بسمه تعالی

نگرش نوین بر طراحی و اجرای پی های عمیق (شمع ها)

عنوان ارائه : توسعه و کاربرد بانک‌های اطلاعاتی پی‌های عمیق

Development and Applications of Databases in Deep Foundation Engineering

By: Eslami & Moshfeghi

ارائه دهنده: دکتر ابوالفضل اسلامی

با همکاری مهندس سارا مشفقی

۱ آبان ۱۳۹۸

سالن همایش محل دائمی نمایشگاه های تخصصی شهرداری تهران

Outline

1	Data Sources in Geotechnical Engineering	منابع داده‌ها در مهندسی ژئوتکنیک
2	CPT, CPTu & Pile	آزمایش نفوذ مخروط و شمع
3	Recent Iranian Researches on CPT & Pile	دستاوردهای اخیر محققین ایرانی: شمع و CPT
4	Overview of Some CPT & Pile Databases	مرور بانک‌های اطلاعاتی شمع و CPT
5	Introduction to AUT;Geo-CPT&Pile Database	پایگاه داده‌های ژئوتکنیکی دانشگاه صنعتی امیرکبیر
6	Typical Implementations	کاربردهای موردی
7	Concluding Remarks	جمع‌بندی نهایی

1. Sources of Data in GE

Sources of Data:

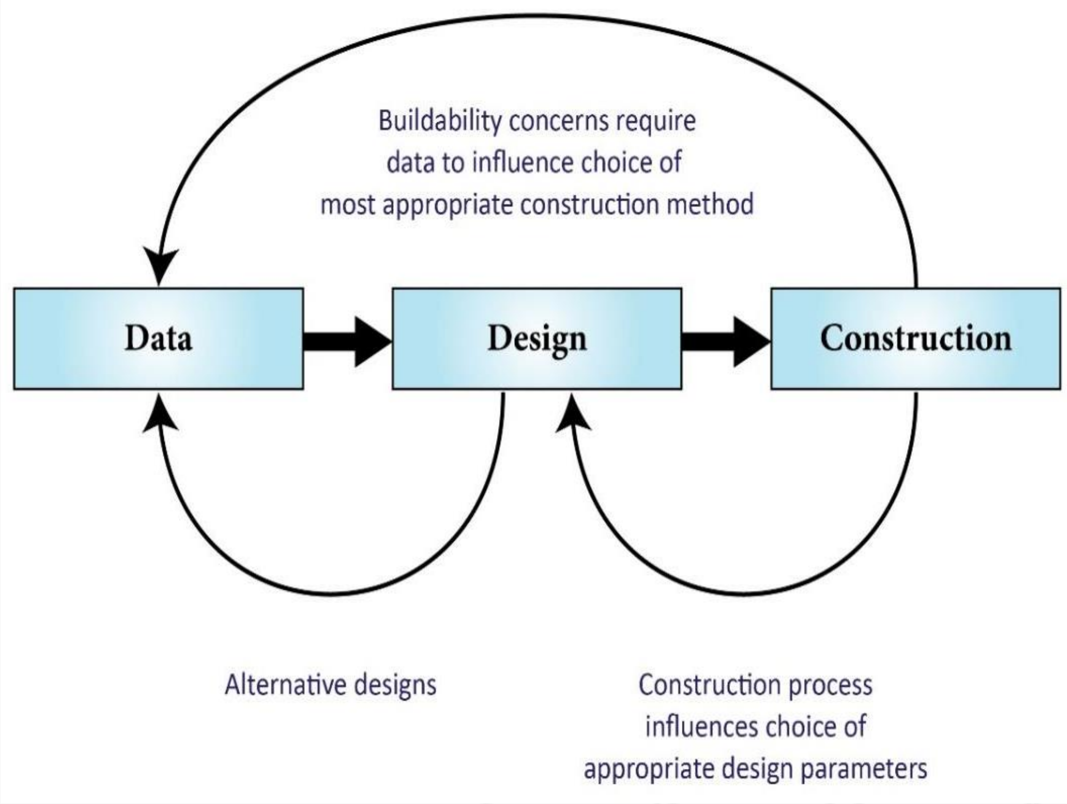
منابـــع داده‌هـــا در مهندسی ژئوتکنیک

1. Maps
2. Site visit
3. Drilling, boring, and sampling
4. Non-destructive tests (Geophysical tests)
5. On-situ tests
6. In-situ penetrating tests
7. Laboratory element testing
8. Laboratory physical modeling (model scale)
9. Full-scale testing
10. Instrumentation and Monitoring

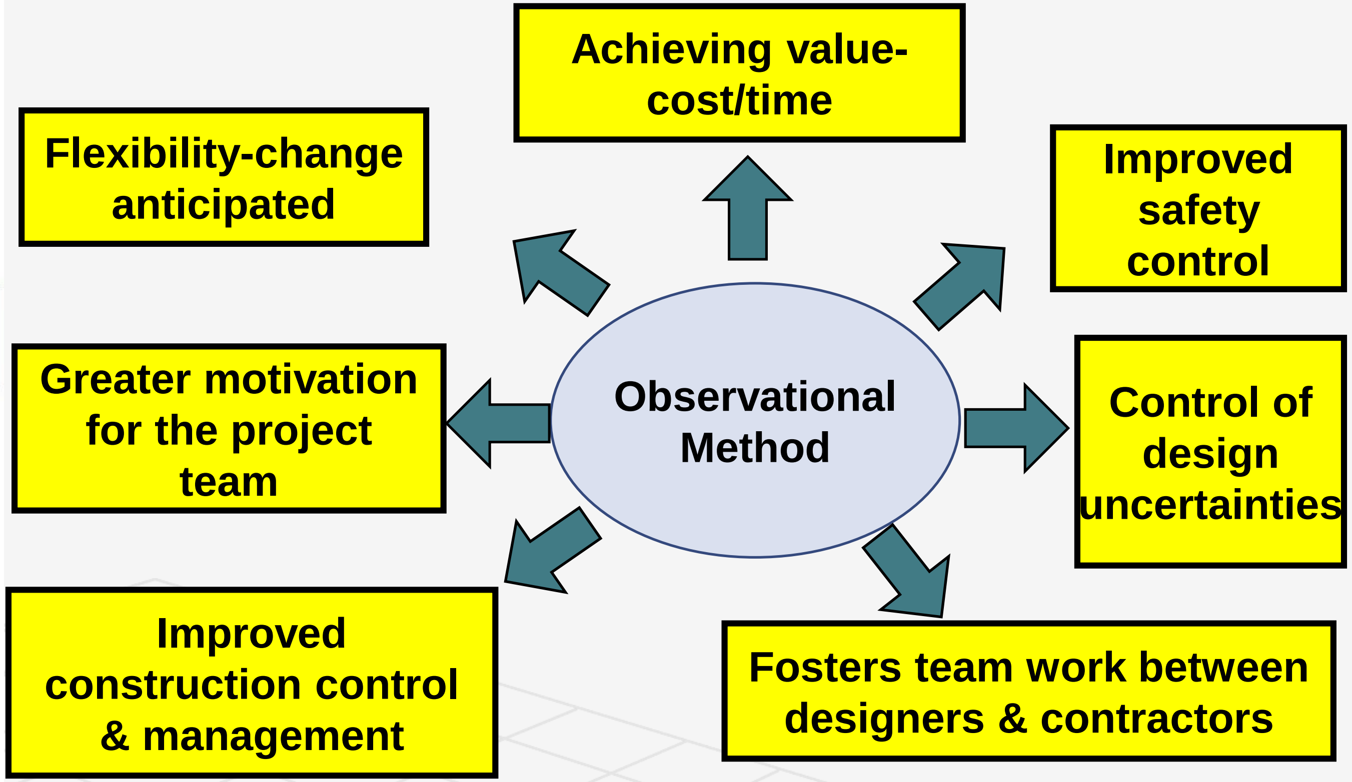
1. Sources of Data in GE

1. Sources of Data in GE

متد مشاهده‌ای و چرخه طراحی



Cycle of data, design, and performance (Burland, 2012)



Some potential benefits of the OM (CIRIA 185)

2. CPT, CPTu & Pile

In-situ Testing vs. Laboratory Testing

Laboratory Tests Problems

- Difficulties in preparing undisturbed sample
- Soil disturbance
- Soil volume change
- Omitting confinement pressure
- Size effect and size limits

In Situ Tests

- Overcome sampling difficulties
- Simple and fast
- Economical
- Generally applicable in foundation engineering

آزمایش‌های درجا و تست‌های آزمایشگاهی: مکمل در مهندسی ژئوتکنیک

Applicability of in-situ tests

test	Soil classification	Vertical soil profiling	Relative density, D_r	Friction angle, φ	Undrained shear strength, S_u	Pore pressure, u	Stress history, OCR and K_0	E_s and G modulus	Compressibility factors, m_v and C_c	Consolidation factors, c_v and c_h	Permeability, k	Stress-strain diagram	Liquefaction resistance
Acoustic probe	C	B	B	C	C		C	C					C
Borehole permeability	C					A				B	A		
Cone (CPT)													
Dynamic	C	A	B	C	C		C						C
Electrical friction	B	A	B	C	B		C	B	C				B
Electrical piezocone	A	A	B	B	B	A	A	B	B	A	B	B	A
Mechanical	B	A	B	C	B		C	B	C				B
Seismic down hole	C	C	C					A				B	B
Dilatometer (DMT)	B	A	B	C	B		B	B	C			C	B
Hydraulic fracture						B	B			C	C		
Nuclear density tests (NDT)			A	B				C					
Plate load tests (PLT)	C	C	B	B	C		B	A	B	C	C	B	B
Pressure meter menard (PMT)	B	B	C	B	B		C	B	B			C	C
Self-boring pressure (SBPMT)	B	B	A	A	A	A	A	A	A	A	B	A	A
Screw plate (SPLT)	C	C	B	C	B		B	A	B	C	C	B	B
Seismic down-hole	C	C	C					A				B	B
Seismic refraction (SR)	C	C						B					B
Shear vane (VST)	B	C			A		B						
Standard penetration test (SPT)	B	B	B	C	C				C				A

