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PRESTRES USER'S GUIDE

BETA VERSION

PRESTRESSED CONCRETE BEAM DESIGN AND ANALYSIS

by

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PREFACE

The purpose of this report is to present technical information. The information contained in this report is technical in nature. It does not represent the policy of the Naval Civil Engineering Laboratory, the Naval Facilities Engineering Command, the Assistant Commander of Engineering and Design, or the Director of Engineering System Division. It is one of a series designed to provide technical information and documentation for studies conducted in support of the Naval Facilities Engineering Command Graphics Engineering and Mapping System, Engineering Microcomputer Graphics, Computer-Aided Design, Cost Engineering System, and Guide Specifications System as they relate to the Naval Facilities System and life cycle facilities management.

CONTENTS

INTRODUCTION

PRESTRES is a prestressed concrete beam design and analysis program for simply supported beams. The program has been tailored for highway bridge girders; however, with modifications, it can be used to design piers and buildings. The American Association of State Highway and Transportation Officials (AASHTO) and the Prestressed Concrete Institute (PCI) standard bridge beams and design procedures are currently used in the program.

CAPABILITIES

PRESTRES is a simple beam design program for highway bridge girders (Ref 1). The beam cross sections are limited to the three AASHTO-PCI shapes. The loading conditions are limited to the AASHTO standard truck and lane loading with optional overload conditions (Ref 2). The program computes the compression and tension bending stress for the extreme fibers of the beam. The prestressing force and maximum and minimum eccentricity at each of 20 equally spaced sections along the beam are determined. Additional tension and shear reinforcement steel requirements are also determined.

SOLUTION METHOD

The AASHTO-PCI standard bridge beams are used in the program. These include the six I-beams, eight box beams, and the eight slab beams. The cross-section dimensions for these beams are shown in Figure 1. The basic section properties for these sections are part of the program, so the user does not have to be concerned with these details. The prestressing strands have been arranged for each of the cross sections.

The prestressing strand arrangement is based upon geometric constraints and manufacturing procedures of a typical manufacturing plant. The clearances between strands and exterior surfaces have been defined. The bottom-most row is filled with strands before starting a new row. The prestressing force and the eccentricity of the strand group centroid with respect to the centroidal axis of the cross section are determined without user direction. This information is placed in a table of prestressing forces and associated eccentricities for each cross-section type.

The girder may be designed to include the effects of composite section properties. When designed in this manner, the shoring in the actual structure must not be removed until the supported elements have developed the design properties required in the analysis. The effective depth of the slab, total depth less the wearing surface, and the effective flange width (AASHTO Section 1.7.99), defined as the minimum of: (1) one-fourth of the beam span length, (2) the center-to-center distance between the girders, and (3) twelve times the slab minimum thickness, are used in the computation of the composite section properties.

The live and dead load are considered in the selection of the member size. The live load may be selected from any of the standard AASHTO highway loadings: H10-44, H15-44, H20-44, HS15-44, and HS20-44. The truck and lane loads associated with these designations are shown in Figure 2. A military loading, consisting of two 24-kip loads separated by 4 feet, or a load factor applied to the HS20-44 load, can be used to create heavier loads. The program calculates the effects of these moving loads by using superposition.

The moment and shear diagrams are computed as the load moves across the structure. Manual methods use the influence diagram (line) concept, which computes the reaction, shear, or bending moment values at one particular point along the beam length for a unit concentrated load moving across the beam. The method used in the program computes, at each of 21 equally spaced locations along the length of the beam, the maximum shear and bending moment that occurs as the load moves across the structure. When added to the uniform dead load moment and shear values, the maximum moment and shear envelope for the entire length of the member is known.

AASHTO design factors are applied to the shear and moment values. The impact factor (AASHTO Section 1.2.12) is applied to account for dynamic effects of moving loads. Lateral distribution of wheel loads to interior beams (AASHTO Section 1.3.1) is considered. Finally, the distribution of the concentrated wheel loads for the standard trucks shown in Figure 2 is accomplished.

The moment and shear quantities for the right-hand side of the member are compared to their respective quantities on the left-hand side of the member. Symmetric moment and shear diagrams are obtained by using the largest value found at each of the respective equally spaced locations in the right and left half of the beam.

The allowable stress design method is used to select the prestressing force and eccentricity values for the specified service loads. Allowable stress values for flexure are defined for the transfer condition when the prestressing force is transferred from the jacking system to the beam, and after the prestressing force has reduced due to losses. The flexural stress, composed of the axial prestressing force stress, the prestressing force eccentricity bending stress, and the bending stress induced by the service load moment, are compared to the allowable stress values.. The minimum prestressing force and associated eccentricity are selected when the allowable stress constraints have been satisfied. If the table of prestressing forces is exhausted before the stress constraints are satisfied, a larger section will be tried.

The maximum and minimum eccentricities at each of the 21 equally spaced locations along the length of the beam are determined. The allowable stress constraints will be satisfied as long as the centroid of the prestressing strand group is located within these limits. These limits can be used to locate hold-down points to cause the prestressing strands to be draped so the group centroid will remain within the limits. The hold-down points are symmetrically located with respect to the center of the beam.

