

TNMN
Version 1.5
A Program for Analysing
Seismic Displacements

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1 Introduction

TNMN is a program for seismic analyses of slopes or retaining walls which computes the displacement of a potential sliding mass by double-integrating the difference between the applied acceleration history and the yield acceleration, that is, the horizontal acceleration which reduces the conventional static factor of safety to unity (also called the critical seismic coefficient), in accordance with the suggestion of Newmark[1].

The overall calculation will normally involve a number of assumptions - that the potential sliding mass is rigid, that there is a well-defined potential slip surface, that the yield acceleration is constant (or can at least be represented by several segments each of which is constant) - and the engineer must make his or her own judgement as to the reasonableness of these assumptions.

The computed displacements will also be very sensitive to the character of the acceleration histories which are assumed to act on the potential sliding mass. Motions with longer durations and larger numbers of broad peaks will clearly generate larger computed displacements (all other things being equal) and these parameters can vary substantially even among recorded motions that have been generated by earthquakes with the same local magnitudes. Indeed, there can be a surprisingly large difference between the displacements which are obtained by applying the same acceleration history in the "normal" and "reversed" directions (equivalent to flipping the acceleration history about the time axis), something that TNMN does automatically.

Various libraries of strong motion acceleration histories are available for downloading via the Internet. The National Service for Earthquake Engineering (NISEE) at the University of California, Berkeley describes many sources at their web-site.¹

The only printed output that is produced by TNMN are the final displacements for the normal and reversed motions since the results of the calculation are best shown graphically as plots of the acceleration history, the relative velocity history and the displacement history. The present version of TNMN offers the choice of HPGL plot-files or DXF files which can be converted to AutoCAD drawing files and viewed on a graphics monitor, edited if necessary for final presentation and then directed to any of the printers or plotters supported by AutoCAD. This choice is made interactively at runtime. A choice is also offered between directing the output to disk files or to a printer, however, the latter choice only makes sense if you are running a quick check without requesting the generation of plot-files.

¹ http://nisee.berkeley.edu/software_and_data/strong_motion/

2 Input Instructions

TNMN requires that a simple input file be prepared in advance in accordance with the instructions given below. If you wish to run a number of input files and wish to avoid the need to enter each input filename separately, list the names of those input files on successive lines in a file named BATCH.DAT and then give BATCH.DAT as the name of the initial input file.

2.1 Title Data

Titles must be on first two lines, no blank lines are allowed. After that, blank lines or comments and labels, that is, any text preceded by a capital C in the first column, may be used as shown in the example input files.

First line: TITLE NO.1 (Maximum of 40 characters)

Second line: TITLE NO.2 (Maximum of 40 characters)

2.2 Acceleration Control Data

Third line of data: Enter six numbers.

1. NUMBER OF POINTS IN ACCELERATION HISTORY
2. TIME STEP (in seconds)
3. DESIRED PEAK ACCELERATION (in g) (enter 0. for no change) (enter -1. for no multiplier but read in values in cm/sec/sec and change them to g)
4. GRAVITATIONAL ACCELERATION (in the system of units to be used for velocity and displacement)
5. CODE FOR FORMAT USED TO READ MOTION
 - 0 = 8F9.*
 - 2 = free format, one pair of time and a/v per line
 - 3-10 = free format, N values per line (add 10 to have line numbers reported to monitor)
 - 99 = input motion specified in separate file
6. CODE FOR OUTPUT TIME HISTORIES
 - 0 = no output histories
 - 1 = output histories saved in addition to plot files
 - 2 = output histories saved in a single file

Fourth line of data: Enter three numbers.

1. CODE FOR METHOD OF SPECIFYING VALUES OF YIELD ACCELERATION (KODE)
 - 1 = Calculation to be performed for one or more constant values of the yield acceleration.
 - 2 = Calculation to be performed for stepped values of yield acceleration.
2. LENGTH OF X AXIS IN INCHES (limited to 4,5 or 6)
3. SCALE FOR X AXIS (In seconds per inch) (if plotted output is not requested at runtime these last two values can be zero.)