A: high application B: medium application C:limited application

2. CPT, CPTu & Pile

Cone Penetrometer (CPTu) Probes and Terminology

- ASTM D 5778 procedures
- No boring, No samples, No spoil
- Hydraulic Push at 20 mm/s
- Range of sizes:10 cm^2 and 15 cm^2 probes

Advantages:

- Fast and continuous profiling
- Repeatable and reliable
- Continuous records of q_c, f_s, u per 2.5 cm
- Strong theoretical basis for interpretation

Disadvantages:

- High capital investment
- Requires skilled operators
- Limitation of use in gravel or cemented soils

2. CPT, CPTu & Pile

Cone Tracks, Trucks and Special Rigs



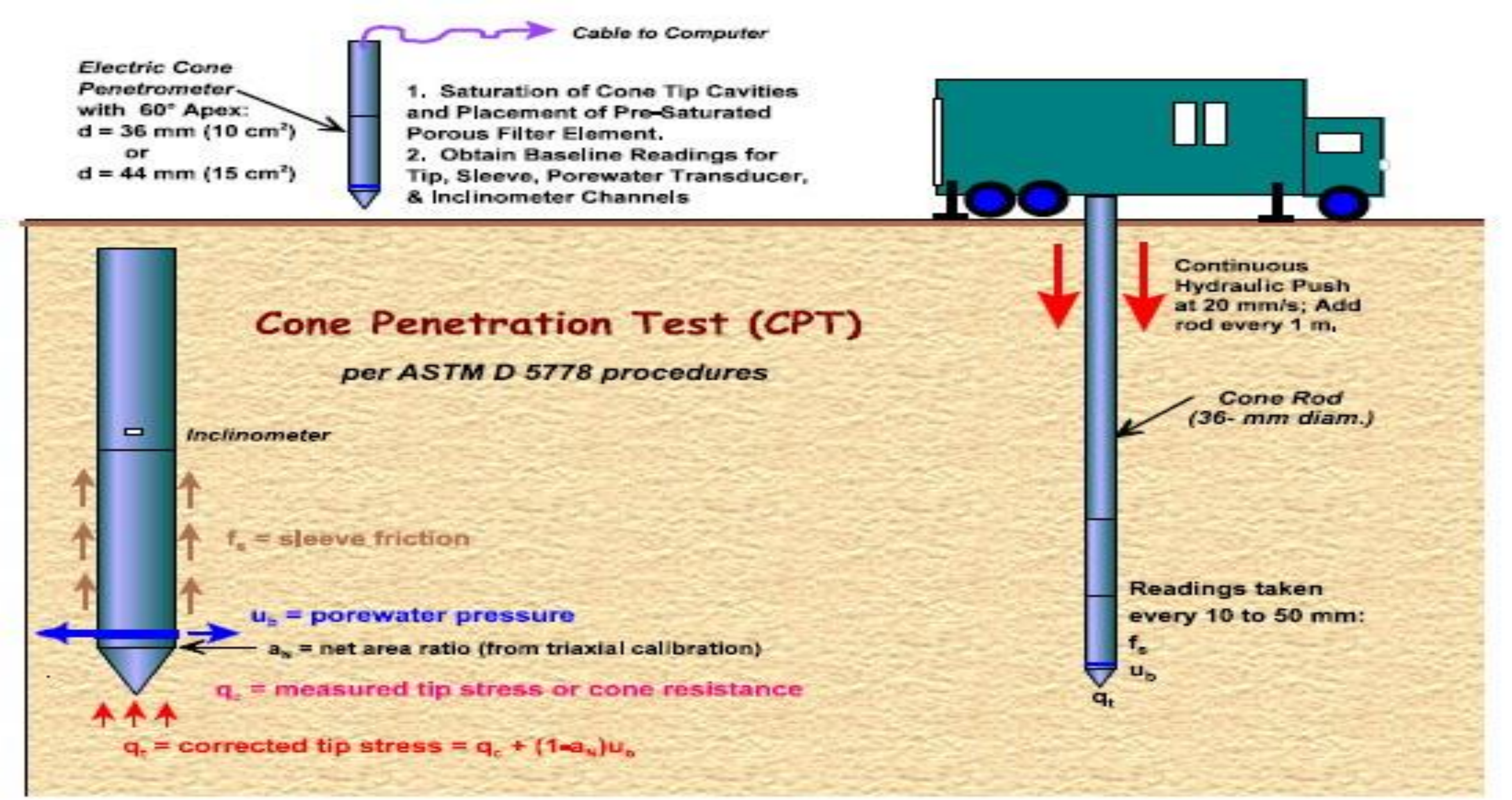






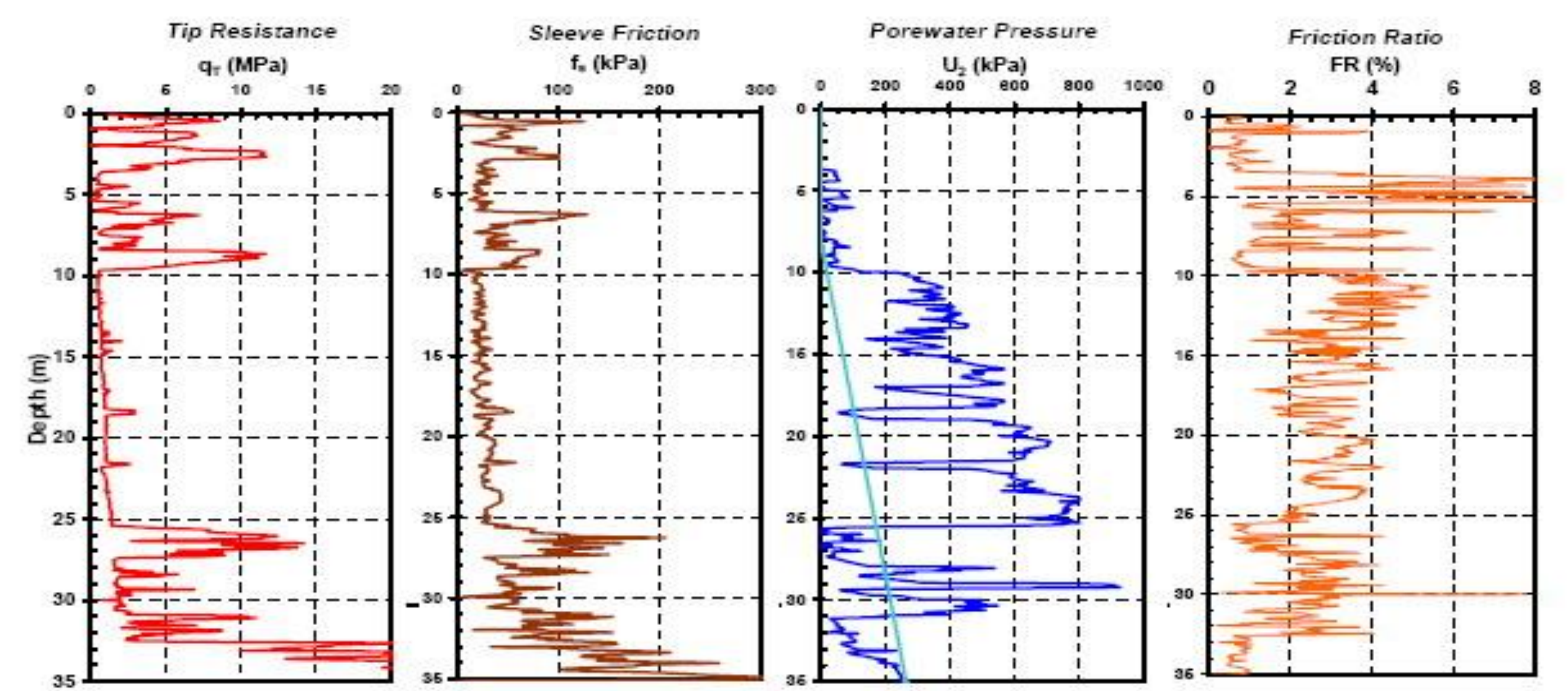
2. CPT, CPTu & Pile

CPTu Performance and Records



2. CPT, CPTu & Pile

CPTu: Graphical Records and Log



Typical CPTu Profile , Vancouver, BC, Canada (Campanella, 1988)