The ultimate moment criteria (AASHTO Sections 1.6.5.E and 1.6.10) are evaluated. The percentage of prestressing steel can be increased or a new section can be tried if this criteria is exceeded.

Nonprestresssed tension reinforcement may be required at transfer. This requirement is based upon exceeding allowed tension criteria (AASHTO Section 1.6.7.B.1). The area of steel required to reinforce the top fibers of the beam during the transfer condition is determined. The detailer selects the actual bar size and length.

Diagonal tension stress reinforcement or shear reinforcement placed perpendicular to the axis of the member is determined (AASHTO Section 1.6.13). The shear reinforcement for the web and additional stirrup steel required in the end block is determined.

Deflection is computed for the dead loads. The deflection that occurs at transfer, and the deflection after the placement of the slab is determined.

PROBLEM DATA PREPARATION INSTRUCTIONS

A prestressed beam may be designed by providing the following data:

Line Type A: Problem Identification

Column	Variable	Description
1 - 40	HEAD1	Project title
41 - 60	HEAD2	Project engineer
61 - 72	HEAD3	Date

Line Type B: Design Control

Column	Variable	Description
1 - 5	NAMBEM	AASHTO section designator
6 - 10	DESIGN	PRE or POST tension design.
11 - 15	ICOMP	Design for a beam and slab composite section for one of the following loading conditions: LIVE load, DEAD load, or NO load.
16 - 20	TENZRO	Design for zero tension bending stress: YES or NO
21 - 25	INVEST	Design investigation, known prestressing force and eccentricity: YES or NO

Line Type C: Geometry

Column	Variable	Description
1 - 10	SPAN	Beam span (ft)
11 - 20	BSPACE	Distance between beams (ft)

21 - 30	TSLAB	Total slab depth (in)
31 - 40	WEAR	Wearing surface thickness (in)
41 - 50	CAMBER	Additional concrete added to the slab to reduce the effects of camber caused by prestressing (in).
51 - 60	ADLOAD	Additional uniform dead load (lb/ft)

Line Type D: Concrete and Steel

Column	Variable	Description
1 - 10	FPCPRS	Prestressed concrete compressive strength (ksi)
11 - 20	FPCI	Concrete compressive strength at transfer (ksi)
21 - 30	FPCSLB	Slab concrete compressive strength (ksi)
31 - 40	ALPHA	Prestressing force ratio, the transfer force divided by the after losses force usually about 1.11.
41 - 50	FPY	Reinforcing steel yield strength (ksi)
51 - 55	IBAR	Additional tension and shear reinforcing steel bar size number.

Line Type E: Loading

Column	Variable	Description
1 - 5	ITRUCK	AASHTO truck loading: HS20, HS15, H20, H15, H10
6 - 10	MILLOD	Military lane loading: YES or NO
11 - 20	LODFAC	Load factor to increase HS20 loading.

Line Type F: Prestressing Conditions for Design Investigation

Column	Variable	Description
1 - 10	F	Known prestressing force (lb)
11 - 20	E	Known hold-down point eccentricity (in).

EXECUTION INSTRUCTIONS

The program is designed to run on an IBM PC compatible personal computer having at least 512K memory and a math coprocessor. There are a number of ways to execute these programs, and each will be discussed.

Installation

The PRESTRES program is on a single diskette. The diskette contains:

PRESTRES.EXE	The executable program
TEST.DAT	The example problem (Ref 3) in the appendix

These files should be copied to the hard disk or to another floppy disk before the program is used. The standard DOS COPY Command can be used:

```
COPY A:*.* C:   For the hard disk
COPY A:*.* B:   For the floppy disk
```

The program is now ready to run using one of the methods described below.

Standard Execution

The standard way of executing the program involves preparing an input file and running the program with the print output going to a file. The program assumes the input data are contained in the file PRESTRES.DAT. The data can be prepared using any line or screen editor program, such as the DOS EDLIN editor. The user should prepare this file using the PRESTRES.DAT file name, or the input can be prepared by using any file name, and then copying the prepared file to PRESTRES.DAT by using the standard DOS COPY Command. The program will write the output to PRESTRES.OUT. The PRESTRES.OUT file can be printed using the standard DOS PRINT Command.

The program PRESTRES.EXE is executed by typing:

```
PRESTRES
```

Output Redirection

The user can use the DOS SET Command to redirect the input and output. The default input, output, and plot file names can be changed by:

```
SET PRESTRES.DAT= your input file name
SET PRESTRES.OUT= your output file name
```

Then the program can be run by the PRESTRES command. CAUTION! The DOS redirection mechanism is active for the duration of the run of the program. The SET Command stays set until the connection is broken in the following manner or through a system reboot:

```
SET PRESTRES.DAT=
SET PRESTRES.OUT=
```

Batch File Execution

The programs can be run with a batch file. For example, the batch file might be called RUNPCB.BAT, and it would contain:

```
SET PRESTRES.DAT=%1.DAT
SET PRESTRES.OUT=LPT1
PRESTRES
SET PRESTRES.DAT=
SET PRESTRES.OUT=
```

The program would then be executed by the command:

```
RUNPCB   <your data file name>
```

The data file name should be typed without the assumed DAT extension.

