



# Soil Liquefaction Analysis Software

## NovoLiq

Soil liquefaction is a phenomenon in which the strength and stiffness of soil is reduced during earthquake shaking. The main reason for loss of shear strength of soil is pore pressure build up.

Susceptibility of a site to liquefaction depends on a series of parameters including but not limited to:

Soil void ratio

Soil density

Soil permeability

Geological history of site

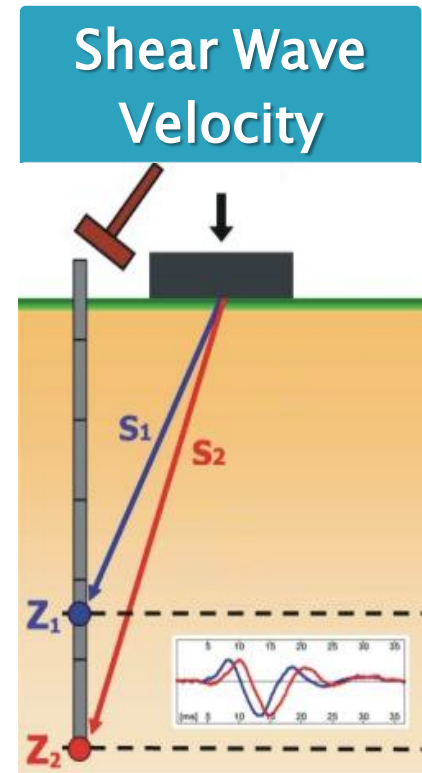
Ground water level

Nature of the earthquake shaking



Many different methodologies have been developed during last few decades for soil liquefaction assessment. Most of them use in-situ test results in conjunction with site stratigraphy to estimate the potential of soil layers to liquefaction.

Following is the list of the most common tests:



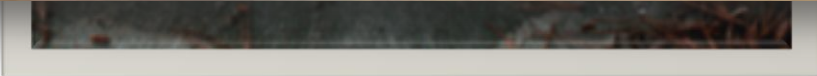
Liquefaction-induced movements and residual shear strength of the soil are very critical in liquefaction analysis. Following pictures show the disastrous lateral spreading during earthquake:



Before



After



# What is your tools for liquefaction analysis?

- Excel spreadsheets?
  - Design charts?
  - Flac?
  - ...
- 
- How much does it cost for you?
  - Are the results reliable?
  - How long does it take?
  - How many methods are incorporated into your analysis?