Optional fifth and sixth lines

If the calculation is to be performed for constant values of the yield acceleration, then specify: NUMBER OF VALUES OF YIELD ACCELERATION (Maximum of 6) on one line and the values themselves on the next line.

Optional fifth and sixth lines

If the calculation is to be performed for stepped values of the yield acceleration, specify:

1. NUMBER OF TIME SEGMENTS (Maximum of 6) on one line,

and then list the TIME SPAN and the corresponding YIELD ACCELERATIONS on successive lines, as two numbers per line:

1. TIME SPAN
2. YIELD ACCELERATION

2.3 Acceleration History

Finally, list the ACCELERATION history. There are two ways to specify the acceleration history: in-line or in an external file, as determined by item 5 in the third input data line, see above.

2.3.1 In-line Acceleration History

List VALUES OF ACCELERATION, N values per line (see Examples 1 and 23.1,3.2.)

2.3.2 Acceleration History in External File

If Code = 99 (see example 33.3), specify on one line three numbers:

1. NUMBER OF LINES IN HEADER OF INPUT MOTION FILE
2. NUMBER OF VALUES PER LINE
3. CODE for reporting line numbers to monitor - 0 for no, 1 for yes.

And on the following line:

- NAME OF INPUT MOTION FILE

And on the last line:

- THE FORMAT OF THE INPUT FILE in parentheses, like: (8F9.0)

3 Examples

3.1 Example 1

3.1.1 Input Data

Please note that the acceleration history has been truncated due to its large size.

Standard TNMN Example Problem
 Castaic N21E fitted to SUL mean + 1

```
C NACC      DT      Amax      G KREAD KOUT
  1000      0.02    0.25  32.2  0  0
```

```
C KODE      XAXLEN      XSCALE
  2          4.          5.
```

```
C Number of (time segments and) yield accelerations
  3
```

```
C Time Segments and/or Yield Accelerations
  5.0          0.2
  5.0          0.15
  10.0         0.1
```

C Accelerations ...

```
.365735 .507051 .522910 .331380 -.091153 -.346122 -.282391 -.108556
-.042525 .018981 .170357 .252807 .120095 -.079936 -.159364 -.087694
-.116279 -.320395 -.359013 -.136943 -.003601 -.098753 -.208256 -.155918
-.118265 -.192837 -.098236 .162811 .295273 .220008 .097280 .072002
.107883 .090778 -.004274 -.095919 -.264686 -.387560 -.218087 .011069
.099504 .127892 .189476 .284981 .240872 -.039361 -.301951 -.198052
.016040 -.145330 -.518364 -.768680 -.845856 -.797241 -.501462 -.092309
```

...

```
-.183618 -.132762 -.080738 -.033803 -.006411 -.011376 -.045454 -.096067
-.153198 -.205139 -.233196 -.226142 -.191398 -.141498 -.078638 -.005411
.062378 .107517 .127684 .126831 .102780 .056050 .001274 -.045245
-.078803 -.097244 -.089875 -.050130 .012719 .085055 .161913 .236638
.292939 .319047 .319421 .300236 .258217 .193951 .123632 .063931
.018956 -.009533 -.012496 .012858 .054741 .100110 .144463 .179230
.187781 .162618 .114477 .055356 -.010716 -.076491 -.127521 -.159263
-.180326 -.194948 -.196723 -.185836 -.172137 -.158479 -.136352 -.104110
-.070933 -.044610 -.030600 -.043202 -.093645 -.169662 -.242193 -.291816
```

3.1.2 Summary Output

```
*****
*****
```

```
TNMN - Version 1.5
Copyright, 1998, TAGAssoft Limited
Compiled by rmp on 09/08/98 using
Microsoft FORTRAN POWERSTATION v.1.0
Serial Number 1039
```

```
*****
*****
```

```
DATE: 6:26:2002
TIME: 14:51:48
INPUT/OUTPUT FILE NAME: ex
```

```
*****
Standard TNMN Example Problem
*****
```

```
*****
Castaic N21E fitted to SUL mean + 1
*****
```

