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USER'S MANUAL FOR PROGRAM MENVLP

COMPUTER PROGRAM TO PRODUCE MOMENT ENVELOPES
FOR ARBITRARY SETS OF WHEEL LOADS

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July 1975

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1. Introduction

In certain structural analysis problems, and more specifically, in bridge superstructures, it becomes necessary to find the maximum moment envelope that can be generated by a given set of loads. One of the primary applications of this concept has been the overload analysis of simple span beam-slab type highway bridges where the vehicle traverses the bridge over a given traffic lane for a number of times. One of the approaches in a problem of this nature in the determination of the most unfavorable loading condition has been the placement of the vehicle at a location which will produce the worst flexural response (Refs. 1, 2). Another approach that can be employed is to determine the maximum moment envelope that will develop as a result of the traverse of the vehicle and to determine the equivalent nodal forces, if the finite element scheme is used, and analyze the superstructure for the given loading condition.

The program described herein determines the maximum moment envelope for simple span bridges treated as simple beams. Input for the program is accomplished via the data cards. The output is provided in the form of printout. Depending upon the needs of the computer program that will employ the developed moment envelope, the new set of data needs to be prepared manually from the provided output.
2. **Input**

First Card, FORMAT(I5)
Contains NTIMES, the number of separate analyses to be conducted with different vehicles.

Second Card, FORMAT(I5)
Contains NL, the number of wheel groups. Should be less than or equal to 20.

Third Card(s), FORMAT(8F10.0)
Contains TL, the values of the loads for each wheel group.

Fourth Card(s), FORMAT(8F10.0)
Contains TP, the relative distance between each wheel group. The front wheel has the value of 0.0. The subsequent distances between the other wheel groups are to be entered with their appropriate numerical value. There are as many "distances" as the number of wheel groups.

Fifth Card, FORMAT(F10.0)
Contains BL, span length of the bridge.

Sixth Card, FORMAT(I5)
Contains NBM, the number of sections where moments will be computed. NBM should be less than or equal to 100.
Seventh Card, FORMAT(I5)

Contains NLP, the number of equally spaced positions where the vehicle will be located. The vehicle will be advanced until the rear wheel leaves the span.

If the problem under study requires the consideration of more than one vehicular configuration, up to NTIMES, the data described above as the "second card" through "seventh card" needs to be repeated NTIMES.

3. Output

The output of the program includes the following information:

(1) An echo print of the input information.
(2) Moment envelope at predefined points.
(3) Moment values, corresponding to the moment diagram with the largest moment, at predefined points. It should be noted that these values do not correspond to the moment envelope.
(4) Normalized moment envelope at predefined points. In obtaining the normalized envelope the largest moment is set equal to unity.
(5) Normalized moment values, corresponding to the moment diagram with the largest moment, at predefined points.
(6) Plots of the normalized moment envelope and the maximum moment diagrams (See Ref. 1). Section 6 of this report contains a sample output of the program.

4. Utilization of the Output

Either the maximum moment diagram or the maximum moment envelope can be used to find the vertical forces that can be applied to a bridge superstructure of the given span. If the analysis is to be based on the finite element approach, then the computed vertical forces correspond to the nodal forces that are to be applied to the superstructure. The slopes of the moment diagram curve segments between two node points, defining an element, correspond to the shear, i.e. $V=\frac{dM}{dx}$. By knowing the various "constant shear values" for the elements, the consistent set of nodal forces can then be determined. These forces can be used for the analysis of the superstructure.

5. References

1. Peterson, William S and Kostem, Celal N.


2. Peterson, William S. and Kostem, Celal N.

**6. Sample Output**

**Number of Different Vehicles, Ntimes = 1**

**Number of Wheel Loads, NL = 5**

<table>
<thead>
<tr>
<th>Wheel Loads</th>
<th>11,500</th>
<th>9,000</th>
<th>9,000</th>
<th>60,000</th>
<th>60,000</th>
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</table>

**Distance Between Adjacent Wheel Groups Are**

<table>
<thead>
<tr>
<th></th>
<th>100</th>
<th>16.167</th>
<th>5,000</th>
<th>32,000</th>
<th>4,030</th>
</tr>
</thead>
</table>