**Introducing:**

**Liquefaction Analysis Software**

**NovoLiq**



**Developed by:  
Novo Tech Software Ltd.  
Vancouver, Canada**

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4108 Hoskins Road,  
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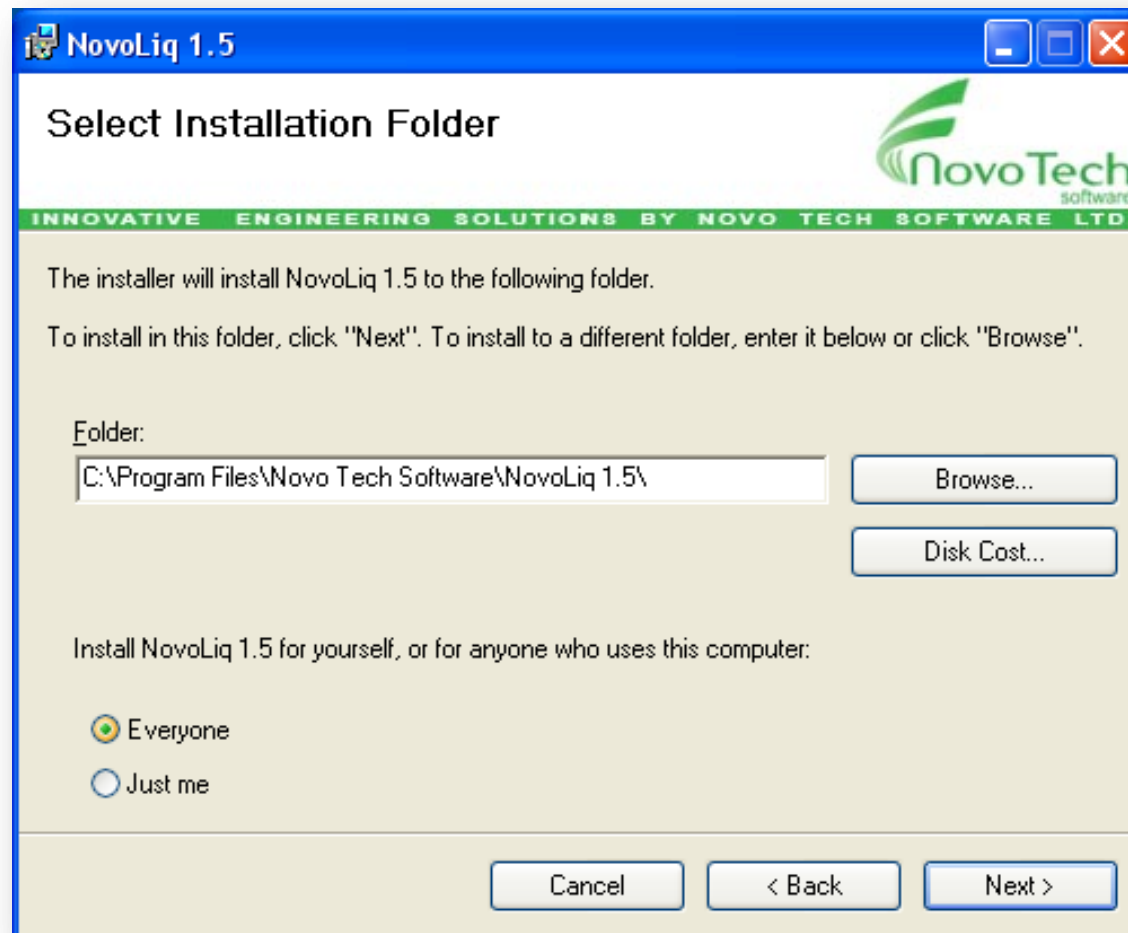
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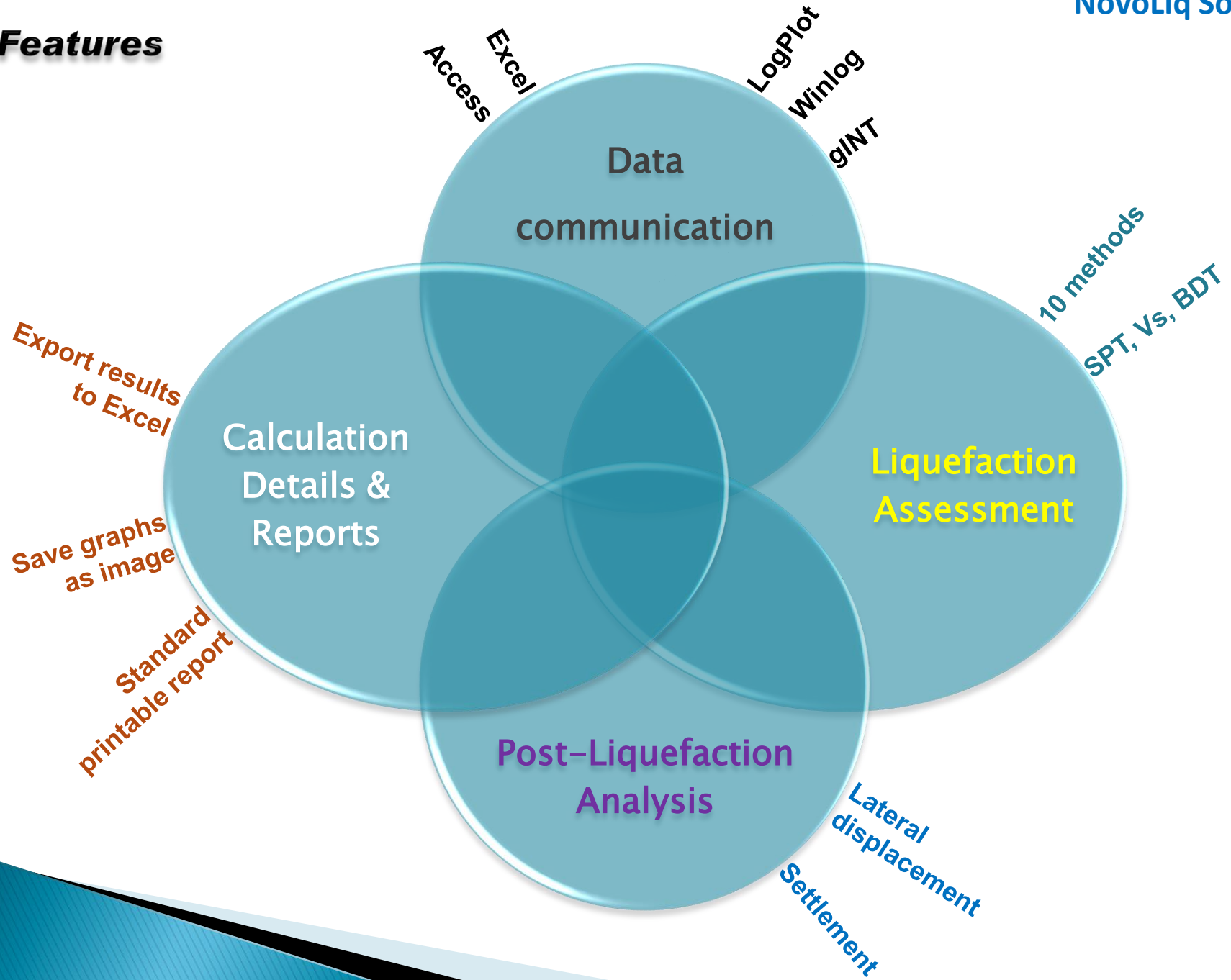
- [SPT Correlation Program \(NovoSPT\)](#)
- [CPT Interpretation Software \(NovoCPT\)](#)
- [Borehole Log Visualization Software \(VisLog\)](#)
- [Lateral Earth Pressure Coefficient Program \(Lateralk\)](#)
- [Beam Section Properties Software \(BeamProps\)](#)
- [Liquefaction Analysis Software \(NovoLiq\)](#)
- [PEYSANJ Geotechnical Software](#)



