



COMUNE DI CERVIA

Provincia di Ravenna

Settore Programmazione e Gestione del Territorio



Il Sindaco

Dott. Luca Coffari

L'Assessore all'Urbanistica

Arch. Natalino Giambi

Il Dirigente del Settore

Ing. Daniele Capitani

Il Servizio Urbanistica

Geom. Gianluca Magnani

Ing. Annalena Arfelli

Geom. Elena Taffagi

Arch. M. Laura Callegati

Nadia Nicolini



Quadro Conoscitivo



Adottato con DCC n. del

Approvato con DCC n. del

Oggetto

Scala

Elaborato

Verifiche di liquefacibilità Fascia costiera

H2



**DIRIGENTE DEL SETTORE PROGRAMMAZIONE E GESTIONE DEL TERRITORIO**

Ing. Daniele Capitani

SERVIZIO URBANISTICA

Geom. Gianluca Magnani

Ing. Annalena Arfelli

Arch. M. Laura Callegati

Geom. Elena Taffagli

Nadia Nicolini

COLLABORATRICE: Arch. Margherita Bastoni

GRUPPO DI LAVORO:

ATI composta da: Tecnicoop soc. coop.va; Arch. Carla Ferrari; Arch. Giuseppe Campos Venuti (QUADRO CONOSCITIVO ANNO 2013)

Arch. Carlo Lazzari (INDAGINE STORICA)

Arch. Sandra Vecchietti (DPQU)

Ing. Simona Savini (DPQU)

Dott. Geol. Fabbri Fabio (RISCHIO IDRAULICO)

Dott. Geol. Carlo Copioli (ZONAZIONE SISMICA ARENILE)

Dott. Geol. Samuel Sangiorgi (ZONAZIONE SISMICA)

Dott. For. Paolo Rigoni – Studio Silva Srl (PIANO DI FRUIZIONE DEL SIC/ZPS IT4070007" SALINA DI CERVIA")

Dott. Loris Venturini (CLASSIFICAZIONE ACUSTICA)

Ing. Chiara Semprini (VALSAT ARENILE)

APPORTI SPECIALISTICI SERVIZI COMUNALI

Edilizia Privata, Progettazione Infrastrutture e Mobilità Sostenibile, Viabilità e Manutenzione Infrastrutture, Progettazione e Manutenzione Fabbricati, Sviluppo Economico - Parco della Salina, Ambiente, SUAP, Protezione civile, Verde, Demografici, Demanio e Porto, Patrimonio, Turismo, Servizi alla persona, Servizi alla comunità, Progettazione culturale, Politiche educative, Tributi, Polizia municipale

ENTI E SOCIETA' DI SERVIZI

ANAS, Agenzia del Territorio Ravenna, ARPAE, Autorità Bacini Regionali Romagnoli, AUSL, CER, Consorzio di Bonifica della Romagna, ENEL, FF.SS., HERA Ravenna, Provincia di Ravenna, Regione Emilia Romagna, Romagna Acque, Servizi Tecnici di Bacino, SNAM, TERNA, Soprintendenza per i beni architettonici e per il paesaggio

COMUNE DI CERVIA

PROVINCIA DI RAVENNA

STUDIO GEOLOGICO E DI MICROZONIZZAZIONE SISMICA DI III LIVELLO
DI APPROFONDIMENTO PER L'ADEGUAMENTO DEL PIANO
DELL'ARENILE DEL COMUNE DI CERVIA ALLA L.R. 9/2002 E ALLE
DISPOSIZIONI DELLA DELIBERA DELLA REGIONE
EMILIA-ROMAGNA N. 468/2003



RELAZIONE GEOLOGICA

ELABORATO 2 - VERIFICHE DI LIQUEFACIBILITA'

Dott. Geol. Carlo Copioli

Collaboratore: Dott. Geol. Fabio Vannoni



GEOPROGET

Studio di Geologia
via Ceccarini, 171 - Palazzo La Viola
Riccione - 47838 - (RN) Tel/Fax 0541/606464
E-MAIL vannoni.fabio1960@libero.it
copiolicarlo@libero.it

Rif.2198 - Maggio 2016

ALLEGATO N.1

**"VERIFICHE DI CALCOLO DEL POTENZIALE DI LIQUEFACIBILITÀ CON
MAGNITUDO MW = 5,50 "**



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CPT-based liquefaction triggering analysis for a single sounding

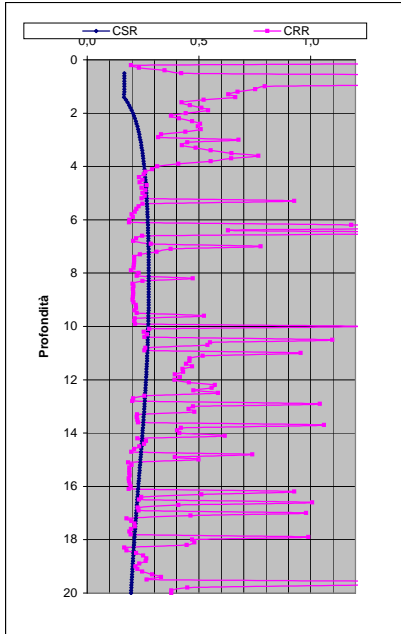
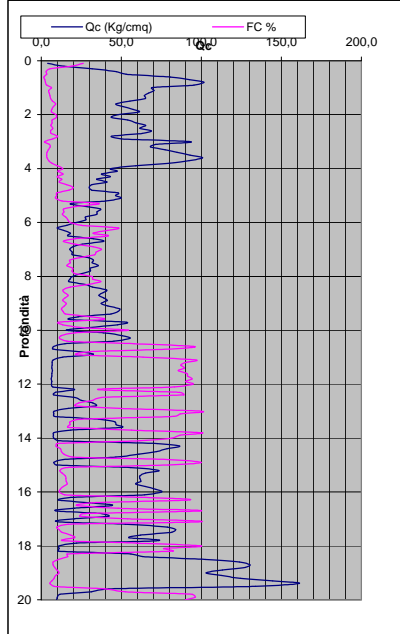
Environmental parameters, soil classification, and various probability and susceptibility charts for liquefaction analysis.

Main data table with columns for Depth (m), Soil Classification, and various geotechnical parameters like q_v, q_u, F, I_c, etc.

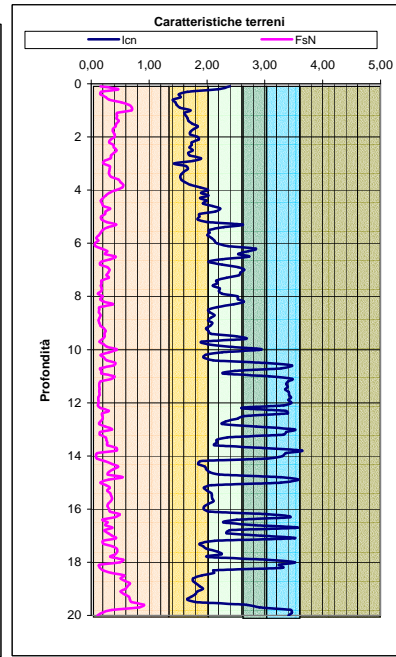
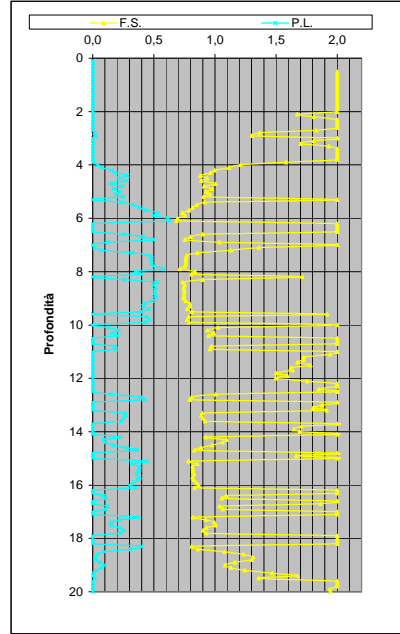
Main data table with columns for Depth (m), Soil Classification, and various geotechnical parameters like q_v, q_u, F, I_c, etc.

Summary table with key values: LDI = 2,679; Stot = 0,251 (m); IPL = 6,35; PL = 15,33; LD = 0,00 (m); PG = 0,45; SLiq = 8,0 (m); LSN = 27,7.

DIAGRAMMI DI RIFERIMENTO VERIFICA LIQUEFAZIONE - METODO R. & W. , 2009



PROVA CPT E 1



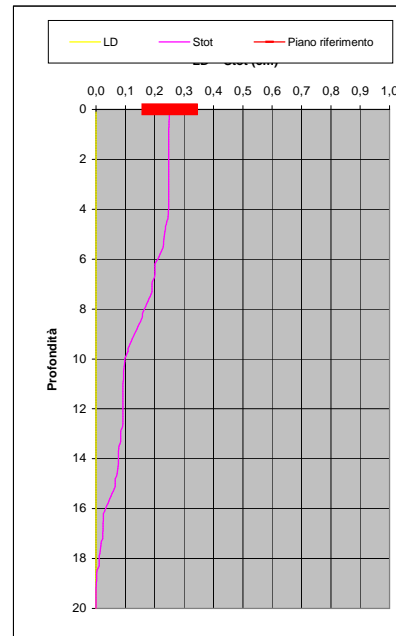
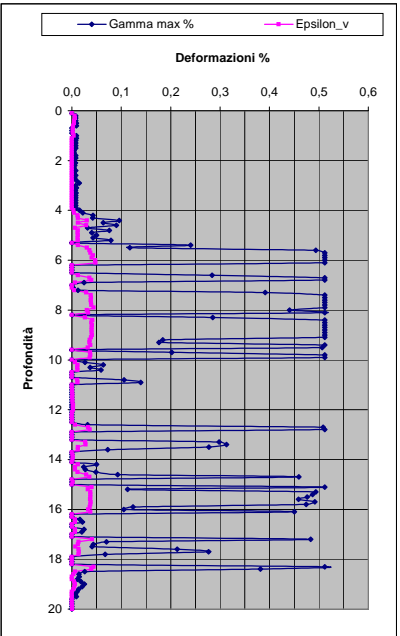
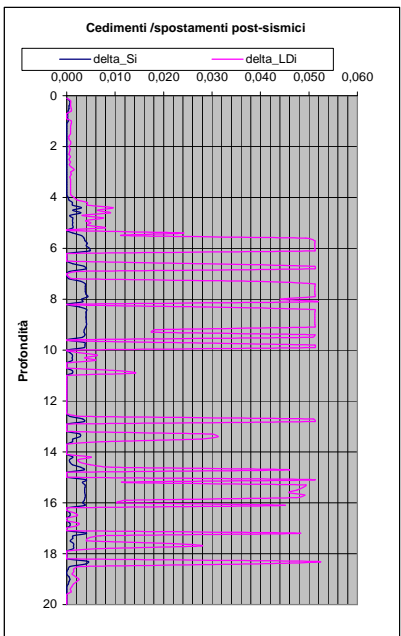
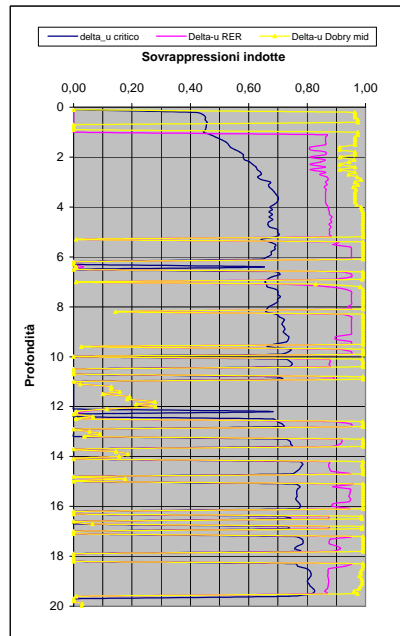
Soil Classification	Zone No.*	Range of CPT Index I_c Values
Organic Clay Soils	2	$I_c > 3.60$
Clays	3	$2.95 < I_c < 3.60$
Silt Mixtures	4	$2.60 < I_c < 2.95$
Sand Mixtures	5	$2.05 < I_c < 2.60$
Sands	6	$1.31 < I_c < 2.05$
Gravelly Sands	7	$I_c < 1.31$

After Robertson and Wride (1998).
*Note: Zone number per Robertson SBT (1990).

- Argille - terreni organici
- Argille - argilla/argilla limosa
- Miscela di limi - limo argilloso/argilla limosa
- Miscela di sabbie - sabbia limosa/limo sabbioso
- Sabbie - sabbie pulite/sabbie limose
- sabbie ghiaiose / sabbie dense

LEGENDA

- Qc** = Res. alla penetraz. (Kg/cmq)
- FC** = Fine content - passante 0.074 mm (%)
- FsN** = Attrito laterale (Kg/cmq)
- F** = rapporto di frizione
- Qtn** = parametro di resist. alla punta normal.
- Icn** = Soil behaviour index normalized (ad)
- qc1N-cs** = Resist. alla pentrez. corretta all'FC e normalizzata
- ξ = parametro di stato
- KH** = fatt. correttivo per spessore strato (ad)
- Rd** = stress reduction coefficient (ad)
- CN** = fattore di normalizzazione per carico litostatico (ad)
- K σ** = fatt. correttivo per sovraccarico-profondità (ad)
- K α** = fatt. correttivo per sforzi di taglio (ad)
- MSF** = magnitudo scaling factor (ad)
- F.S.** = Fattore di sicurezza (CRR/CSR con correzioni) (ad)
- CSR** = Cyclic Stress ratio (ad)
- CRR** = Cyclic Resistance Ratio (ad)
- P.L.** = Probabilità di liquefazione (ad)
- IPL** = Indice del potenziale di liquefazione (ad)
- γ_{max}** = deformazione di taglio massima indotta dal sisma (%)
- ev** = vertical reconsolidation strain
- Δs_i** = cedimento i-esimo dello strato (mt)
- Su** = S_u / σ'_{vc} resistenza totale non drenata - strati coesivi (ad)
- Sur** = S_{ur} / σ'_{vc} resistenza totale residua non drenata - strati coesivi (ad)
- qc1N-sr** = Resist. alla pentrez. corretta all'FC e normalizzata
- Sr** = S_r / σ'_{vc} resistenza residua - strati incoerenti (ad)
- Ruc** = $\Delta u / \sigma'_{vc}$ critico - stima sogliadi innesco fenomeni di instabilità/liquefazione
- Δu RER = $\Delta u / \sigma'_{vc}$ sovrappressioni circ. 112/2007 - tabella 2 R.E.R.
- Δu Dobry M. = $\Delta u / \sigma'_{vc}$ Dobry et al. 1984 "mean" x sabbie-Robertson '09 x argille
- Δu Dobry L. = $\Delta u / \sigma'_{vc}$ Dobry et al. 1984 "lower bound" x sabbie-Robertson '09 x argille
- Δu Dobry U. = $\Delta u / \sigma'_{vc}$ Dobry et al. 1984 "Upper bound" x sabbie-Robertson '09 x argille
- Stot** = Cedimento post-sismico totale (mt)
- LDI** = Lateral Displacement Index (mt)
- Dr** = Densità relativa (ad)
- ϕ = angolo di attrito interno (deg)
- OCR** = rapporto di sovraconsolidazione (sabbie e argille) (ad)
- St** = coefficiente di sensitività delle argille (ad)
- LSN** = Liquefaction Severity Number (ad)



IPL = 6,35

PL = 15,33

LDI = 2,679 Stot = 0,251 (mt)

LD = 0,00 (mt)

SLiq = 8,00 (mt)

LSN = 27,66 PG = 0,45

LSN Range	Expected ground surface damage
0-10	Little to no expression of liquefaction, minor effects
10-20	Minor expression of liquefaction, some sand boils
20-30	Moderate expression of liquefaction, with some sand boils and structural damage
30-40	Moderate to severe expression of liquefaction, settlement can cause structural damage
40-50	Major expression of liquefaction, undulations and damage to ground surface, severe total and differential settlements of structures
>50	Severe damage, extensive evidence of liquefaction at surface, severe total and differential settlements affecting structures, damage to services.

* Table based on Table 13.1 from I&T report: Liquefaction Vulnerability Study

Probability	Description of the risk of liquefaction-induced ground failure
$0.9 < P_G$	extremely high to absolutely certain
$0.7 < P_G \leq 0.9$	high
$0.3 < P_G \leq 0.7$	medium
$0.1 < P_G \leq 0.3$	low
$P_G \leq 0.1$	extremely low to none

CPT-based liquefaction triggering analysis for a single sounding

Enviromenti: C Hill-H Plain-P Coast-C Behaviours: E Sand like-S

Computer constants: no. n: 1.0; Patm: 101.32; cov=0.35-35%; MSF NCEER: 1; MSF ANDRUS: 1; MSF SID: 1; MSF C: 1

Probabilità e potenziale di liquefazione: Probabilità: 0.943; Pot di Liq: IPL-15

Probabilità e suscettibilità di liquefazione: Probabilità: 0.943; Suscettibilità: Quasi certa

PL Overall Probability: Risk lev. IPL: 15; PL: 54

Robertson & Wride, agg. 2009

PROVA "CPTE 2"



Severe Damage: >50; Major expr: 40-50; Moderate to Sev: 30-40; Moderate: 20-30; Mild: 10-20; Little to No: 0-10

Table with columns for input parameters (Peak ground accel, Earthquake magnitude, Water table depth, etc.), soil classification, and various probability and liquefaction parameters.

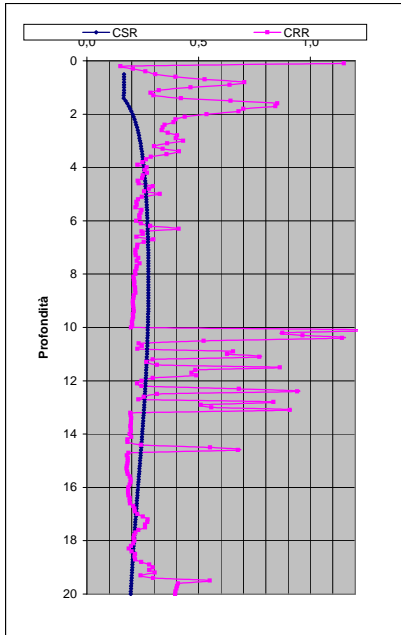
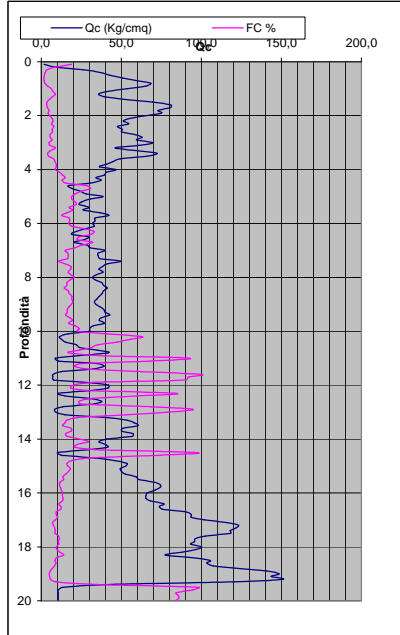
Table with columns for depth (m), soil type, and various soil parameters (qc, q, fs, etc.) and liquefaction parameters (FS, etc.).

PROFONDITA' DI CALCOLO (mt da p.c.): 0,0; LDI = 3,884; Stot = 0,343 (mt); IPL = 7,92; PL = 20,34; LD = 0,00 (mt); PG = 0,71; SLiq = 10,1 (mt); LSN = 36,2

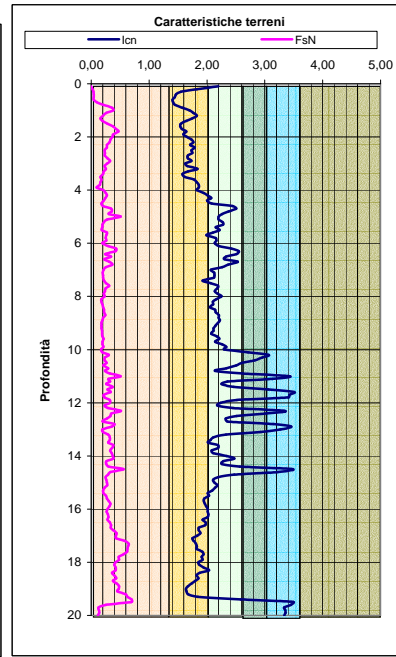
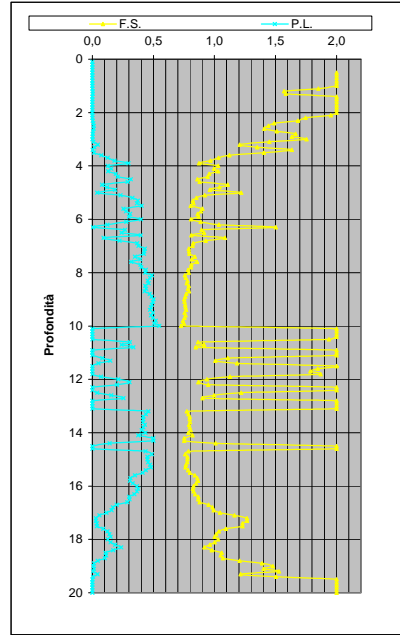
Main data table with columns for depth (m), soil type, and various soil parameters (qc, q, fs, etc.) and liquefaction parameters (FS, etc.) for each sounding.

Final summary row for the data table.

DIAGRAMMI DI RIFERIMENTO VERIFICA LIQUEFAZIONE - METODO R. & W. , 2009



PROVA CPT2



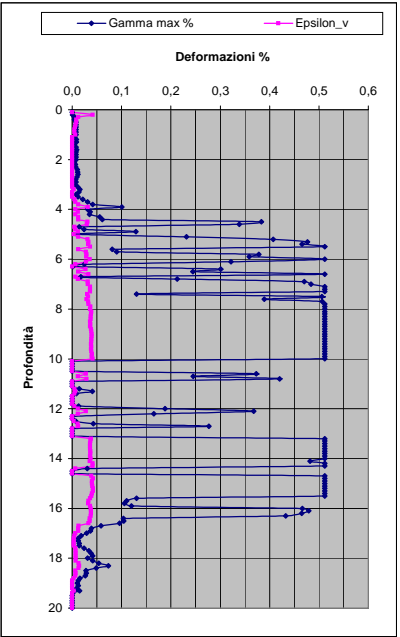
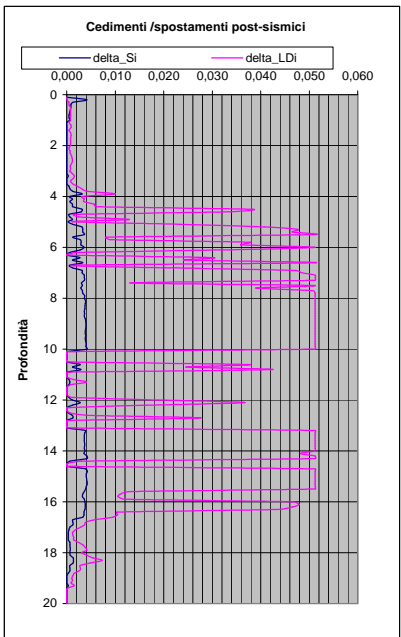
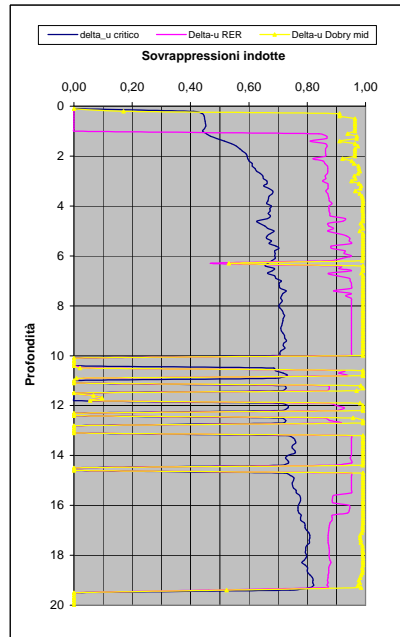
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$P_G \leq 0.1$	extremely low to none

IPL = 7,92 PL = 20,34 LDI = 3,884 Stot = 0,343 (mt) LD = 0,00 (mt) SLiq = 10,10 (mt) LSN = 36,17 PG = 0,71

CPT-based liquefaction triggering analysis for a single sounding

Enviroments: Hill-H Plain-P Coast-C Behaviours: Sand like-S

Computer constants: (B' 2007 - Cefin 2004 - NCEER - Blake) alpha (N) = 1.0 MSF NCEER

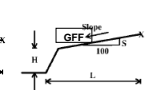
Probabilità e potenziale di liquefazione

Probabilità e suscettibilità di liquefazione

PL Overall Probability

Robertson & Wride, agg. 2009

PROVA "CPTE 3"

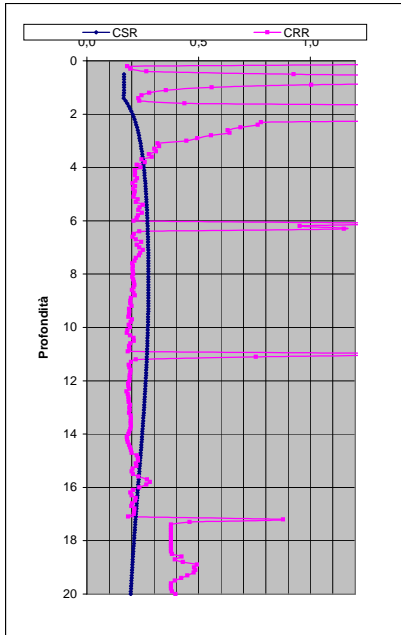
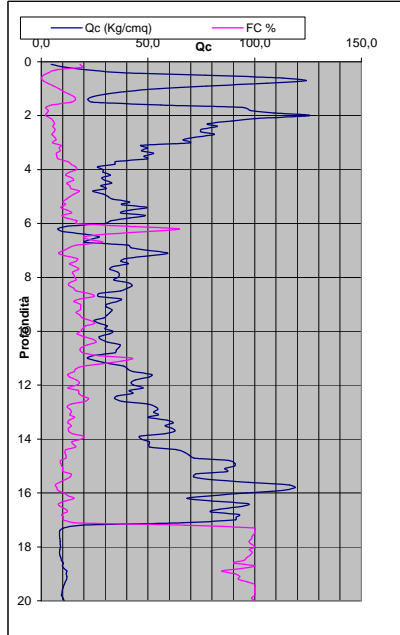


Potential flow failure if (N) q_c < 1.0 and (q) q_{c1N} < 0.5 No flow liquefaction if (q) q_{c1N} < 0.5

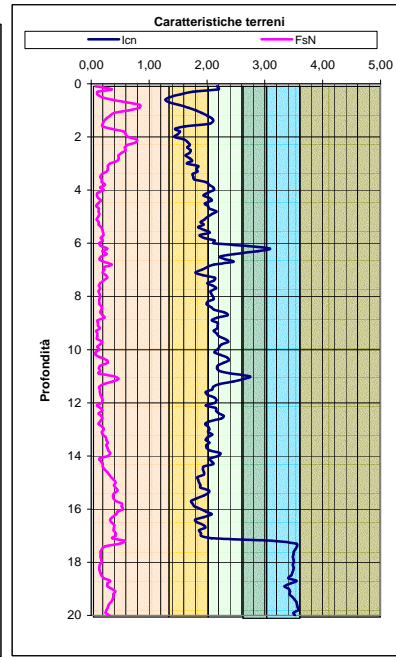
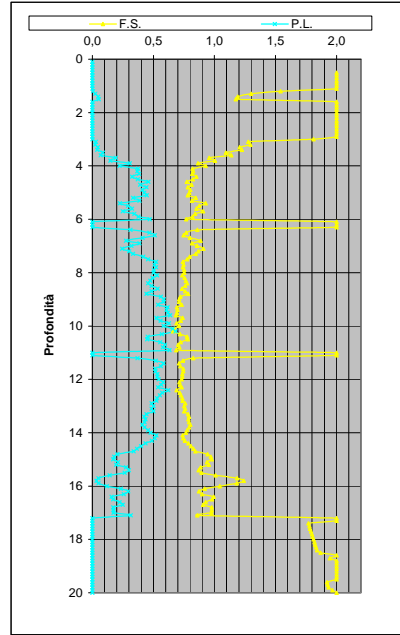
Table with columns for input parameters (Peak ground accel, Earthquake magnitude, Water table depth, etc.), soil classification, and various probability and liquefaction indices (PL, LDI, Stot, etc.).

Main data table with columns for Depth (m), q_c (kPa), q_{c1N} (kPa), and various soil parameters. The table contains 101 rows of data, with some cells highlighted in red and green.

DIAGRAMMI DI RIFERIMENTO VERIFICA LIQUEFAZIONE - METODO R. & W. , 2009



PROVA CPTE 3



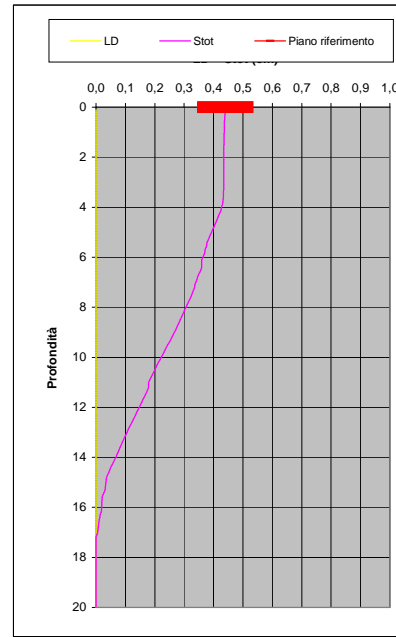
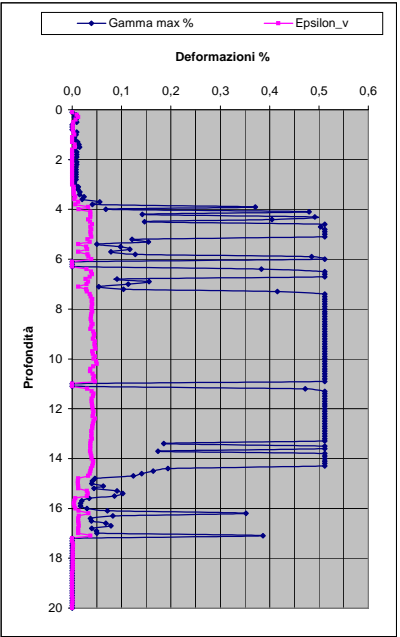
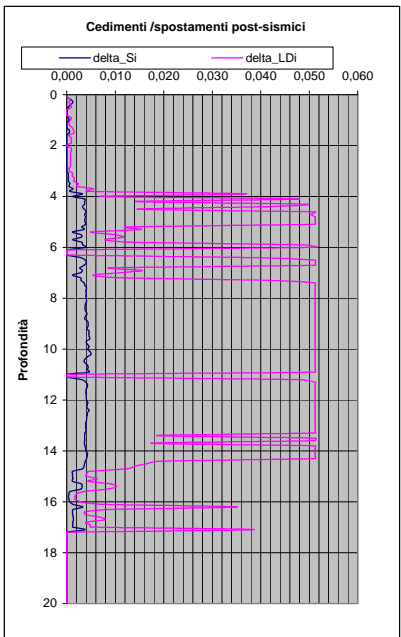
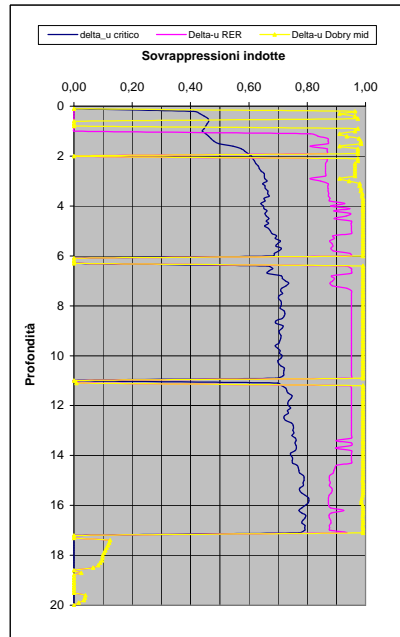
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- Δu Dobry U. = $\Delta u / \sigma'_{vc}$ Dobry et al. 1984 "Upper bound" x sabbie-Robertson '09 x argille
- Stot** = Cedimento post-sismico totale (mt)
- LDI** = Lateral Displacement Index (mt)
- Dr** = Densità relativa (ad)
- θ = angolo di attrito interno (deg)
- OCR** = rapporto di sovraconsolidazione (sabbie e argille) (ad)
- St** = coefficiente di sensitività delle argille (ad)
- LSN** = Liquefaction Severity Number (ad)



IPL= 12,49 PL= 40,86 LDI = 4,678 Stot = 0,440 (mt) LD = 0,00 (mt) SLiq = 12,40 (mt) LSN = 51,02 PG= 0,98

LSN Range	Expected ground surface damage
0-10	Little to no expression of liquefaction, minor effects
10-20	Minor expression of liquefaction, some sand boils
20-30	Moderate expression of liquefaction, with some sand boils and structural damage
30-40	Moderate to severe expression of liquefaction, settlement can cause structural damage
40-50	Major expression of liquefaction, undulations and damage to ground surface, severe total and differential settlements of structures
>50	Severe damage, extensive evidence of liquefaction at surface, severe total and differential settlements affecting structures, damage to services.

* Table based on Table 13.1 from I&T report: Liquefaction Vulnerability Study

Probability	Description of the risk of liquefaction-induced ground failure
$0.9 < P_G$	extremely high to absolutely certain
$0.7 < P_G \leq 0.9$	high
$0.3 < P_G \leq 0.7$	medium
$0.1 < P_G \leq 0.3$	low
$P_G \leq 0.1$	extremely low to none

CPT-based liquefaction triggering analysis for a single sounding

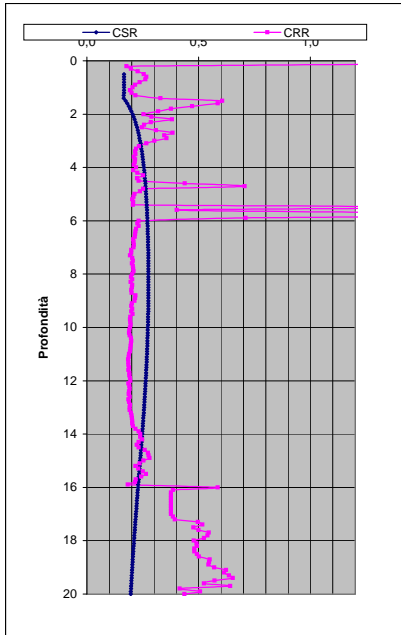
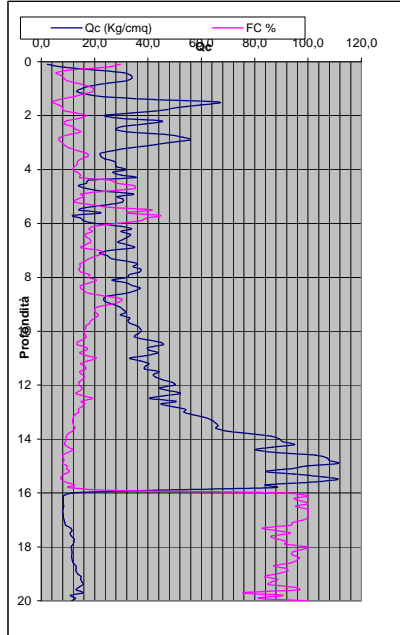
Environmental parameters, soil classification, and various probability and potentiality charts for liquefaction analysis.

Table with columns for Depth (m), Soil Classification, and various parameters like q_v, q_u, F, I_c, etc.

