLOUT
S2-5	SS	7.23	SA-6	FAT	V	5.8	.05	--	5.8	.12	1500	FAILED STAT
210	REG	4.90	LB-5	STAT	V	19.0	.45	--	20.0	.70	--	BOLT SHEARED
70	SS	5.16	LB-6	DYN	V	10.8	.22	7.8	10.8	--	34	PULLOUT

OF DATA SORTED BY TEST TYPE AND ULTIMATE LOAD (PU.) IN THAT ORDER CONT.

COMBINED SHEAR AND TENSION TESTS

SPEC NUMB	CONC TYPE	F.C KSI	BOLT TYPE	TEST TYPE	P1 KIP	D1 IN	DELTA KC	PU KIP	DU IN	DELTA KC	FAILURE MODE	
52	MAG	--	SB-6	STAT	C	12.0	.02	--	15.4	.23	--	CONC FAILED
54	MAG	8.14	LB-6	STAT	C	5.8	.08	--	15.4	--	--	CONC FAILED
58	MAG	--	SB-6	DYN	C	8.0	.20	7.8	14.6	.24	104	CONC FAILED
30	REG	5.85	LB-6	STAT	C	8.4	.19	--	14.4	1.35	--	CONC FAILED
51	MAG	8.07	LB-6	STAT	C	7.2	.09	--	14.2	.93	--	CONC FAILED
81	REG	7.10	LA-6	STAT	C	9.0	.40	--	13.3	.55	---	PULLOUT
83	REG	6.86	SA-6	DYN	C	6.5	.25	7.8	13.2	.50	107	PULLOUT
17	REG	6.02	SB-8	STAT	C	10.0	.20	--	13.0	.25	--	CONC FAILED
80	REG	7.17	SB-6	STAT	C	9.0	.20	--	13.0	.30	--	PULLOUT
23	REG	7.14	SA-8	STAT	C	10.0	.20	--	12.6	.25	--	CONC FAILED
59	MAG	8.62	SA-6	DYN	C	8.2	.04	7.8	12.0	.08	102	CONC FAILED
27	REG	7.12	LA-6	STAT	C	11.0	.14	--	12.0	.16	--	CONC FAILED
1	REG	6.71	SB-6	DYN	C	6.5	.50	7.8	11.8	1.0	102	PULLOUT
21	REG	5.80	LB-5	STAT	C	6.4	.15	--	11.8	1.0	--	PULLOUT
20	REG	6.77	SA-8	DYN	C	8.0	.36	7.8	11.6	.57	102	CONC FAILED
35	REG	4.90	SB-5	STAT	C	11.6	.07	--	11.6	.10	--	CONC FAILED
46	REG	5.30	LB-5	STAT	C	8.0	.30	--	11.4	1.1	--	PULLOUT
55	MAG	--	SA-6	STAT	C	8.0	.15	--	11.4	.20	--	CONC FAILED
39	REG	6.11	LA-5	STAT	C	4.0	.10	--	11.2	.95	--	BOLT FAILED
215	SS	6.38	LB-6	STAT	C	8.6	.12	--	11.2	.41	--	CONC FAILED
61	SS	7.65	LB-6	STAT	C	9.6	.11	--	11.2	.94	--	CONC FAILED
62	SS	7.90	SB-6	STAT	C	6.0	.08	--	10.4	.17	--	BOLT FAILED
50	REG	6.22	SA-6	FAT	C	2.6	.01	--	10.3	.29	2005	CONC FAILED
213	SS	8.14	SA-6	DYN	C	6.0	.20	7.8	10.0	.43	71.8	BOLT FAILED
45	REG	6.10	SB-5	DYN	C	6.6	.10	7.8	9.6	.35	102	BOLT SHEARED

TABLE OF DATA SORTED BY TEST TYPE AND ULTIMATE LOAD (PU), IN THAT ORDER CONT.

COMBINED SHEAR AND TENSION TESTS CONT.

SPEC NUMB	CONC TYPE	F _{IC} KSI	BOLT TYPE	TEST TYPE	P1 KIP	D1 IN.	DELTA KC	PU KIP	DU IN.	DELTA KC	FAILURE MODE	
29	REG	6.52	SA-8	DYN	C	8.0	.14	7.8	8.0	.34	74	CONC FAILED
32	REG	7.01	LB-6	DYN	C	7.2	.32	7.8	7.2	--	63.3	BOLT SHEARED
28	REG	6.43	LB-6	DYN	C	7.2	.54	7.8	7.2	--	39.5	BOLT SHEARED
33	REG	5.00	LB-5	DYN	C	7.2	.15	7.8	7.2	.40	16.5	BOLT SHEARED
43	REG	5.70	LB-5	DYN	C	7.0	.05	7.2	7.0	.46	41	PULLOUT
36	REG	6.30	SA-5	DYN	C	6.6	.15	7.8	6.6	.45	37.0	PULLOUT
18	REG	6.70	SC-5	DYN	C	6.6	.27	7.8	6.6	--	28.0	PULLOUT
24	REG	6.50	SA-5	DYN	C	6.6	.09	7.8	6.6	.10	22.0	PULLOUT
10	REG	5.80	SB-5	DYN	C	6.6	.07	7.8	6.6	--	17.9	BOLT SHEARED
4	REG	6.20	SC-5	DYN	C	6.6	.05	7.8	6.6	.07	15.6	PULLOUT
34	REG	5.92	LA-5	DYN	C	6.6	.07	7.8	6.6	.07	7.8	PULLOUT
44	REG	6.61	LA-5	DYN	C	6.6	.07	7.8	6.6	.07	7.8	PULLOUT
56	MAG	8.07	LB-6	DYN	C	6.4	.07	7.8	6.4	--	67	PULLOUT
6	SS	6.86	LB-6	DYN	C	6.4	.14	7.8	6.40	--	7.9	PULLOUT
14	SS	8.77	LB-6	DYN	C	6.3	.11	7.8	6.25	--	44.6	STUD SHEARED
53	MAG	7.90	LB-6	DYN	C	6.4	.09	7.8	6.2	--	95.5	BOLT SHEARED
219	SS	8.53	SA-6	DYN	C	6.1	.17	7.8	6.1	.26	84.0	BOLT FAILED
217	SS	8.09	SA-6	FAT	C	2.0	.02	--	6.0	.35	2006	BOLT SHEARED
25	REG	--	SB-5	STAT	C	6.8	.12	--	10.6	.43	--	CONC FAILED
26	REG	--	LB-6	STAT	C	6.0	.15	--	10.4	--	--	CONC FAILED