Influence Line - User Manual

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April 2014

1 Introduction

This program is intended as a preliminary design tool to determine the maximum design effect; bending moment, shear force, deflection etc., on any single line linear span configuration due to any vehicle or moving load pattern. The user is required to input the coordinates for the relevant influence line diagram together with dimensions and loads to define the load pattern.

The Units specified in the program are metres (m) and kilonewtons (kN). However, any units may be used providing they are consistent for all input. The output will be in those same Units.

It is expected that the user has a good understanding of the derivation and use of Influence Line diagrams for the span configurations under consideration and accepts full responsibility for using this software.

2 Influence Line

2.1 Definition

The influence line (I.L.) is defined by a user specified number of coordinates. These can be derived from first principles or from reference to the geometry for specific effect, location and span arrangement as shown in literature such as the Steel Designer's Manual; The Steel Construction Institute; ISBN 0-632-03877-2.

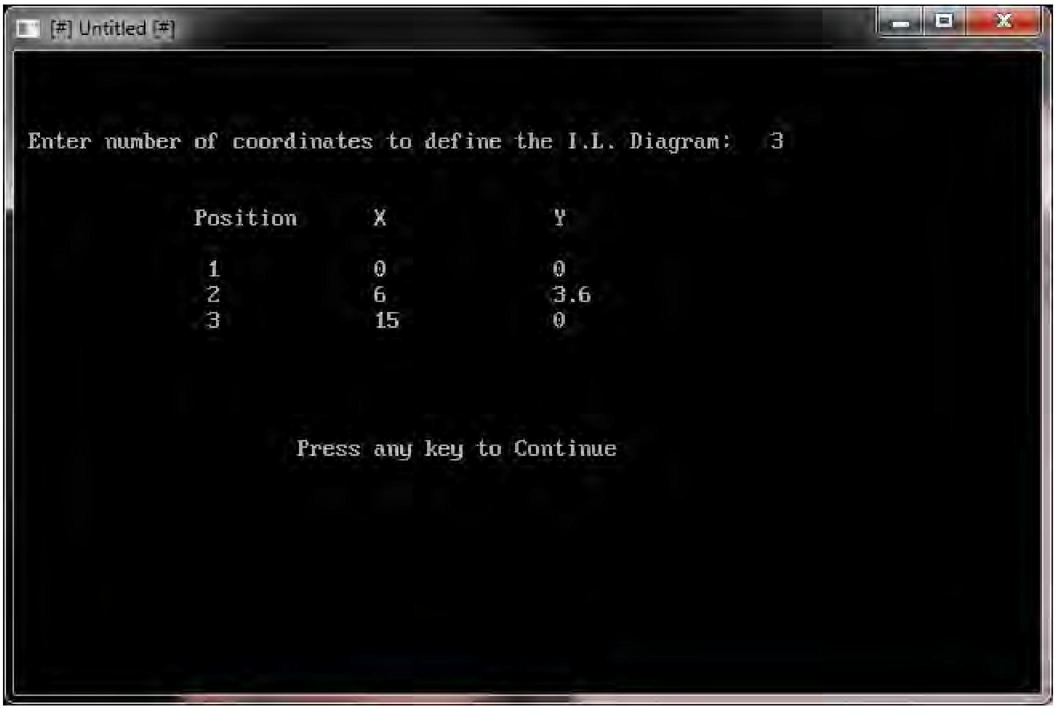


Fig 2-1; Input I.L. Diagram Coordinates

The user is prompted for the number of coordinated points required to define the I.L. and then prompted for the X and Y value for each coordinate. Press Enter / Return after each value (Fig 2-1). There is no auto check or undo routine during data entry therefore the user should check the input before pressing return.

Intermediate vertical diagram components, such as those for shear force, should be given a minor horizontal increment between upper and lower coordinates in order that the maximum effect is be properly identified.

2.2 Influence Line Diagram

On completion of the defining data input and pressing a key to continue the user is presented with a general illustration of the I.L. diagram (Fig 2-2). Although there are no dimensions stated, this can be used to adequately verify the expected shape.