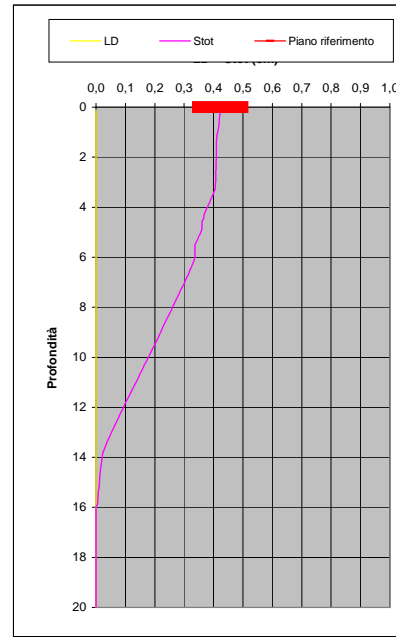
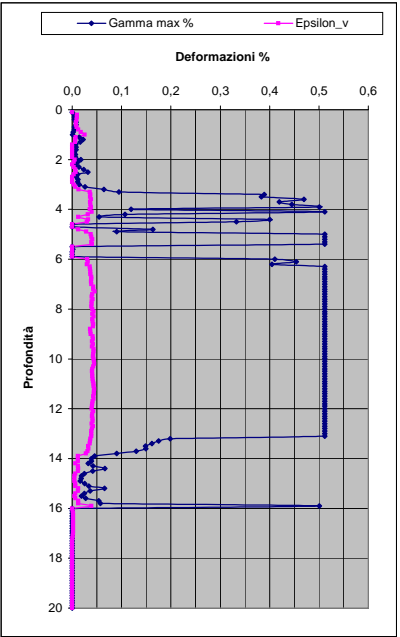
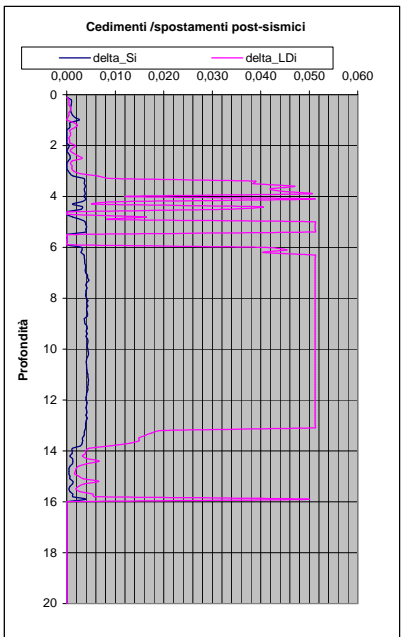
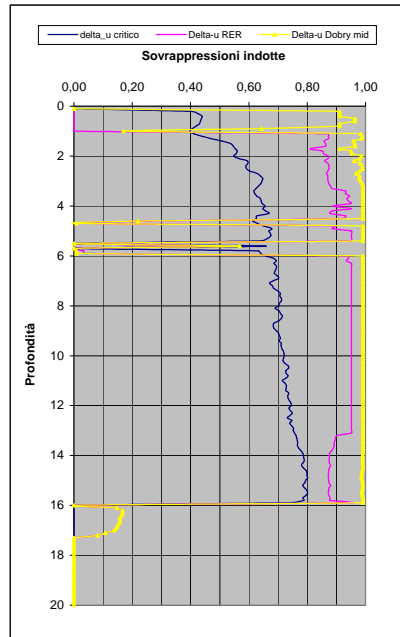
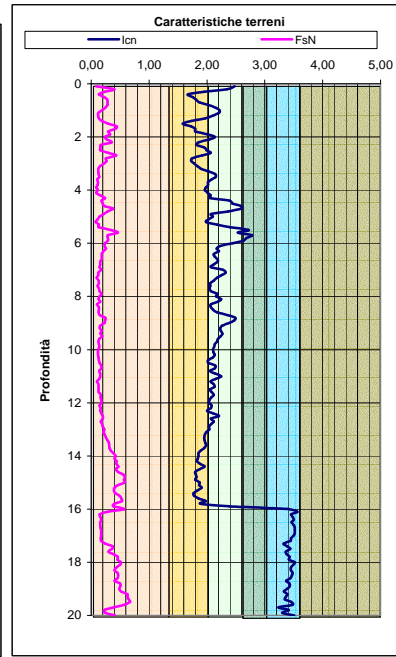
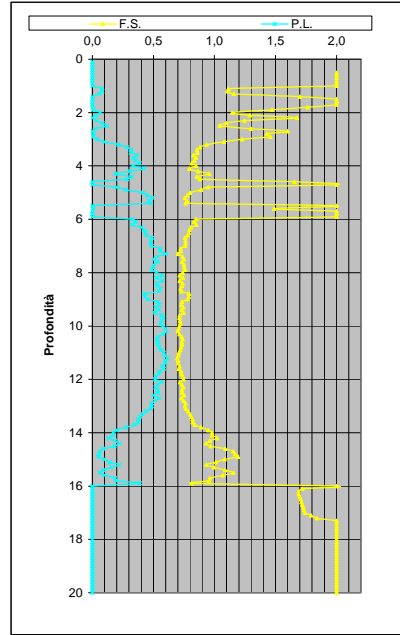
Main data table with columns for Depth (m), Soil Classification, and various parameters like q_v, q_u, F, I_c, etc. Includes a large red vertical bar on the right side.

Summary table with columns for L_{SN}, L_{SN} Expression, and other key values.

DIAGRAMMI DI RIFERIMENTO VERIFICA LIQUEFAZIONE - METODO R. & W. , 2009



PROVA CPTE 4



Soil Classification	Zone No.*	Range of CPT Index I_c Values
Organic Clay Soils	2	$I_c > 3.60$
Clays	3	$2.95 < I_c < 3.60$
Silt Mixtures	4	$2.60 < I_c < 2.95$
Sand Mixtures	5	$2.05 < I_c < 2.60$
Sands	6	$1.31 < I_c < 2.05$
Gravelly Sands	7	$I_c < 1.31$

After Robertson and Wride (1998).
*Note: Zone number per Robertson SBT (1990).

- Argille - terreni organici
- Argille - argilla/argilla limosa
- Miscela di limi - limo argilloso/argilla limosa
- Miscela di sabbie - sabbia limosa/limo sabbioso
- Sabbie - sabbie pulite/sabbie limose
- sabbie ghiaiose / sabbie dense

LEGENDA

- Qc** = Res. alla penetraz. (Kg/cmq)
- FC** = Fine content - passante 0.074 mm (%)
- FsN** = Attrito laterale (Kg/cmq)
- F** = rapporto di frizione
- Qtn** = parametro di resist. alla punta normal.
- Icn** = Soil behaviour index normalized (ad)
- qc1N-cs** = Resist. alla pentrez. corretta all'FC e normalizzata
- ξ = parametro di stato
- KH** = fatt. correttivo per spessore strato (ad)
- Rd** = stress reduction coefficient (ad)
- CN** = fattore di normalizzazione per carico litostatico (ad)
- K σ** = fatt. correttivo per sovraccarico-profondità (ad)
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- MSF** = magnitudo scaling factor (ad)
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- CSR** = Cyclic Stress ratio (ad)
- CRR** = Cyclic Resistance Ratio (ad)
- P.L.** = Probabilità di liquefazione (ad)
- IPL** = Indice del potenziale di liquefazione (ad)
- gamma_max** = deformazione di taglio massima indotta dal sisma (%)
- ev** = vertical reconsolidation strain
- delta_si** = cedimento -esimo dello strato (mt)
- Su** = S_u / σ'_{vc} resistenza totale non drenata - strati coesivi (ad)
- Sur** = S_{ur} / σ'_{vc} resistenza totale residua non drenata - strati coesivi (ad)
- qc1N-sr** = Resist. alla pentrez. corretta all'FC e normalizzata
- Sr** = S_r / σ'_{vc} resistenza residua - strati incoerenti (ad)
- Ruc** = $\Delta u / \sigma'_{vc}$ critico - stima sogliadi innesco fenomeni di instabilità/liquefazione
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- LDI** = Lateral Displacement Index (mt)
- Dr** = Densità relativa (ad)
- ϕ = angolo di attrito interno (deg)
- OCR** = rapporto di sovraconsolidazione (sabbie e argille) (ad)
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$0.1 < P_G \leq 0.3$	low
$P_G \leq 0.1$	extremely low to none

IPL= 12,70 PL= 42,00 LDI = 4,630 Stot = 0,423 (mt) LD = 0,00 (mt) SLiq = 11,10 (mt) LSN = 54,77 PG= 0,99

CPT-based liquefaction triggering analysis for a single sounding

Input parameters table including Peak ground accel (g), Earthquake magnitude (M), Water table depth (m), Average above water table (N160), Average below water table (N120), and Equipment (CPT-CPT1).

Environments: Hill-H Plain-P Coast-C. Behaviours: Sand-like-S.

Soil Classification table with columns for Soil Classification, Zone No., and Range of CPT Index / Values.

Computer constants:

Computer constants table with parameters like alpha (N1) = 0.35, beta = 0.0357, and various soil strength and stress ratio parameters.

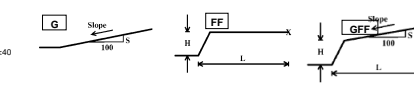
Probabilità e potenziale di liquefazione table with columns for Probabilità, Pot di Liq, and IPL-15.

Probabilità e suscettibilità di liquefazione table with columns for Probabilità, Suscettibilità, and Quasi certa.

PL Overall Probability table with columns for Risk level, IPL, and PL.

Robertson & Wride, agg. 2009

PROVA "CPTE 5"

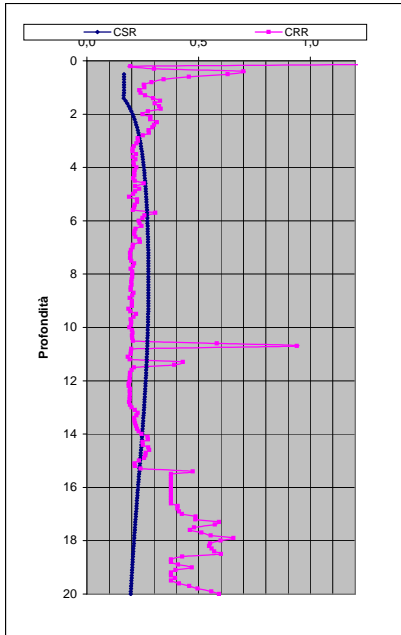
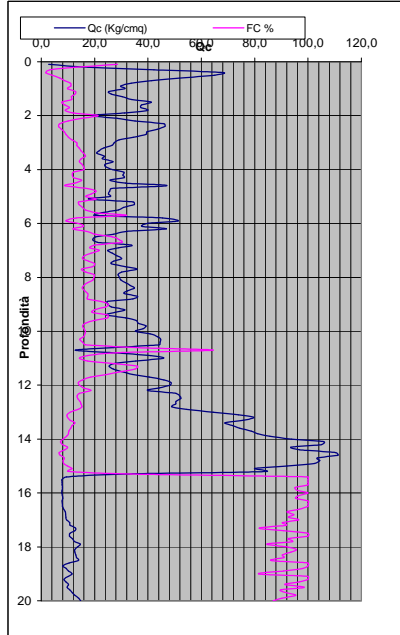


Potential flow failure if (N1)60 <= 10 and (q_c)160 >= 50. No flow liquefaction if (q_c)160 <= 50.

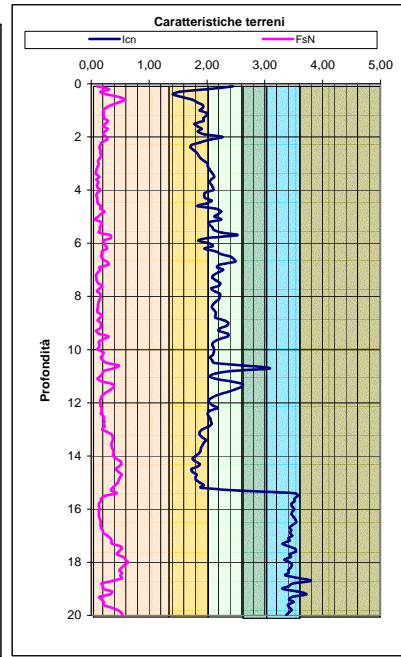
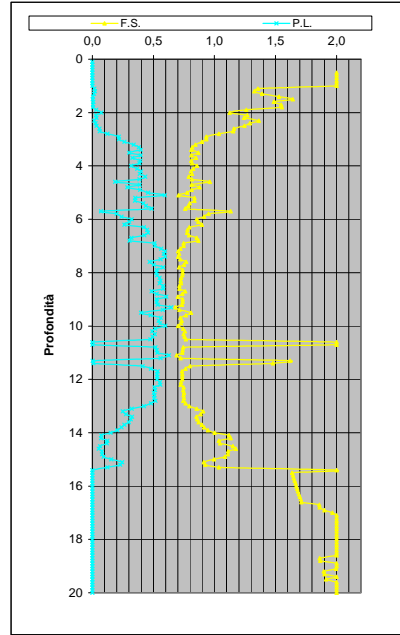
Main data table header with columns for Depth (m), q_c1N, q_c, F, Ic, N1(60), n, Kc, Layer, and various soil strength and stress ratio parameters.

Main data table body containing 101 rows of soil test data, including depth, cone resistance, and various calculated parameters.

DIAGRAMMI DI RIFERIMENTO VERIFICA LIQUEFAZIONE - METODO R. & W. , 2009



PROVA CPTE 5



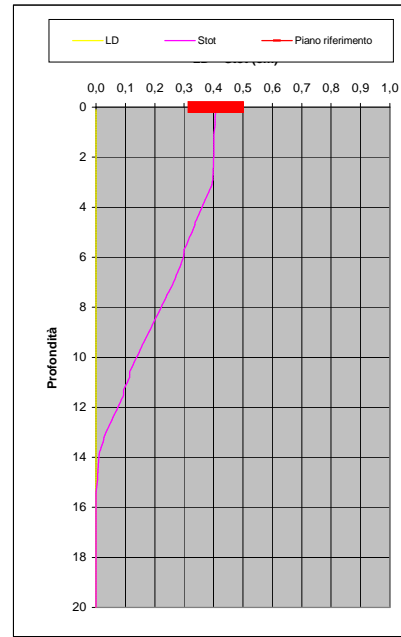
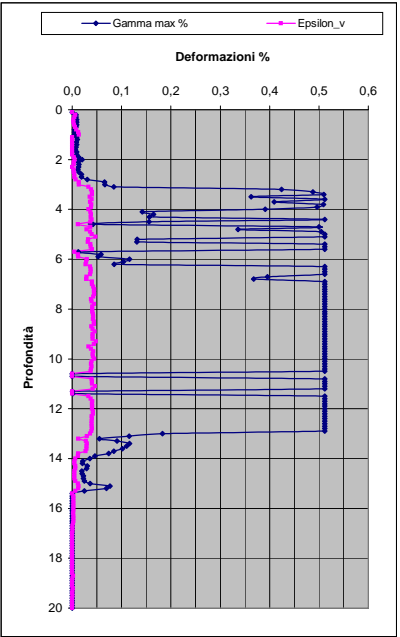
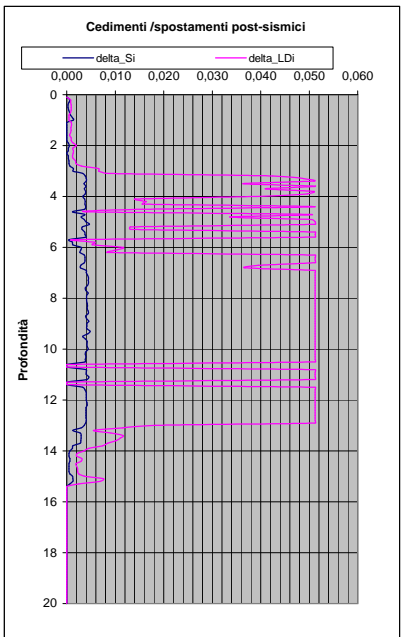
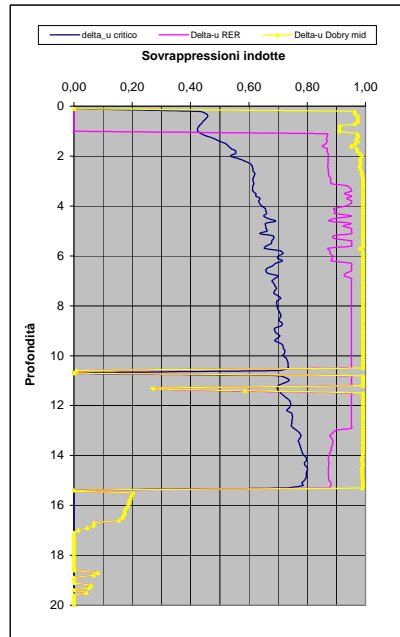
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Clays	3	$2.95 < I_c < 3.60$
Silt Mixtures	4	$2.60 < I_c < 2.95$
Sand Mixtures	5	$2.05 < I_c < 2.60$
Sands	6	$1.31 < I_c < 2.05$
Gravelly Sands	7	$I_c < 1.31$

After Robertson and Wride (1998).
*Note: Zone number per Robertson SBT (1990).

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LEGENDA

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- ξ = parametro di stato
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LSN Range	Expected ground surface damage
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* Table based on Table 13.1 from I&T report: Liquefaction Vulnerability Study

Probability	Description of the risk of liquefaction-induced ground failure
$0.9 < P_G$	extremely high to absolutely certain
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$0.3 < P_G \leq 0.7$	medium
$0.1 < P_G \leq 0.3$	low
$P_G \leq 0.1$	extremely low to none

IPL= 12,98

PL= 43,47

LDI = 4,381 Stot = 0,407 (mt)

LD = 0,00 (mt)

SLiq = 10,90 (mt)

LSN = 57,24 PG= 0,99

CPT-based liquefaction triggering analysis for a single sounding

Enviromenti: C Hill-H Plain-P Coast-C Behaviours: Sand like-S

Computer constants: no. n=10, N=101.32, alpha (N)=0.35, Patm=101.32, cov=0.35-35%, kDR=350, IP COR=1.2

Probabilità e potenziale di liquefazione

Probabilità e suscettibilità di liquefazione

PL Overall Probability

Robertson & Wride, agg. 2009

PROVA "CPTE 6"



Potential flow failure if (N) ID<C<10 and (q) N<50 and No flow liquefaction if (q) N<65

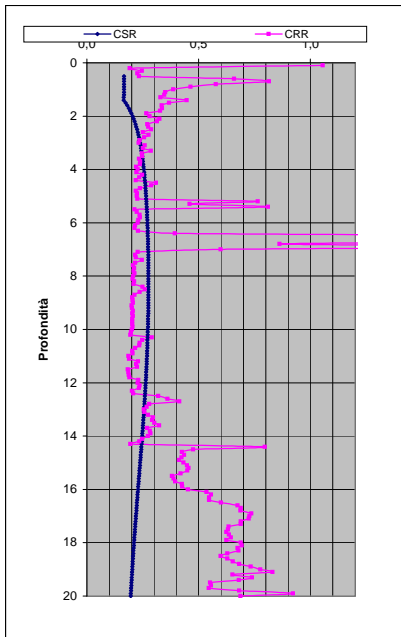
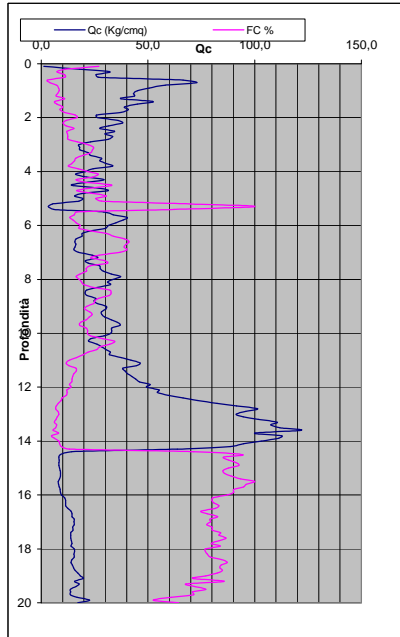
Summary table with columns for Risk level, IPL, PL, and various probability values. Includes a small table for Severe Damage, Moderate to Severe, and Little to No damage.

Main data table header with columns for Depth (m), q (kPa), qc (kPa), F, Ic, N1(60), n, Kc, Layer, FC, Kh, CSR, Ks, Ks, CRR, MSF, Limiting shear strain, PL, ALDI, Vertical recons. Strain, ASI, F, I, R, Dr, S, Ruc, Su/ovc, OCR, qc1N, Sr, Su/r, LSN.

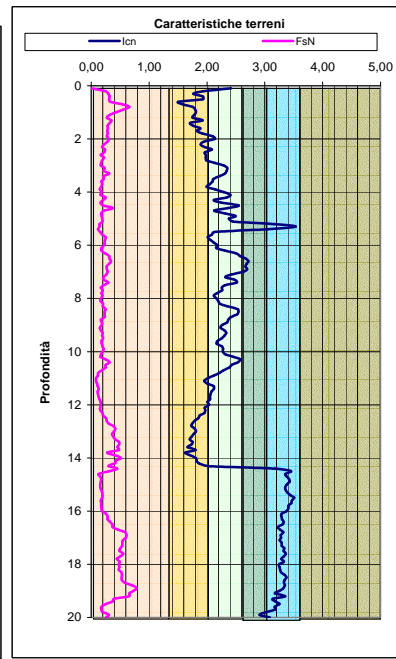
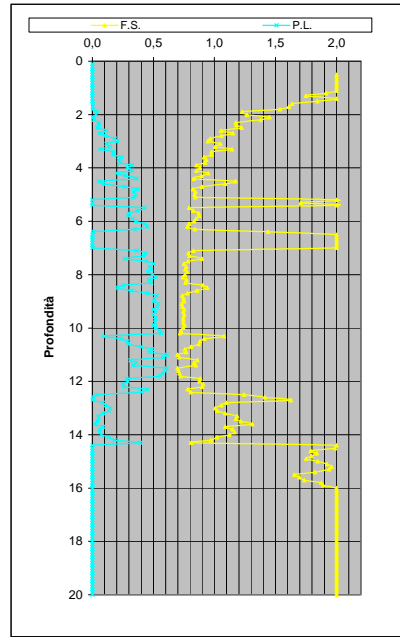
PROFONDITA' DI CALCOLO (mt da p.c.): 0,0 LDI = 3,142 Stot = 0,281 (mt) IPL = 8,48 PL = 22,39 LD = 0,00 (mt) PG = 0,79 SLiq = 8,2 (mt) LSN = 38,1

Main data table body containing 100 rows of soil test data with columns for Depth, q, qc, F, Ic, N1(60), n, Kc, Layer, FC, Kh, CSR, Ks, Ks, CRR, MSF, Limiting shear strain, PL, ALDI, Vertical recons. Strain, ASI, F, I, R, Dr, S, Ruc, Su/ovc, OCR, qc1N, Sr, Su/r, LSN.

DIAGRAMMI DI RIFERIMENTO VERIFICA LIQUEFAZIONE - METODO R. & W. , 2009



PROVA CPTE 6



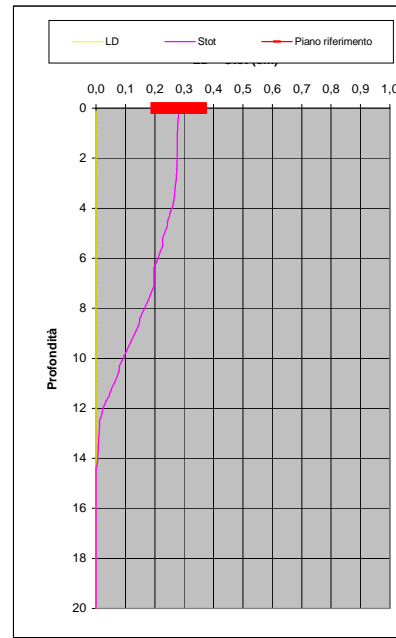
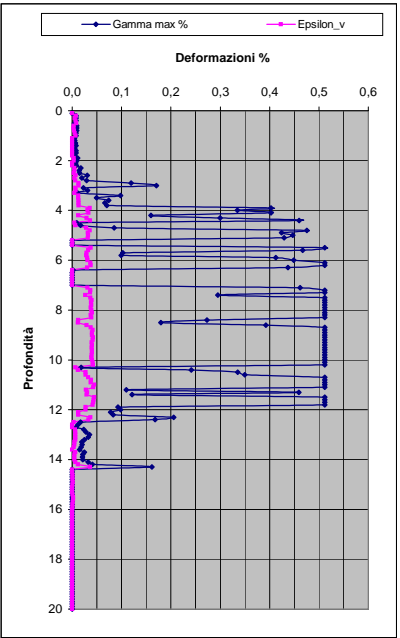
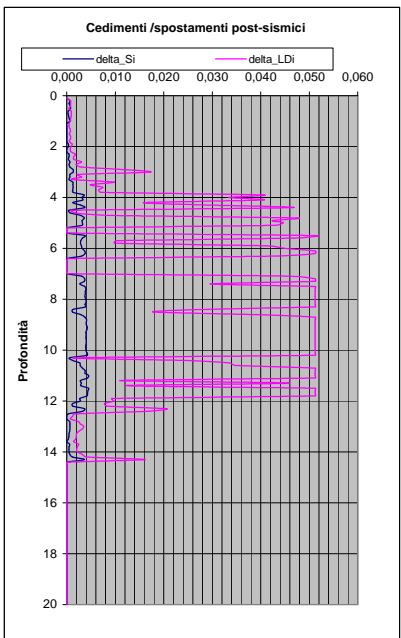
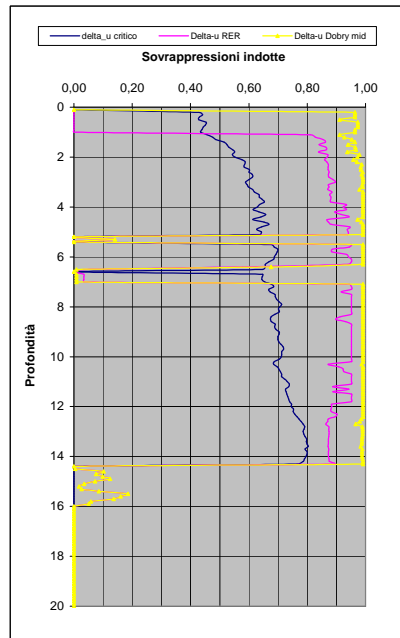
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$0.3 < P_G \leq 0.7$	medium
$0.1 < P_G \leq 0.3$	low
$P_G \leq 0.1$	extremely low to none

IPL = 8,48 PL = 22,39 LDI = 3,142 Stot = 0,281 (mt) LD = 0,00 (mt) SLiq = 8,20 (mt) LSN = 38,13 PG = 0,79

CPT-based liquefaction triggering analysis for a single sounding

Input parameters table including Peak ground accel (g), Earthquake magnitude (M), Water table depth (m), Average above water table (N60)30, Average below water table (N60)30, and Equipment (CPT-CPT1).

Environments: Hill-H Plain-P Coast-C, Behaviours: Sand-like-S, Sand-Clay-SC, Building (V)M, Sedimentary environment, C-constit: D-deltaflag - I-interbedded, CPTs: CPT1=1

Computer constants: alpha (N) = 1, Patm = 101.32, cov=0.35-35%, K0 = 0.95, Nk = 25, L (m) = 10, Cst(Kpa) = 98

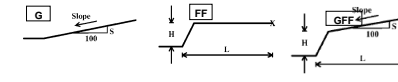
Probabilità e potenziale di liquefazione: Probabilità, Pot di Liq, IPL-15

Probabilità e suscettibilità di liquefazione: Probabilità, Suscettibilità, Quasi certa

PL Overall Probability: Risk lev., IPL, PL

Robertson & Wride, agg. 2009

PROVA "CPTE 7"



Potential flow failure if (N1)60<=10 and (q1)N60<=5, No flow liquefaction if (q1)N60<=5

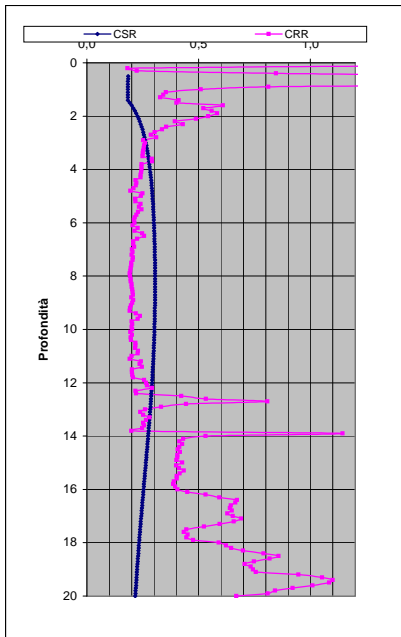
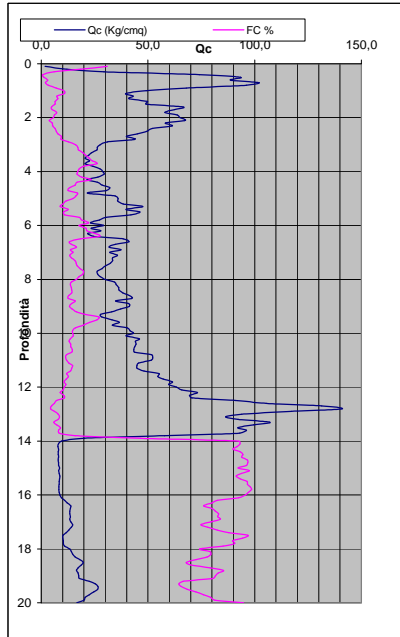
Table with 2 columns: LsN, LsN Expression, and Severe Damage/Moderate to Severe/Moderate/Little to No

Main data table header with columns: Depth (m), q1, qn, F, Ic, In2, N1(60), n, Kc, Layer, Flag, FC, Kh, Interpret, qcN, qc1N, On-cs, R, CSR, Ks, xi, Kc, crr, CRR, Factor of Safety FS, MSF, Limiting shear strain, PL, JUNG, F, IPI, Au/O', Ru, Au/O', Dr, Ruc, Su/O'vc, OCR, qc1N, Sr/O'vc, Su/O'vc, LSN

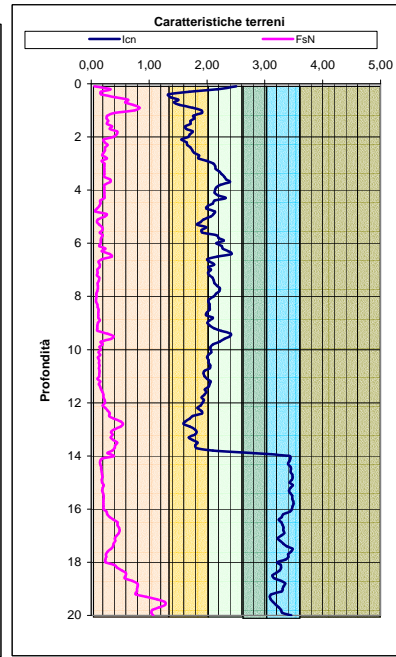
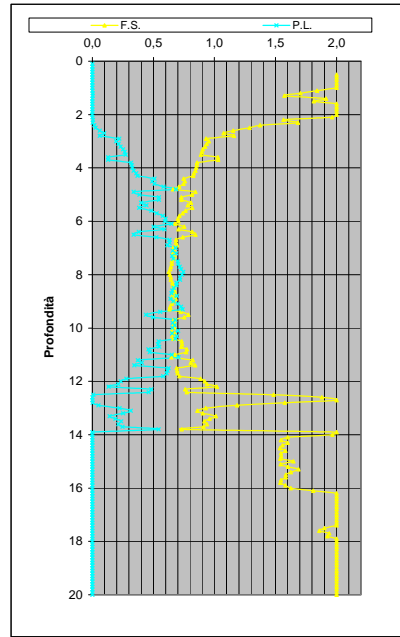
PROFONDITA' DI CALCOLO (mt da p.c.): 0,0 | LDI = 3,725 | Stot = 0,342 (mt) | IPL = 14,81 | PL = 53,41 | LD = 0,00 (mt) | PG = 1,00 | SLiq = 10,1 (mt) | LSN = 48,0

Main data table body containing 101 rows of soil profile data with various parameters and calculated values.

DIAGRAMMI DI RIFERIMENTO VERIFICA LIQUEFAZIONE - METODO R. & W. , 2009



PROVA CPTE 7



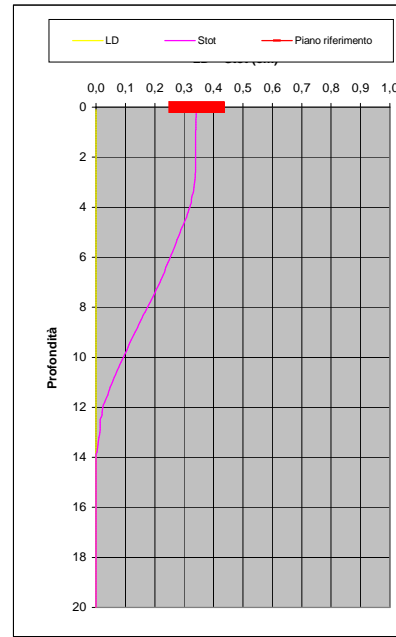
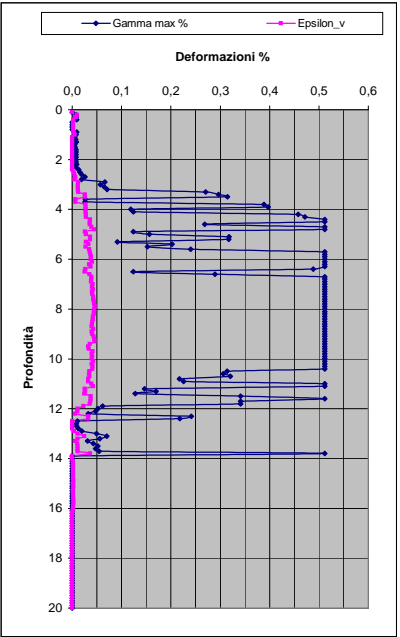
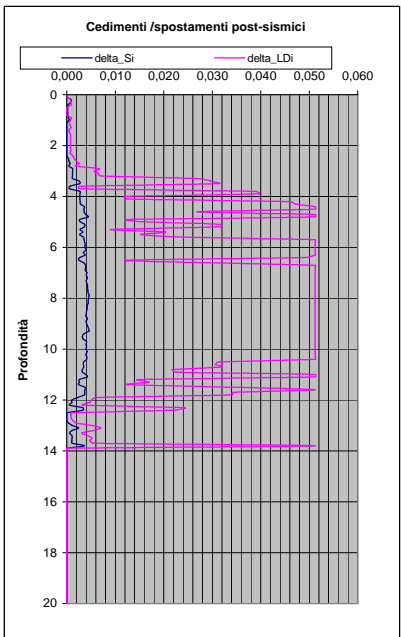
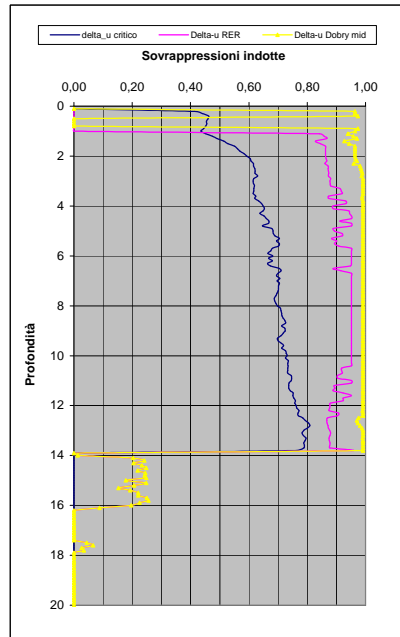
Soil Classification	Zone No.*	Range of CPT Index I_c Values
Organic Clay Soils	2	$I_c > 3.60$
Clays	3	$2.95 < I_c < 3.60$
Silt Mixtures	4	$2.60 < I_c < 2.95$
Sand Mixtures	5	$2.05 < I_c < 2.60$
Sands	6	$1.31 < I_c < 2.05$
Gravelly Sands	7	$I_c < 1.31$

After Robertson and Wride (1998).
*Note: Zone number per Robertson SBT (1990).

- Argille - terreni organici
- Argille - argilla/argilla limosa
- Miscela di limi - limo argilloso/argilla limosa
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- Sabbie - sabbie pulite/sabbie limose
- sabbie ghiaiose / sabbie dense

LEGENDA

- Qc** = Res. alla penetraz. (Kg/cmq)
- FC** = Fine content - passante 0.074 mm (%)
- FsN** = Attrito laterale (Kg/cmq)
- F** = rapporto di frizione
- Qtn** = parametro di resist. alla punta normal.
- Icn** = Soil behaviour index normalized (ad)
- qc1N-cs** = Resist. alla pentrez. corretta all'FC e normalizzata
- ξ = parametro di stato
- KH** = fatt. correttivo per spessore strato (ad)
- Rd** = stress reduction coefficient (ad)
- CN** = fattore di normalizzazione per carico litostatico (ad)
- K σ** = fatt. correttivo per sovraccarico-profondità (ad)
- K α** = fatt. correttivo per sforzi di taglio (ad)
- MSF** = magnitudo scaling factor (ad)
- F.S.** = Fattore di sicurezza (CRR/CSR con correzioni) (ad)
- CSR** = Cyclic Stress ratio (ad)
- CRR** = Cyclic Resistance Ratio (ad)
- P.L.** = Probabilità di liquefazione (ad)
- IPL** = Indice del potenziale di liquefazione (ad)
- γ_{max}** = deformazione di taglio massima indotta dal sisma (%)
- ev** = vertical reconsolidation strain
- Δs_i** = cedimento i-esimo dello strato (mt)
- Su** = S_u / σ'_{vc} resistenza totale non drenata - strati coesivi (ad)
- Sur** = S_{ur} / σ'_{vc} resistenza totale residua non drenata - strati coesivi (ad)
- qc1N-sr** = Resist. alla pentrez. corretta all'FC e normalizzata
- Sr** = S_r / σ'_{vc} resistenza residua - strati incoerenti (ad)
- Ruc** = $\Delta u / \sigma'_{vc}$ critico - stima sogliadi innescio fenomeni di instabilità/liquefazione
- Δu RER = $\Delta u / \sigma'_{vc}$ sovrappressioni circ. 112/2007 - tabella 2 R.E.R.
- Δu Dobry M. = $\Delta u / \sigma'_{vc}$ Dobry et al. 1984 "mean" x sabbie-Robertson '09 x argille
- Δu Dobry L. = $\Delta u / \sigma'_{vc}$ Dobry et al. 1984 "lower bound" x sabbie-Robertson '09 x argille
- Δu Dobry U. = $\Delta u / \sigma'_{vc}$ Dobry et al. 1984 "Upper bound" x sabbie-Robertson '09 x argille
- Stot** = Cedimento post-sismico totale (mt)
- LDI** = Lateral Displacement Index (mt)
- Dr** = Densità relativa (ad)
- ϕ = angolo di attrito interno (deg)
- OCR** = rapporto di sovraconsolidazione (sabbie e argille) (ad)
- St** = coefficiente di sensitività delle argille (ad)
- LSN** = Liquefaction Severity Number (ad)



LSN Range	Expected ground surface damage
0-10	Little to no expression of liquefaction, minor effects
10-20	Minor expression of liquefaction, some sand boils
20-30	Moderate expression of liquefaction, with some sand boils and structural damage
30-40	Moderate to severe expression of liquefaction, settlement can cause structural damage
40-50	Major expression of liquefaction, undulations and damage to ground surface, severe total and differential settlements of structures
>50	Severe damage, extensive evidence of liquefaction at surface, severe total and differential settlements affecting structures, damage to services.

* Table based on Table 13.1 from I&T report: Liquefaction Vulnerability Study

Probability	Description of the risk of liquefaction-induced ground failure
$0.9 < P_G$	extremely high to absolutely certain
$0.7 < P_G \leq 0.9$	high
$0.3 < P_G \leq 0.7$	medium
$0.1 < P_G \leq 0.3$	low
$P_G \leq 0.1$	extremely low to none

IPL= 14,81

PL= 53,41

LDI = 3,725 Stot = 0,342 (mt)

LD = 0,00 (mt)

SLiq = 10,10 (mt)

LSN = 47,97 PG= 1,00

CPT-based liquefaction triggering analysis for a single sounding

Environmental parameters, soil classification, and various probability and potentiality charts for liquefaction analysis.