REFERENCES

1. F.R. Johnson. "An interactive design algorithm for prestressed concrete girders," Computers and Structures, Great Britain, vol 2, Dec 1972, pp 1075-1088.

2. American Association of State Highway and Transportation Officials. Standard specifications for highway bridges, Ninth Edition, 1965. Washington, DC, 1966.

3. H.K. Preston and N.J. Sollenberger. Modern prestressed concrete, New York, NY., McGraw Hill, 1967.

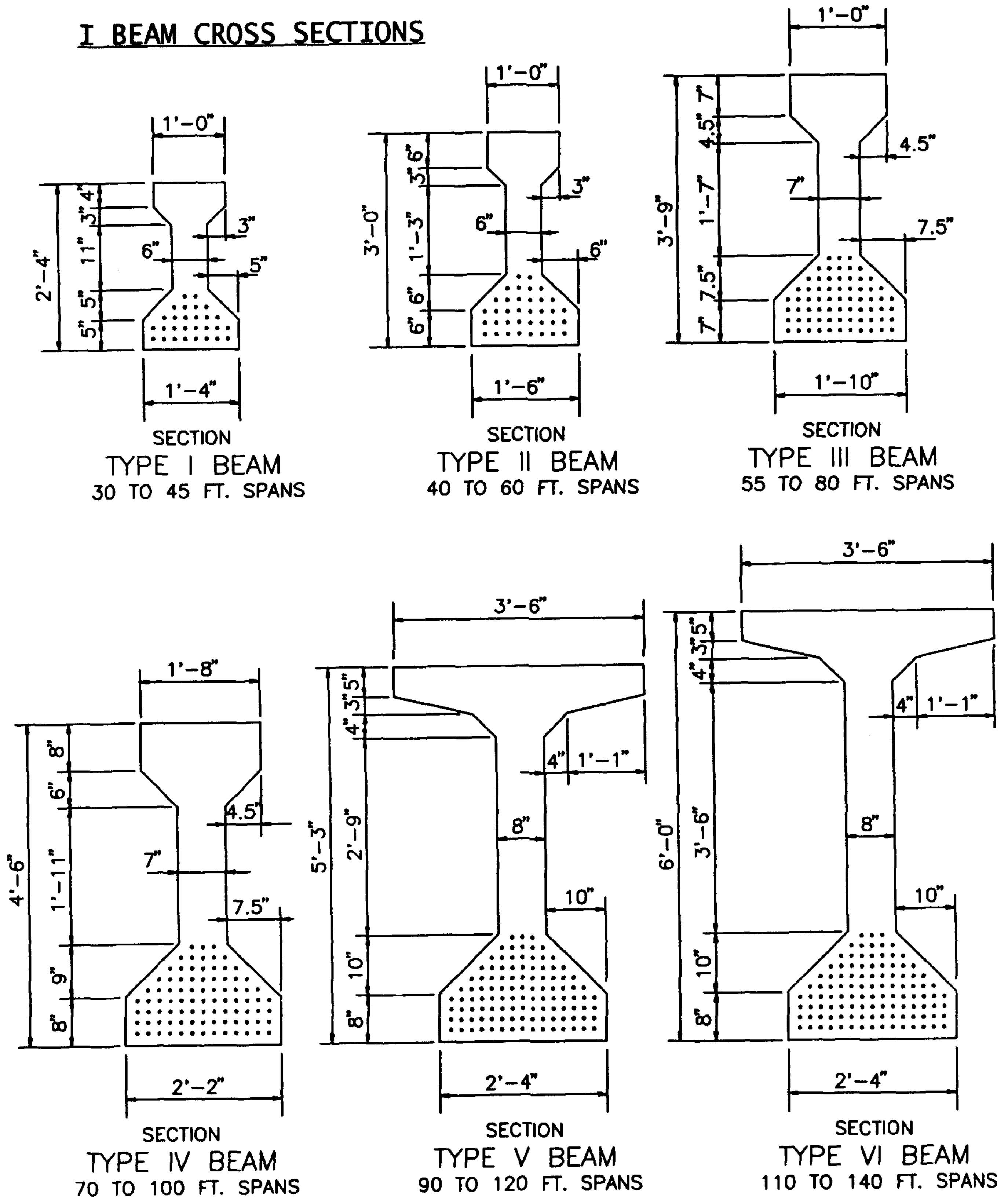

Figure 1. AASHTO-PCl standard bridge beams.

