

# NOVO TECH SOFTWARE

## Reference Book

This booklet contains part of the geotechnical correlations and formulas implemented in NovoSPT, NovoCPT, NovoLiq and NovoFormula. For more information please visit our website.

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## Depth Correction Factor (CN)

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

## Other Correction Factors

Borehole diameter (CB)  
 Energy ratio (CE)  
 Rod length (CR)  
 Sampling method (CS)

## Modulus of Elasticity (Es)

AASHTO, 1996 (4 equations)  
 Bowles, 1996 (6 equations)  
 Bowles and Denver, 1982  
 D'Appolonia et al., 1970 (3 equations)  
 Ghahramani and Behpoor, 1989 (saturated clays)  
 Kulhawy and Mayne, 1990  
 Mezenbach, 1961 (7 equations)  
 Papadopoulos, 1992  
 Schultz and Muhs, 1967  
 Skempton, 1986  
 Stroud, 1988  
 Tan et al., 1991 (4 equations)

## Friction angle ( $\theta$ )

Ayuthaya (2 equations)  
 Bowles, 2002  
 Chonburi (2 equations)  
 Duncan, 2004 (3 equations)  
 Dunham, 1954 (3 equations)  
 Hatanaka and Uchida, 1996 (3 equations)  
 Hettiarachchi and Brown, 2009 (2 equations)  
 Japan Road Association, 1990  
 Kampengsen (2 equations)  
 Kulhawy and Mayne, 1990  
 Moh, Chin, Lin and Woo, 1989

Meyerhof, 1959  
 Mezenbach, 1961 (7 equations)  
 Ohsaki et al., 1959  
 Peck et al., 1953  
 Peck, Hanson and Thornburn, 1974  
 Schmertmann, 1975  
 Shioi and Fukui, 1954 (3 equations)  
 Terzaghi, Peck and Mesri (2 equations)  
 Wolff, 1989 (2 equations)

## Relative Density of Sands (Dr)

Cubrinovski and Ishihara, 1999 (4 equations)  
 Gibbs and Holtz, 1957  
 Idriss and Boulanger, 2003  
 Jamiolkowski, 1988  
 Meyerhof, 1957  
 Skempton, 1986  
 Yoshida et al., 1988

## California Bearing Ratio (CBR)

Coonse, 1999  
 Ese, 1995  
 Harison, 1987  
 Kleyn, 1975  
 Livneh, 1987  
 Livneh et al., 1992  
 NCDOT, 1998  
 Webster et al., 1992

## Un-drained Shear Strength (Su)

Ajayi and Balogun, 1988  
 Bowles, 1988  
 Decourt, 1989  
 Ghahramani and Behpoor, 1989  
 Hara et al., 1974  
 Hatef and Keshavarz, 2004  
 Hettiarachchi and Brown, 2009  
 Japanese Road Association  
 Kulhawy and Mayne, 1990  
 Meyerhof, 1956  
 Peck et al., 1974  
 Reese, Touma and O'Neill, 1976

Stroud, 1974  
Stroud, 1989  
Stroud and Butler, 1975  
Sowers, 1979  
Tavares, 1988  
Terzaghi and Peck, 1967

## Shear Wave Velocity ( $V_s$ )

Andres Alfaro, 2007 (2 equations)  
Athanasopoulos, 1995  
Baziar, Fallah, Razeghi and Khorasani, 1998  
Fujiwara, 1972  
Hasancebi and Ulusay, 2007 (3 equations)  
Imai, 1977 (3 equations)  
Imai and Tonouchi, 1982  
Imai and Yoshimura, 1970  
Imai and Yoshimura, 1975  
Imai et al., 1975  
Iyisan  
Jafari et al., 1997  
Jafari, Shafiee and Razmkhah, 2002 (3 equations)  
Japan Road Association, 1980  
Jinan, 1987  
Kanai et al., 1966  
Kiku et al., 2001  
Lee, 1990 (3 equations)  
Lee, 1992 (2 equations)  
NCREE (Taiwan)  
Ohba and Toriumi, 1970  
Ohta and Goto, 1978 (8 equations)  
Ohta et al., 1972  
Ohsaki and Iwazaki, 1973 (2 equations)  
Okamoto et al., 1989  
Pitilakis, 1999  
Schmermann, 1978  
Seed et al., 1983  
Seed and Idriss, 1981  
Sisman, 1995  
Shibata, 1970  
Sykora and Stokoe, 1983  
Tomio Inazaki, Public Works Research Institute of Japan, 2006  
Tamura and Yamazaki, 2002  
Ulegergerli and Uyanik, 2004