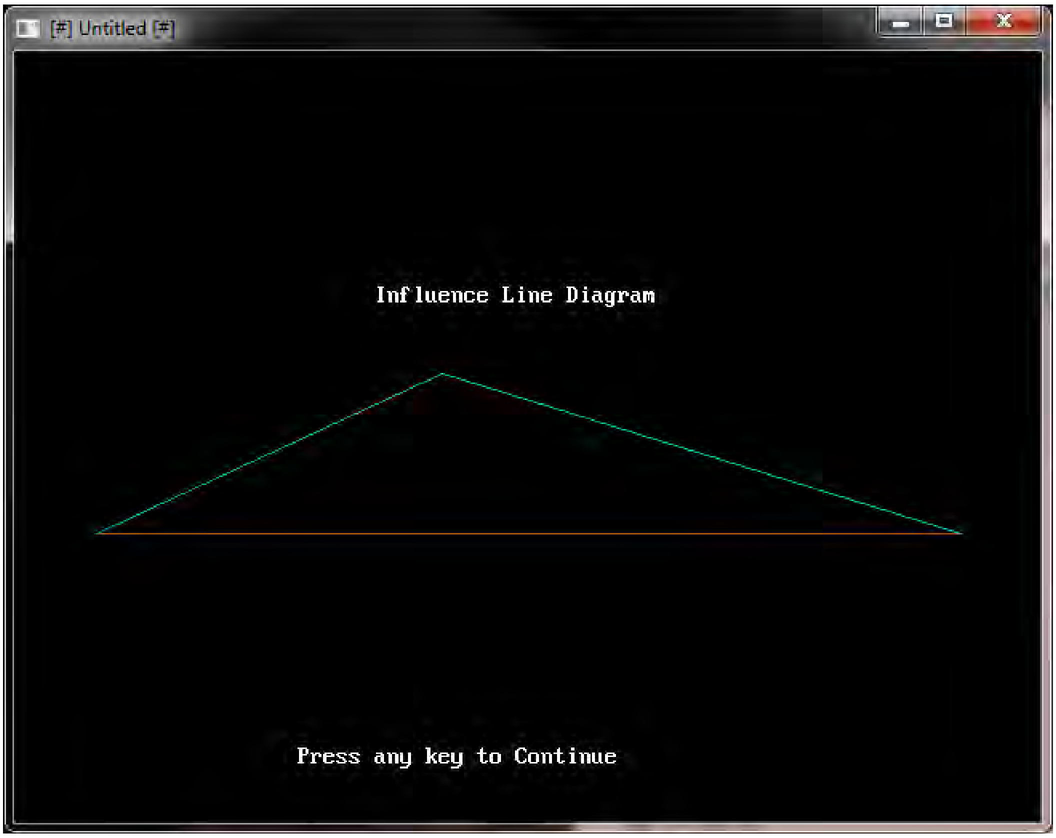


Fig 2-2; I.L. Diagram General Illustration

3 Vehicle Definition

The vehicle or point load pattern is similarly defined by first entering the number of axles (or point loads) and then stating the position and corresponding load for each axle. At this stage the axle positions are entered relative to each other and not to the structure. Their positions can therefore be defined relative to any reference point, although it is easier to consider them relative to the first axle.

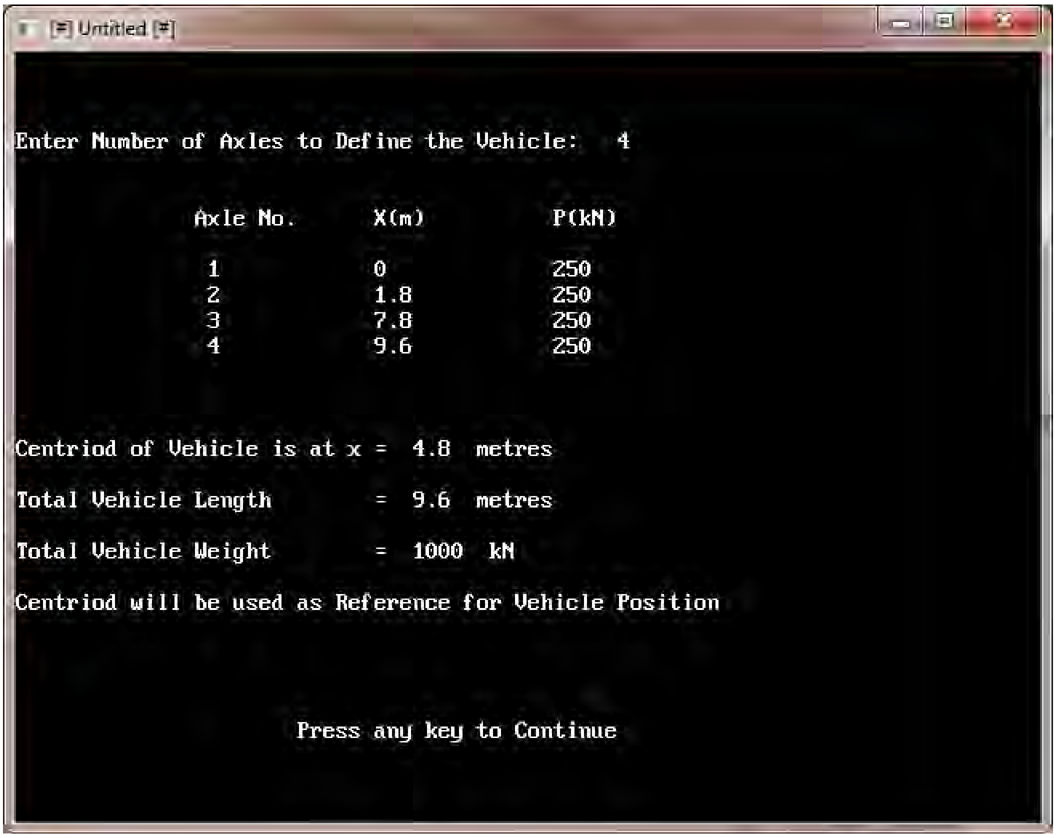


Fig 3-1; Vehicle Definition Input and Summary Output

After entering the final axle details the program lists a vehicle summary including centroid distance from reference point, vehicle length and total load (Fig 3-1).

4 Vehicle Position(s)

4.1 Vehicle Axle Positions Coincide with I.L. Input Coordinates

Although there are three options for specifying the position(s) of the vehicle, or point load pattern on the structure (Fig 4-1), this first option should be sufficient to determine the optimum location and maximum effect. This effectively considers the vehicle travelling along the defined structure with the total load effect calculated at every position where a load coincides with a defined I.L. coordinate. No further input is required for this option.