2. CPT, CPTu & Pile

CPTu: Digital Records

368-LAMONTC10-He-CPT.xlsx

CPT DIGITALS

Z (m)	q_c (MPa)	f_s (MPa)	u_2 (MPa)	u_0 (MPa)	R_f (%)
0.0	0.237	0.000	0.007	0.000	0.000
0.1	1.956	0.002	0.016	0.000	0.102
0.2	4.859	0.031	0.070	0.000	0.633
0.3	7.141	0.036	0.311	0.000	0.509
0.4	8.681	0.067	0.047	0.000	0.771
0.5	10.252	0.118	0.046	0.000	1.150
0.6	8.593	0.104	0.013	0.000	1.208
0.7	5.956	0.153	0.004	0.000	2.562
0.8	4.919	0.145	0.003	0.000	2.940
0.9	5.481	0.130	0.006	0.000	2.380
1.0	6.548	0.112	0.007	0.000	1.718
1.1	7.052	0.146	0.013	0.000	2.074
1.2	8.830	0.168	0.013	0.000	1.900
1.3	9.748	0.173	0.013	0.000	1.776
1.4	10.252	0.202	0.013	0.000	1.972
1.5	10.252	0.215	0.013	0.000	2.096
1.6	11.052	0.246	0.019	0.000	2.227
1.7	13.570	0.252	0.019	0.000	1.856
1.8	12.948	0.316	0.046	0.000	2.438
1.9	19.585	0.319	0.126	0.000	1.630
2.0	32.119	0.168	0.086	0.000	0.524
2.1	28.444	0.257	0.004	0.000	0.902
2.2	19.970	0.464	0.189	0.000	2.322

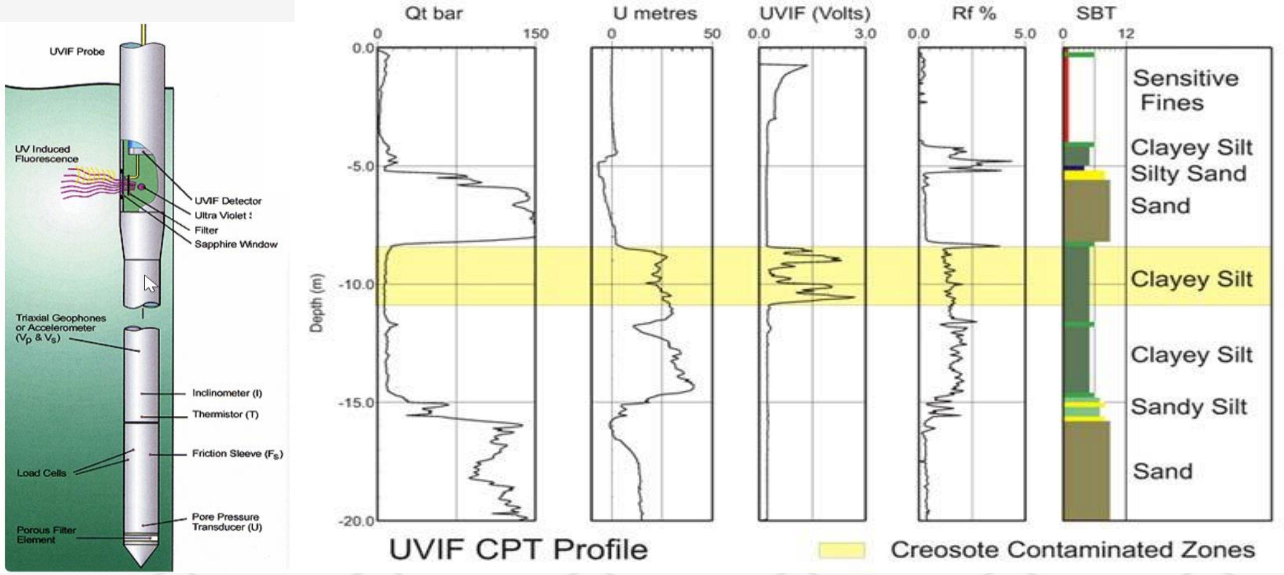
CPT LOGS | CPT DIGITALS

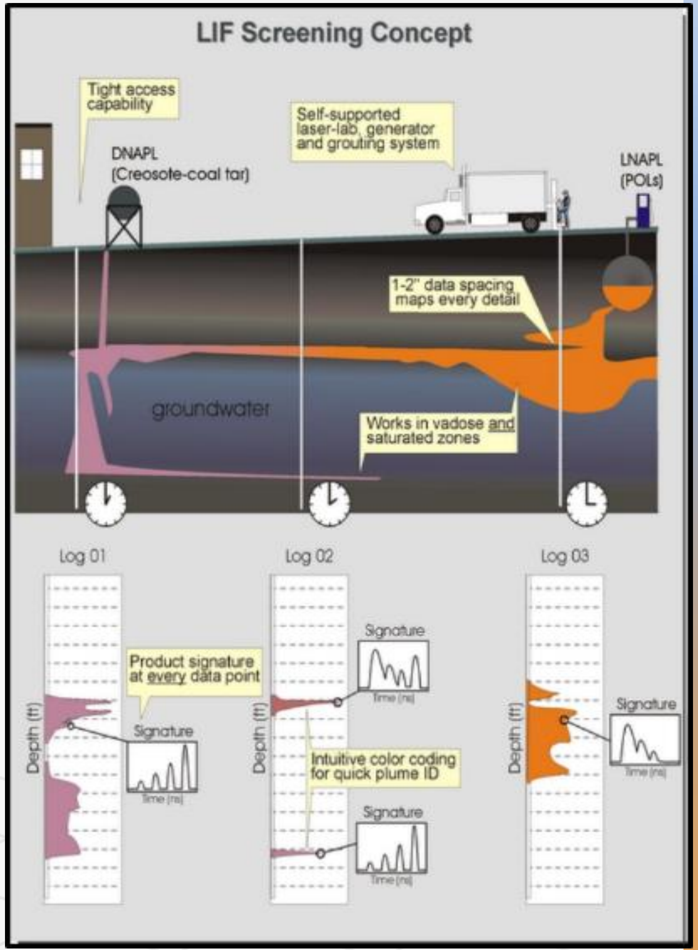
تولید حجم بسیار زیاد داده‌ها توسط CPT

2. CPT, CPTu & Pile

Special Piezocones

- Resistivity Cone Penetration Test (RCPTu)
- Seismic Cone Penetration Test (SCPTu)
- Piezovibrocone
- Ultra violet induced fluorescence Cone Penetration Test (UVIF CPT)
- Dynamic Cone Penetration Test (DCPT)
- Cone Pressuremeter (CPMT)





2. CPT, CPTu & Pile

کاربردهای CPT و CPTu در مهندسی ژئوتکنیک

APPLICATIONS OF CPT IN GEOTECHNICAL ENGINEERING

Soil Behavior Classification (SBC) & Profiling

- Estimating soil strength and stiffness parameters
- Soil improvement assessment
- Problematic soils recognition

Foundation Engineering

- Direct approaches
- Indirect approaches

Geo-environmental Engineering

2. CPT, CPTu & Pile

Bearing Capacity Estimation Methods

1. Static Methods
2. **In-situ Tests**
3. Static Loading Test
4. Dynamic Methods
5. Numerical Analysis

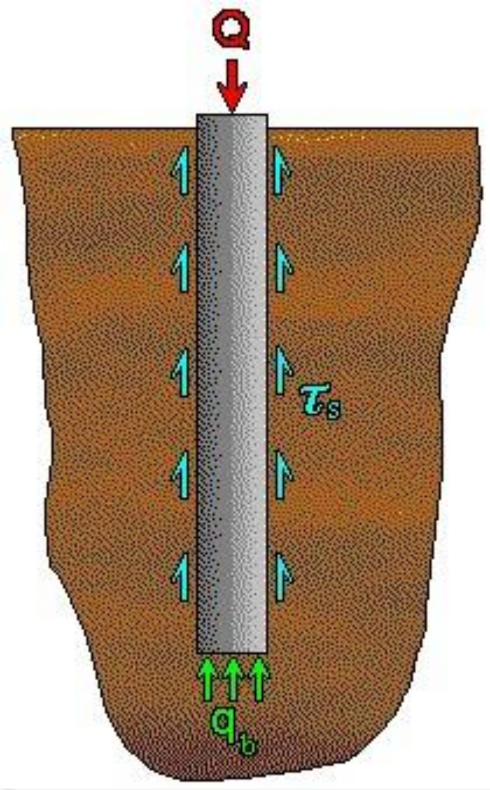
1- Direct Approaches:

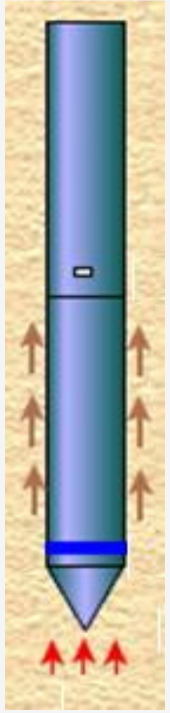
$f_s \rightarrow r_s$

$q_c \rightarrow r_t$

2- Indirect Approaches:

$q_c,\ f_s \rightarrow c,\ \phi \rightarrow q_{ult}$





Similarities between the cone penetrometer and piles

Penetrometer can be realized as a model pile.