Table with columns for Depth (m), Soil Classification, and various geotechnical parameters like qc, N, and stress ratios.

Main data table with columns for Depth (m), Soil Classification, and various geotechnical parameters including qc, N, and stress ratios.

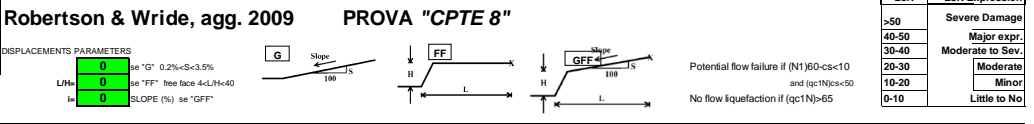
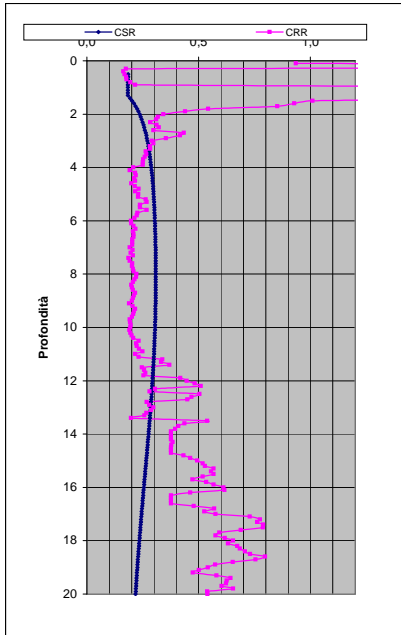
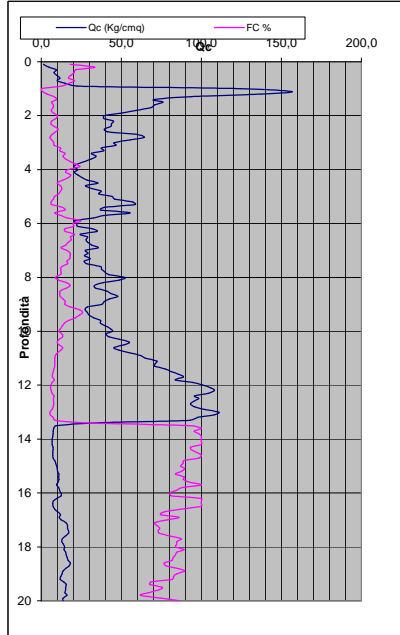


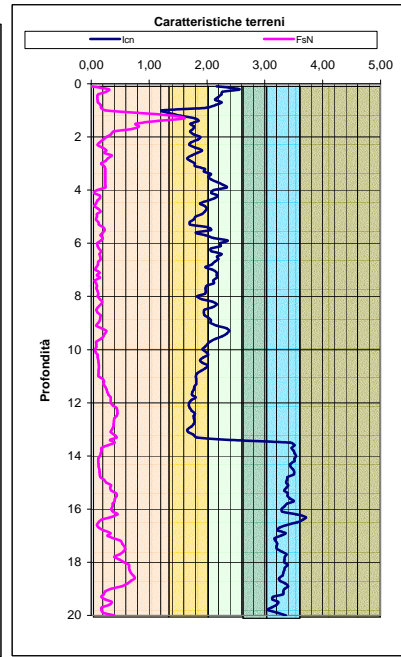
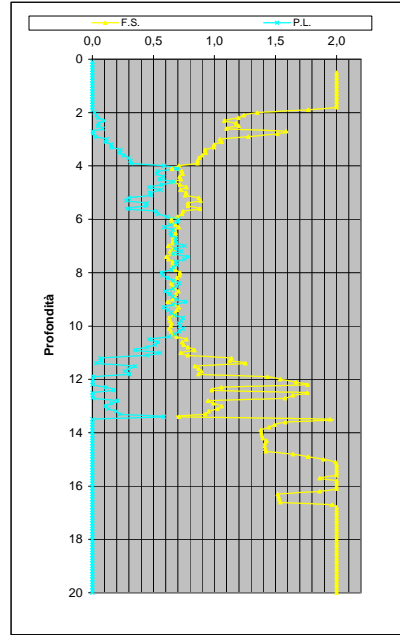
Table with columns for LSN, LSN Expression, and Severe Damage, Moderate to Severe, and Little to No.

Table with columns for LSN, LSN Expression, and Severe Damage, Moderate to Severe, and Little to No.

DIAGRAMMI DI RIFERIMENTO VERIFICA LIQUEFAZIONE - METODO R. & W. , 2009



PROVA CPTE 8



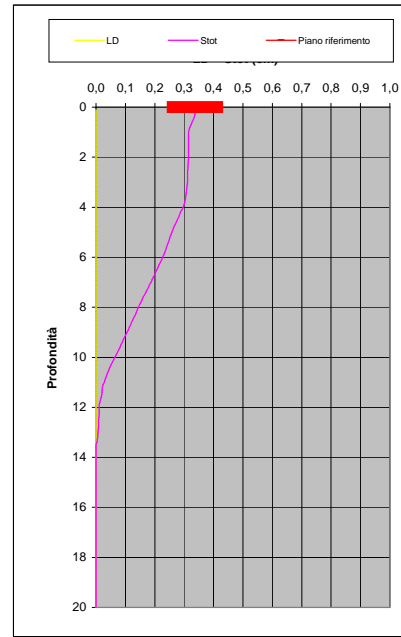
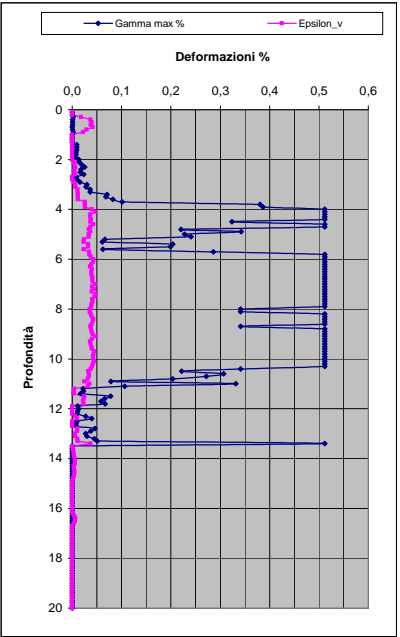
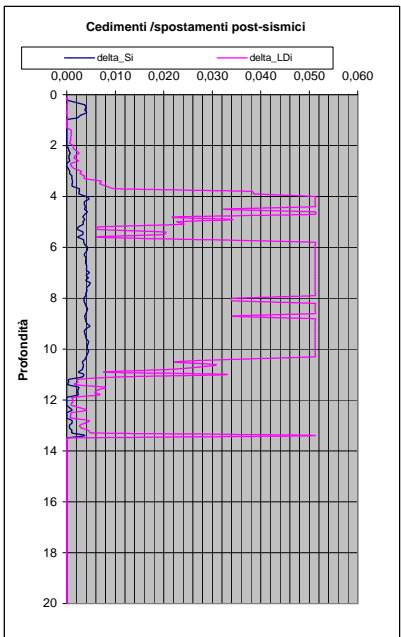
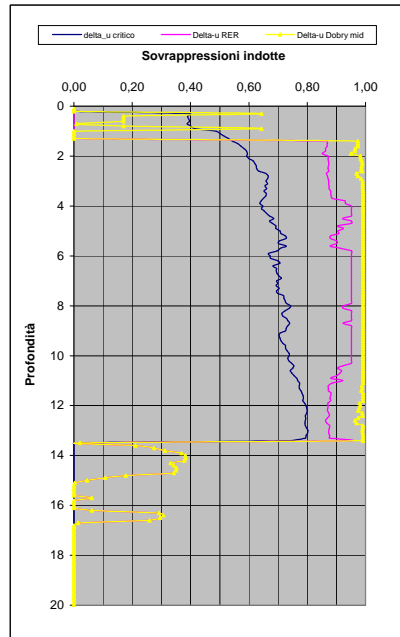
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After Robertson and Wride (1998).
*Note: Zone number per Robertson SBT (1990).

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LEGENDA

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- IPL** = Indice del potenziale di liquefazione (ad)
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- Sr** = S_r / σ'_{vc} resistenza residua - strati incoerenti (ad)
- Ruc** = $\Delta u / \sigma'_{vc}$ critico - stima sogliadi innescio fenomeni di instabilità/liquefazione
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- LDI** = Lateral Displacement Index (mt)
- Dr** = Densità relativa (ad)
- θ = angolo di attrito interno (deg)
- OCR** = rapporto di sovraconsolidazione (sabbie e argille) (ad)
- St** = coefficiente di sensitività delle argille (ad)
- LSN** = Liquefaction Severity Number (ad)



LSN Range	Expected ground surface damage
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Probability	Description of the risk of liquefaction-induced ground failure
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$0.3 < P_G \leq 0.7$	medium
$0.1 < P_G \leq 0.3$	low
$P_G \leq 0.1$	extremely low to none

IPL= 14,40 PL= 51,17 LDI = 3,337 Stot = 0,337 (mt) LD = 0,00 (mt) SLiq = 9,00 (mt) LSN = 46,57 PG= 1,00

CPT-based liquefaction triggering analysis for a single sounding

Environments: C Hill-H Plain-P Coast-C Behaviours: Sand-like-S

Computer constants: no. of Blows (N) = 10.32; MSF NEER = 0.535; Patm = 101.32; cov 0.30-35% = 1.350; IP COR = 1.2

Probabilità e potenziale di liquefazione: Probabilità e suscettibilità di liquefazione

PL Overall Probability: Risk lev. Very High High Low

ROBERTSON & WRIDE, agg. 2009: PL Overall Probability: Risk lev. Very High High Low

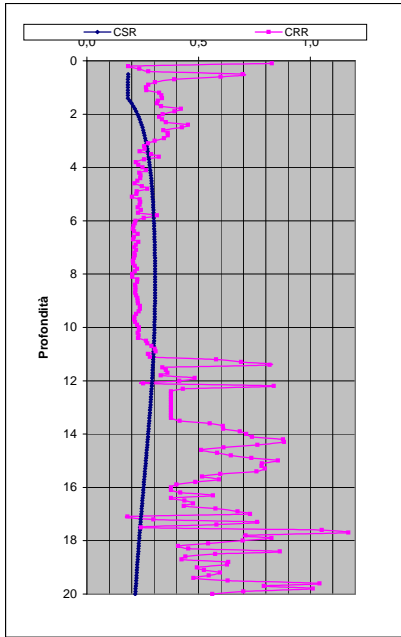
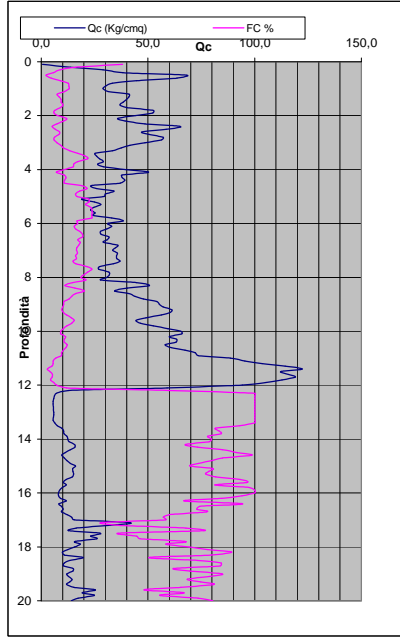


Table with 12 columns: Depth (m), qc(N)/qc(S), FAN, qcvc, qcvc, Qi, Qtn, F, Ic, Ic2N, N1(60), n, Kc, Layer, Flag, FC, Kh, Interpret, qc(N), qc1N, Qn-cs, R, CSR, Ks, xi, Kc, crr, CRR, FS, MSF, Limiting shear strain, PL, JUNG, F, I, Au/09, Au/09, Ru, Au/09, Dr, Ruc, Su/09vc, OCR, qc1N, Sr, Su/09vc, LSN, LSN Expression.

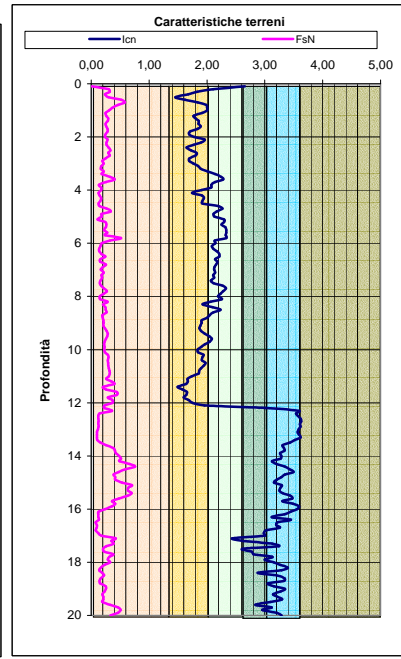
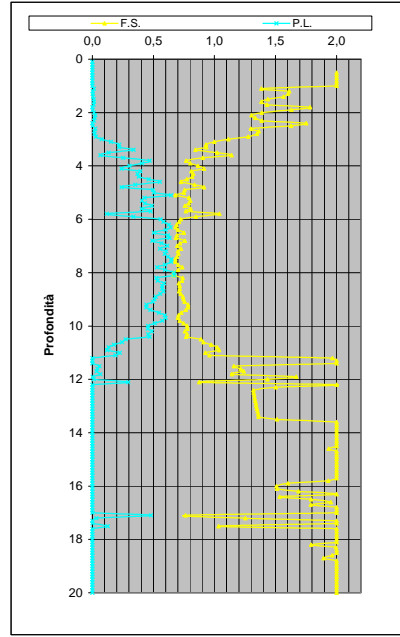
PROFONDITA' DI CALCOLO (mt da p.c.): 0,0; LDI = 2,808; Stot = 0,258 (mt); IPL = 11,20; PL = 34,28; LD = 0,00 (mt); PG = 0,96; SLiq = 7,8 (mt); LSN = 38,0

Main data table with 12 columns corresponding to the headers in the previous table. It contains numerical data for each depth from 0.1m to 10.1m.

DIAGRAMMI DI RIFERIMENTO VERIFICA LIQUEFAZIONE - METODO R. & W. , 2009



PROVA CPTE 9



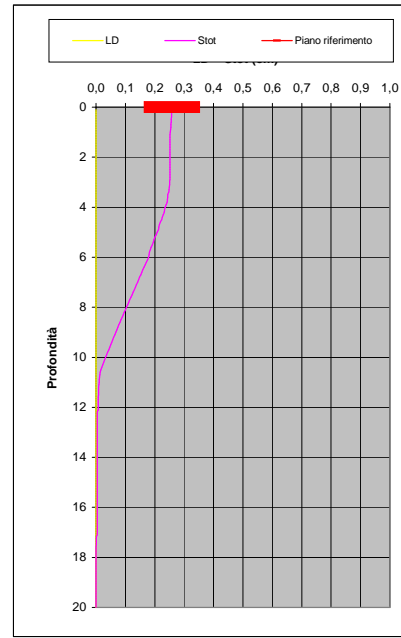
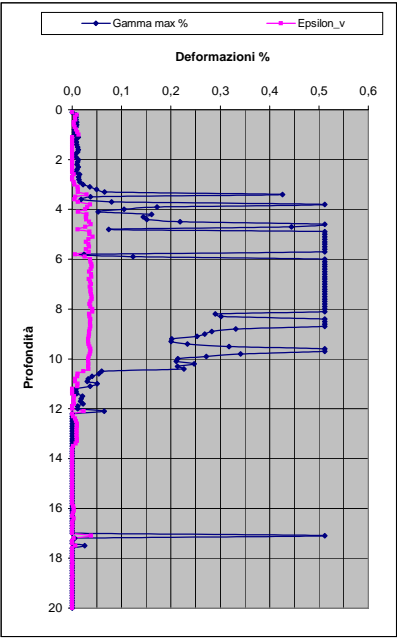
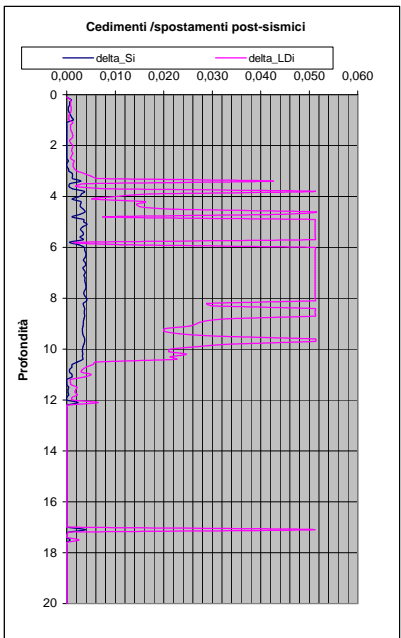
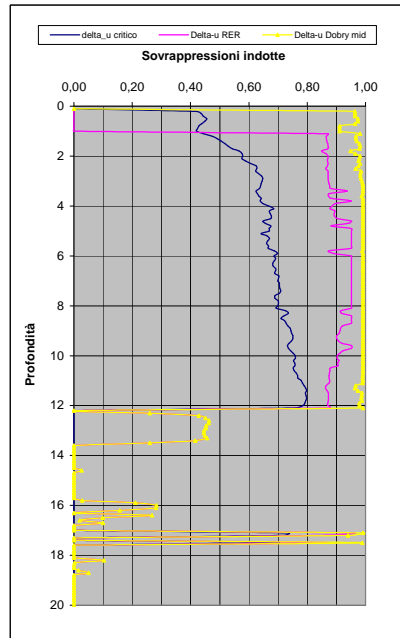
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After Robertson and Wride (1998).
*Note: Zone number per Robertson SBT (1990).

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LEGENDA

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- Sr** = S_r / σ'_{vc} resistenza residua - strati incoerenti (ad)
- Ruc** = $\Delta u / \sigma'_{vc}$ critico - stima sogliadi innesco fenomeni di instabilità/liquefazione
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* Table based on Table 13.1 from I&T report: Liquefaction Vulnerability Study

Probability	Description of the risk of liquefaction-induced ground failure
$0.9 < P_G$	extremely high to absolutely certain
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$0.3 < P_G \leq 0.7$	medium
$0.1 < P_G \leq 0.3$	low
$P_G \leq 0.1$	extremely low to none

IPL = 11,20

PL = 34,28

LDI = 2,808 Stot = 0,258 (mt)

LD = 0,00 (mt)

SLiq = 7,80 (mt)

LSN = 38,00 PG = 0,96

CPT-based liquefaction triggering analysis for a single sounding

Environments: C Hill-H Plain-P Coast-C Behaviours: Sand like-S

Computer constants: no. n=Blank ("B" 2007 - "Cefin" 2004 - "NCEER" - "Blake")

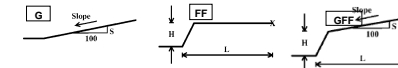
Probabilità e potenziale di liquefazione

Probabilità e suscettibilità di liquefazione

PL Overall Probability

Robertson & Wride, agg. 2009

PROVA "CPTe 10"



Potential flow failure if (N) < 60-cv<10 and (q) < 100-cv<10 No flow liquefaction if (q) < 10-cv<65

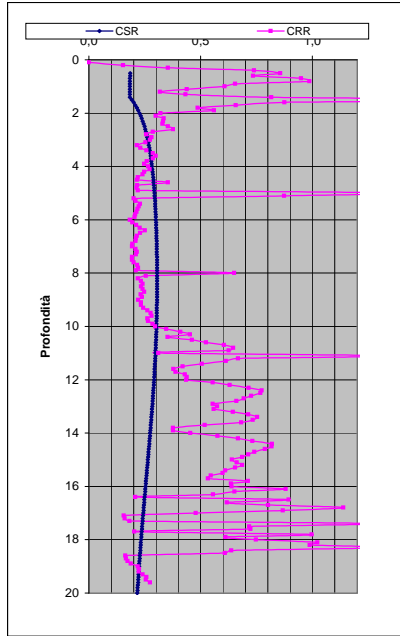
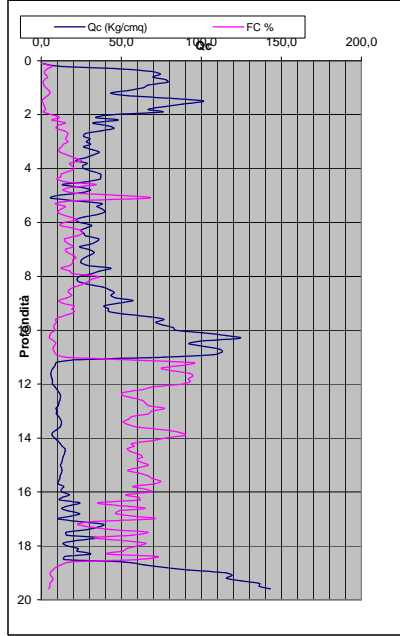
Table with 2 columns: LSN and LSN Expression. It shows ranges for LSN values and corresponding expressions for different levels of damage or liquefaction.

Main data table with columns for input parameters (Peak ground accel, Earthquake magnitude, Water table depth, etc.), soil classification, and various calculated parameters (Q1, Qtn, F, Ic, etc.).

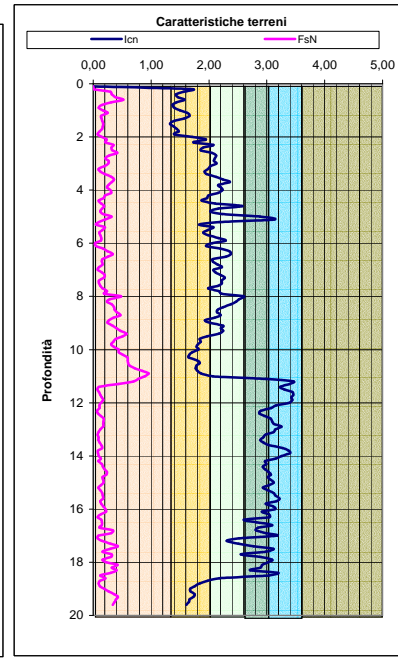
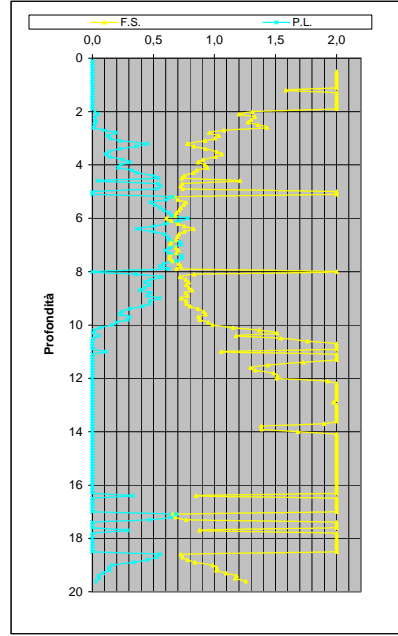
PROFONDITA' DI CALCOLO (mt da p.c.): 0,0 LDI = 2,742 Stot = 0,256 (mt) IPL = 10,04 PL = 28,82 LD = 0,00 (mt) PG = #NUM! SLiq = 7,4 (mt) LSN = 36,8

Main data table with columns for Depth (m), q (kPa), q1 (kPa), F (kPa), Ic, etc. This table contains the primary data for the liquefaction analysis, including soil strength parameters and calculated values for each depth interval.

DIAGRAMMI DI RIFERIMENTO VERIFICA LIQUEFAZIONE - METODO R. & W. , 2009



PROVA CPT E 10



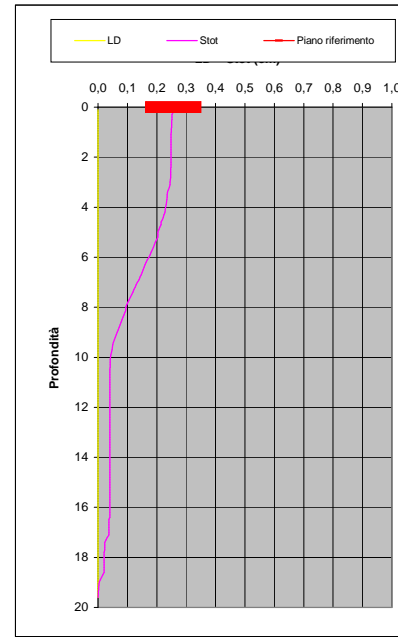
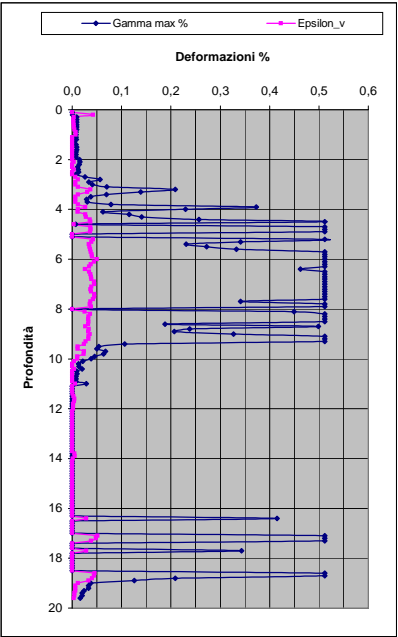
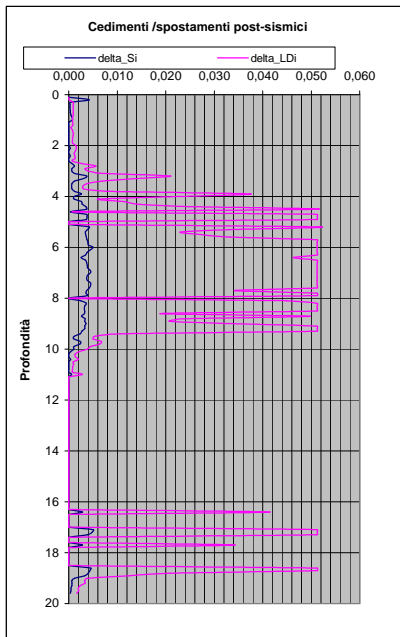
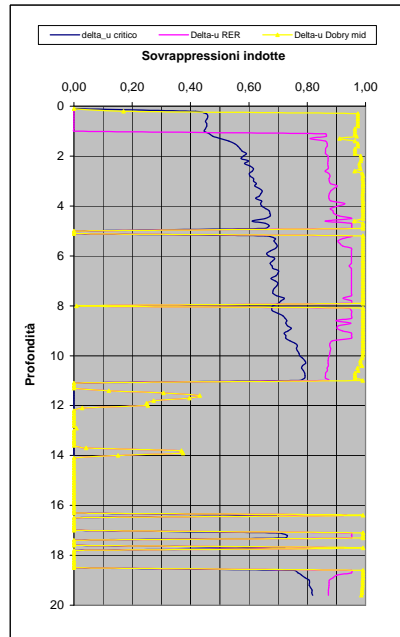
Soil Classification	Zone No.*	Range of CPT Index I_c Values
Organic Clay Soils	2	$I_c > 3.60$
Clays	3	$2.95 < I_c < 3.60$
Silt Mixtures	4	$2.60 < I_c < 2.95$
Sand Mixtures	5	$2.05 < I_c < 2.60$
Sands	6	$1.31 < I_c < 2.05$
Gravelly Sands	7	$I_c < 1.31$

After Robertson and Wride (1998).
*Note: Zone number per Robertson SBT (1990).

- Argille - terreni organici
- Argille - argilla/argilla limosa
- Miscela di limi - limo argilloso/argilla limosa
- Miscela di sabbie - sabbia limosa/limo sabbioso
- Sabbie - sabbie pulite/sabbie limose
- sabbie ghiaiose / sabbie dense

LEGENDA

- Qc** = Res. alla penetraz. (Kg/cmq)
- FC** = Fine content - passante 0.074 mm (%)
- FsN** = Attrito laterale (Kg/cmq)
- F** = rapporto di frizione
- Qtn** = parametro di resist. alla punta normal.
- Icn** = Soil behaviour index normalized (ad)
- qc1N-cs** = Resist. alla pentrez. corretta all'FC e normalizzata
- ξ = parametro di stato
- KH** = fatt. correttivo per spessore strato (ad)
- Rd** = stress reduction coefficient (ad)
- CN** = fattore di normalizzazione per carico litostatico (ad)
- K σ** = fatt. correttivo per sovraccarico-profondità (ad)
- K α** = fatt. correttivo per sforzi di taglio (ad)
- MSF** = magnitudo scaling factor (ad)
- F.S.** = Fattore di sicurezza (CRR/CSR con correzioni) (ad)
- CSR** = Cyclic Stress ratio (ad)
- CRR** = Cyclic Resistance Ratio (ad)
- P.L.** = Probabilità di liquefazione (ad)
- IPL** = Indice del potenziale di liquefazione (ad)
- Ymax** = deformazione di taglio massima indotta dal sisma (%)
- ev** = vertical reconsolidation strain
- Δ si** = cedimento -esimo dello strato (mt)
- Su** = S_u / σ'_{vc} resistenza totale non drenata - strati coesivi (ad)
- Sur** = S_{ur} / σ'_{vc} resistenza totale residua non drenata - strati coesivi (ad)
- qc1N-sr** = Resist. alla pentrez. corretta all'FC e normalizzata
- Sr** = S_r / σ'_{vc} resistenza residua - strati incoerenti (ad)
- Ruc** = $\Delta u / \sigma'_{vc}$ critico - stima sogliadi innesco fenomeni di instabilità/liquefazione
- Δu RER = $\Delta u / \sigma'_{vc}$ sovrappressioni circ. 112/2007 - tabella 2 R.E.R.
- Δu Dobry M. = $\Delta u / \sigma'_{vc}$ Dobry et al. 1984 "mean" x sabbie-Robertson '09 x argille
- Δu Dobry L. = $\Delta u / \sigma'_{vc}$ Dobry et al. 1984 "lower bound" x sabbie-Robertson '09 x argille
- Δu Dobry U. = $\Delta u / \sigma'_{vc}$ Dobry et al. 1984 "Upper bound" x sabbie-Robertson '09 x argille
- Stot** = Cedimento post-sismico totale (mt)
- LDI** = Lateral Displacement Index (mt)
- Dr** = Densità relativa (ad)
- θ = angolo di attrito interno (deg)
- OCR** = rapporto di sovraconsolidazione (sabbie e argille) (ad)
- St** = coefficiente di sensitività delle argille (ad)
- LSN** = Liquefaction Severity Number (ad)



LSN Range	Expected ground surface damage
0-10	Little to no expression of liquefaction, minor effects
10-20	Minor expression of liquefaction, some sand boils
20-30	Moderate expression of liquefaction, with some sand boils and structural damage
30-40	Moderate to severe expression of liquefaction, settlement can cause structural damage
40-50	Major expression of liquefaction, undulations and damage to ground surface, severe total and differential settlements of structures
>50	Severe damage, extensive evidence of liquefaction as surfaco, severe total and differential settlements affecting structures, damage to services.

* Table based on Table 13.1 from I&T report: Liquefaction Vulnerability Study

Probability	Description of the risk of liquefaction-induced ground failure
$0.9 < P_G$	extremely high to absolutely certain
$0.7 < P_G \leq 0.9$	high
$0.3 < P_G \leq 0.7$	medium
$0.1 < P_G \leq 0.3$	low
$P_G \leq 0.1$	extremely low to none

IPL= 10,04

PL= 28,82

LDI = 2,742 Stot = 0,256 (mt)

LD = 0,00 (mt)

SLiq = 7,40 (mt)

LSN = 36,77 PG= #NUM!

CPT-based liquefaction triggering analysis for a single sounding

Peak ground accel (g) = 0.236, Earthquake magnitude, M = 5.9, Water table depth (m) = 3.1, Average of above water table (N/m^2) = 107, Average of below water table (N/m^2) = 20

Soil Classification, Soil No., Range of CPT Index Values, Soil Name, Plasticity Index, etc.

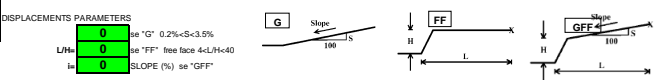
Computer constants: alpha (N) = 3, beta = 1, gamma = 1, delta = 1, epsilon = 1, zeta = 1, eta = 1, theta = 1, etc.

Probabilità e potenziale di liquefazione, Probabilità e suscettibilità di liquefazione, PL Overall Probability

PL Overall Probability, Risk lev., IPL, IPI, ILS, etc.

Robertson & Wride, agg. 2009

PROVA "CPT-E 11"



Potential flow failure if (N1)q1 < 10 and (q1)N50 > 50, No flow liquefaction if (q1)N50 < 65

Main header table for soil profile data, including columns for depth, soil parameters, and calculated values.

Main data table with multiple columns (depth, soil type, stress, etc.) and rows for each depth interval, showing various calculated values and flags.

Table with 3 columns: L&N, L&N Expression, Severity (Severe Damage, Major expr., Moderate to Sev., Moderate, Mild, Little to No)

Table with 3 columns: L&N, L&N Expression, Severity

PROFONDITA' DI CALCOLO (mt da p.c.): 0,0

LDI = 1,967, Stot = 0,203 (mt)

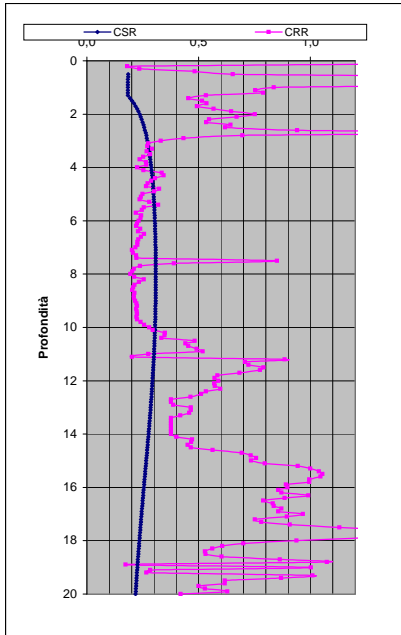
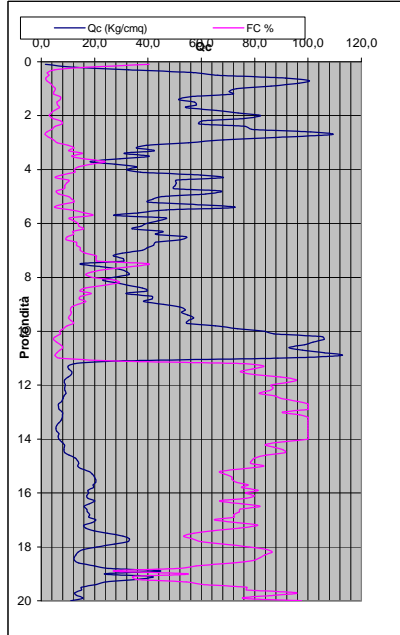
IPL = 8,78

PL = 23,55

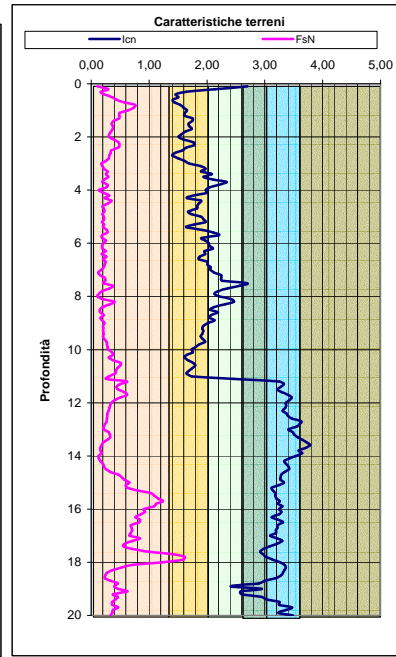
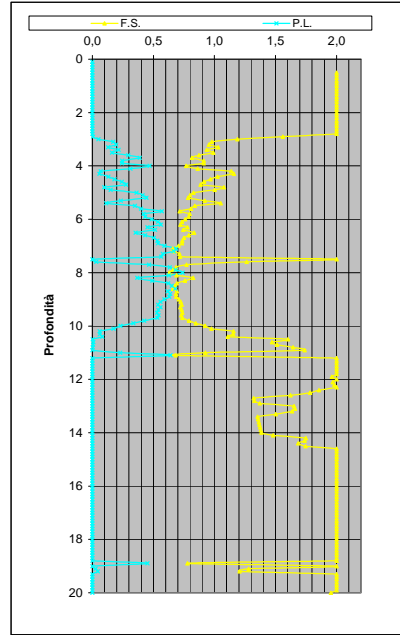
LD = 0,00 (mt), PG = 0,82

SLiq = 6,5 (mt), LSN = 29,8

DIAGRAMMI DI RIFERIMENTO VERIFICA LIQUEFAZIONE - METODO R. & W. , 2009



PROVA CPT E 11



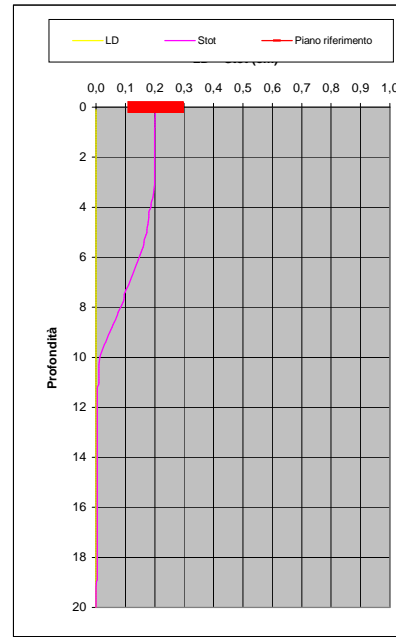
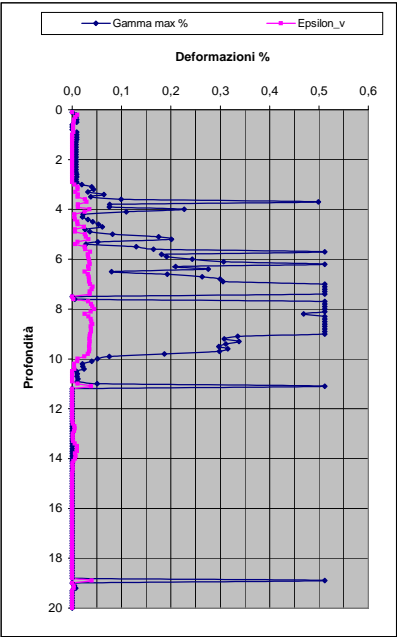
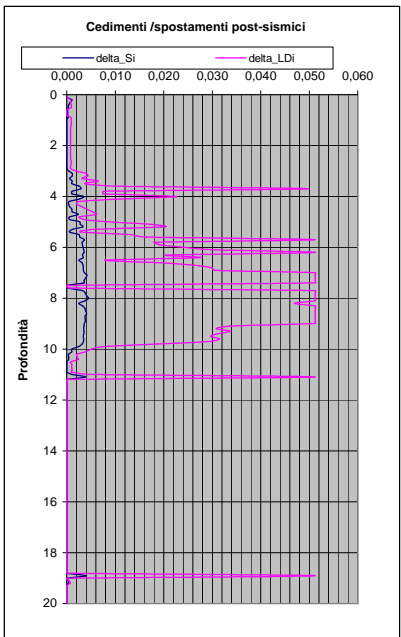
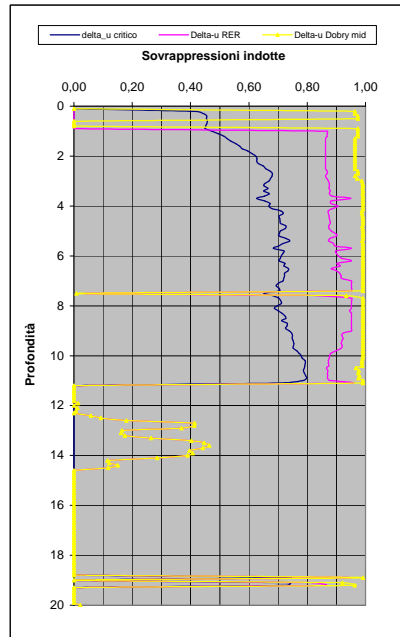
Soil Classification	Zone No.*	Range of CPT Index I_c Values
Organic Clay Soils	2	$I_c > 3.60$
Clays	3	$2.95 < I_c < 3.60$
Silt Mixtures	4	$2.60 < I_c < 2.95$
Sand Mixtures	5	$2.05 < I_c < 2.60$
Sands	6	$1.31 < I_c < 2.05$
Gravelly Sands	7	$I_c < 1.31$

After Robertson and Wride (1998).
*Note: Zone number per Robertson SBT (1990).