Fig 4-1; Vehicle Travel Options

4.2 Vehicle to Travel Defined Range

Vehicle travel option (2) requires the user to define the travel range by inputting the start and finish X ordinate position of the first (left-most) axle relative to the first I.L. coordinate, together with the number of incremental positions to be considered (Fig 4-2).

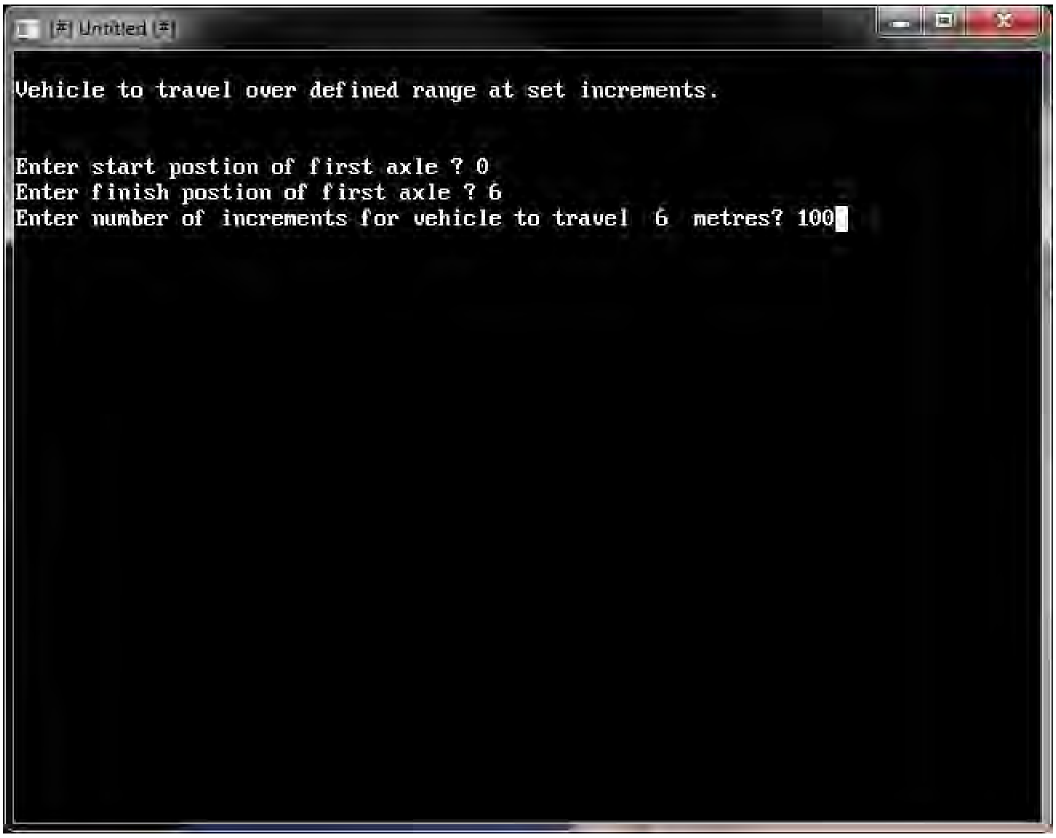


Fig 4-2; Input for Vehicle to Travel over Defined Range

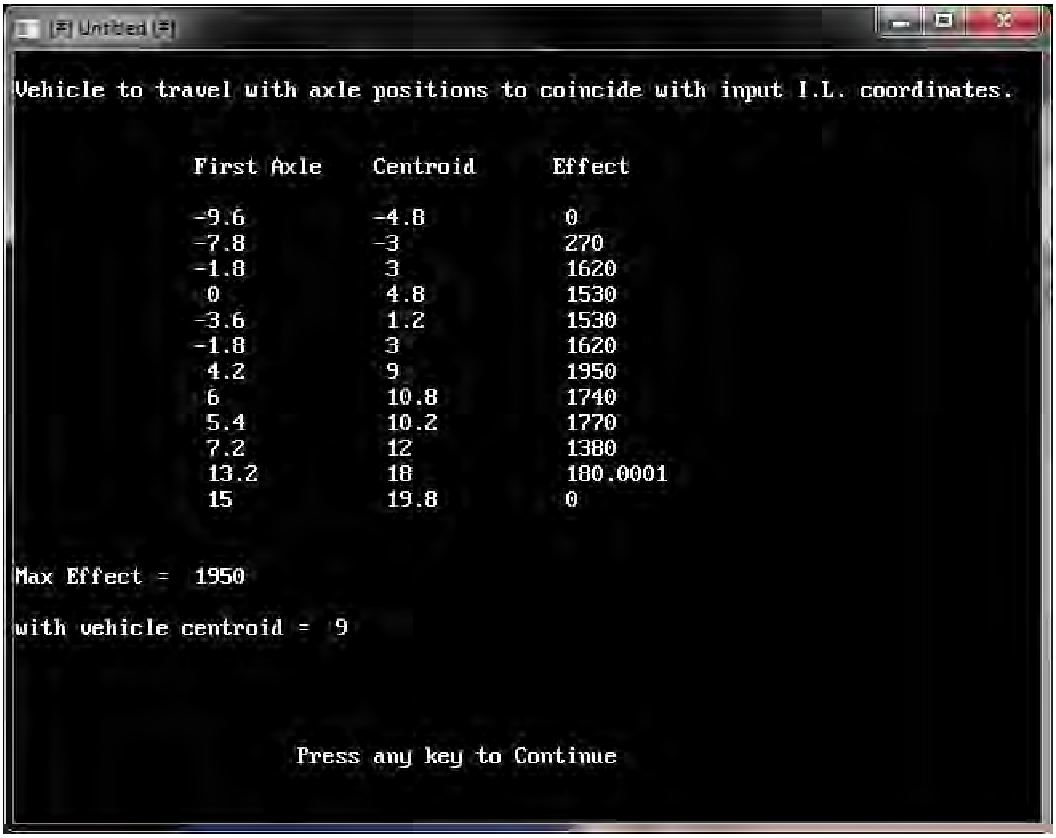
4.3 Vehicle at Defined Location

This option may be selected if the user already knows the optimum location of the vehicle or wishes to investigate the diminished effect due to other vehicle location(s). In this case the vehicle position is defined by inputting the position of the first (left-most) axle relative to the first I.L. coordinate (Fig 5-3).

5 Output

5.1 Vehicle Axle Positions Coincide with I.L. Input Coordinates

On selection of vehicle positioning option (1) the total effect will be tabulated for each vehicle position, defined by both the first axle (left-most) and vehicle centroid distance from the first I.L. coordinate. If the number of vehicle positions is greater than the number of screen lines then the details for the first positions will scroll off the screen. However, the maximum effect and optimum position will still be visible at the bottom of the table (Fig 5-1). If the user is interested to see details of those effects that have scrolled off the screen then they may refine the investigated travel using options (2) or (3).