BOX BEAM CROSS SECTIONS

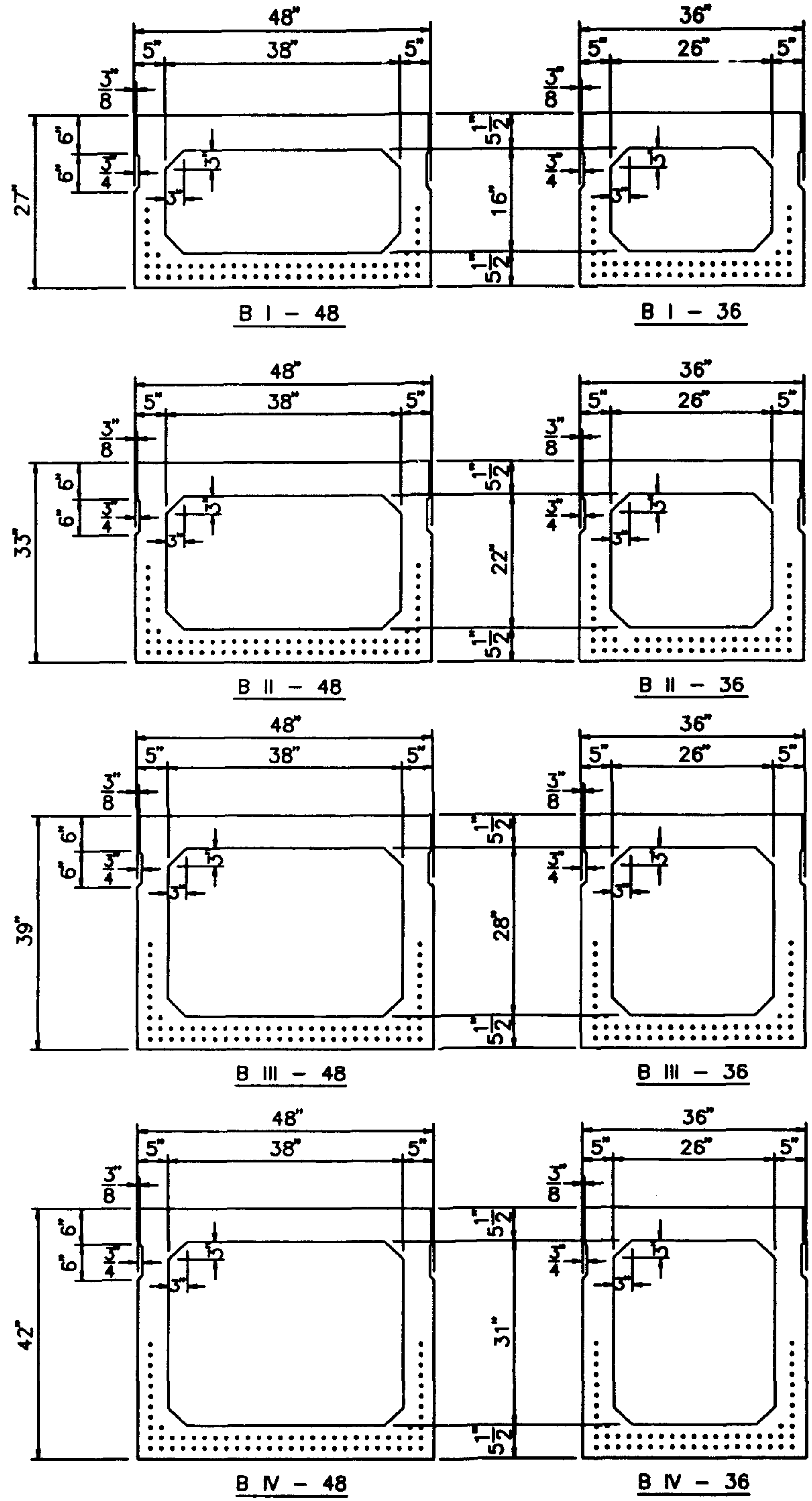

Figure 1. Continued

SLAB BEAM CROSS SECTIONS

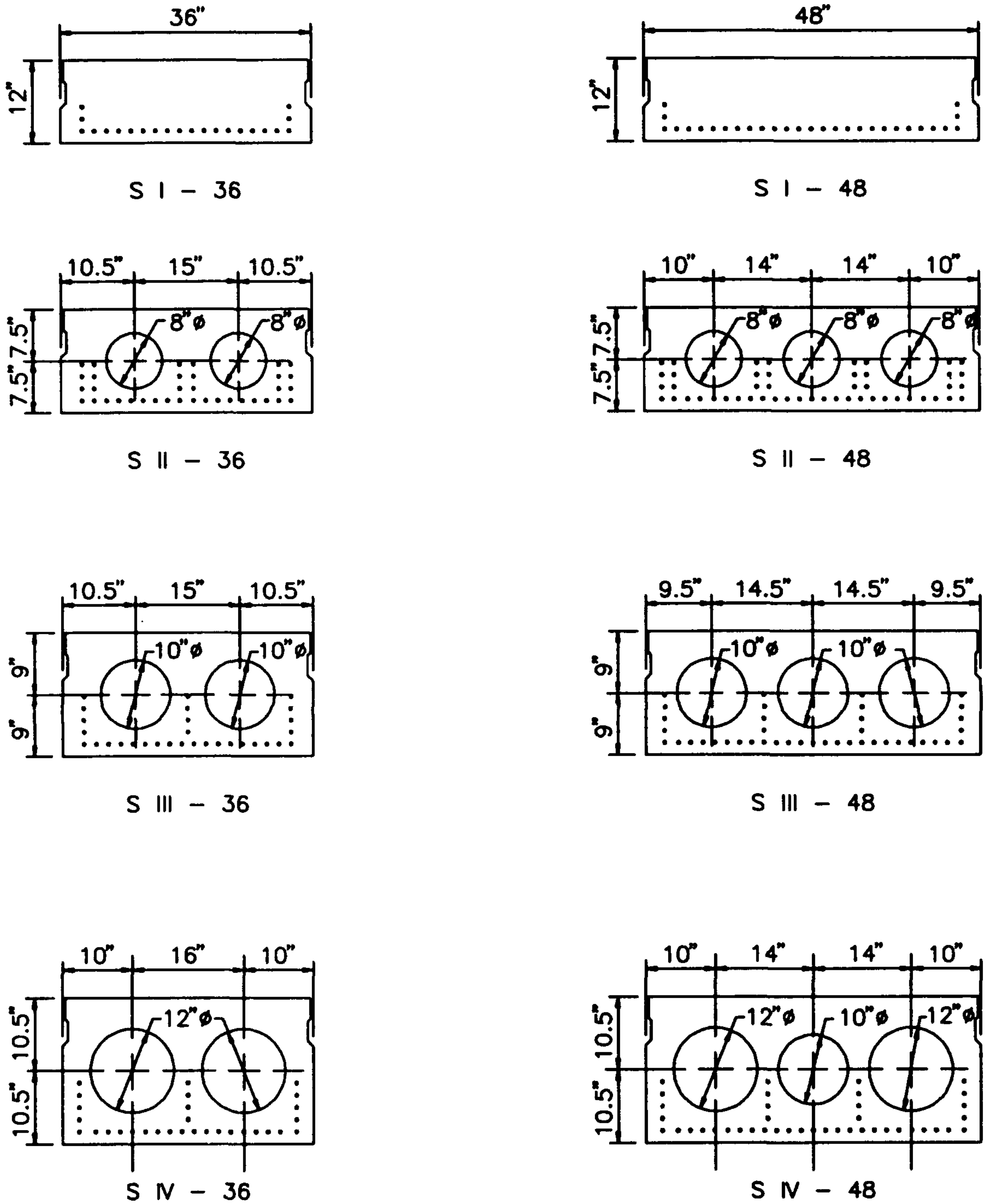

Figure 1. Continued

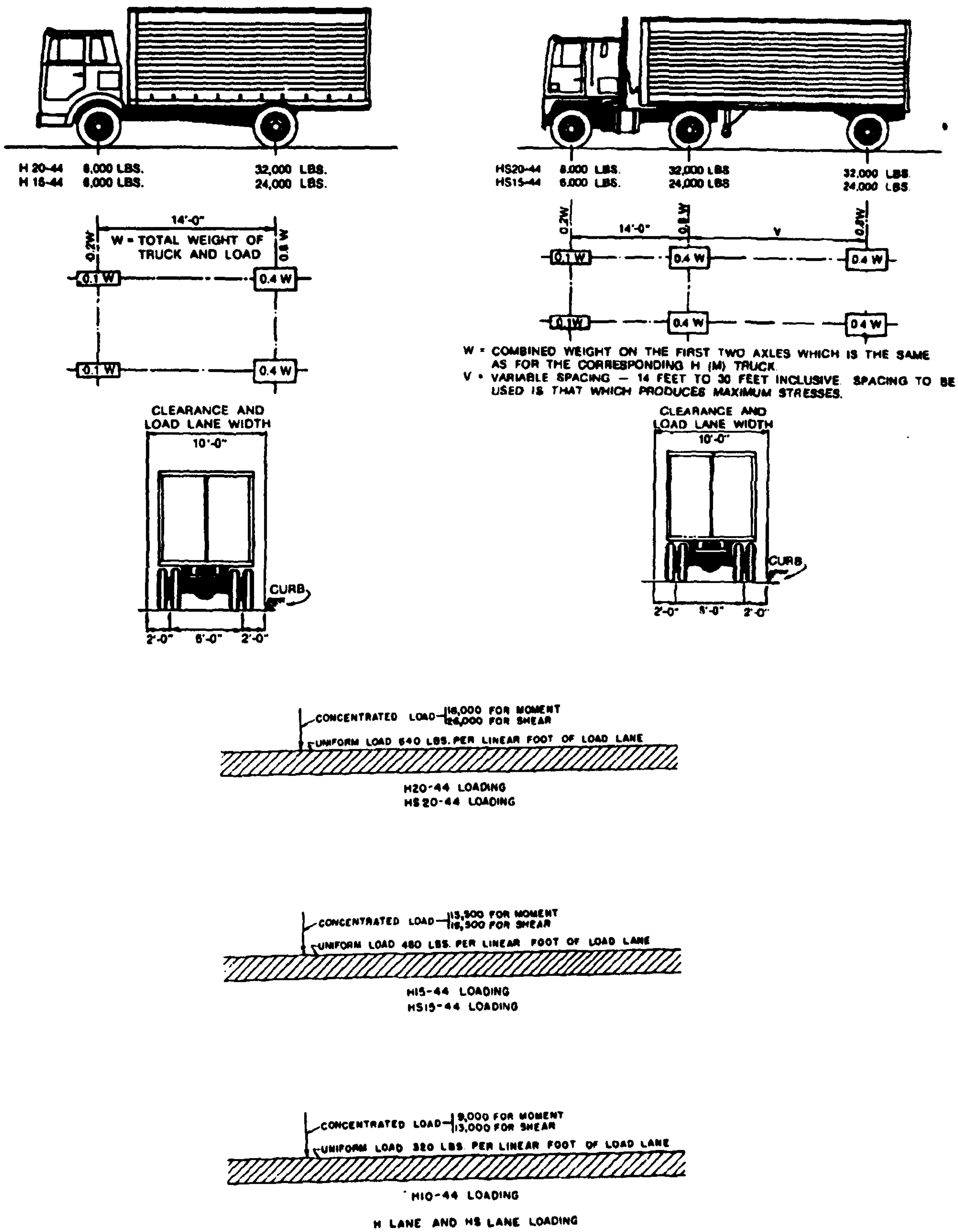

Figure 2. AASHTO highway loading (Ref 1).

APPENDIX A

EXAMPLE PROBLEM

Data Input File

```
LINE |                                    COLUMN
TYPE |         1         2         3         4         5         6         7
     |1234567890123456789012345678901234567890123456789012345678901234567890
-----+----------------------------------------------------------------------
  A  |PRESTON AASHTO BRIDGE PROBLEM, PAGE 51  FRANK JOHNSON       MAY 1970
  B  |I3   PRE  LIVE NO   NO
  C  |80.0      5.5       8.0       1.0       0.0       0.
  D  |5.0       4.0       3.85      1.11      40.0          4
  E  |HS20 YES  0.
```

PRESTRESSED GIRDER DESIGN AND ANALYSIS FOR HIGHWAY BRIDGES
VERSION 1970

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ENGINEER FRANK JOHNSON
DATE MAY 1970

PRE-TENSIONED DESIGN PARAMETERS