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- Argille - argilla/argilla limosa
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- sabbie ghiaiose / sabbie dense

LEGENDA

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- FC** = Fine content - passante 0.074 mm (%)
- FsN** = Attrito laterale (Kg/cmq)
- F** = rapporto di frizione
- Qtn** = parametro di resist. alla punta normal.
- Icn** = Soil behaviour index normalized (ad)
- qc1N-cs** = Resist. alla pentrez. corretta all'FC e normalizzata
- ξ = parametro di stato
- KH** = fatt. correttivo per spessore strato (ad)
- Rd** = stress reduction coefficient (ad)
- CN** = fattore di normalizzazione per carico litostatico (ad)
- K σ** = fatt. correttivo per sovraccarico-profondità (ad)
- K α** = fatt. correttivo per sforzi di taglio (ad)
- MSF** = magnitudo scaling factor (ad)
- F.S.** = Fattore di sicurezza (CRR/CSR con correzioni) (ad)
- CSR** = Cyclic Stress ratio (ad)
- CRR** = Cyclic Resistance Ratio (ad)
- P.L.** = Probabilità di liquefazione (ad)
- IPL** = Indice del potenziale di liquefazione (ad)
- γ_{max}** = deformazione di taglio massima indotta dal sisma (%)
- ev** = vertical reconsolidation strain
- Δs_i** = cedimento i-esimo dello strato (mt)
- Su** = S_u / σ'_{vc} resistenza totale non drenata - strati coesivi (ad)
- Sur** = S_{ur} / σ'_{vc} resistenza totale residua non drenata - strati coesivi (ad)
- qc1N-sr** = Resist. alla pentrez. corretta all'FC e normalizzata
- Sr** = S_r / σ'_{vc} resistenza residua - strati incoerenti (ad)
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- Δu Dobry M. = $\Delta u / \sigma'_{vc}$ Dobry et al. 1984 "mean" x sabbie-Robertson '09 x argille
- Δu Dobry L. = $\Delta u / \sigma'_{vc}$ Dobry et al. 1984 "lower bound" x sabbie-Robertson '09 x argille
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- Stot** = Cedimento post-sismico totale (mt)
- LDI** = Lateral Displacement Index (mt)
- Dr** = Densità relativa (ad)
- ϕ = angolo di attrito interno (deg)
- OCR** = rapporto di sovraconsolidazione (sabbie e argille) (ad)
- St** = coefficiente di sensitività delle argille (ad)
- LSN** = Liquefaction Severity Number (ad)



IPL = 8,78

PL = 23,55

LDI = 1,967 Stot = 0,203 (mt)

LD = 0,00 (mt)

SLiq = 6,50 (mt)

LSN = 29,78 PG = 0,82

LSN Range	Expected ground surface damage
0-10	Little to no expression of liquefaction, minor effects
10-20	Minor expression of liquefaction, some sand boils
20-30	Moderate expression of liquefaction, with some sand boils and structural damage
30-40	Moderate to severe expression of liquefaction, settlement can cause structural damage
40-50	Major expression of liquefaction, undulations and damage to ground surface, severe total and differential settlements of structures
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* Table based on Table 13.1 from I&T report: Liquefaction Vulnerability Study

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$0.9 < P_G$	extremely high to absolutely certain
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$0.1 < P_G \leq 0.3$	low
$P_G \leq 0.1$	extremely low to none

CPT-based liquefaction triggering analysis for a single sounding

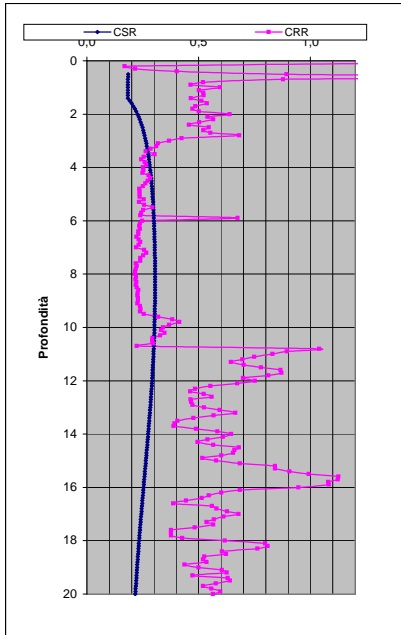
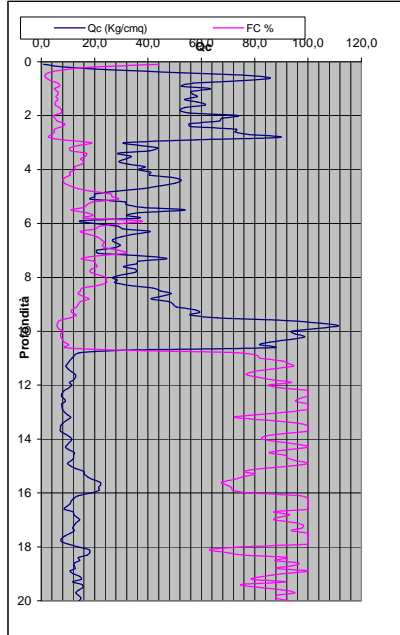
Environmental parameters: Soil Classification, Zone No., Range of CPT Index Values, Peak ground accel (g), Earthquake magnitude, Water table depth, Average above water table, Average below water table, Equipment. Behaviours: Sand-like, Sand-Clay-SC, Building (V)M, Sedimentary environment, CPTs - CPTU-1. Computer constants: alpha (N), N, Patm, Q, MSF, NCEER, etc. Probabilità e potenziale di liquefazione: Probabilità, Pot di Liq, IPL, etc. Probabilità e suscettibilità di liquefazione: Suscettibilità, Quasi certa, etc. PL Overall Probability: Risk lev., IPL, etc. Displacements parameters: Delta H, ALDI, etc. Diagrams: PROVA "CPTe 12", Potential flow failure (N) i60-co-10, No flow liquefaction if (qc1N)/65.

Table with columns: Depth (m), qc1N, qc2N, qc3N, qc4N, qc5N, qc6N, qc7N, qc8N, qc9N, qc10N, qc11N, qc12N, qc13N, qc14N, qc15N, qc16N, qc17N, qc18N, qc19N, qc20N, qc21N, qc22N, qc23N, qc24N, qc25N, qc26N, qc27N, qc28N, qc29N, qc30N, qc31N, qc32N, qc33N, qc34N, qc35N, qc36N, qc37N, qc38N, qc39N, qc40N, qc41N, qc42N, qc43N, qc44N, qc45N, qc46N, qc47N, qc48N, qc49N, qc50N, qc51N, qc52N, qc53N, qc54N, qc55N, qc56N, qc57N, qc58N, qc59N, qc60N, qc61N, qc62N, qc63N, qc64N, qc65N, qc66N, qc67N, qc68N, qc69N, qc70N, qc71N, qc72N, qc73N, qc74N, qc75N, qc76N, qc77N, qc78N, qc79N, qc80N, qc81N, qc82N, qc83N, qc84N, qc85N, qc86N, qc87N, qc88N, qc89N, qc90N, qc91N, qc92N, qc93N, qc94N, qc95N, qc96N, qc97N, qc98N, qc99N, qc100N. Includes various parameters like N, Kc, L, Layer, etc.

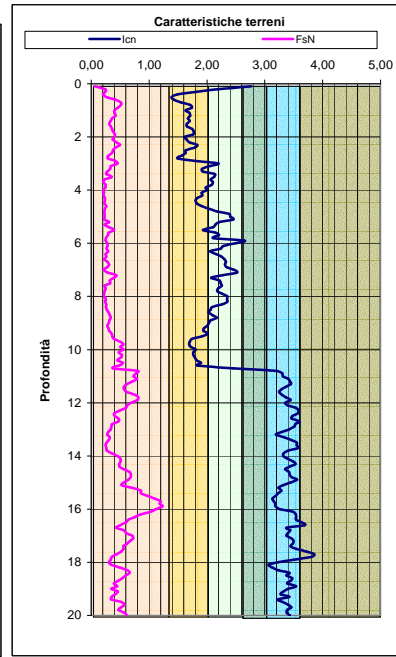
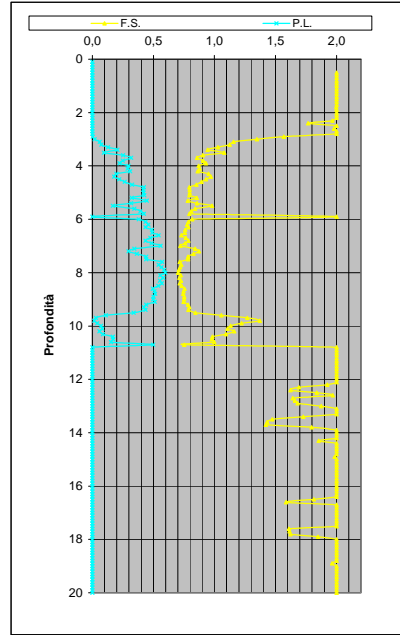
PROFONDITA' DI CALCOLO (mt da p.c.): 0,0 LDI = 2,109 Stot = 0,190 (mt) IPL = 7,79 PL = 19,89 LD = 0,00 (mt) PG = 0,69 SLiq = 6,4 (mt) LSN = 28,8

Main data table with 100 rows and 100 columns. Columns include depth, qc values, N, Kc, L, Layer, and various probability and displacement parameters. The table is color-coded with green, yellow, and red cells indicating different risk levels or states.

DIAGRAMMI DI RIFERIMENTO VERIFICA LIQUEFAZIONE - METODO R. & W. , 2009



PROVA CPT E 12



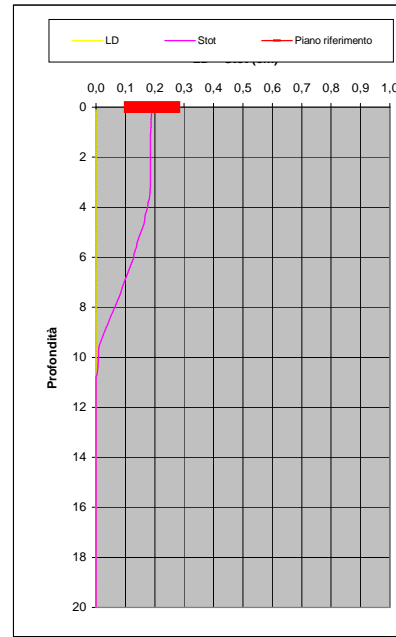
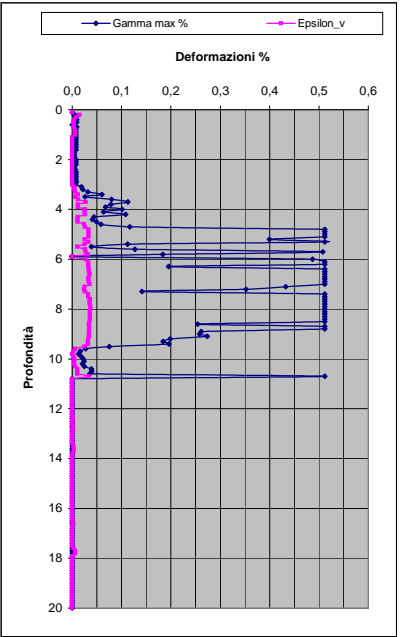
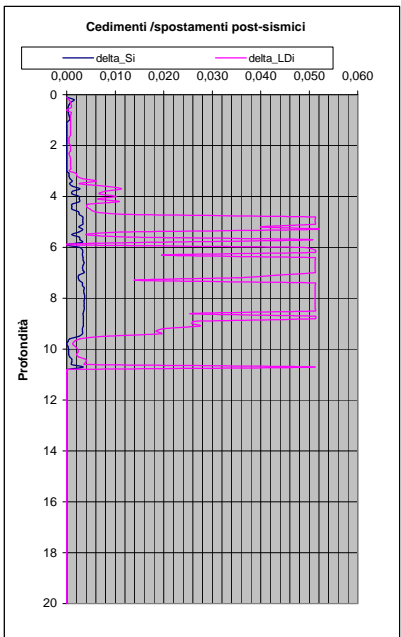
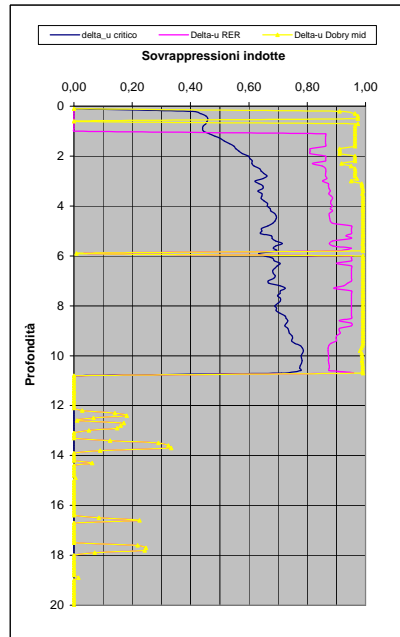
Soil Classification	Zone No.*	Range of CPT Index I_c Values
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After Robertson and Wride (1998).
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LEGENDA

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- K α** = fatt. correttivo per sforzi di taglio (ad)
- MSF** = magnitudo scaling factor (ad)
- F.S.** = Fattore di sicurezza (CRR/CSR con correzioni) (ad)
- CSR** = Cyclic Stress ratio (ad)
- CRR** = Cyclic Resistance Ratio (ad)
- P.L.** = Probabilità di liquefazione (ad)
- IPL** = Indice del potenziale di liquefazione (ad)
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- Δs_i** = cedimento i-esimo dello strato (mt)
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LSN Range	Expected ground surface damage
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* Table based on Table 13.1 from I&T report: Liquefaction Vulnerability Study

Probability	Description of the risk of liquefaction-induced ground failure
$0.9 < P_G$	extremely high to absolutely certain
$0.7 < P_G \leq 0.9$	high
$0.3 < P_G \leq 0.7$	medium
$0.1 < P_G \leq 0.3$	low
$P_G \leq 0.1$	extremely low to none

IPL = 7,79 PL = 19,89 LDI = 2,109 Stot = 0,190 (mt) LD = 0,00 (mt) SLiq = 6,40 (mt) LSN = 28,83 PG = 0,69

CPT-based liquefaction triggering analysis for a single sounding

Environment: Hill-H Plain-P Coast-C
Behaviours: Sand like-S

Computer constants: α (N) = 1, N = 101,32, MSF NCEER = 0,357

Probabilità e potenziale di liquefazione

Probabilità e suscettibilità di liquefazione

PL Overall Probability

Robertson & Wride, agg. 2009

PROVA "CPTU 1" - Colonia Montecatini

Input parameters table including Peak ground accel (g), Earthquake magnitude (M), Water table depth (m), Average above water table (N60)30, Average below water table (N60)30, Equipment (CPT-CPT1)

Soil Classification table with columns for Zone No., Range of CPT Index / Values, and Soil Name (e.g., Organic Clay Silts, Silts)

Probabilità e potenziale di liquefazione table with columns for Probabilità, Pot di Liq., IPL, and various soil parameters

Probabilità e suscettibilità di liquefazione table with columns for Probabilità, Suscettibilità, Quasi certa, and various soil parameters

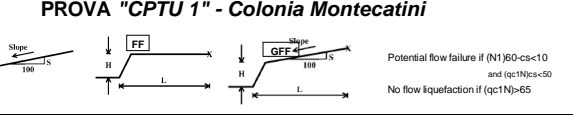


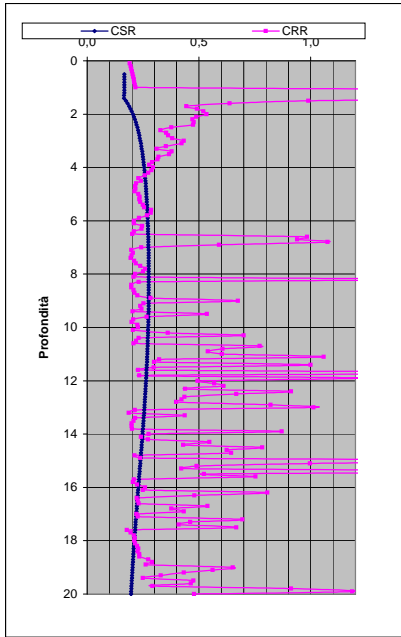
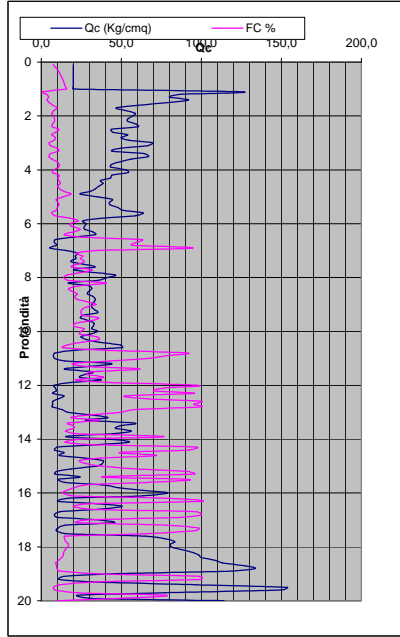
Table with columns LsN and LsN Expression, showing values for different ranges like >50, 40-50, 30-40, 20-30, 10-20, 0-10

Main data table header with columns for Depth (m), q (kPa), fs (kPa), q/cv, cv/cv, Q1, Qtn, F, Ic, Ic2, N1(60), n, Kc, Layer, Flag, FC, Kh, Interpret, qc1N, On-cs, R, CSR, Ks, ξ, Kα, CRR, Factor of Safety FS, MSF SAND & CLAY, Limiting shear strain γlim%, Parameter, ΔH, ALDI, Vertical recons. Strain, ASI, Pmax PL, PL, F, IPI, Au/σ', Au/σ', Ru, Au/σ', Dr, θ, Ruc, Su/σ'vc, OCR, qc1N, Sr/σ'vc, Su/σ'vc, LSN

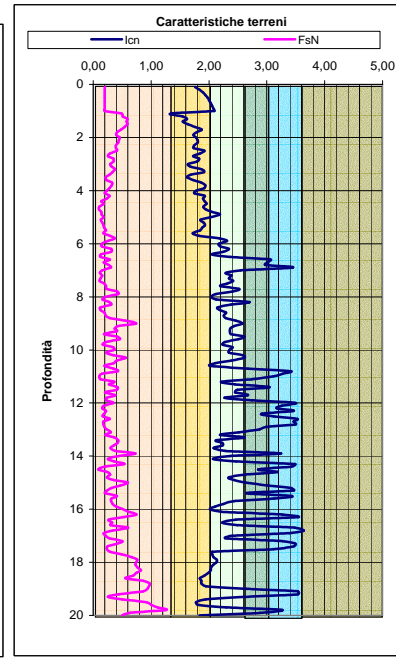
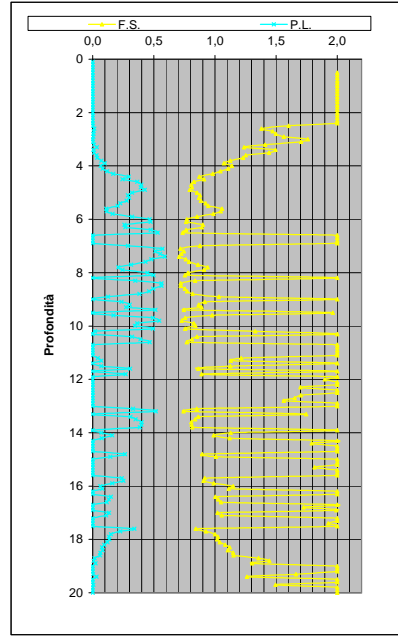
PROFONDITA' DI CALCOLO (mt da p.c.): 0,0 | LDI = 2,495 | Stot = 0,237 (mt) | IPI = 6,30 | PL = 15,20 | LD = 0,00 (mt) | PG = 0,44 | SLiq = 6,8 (mt) | LSN = 28,3

Main data table body containing 101 rows of soil test data, including depth, cone resistance, sleeve friction, and various calculated parameters.

DIAGRAMMI DI RIFERIMENTO VERIFICA LIQUEFAZIONE - METODO R. & W. , 2009



PROVA CPTU 1 - Colonia Montecatini



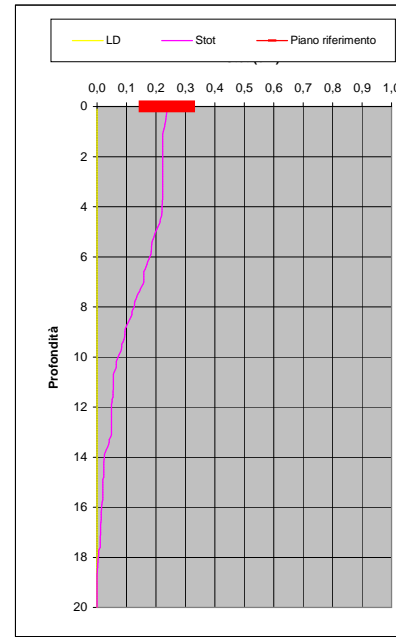
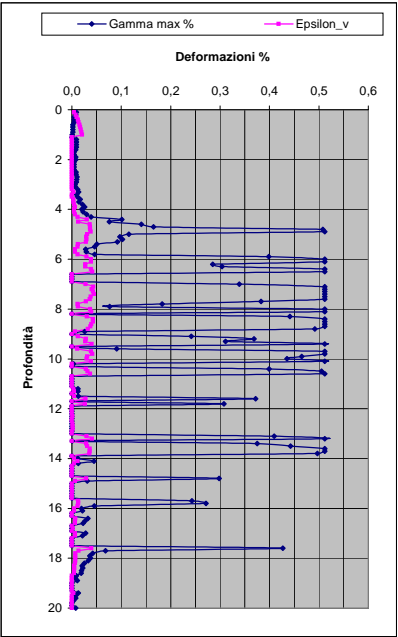
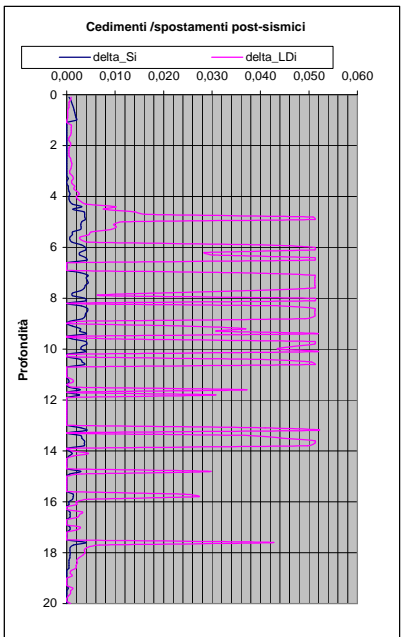
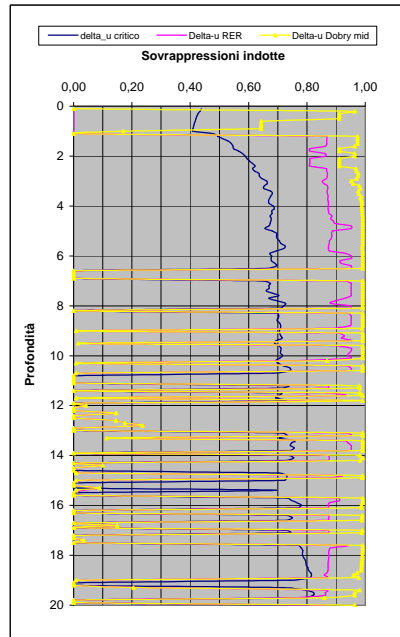
Soil Classification	Zone No.*	Range of CPT Index I_c Values
Organic Clay Soils	2	$I_c > 3.60$
Clays	3	$2.95 < I_c < 3.60$
Silt Mixtures	4	$2.60 < I_c < 2.95$
Sand Mixtures	5	$2.05 < I_c < 2.60$
Sands	6	$1.31 < I_c < 2.05$
Gravelly Sands	7	$I_c < 1.31$

After Robertson and Wride (1998).
*Note: Zone number per Robertson SBT (1990).

- Argille - terreni organici
- Argille - argilla/argilla limosa
- Miscela di limi - limo argilloso/argilla limosa
- Miscela di sabbie - sabbia limosa/limo sabbioso
- Sabbie - sabbie pulite/sabbie limose
- sabbie ghiaiose / sabbie dense

LEGENDA

- Qc** = Res. alla penetraz. (Kg/cmq)
- FC** = Fine content - passante 0.074 mm (%)
- FsN** = Attrito laterale (Kg/cmq)
- F** = rapporto di frizione
- Qtn** = parametro di resist. alla punta normal.
- Icn** = Soil behaviour index normalized (ad)
- qc1N-cs** = Resist. alla pentrez. corretta all'FC e normalizzata
- ξ = parametro di stato
- KH** = fatt. correttivo per spessore strato (ad)
- Rd** = stress reduction coefficient (ad)
- CN** = fattore di normalizzazione per carico litostatico (ad)
- K σ** = fatt. correttivo per sovraccarico-profondità (ad)
- K α** = fatt. correttivo per sforzi di taglio (ad)
- MSF** = magnitudo scaling factor (ad)
- F.S.** = Fattore di sicurezza (CRR/CSR con correzioni) (ad)
- CSR** = Cyclic Stress ratio (ad)
- CRR** = Cyclic Resistance Ratio (ad)
- P.L.** = Probabilità di liquefazione (ad)
- IPL** = Indice del potenziale di liquefazione (ad)
- γ_{max}** = deformazione di taglio massima indotta dal sisma (%)
- ev** = vertical reconsolidation strain
- Δs_i** = cedimento i-esimo dello strato (mt)
- Su** = S_u / σ'_{vc} resistenza totale non drenata - strati coesivi (ad)
- Sur** = S_{ur} / σ'_{vc} resistenza totale residua non drenata - strati coesivi (ad)
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- Sr** = S_r / σ'_{vc} resistenza residua - strati incoerenti (ad)
- Ruc** = $\Delta u / \sigma'_{vc}$ critico - stima sogliadi innesco fenomeni di instabilità/liquefazione
- Δu RER = $\Delta u / \sigma'_{vc}$ sovrappressioni circ. 112/2007 - tabella 2 R.E.R.
- Δu Dobry M. = $\Delta u / \sigma'_{vc}$ Dobry et al. 1984 "mean" x sabbie-Robertson '09 x argille
- Δu Dobry L. = $\Delta u / \sigma'_{vc}$ Dobry et al. 1984 "lower bound" x sabbie-Robertson '09 x argille
- Δu Dobry U. = $\Delta u / \sigma'_{vc}$ Dobry et al. 1984 "Upper bound" x sabbie-Robertson '09 x argille
- Stot** = Cedimento post-sismico totale (mt)
- LDI** = Lateral Displacement Index (mt)
- Dr** = Densità relativa (ad)
- ϕ = angolo di attrito interno (deg)
- OCR** = rapporto di sovraconsolidazione (sabbie e argille) (ad)
- St** = coefficiente di sensitività delle argille (ad)
- LSN** = Liquefaction Severity Number (ad)



IPL = 6,30 PL = 15,20 LDI = 2,495 Stot = 0,237 (mt) LD = 0,00 (mt) SLiq = 6,80 (mt) LSN = 28,33 PG = 0,44

LSN Range	Expected ground surface damage
0-10	Little to no expression of liquefaction, minor effects
10-20	Minor expression of liquefaction, some sand boils
20-30	Moderate expression of liquefaction, with some sand boils and structural damage
30-40	Moderate to severe expression of liquefaction, settlement can cause structural damage
40-50	Major expression of liquefaction, undulations and damage to ground surface, severe total and differential settlements of structures
>50	Severe damage, extensive evidence of liquefaction as surface, severe total and differential settlements affecting structures, damage to services.

* Table based on Table 13.1 from I&T report: Liquefaction Vulnerability Study

Probability	Description of the risk of liquefaction-induced ground failure
$0.9 < P_G$	extremely high to absolutely certain
$0.7 < P_G \leq 0.9$	high
$0.3 < P_G \leq 0.7$	medium
$0.1 < P_G \leq 0.3$	low
$P_G \leq 0.1$	extremely low to none

CPT-based liquefaction triggering analysis for a single sounding

Enviromenti: C Hill-H Plain-P Coast-C Behaviours: Sand like-S

Computer constants: no. n=10, N=101,32, MSF NECEER=350, Patm=101,32, cov=30-35%, k=1,350, IP COR=1,2

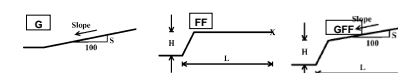
Probabilità e potenziale di liquefazione

Probabilità e suscettibilità di liquefazione

PL Overall Probability

Robertson & Wride, agg. 2009

PROVA "CPTU 2 II Canalino"



Potential flow failure if (N1)60<C<10 and (q1)10<C<20 No flow liquefaction if (q1)10<C<5

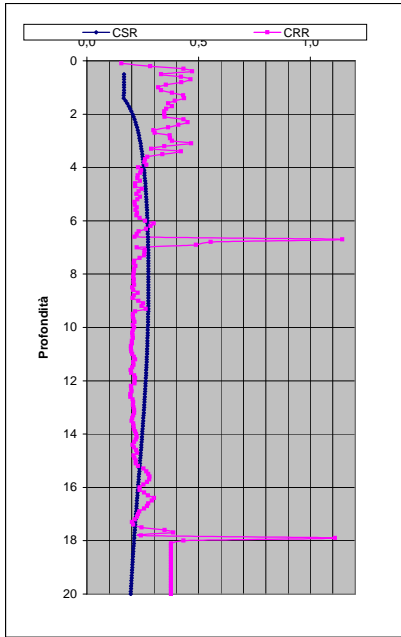
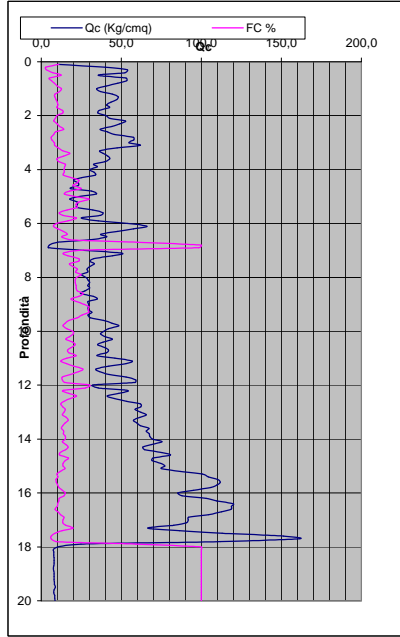
Table with 2 columns: LsN, LsN Expression. Values range from >50 to <0.

Main header table for the data, including columns for Depth (m), q (kPa), q_c (kPa), F, Ic, N1(60), n, Kc, Layer, etc.

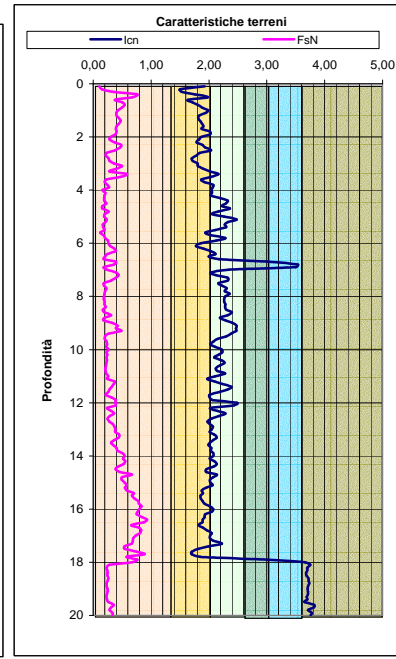
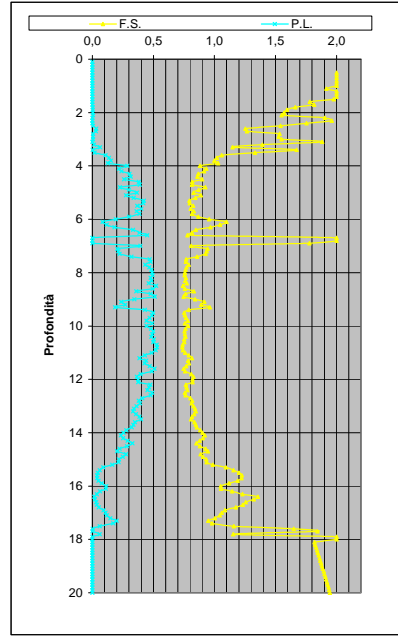
PROFONDITA' DI CALCOLO (mt da p.c.): 0,0 LDI = 3,839 Stot = 0,356 (mt) IPL = 9,73 PL = 27,46 LD = 0,00 (mt) PG = 0,90 SLiq = 11,0 (mt) LSN = 41,1

Main data table with 40 columns and 100 rows of numerical data for each depth interval.

DIAGRAMMI DI RIFERIMENTO VERIFICA LIQUEFAZIONE - METODO R. & W. , 2009



PROVA CPTU 2 - Il Canalino



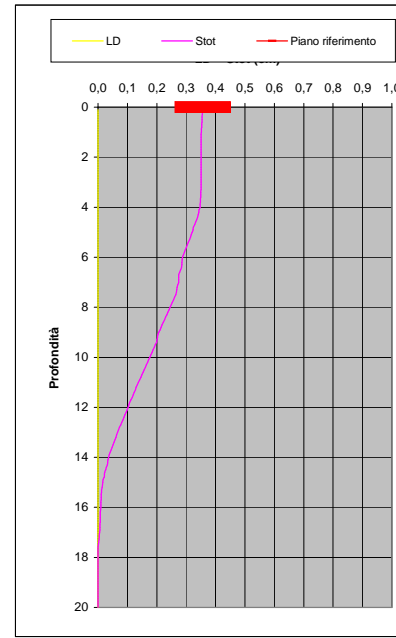
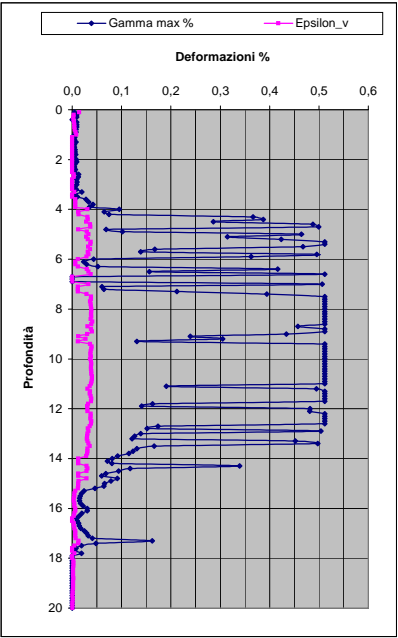
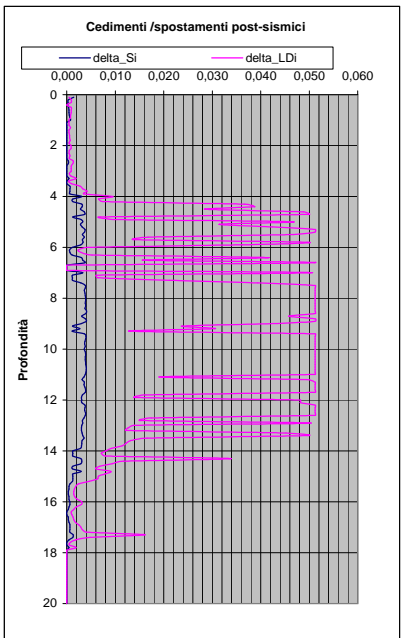
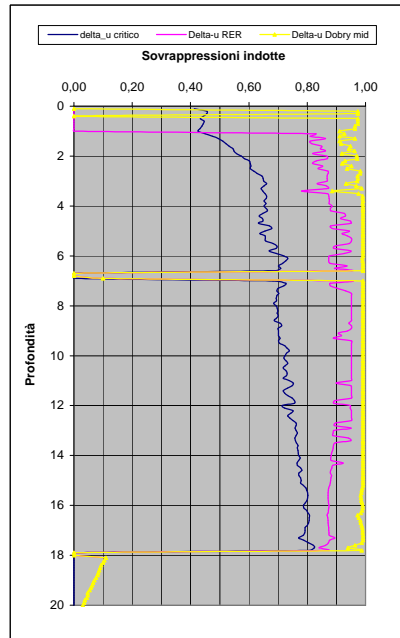
Soil Classification	Zone No.*	Range of CPT Index I_c Values
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Clays	3	$2.95 < I_c < 3.60$
Silt Mixtures	4	$2.60 < I_c < 2.95$
Sand Mixtures	5	$2.05 < I_c < 2.60$
Sands	6	$1.31 < I_c < 2.05$
Gravelly Sands	7	$I_c < 1.31$

After Robertson and Wride (1998).
*Note: Zone number per Robertson SBT (1990).