2. CPT, CPTu & Pile

Bearing Capacity Direct CPT and CPTu-based methods: Pile Bearing Capacity

روش‌های مبتنی بر CPT و CPTu: تعیین ظرفیت باربری شمع‌ها

No.	Method/ Reference	No.	Method/ Reference
1	Begemann (1963, 1965, 1969)	15	Fugro-05 (Kolk et al. 2005)
2	Meyerhof (1956, 1976, 1983)	16	UCD-05 (Gavin and Lehane 2005)
3	Aoki and Velloso (1975)	17	ICP-05 (Jardine et al. 2005)
4	Nottingham (1975), Schmertmann (1978)	18	UWA-05 (Lehane et al. 2005)
5	Penpile (Clisby et al.1978)	19	NGI-05 (Clausen et al. 2005)
6	Dutch (de Ruiter & Beringen 1979)	20	Cambridge-05 (White & Bolton 2005)
7	Philipponnat (1980)	21	Togiliani (2008)
8	LCPC (Bustamante & Gianeselli 1982)	22	German (Kempfert and Becker 2010)
9	Cone-m (Tumay & Fakhroo 1982)	23	UCD-11 (Igoe et al. 2010, 2011)
10	Price and Wardle (1982)	24	V–K (Van Dijk and Kolk 2011)
11	Gwizdala (1984)	25	SEU (Cai et al. 2011, 2012)
12	UniCone (Eslami & Fellenius 1997)	26	HKU (Yu and Yang 2012)
13	KTRI (Takesue et al. 1998)	27	UWA-13 (Lehane et al. 2013)
14	TCD-03 (Gavin and Lehane 2003)	28	Modified UniCone (Niazi and Mayne 2016)

3. Recent Iranian Researches on CPT & Pile

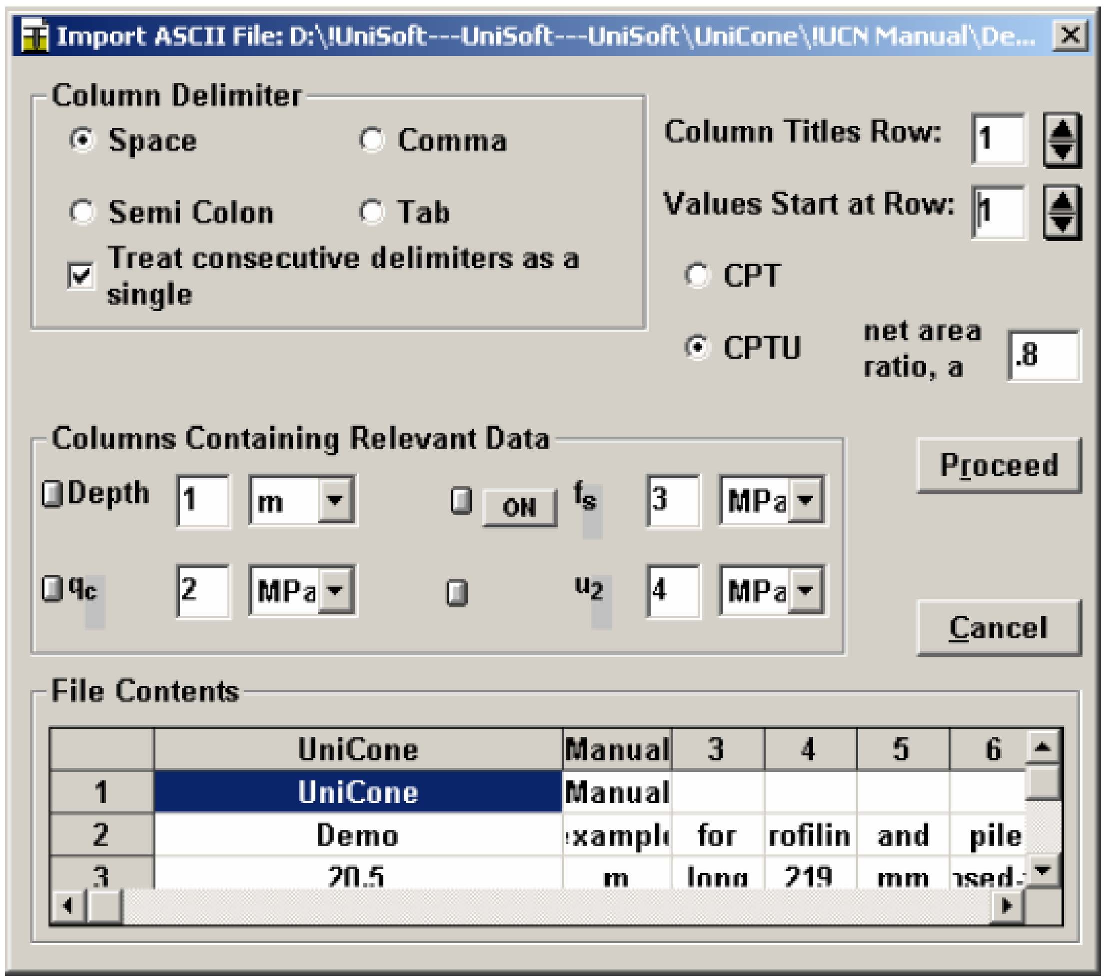
UniCone Program:
Fellenius, Infante and Eslami (2002)

متد و نرم افزار UniCone

- Pile Design (CPT/CPTu)
- Soil Profiling (CPT/CPTu)