```
Vehicle to travel with axle positions to coincide with input I.L. coordinates.

            First Axle    Centroid     Effect

            -9.6          -4.8         0
            -7.8          -3           270
            -1.8           3           1620
             0             4.8         1530
            -3.6           1.2         1530
            -1.8           3           1620
             4.2           9           1950
             6             10.8        1740
             5.4           10.2        1770
             7.2           12          1380
             13.2          18          180.0001
             15            19.8        0

Max Effect =  1950

with vehicle centroid =  9

                   Press any key to Continue
```

Fig 5-1; Output for Vehicle Axle Positions to Coincide with I.L. Coordinates

5.2 Vehicle to Travel Defined Range

As with option (1) the total effect will be tabulated against each vehicle position, but defined only by the first axle (left-most) distance from the first I.L. coordinate. Similarly the leading effects are likely to have scrolled off the screen unless the travel distance or increment are purposefully limited (Fig 5-2).

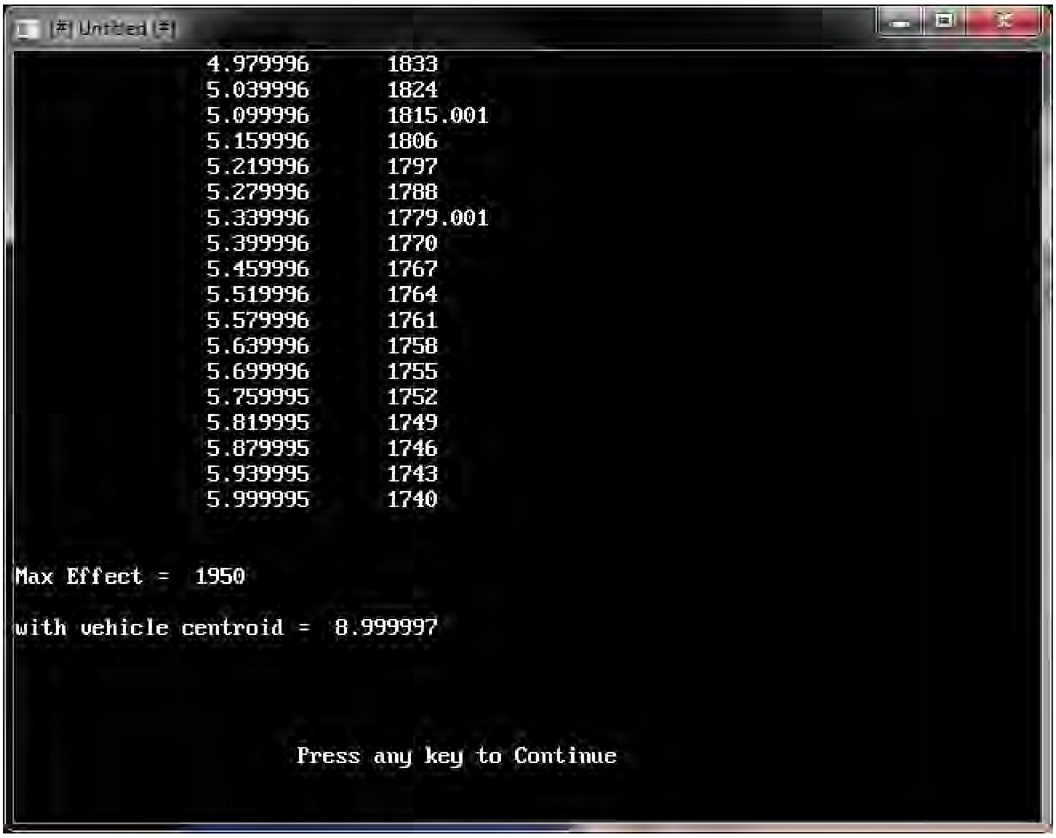


Fig 5-2; Output for Vehicle to Travel over Defined Range

5.3 Vehicle at Defined Location

Output for this option confirms the first axle and vehicle centroid X ordinate together with the maximum effect (Fig 5-3).