DIMENSIONS	
SPAN CENTER-TO-CENTER DISTANCE	80.00 FT
GIRDER SPACING C. TO C.	5.50 FT
DIAPHRAM DEPTH	2.54 FT
TOTAL SLAB THCKNESS	8.00 IN
DEPTH OF WEARING SURFACE	1.00 IN
DEPTH OF CAMBER FILLER	0.00 IN
WEIGHT OF FUTURE WEARING SURFACE	15.00 LB/FT**2
PRESTRESSING STRANDS	7/16 IN, 270K
28-DAY COMPRESSIVE STRENGTH	
PRECAST PRESTRESSED GIRDER	5000.00 PSI
POURED-IN-PLACE SLAB	3850.00 PSI
STRENGTH OF CONCRETE AT TRANSFER	4000.00 PSI
WEIGHT OF CONCRETE	150.00 LB/FT**3
CONVENTIONAL REINFORCING STEEL YIELD POINT	40000.00 PSI
ADDITIONAL UNIFORM DEAD LOAD	0.00 LB/FT
PRESTRESSING FORCE RATIO	1.11

SECTION PROPERTIES ** AASHO-PCI BEAM TYPE 13

AREA	560.00 IN**2
TOP FIBER TO C.G.C.	-24.73 IN
BOTTOM FIBER TO C.G.C.	20.27 IN
MOMENT OF INERTIA	125390.00 IN**4
TOP SECTION MODULAS	-5070.36 IN**3
BOTTOM SECTION MODULAS	6185.99 IN**3
WEIGHT OF SECTION	583.33 LB/FT

LIVE LOAD COMPOSITE SECTION PROPERTIES

AREA	965.40 IN**2
TOP FIBER TO C.G.C.	-19.88 IN
BOTTOM FIBER TO C.G.C.	32.12 IN
MOMENT OF INERTIA	314453.50 IN**4