## Quick and easy installation



**Features**



# Input data for soil liquefaction analysis

**Liquefaction Analysis Program - NovoLiq(ProG) 1.5.0.44 Beta**

File Input Results Tables Tools Help

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**Soil Data** Seismic Data

**Liquefaction Triggering Parameters**

Peak Ground Acceleration (PGA): 0.47 g

Earthquake Magnitude: 7.5

Magnitude Scale Factor (MSF): Seed & Idriss, 1982

Fines Content Correction: Idriss & Seed, 1996 (NCEE)

Depth Reduction Factor (rd): Thomas F. Blake

Cyclic Resistance Ratio (Base CRR1):

- Japanese Highway Bridge Code
- Chinese Code
- Seed et al. (1983)
- Tokimatsu Yoshimi (1983)
- Shibata (1981)
- Kokusho et al. (1983)
- Vancouver Task Force (2007)
- NCEE Workshop (1997)
- Boulanger Idriss (2004)
- Cetin et al. (2004)

**Post-Liquefaction Displacement Parameters**

Please specify site topography: Gently Sloped S (%) = 0.6

Relative density (Dr) estimation method: Idriss & Boulanger, 2003

Free Face L/H =

Distance from fault (km) = 15

**Ground Improvement**

This feature helps you find out the liquefaction potential and post-liquefaction displacements in case of ground improvement in the site. Please specify the depth range in which liquefaction is not susceptible due to ground improvement:

Ground improvement will be carried out

From (m): 0 To (m): 0

**Schematic soil stratigraphy:**

The schematic soil stratigraphy shows a vertical cross-section of the ground. From top to bottom, the layers are: a yellow layer labeled 'CLAY (5.5 m)', a green layer labeled 'SAND (4 m)', an orange layer labeled 'SILT (3 m)', a green layer labeled 'SAND (4.5 m)', and a thick green layer at the bottom labeled 'SAND (20 m)'. A small building icon is shown on the surface above the clay layer.

E:\Programs\NET\\_Components 2010\NovoLiq\bin\Debug\Example1.nliq

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***NovoLiq, provides you with several options:***

## Field Tests

- Standard Penetration Test (SPT)
- Becker Penetration Test (BPT)
- Shear Wave Velocity ( $V_s$ )

## Overburden Correction Methods

- Gibbs and Holtz, 1957
- Peck and Bazaraa, 1969
- Peck, Hanson and Thornburn, 1974
- Seed, 1976
- Tokimatsu and Yoshimi, 1983
- Liao and Whitman, 1986
- Skempton, 1986
- Samson, 1986
- Canadian Foundation Engineering Manual, 2006

## SPT Corrections

- Depth (Overburden) Corrections
- Hammer Energy Correction
- Borehole Diameter Correction
- Rod Length Correction
- Sampling Method Correction
- Water Level Correction