**Bridge Length, SL = 60.00**

**Number of Bridge Divisions at Which Moments Will Be Reported, NBM = 64**

**Number of Load Locations Across Bridge, NLP = 79**

**Max Envelope Value Is** \(1.6810162376476E+03\)

**Max 4-Girder Value Is** \(1.540162376476E+03\)

**Front Wheel Distance Is** \(8.124786714E+01\)

**Envelope**

<table>
<thead>
<tr>
<th>Number</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.035E+07</td>
</tr>
<tr>
<td>2</td>
<td>2.34E+02</td>
</tr>
<tr>
<td>3</td>
<td>1.447E+02</td>
</tr>
<tr>
<td>4</td>
<td>4.45E+02</td>
</tr>
<tr>
<td>5</td>
<td>3.43E+02</td>
</tr>
<tr>
<td>6</td>
<td>6.46E+02</td>
</tr>
<tr>
<td>7</td>
<td>7.36E+02</td>
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<tr>
<td>8</td>
<td>8.26E+02</td>
</tr>
<tr>
<td>9</td>
<td>9.09E+02</td>
</tr>
<tr>
<td>10</td>
<td>9.76E+02</td>
</tr>
</tbody>
</table>

**Maximum Moment Diagram**

<table>
<thead>
<tr>
<th>Number</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>5</td>
<td>5.94E+02</td>
</tr>
<tr>
<td>6</td>
<td>6.59E+02</td>
</tr>
<tr>
<td>7</td>
<td>7.12E+02</td>
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<tr>
<td>8</td>
<td>7.77E+02</td>
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<tr>
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<td>8.37E+02</td>
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<tr>
<td>10</td>
<td>8.97E+02</td>
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<tr>
<td>11</td>
<td>9.57E+02</td>
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<tr>
<td>12</td>
<td>1.01E+03</td>
</tr>
<tr>
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<td>1.13E+03</td>
</tr>
<tr>
<td>15</td>
<td>1.19E+03</td>
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</table>

**Normalized Plots**

**Envelope**

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<tr>
<td>6</td>
<td>6.79E+02</td>
</tr>
<tr>
<td>5</td>
<td>6.53E+02</td>
</tr>
<tr>
<td>4</td>
<td>6.27E+02</td>
</tr>
<tr>
<td>3</td>
<td>6.01E+02</td>
</tr>
<tr>
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<td>5.75E+02</td>
</tr>
<tr>
<td>1</td>
<td>5.50E+02</td>
</tr>
</tbody>
</table>

**Max. 4-Girder Value Is** \(1.4910162376476E+03\)

**Front Wheel Distance Is** \(8.124786714E+01\)
<table>
<thead>
<tr>
<th>X</th>
<th>Y</th>
<th>Z</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
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<tbody>
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<tr>
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<td>7.53E-01</td>
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<td>7.53E-01</td>
<td>8.59E-01</td>
<td>7.53E-01</td>
</tr>
</tbody>
</table>

MAXIMUM MOMENT DIAGRAM

<table>
<thead>
<tr>
<th>X</th>
<th>Y</th>
<th>Z</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
</tr>
</thead>
<tbody>
<tr>
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<td>7.12E+00</td>
<td>1.06E+00</td>
<td>4.20E+00</td>
<td>4.96E+00</td>
<td>5.43E+00</td>
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<td>7.47E+00</td>
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<tr>
<td>4.91E+00</td>
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<td>4.83E+00</td>
<td>5.39E+00</td>
<td>6.07E+00</td>
<td>6.76E+00</td>
<td>7.47E+00</td>
<td>8.19E+00</td>
<td>8.92E+00</td>
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<td>7.79E+00</td>
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<td>8.19E+00</td>
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<tr>
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<td>2.50E+00</td>
<td>2.14E+00</td>
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<td>7.15E+00</td>
<td>3.58E+00</td>
<td>3.58E+00</td>
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</tr>
</tbody>
</table>
7. Listing

PROGRAM HVELLOPE(INPUT,OUTPUT)
DIMENSION TL(20), TP(20), RM(100), TM(100), SM(100)

TEMPORARY IS TM
ENVELOPE IS RM
MAX M-DIAG IS SM

XL=5.
TX=0.
DX=.2
YL=5.
TY=0.
DY=.2
ITX=10*X-D-RATIO*
ITY=10*X-M-RATIO*
ITG=10*

CALL QIKSET(XL, TX, DX, YL, TY, DY)
CALL QIKPLT(0., 0., 1, ITX, ITY, ITG)
KS=-XL-1.
CALL PLOT(KS, 1.6, 3)

READ 130, NTIMES
PRINT 126, NTIMES

120 FORMAT(1H1,1X,*NUMBER OF DIFFERENT VEHICLES, NTIMES =*,13)
DO 360 ITIMES=1,NTIMES

READ 130, NL

130 FORMAT(1I6)
PRINT 140, NL

140 FORMAT(1H3,1H,*NUMBER OF WHEEL LOADS, NL =*,15,)

READ 150, (ITL(I), I=1,NL)
150 FORMAT(8F10.0)
PRINT 150, (ITL(I), I=1,NL)