TOP SECTION MODULAS	-15821.30 IN**3
BOTTOM SECTION MODULAS	9788.54 IN**3
WEIGHT OF SECTION	1133.33 LB/FT

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MAXIMUM SHEAR AND MOMENT ENVELOPE TABLE

LOADING PATTERN CODES
1 HS20 STANDARD TRUCK LOADING
2 HS20 LANE LOADING
3 AASHO MILITARY LOADING

NODE	DEAD LOAD SHEAR (KIP)	DEAD LOAD MOMENT (KIP FT)	LIVE LOAD SHEAR (KIP)	LIVE LOAD MOMENT (KIP FT)	TOTAL LOAD SHEAR (KIP)	TOTAL LOAD MOMENT (KIP FT)	LOADING PATTERN
0	48	0	63	0	112	0	1
1	43	189	60	240	103	429	1
2	38	359	56	451	95	810	1
3	34	509	52	633	86	1142	1
4	29	638	49	787	78	1426	1
5	24	748	45	912	69	1660	1
6	19	838	42	1008	61	1846	1
7	14	908	38	1075	53	1983	1
8	9	958	34	1113	44	2071	1
9	4	988	31	1128	36	2116	1
10	0	998	27	1152	27	2150	1
11	-4	988	-25	1147	-30	2135	1
12	-9	958	-29	1113	-38	2071	1
13	-14	908	-32	1051	-47	1959	1
14	-19	838	-36	969	-55	1808	1
15	-24	748	-40	864	-64	1612	1
16	-29	638	-43	729	-72	1368	1
17	-34	509	-47	566	-81	1075	1
18	-38	359	-50	403	-89	762	1
19	-43	189	-53	214	-97	404	1
20	-48	0	-56	0	-105	0	1