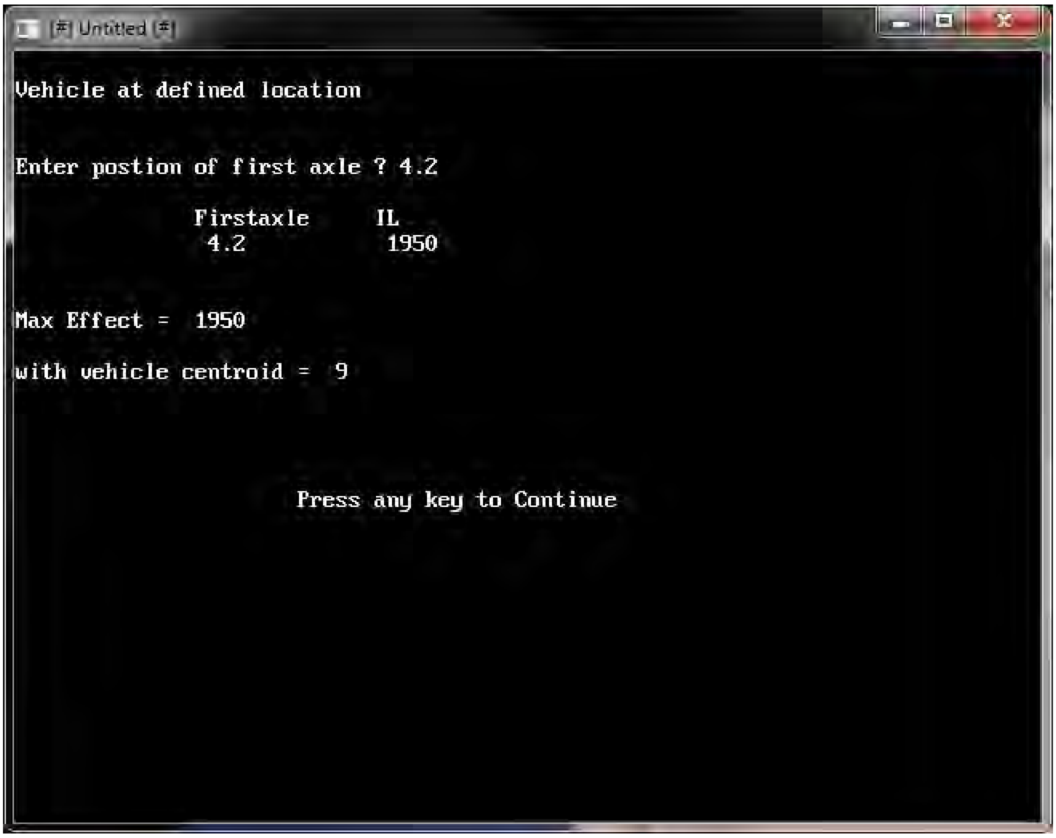


Fig 5-3; Output for Vehicle at Defined Location

6 Final Options

After the first analysis is complete the user can amend the vehicle position or the vehicle definition in which case they are returned to the screens shown in Figs 4-1 and 3-1 respectively (Fig 6-1).