Input Data

- CPT/CPTu test results
- Pile Properties
- Soil Layers properties

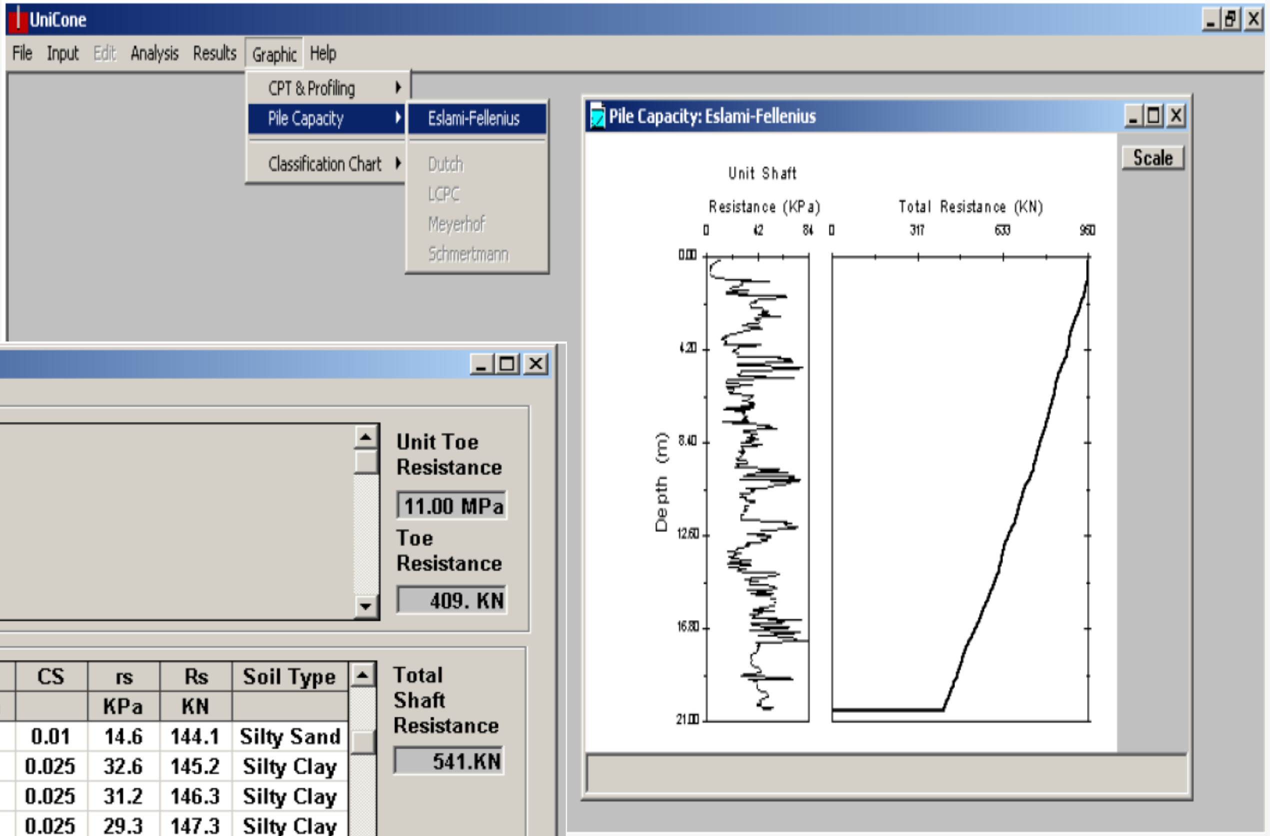


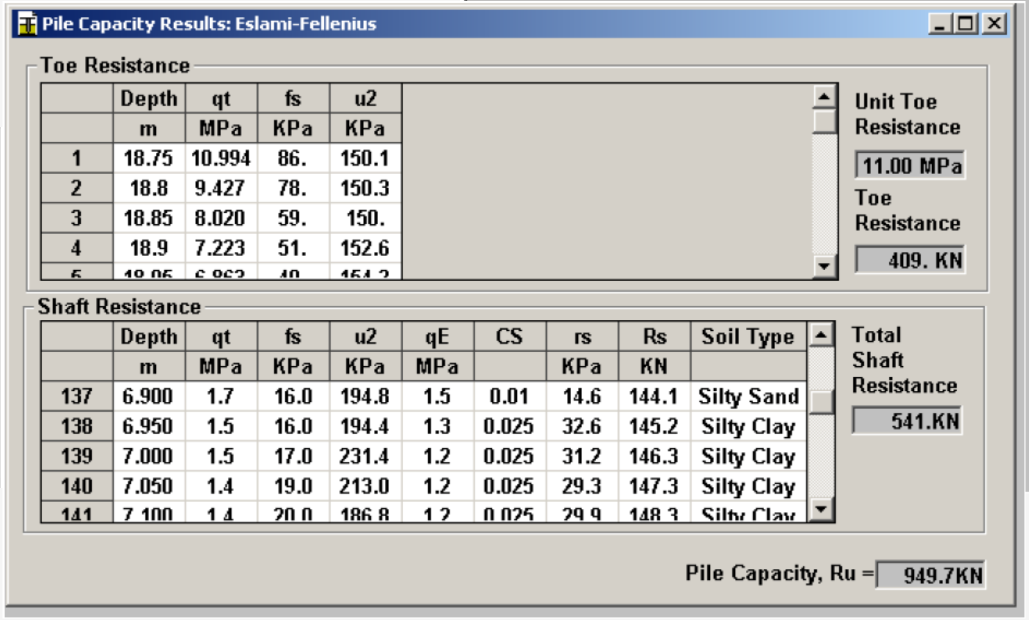
3. Recent Iranian Researches on CPT & Pile

UniCone Program:
Fellenius, Infante and Eslami (2002)

متد و نرم افزار UniCone

Pile Capacity Calculation





Pile Capacity Results: Eslami-Fellenius

Toe Resistance

	Depth	qt	fs	u2
	m	MPa	KPa	KPa
1	18.75	10.994	86.	150.1
2	18.8	9.427	78.	150.3
3	18.85	8.020	59.	150.
4	18.9	7.223	51.	152.6
5	18.95	6.963	40.	154.2

Unit Toe Resistance: 11.00 MPa

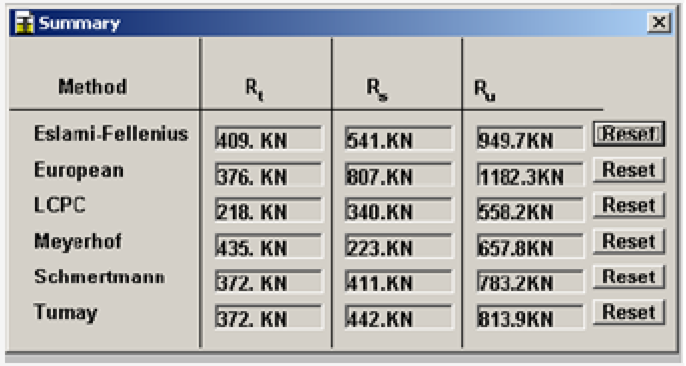
Toe Resistance: 409. KN

Shaft Resistance

	Depth	qt	fs	u2	qE	CS	rs	Rs	Soil Type
	m	MPa	KPa	KPa	MPa		KPa	KN	
137	6.900	1.7	16.0	194.8	1.5	0.01	14.6	144.1	Silty Sand
138	6.950	1.5	16.0	194.4	1.3	0.025	32.6	145.2	Silty Clay
139	7.000	1.5	17.0	231.4	1.2	0.025	31.2	146.3	Silty Clay
140	7.050	1.4	19.0	213.0	1.2	0.025	29.3	147.3	Silty Clay
141	7.100	1.4	20.0	186.8	1.2	0.025	29.9	148.3	Silty Clay

Total Shaft Resistance: 541.KN

Pile Capacity, Ru = 949.7KN



Summary

Method	R_t	R_s	R_u	
Eslami-Fellenius	409. KN	541.KN	949.7KN	Reset
European	376. KN	807.KN	1182.3KN	Reset
LCPC	218. KN	340.KN	558.2KN	Reset
Meyerhof	435. KN	223.KN	657.8KN	Reset
Schmertmann	372. KN	411.KN	783.2KN	Reset
Tumay	372. KN	442.KN	813.9KN	Reset

CPT & Pile Databases
By: Eslami & Moshfeghi

3. Recent Iranian Researches on CPT & Pile

UniCone Program:
Fellenius, Infante and Eslami (2002)

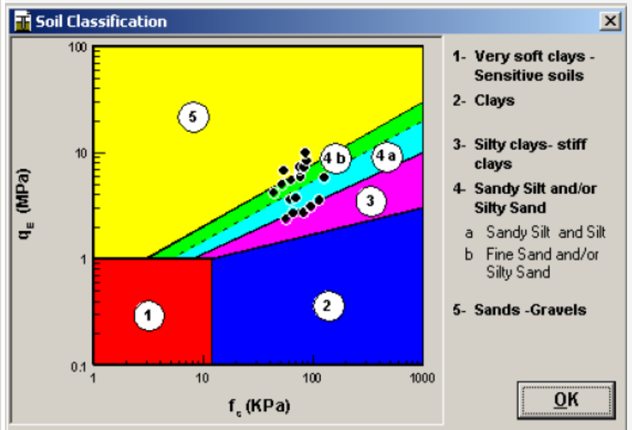
متد و نرم افزار UniCone

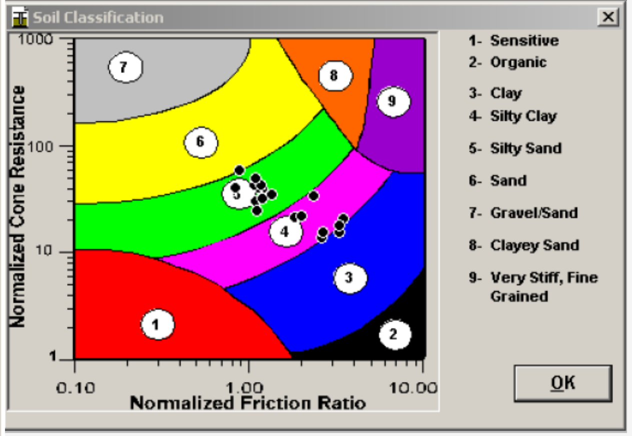
Soil Profiling

Soil Profiling Results: Eslami-Fellenius

	Depth	qt	fs	u2	qE	Rf	Soil Type
	m	MPa	KPa	KPa	MPa	%	
330	16.500	2.5	57.0	133.0	2.3	2.3	Silty Clay
331	16.550	3.7	62.0	110.7	3.6	1.7	Silty Sand to Silt
332	16.600	3.8	70.0	64.8	3.7	1.8	Silty Sand to Silt
333	16.650	5.1	52.0	83.2	5.0	1.0	Fine Sand and/or Silty Sand
334	16.700	6.8	54.0	12.2	6.8	0.8	Sand
335	16.750	6.6	75.0	12.7	6.6	1.1	Fine Sand and/or Silty Sand
336	16.800	5.8	127.0	1.4	5.8	2.2	Silty Sand to Silt
337	16.850	3.6	114.0	24.0	3.6	3.2	Silty Sand to Silt
338	16.900	2.8	82.0	76.1	2.7	2.9	Silty Clay
339	16.950	3.2	95.0	90.5	3.1	3.0	Silty Clay
340	17.000	2.8	66.0	92.4	2.7	2.4	Silty Clay
341	17.050	4.3	44.0	114.3	4.2	1.0	Fine Sand and/or Silty Sand
342	17.100	5.6	63.0	39.8	5.6	1.1	Fine Sand and/or Silty Sand
343	17.150	6.0	77.0	41.8	6.0	1.3	Fine Sand and/or Silty Sand
344	17.200	7.0	75.0	59.1	6.9	1.1	Sand
345	17.250	7.4	76.0	45.7	7.3	1.0	Sand
346	17.300	7.4	83.0	59.1	7.3	1.1	Sand
347	17.350	8.5	88.0	83.5	8.4	1.0	Sand
348	17.400	10.1	85.0	101.9	10.0	0.8	Sand

Plot Values





3. Recent Iranian Researches on CPT & Pile

Eslami Fellenius (1992-1996)-CGJ

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Pile capacity by direct CPT and CPTu methods applied to 102 case histories

Abolfazl Eslami and Bengt H. Fellenius

Abstract: Six methods to determine axial pile capacity directly from cone penetration test (CPT) data are presented, discussed, and compared. Five of the methods are CPT methods that apply total stress and a filtered arithmetic average of cone resistance. One is a recently developed method, CPTu, that considers pore-water pressure and applies an unfiltered geometric average of cone resistance. To determine unit shaft resistance, the new method uses a new soil profiling chart based on CPTu data. The six methods are applied to 102 case histories combining CPTu data and capacities obtained in static loading tests in compression and tension. The pile capacities range from 80 to 8000 kN. The soil profiles range from soft to stiff clay, medium to dense sand, and mixtures of clay, silt, and sand. The pile embedment lengths range from 5 to 67 m and the pile diameters range from 200 to 900 mm. The new CPTu method for determining pile capacity demonstrates better agreement with the capacity determined in a static loading test and less scatter than by CPT methods.

Key words: cone penetration test, pile capacity, toe resistance, shaft resistance, soil classification.