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DATE MAY 1970

MAXIMUM SHEAR AND MOMENT TABLE WITH AASHO LIVE LOAD FACTORS APPLIED

LIVE LOAD FACTORS

IMPACT	1.24
LATERAL DISTRIBUTION	1.00

NODE	DEAD LOAD		LIVE LOAD		TOTAL LOAD	
	SHEAR (KIP)	MOMENT (KIP FT)	SHEAR (KIP)	MOMENT (KIP FT)	SHEAR (KIP)	MOMENT (KIP FT)
0	48	0	39	0	88	0
1	43	189	37	149	81	338
2	38	359	35	280	74	639
3	34	509	32	394	66	903
4	29	638	30	489	59	1128
5	24	748	28	567	52	1315
6	19	838	26	626	45	1465
7	14	908	23	668	38	1577
8	9	958	21	692	31	1650
9	4	988	19	701	24	1689
10	0	998	17	716	17	1714
11	-4	988	-15	713	-20	1701
12	-9	958	-18	692	-27	1650
13	-14	908	-20	653	-35	1562
14	-19	838	-22	603	-42	1441
15	-24	748	-24	537	-49	1285
16	-29	638	-27	453	-56	1092
17	-34	509	-29	352	-63	861
18	-38	359	-31	250	-70	610
19	-43	189	-33	133	-77	323
20	-48	0	-35	0	-84	0

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CONCRETE STRESSES FOR HALF OF THE GIRDER ** PSI **

ALLOWABLE STRESSES (AASHO)

	TRANSFER	AFTER LOSSES
TENSION	189.74	212.13
WITH STANDARD REINFORCEMENT	474.34	212.13
COMPRESSION	-2400.00	-2000.00

EXTREME FIBER BEFORE PRESTRESSING

NODE	GIRDER TOP	GIRDER BOTTOM	SLAB TOP
0	0.00	0.00	0.00
1	-498.63	541.90	-107.69
2	-943.69	1024.06	-202.58
3	-1335.18	1446.49	-284.68
4	-1673.10	1809.17	-353.97
5	-1957.46	2112.12	-410.46
6	-2188.25	2355.32	-454.15
7	-2365.47	2538.79	-485.05
8	-2489.12	2662.52	-503.14
9	-2566.54	2744.81	-518.36
10	-2590.39	2767.36	-520.79

EXTREME FIBERS OF THE GIRDER AFTER PRESTRESSING

USE 33 STRANDS, F = 581.31 KIP, AT MID SPAN E = 16.52 IN

NODE	TRANSFER TOP	TRANSFER BOTTOM	AFTER LOSSES TOP	AFTER LOSSES BOTTOM	MINIMUM E (IN)
0	-2208.03	-286.85	-1989.22	-258.42	-8.30
1	-1861.12	-571.20	-1986.26	-127.65	-3.92
2	-1555.75	-821.50	-1987.06	-9.63	-0.05
3	-1291.91	-1037.75	-1991.61	95.64	3.33
4	-1069.62	-1219.95	-1999.92	188.16	6.20
5	-809.33	-1433.30	-1940.33	209.19	9.20
6	-574.68	-1625.63	-1870.17	205.72	11.83
7	-397.47	-1770.88	-1818.09	201.24	13.83
8	-293.62	-1856.00	-1798.44	207.51	15.08
9	-215.40	-1920.12	-1775.54	207.57	15.95
10	-194.63	-1937.14	-1770.73	206.63	16.20

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EXTREME FIBERS OF THE GIRDER AFTER PRESTRESSING - CONTINUED

NODE	TRANSFER		AFTER LOSSES		MAXIMUM E
	TOP	BOTTOM	TOP	BOTTOM	(IN)
0	-4.35	-2093.10	-3.92	-1885.68	9.02
1	183.49	-2247.06	-144.27	-1637.44	12.15
2	186.62	-2249.63	-417.36	-1296.23	13.65
3	180.02	-2244.23	-665.54	-991.27	14.90
4	179.61	-2243.89	-874.49	-734.31	16.02
5	121.75	-2196.46	-1101.52	-478.35	16.52
6	22.35	-2114.99	-1332.31	-235.14	16.52
7	-54.96	-2051.62	-1509.53	-51.67	16.52
8	-110.19	-2006.36	-1633.18	72.06	16.52
9	-143.32	-1979.20	-1710.60	154.34	16.52
10	-154.36	-1970.14	-1734.45	176.89	16.52