160 FORMAT(1H5,*WHEEL LOADS ARE*,(/,10X,10(F8,3,2X)))

READ 150, (ITP(I), I=1,NL)
160 FORMAT(1H5,*WHEEL LOADS ARE*,(/,10X,10(F8,3,2X)))

PRINT 170, (ITP(I), I=1,NL)
170 FORMAT(1H5,*DISTANCE BETWEEN ADJACENT WHEEL GROUPS ARE*,(/,10X,11)

PRINT 190, BL

READ 150, NBM
READ 130, NLP
PRINT 190, BL, NBM, NLP

180 FORMAT(1H5,*BRIDGE LENGTH, 3L =*,8.2,1H,*NUMBER OF BRIDGE DIV

ATIONS AT WHICH MOMENTS WILL BE REPORTED, NBM =*,19,1H,* NUMBER

2F LOAD LOCATIONS ACROSS BRIDGE, NLP =*,15)

A=NBM
DXB=BL/A
SUM = 0.
DO 190 I = 1, NL
190 SUM = SUM + TP(I)
A = NLP
DXL = (BL + SUM) / A
DO 200 I = 1, NBM
RM(I) = 0,
TM(I) = 0,
SM(I) = 0.
200 CONTINUE
XL = 0.
DO 290 II = 1, NLP
290 COMPUTE REACTIONS
XL = XL + XL
SUM = 0.
KS = 0.
DO 210 I = 1, NL
SUM = SUM + TP(I)
IF ( (XL - SUM) .LE. 0. ) GO TO 225
IF ( (XL - SUM) .GE. PL ) GO TO 210
RS = RS * IL(I) * (bl - xl + SUM)
210 CONTINUE
225 RS = - RS / bl
230 CONTINUE
COMPUTE MOMENT AT POSITION XP
XP = 0.
DO 250 J = 1, NBM
XP = XP + X(J)
XM = RS * XP
SUM = 0.
DO 230 I = 1, ML
SUM = SUM + TP(I)
IF ( (XL - SUM) .LE. 0. ) GO TO 240
IF ( (XL - SUM) .GE. XP ) GO TO 230
XM = XM + IL(I) * (xp - xl + SUM)
230 CONTINUE
240 XM = XM
IF ( X(J) .LT. XM ) RM(J) = XM
TM(J) = XM
250 CONTINUE
FIND MAXIMUM MOMENT DIAMETER
A = 0.
SUM = 0.
DO 270 I = 1, NBM
IF ( TM(I) .GT. A ) A = TM(I)
IF ( SM(I) .GT. SUM ) SUM = SM(I)
270 CONTINUE
270 CONTINUE
   IF (A.LT.SUM) GO TO 290
   DO 280 I=1, NBM
   SM(I)=TM(I)
280 CONTINUE
   XLMAX=XL
290 CONTINUE
   A=0.
   SUM=0.
   DO 300 I=1, NBM
      IF (RM(I).GT.A) A=RM(I)
      IF (SM(I).GT.SUM) SUM=SM(I)
300 CONTINUE
   PRINT 310, A, SUM, XLMAX
310 FORMAT (1H0, 5X, *MAX ENVELOPE VALUE IS *E15.9, 6X, *MAX M-DIAG VALUE 1 IS *E15.9, 3) *FRONT WHEEL DISTANCE IS *E15.9)
   PRINT 320, (RM(I), I=1, NBM)
320 FORMAT (1H0, 5X, *ENVELOPE*, (/ , 11X, 10(E10,3,2X)))
   PRINT 330, (SM(I), I=1, NBM)
330 FORMAT (1H0, 5X, *MAXIMUM MOMENT DIAGRAM*, (/ , 10X, 10(E10,3,2X)))
   NORMALIZE
   PRINT 340
340 FORMAT (1H0, '/', , 1X, *NORMALIZED PLOTS*)
   XP=NB M
   DO 350 I=1, NBM
      PS=I
      RM(I)=RM(I)/A
      SM(I)=SM(I)/SUM
      TM(I)=PS/XP
350 CONTINUE
   PRINT 320, (RM(I), I=1, NBM)
   PRINT 330, (SM(I), I=1, NBM)
   CALL PLOT (0., 0., , 3)
   CALL QLINE (TM, SM, NBM, I)
   CALL PLOT (0., 0., , 3)
   CALL QLINE (TM, RM, NBM, I)
360 CONTINUE
   CALL ENG.PLT
   END