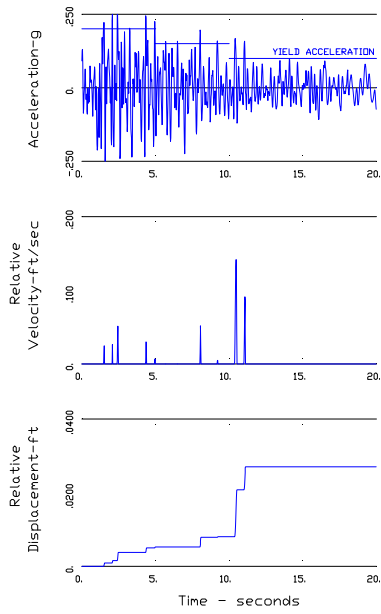
```
Peak acceleration of input motion = 1.000
Desired peak acceleration = .250
```

```
FOR NORMAL DIRECTION OF MOTION
AND A YIELD ACCELERATION OF .20 OVER 5.00 SECONDS
AND A YIELD ACCELERATION OF .15 OVER 5.00 SECONDS
AND A YIELD ACCELERATION OF .10 OVER 10.00 SECONDS
MAXIMUM DISPLACEMENT = .028 UNITS OF LENGTH
```

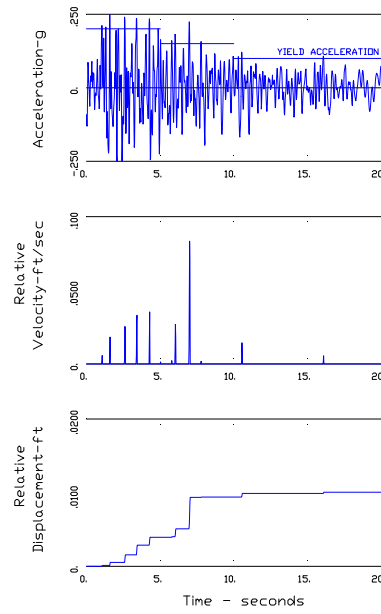
```
FOR REVERSED MOTION
AND A YIELD ACCELERATION OF .20 OVER 5.00 SECONDS
AND A YIELD ACCELERATION OF .15 OVER 5.00 SECONDS
AND A YIELD ACCELERATION OF .10 OVER 10.00 SECONDS
MAXIMUM DISPLACEMENT = .012 UNITS OF LENGTH
```

```
*****
ELAPSED TIME = 0 MINS 2 SECS
*****
```

3.1.3 Plots



Standard TNMN Example Problem
Castaic N21E fitted to SUL mean + 1
NORMAL MOTION



Standard TNMN Example Problem
Castaic N21E fitted to SUL mean + 1
REVERSED MOTION

Figure 1: Example 1. Normal Motion (left) and reverse motion(right)

3.2 Example 2

3.2.1 Input Data

Please note that the acceleration history has been truncated due to its large size.

APEEL ARRAY #2, REDWOOD CITY, 133 DEGREES
EARTHQUAKE OF OCTOBER 18, 1989 - 0004 GMT

```
C  NACC      DT      Amax      G  KREAD  KOUT
   4000      0.005    -1.    32.2   20   1
```

```
C  KODE     XAXLEN     XSCALE
   1         4.         5.
```

```
C  Number of (time segments and) yield accelerations
   2
```

```
C  Time Segments and/or Yield Accelerations
   0.02   0.05
```

C Accelerations ...

```
 12.71   3.53   11.88   12.35   11.93   12.32   9.53   6.90   6.55   5.83
   4.14   3.50   1.69   0.75   0.39   -1.92   -3.18   -4.81   -6.95   -7.44
  -9.34  -11.06  -10.78  -11.35  -12.17  -12.51  -12.36  -11.20  -11.25  -10.94
 -11.10  -11.66   -9.73   -9.43   -9.42   -8.85   -9.01   -8.32   -8.69   -9.12
  -9.59  -10.27   -9.69   -9.36   -9.45   -7.57   -5.14   -5.33   -4.21   -1.97
  -1.04   0.11   0.64   1.78   1.36   0.58   2.18   2.56   1.60   1.65
   2.71   3.37   3.66   3.57   2.95   2.38   3.28   3.46   1.75   1.31
   1.80   1.67   2.44   3.32   2.63   3.31   4.18   4.15   4.74   5.88
   6.63   7.45   8.40   8.67   9.41  10.35  12.11  11.93  12.48  14.57
  14.04  14.64  14.58  13.43  13.59  12.28   9.86   8.22   7.21   5.28
```