ULTIMATE FLEXURAL STRENGTH

ULTIMATE MOMENT	3288.32 KIP FT
ALLOWED ULTIMATE MOMENT	3832.63 KIP FT

STRAND CENTROID DRAPE

NODE	TRANSFER		AFTER LOSSES		DRAPE
	TOP	BOTTOM	TOP	BOTTOM	(IN)
0	-4.35	-2093.10	-3.92	-1885.68	9.02
1	-94.90	-2018.89	-395.07	-1431.87	9.96
2	-163.35	-1962.78	-732.65	-1037.81	10.90
3	-209.71	-1924.78	-1016.65	-703.48	11.83
4	-233.98	-1904.88	-1247.10	-428.90	12.77
5	-236.17	-1903.09	-1423.97	-214.05	13.71
6	-216.26	-1919.41	-1547.27	-58.94	14.65
7	-174.27	-1953.83	-1617.01	36.43	15.58
8	-110.19	-2006.36	-1633.18	72.06	16.52
9	-143.32	-1979.20	-1710.60	154.34	16.52
10	-154.36	-1970.14	-1734.45	176.89	16.52

LOCATION FROM LEFT END OF THE HOLD POINTS

NODE	DISTANCE (FT)
8	32.00

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PRE-TENSIONED DESIGN PARAMETERS

DIMENSIONS	
SPAN CENTER-TO-CENTER DISTANCE	80.00 FT
GIRDER SPACING C. TO C.	5.50 FT
DIAPHRAM DEPTH	2.54 FT
TOTAL SLAB THCKNESS	8.00 IN
DEPTH OF WEARING SURFACE	1.00 IN
DEPTH OF CAMBER FILLER	5000.00 IN
WEIGHT OF FUTURE WEARING SURFACE	15.00 LB/FT**2
PRESTRESSING STRANDS	7/16 IN, 270K
28-DAY COMPRESSIVE STRENGTH	
PRECAST PRESTRESSED GIRDER	3850.00 PSI
POURED-IN-PLACE SLAB	4000.00 PSI
STRENGTH OF CONCRETE AT TRANSFER	
CONVENTIONAL REINFORCING STEEL YIELD POINT	40000.00 PSI
ADDITIONAL UNIFORM DEAD LOAD	0.00 LB/FT
PRESTRESSING FORCE RATIO	
LOADING	HS20 MILITARY

USE AASHO-PCI BEAM TYPE I3

STRAND DESIGN

PRESTRESSING FORCE AT TRANSFER	645.25 KIP
PRESTRESSING FORCE AFTER LOSSES	581.31 KIP
PRESTRESSING FORCE RATIO	1.11

USE 33 STRANDS

STRAND PATH

	DISTANCE (FT)	ECCENTRICITY (IN)
END	0.0	9.02
HOLD DOWN	32.00	16.52
CENTER	40.00	16.52

SHEAR REINFORCEMENT

USE NO. 4 STIRRUPS AT MAXIMUM SPACING 21.80 IN FOR FULL LENGTH OF THE GIRDER. EXTEND BARS INTO POURED-IN-PLACE SLAB FOR VERTICAL TIES WHEN DESIGNING COMPOSITE SECTIONS.

PROVIDE 1.29 IN**2 ADDITIONAL STIRRUP STEEL WITHIN 10.19 IN. OF THE MEMBER END.

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DEAD LOAD DEFLECTIONS AT MID SPAN

AT TRANSFER	-1.24 IN
AFTER PLACEMENT OF THE SLAB	-0.54 IN

DEPARTMENT OF THE NAVY

Naval Civil Engineering Laboratory
Port Hueneme, CA 93043-5003

Official Business
Penalty for Private Use, $300

NO POSTAGE
NECESSARY
IF MAILED
IN THE
UNITED STATES

BUSINESS REPLY CARD

FIRST CLASS PERMIT NO. 69

POSTAGE WILL BE PAID BY ADDRESSE

Commanding Officer
Code L54 (NAVFAC GEMS Support Group)
Naval Civil Engineering Laboratory
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PRESTRES BETA VERSION

FEEDBACK REPORT

The Naval Civil Engineering Laboratory is fully dedicated to supporting GEMS users. A primary requirement for this task is to establish a priority listing of user requirements. It would be of great value to the development of new software if you, the user, would complete the feedback questions below. Since each individual user may have specific requirements, please reproduce this page as many times as necessary.

Please circle the number that best applies in questions 1 through 4, complete the other questions, fold at tic marks, and mail to NCEL with franked label on reverse side or to address at bottom of page.

1. Was the software beneficial (productive)?

   No benefit 0 1 2 3 4 5 6 7 8 9 10 Very beneficial

2. Was it easy to use (user friendly)?

   Difficult 0 1 2 3 4 5 6 7 8 9 10 Very easy

3. Does this software make decisions more reliable?

   No 0 1 2 3 4 5 6 7 8 9 10 Yes

4. Does it better document the design?

   No 0 1 2 3 4 5 6 7 8 9 10 Yes

5. Did it save time?

   Yes_____ No_____ Estimated percent saved_____

6. What would make future software more user friendly?

7. What further support would you like to have on the GEMS system?

8. What other comments or remarks would you like to add?

Activity____

Telephone____

Mail address is:

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