Unal Dikmen, 2008 (4 equations)  
Yokota et al., 1991

## Shear Modulus ( $G_{max}$ )

Anbazhagan, Sitharam and Diryac, 2007 (4 equations)  
Imai and Tonouchi, 1982  
Ohsaki and Owasaki, 1973  
Randolph, 1981  
Seed, Idriss and Arango, 1983  
Seed et al., 1986 (2 equations)  
Wroth et al., 1979

## Liquefaction Cyclic Resistance Ratio (CRR)

Idriss and Boulanger (University of California at Davis), 2004  
Chinese Code  
Kokusho  
NCEER, 1977  
Seed et al.  
Shibata  
Tokimatsu

## Bearing Capacity of Shallow Foundations

Bowles, 1976  
Burland and Burbidge, 1985  
Parry, 1977  
Peck et al., 1974  
Terzaghi

## Settlement of Shallow Footings ( $S$ )

Alpan, 1964  
Anagnostopoulos et al., 1991  
Burland and Burbidge, 1985  
Duncan and Buchignani, 1976  
Modified Meyerhof, 1965  
Modified Meyerhof (based on Terzaghi and Peck)

Peck and Bazaraa, 1969  
Peck, Hanson and Thornburn, 1974  
Terzaghi and Peck, 1967

## **Soil Consistency**

Terzaghi and Peck, 1948  
AASHTO, 1988

## **Becker Penetration Test BPT (equivalent values)**

Alex Sy and Campanella, 1994  
Harder and Seed, 1986

## **Pile Skin and End Bearing**

Detta et al., 1980  
GEO, 1996 and Yau, 2000  
Meyerhof, 1976 (4 equations)  
O'Neill and Hassan, 1994  
Quiros and Reese, 1977  
Reese and O'Neill, 1988 (2 equations)  
Reese and Wright, 1977 (2 equations)  
Yves Robert, 1997

## **Compressibility Factor (mV)**

Stroud, 1989 (2 equations)

## **Normalized Dilation Angle ( $v_1$ )**

D. Roy, J. Hughes and R.G. Campanella

## **Pressuremeter Modulus ( $E_m$ , PL)**

Bozbey and Togrol, 2009 (4 equations)  
Chiang and Ho, 1980 (2 equations)  
Ohya et al., 1982  
Yagiz et al., 2008 (2 equations)

## **Saturated Unit Weight**

Kulhawy and Mayne, 1990 (2 equations)

## **OCR**

Mayne and Kemper, 1984

## **Wildcat and Durham DCP Conversion**

J. Fred Triggs, Paul D. Simpson, 1990

## **Modulus of Subgrade Reaction ( $K_{s30}$ )**

Zhang and Wang

## **Initial Modulus of Stiffness ( $G_0$ , E)**

FHWA, 2002  
Sandroni, 1991  
Schnaid et al., 2004 (2 equations)  
Seed et al., 1986

## Hydraulic Conductivity K

Robertson et al., 1986

## Shear Strength Su

Nk

Nkt

Nke

## Clay Sensitivity (St)

Robertson and Campanella, 1988

Rad and Lunne, 1986

Schmertmann

## Clay Un-drained Young's Modulus (Es)

Duncan and Buchihmami 1976

## Sand Young's Modulus Es

Bellotti et al., 1989

## Sand Internal Friction Angle ( $\theta$ )

Hatanaka and Uchida, 1996

Kulhawy and Mayne, 1990

Mayne, 2005

Robertson and Campanella, 1983

Sunnset et al., 1989

## Depth Correction Factor Rd

Seed and Idriss, 1971 (tri-linear function)

## Soil Behavior Type Index (Ic)

Robertson, 1990

## Constrained Modulus M

Robertson, 2009

## Equivalent SPT N60

Jefferies and Davis, 1993

## Overconsolidation Ratio (OCR)

Lunne et al., 1989

Mayne, 2005

Powel et al., 1998

## Sand Relative Density (Dr)

Jamiolkowski et al., 1985

Baldi et al., 1986

Tatsuoka, 1990

## Shear Wave Velocity (Vs)

Baldi, 1989 (sands) and Mayne and Rix, 1995 (clays)

Hegazy and Mayne, 1995 (all soils)

Mayne, 2006c (all soils)

## Fines Content Fc

Robertson and Fear 1995 ( $FC=1.75^{*}IC3-3.7$ )