ظرفیت باربری محوری شمع‌ها بـا اسـتفاده از نتایج CPT و CPTu

طبقه‌بندی رفتاری خاک‌ها (SBC)

3. Recent Iranian Researches on CPT & Pile

CPT & Pile Databases
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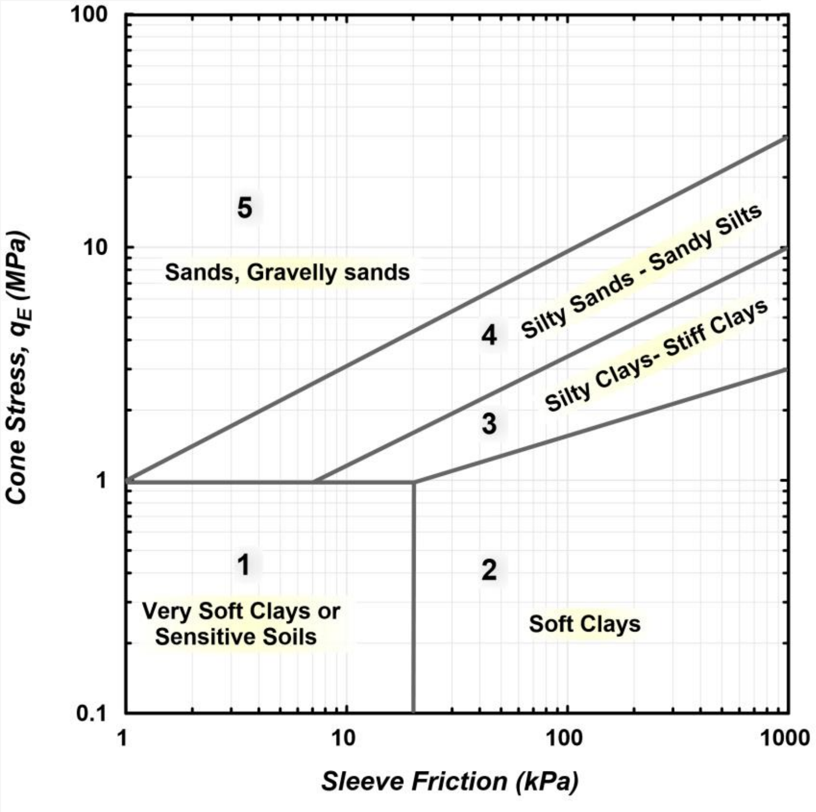
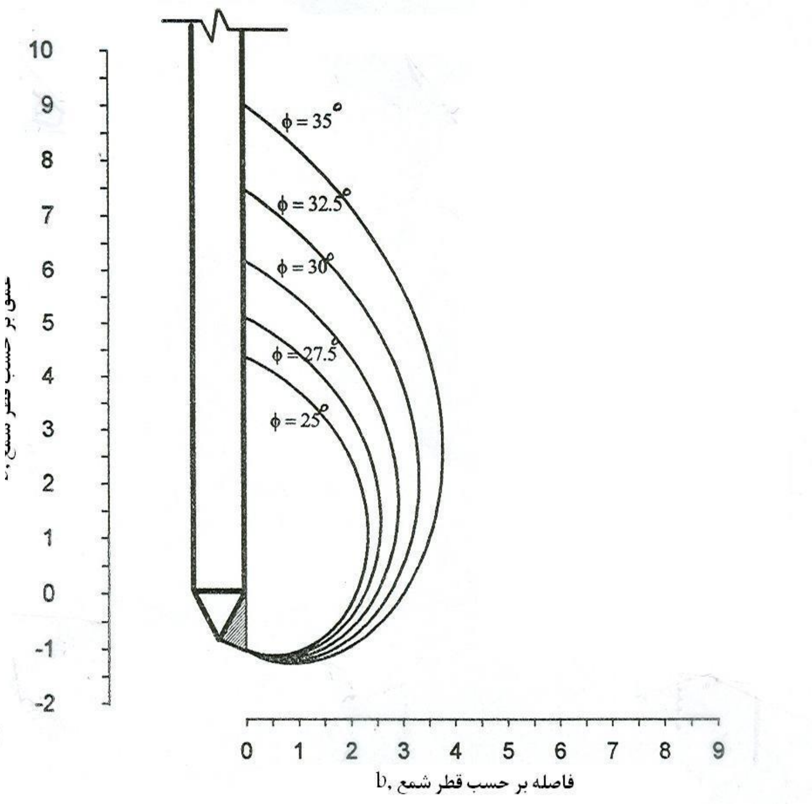
Eslami & Fellenius (1992-1996)

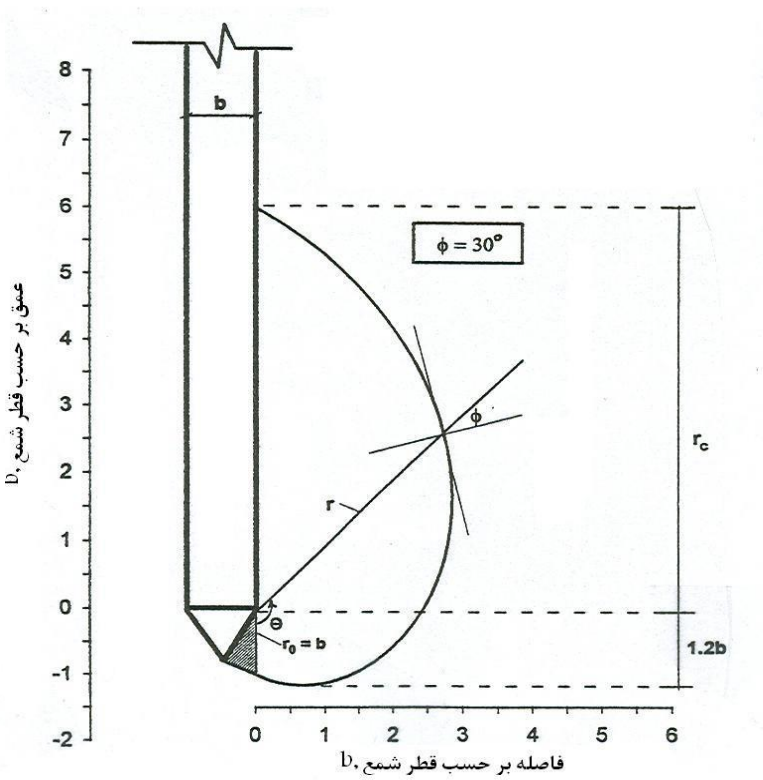
ظرفیت باربری محوری شمع ها با استفاده از نتایج CPTu

Influence and Failure Zone



Soil Classification Chart





Geometric average of cone resistance q_c for different size zones

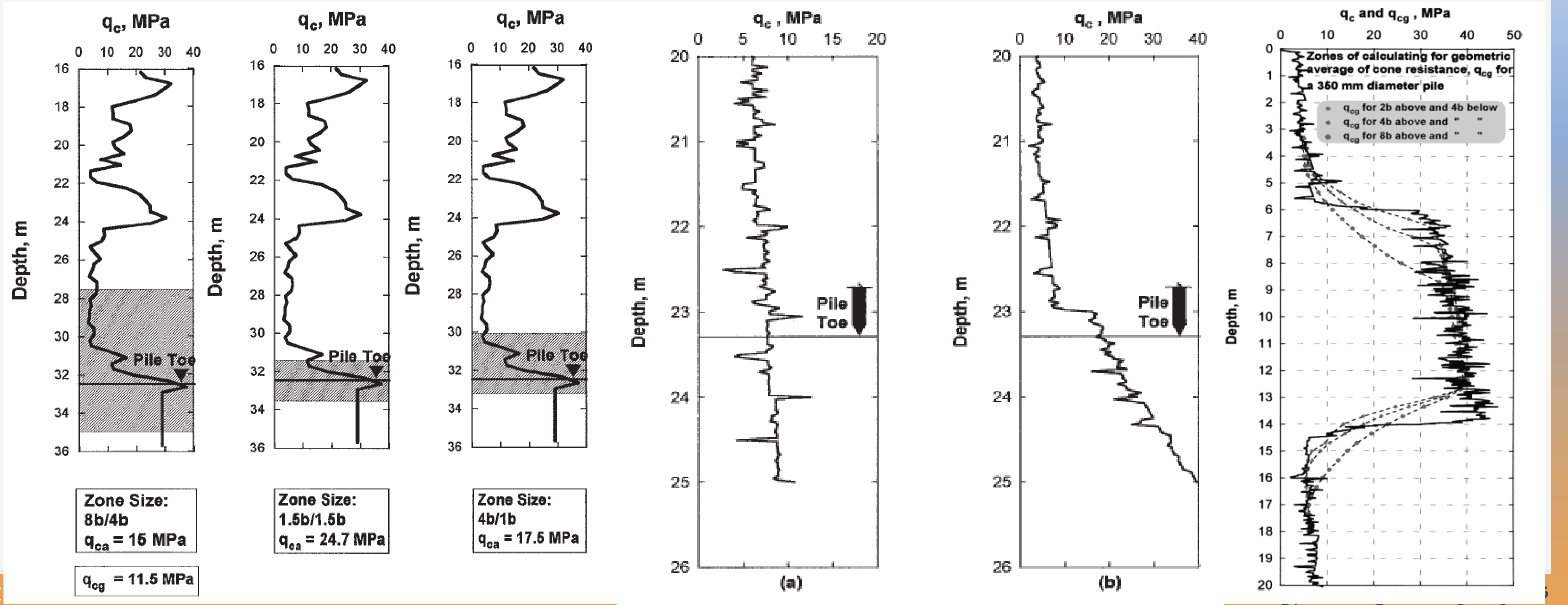
3. Recent Iranian Researches on CPT & Pile