## Becker Conversion

- Harder & Seed
- Alex Sy & Campanella

***NovoLiq, provides you with several options:*****Liquefaction Analysis Methods (CRR)**

- NCEER Workshop (1997)
- Vancouver Task Force (2007)
- Boulanger and Idriss (2004)
- Cetin et al. (2004)
- Japanese Bridge Code
- Chinese Code
- Seed et al. (1983)
- Tokimatsu-Yoshimi (1983)
- Shibata (1981)
- Kokusho et al. (1983)

**Depth Reduction Factor (rd)**

- NCEER Workshop, 1997 recommended
- Thomas F. Blake
- Idriss & Boulanger, 2006
- Kayen et al., 1992
- Cetin et al., 2004

**Silt Content Correction**

- Idriss & Seed, 1997 (NCEER Workshop)
- Robertson & Wride, 1997 (NCEER Workshop)
- Idriss & Boulanger, 2004
- Cetin et al., 2004

**Magnitude Scaling Factor**

- Seed & Idriss, 1982
- Idriss
- Ambraseys, 1988
- Andrus & Stokoe
- Arango, 1996
- Youd & Noble, 1996 Ohba and Toriumi, 1970
- Tokimatsu and Seed, 1987

***NovoLiq, provides you with several options:*****Liq. Lateral Displacement**

- Zhang, Robertson & Brachman, 2004
- Youd et. al., 2002
- Barlett and Youd, 1992
- Hamada et. al., 1986
- Youd and Perkins, 1987

**Probability of Liquefaction**

- Youd and Noble, 2001
- Cetin et al., 2004

**Liq. Settlement**

- Ishihara & Yoshimi, 1992

**Residual Strength**

- Idriss & Boulanger, 2009

***Please see more options in our website ...***

# Import your borehole log/ SPT data from gINT files

## Database structure

The screenshot shows the 'NovoTech SmartSync 1.4.0.11 Beta' application window. It is divided into several sections for configuring data import:

- Project data:** Table: PROJECT, Project title field: GintRecID, Depth unit: m.
- Soil layers data:** Table: LITHOLOGY, Soil symbol field: Graphic, From depth field: Depth, To depth field: (empty).
- In-situ test data:** Test type: SPT. Blow counts and penetrations are stored in:  Separate fields,  Same fields (e.g. 23/15cm).  Consider blow counts more than this, as refusal: 50.  Consider total penetration less than this, as refusal: 0.3.  Remove refusals from dataset. [Preview SPT Data!](#)
- Boreholes data:** Table: POINT, Borehole title field: PointID, Ground water field: GW\_Level (m).
- Coordinates:** Table: POINT, X field: North (m), Y field: East (m), Z field: Elevation (m).
- Table: BLOW\_COUNT:** Depth field: Depth (m). Blow count fields:  Length,  Value. Penetration fields (if applicable):  Length,  Value.
- Available boreholes:** List includes TP09-1 through TP09-6 and AH09-1 through AH09-3. AH09-3 is selected.
- Coordinates:** X = 2055, Y = 1210, Z = 48.
- SPT Data Table:**