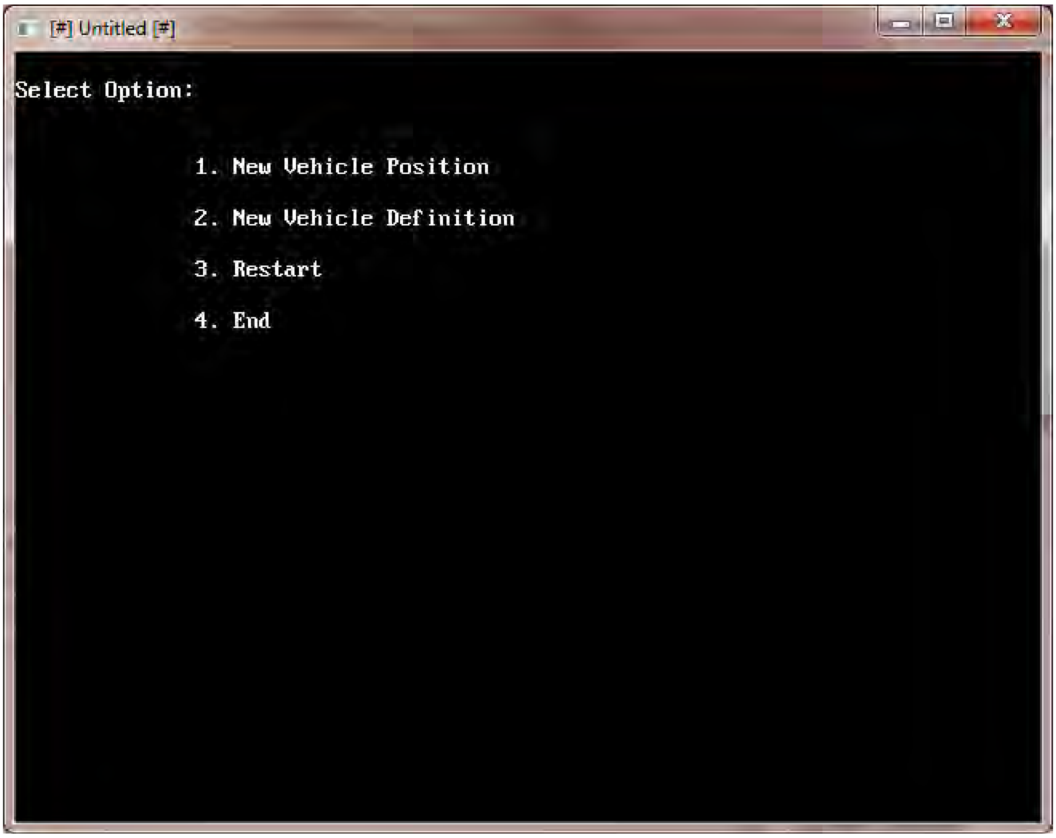


Fig 6-1; Final Options

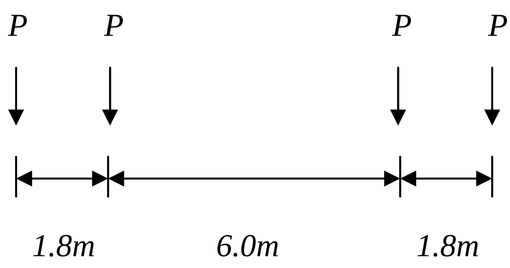
The final two options to restart or end the program are self-explanatory.

7 Example

7.1 Maximum Bending Moment and Position

Find the maximum global bending moment (BM) magnitude and position due to 25 Units of HB loading crossing a 15m span bridge:

Loading



Axle load P = 25 x 10 = 250kN

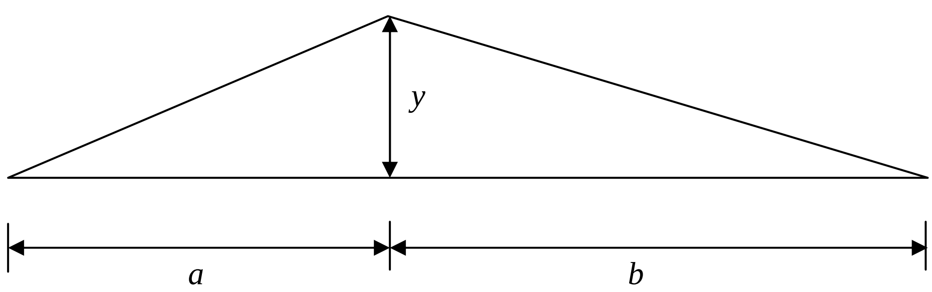
Load Position

The maximum BM due to a load group will occur under a point load when the centre of the span is equi-distant between the centroid of the load group and that point load.

Therefore, the distance 'a' from the left support to the point of maximum BM is:

a = 15/2 - 6/4 = 7.5 - 1.5 = 6.0m

BM Influence Line Diagram



b = span - a = 15 - 6 = 9.0m

y = a x b / span = 6 x 9 / 15 = 54 / 15 = 3.6m

Program Input

Influence Line Definition:

The X and Y ordinates are derived from the BM influence line diagram:

X(m)	Y(m)
0	0
6	3.6
15	0

Refer to Figure 2-1 to see how these values have been input.

Vehicle Definition:

The vehicle definition parameters are derived from the Loading diagram:

Axle	X(m)	P(kN)
1	0	250
2	1.8	250
3	7.8	250
4	9.6	250

Refer to Figure 3-1 to see how these values have been input.

Vehicle Position(s)

Although the position of the vehicle to provide the maximum BM has already been determined whilst developing the shape of the influence line diagram it is easiest to select option (1) which requires no further input.

Program Output

With reference to Figure 5-1 it can be seen that the maximum global BM is 1950kNm with vehicle centroid at X = 9.0m / first axle at X =

4.2m. This maximum BM occurs at X = 6.0m, that is, 1.5m from centre span.

7.2 Maximum Mid-span Bending Moment.

Find the maximum global bending moment (BM) that occurs mid span for the bridge and loading stated in the previous example.

BM Influence Line Diagram

a = b = span / 2 = 15 / 2 = 7.5m

y = a x b / span = 7.5 x 7.5 / 15 = 56.25 / 15 = 3.75m

Program Input

Influence Line Definition:

The X and Y ordinates are derived from the BM influence line diagram:

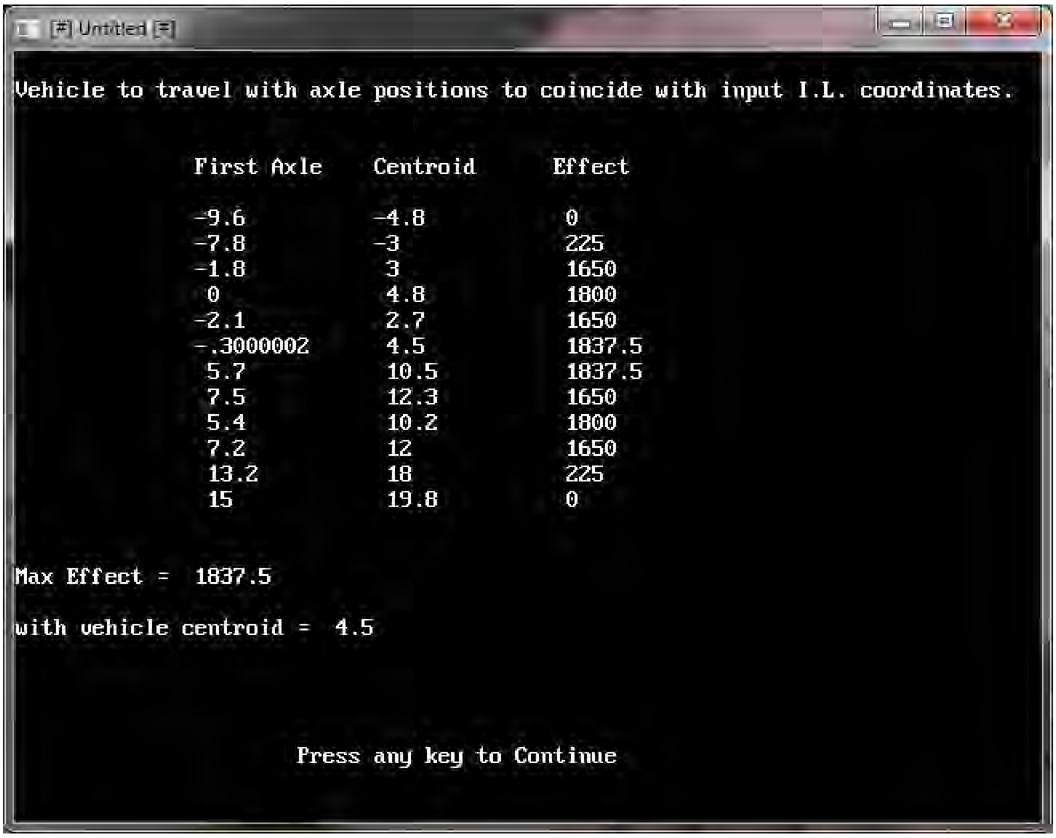
X(m)	Y(m)
0	0
7.5	3.75
15	0

Vehicle Definition and Position(s)

As previous example.:

Program Output

With reference to Figure 7-1 it can be seen that the maximum global mid span BM is 1837.5kNm with vehicle centroid at X = 4.5m or 10.5m.



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[#] Untitled [#]

Vehicle to travel with axle positions to coincide with input I.L. coordinates.

            First Axle     Centroid      Effect

            -9.6           -4.8           0
            -7.8           -3             225
            -1.8            3             1650
             0              4.8           1800
            -2.1            2.7           1650
            -.3000002       4.5           1837.5
             5.7           10.5           1837.5
             7.5           12.3           1650
             5.4           10.2           1800
             7.2           12             1650
             13.2          18             225
             15            19.8           0