CPT & Pile Databases
By: Eslami & Moshfeghi

Eslami & Fellenius (1992-1996)

ظرفیت باربری محوری شمع ها با استفاده از نتایج CPTu

Scale Effects



3. Recent Iranian Researches on CPT & Pile

Eslami & Gholami (2003, 2006)

ظرفیت باربری پی ها با استفاده از نتایج CPTu

Scientia Iranica, Vol. 13, No. 3, pp 223–233
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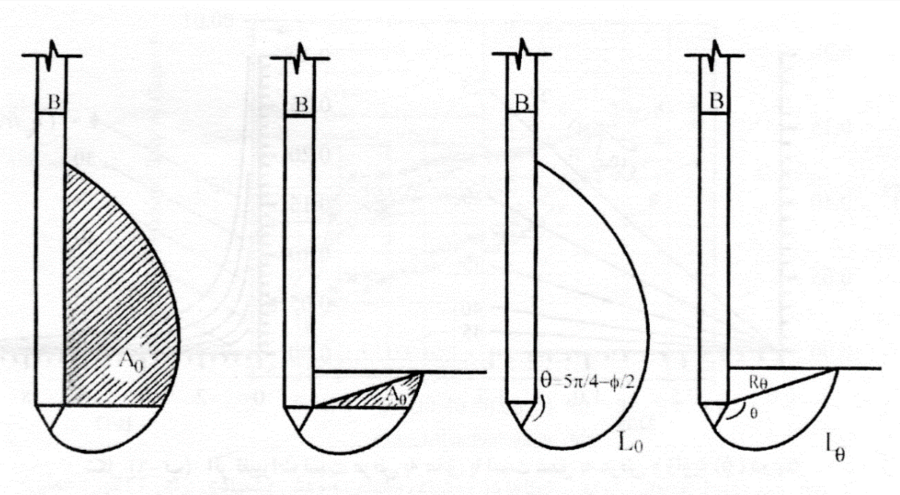
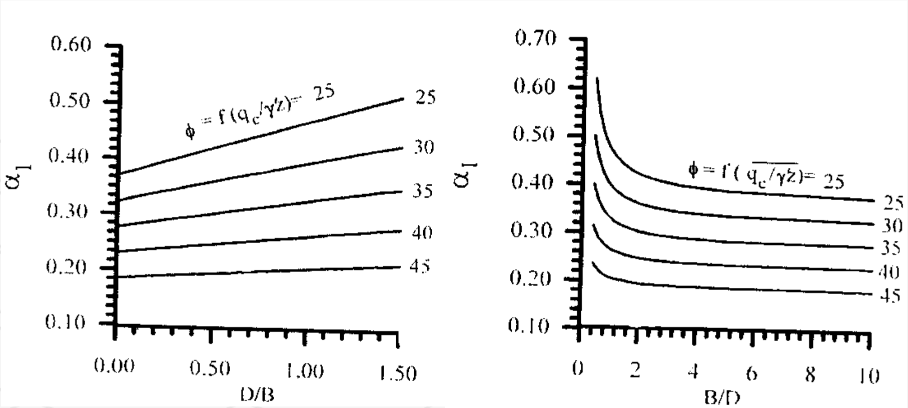
Analytical Model for the Ultimate Bearing Capacity of Foundations from Cone Resistance

A. Eslami* and M. Gholami[1]

By application of Cone Penetration Test (CPT) data for shallow foundation (footing) design, the problems of providing representative undisturbed samples and, rather, $\varphi - N$ coefficient relations will be eliminated. An analytical model, based on a general shear failure mechanism of the logarithm spiral type, has been developed for calculating, directly, the bearing capacity of footings, q_{ult} from cone resistance, q_c. The transform of the failure mechanism from a shallow to a deep foundation and the scale effect have been considered in the proposed method. Six current CPT direct methods for determining the bearing capacity of footings have been investigated. The proposed method and others were compared to the measured capacity, ranging from 1.7 to 15 kg/cm^2, of 28 footings compiled in a database with a range of diameter from 0.3 to 3 m located in different soils. The graphical and cumulative probability approaches for the validation of the methods indicates optimistic results for the bearing capacity estimation of the proposed method, which is simple and routine.





3. Recent Iranian Researches on CPT & Pile

Shariatmadari, Eslami & KarimpourFard (2008)

Iranian Journal of Science & Technology, Transaction B, Engineering, Vol. 32, No. B2, pp 125-140
Printed in The Islamic Republic of Iran, 2008

BEARING CAPACITY OF DRIVEN PILES IN SANDS FROM SPT–APPLIED TO 60 CASE HISTORIES*

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Abstract– In recent years determining bearing capacity of piles from in-situ testing data as a complement of static and dynamic analysis has been used by geotechnical engineers. In this paper, different approaches for estimating the bearing capacity of piles from SPT data have been explained and compared. A new method based on the N-value from SPT is presented and calibrated. Data averaging, failure zone extension, and plunging failure of piles has been noticed in the proposed approach. A data base has been compiled including 43 full scale static pile load tests and 17 dynamic testings which were analyzed with the signal matching technique by CAPWAP. The SPT data were performed close to pile locations are also included in the data base. A comparison of current methods by error investigation with cumulative probability and Log-Normal approaches demonstrates that the proposed method predicts pile capacity with more accuracy and less scatter than other methods. Results of prediction with good agreement to measured capacities indicate that the proposed method can be used as an alternative for determining the bearing capacity of piles in geotechnical practice.

Keywords– Pile, bearing capacity, standard penetration test, SPT, static and dynamic load tests

ظرفیت باربری شمع های کوبشی در ماسه با استفاده از نتایج SPT، CPT و موارد عملی

3. Recent Iranian Researches on CPT & Pile

Ahmadi, Byrne and Campanella (2011)

Cone tip resistance in sand: modeling, verification, and applications

M.M. Ahmadi, P.M. Byrne, and R.G. Campanella

Abstract: A numerical modeling procedure is presented to evaluate cone tip resistance in sand. The procedure involves a moving boundary simulating cone penetration. The soil is modeled as a Mohr–Coulomb elastic–plastic material with stress-dependent parameters. The procedure is verified by comparing predicted numerical values of cone tip resistance with published experimental measurements from calibration chamber tests. The selected database consists of 59 calibration chamber tests on Ticino sand with different relative densities, overconsolidation ratios, stresses, and boundary conditions. Several applications of the modeling procedure are also presented. The computer program FLAC is used to carry out the analysis.

Key words: cone tip resistance, numerical modeling, sand, calibration chamber, Mohr–Coulomb, in situ horizontal stress.

Résumé : On présente une procédure de modélisation pour évaluer la résistance de pointe du cône dans le sable. La procédure implique une frontière mobile simulant la pénétration du cône. Le sol est modélisé comme un matériau élasto-plastique Mohr–Coulomb avec des paramètres dépendant des contraintes. La procédure est vérifiée en comparant les valeurs numériques prédites de la résistance de pointe du cône avec les mesures expérimentales publiées d'essais en chambre de calibrage. La banque de données choisie comprend 59 essais en chambre de calibrage sur le sable de Ticino avec des valeurs différentes de densités, d'OCR, de contraintes et de conditions aux frontières. On présente aussi plusieurs applications de procédures de modélisation. Le programme d'ordinateur FLAC est utilisé pour réaliser l'analyse.

Mots clés : résistance à la pointe du cône, modélisation numérique, sable, chambre de calibrage; Mohr–Coulomb, contrainte horizontale in situ.

[Traduit par la Rédaction]

CPT در ماسه:
- ❖ مدلسازی
- ❖ صحت سنجی
- ❖ کاربرد

3. Recent Iranian Researches on CPT & Pile

Ahmadi and Robertson (2008)

Scientia Iranica, Vol. 15, No. 5, pp 541–553
© Sharif University of Technology, October 2008

SCIENTIA IRANICA

A Numerical Study of Chamber Size and Boundary Effects on CPT Tip Resistance in NC Sand

M.M. Ahmadi[1,*] and P.K. Robertson[2]