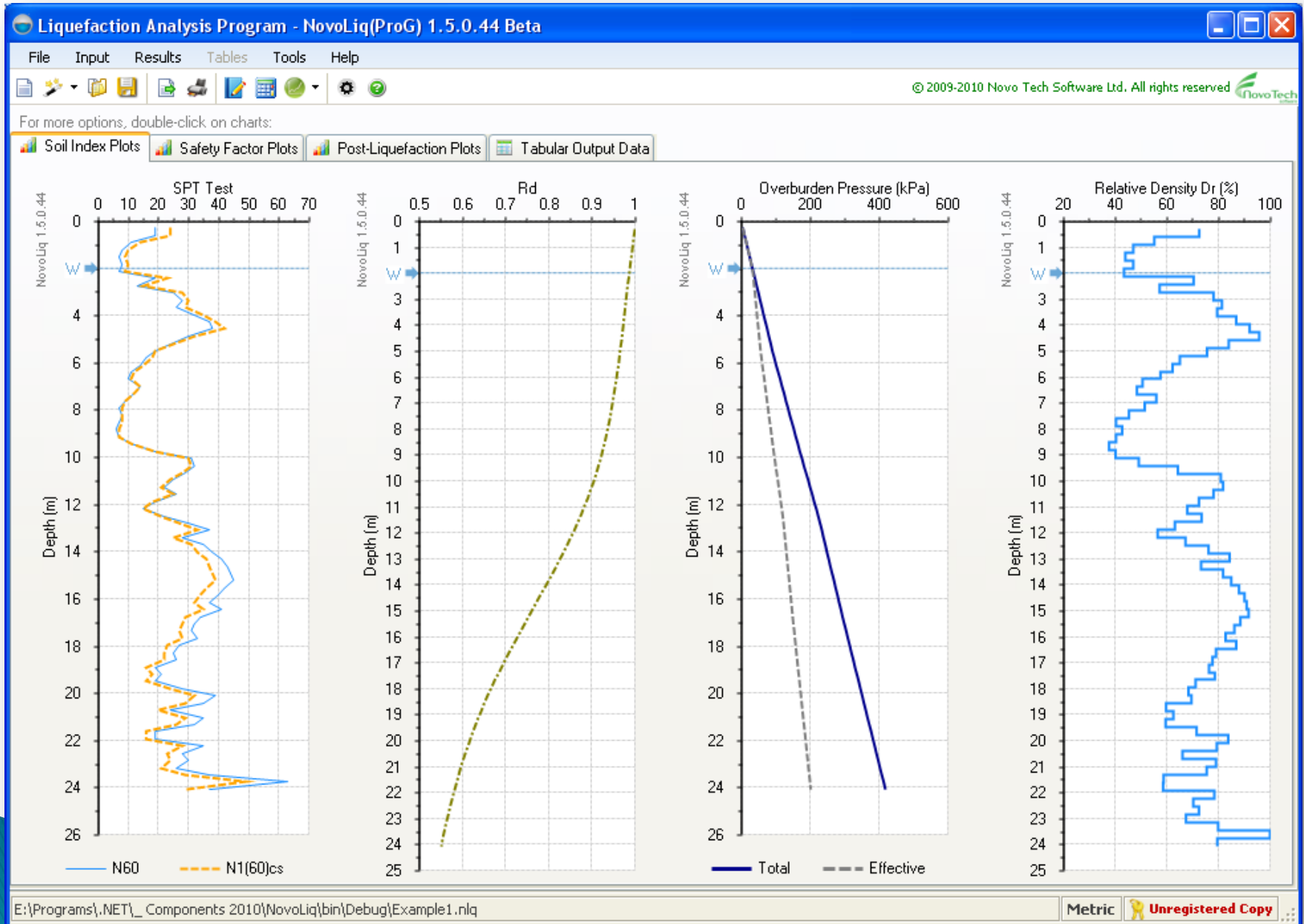
| Depth (m) | N60 |
|-----------|-----|
| 0.3       | 3   |
| 0.6       | 7   |
| 0.9       | 6   |
| 1.2       | 24  |
| 1.5       | 23  |
| 1.8       | 19  |
| 2.1       | 9   |
| 2.4       | 8   |
| 2.7       | 7   |
| 3         | 5   |
| 3.3       | 13  |
| 3.6       | 10  |
- Schematic soil layers and SPT plot:** A vertical plot showing soil layers (CL, ML, TL) and an SPT blow count curve. A red arrow points to the plot.