Max Effect =  1837.5

with vehicle centroid =  4.5

                    Press any key to Continue
```

Fig 7-1; Maximum mid-span BM for 25 Units HB - 15m Span

7.3 Maximum Interior Support Shear Force.

Find the maximum global Shear Force (SF) to the centre span support on a continuous 3 x 10m span bridge with loading as the previous examples.

Loading

As previous examples.

Vehicle Position

Although this is self evident for the load and span configuration in this example, the program will confirm the optimum position.

SF Influence Line Diagram

The following X and Y coordinates are provided in the Steel Designers' Manual 5th Edition; The Steel Construction Institute; ISBN 0-632-03877-2, page 1060.

X(m)	Y(m)	X(m)	Y(m)	X(m)	Y(m)
0	0	10	1	20	0
1	0.033	11	0.924	21	-0.057
2	0.064	12	0.832	22	-0.096
3	0.091	13	0.728	23	-0.119
4	0.112	14	0.616	24	-0.128
5	0.125	15	0.5	25	-0.125
6	0.128	16	0.384	26	-0.112
7	0.119	17	0.272	27	-0.091
8	0.096	18	0.168	28	-0.064
9	0.057	19	0.076	29	-0.033
9.999*	0*			30	0

* coordinate added to provide incline to the intermediate vertical component.

The shape of the I.L. diagram is confirmed by the program after the coordinates have been entered (Fig. 7-2)

Program Output

With reference to Figure 7-3 it can be seen that the maximum global Shear Force (SF) to the centre span support is 517.7kN with vehicle centroid at X = 14.8m, and first axle over the support as expected.

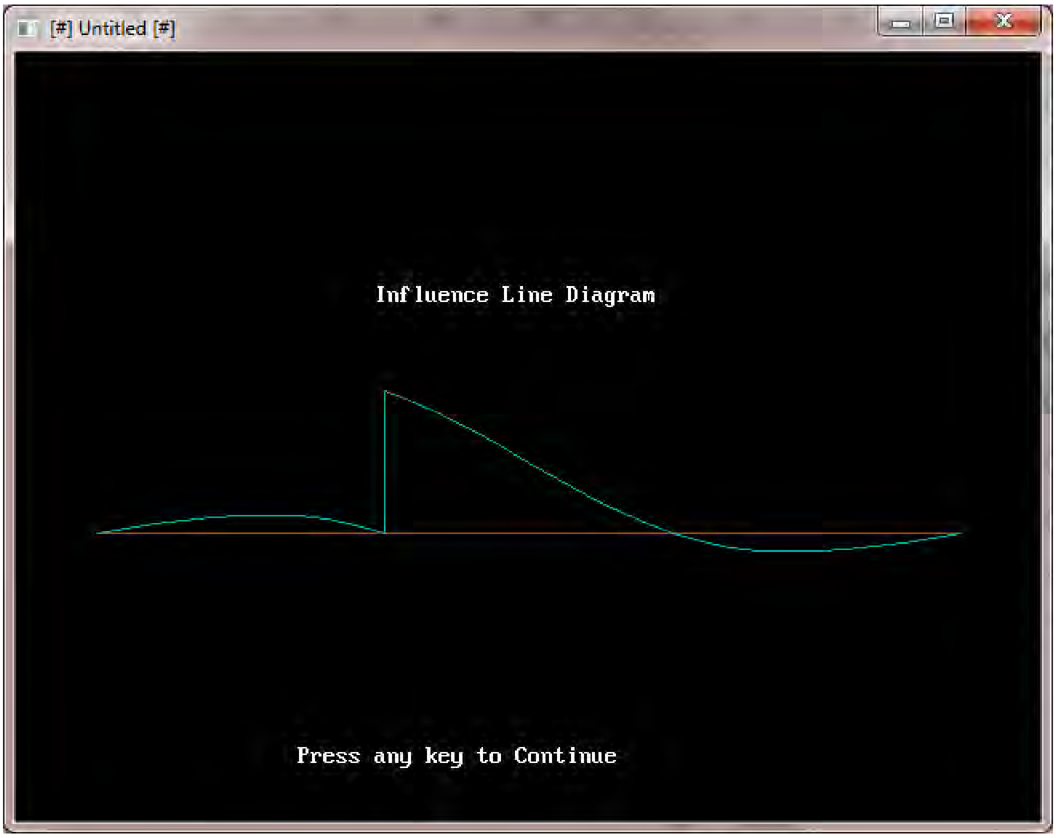

Fig. 7-2 Shape of Influence Line Diagram conformed by the Program

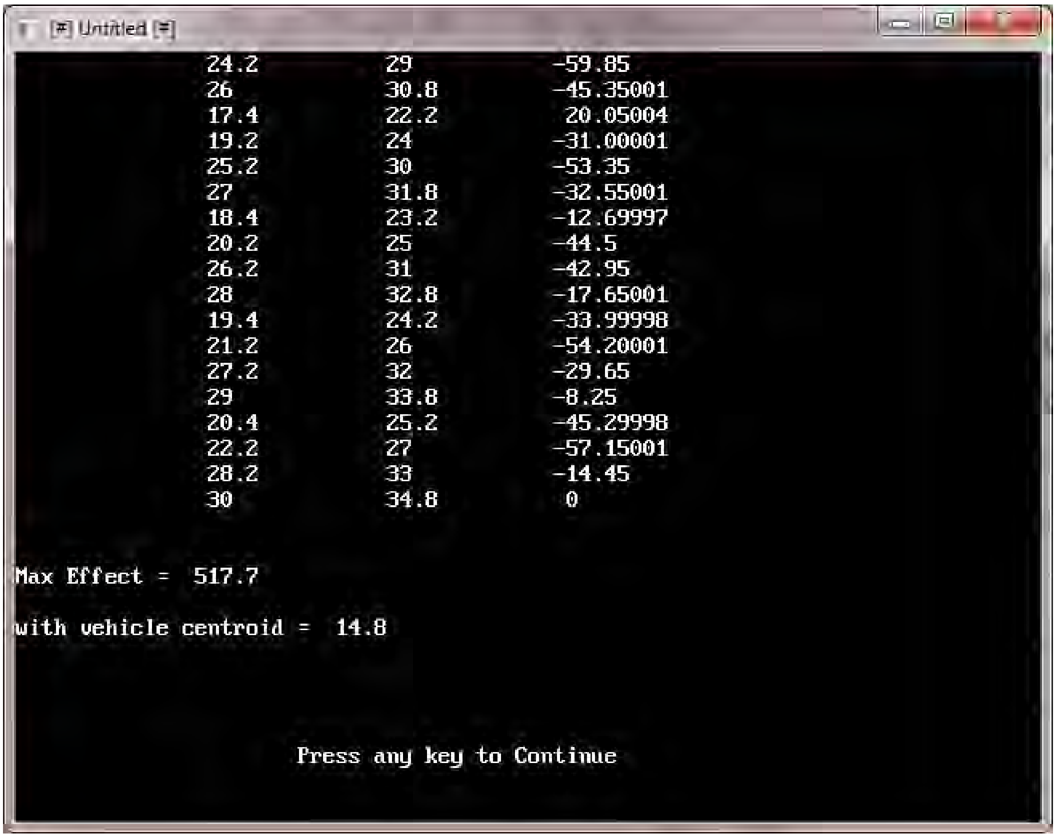

Fig. 7-2 Maximum Centre Span Shear Force