...

```
-1.47  -2.29  -2.52  -2.34  -1.90  -3.23  -4.66  -2.79  -3.06  -4.12
-3.60  -3.74  -4.22  -4.82  -4.58  -4.46  -5.35  -5.07  -5.23  -6.12
-5.51  -5.68  -6.84  -6.65  -5.96  -6.30  -7.08  -7.29  -7.00  -7.29
-7.72  -7.49  -7.92  -6.82  -6.06  -7.27  -7.38  -6.60  -5.45  -6.66
-6.68  -4.13  -4.17  -5.05  -4.43  -3.52  -3.20  -3.59  -3.38  -2.13
-1.68  -1.63  -1.28  -1.43  -0.65   0.54   0.71   1.32   1.45   2.08
  2.96   2.08   2.86   4.50   3.26   2.85   4.05   3.61   3.41   4.62
  5.08   4.48   4.89   5.02   5.04   5.80   5.71   4.53   4.79   5.69
  5.04   4.67   4.84   5.62   5.48   4.99   5.01   4.97   5.20   5.00
  6.17   6.23   5.07   5.91   5.86   5.76   6.15   5.70   5.77   6.13
  6.30   6.24   6.33   6.80   7.26   7.48   7.73   7.82   7.76   8.21
  8.09   8.19   8.95   8.18   7.57   9.47  10.22   8.23   7.79   9.07
  8.78   7.13   7.70
```

3.2.2 Summary Output

```
*****
*****
```

TNMN - Version 1.5
Copyright, 1998, TAGAssoft Limited

Compiled by rmp on 09/08/98 using
 Microsoft FORTRAN POWERSTATION v.1.0
 Serial Number 1039