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- Argille - argilla/argilla limosa
- Miscela di limi - limo argilloso/argilla limosa
- Miscela di sabbie - sabbia limosa/limo sabbioso
- Sabbie - sabbie pulite/sabbie limose
- sabbie ghiaiose / sabbie dense

LEGENDA

- Qc = Res. alla penetraz. (Kg/cmq)
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- F = rapporto di frizione
- Qtn = parametro di resist. alla punta normal.
- Icn = Soil behaviour index normalized (ad)
- qc1N-cs = Resist. alla pentrez. corretta all'FC e normalizzata
- ξ = parametro di stato
- KH = fatt. correttivo per spessore strato (ad)
- Rd = stress reduction coefficient (ad)
- CN = fattore di normalizzazione per carico litostatico (ad)
- K σ = fatt. correttivo per sovraccarico-profondità (ad)
- K α = fatt. correttivo per sforzi di taglio (ad)
- MSF = magnitudo scaling factor (ad)
- F.S. = Fattore di sicurezza (CRR/CSR con correzioni) (ad)
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- qc1N-sr = Resist. alla pentrez. corretta all'FC e normalizzata
- Sr = S_r / σ'_{vc} resistenza residua - strati incoerenti (ad)
- Ruc = $\Delta u / \sigma'_{vc}$ critico - stima sogliadi innesco fenomeni di instabilità/liquefazione
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- Δu Dobry U. = $\Delta u / \sigma'_{vc}$ Dobry et al. 1984 "Upper bound" x sabbie-Robertson '09 x argille
- Stot = Cedimento post-sismico totale (mt)
- LDI = Lateral Displacement Index (mt)
- Dr = Densità relativa (ad)
- θ = angolo di attrito interno (deg)
- OCR = rapporto di sovraconsolidazione (sabbie e argille) (ad)
- St = coefficiente di sensitività delle argille (ad)
- LSN = Liquefaction Severity Number (ad)



IPL = 9,73

PL = 27,46

LDI = 3,839 Stot = 0,356 (mt)

LD = 0,00 (mt)

SLiq = 11,00 (mt)

LSN = 41,13 PG = 0,90

LSN Range	Expected ground surface damage
0-10	Little to no expression of liquefaction, minor effects
10-20	Minor expression of liquefaction, some sand boils
20-30	Moderate expression of liquefaction, with some sand boils and structural damage
30-40	Moderate to severe expression of liquefaction, settlement can cause structural damage
40-50	Major expression of liquefaction, undulations and damage to ground surface, severe total and differential settlements of structures
>50	Severe damage, extensive evidence of liquefaction as surface, severe total and differential settlements affecting structures, damage to services.

* Table based on Table 13.1 from I&T report: Liquefaction Vulnerability Study

Probability	Description of the risk of liquefaction-induced ground failure
$0.9 < P_G$	extremely high to absolutely certain
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$0.3 < P_G \leq 0.7$	medium
$0.1 < P_G \leq 0.3$	low
$P_G \leq 0.1$	extremely low to none

ALLEGATO N.2

**"VERIFICHE DI CALCOLO DEL POTENZIALE DI LIQUEFACIBILITÀ CON
MAGNITUDO MW = 6,14 "**



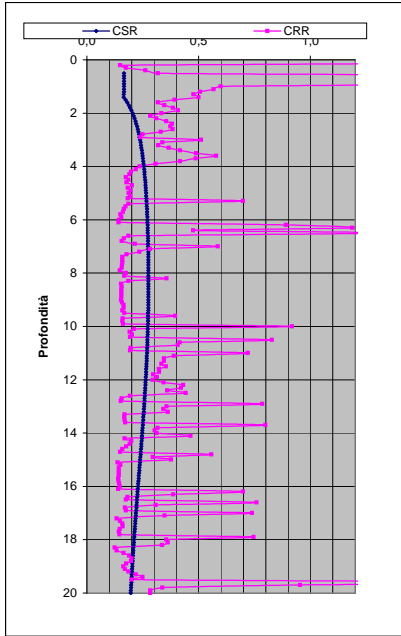
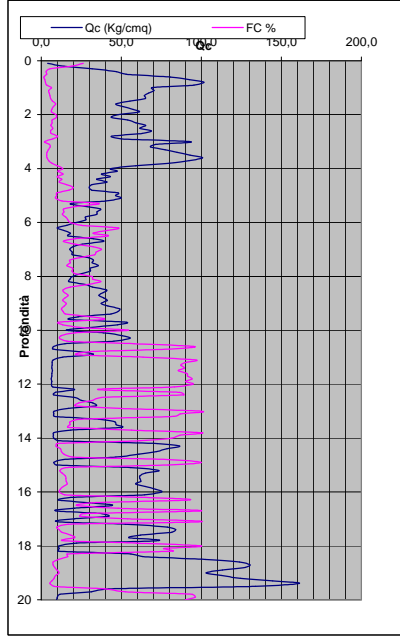
GEOPROGET

Studio di Geologia

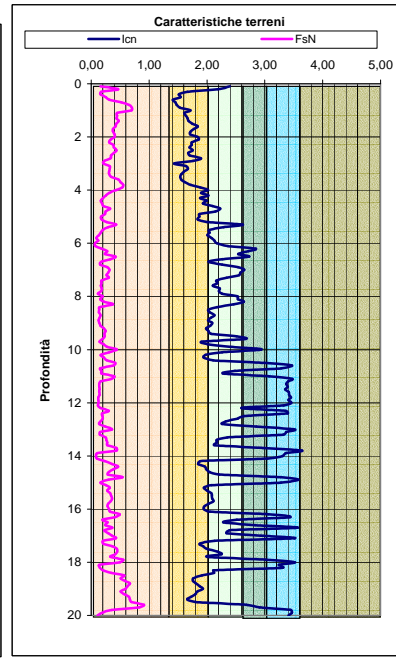
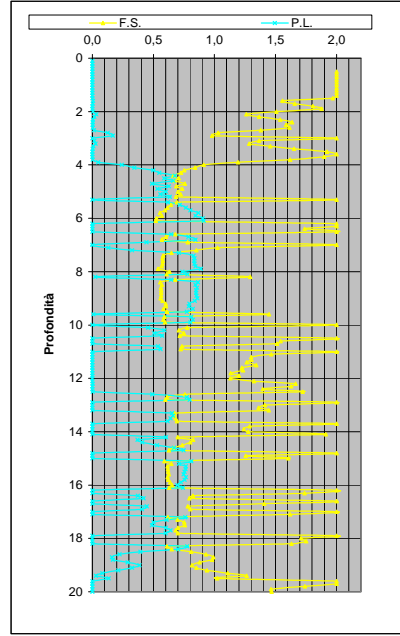
via Ceccarini, 171 - Palazzo La Viola
Riccione - 47838 - (RN) Tel/Fax 0541/606464

E-MAIL vannoni.fabio1960@libero.it
copicicarlo@libero.it

DIAGRAMMI DI RIFERIMENTO VERIFICA LIQUEFAZIONE - METODO R. & W. , 2009



PROVA CPT E 1



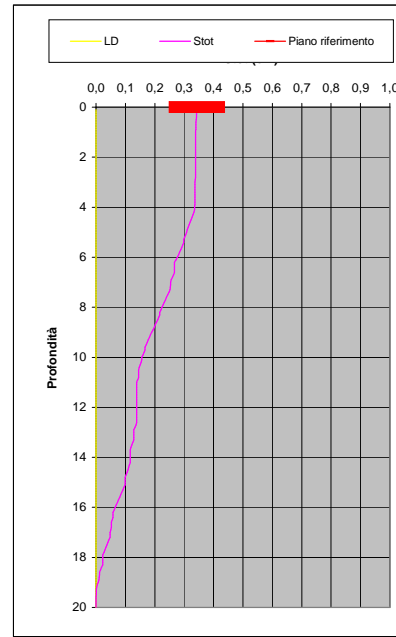
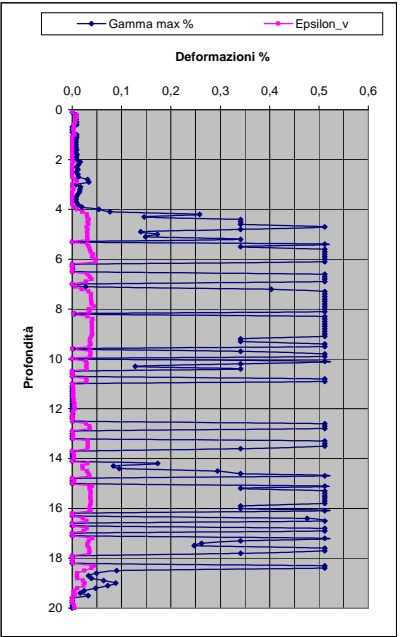
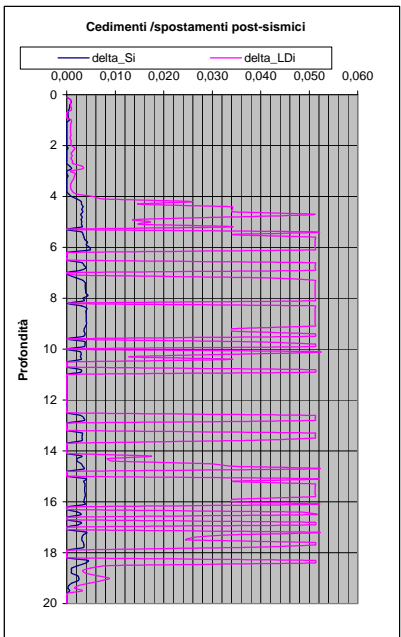
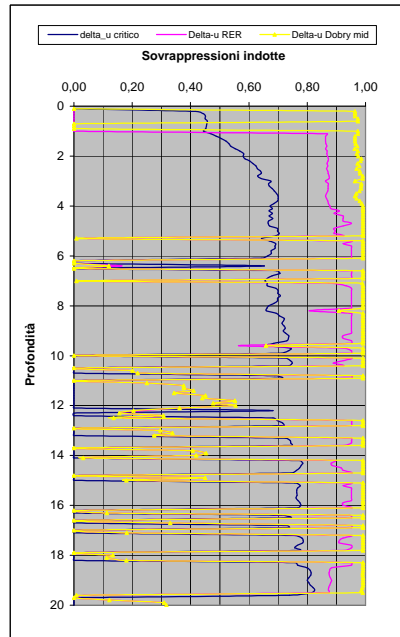
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Clays	3	$2.95 < I_c < 3.60$
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Sands	6	$1.31 < I_c < 2.05$
Gravelly Sands	7	$I_c < 1.31$

After Robertson and Wride (1998).
*Note: Zone number per Robertson SBT (1990).

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LEGENDA

- Qc** = Res. alla penetraz. (Kg/cmq)
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- ξ = parametro di stato
- KH** = fatt. correttivo per spessore strato (ad)
- Rd** = stress reduction coefficient (ad)
- CN** = fattore di normalizzazione per carico litostatico (ad)
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- K α** = fatt. correttivo per sforzi di taglio (ad)
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- Dr** = Densità relativa (ad)
- θ = angolo di attrito interno (deg)
- OCR** = rapporto di sovraconsolidazione (sabbie e argille) (ad)
- St** = coefficiente di sensibilità delle argille (ad)
- LSN** = Liquefaction Severity Number (ad)



LSN Range	Expected ground surface damage
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* Table based on Table 13.1 from I&T report: Liquefaction Vulnerability Study

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$0.9 < P_G$	extremely high to absolutely certain
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$0.3 < P_G \leq 0.7$	medium
$0.1 < P_G \leq 0.3$	low
$P_G \leq 0.1$	extremely low to none

IPL= 15,35

PL= 56,30

LDI = 4,101 Stot = 0,343 (mt)

LD = 0,00 (mt)

SLiq = 10,30 (mt)

LSN = 38,42 PG= 1,00

CPT-based liquefaction triggering analysis for a single sounding

Enviromenti: C Hill-H Plain-P Coast-C Behaviours: Sand like-S

Computer constants: no. n=180, Patm=101.32, cov=0.35-35%, K=1.2, alpha(N)=0.0357

Input parameter: Peak ground accel (g)=0.213, Earthquake magnitude, M=6.14, Water table depth (m)=1.79, Average of above water table (N/m2)=19.3, Average of below water table (N/m2)=10.26

Soil Classification table with columns: Soil Classification, Zone No., Range of CPT Index / Values

Sand-Clay-SC, Building (V/N), Sedimentary environment, CPTs - CPTU=1, CPTs - CP=1

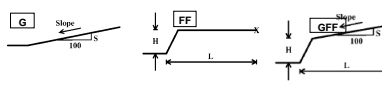
Probabilità e potenziale di liquefazione, Probabilità e suscettibilità di liquefazione, PL Overall Probability

Probabilità e suscettibilità di liquefazione, Probabilità e suscettibilità di liquefazione, Probabilità e suscettibilità di liquefazione

PL Overall Probability, Risk lev., IPL, PL

Robertson & Wride, agg. 2009

PROVA "CPTE 2"



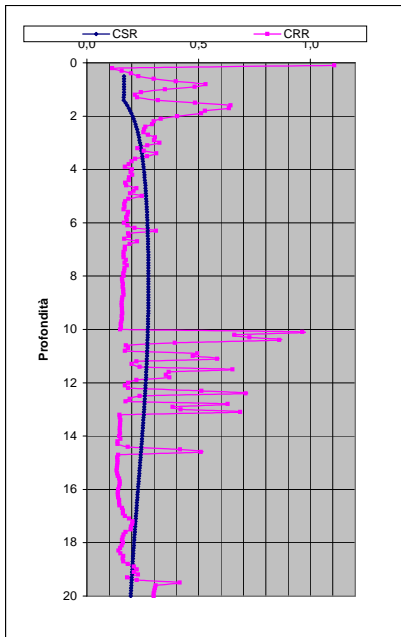
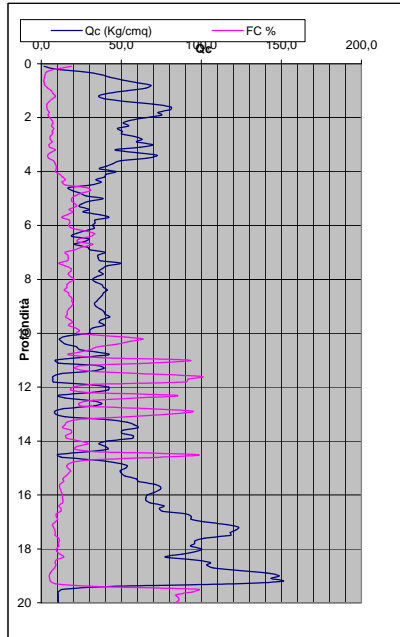
Potential flow failure if (N1)K0<=10 and (q1/N) >= 50, No flow liquefaction if (q1/N)<=50

Main data table with columns: Depth (m), q1(N/m2), qN(N/m2), FAN, qvc (kPa), q'vc (kPa), Q1, Qtn, F, Ic, IcN2, N1(60), n, Kc, Layer, Flag, FC, Kh, Interpret, qcN, qc1N, On-cs, R, CSR, Ks, xi, Ks, crr, CRR, Factor of Safety FS, MSF SAND & CLAY, Limiting shear strain, PL, JUNG, F, IPI, Au/O', Ru, Au/O', Dr, S, Ruc, Su/O'vc, OCR, qc1N, Sr/O'vc, Su/O'vc, LSN

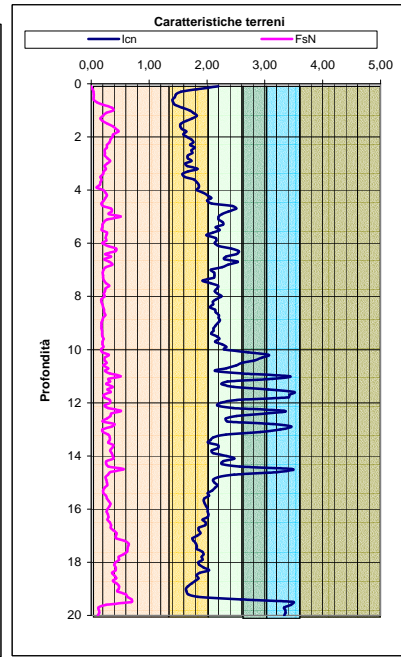
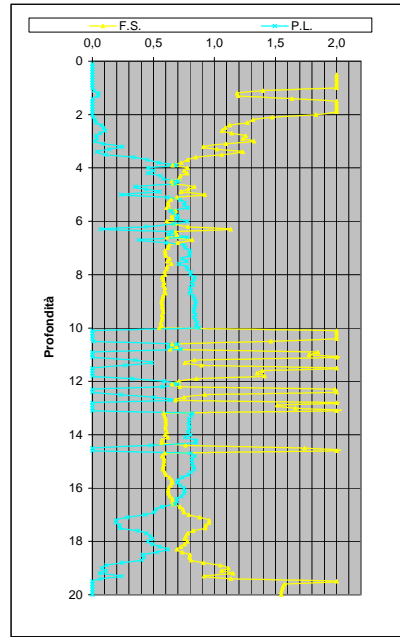
PROFONDITA' DI CALCOLO (mt da p.c.): 0,0, LDI = 5,441, Stot = 0,457 (mt), IPL = 19,61, PL = 76,54, LD = 0,00 (mt), PG = 1,00, SLiq = 13,4 (mt), LSN = 51,2

Main data table containing 100 rows of soil test results with columns for depth, CPT parameters, soil classification, and various calculated indices.

DIAGRAMMI DI RIFERIMENTO VERIFICA LIQUEFAZIONE - METODO R. & W. , 2009



PROVA CPT2



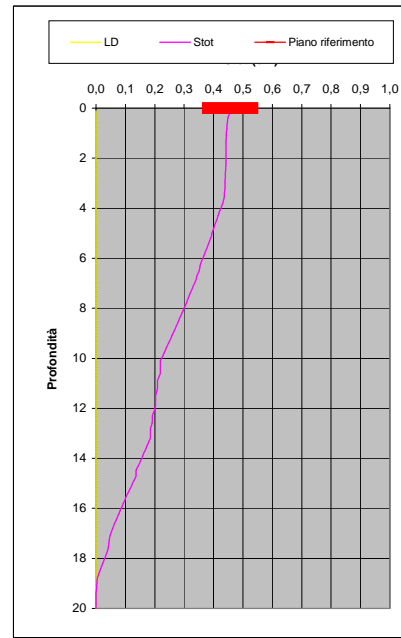
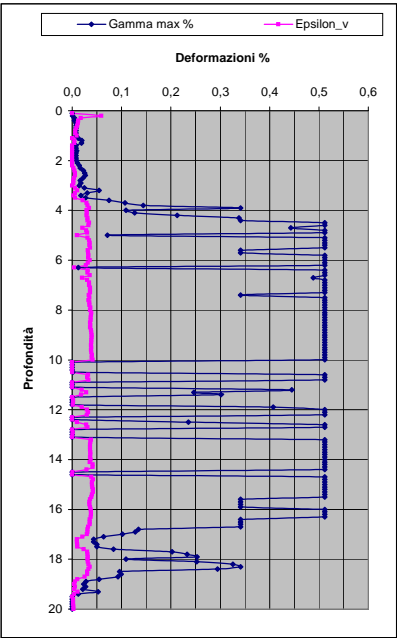
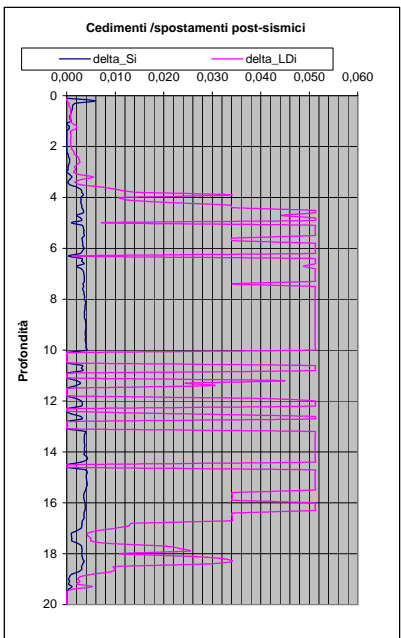
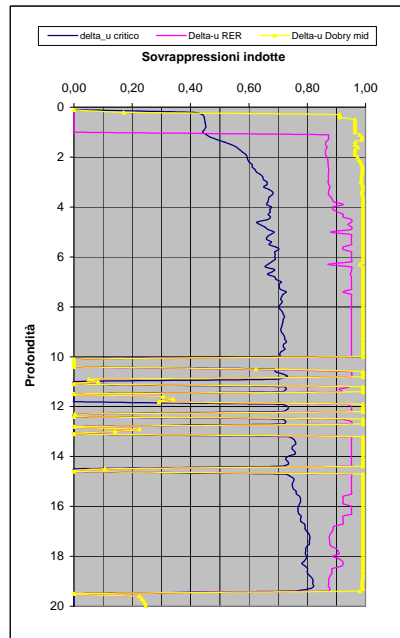
Soil Classification	Zone No.*	Range of CPT Index I_c Values
Organic Clay Soils	2	$I_c > 3.60$
Clays	3	$2.95 < I_c < 3.60$
Silt Mixtures	4	$2.60 < I_c < 2.95$
Sand Mixtures	5	$2.05 < I_c < 2.60$
Sands	6	$1.31 < I_c < 2.05$
Gravelly Sands	7	$I_c < 1.31$

After Robertson and Wride (1998).
*Note: Zone number per Robertson SBT (1990).

- Argille - terreni organici
- Argille - argilla/argilla limosa
- Miscela di limi - limo argilloso/argilla limosa
- Miscela di sabbie - sabbia limosa/limo sabbioso
- Sabbie - sabbie pulite/sabbie limose
- sabbie ghiaiose / sabbie dense

LEGENDA

- Qc** = Res. alla penetraz. (Kg/cmq)
- FC** = Fine content - passante 0.074 mm (%)
- Fsn** = Attrito laterale (Kg/cmq)
- F** = rapporto di frizione
- Qtn** = parametro di resist. alla punta normal.
- Icn** = Soil behaviour index normalized (ad)
- qc1N-cs** = Resist. alla pentrez. corretta all'FC e normalizzata
- ξ = parametro di stato
- KH** = fatt. correttivo per spessore strato (ad)
- Rd** = stress reduction coefficient (ad)
- CN** = fattore di normalizzazione per carico litostatico (ad)
- K σ** = fatt. correttivo per sovraccarico-profondità (ad)
- K α** = fatt. correttivo per sforzi di taglio (ad)
- MSF** = magnitudo scaling factor (ad)
- F.S.** = Fattore di sicurezza (CRR/CSR con correzioni) (ad)
- CSR** = Cyclic Stress ratio (ad)
- CRR** = Cyclic Resistance Ratio (ad)
- P.L.** = Probabilità di liquefazione (ad)
- IPL** = Indice del potenziale di liquefazione (ad)
- γ_{max}** = deformazione di taglio massima indotta dal sisma (%)
- ev** = vertical reconsolidation strain
- Δs_i** = cedimento i-esimo dello strato (mt)
- Su** = S_u / σ'_{vc} resistenza totale non drenata - strati coesivi (ad)
- Sur** = S_{ur} / σ'_{vc} resistenza totale residua non drenata - strati coesivi (ad)
- qc1N-sr** = Resist. alla pentrez. corretta all'FC e normalizzata
- Sr** = S_r / σ'_{vc} resistenza residua - strati incoerenti (ad)
- Ruc** = $\Delta u / \sigma'_{vc}$ critico - stima sogliadi innesco fenomeni di instabilità/liquefazione
- Δu RER = $\Delta u / \sigma'_{vc}$ sovrappressioni circ. 112/2007 - tabella 2 R.E.R.
- Δu Dobry M. = $\Delta u / \sigma'_{vc}$ Dobry et al. 1984 "mean" x sabbie-Robertson '09 x argille
- Δu Dobry L. = $\Delta u / \sigma'_{vc}$ Dobry et al. 1984 "lower bound" x sabbie-Robertson '09 x argille
- Δu Dobry U. = $\Delta u / \sigma'_{vc}$ Dobry et al. 1984 "Upper bound" x sabbie-Robertson '09 x argille
- Stot** = Cedimento post-sismico totale (mt)
- LDI** = Lateral Displacement Index (mt)
- Dr** = Densità relativa (ad)
- ϕ = angolo di attrito interno (deg)
- OCR** = rapporto di sovraconsolidazione (sabbie e argille) (ad)
- St** = coefficiente di sensitività delle argille (ad)
- LSN** = Liquefaction Severity Number (ad)



LSN Range	Expected ground surface damage
0-10	Little to no expression of liquefaction, minor effects
10-20	Minor expression of liquefaction, some sand boils
20-30	Moderate expression of liquefaction, with some sand boils and structural damage
30-40	Moderate to severe expression of liquefaction, settlement can cause structural damage
40-50	Major expression of liquefaction, undulations and damage to ground surface, severe total and differential settlements of structures
>50	Severe damage, extensive evidence of liquefaction as surface, severe total and differential settlements affecting structures, damage to services.

* Table based on Table 13.1 from I&T report: Liquefaction Vulnerability Study

Probability	Description of the risk of liquefaction-induced ground failure
$0.9 < P_G$	extremely high to absolutely certain
$0.7 < P_G \leq 0.9$	high
$0.3 < P_G \leq 0.7$	medium
$0.1 < P_G \leq 0.3$	low
$P_G \leq 0.1$	extremely low to none

IPL= 19,61

PL= 76,54

LDI = 5,441 Stot = 0,457 (mt)

LD = 0,00 (mt)

SLiq = 13,40 (mt)

LSN = 51,16 PG= 1,00

CPT-based liquefaction triggering analysis for a single sounding

Enviromenti Behaviours

Computer constants

no. n (Blaise) ("B" 2007 - "Cefin" 2004 - "NCEER" - "Blaise")

Probabilità e potenziale di liquefazione

Probabilità e suscettibilità di liquefazione

Robertson & Wride, agg. 2009

PROVA "CPTE 3"



Potential flow failure if (N1) < 100-cv+10 and (q1) < 100-cv+50

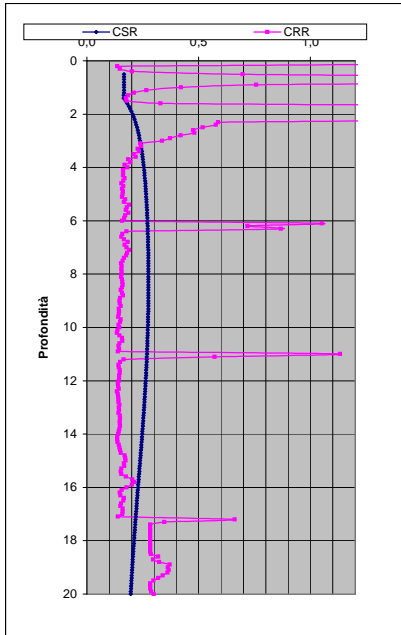
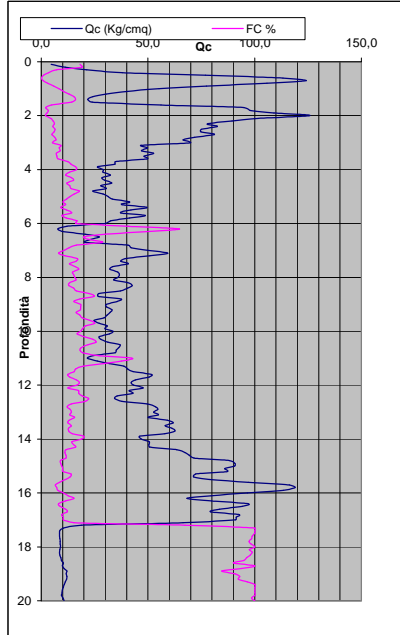
No flow liquefaction if (q1) < 100-cv+65

Table with 2 columns: LsN, LsN Expression. Values range from >50 to <0.

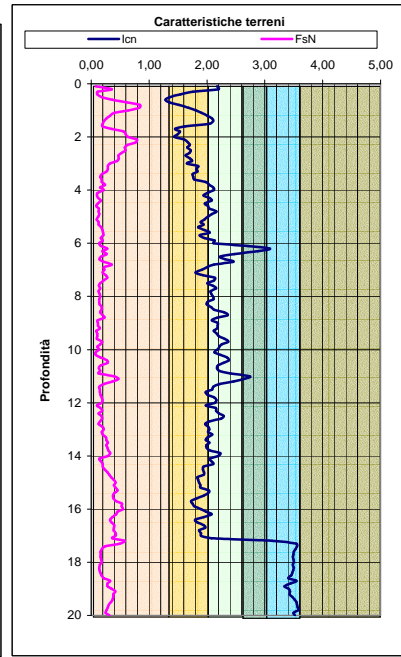
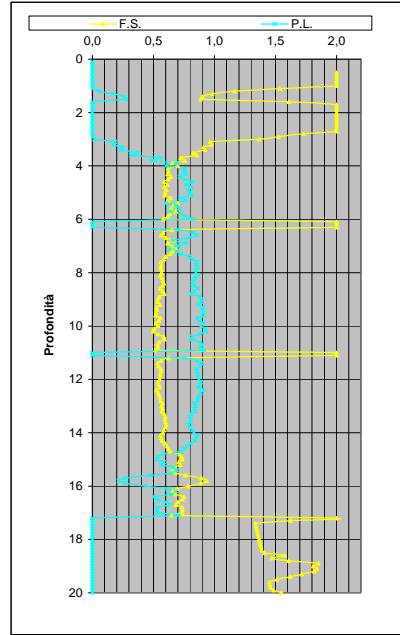
Main data table with columns for Depth (m), Soil Classification, q (kPa), qc (kPa), F, Ic, N60, n, Kc, Layer, etc. Includes a 'PROFONDITA' DI CALCOLO' row with value 0,0.

Main data table continuing from the previous one, listing soil properties and liquefaction parameters for each depth from 0.1m to 10.1m.

DIAGRAMMI DI RIFERIMENTO VERIFICA LIQUEFAZIONE - METODO R. & W. , 2009



PROVA CPT 3



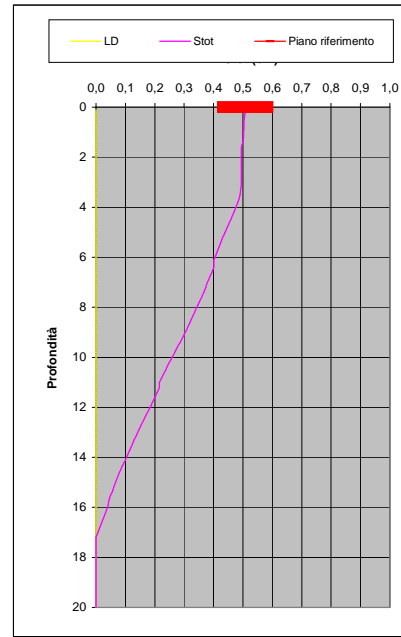
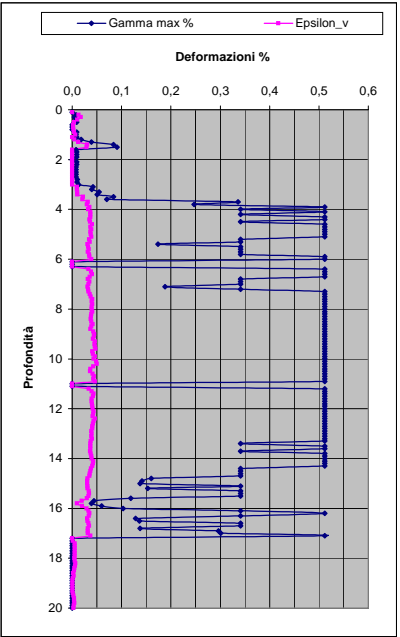
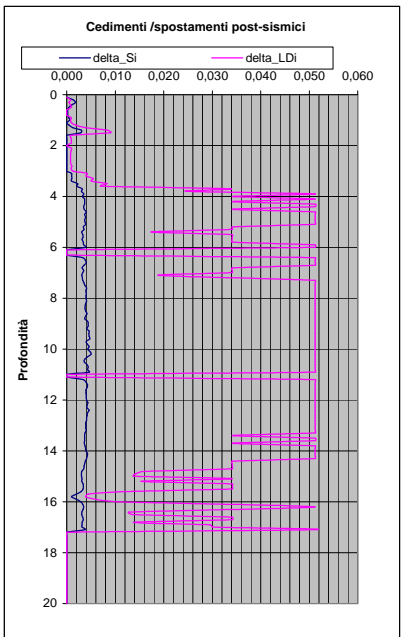
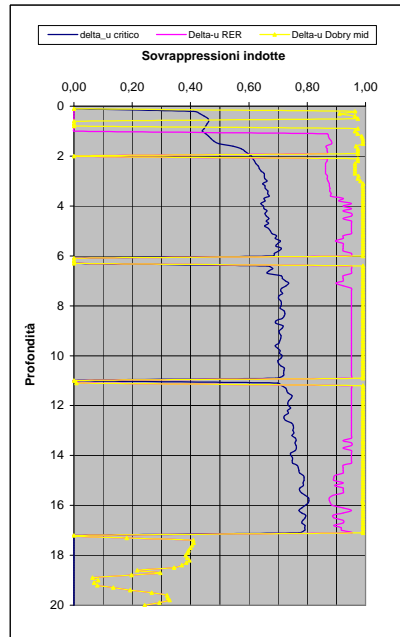
Soil Classification	Zone No.*	Range of CPT Index I_c Values
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Clays	3	$2.95 < I_c < 3.60$
Silt Mixtures	4	$2.60 < I_c < 2.95$
Sand Mixtures	5	$2.05 < I_c < 2.60$
Sands	6	$1.31 < I_c < 2.05$
Gravelly Sands	7	$I_c < 1.31$

After Robertson and Wride (1998).
*Note: Zone number per Robertson SBT (1990).

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LEGENDA

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- ξ = parametro di stato
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- K α** = fatt. correttivo per sforzi di taglio (ad)
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- qc1N-sr** = Resist. alla pentrez. corretta all'FC e normalizzata
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- Δu Dobry M. = $\Delta u / \sigma'_{vc}$ Dobry et al. 1984 "mean" x sabbie-Robertson '09 x argille
- Δu Dobry L. = $\Delta u / \sigma'_{vc}$ Dobry et al. 1984 "lower bound" x sabbie-Robertson '09 x argille
- Δu Dobry U. = $\Delta u / \sigma'_{vc}$ Dobry et al. 1984 "Upper bound" x sabbie-Robertson '09 x argille
- Stot** = Cedimento post-sismico totale (mt)
- LDI** = Lateral Displacement Index (mt)
- Dr** = Densità relativa (ad)
- θ = angolo di attrito interno (deg)
- OCR** = rapporto di sovraconsolidazione (sabbie e argille) (ad)
- St** = coefficiente di sensitività delle argille (ad)
- LSN** = Liquefaction Severity Number (ad)



IPL= 25,15 PL= 91,62 LDI = 5,638 Stot = 0,508 (mt) LD = 0,00 (mt) SLiq = 13,90 (mt) LSN = 63,12 PG= 1,00

LSN Range	Expected ground surface damage
0-10	Little to no expression of liquefaction, minor effects
10-20	Minor expression of liquefaction, some sand boils
20-30	Moderate expression of liquefaction, with some sand boils and structural damage
30-40	Moderate to severe expression of liquefaction, settlement can cause structural damage
40-50	Major expression of liquefaction, undulations and damage to ground surface, severe total and differential settlements of structures
>50	Severe damage, extensive evidence of liquefaction as surface, severe total and differential settlements affecting structures, damage to services.

* Table based on Table 13.1 from I&T report: Liquefaction Vulnerability Study

Probability	Description of the risk of liquefaction-induced ground failure
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$0.1 < P_G \leq 0.3$	low
$P_G \leq 0.1$	extremely low to none

CPT-based liquefaction triggering analysis for a single sounding

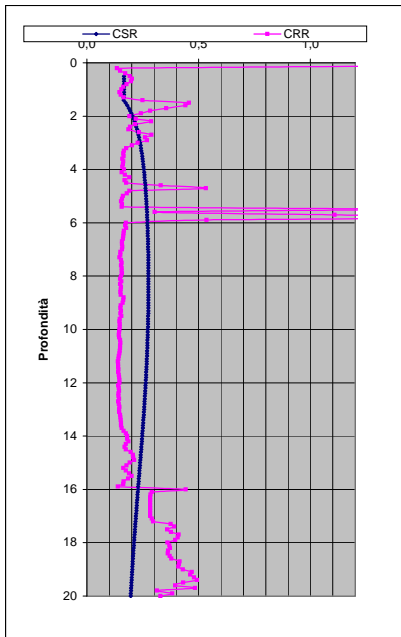
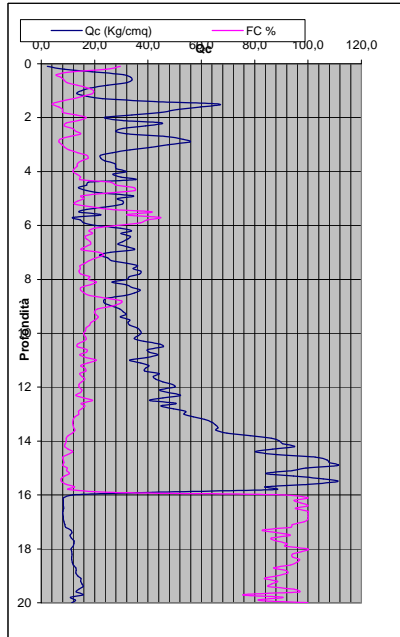
Environmental parameters, soil classification, and various probability and potentiality charts for liquefaction analysis.