All type of SPT data storage are supported

Schematic soil layers and SPT plot

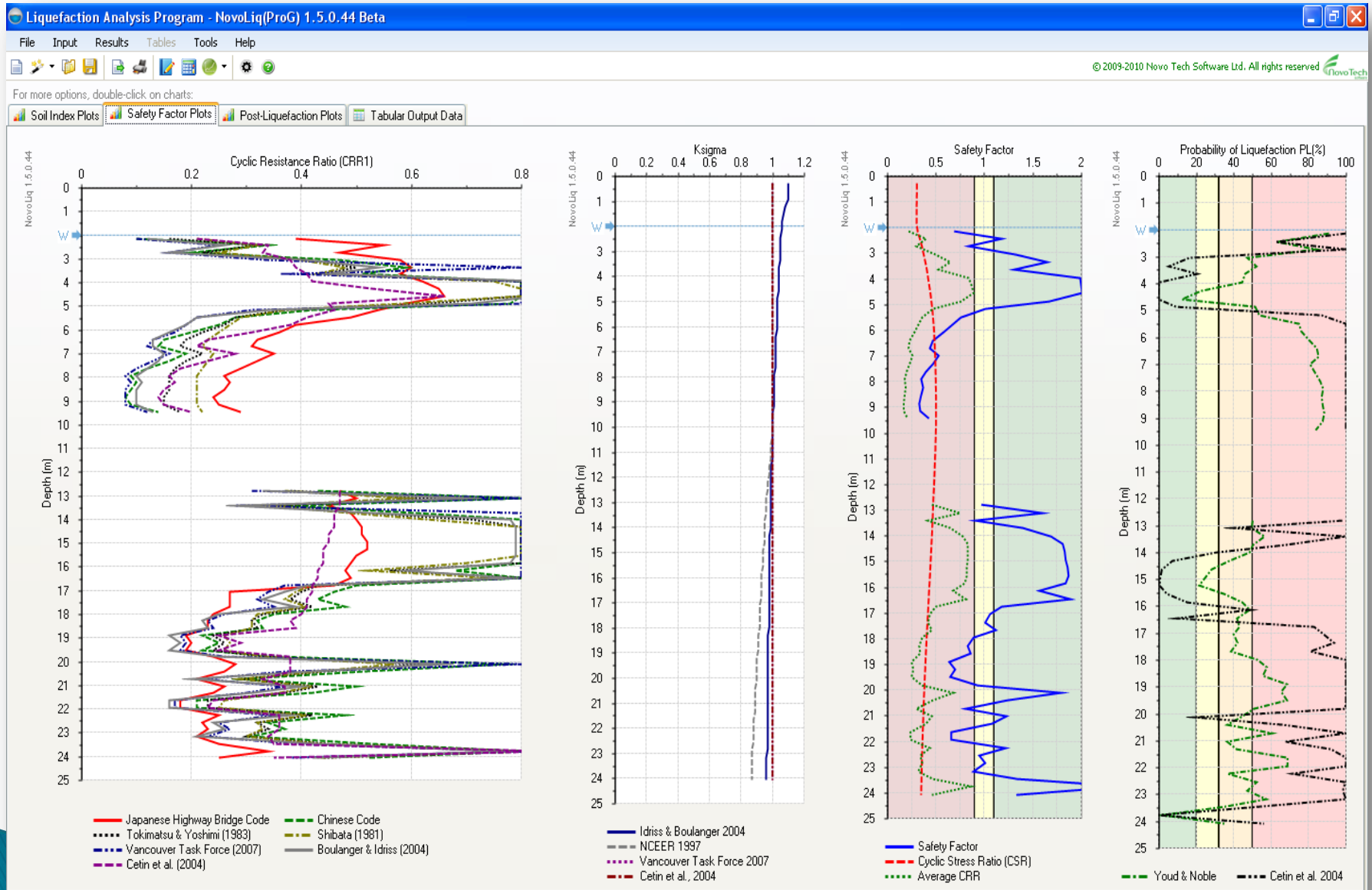
SPT blow counts for selected borehole

# Analysis results include:





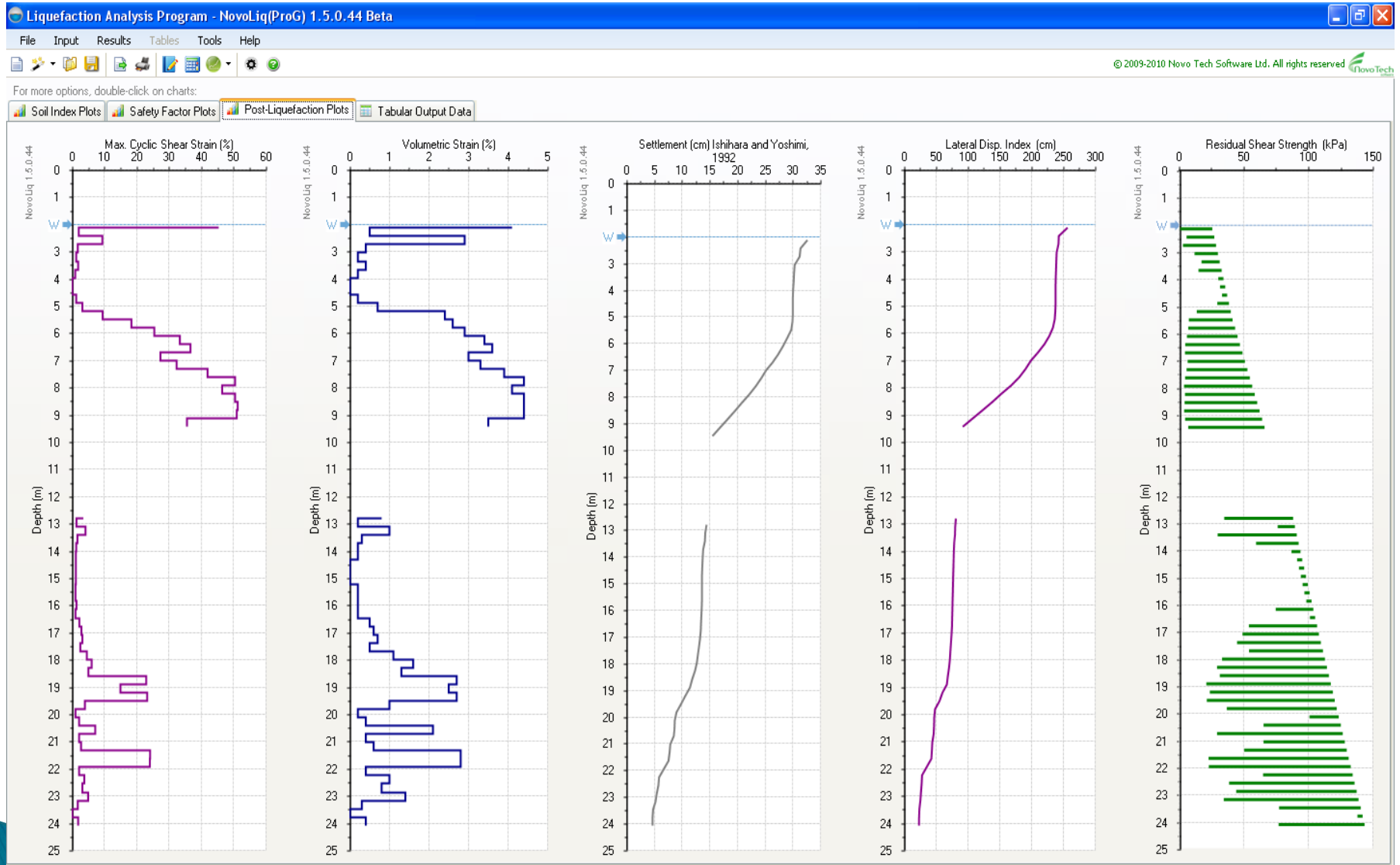
# Analysis results include:



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# Analysis results include:



E:\Programs\MET\\_Components 2010\NovoLiq\bin\Debug\Example1.nli

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# All calculation details are presented as tabular data:

Liquefaction Analysis Program - NovoLiq(ProG) 1.5.0.44 Beta

File Input Results Tables Tools Help

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For more options, double-click on charts:

Soil Index Plots Safety Factor Plots Post-Liquefaction Plots Tabular Output Data

Ksigma Post-Liquefaction Parameters Liquefaction Triggering

Table II : Details of lateral spreading, vertical settlement and residual settlement calculations