DATE: 6:26:2002
 TIME: 14:52: 4
 INPUT/OUTPUT FILE NAME: ex2

 APEEL ARRAY #2, REDWOOD CITY, 133 DEGRE

 EARTHQUAKE OF OCTOBER 18, 1989 - 0004 G

Peak acceleration of input motion = 222.520
 Desired peak acceleration = -1.000

FOR NORMAL DIRECTION OF MOTION
 AND A YIELD ACCELERATION OF .02
 MAXIMUM DISPLACEMENT = 1.743 UNITS OF LENGTH

FOR REVERSED MOTION
 AND A YIELD ACCELERATION OF .02
 MAXIMUM DISPLACEMENT = 1.866 UNITS OF LENGTH

FOR NORMAL DIRECTION OF MOTION
 AND A YIELD ACCELERATION OF .05
 MAXIMUM DISPLACEMENT = .666 UNITS OF LENGTH

FOR REVERSED MOTION
 AND A YIELD ACCELERATION OF .05
 MAXIMUM DISPLACEMENT = 1.047 UNITS OF LENGTH

 ELAPSED TIME = 0 MINS 7 SECS

3.2.3 Plots

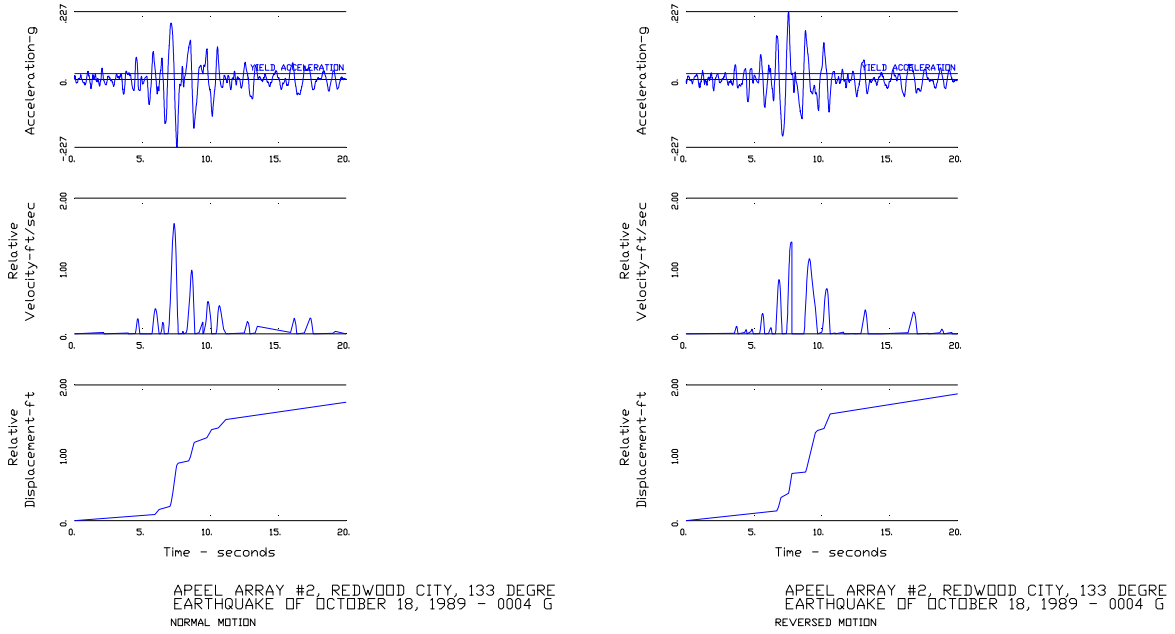


Figure 2: Example 2. Normal Motion (left) and reverse motion(right) for yield acceleration = 0.02

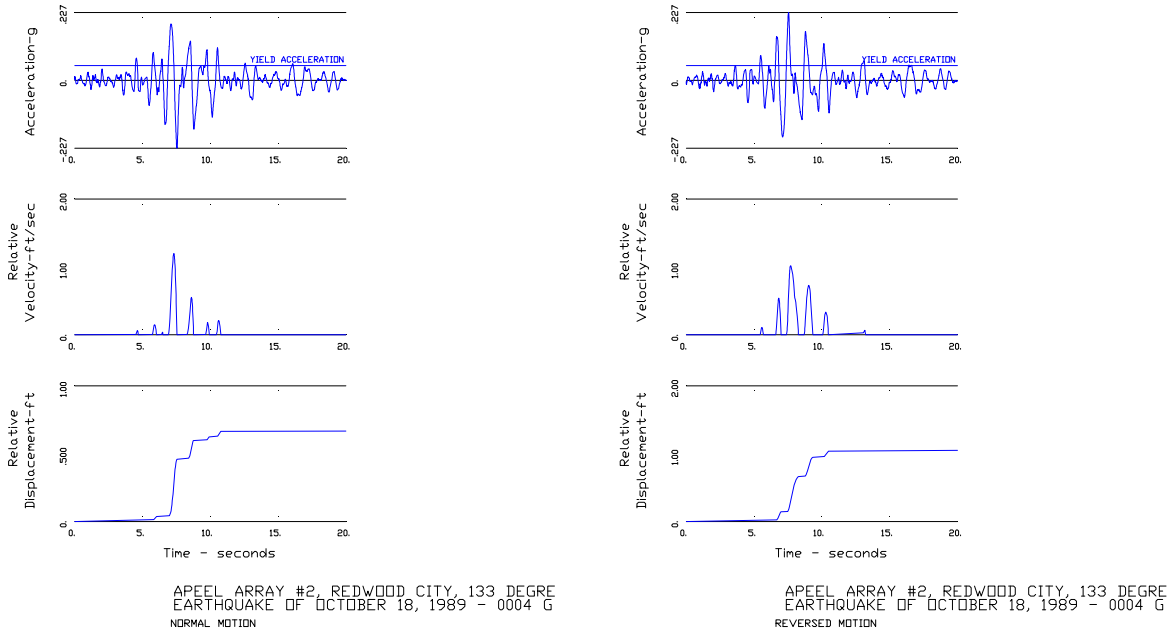


Figure 3: Example 2. Normal Motion (left) and reverse motion(right) for yield acceleration = 0.05