Table with columns for Depth (m), Soil Classification, and various parameters like q_c, q_u, F, I_c, etc.

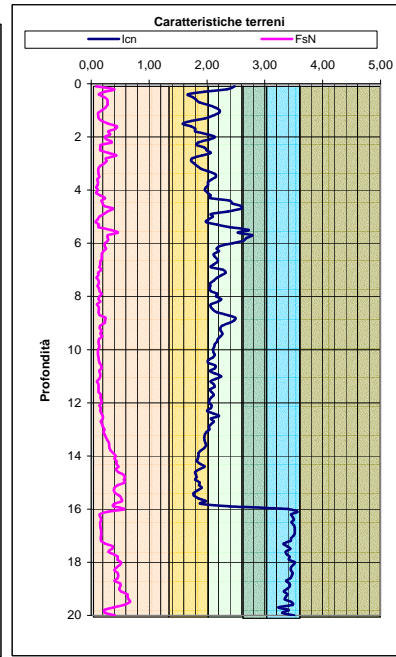
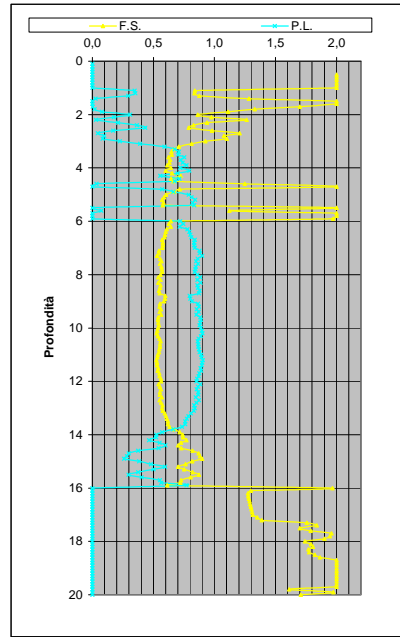
Main data table with columns for Depth (m), Soil Classification, and various parameters like q_c, q_u, F, I_c, etc. Includes a large section of numerical data.

Summary table with columns for L_{SN}, L_{SN} Expression, and other summary metrics.

DIAGRAMMI DI RIFERIMENTO VERIFICA LIQUEFAZIONE - METODO R. & W. , 2009



PROVA CPTE 4



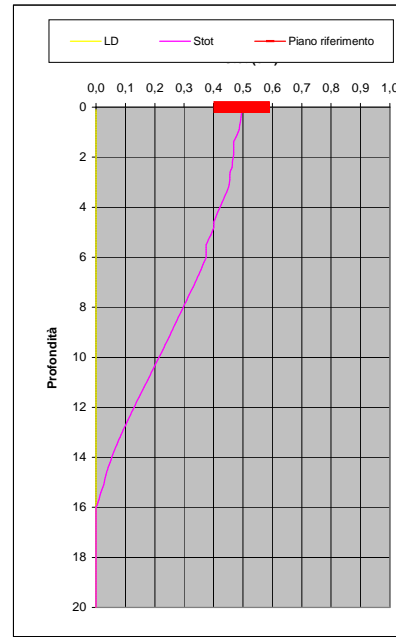
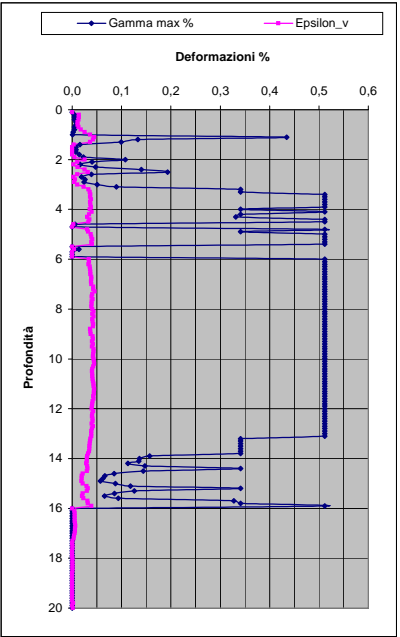
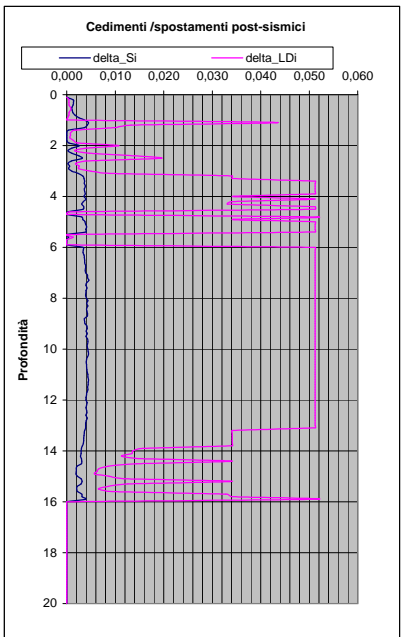
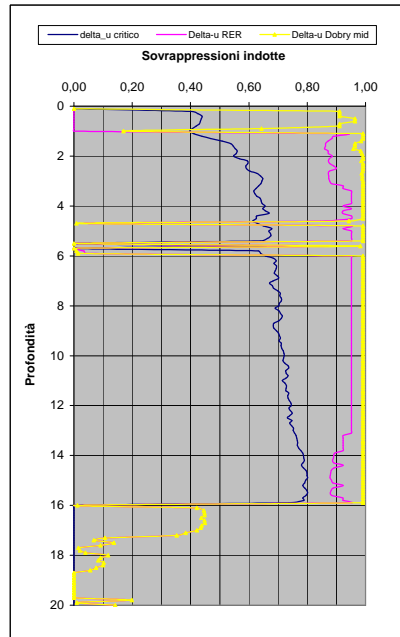
Soil Classification	Zone No.*	Range of CPT Index I_c Values
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Clays	3	$2.95 < I_c < 3.60$
Silt Mixtures	4	$2.60 < I_c < 2.95$
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Sands	6	$1.31 < I_c < 2.05$
Gravelly Sands	7	$I_c < 1.31$

After Robertson and Wride (1998).
*Note: Zone number per Robertson SBT (1990).

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- Argille - argilla/argilla limosa
- Miscela di limi - limo argilloso/argilla limosa
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- Sabbie - sabbie pulite/sabbie limose
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LEGENDA

- Qc** = Res. alla penetraz. (Kg/cmq)
- FC** = Fine content - passante 0.074 mm (%)
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- F** = rapporto di frizione
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- Icn** = Soil behaviour index normalized (ad)
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- ξ = parametro di stato
- KH** = fatt. correttivo per spessore strato (ad)
- Rd** = stress reduction coefficient (ad)
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- K σ** = fatt. correttivo per sovraccarico-profondità (ad)
- K α** = fatt. correttivo per sforzi di taglio (ad)
- MSF** = magnitudo scaling factor (ad)
- F.S.** = Fattore di sicurezza (CRR/CSR con correzioni) (ad)
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- P.L.** = Probabilità di liquefazione (ad)
- IPL** = Indice del potenziale di liquefazione (ad)
- γ_{max}** = deformazione di taglio massima indotta dal sisma (%)
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- Δs_i** = cedimento -esimo dello strato (mt)
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- Sr** = S_r / σ'_{vc} resistenza residua - strati incoerenti (ad)
- Ruc** = $\Delta u / \sigma'_{vc}$ critico - stima sogliadi innesco fenomeni di instabilità/liquefazione
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- Δu Dobry M. = $\Delta u / \sigma'_{vc}$ Dobry et al. 1984 "mean" x sabbie-Robertson '09 x argille
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- Δu Dobry U. = $\Delta u / \sigma'_{vc}$ Dobry et al. 1984 "Upper bound" x sabbie-Robertson '09 x argille
- Stot** = Cedimento post-sismico totale (mt)
- LDI** = Lateral Displacement Index (mt)
- Dr** = Densità relativa (ad)
- ϕ = angolo di attrito interno (deg)
- OCR** = rapporto di sovraconsolidazione (sabbie e argille) (ad)
- St** = coefficiente di sensitività delle argille (ad)
- LSN** = Liquefaction Severity Number (ad)



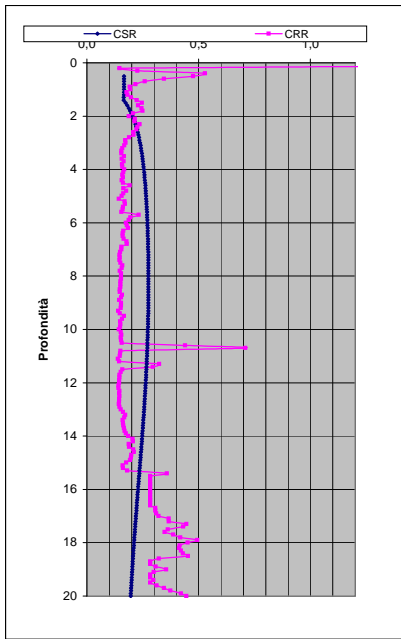
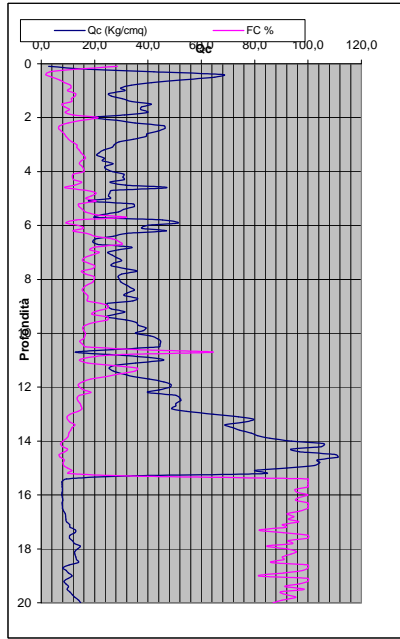
IPL = 25,74 PL = 92,55 LDI = 5,410 Stot = 0,496 (mt) LD = 0,00 (mt) SLiq = 13,20 (mt) LSN = 73,54 PG = 1,00

LSN Range	Expected ground surface damage
0-10	Little to no expression of liquefaction, minor effects
10-20	Minor expression of liquefaction, some sand boils
20-30	Moderate expression of liquefaction, with some sand boils and structural damage
30-40	Moderate to severe expression of liquefaction, settlement can cause structural damage
40-50	Major expression of liquefaction, undulations and damage to ground surface, severe total and differential settlements of structures
>50	Severe damage, extensive evidence of liquefaction as surface, severe total and differential settlements affecting structures, damage to services.

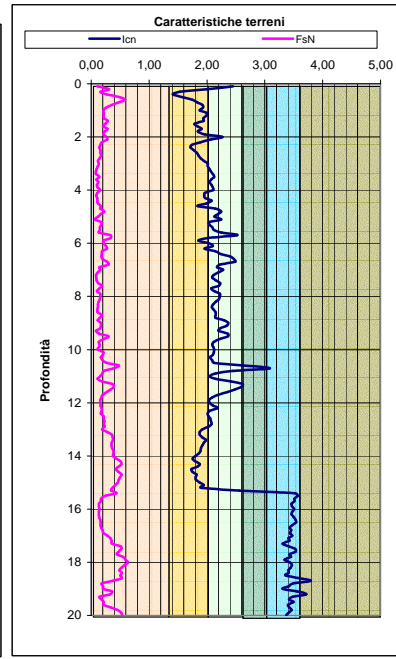
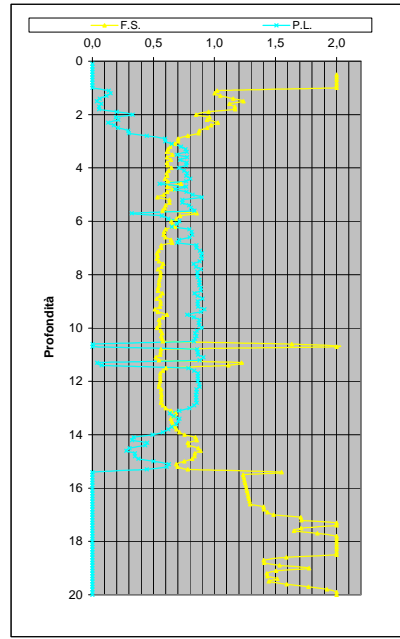
* Table based on Table 13.1 from I&T report: Liquefaction Vulnerability Study

Probability	Description of the risk of liquefaction-induced ground failure
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$0.3 < P_G \leq 0.7$	medium
$0.1 < P_G \leq 0.3$	low
$P_G \leq 0.1$	extremely low to none

DIAGRAMMI DI RIFERIMENTO VERIFICA LIQUEFAZIONE - METODO R. & W. , 2009



PROVA CPTE 5



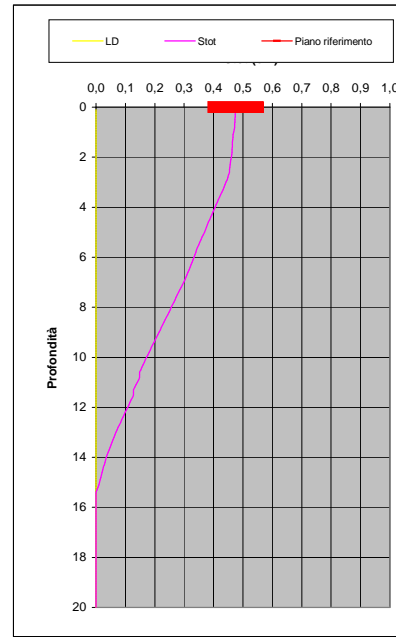
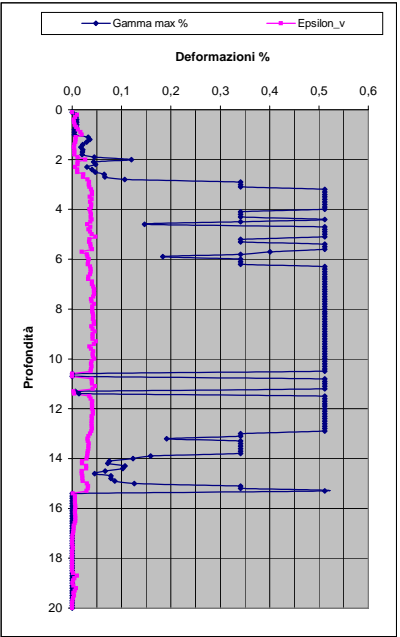
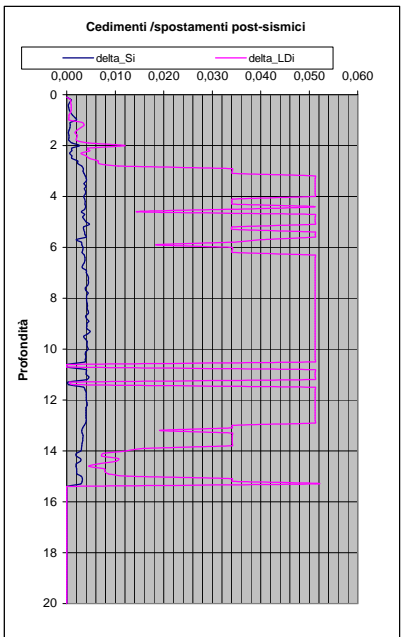
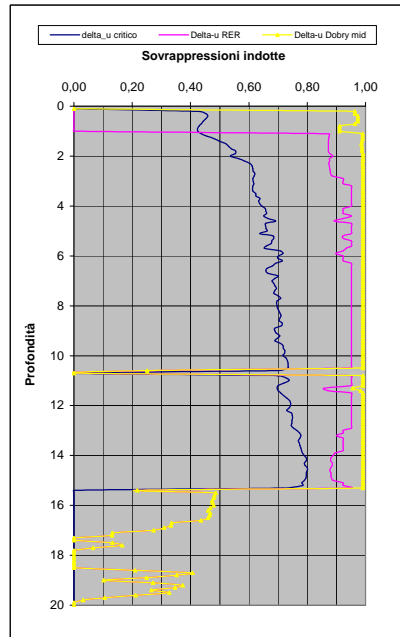
Soil Classification	Zone No.*	Range of CPT Index I_c Values
Organic Clay Soils	2	$I_c > 3.60$
Clays	3	$2.95 < I_c < 3.60$
Silt Mixtures	4	$2.60 < I_c < 2.95$
Sand Mixtures	5	$2.05 < I_c < 2.60$
Sands	6	$1.31 < I_c < 2.05$
Gravelly Sands	7	$I_c < 1.31$

After Robertson and Wride (1998).
*Note: Zone number per Robertson SBT (1990).

- Argille - terreni organici
- Argille - argilla/argilla limosa
- Miscela di limi - limo argilloso/argilla limosa
- Miscela di sabbie - sabbia limosa/limo sabbioso
- Sabbie - sabbie pulite/sabbie limose
- sabbie ghiaiose / sabbie dense

LEGENDA

- Qc** = Res. alla penetraz. (Kg/cmq)
- FC** = Fine content - passante 0.074 mm (%)
- FsN** = Attrito laterale (Kg/cmq)
- F** = rapporto di frizione
- Qtn** = parametro di resist. alla punta normal.
- Icn** = Soil behaviour index normalized (ad)
- qc1N-cs** = Resist. alla pentrez. corretta all'FC e normalizzata
- ξ = parametro di stato
- KH** = fatt. correttivo per spessore strato (ad)
- Rd** = stress reduction coefficient (ad)
- CN** = fattore di normalizzazione per carico litostatico (ad)
- K σ** = fatt. correttivo per sovraccarico-profondità (ad)
- K α** = fatt. correttivo per sforzi di taglio (ad)
- MSF** = magnitudo scaling factor (ad)
- F.S.** = Fattore di sicurezza (CRR/CSR con correzioni) (ad)
- CSR** = Cyclic Stress ratio (ad)
- CRR** = Cyclic Resistance Ratio (ad)
- P.L.** = Probabilità di liquefazione (ad)
- IPL** = Indice del potenziale di liquefazione (ad)
- γ_{max}** = deformazione di taglio massima indotta dal sisma (%)
- ev** = vertical reconsolidation strain
- Δs_i** = cedimento -esimo dello strato (mt)
- Su** = S_u / σ'_{vc} resistenza totale non drenata - strati coesivi (ad)
- Sur** = S_{ur} / σ'_{vc} resistenza totale residua non drenata - strati coesivi (ad)
- qc1N-sr** = Resist. alla pentrez. corretta all'FC e normalizzata
- Sr** = S_r / σ'_{vc} resistenza residua - strati incoerenti (ad)
- Ruc** = $\Delta u / \sigma'_{vc}$ critico - stima sogliadi innesco fenomeni di instabilità/liquefazione
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- Stot** = Cedimento post-sismico totale (mt)
- LDI** = Lateral Displacement Index (mt)
- Dr** = Densità relativa (ad)
- θ = angolo di attrito interno (deg)
- OCR** = rapporto di sovraconsolidazione (sabbie e argille) (ad)
- St** = coefficiente di sensitività delle argille (ad)
- LSN** = Liquefaction Severity Number (ad)



LSN Range	Expected ground surface damage
0-10	Little to no expression of liquefaction, minor effects
10-20	Minor expression of liquefaction, some sand boils
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>50	Severe damage, extensive evidence of liquefaction as surface, severe total and differential settlements affecting structures, damage to services.

* Table based on Table 13.1 from I&T report: Liquefaction Vulnerability Study

Probability	Description of the risk of liquefaction-induced ground failure
$0.9 < P_G$	extremely high to absolutely certain
$0.7 < P_G \leq 0.9$	high
$0.3 < P_G \leq 0.7$	medium
$0.1 < P_G \leq 0.3$	low
$P_G \leq 0.1$	extremely low to none

IPL = 26,59

PL = 93,73

LDI = 5,276 Stot = 0,475 (mt)

LD = 0,00 (mt)

SLiq = 13,00 (mt)

LSN = 71,26 PG = 1,00

CPT-based liquefaction triggering analysis for a single sounding

Enviromenti: C Hill-H Plain-P Coast-C Behaviours: Sand like-S

Computer constants: no. n=10, N=101,32, MSF NECEER=0,357, Patm=101,32, cov=0,35-35%, kDR=350, IP COR=1,2

Probabilità e potenziale di liquefazione

Probabilità e suscettibilità di liquefazione

PL Overall Probability

Robertson & Wride, agg. 2009

PROVA "CPTE 6"



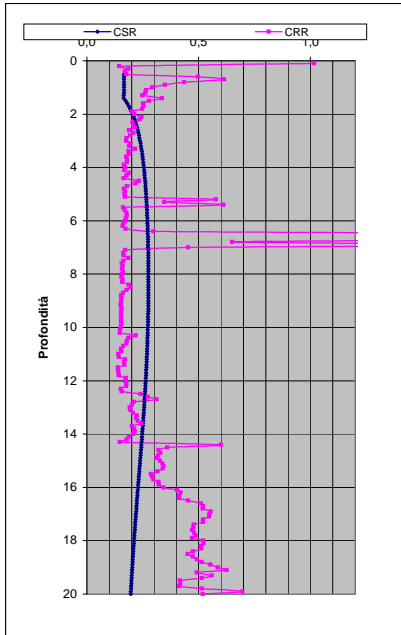
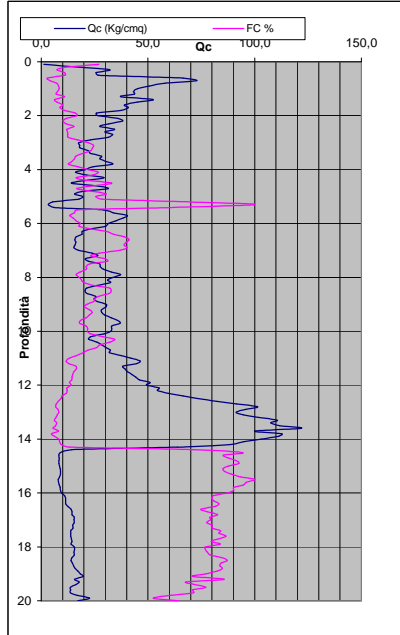
Potential flow failure if (N1)60<=10 and (q1)15<=20 No flow liquefaction if (q1)15<=65

Table with columns for input parameters (Peak ground accel, Earthquake magnitude, etc.), soil classification, and various probability and liquefaction parameters.

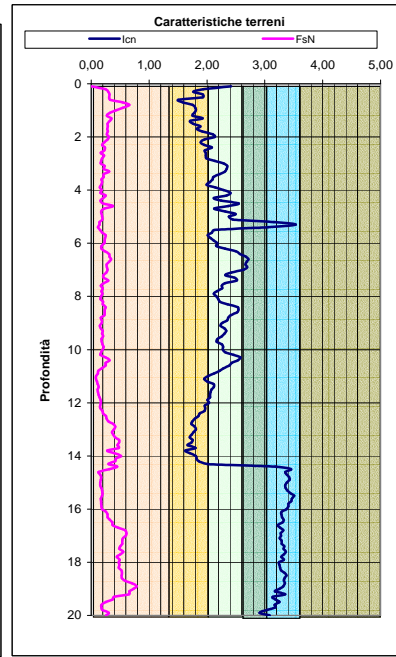
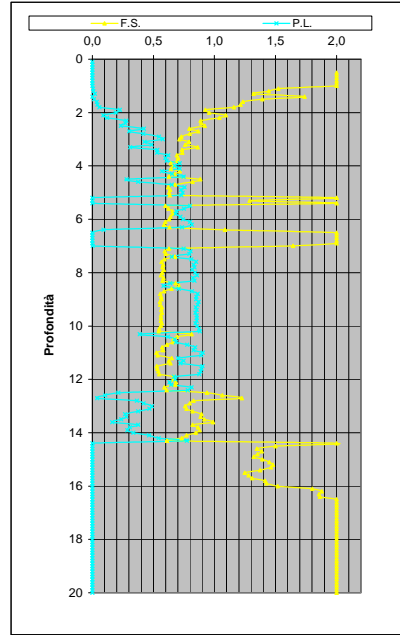
PROFONDITA' DI CALCOLO (mt da p.c.): 0,0 LDI = 4,366 Stot = 0,368 (mt) IPL = 20,64 PL = 80,33 LD = 0,00 (mt) PG = 1,00 SLiq = 11,1 (mt) LSN = 55,8

Main data table with columns for Depth (m), q1, qn, F, Ic, In2, N1(60), n, Kc, Layer, and various soil parameters. The table contains multiple rows of data for different depths.

DIAGRAMMI DI RIFERIMENTO VERIFICA LIQUEFAZIONE - METODO R. & W. , 2009



PROVA CPT E 6



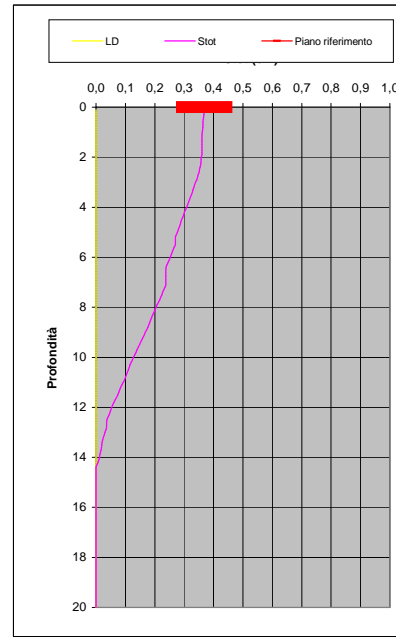
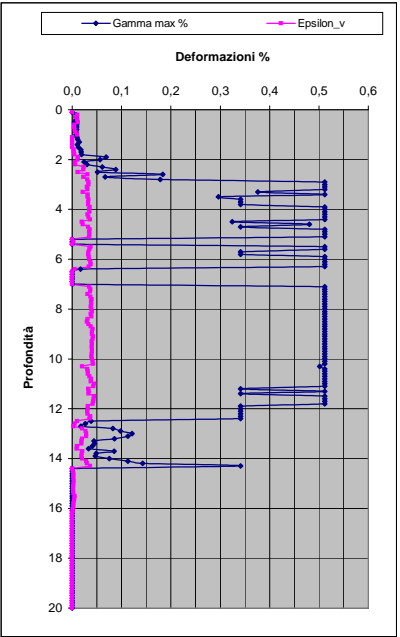
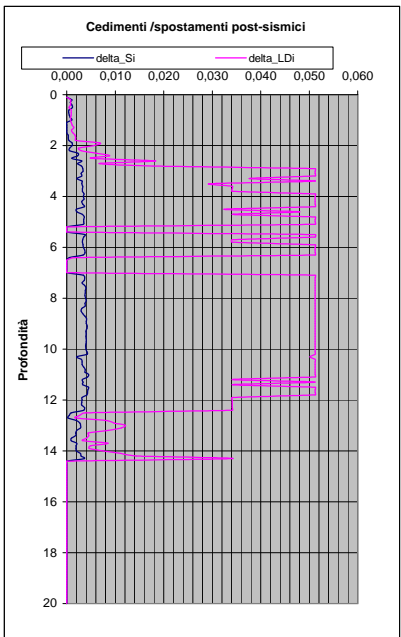
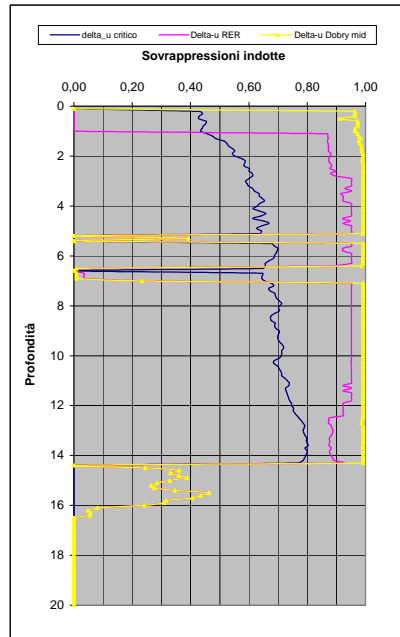
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Sands	6	$1.31 < I_c < 2.05$
Gravelly Sands	7	$I_c < 1.31$

After Robertson and Wride (1998).
*Note: Zone number per Robertson SBT (1990).

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LEGENDA

- Qc** = Res. alla penetraz. (Kg/cmq)
- FC** = Fine content - passante 0.074 mm (%)
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- F** = rapporto di frizione
- qtn** = parametro di resist. alla punta normal.
- Icn** = Soil behaviour index normalized (ad)
- qc1N-cs** = Resist. alla pentrez. corretta all'FC e normalizzata
- ξ = parametro di stato
- KH** = fatt. correttivo per spessore strato (ad)
- Rd** = stress reduction coefficient (ad)
- CN** = fattore di normalizzazione per carico litostatico (ad)
- K σ** = fatt. correttivo per sovraccarico-profondità (ad)
- K α** = fatt. correttivo per sforzi di taglio (ad)
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- Δu Dobry U. = $\Delta u / \sigma'_{vc}$ Dobry et al. 1984 "Upper bound" x sabbie-Robertson '09 x argille
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- LDI** = Lateral Displacement Index (mt)
- Dr** = Densità relativa (ad)
- ϕ = angolo di attrito interno (deg)
- OCR** = rapporto di sovraconsolidazione (sabbie e argille) (ad)
- St** = coefficiente di sensitività delle argille (ad)
- LSN** = Liquefaction Severity Number (ad)



IPL= 20,64 PL= 80,33 LDI = 4,366 Stot = 0,368 (mt) LD = 0,00 (mt) SLiq = 11,10 (mt) LSN = 55,80 PG= 1,00

LSN Range	Expected ground surface damage
0-10	Little to no expression of liquefaction, minor effects
10-20	Minor expression of liquefaction, some sand boils
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* Table based on Table 13.1 from I&T report: Liquefaction Vulnerability Study

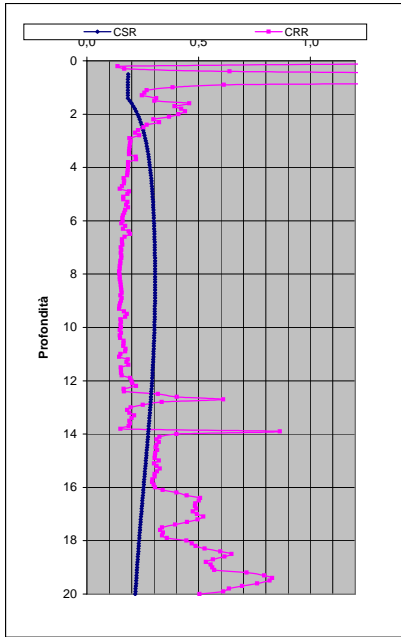
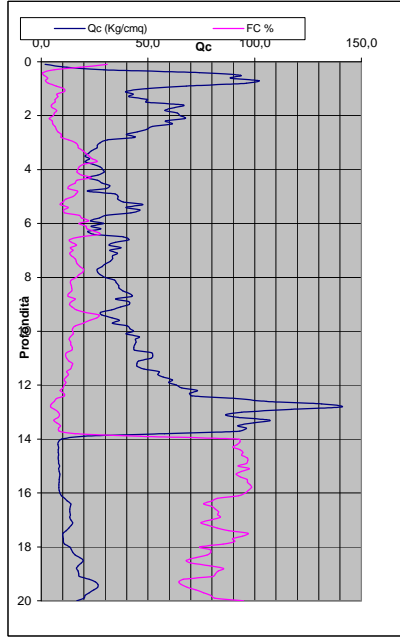
Probability	Description of the risk of liquefaction-induced ground failure
$0.9 < P_G$	extremely high to absolutely certain
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$0.1 < P_G \leq 0.3$	low
$P_G \leq 0.1$	extremely low to none

CPT-based liquefaction triggering analysis for a single sounding

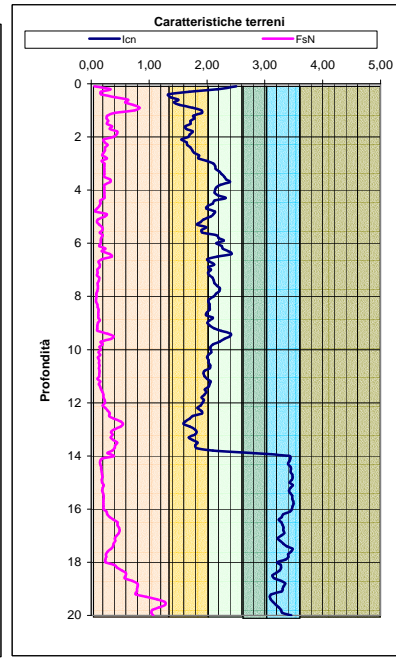
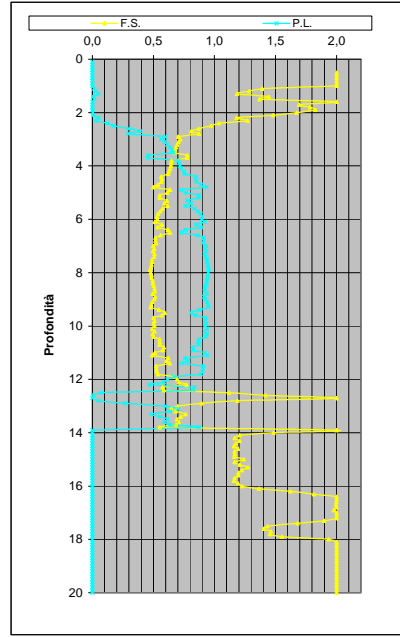
Environmental parameters, soil classification, and various probability and potentiality charts for liquefaction analysis.

Main data table with columns for Depth (m), Soil Classification, and various parameters like q, qc, N, etc. Includes a color-coded 'PROFONDITA' DI CALCOLO' bar at the top of the data section.

DIAGRAMMI DI RIFERIMENTO VERIFICA LIQUEFAZIONE - METODO R. & W. , 2009



PROVA CPTE 7



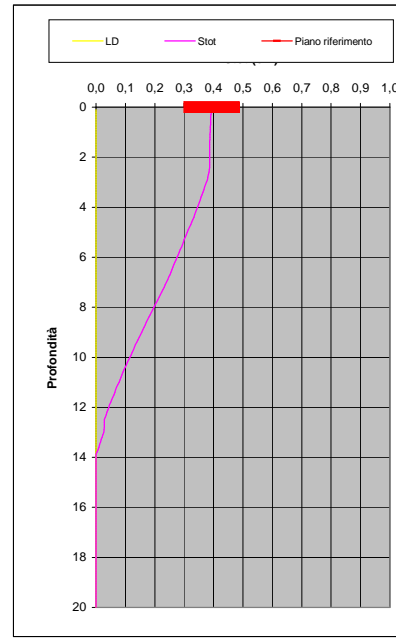
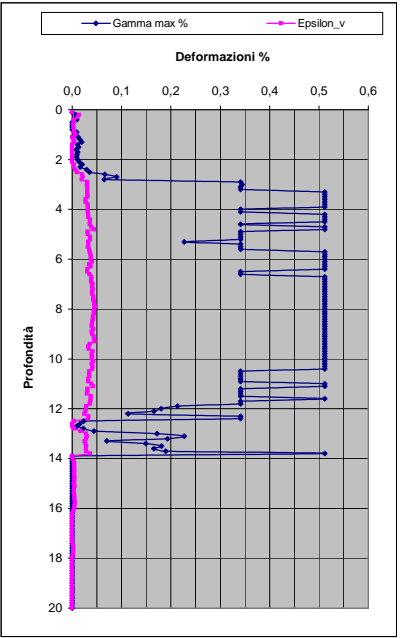
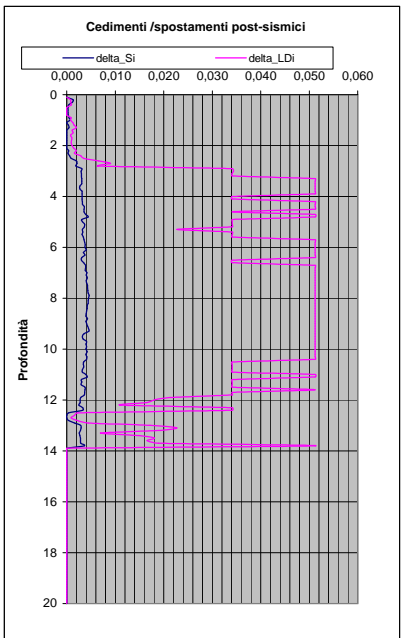
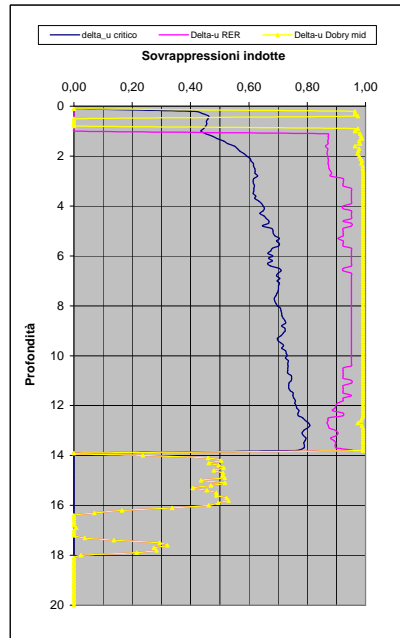
Soil Classification	Zone No.*	Range of CPT Index I_c Values
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After Robertson and Wride (1998).
*Note: Zone number per Robertson SBT (1990).