## Void ratio e

$e = 1.152 - 0.233 \text{ Log}(qc1) + 0.043 \text{ Log}(OCR)$

## Magnitude Scaling Factor (MSF)

Robertson, 2009

## Unit Weight

Robertson et al., 1986

## Clay At-rest Earth Pressure Ko

Kulhawy and Mayne, 1990

## Sand At-rest Earth Pressure Ko

Kulhawy and Mayne, 1990

## CRR Methods

Boulanger and Idriss (2004)  
 Cetin et al. (2004): Probabilistic and Deterministic Assessment  
 Chinese Code  
 Japanese Highway's Bridge Code  
 Kokusho et al. (1983)  
 NCEER Workshop (1997 United States)  
 Seed et al. (1983)  
 Shibata (1981)  
 Tokimatsu and Yoshimi (1983)  
 Vancouver Task Force (2007 Canada)

Simplified Seed and Idriss (1971) method for Cyclic Stress Ratio CSR

## Stress Reduction Factor ( $K_\sigma$ )

Cetin et al. 2004  
 Idriss and Boulanger 2004  
 NCEER 1997 Workshop  
 Vancouver task force 2007

## BDT to SPT Conversion

Alex Sy and Campanella (considers friction)  
 Harder and Seed

## SPT Overburden Correction ( $C_n$ )

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

## Shear Wave Velocity

Robertson et al., 1992

## Fines Content Correction

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

## Relative Density Dr

Idriss and Boulanger, 2003  
 Gibbs and Holtz, 1957  
 Meyerhof, 1957  
 Skempton, 1986  
 Yoshida, 1988

## Post Liq. Residual Strength Sr

Idriss and Boulanger, 2009

## SPT Corrections

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

## Probability of Liquefaction (PL)

Cetin et al., 2004  
 Youd and Noble, 2001

## Magnitude Scaling Factor (MSF)

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

## Post Liquefaction Settlements

Cetin et al., 2004  
 Depth Reduction Factor (Rd)  
 Idriss and Boulanger, 2006  
 Kayen et al., 1992  
 NCEER Workshop, 1997  
 Thomas F. Blake  
 Wu (Ishihara), 2002

## Post Liq. Lateral Displacement

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

## Consolidation Compression Index (Cc)

Al-khafaji & Andersland, 1992  
 Azzouz et al., 1976 (6 equations)  
 Bowles, 1989 (3 equations)  
 Carrier, 1985  
 Cozzolino, 1961 (3 equations)  
 Herrero, 1980 (3 equations)  
 Hough, 1957 (2 equations)  
 Koppula, 1981 (2 equations)  
 Koppula, 1986  
 Mayne, 1980  
 Moh, Chin, Lin & Woo, 1989 (2 equations)  
 Nacci et al., 1975  
 Nagaraj & Murthy, 1983 (3 equations)  
 Nagaraj et al., 1995  
 Nakase et al., 1988 (8 equations)  
 Nishant Dayal et al., 2006  
 Nishida, 1956 (3 equations)  
 Park & Koumoto, 2004 (2 equations)  
 Rendon & Herrero, 1983 (2 equations)  
 Shorten, 1995  
 Shouka, 1964  
 Skempton, 1944  
 Sowers, 1970  
 Sridharan & Nagaraj, 1999  
 Terzaghi & Peck, 1967  
 Tsuchida, 1991 (2 equations)  
 Worth & Wood, 1978 (2 equations)  
 Yamagutshi, 1959  
 Yoon et al., 2004 (15 equations)

## Consolidation Recompression Index (Cs)

Nagaraj & Srinivasa Murthy, 1985  
 Nakase et al., 1988

## Resilient Modulus of Soil (Er)

AASHTO, 1993  
 Angell, 1988  
 Corney & Corney, 1991  
 Heukelom & Klomp, 1998

NAASRA, 1950 (3 equations)  
 Powell, Potter, Mayhew & Nunn, 1984  
 Queensland Main Roads, 1988

## Soil Friction Angle ( $\theta$ )

Kulhawy & Mayne, 1990  
 Meyerhof, 1956

## Hydraulic Conductivity (K)

Chapuis, 2004  
 Hazen, 1911 (3 equations)  
 Kozeny  
 Kruger  
 Moh, Chin, Lin & Woo, 1989  
 NAVFAC: Chapuis et al., 1989  
 Terzaghi

## At-rest Earth Pressure Coefficient ( $K_0$ )

Alpan, 1967  
 Brooker & Ireland, 1965 (5 equations)  
 Holtz & Kovacs, 1981  
 Jacky  
 Massarsch, 1979

## Undrained Shear Strength ( $S_u$ )

Bjerrum & Simons, 1960 (2 equations)  
 Karlsson & Viberg, 1967  
 Skempton & Henkel, 1953

and 40 more correlations ...



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