| Depth (m) | Max. Cyclic Shear Strain (%) | Volumetric Strain (%) | Lateral Spreading |        | Settlement (cm) |       | Residual Strength Sr (kPa) |             |
|-----------|------------------------------|-----------------------|-------------------|--------|-----------------|-------|----------------------------|-------------|
|           |                              |                       | delta LDI         | LDI    | delta S         | S     | Lower limit                | Upper limit |
| 0.3048    | -                            | -                     | -                 | -      | -               | -     | -                          | -           |
| 0.6096    | -                            | -                     | -                 | -      | -               | -     | -                          | -           |
| 0.9144    | -                            | -                     | -                 | -      | -               | -     | -                          | -           |
| 1.2192    | -                            | -                     | -                 | -      | -               | -     | -                          | -           |
| 1.524     | -                            | -                     | -                 | -      | -               | -     | -                          | -           |
| 1.8288    | -                            | -                     | -                 | -      | -               | -     | -                          | -           |
| 2.1336    | -                            | -                     | -                 | -      | -               | -     | -                          | -           |
| 2.4384    | -                            | -                     | -                 | -      | -               | -     | -                          | -           |
| 2.7432    | -                            | -                     | -                 | -      | -               | -     | -                          | -           |
| 3.048     | -                            | -                     | -                 | -      | -               | -     | -                          | -           |
| 3.3528    | 45.3                         | 4.1                   | 13.8              | 256.46 | 1.24            | 32.63 | 0.8                        | 25.7        |
| 3.6576    | 2                            | 0.5                   | 0.61              | 242.67 | 0.16            | 31.39 | 5.7                        | 27.2        |
| 3.9624    | 9.3                          | 2.9                   | 2.83              | 242.06 | 0.89            | 31.23 | 2.9                        | 28.6        |
| 4.2672    | 1.7                          | 0.4                   | 0.52              | 239.22 | 0.11            | 30.34 | 11.9                       | 30          |
| 4.572     | 1.2                          | 0.2                   | 0.35              | 238.7  | 0.07            | 30.23 | 17.3                       | 31.4        |
| 4.8768    | 1.8                          | 0.4                   | 0.56              | 238.35 | 0.11            | 30.16 | 15                         | 32.9        |
| 5.1816    | 0.9                          | 0.2                   | 0.27              | 237.79 | 0.05            | 30.05 | 30.3                       | 34.3        |
| 5.4864    | 0                            | 0                     | 0                 | 237.52 | 0               | 30.01 | 31.7                       | 35.7        |
| 5.7912    | 0                            | 0                     | 0                 | 237.52 | 0               | 30.01 | 33.2                       | 37.2        |
| 6.096     | 1.2                          | 0.2                   | 0.36              | 237.52 | 0.07            | 30.01 | 29.5                       | 38.6        |
| 6.4008    | 3.1                          | 0.7                   | 0.96              | 237.16 | 0.22            | 29.94 | 13.7                       | 40          |
| 6.7056    | 9.4                          | 2.4                   | 2.87              | 236.2  | 0.73            | 29.72 | 7.5                        | 41.4        |
| 7.0104    | 18.3                         | 2.6                   | 5.57              | 233.33 | 0.78            | 28.99 | 7                          | 43.3        |

Table III : Summary of total estimated lateral and vertical movements

| Type              | Method                 | Movement (cm)                |
|-------------------|------------------------|------------------------------|
| Lateral Spreading | Zhang, Robertson and   | 205                          |
|                   | Youd et al., 2002      | 324                          |
|                   | Barlett and Youd, 1992 | 141                          |
|                   | Hamada et al., 1986    | 238                          |
| Vertical          | Youd and Perkins, 1987 | LSI ~ 48 (see details below) |
|                   | Ishihara and Yoshimi,  | 33                           |

Compare Spreadings Youd & Perkins descriptions

Legend:

- Zhang, Robertson and Brachman, 2004
- Youd et al., 2002
- ◆ Barlett and Youd, 1992
- ▲ Youd and Perkins, 1987

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# Help file for using program features as well as theory manual:

NovoLiq User Manual
\_ □ ×

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  - Cyclic Resistance Rat
    - SPT-Based CRR**
    - BDT-Based CRR
    - Vs-Based CRR
  - Post-Liquefaction

## Liquefaction Assessment Theory - Standard Penetration Test (SPT)

All CRR<sub>1</sub> calculation methods utilized in NovoLiq are described below:

**NCEER (1997) and Vancouver Task Force Report (2007)**

These two methods are very similar expect that in "Vancouver Task Force Report (2007)" a  $K_{\sigma}$  parameter is multiplied in CRR<sub>1</sub>. In these methodologies, CRR<sub>1</sub> is a function of depth corrected SPT blow counts  $N1_{(60)}$  for clean sand (fines content less than 5 percent). For sands containing more fines content, more corrections will be applied on  $N1_{(60)}$ . The CRR<sub>1</sub> curve proposed by these methodologies based on  $N1_{(60)}$  is shown below:

Cyclic Stress Ratio,  $\tau_{av} / \sigma'_{v0}$  vs Corrected Blow Count,  $(N1)_{60}$

Percent Fines = 35 15 5  
CRR curves for 5,15, and 35 percent fines, respectively  
FINES CONTENT  $\geq$  5%  
Modified Chinese Code Proposal (clay content = 5%)

Adjustment Recommended By Workshop  
Pan - American data  
Japanese data  
Chinese data

Marginal Liquefaction  
No Liquefaction

In **NovoLiq**, the equation proposed by Thomas F. Blake (Fugro West Inc., Ventura, California) recommended by NCEER Workshop (1997) for clean sand curve, is used. The factor  $K_{\sigma}$  is calculated from the following formula:

$$K = (\sigma' / P)^{f-1}$$



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