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LEGENDA

- Qc** = Res. alla penetraz. (Kg/cmq)
- FC** = Fine content - passante 0.074 mm (%)
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- F** = rapporto di frizione
- Qtn** = parametro di resist. alla punta normal.
- Icn** = Soil behaviour index normalized (ad)
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- KH** = fatt. correttivo per spessore strato (ad)
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- CN** = fattore di normalizzazione per carico litostatico (ad)
- K σ** = fatt. correttivo per sovraccarico-profondità (ad)
- K α** = fatt. correttivo per sforzi di taglio (ad)
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- F.S.** = Fattore di sicurezza (CRR/CSR con correzioni) (ad)
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- Δs_i** = cedimento i-esimo dello strato (mt)
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- Sr** = S_r / σ'_{vc} resistenza residua - strati incoerenti (ad)
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LSN Range	Expected ground surface damage
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* Table based on Table 13.1 from I&T report: Liquefaction Vulnerability Study

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$0.9 < P_G$	extremely high to absolutely certain
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$0.1 < P_G \leq 0.3$	low
$P_G \leq 0.1$	extremely low to none

IPL = 26,85

PL = 94,06

LDI = 4,501 Stot = 0,393 (mt)

LD = 0,00 (mt)

SLiq = 11,00 (mt)

LSN = 58,35 PG = 1,00

CPT-based liquefaction triggering analysis for a single sounding

Environment: Hill-H Plain-P Coast-C
Behaviours: Sand like-S

Computer constants: α (N) = 1.0, N = 101.32, Patm = 101.32, MSF NCEER = 0.0357, MSF NCEER = 0.0357

Probabilità e potenziale di liquefazione

Probabilità e suscettibilità di liquefazione

PL Overall Probability

Robertson & Wride, agg. 2009

PROVA "CPTE 8"

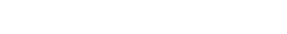


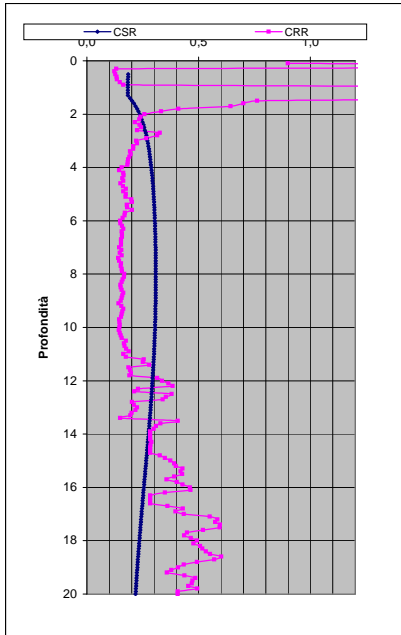
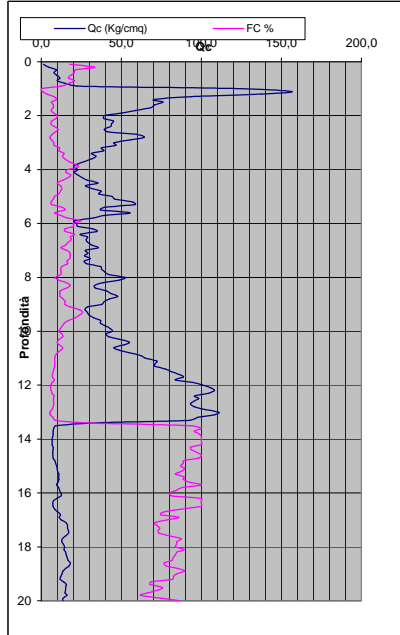
Table with 2 columns: LsN, LsN Expression. Values range from >50 to 0-10.

Main data table with columns: Depth (m), q (kPa), fs (kPa), q/cv, fs/cv, etc. Includes various soil parameters and calculated values.

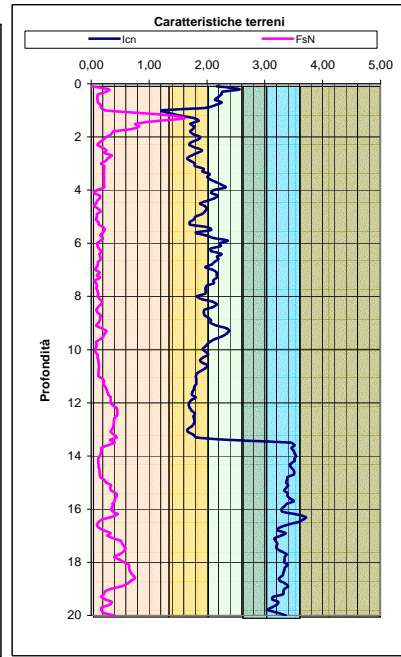
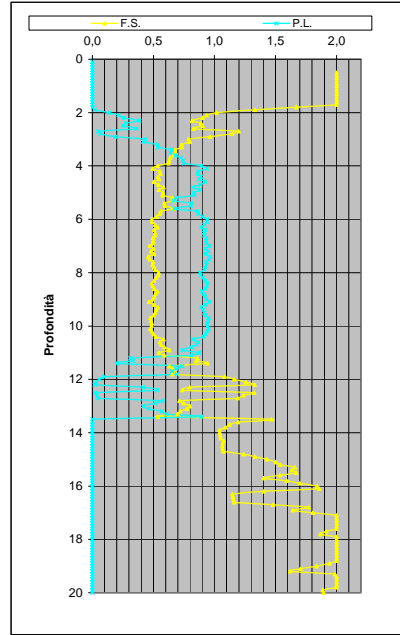
PROFONDITA' DI CALCOLO (mt da p.c.): 0,0 | LDI = 3,855 | Stot = 0,392 (mt) | IPL = 25,90 | PL = 92,79 | LD = 0,00 (mt) | PG = 1,00 | SLiq = 10,5 (mt) | LSN = 56,6

Main data table containing 100 rows of soil sounding data, including depth, cone resistance, sleeve friction, and various calculated parameters.

DIAGRAMMI DI RIFERIMENTO VERIFICA LIQUEFAZIONE - METODO R. & W. , 2009



PROVA CPT E 8



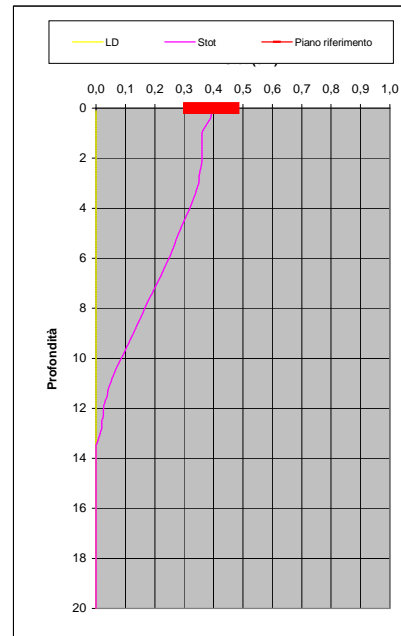
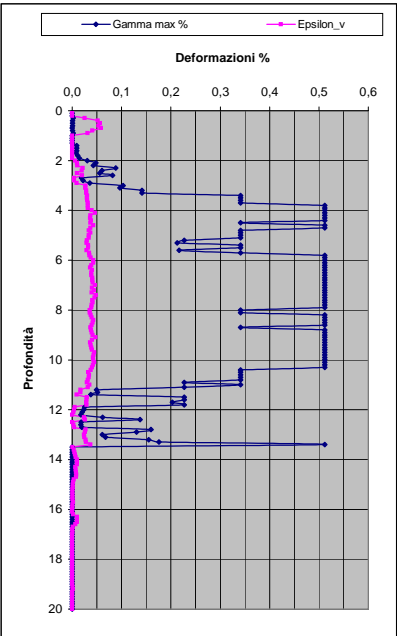
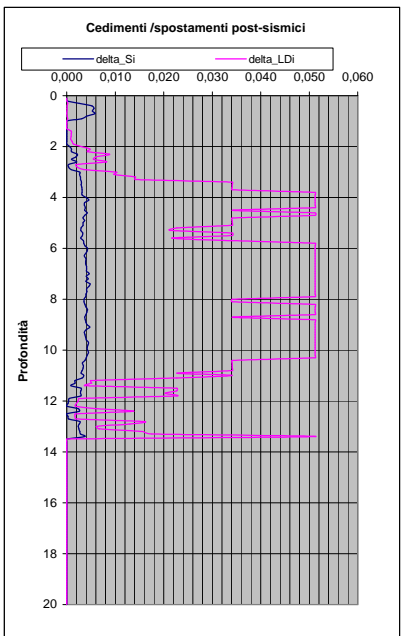
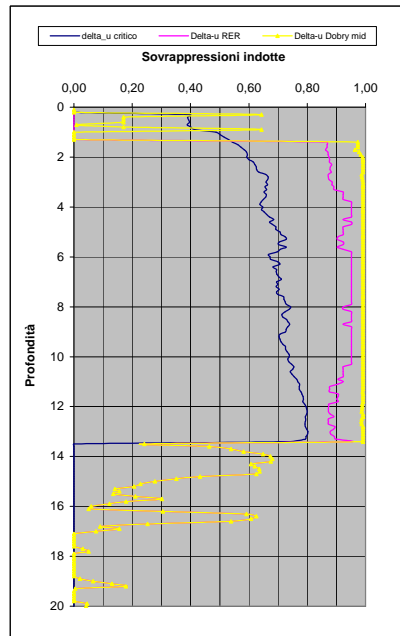
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- K α** = fatt. correttivo per sforzi di taglio (ad)
- MSF** = magnitudo scaling factor (ad)
- F.S.** = Fattore di sicurezza (CRR/CSR con correzioni) (ad)
- CSR** = Cyclic Stress ratio (ad)
- CRR** = Cyclic Resistance Ratio (ad)
- P.L.** = Probabilità di liquefazione (ad)
- IPL** = Indice del potenziale di liquefazione (ad)
- γ_{max}** = deformazione di taglio massima indotta dal sisma (%)
- ev** = vertical reconsolidation strain
- Δs_i** = cedimento i-esimo dello strato (mt)
- Su** = S_u / σ'_{vc} resistenza totale non drenata - strati coesivi (ad)
- Sur** = S_{ur} / σ'_{vc} resistenza totale residua non drenata - strati coesivi (ad)
- qc1N-sr** = Resist. alla pentrez. corretta all'FC e normalizzata
- Sr** = S_r / σ'_{vc} resistenza residua - strati incoerenti (ad)
- Ruc** = $\Delta u / \sigma'_{vc}$ critico - stima sogliadi innesco fenomeni di instabilità/liquefazione
- Δu RER = $\Delta u / \sigma'_{vc}$ sovrappressioni circ. 112/2007 - tabella 2 R.E.R.
- Δu Dobry M. = $\Delta u / \sigma'_{vc}$ Dobry et al. 1984 "mean" x sabbie-Robertson '09 x argille
- Δu Dobry L. = $\Delta u / \sigma'_{vc}$ Dobry et al. 1984 "lower bound" x sabbie-Robertson '09 x argille
- Δu Dobry U. = $\Delta u / \sigma'_{vc}$ Dobry et al. 1984 "Upper bound" x sabbie-Robertson '09 x argille
- Stot** = Cedimento post-sismico totale (mt)
- LDI** = Lateral Displacement Index (mt)
- Dr** = Densità relativa (ad)
- θ = angolo di attrito interno (deg)
- OCR** = rapporto di sovraconsolidazione (sabbie e argille) (ad)
- St** = coefficiente di sensitività delle argille (ad)
- LSN** = Liquefaction Severity Number (ad)



LSN Range	Expected ground surface damage
0-10	Little to no expression of liquefaction, minor effects
10-20	Minor expression of liquefaction, some sand boils
20-30	Moderate expression of liquefaction, with some sand boils and structural damage
30-40	Moderate to severe expression of liquefaction, settlement can cause structural damage
40-50	Major expression of liquefaction, undulations and damage to ground surface, severe total and differential settlements of structures
>50	Severe damage, extensive evidence of liquefaction at surface, severe total and differential settlements affecting structures, damage to services.

* Table based on Table 13.1 from I&T report: Liquefaction Vulnerability Study

Probability	Description of the risk of liquefaction-induced ground failure
$0.9 < P_G$	extremely high to absolutely certain
$0.7 < P_G \leq 0.9$	high
$0.3 < P_G \leq 0.7$	medium
$0.1 < P_G \leq 0.3$	low
$P_G \leq 0.1$	extremely low to none

IPL= 25,90

PL= 92,79

LDI = 3,855 Stot = 0,392 (mt)

LD = 0,00 (mt)

SLiq = 10,50 (mt)

LSN = 56,55 PG= 1,00

CPT-based liquefaction triggering analysis for a single sounding

Input parameter table with columns for Soil Classification, Zone No., Range of CPT Index / Values, and various soil parameters like Peak ground accel, Earthquake magnitude, etc.

Environments: C Hill-H Plain-P Coast-C Behaviours: E Sand like-S

Computer constants: no. n=Blank, Patm=101.32, cov=0.35-0.5, kDR=350, IP COR=1.2

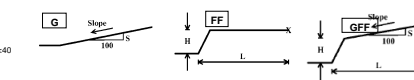
Probabilità e potenziale di liquefazione: Probabilità, Pot di Liq, IPL

Probabilità e suscettibilità di liquefazione: Probabilità, Suscettibilità, Quasi certa

PL Overall Probability: Risk lev., IPL, PL

Robertson & Wride, agg. 2009

PROVA "CPTE 9"



Potential flow failure if (N1)60<=10 and (q1)10<=50 and no flow liquefaction if (qc1)10<=65

Main data table header with columns for Depth (m), q1, qn, F, Ic, IcN2, N1(60), n, Kc, Layer, FC, Kh, Interpretation, q1cN, q1cN1, On-cs, R, CSR, Ks, ξ, Kα, CRR, Factor of Safety FS, MSF, Limiting shear strain γlim%, PL, JUNG, F, IPI, Au', Au'', Ru, Dr, Ruc, Su/σ'vc, OCR, qc1Nc, Sr, Su', LSN

PROFONDITA' DI CALCOLO (mt da p.c.): 0,0

LDI = 3,484

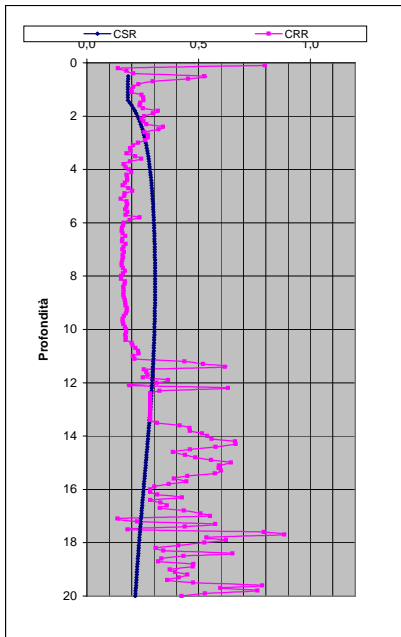
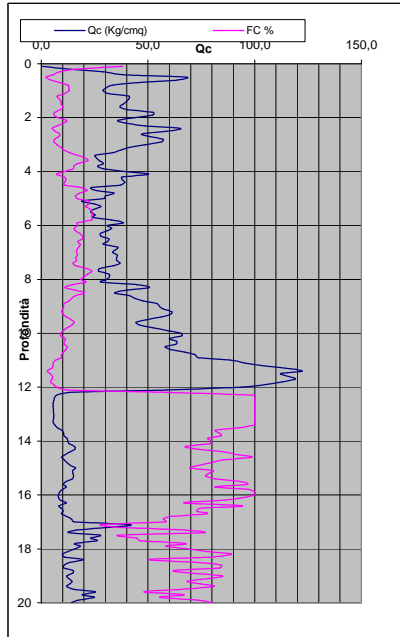
Stot = 0,311 (mt)

IPL = 21,73

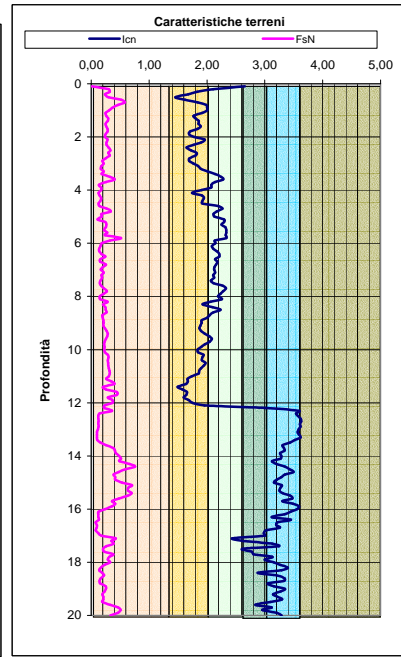
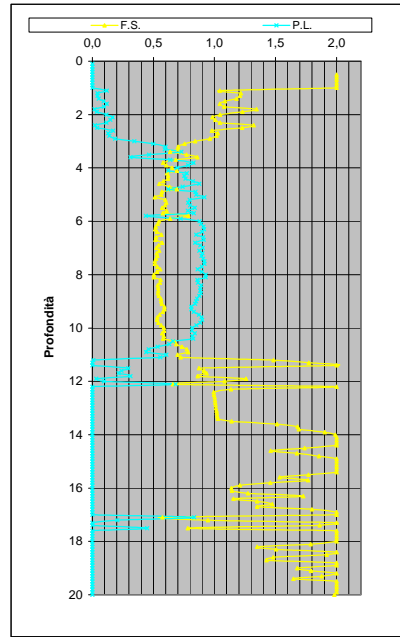
PL = 83,82 LD = 0,00 (mt) PG = 1,00 SLiq = 9,3 (mt) LSN = 50,3

Main data table body containing 100 rows of soil sounding data, including depth, stress, and various calculated parameters.

DIAGRAMMI DI RIFERIMENTO VERIFICA LIQUEFAZIONE - METODO R. & W. , 2009



PROVA CPT E 9



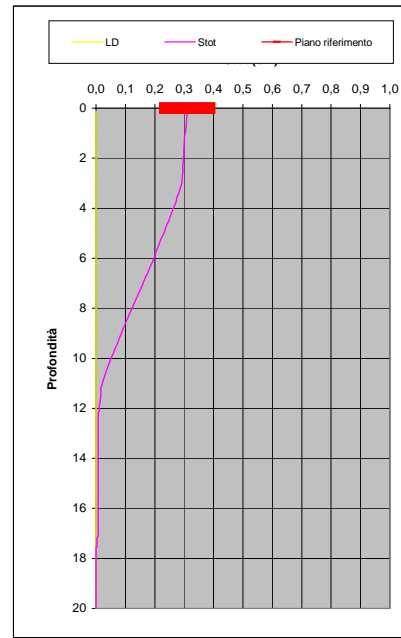
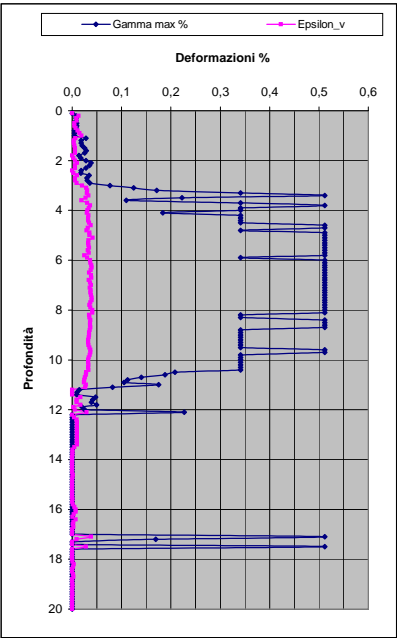
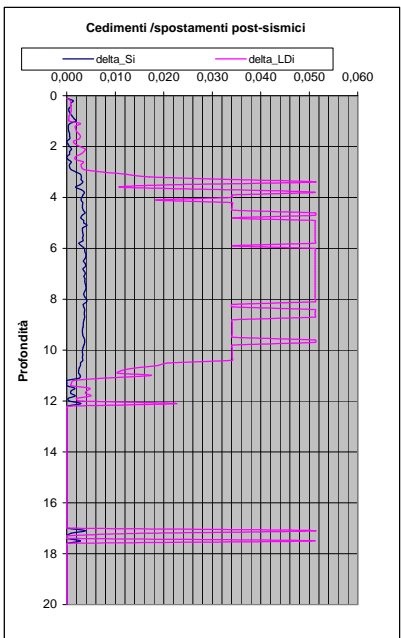
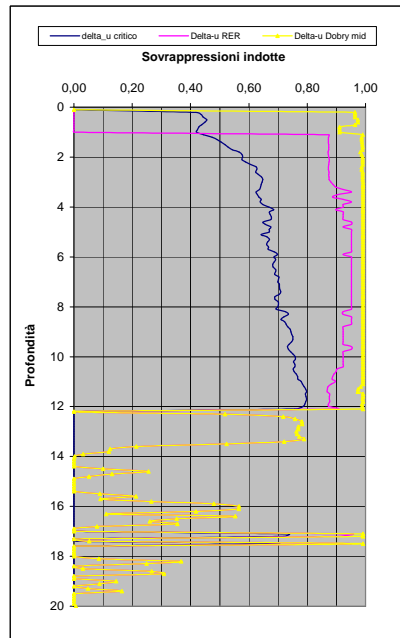
Soil Classification	Zone No.*	Range of CPT Index I_c Values
Organic Clay Soils	2	$I_c > 3.60$
Clays	3	$2.95 < I_c < 3.60$
Silt Mixtures	4	$2.60 < I_c < 2.95$
Sand Mixtures	5	$2.05 < I_c < 2.60$
Sands	6	$1.31 < I_c < 2.05$
Gravelly Sands	7	$I_c < 1.31$

After Robertson and Wride (1998).
*Note: Zone number per Robertson SBT (1990).

- Argille - terreni organici
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- Miscela di sabbie - sabbia limosa/limo sabbioso
- Sabbie - sabbie pulite/sabbie limose
- sabbie ghiaiose / sabbie dense

LEGENDA

- Qc** = Res. alla penetraz. (Kg/cmq)
- FC** = Fine content - passante 0.074 mm (%)
- FsN** = Attrito laterale (Kg/cmq)
- F** = rapporto di frizione
- Qtn** = parametro di resist. alla punta normal.
- Icn** = Soil behaviour index normalized (ad)
- qc1N-cs** = Resist. alla pentrez. corretta all'FC e normalizzata
- ξ = parametro di stato
- KH** = fatt. correttivo per spessore strato (ad)
- Rd** = stress reduction coefficient (ad)
- CN** = fattore di normalizzazione per carico litostatico (ad)
- K σ** = fatt. correttivo per sovraccarico-profondità (ad)
- K α** = fatt. correttivo per sforzi di taglio (ad)
- MSF** = magnitudo scaling factor (ad)
- F.S.** = Fattore di sicurezza (CRR/CSR con correzioni) (ad)
- CSR** = Cyclic Stress ratio (ad)
- CRR** = Cyclic Resistance Ratio (ad)
- P.L.** = Probabilità di liquefazione (ad)
- IPL** = Indice del potenziale di liquefazione (ad)
- γ_{max}** = deformazione di taglio massima indotta dal sisma (%)
- ev** = vertical reconsolidation strain
- Δs_i** = cedimento -esimo dello strato (mt)
- Su** = S_u / σ'_{vc} resistenza totale non drenata - strati coesivi (ad)
- Sur** = S_{ur} / σ'_{vc} resistenza totale residua non drenata - strati coesivi (ad)
- qc1N-sr** = Resist. alla pentrez. corretta all'FC e normalizzata
- Sr** = S_r / σ'_{vc} resistenza residua - strati incoerenti (ad)
- Ruc** = $\Delta u / \sigma'_{vc}$ critico - stima sogliadi innesco fenomeni di instabilità/liquefazione
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- Δu Dobry M. = $\Delta u / \sigma'_{vc}$ Dobry et al. 1984 "mean" x sabbie-Robertson '09 x argille
- Δu Dobry L. = $\Delta u / \sigma'_{vc}$ Dobry et al. 1984 "lower bound" x sabbie-Robertson '09 x argille
- Δu Dobry U. = $\Delta u / \sigma'_{vc}$ Dobry et al. 1984 "Upper bound" x sabbie-Robertson '09 x argille
- Stot** = Cedimento post-sismico totale (mt)
- LDI** = Lateral Displacement Index (mt)
- Dr** = Densità relativa (ad)
- θ = angolo di attrito interno (deg)
- OCR** = rapporto di sovraconsolidazione (sabbie e argille) (ad)
- St** = coefficiente di sensitività delle argille (ad)
- LSN** = Liquefaction Severity Number (ad)



LSN Range	Expected ground surface damage
0-10	Little to no expression of liquefaction, minor effects
10-20	Minor expression of liquefaction, some sand boils
20-30	Moderate expression of liquefaction, with some sand boils and structural damage
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40-50	Major expression of liquefaction, undulations and damage to ground surface, severe total and differential settlements of structures
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* Table based on Table 13.1 from I&T report: Liquefaction Vulnerability Study

Probability	Description of the risk of liquefaction-induced ground failure
$0.9 < P_G$	extremely high to absolutely certain
$0.7 < P_G \leq 0.9$	high
$0.3 < P_G \leq 0.7$	medium
$0.1 < P_G \leq 0.3$	low
$P_G \leq 0.1$	extremely low to none

IPL = 21,73 PL = 83,82

LDI = 3,484 Stot = 0,311 (mt)

LD = 0,00 (mt)

SLiq = 9,30 (mt)

LSN = 50,30 PG = 1,00

CPT-based liquefaction triggering analysis for a single sounding

Enviromenti: C Hill-H Plain-P Coast-C
Behaviours: e Sand like-s

Computer constants: n = 2.00 (B' 2007 - "Cefin" 2004 - "NCEER" - "Blake")

ms. manuale cone c. 35.7 mm s = 0.0357 NCEER
Building (Y/N) Carico Kpa = 210
Sedimentary environment V0 = 210
CPTA - CPTU = 1 K0 = 0.45
nk = 25 L (m) = 10

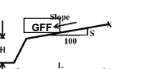
Probabilità e potenziale di liquefazione
Probabilità Pot di Liq. IPL
sPLsPL-sLsL Moto Alto C-PL15

Probabilità e suscettibilità di liquefazione
Probabilità Suscettibilità
sPLsPL-sLsL Moto Alto C-PL15

PL Overall Probability
Risk lev. IPL
Very High IPL-15
High 5-PL15.12 PL-54
Low 0-PL15.12 PL-54.12
No flow quast cert.

Robertson & Wride, agg. 2009

PROVA "CPTe 10"



Potential flow failure if (N1)60<cc=10 and (q1N)65
No flow liquefaction if (q1N)65

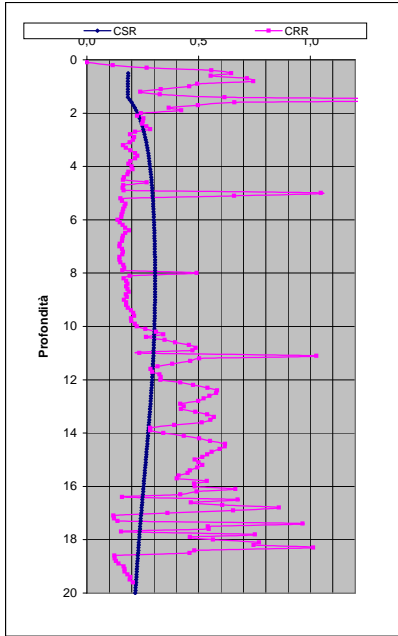
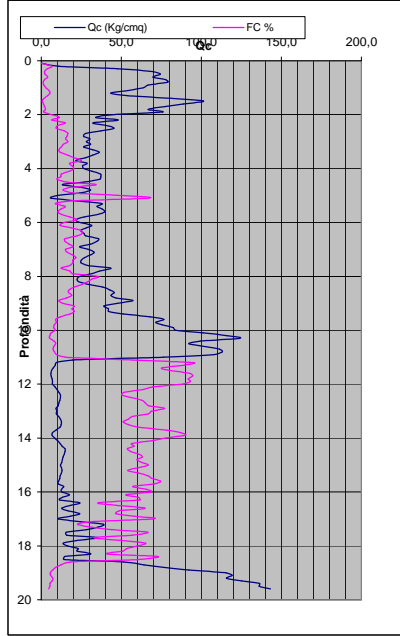
Table with 2 columns: LsN, LsN Expression. Values range from >50 to 0-10.

Main data table with columns: Depth (m), qc (kPa), fs (kPa), q1N (kPa), q1N65 (kPa), etc. Includes various soil parameters and calculated values.

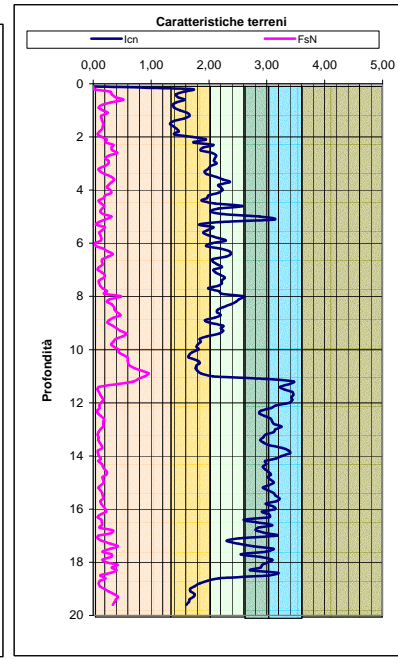
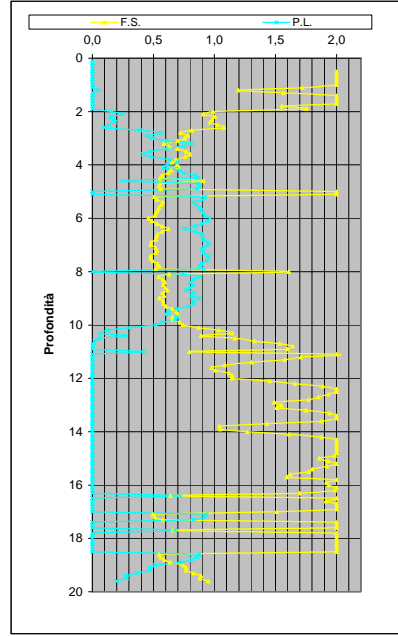
PROFONDITA' DI CALCOLO (mt da p.c.): 0,0 LDI = 3,474 Stot = 0,319 (mt) IPL = 19,85 PL = 77,48 LD = 0,00 (mt) PG = #NUM! SLiq = 9,4 (mt) LSN = 49,2

Main data table with columns: Depth (m), qc (kPa), fs (kPa), q1N (kPa), q1N65 (kPa), etc. This table contains the majority of the data rows, including values for various soil parameters and calculated values.

DIAGRAMMI DI RIFERIMENTO VERIFICA LIQUEFAZIONE - METODO R. & W. , 2009



PROVA CPT E 10



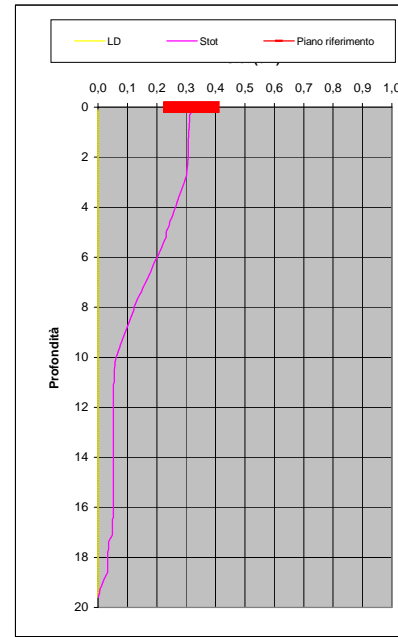
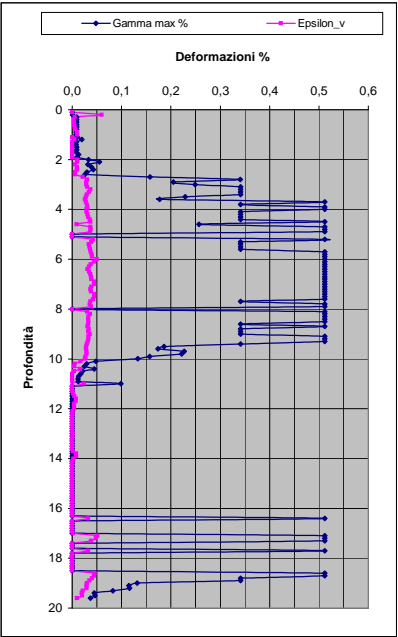
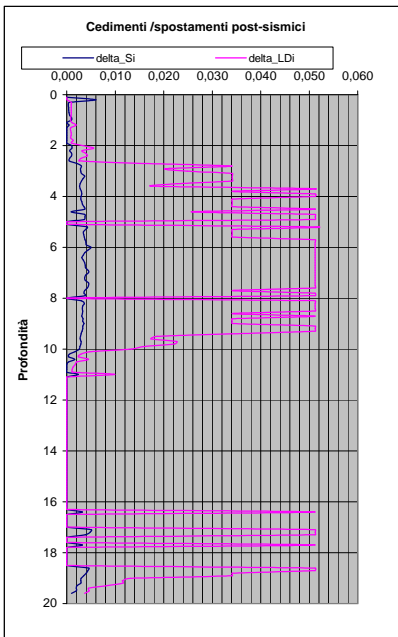
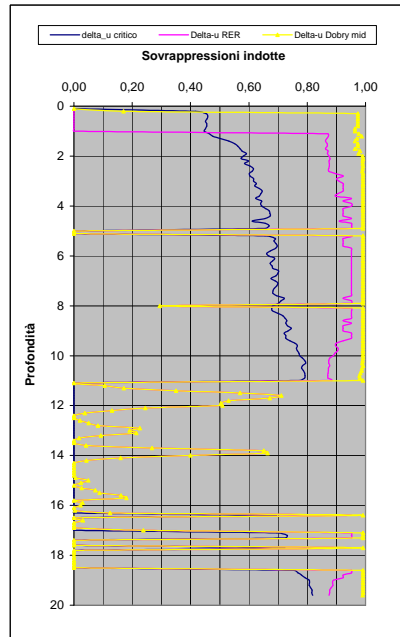
Soil Classification	Zone No.*	Range of CPT Index I_c Values
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Sand Mixtures	5	$2.05 < I_c < 2.60$
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Gravelly Sands	7	$I_c < 1.31$

After Robertson and Wride (1998).
*Note: Zone number per Robertson SBT (1990).

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LEGENDA

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- ξ = parametro di stato
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- P.L.** = Probabilità di liquefazione (ad)
- IPL** = Indice del potenziale di liquefazione (ad)
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- ev** = vertical reconsolidation strain
- Δ si** = cedimento -esimo dello strato (mt)
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$0.1 < P_G \leq 0.3$	low
$P_G \leq 0.1$	extremely low to none

IPL= 19,85

PL= 77,48

LDI = 3,474 Stot = 0,319 (mt)

LD = 0,00 (mt)

SLiq = 9,40 (mt)

LSN = 49,18 PG= #NUM!

CPT-based liquefaction triggering analysis for a single sounding

Enviromenti Behaviours

Computer constants

Probabilità e potenziale di liquefazione

Probabilità e suscettibilità di liquefazione

PL Overall Probability

Robertson & Wride, agg. 2009

PROVA "CPTe 11"

Input parameter table with columns for soil classification, water table depth, and average water table.

Soil Classification table with columns for soil type, zone, and classification code.

Computer constants table with columns for alpha, beta, gamma, and delta.

Probabilità e suscettibilità di liquefazione table with columns for PL and FS.

PL Overall Probability table with columns for Risk level and PL.

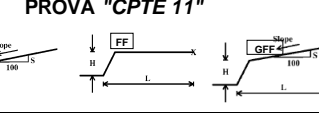
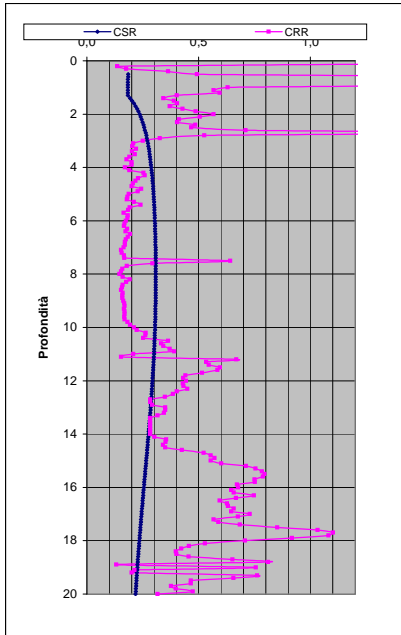
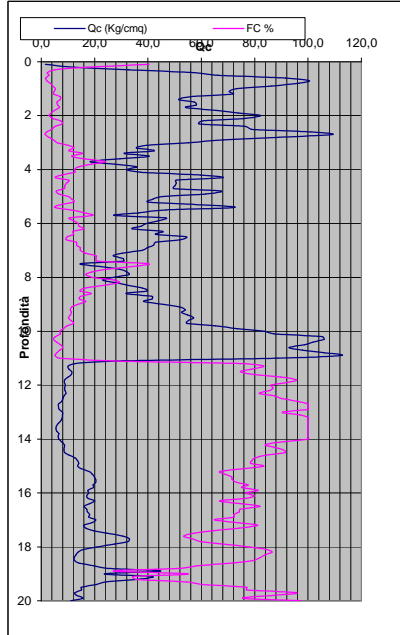


Table with columns for LsN and LsN Expression, showing damage levels from Severe to Little to No.