3.3 Example 3

3.3.1 Input Data

Standard TNMN Example Problem
Castaic N21E fitted to SUL mean + 1

```
C NACC      DT      Amax      G KREAD KOUT
  1000     0.02    0.25  32.2  99  1
```

```
C KODE     XAXLEN    XSCALE
   2        4.        5.
```

```
C Number of (time segments and) yield accelerations
      3
```

```
C Time Segments and/or Yield Accelerations
      5.0                0.2
      5.0                0.15
     10.0                0.1
```

```
C INPUT MOTION
C NHEAD    NPL NREAD
   3      8    1
C Name of File
mcastaic.acc
C Format
(8F9.0)
```

3.3.2 Summary Output

```
*****
*****
```

```
TNMN - Version 1.5
Copyright, 1998, TAGAssoft Limited
Compiled by rmp on 09/08/98 using
Microsoft FORTRAN POWERSTATION v.1.0
Serial Number 1039
```

```
*****
*****
```

```
DATE: 6:26:2002
TIME: 14:52:22
INPUT/OUTPUT FILE NAME: ex3
```

```
*****
Standard TNMN Example Problem
*****
```

```
*****
Castaic N21E fitted to SUL mean + 1
*****
INPUT MOTION READ FROM: mcastaic.acc
```

```
Peak acceleration of input motion = 1.000
```

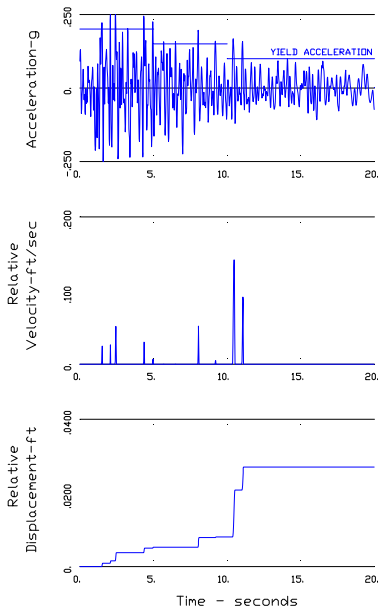
Desired peak acceleration = .250

FOR NORMAL DIRECTION OF MOTION
 AND A YIELD ACCELERATION OF .20 OVER 5.00 SECONDS
 AND A YIELD ACCELERATION OF .15 OVER 5.00 SECONDS
 AND A YIELD ACCELERATION OF .10 OVER 10.00 SECONDS
 MAXIMUM DISPLACEMENT = .028 UNITS OF LENGTH

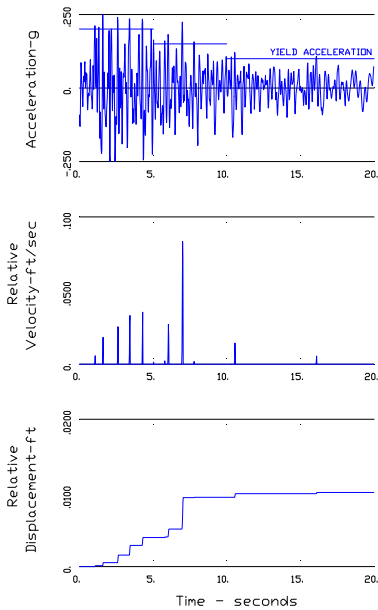
FOR REVERSED MOTION
 AND A YIELD ACCELERATION OF .20 OVER 5.00 SECONDS
 AND A YIELD ACCELERATION OF .15 OVER 5.00 SECONDS
 AND A YIELD ACCELERATION OF .10 OVER 10.00 SECONDS
 MAXIMUM DISPLACEMENT = .012 UNITS OF LENGTH

 ELAPSED TIME = 0 MINS 2 SECS

3.3.3 Plots



Standard TNMN Example Problem
 Castaic N21E fitted to SUL mean + 1
 NORMAL MOTION



Standard TNMN Example Problem
 Castaic N21E fitted to SUL mean + 1
 REVERSED MOTION

Figure 4: Example 3. Normal Motion (left) and reverse motion(right)

References

- [1] N. M. Newmark. Effects of earthquakes on dams and embankments. *Geotechnique*, 15(2):139–160, 1965.