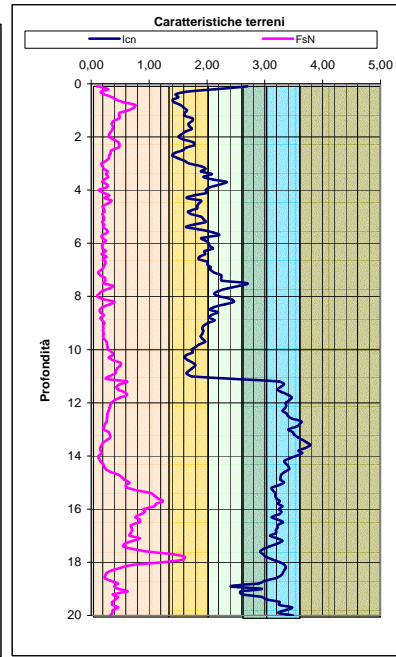
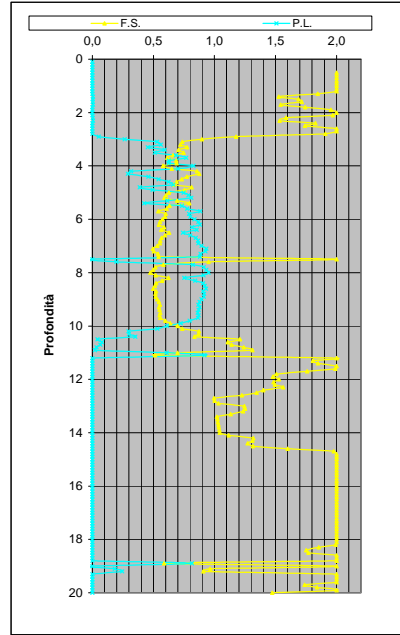
Main data table header with columns for Depth, q, qc, fs, and various soil parameters.

Main data table body containing multiple rows of soil test data and calculated parameters.

DIAGRAMMI DI RIFERIMENTO VERIFICA LIQUEFAZIONE - METODO R. & W. , 2009



PROVA CPT E 11



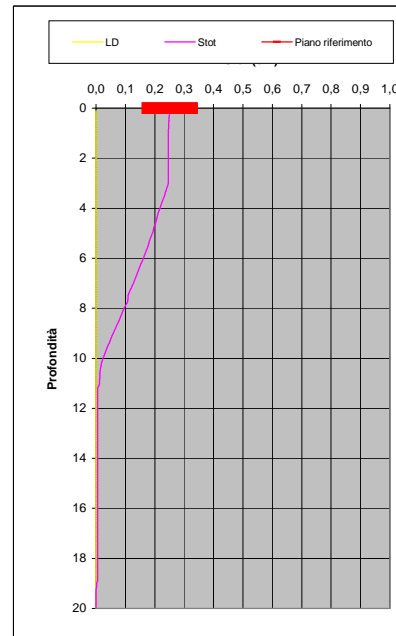
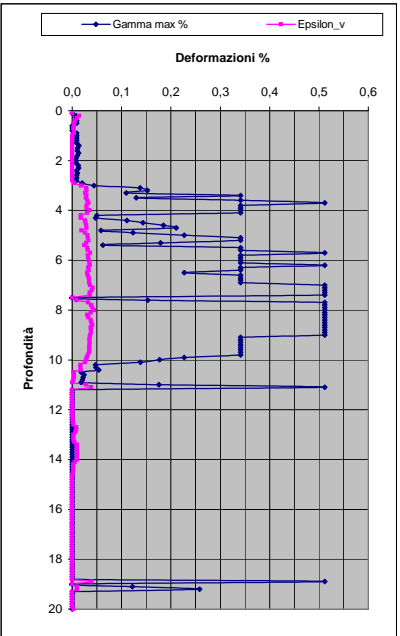
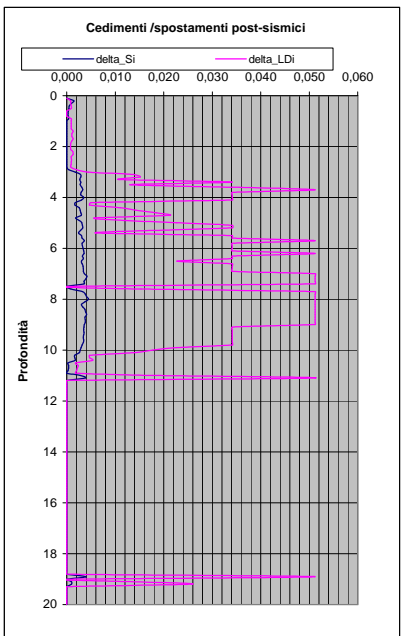
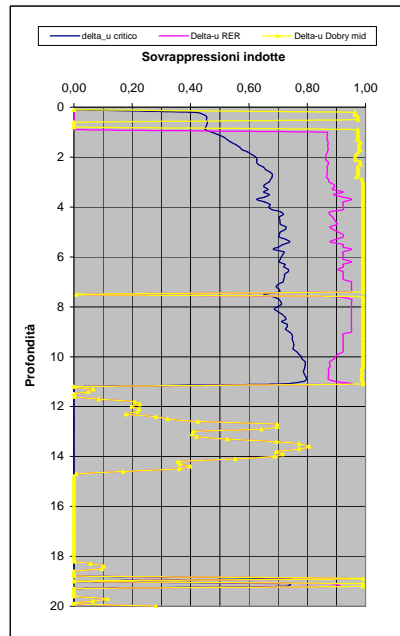
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- sabbie ghiaiose / sabbie dense

LEGENDA

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- ξ = parametro di stato
- KH** = fatt. correttivo per spessore strato (ad)
- Rd** = stress reduction coefficient (ad)
- CN** = fattore di normalizzazione per carico litostatico (ad)
- K σ** = fatt. correttivo per sovraccarico-profondità (ad)
- K α** = fatt. correttivo per sforzi di taglio (ad)
- MSF** = magnitudo scaling factor (ad)
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- CSR** = Cyclic Stress ratio (ad)
- CRR** = Cyclic Resistance Ratio (ad)
- P.L.** = Probabilità di liquefazione (ad)
- IPL** = Indice del potenziale di liquefazione (ad)
- γ_{max}** = deformazione di taglio massima indotta dal sisma (%)
- ev** = vertical reconsolidation strain
- Δs_i** = cedimento i-esimo dello strato (mt)
- Su** = S_u / σ'_{vc} resistenza totale non drenata - strati coesivi (ad)
- Sur** = S_{ur} / σ'_{vc} resistenza totale residua non drenata - strati coesivi (ad)
- qc1N-sr** = Resist. alla pentrez. corretta all'FC e normalizzata
- Sr** = S_r / σ'_{vc} resistenza residua - strati incoerenti (ad)
- Ruc** = $\Delta u / \sigma'_{vc}$ critico - stima sogliadi innesco fenomeni di instabilità/liquefazione
- Δu RER = $\Delta u / \sigma'_{vc}$ sovrappressioni circ. 112/2007 - tabella 2 R.E.R.
- Δu Dobry M. = $\Delta u / \sigma'_{vc}$ Dobry et al. 1984 "mean" x sabbie-Robertson '09 x argille
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- Δu Dobry U. = $\Delta u / \sigma'_{vc}$ Dobry et al. 1984 "Upper bound" x sabbie-Robertson '09 x argille
- Stot** = Cedimento post-sismico totale (mt)
- LDI** = Lateral Displacement Index (mt)
- Dr** = Densità relativa (ad)
- θ = angolo di attrito interno (deg)
- OCR** = rapporto di sovraconsolidazione (sabbie e argille) (ad)
- St** = coefficiente di sensitività delle argille (ad)
- LSN** = Liquefaction Severity Number (ad)



LSN Range	Expected ground surface damage
0-10	Little to no expression of liquefaction, minor effects
10-20	Minor expression of liquefaction, some sand boils
20-30	Moderate expression of liquefaction, with some sand boils and structural damage
30-40	Moderate to severe expression of liquefaction, settlement can cause structural damage
40-50	Major expression of liquefaction, undulations and damage to ground surface, severe total and differential settlements of structures
>50	Severe damage, extensive evidence of liquefaction at surface, severe total and differential settlements affecting structures, damage to services.

* Table based on Table 13.1 from I&T report: Liquefaction Vulnerability Study

Probability	Description of the risk of liquefaction-induced ground failure
$0.9 < P_G$	extremely high to absolutely certain
$0.7 < P_G \leq 0.9$	high
$0.3 < P_G \leq 0.7$	medium
$0.1 < P_G \leq 0.3$	low
$P_G \leq 0.1$	extremely low to none

IPL = 18,22

PL = 70,70

LDI = 2,579 Stot = 0,251 (mt)

LD = 0,00 (mt)

SLiq = 7,90 (mt)

LSN = 39,38 PG = 1,00

CPT-based liquefaction triggering analysis for a single sounding

Enviroments: C Hill-H Plain-P Coast-C Behaviours: E Sand like-S

Computer constants: no. n: 10, 101, 32 Patm = 101,32 (cov=0.35-35%) alpha (N) = 0.5 MSF NECEER Q = 6 kPa (pendo) T = 0.25 (k) ka = 1.2 (k) IP COR

Probabilità e potenziale di liquefazione

Probabilità e suscettibilità di liquefazione

PL Overall Probability

Robertson & Wride, agg. 2009

PROVA "CPTe 12"



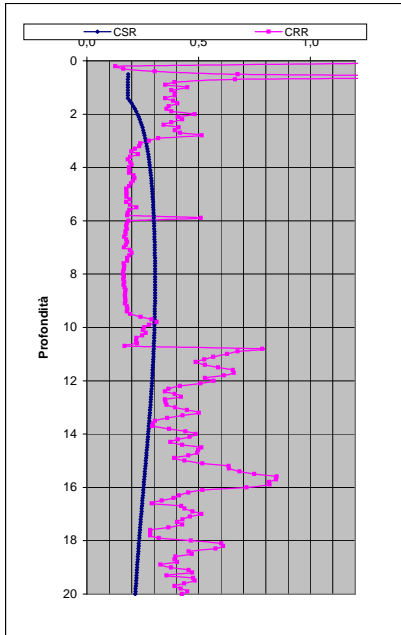
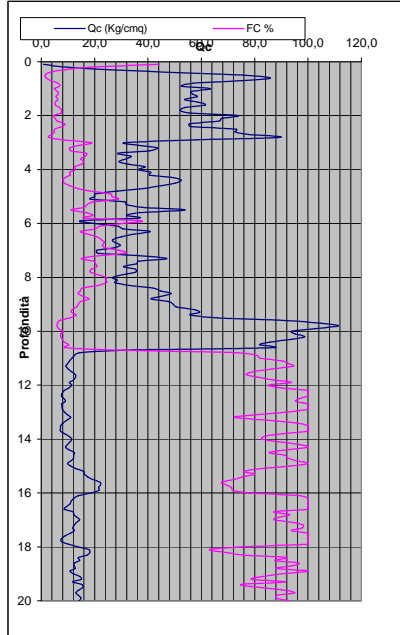
Potential flow failure if (N) i60-cv<10 and (q) i60-cv<50 No flow liquefaction if (q) i60-cv<65

Table with 2 columns: LsN and LsN Expression. Values range from >50 to 0-10, with corresponding damage levels like Severe Damage, Moderate to Severe, etc.

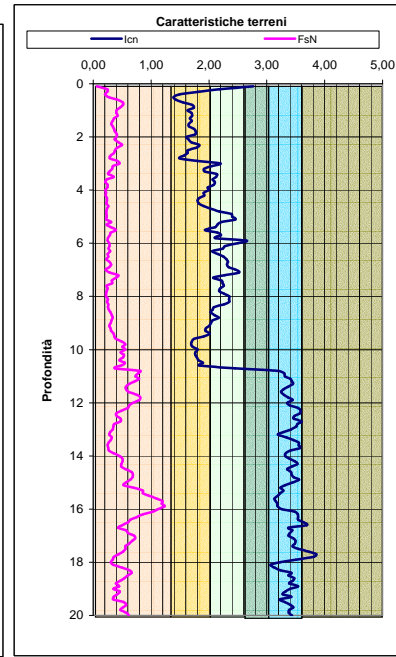
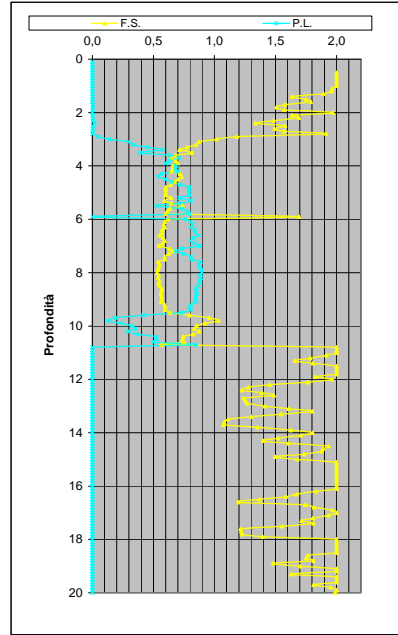
Main data table with columns for Depth (m), q (kPa), qc (kPa), F, Ic, N60, n, Kc, Layer, FC, Kh, CSR, Ks, Ks, r, CRR, FS, MSF, Limiting shear strain, PL, ALDI, ASI, F, I, R, Dr, Ruc, Su/ov, OCR, qc1N, Sr/ov, Su/r, LsN. Includes summary values at the bottom: PROFONDITA' DI CALCOLO (mt da p.c.): 0,0; LDI = 2,697; Stot = 0,235 (mt); IPL = 17,31; PL = 66,39; LD = 0,00 (mt); PG = 1,00; SLiq = 7,5 (mt); LSN = 37,3.

Main data table containing 100 rows of soil test results, including depth, stress, and liquefaction potential values.

DIAGRAMMI DI RIFERIMENTO VERIFICA LIQUEFAZIONE - METODO R. & W. , 2009



PROVA CPT E 12



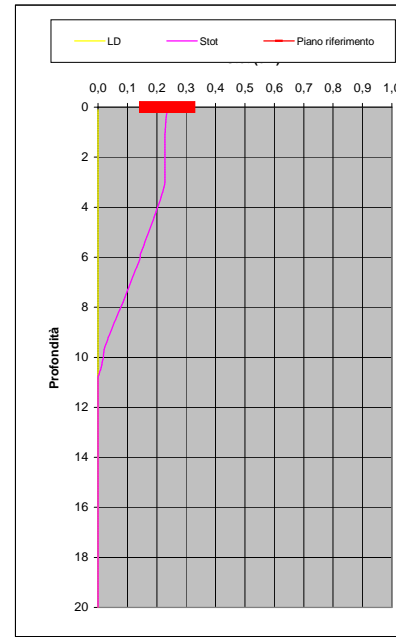
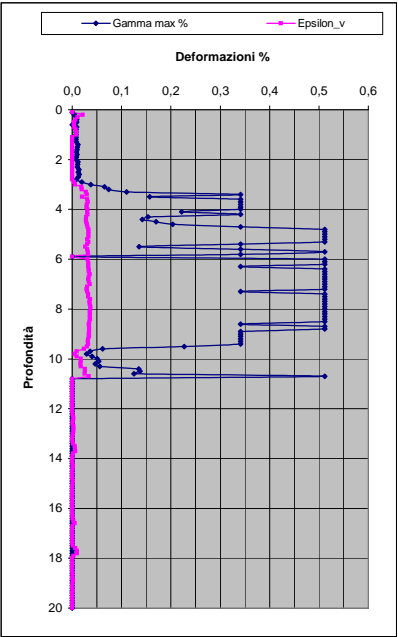
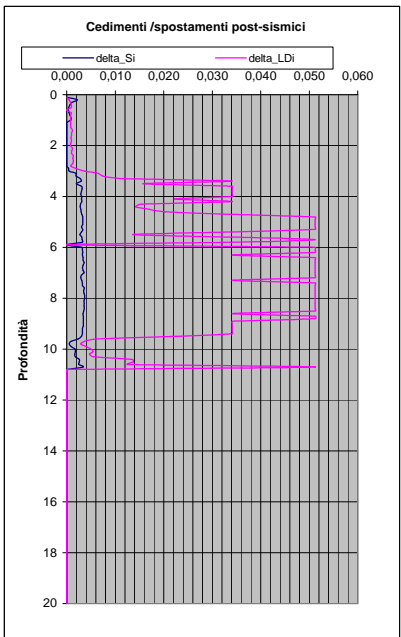
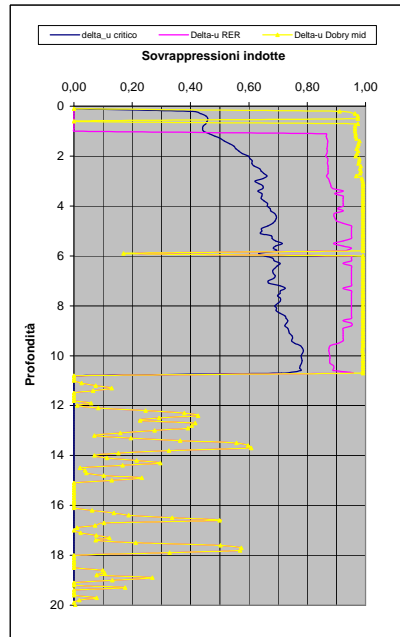
Soil Classification	Zone No.*	Range of CPT Index I_c Values
Organic Clay Soils	2	$I_c > 3.60$
Clays	3	$2.95 < I_c < 3.60$
Silt Mixtures	4	$2.60 < I_c < 2.95$
Sand Mixtures	5	$2.05 < I_c < 2.60$
Sands	6	$1.31 < I_c < 2.05$
Gravelly Sands	7	$I_c < 1.31$

After Robertson and Wride (1998).
*Note: Zone number per Robertson SBT (1990).

- Argille - terreni organici
- Argille - argilla/argilla limosa
- Miscela di limi - limo argilloso/argilla limosa
- Miscela di sabbie - sabbia limosa/limo sabbioso
- Sabbie - sabbie pulite/sabbie limose
- sabbie ghiaiose / sabbie dense

LEGENDA

- Qc** = Res. alla penetraz. (Kg/cmq)
- FC** = Fine content - passante 0.074 mm (%)
- FsN** = Attrito laterale (Kg/cmq)
- F** = rapporto di frizione
- Qtn** = parametro di resist. alla punta normal.
- Icn** = Soil behaviour index normalized (ad)
- qc1N-cs** = Resist. alla pentrez. corretta all'FC e normalizzata
- ξ = parametro di stato
- KH** = fatt. correttivo per spessore strato (ad)
- Rd** = stress reduction coefficient (ad)
- CN** = fattore di normalizzazione per carico litostatico (ad)
- K σ** = fatt. correttivo per sovraccarico-profondità (ad)
- K α** = fatt. correttivo per sforzi di taglio (ad)
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- CRR** = Cyclic Resistance Ratio (ad)
- P.L.** = Probabilità di liquefazione (ad)
- IPL** = Indice del potenziale di liquefazione (ad)
- γ_{max}** = deformazione di taglio massima indotta dal sisma (%)
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- Stot** = Cedimento post-sismico totale (mt)
- LDI** = Lateral Displacement Index (mt)
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- θ = angolo di attrito interno (deg)
- OCR** = rapporto di sovraconsolidazione (sabbie e argille) (ad)
- St** = coefficiente di sensitività delle argille (ad)
- LSN** = Liquefaction Severity Number (ad)



LSN Range	Expected ground surface damage
0-10	Little to no expression of liquefaction, minor effects
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* Table based on Table 13.1 from I&T report: Liquefaction Vulnerability Study

Probability	Description of the risk of liquefaction-induced ground failure
$0.9 < P_G$	extremely high to absolutely certain
$0.7 < P_G \leq 0.9$	high
$0.3 < P_G \leq 0.7$	medium
$0.1 < P_G \leq 0.3$	low
$P_G \leq 0.1$	extremely low to none

IPL= 17,31 PL= 66,39 LDI = 2,697 Stot = 0,235 (mt) LD = 0,00 (mt) SLiq = 7,50 (mt) LSN = 37,32 PG= 1,00

CPT-based liquefaction triggering analysis for a single sounding

Environments: C Hill-H Plain-P Coast-C Behaviours: E Sand like-S

Computer constants: no. 10,32 (B' 2007 - 'Cefin' 2004 - 'NCEER' - 'Blake') alpha (N) 1 MSF NCEER

Probabilità e potenziale di liquefazione

Probabilità e suscettibilità di liquefazione

PL Overall Probability

Robertson & Wride, agg. 2009

PROVA "CPTU 1" - Colonia Montecatini

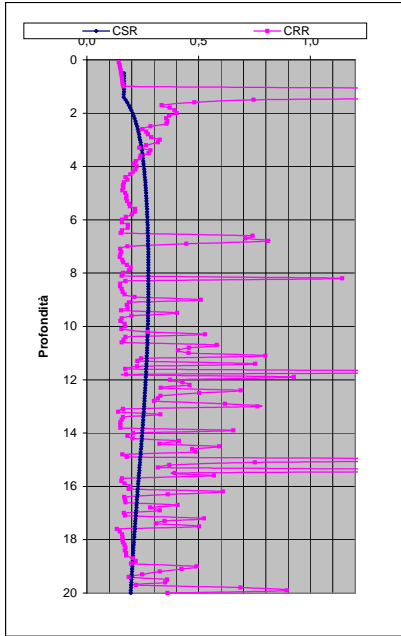
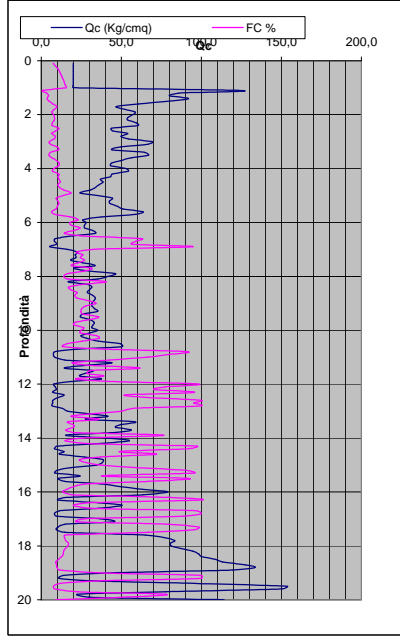
Table with 2 columns: LsN, LsN Expression. Values range from >50 to 0-10.

Main data table with columns: Depth (m), q1, qn, F, Ic, N1(60), n, Kc, Layer, etc. Includes various soil parameters and calculated values.

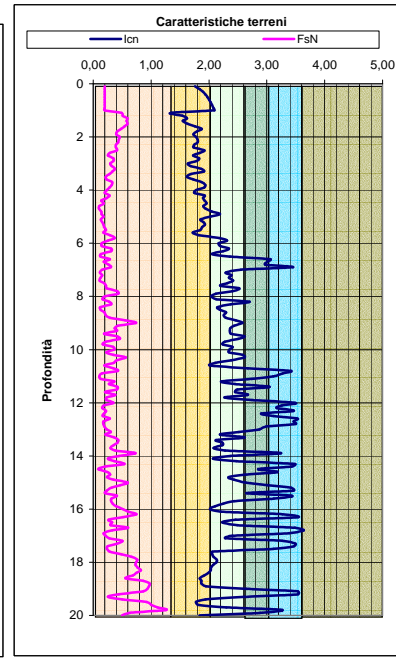
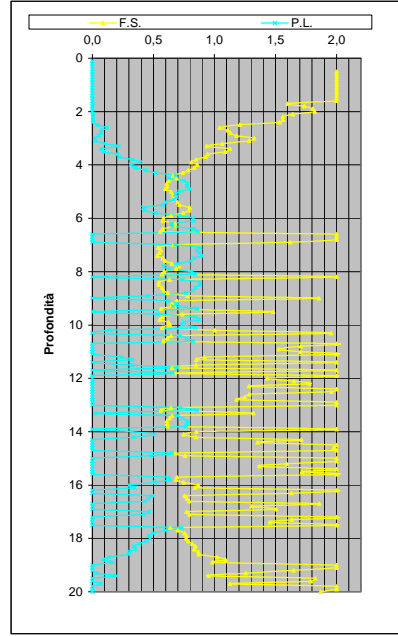
PROFONDITA' DI CALCOLO (mt da p.c.): 0,0 LDI = 3,961 Stot = 0,346 (mt) IPL = 15,88 PL = 59,15 LD = 0,00 (mt) PG = 1,00 SLiq = 10,3 (mt) LSN = 40,8

Main data table with columns: Depth (m), q1, qn, F, Ic, N1(60), n, Kc, Layer, etc. This is the largest table containing the primary data for the sounding.

DIAGRAMMI DI RIFERIMENTO VERIFICA LIQUEFAZIONE - METODO R. & W. , 2009



PROVA CPTU 1 - Colonia Montecatini



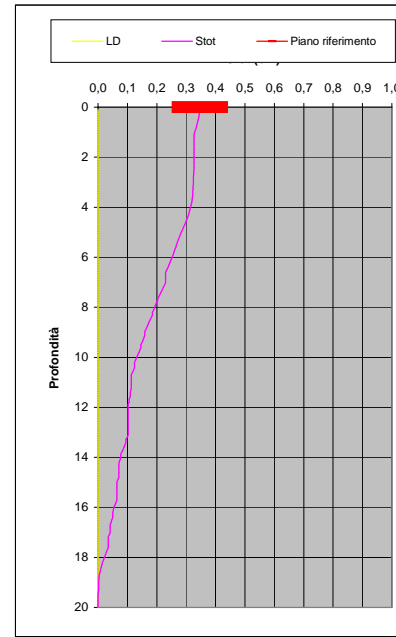
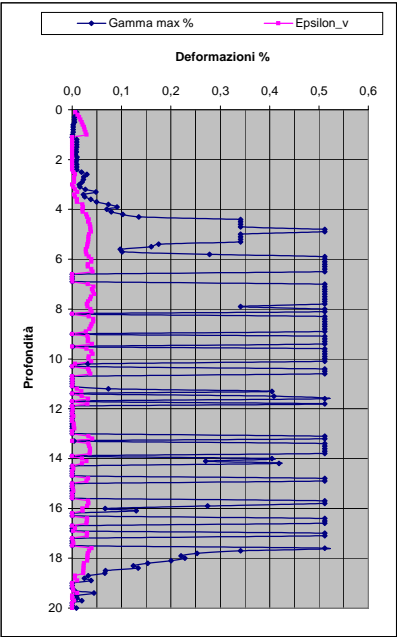
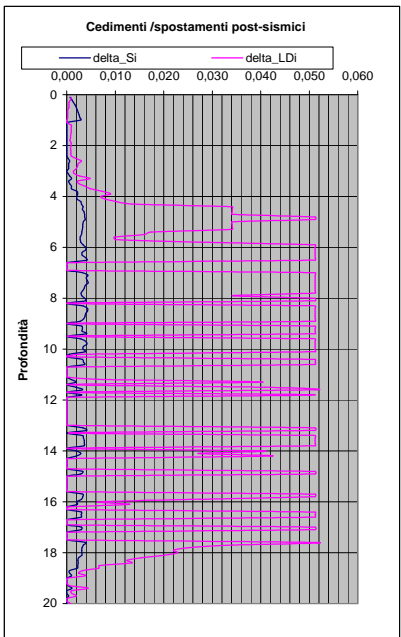
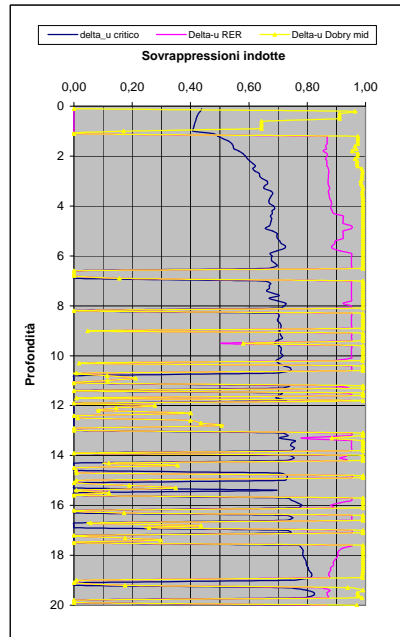
Soil Classification	Zone No.*	Range of CPT Index I_c Values
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Clays	3	$2.95 < I_c < 3.60$
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Sands	6	$1.31 < I_c < 2.05$
Gravelly Sands	7	$I_c < 1.31$

After Robertson and Wride (1998).
*Note: Zone number per Robertson SBT (1990).

- Argille - terreni organici
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LEGENDA

- Qc** = Res. alla penetraz. (Kg/cmq)
- FC** = Fine content - passante 0.074 mm (%)
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- F** = rapporto di frizione
- Qtn** = parametro di resist. alla punta normal.
- Icn** = Soil behaviour index normalized (ad)
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- ξ = parametro di stato
- KH** = fatt. correttivo per spessore strato (ad)
- Rd** = stress reduction coefficient (ad)
- CN** = fattore di normalizzazione per carico litostatico (ad)
- K σ** = fatt. correttivo per sovraccarico-profondità (ad)
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- LSN** = Liquefaction Severity Number (ad)



IPL= 15,88 PL= 59,15 LDI = 3,961 Stot = 0,346 (mt) LD = 0,00 (mt) SLiq = 10,30 (mt) LSN = 40,75 PG= 1,00

LSN Range	Expected ground surface damage
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$P_G \leq 0.1$	extremely low to none

CPT-based liquefaction triggering analysis for a single sounding

Environment: Hill-H Plain-P Coast-C

Behaviours: Sand like-s

Computed constants: no. (Blake) (B' 2007 - C'win 2004 - NCEER - Blake)

Probabilità e potenziale di liquefazione

Probabilità e suscettibilità di liquefazione

PL Overall Probability

Robertson & Wride, agg. 2009

PROVA "CPTU 2 II Canalino"

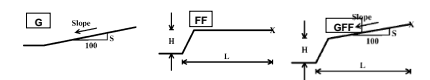
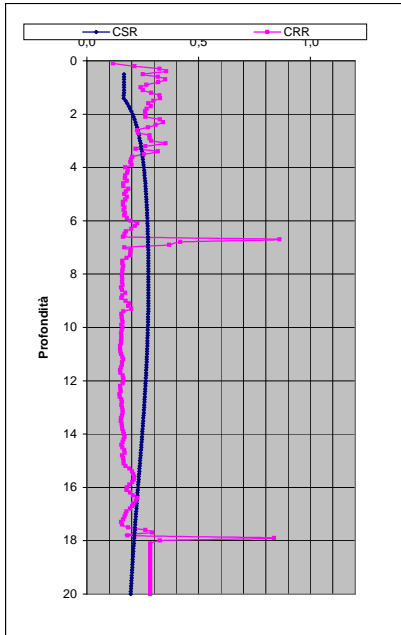
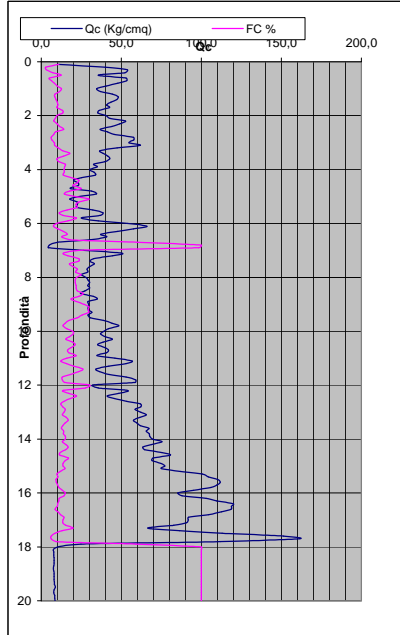


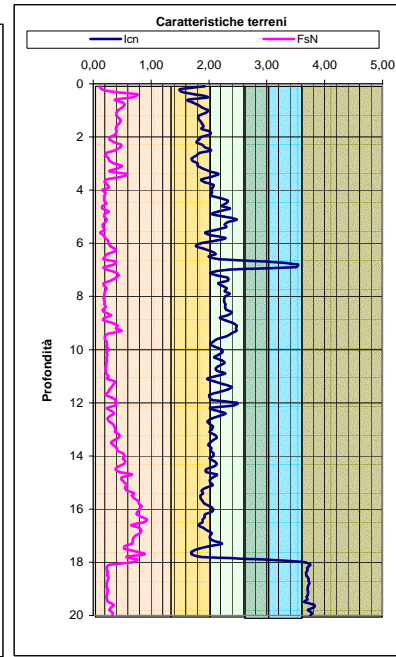
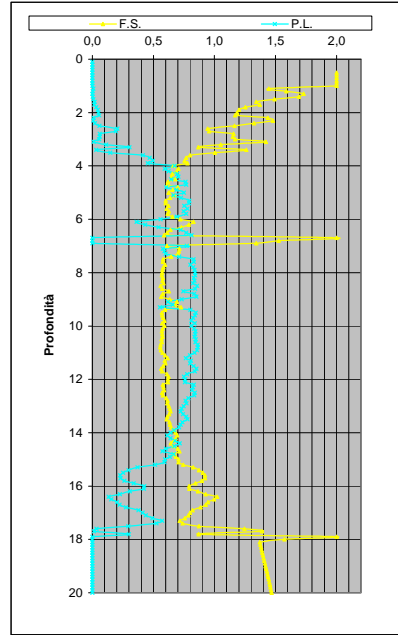
Table showing soil classification and behavior parameters like q1, qn, F, Ic, etc.

Main data table with columns: Depth, Soil Classification, q1, qn, F, Ic, N1(60), n, Kc, L, Layer, etc. It contains numerous rows of data for depth from 0.1 to 10.1 meters.

DIAGRAMMI DI RIFERIMENTO VERIFICA LIQUEFAZIONE - METODO R. & W. , 2009



PROVA CPTU 2 - Il Canalino



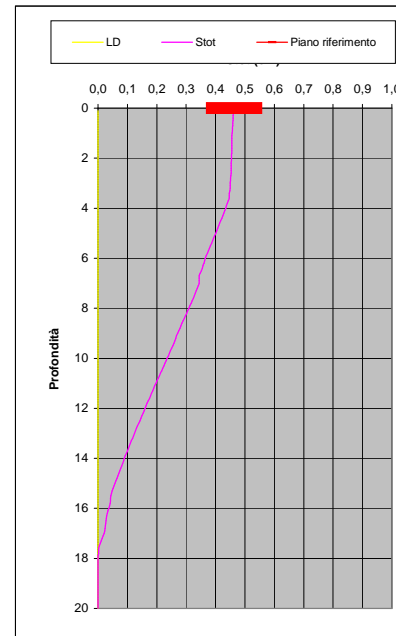
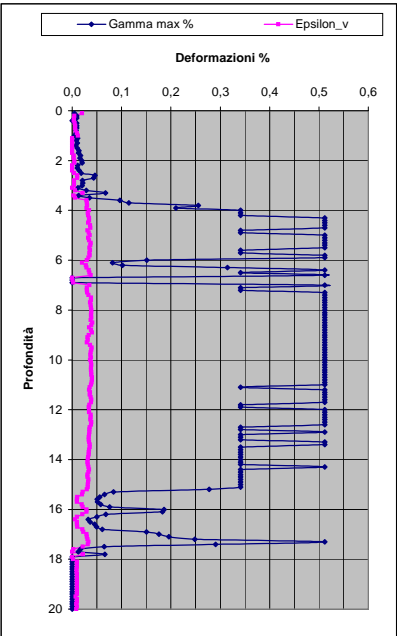
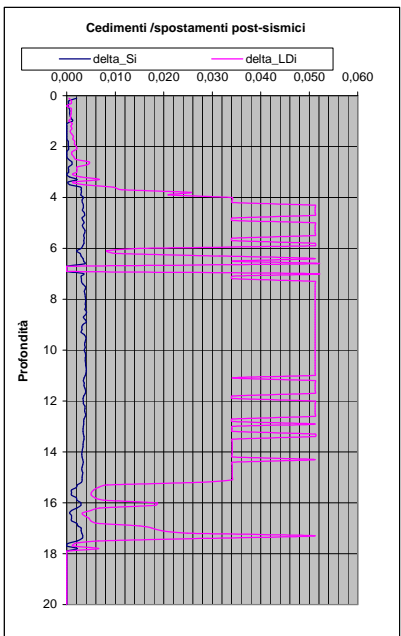
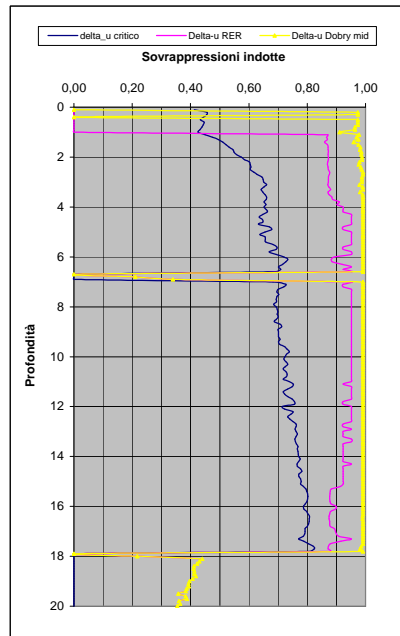
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- St** = coefficiente di sensitività delle argille (ad)
- LSN** = Liquefaction Severity Number (ad)



LSN Range	Expected ground surface damage
0-10	Little to no expression of liquefaction, minor effects
10-20	Minor expression of liquefaction, some sand boils
20-30	Moderate expression of liquefaction, with some sand boils and structural damage
30-40	Moderate to severe expression of liquefaction, settlement can cause structural damage
40-50	Major expression of liquefaction, undulations and damage to ground surface, severe total and differential settlements of structures
>50	Severe damage, extensive evidence of liquefaction as surface, severe total and differential settlements affecting structures, damage to services.

* Table based on Table 13.1 from I&T report: Liquefaction Vulnerability Study

Probability	Description of the risk of liquefaction-induced ground failure
$0.9 < P_G$	extremely high to absolutely certain
$0.7 < P_G \leq 0.9$	high
$0.3 < P_G \leq 0.7$	medium
$0.1 < P_G \leq 0.3$	low
$P_G \leq 0.1$	extremely low to none

IPL = 22,67

PL = 86,41

LDI = 5,301 Stot = 0,463 (mt)

LD = 0,00 (mt)

SLiq = 14,00 (mt)

LSN = 54,87 PG = 1,00