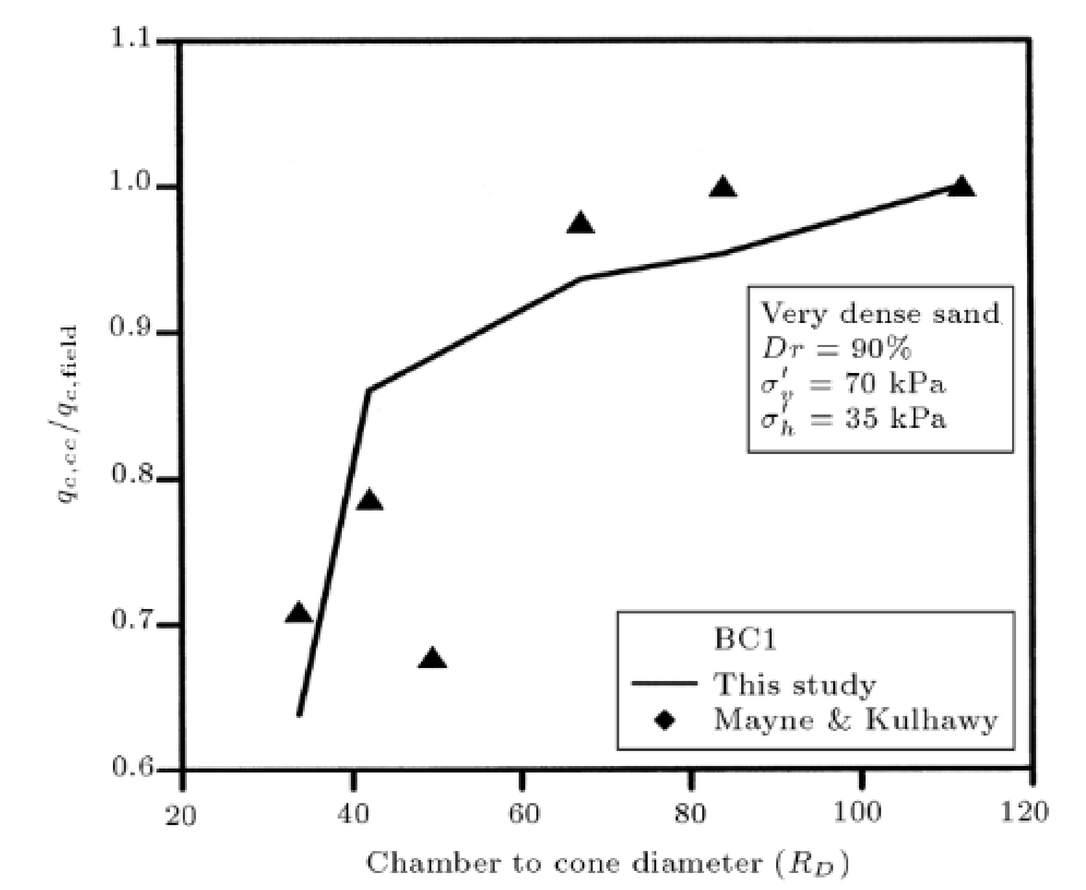
A numerical modeling procedure was used to quantify calibration chamber size and boundary effects for cone penetration testing in sand. In the numerical analyses, chamber diameter and boundary conditions were varied to investigate the effects of chamber size and boundary conditions on cone tip resistance. These analyses show that, for loose sand, a chamber-to-cone diameter ratio of 33 is sufficient for the boundaries to have no influence on the cone tip measurements. However, for very dense sand, the numerical analyses show that the chamber-to-cone diameter ratio should be more than 100 to ensure that boundaries have no influence on cone tip measurements. Numerical analysis indicates that, not only the sand relative density but its stress state is also a significant factor in influencing the chamber size effects. The results of the numerical analyses were compared to existing empirically based relationships. Suggestions are provided to reduce the effects of chamber size and boundaries on cone tip resistance measurements in sand.

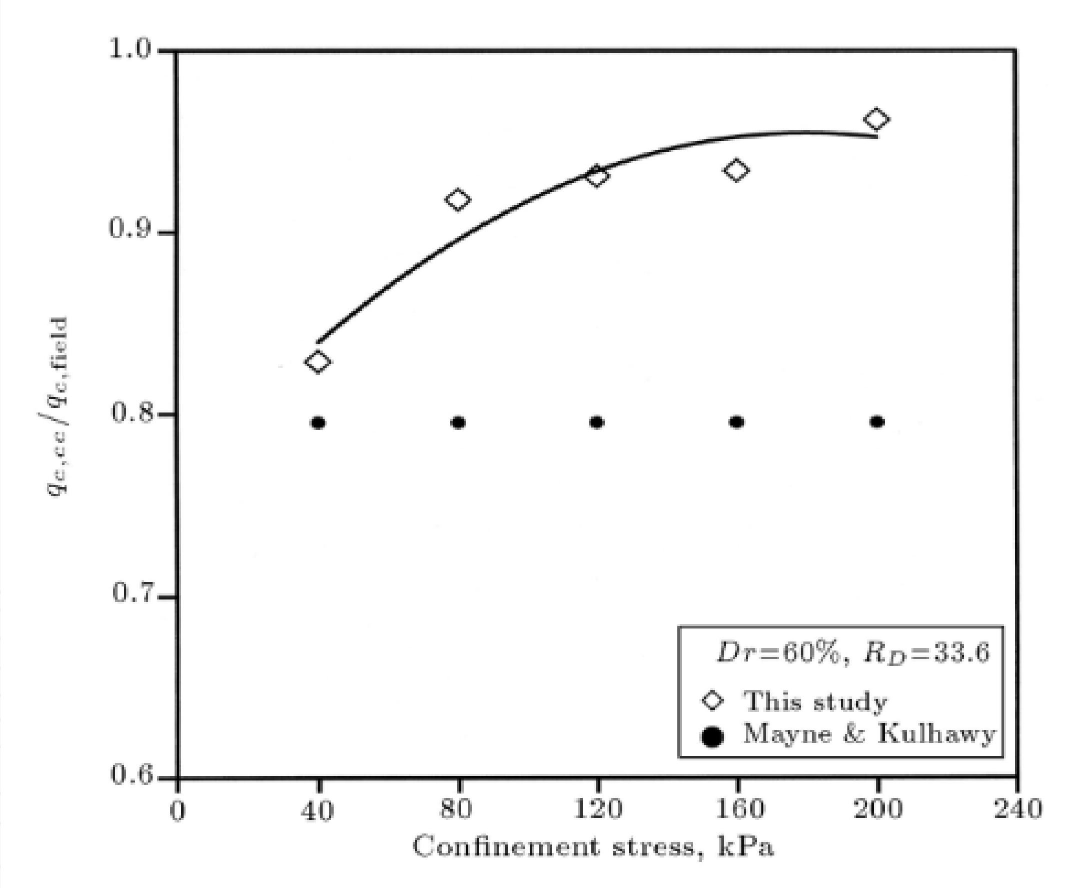
مطالعه عددی اثر شرایط مرزی و سایز محفظه کالیبراسیون بر نتایج CPT

3. Recent Iranian Researches on CPT & Pile

Ahmadi and Robertson (2008)

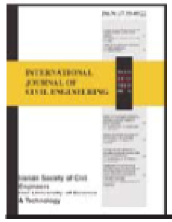
مطالعه عددی اثر شرایط مرزی و سایز محفظه بر نتایج CPT





3. Recent Iranian Researches on CPT & Pile

Eslami, Tajvidi & Karimpour Fard (2013)



International Journal of Civil Engineering

Geotechnical Engineering

Efficiency of methods for determining pile axial capacity-applied to 70 cases histories in Persian Gulf northern shore

A. Eslami[1,*], I. Tajvidi[2], M. Karimpour-Fard[3]

Received: July 2012, Revised: December 2012, Accepted: January 2013

Abstract

Three common approaches to determine the axial pile capacity based on static analysis and in-situ tests are presented, compared and evaluated. The Unified Pile Design (UPD), American Petroleum Institute (API) and a SPT based methods were chosen to be validated. The API is a common method to estimate the axial bearing capacity of piles in marine environments, where as the others are currently used by geotechnical engineers. Seventy pile load test records performed in the northern bank of Persian Gulf with SPT profile have been compiled for methods evaluation. In all cases, pile capacities were measured using full scale static compression and/or pull out loading tests. As the loading tests in some cases were in the format of proof test without reaching the plunging or ultimate bearing capacity, for interpretation the results, offset limit load criteria was employed. Three statistical and probability based approaches in the form of a systematic ranking, called Rank Index, RI, were utilized to evaluate the performance of predictive methods. Wasted Capacity Index (WCI) concept was also applied to validate the efficiency of current methods. The evaluations revealed that among these three predictive methods, the UPD is more accurate and cost effective than the others.

Keywords: *Pile, Axial Bearing Capacity, Full scale load test, Predictive methods efficiency, Wasted capacity index (WCI).*

کارایی روش های تعیین ظرفیت باربری با استفاده از موارد عملی در ناحیه شمالی خلیج فارس (WCI)

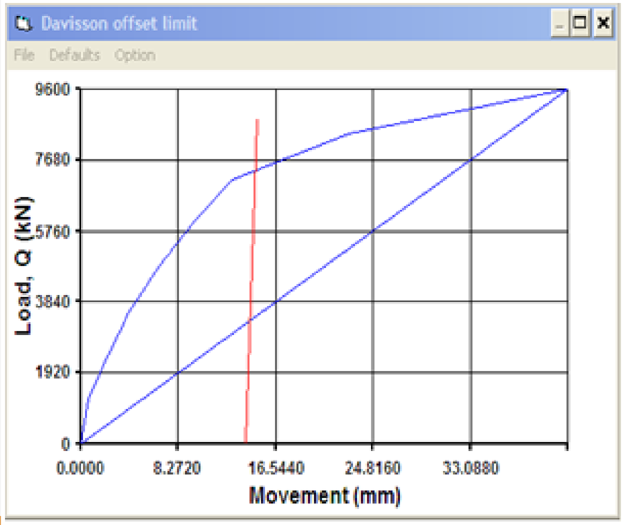
3. Recent Iranian Researches on CPT & Pile

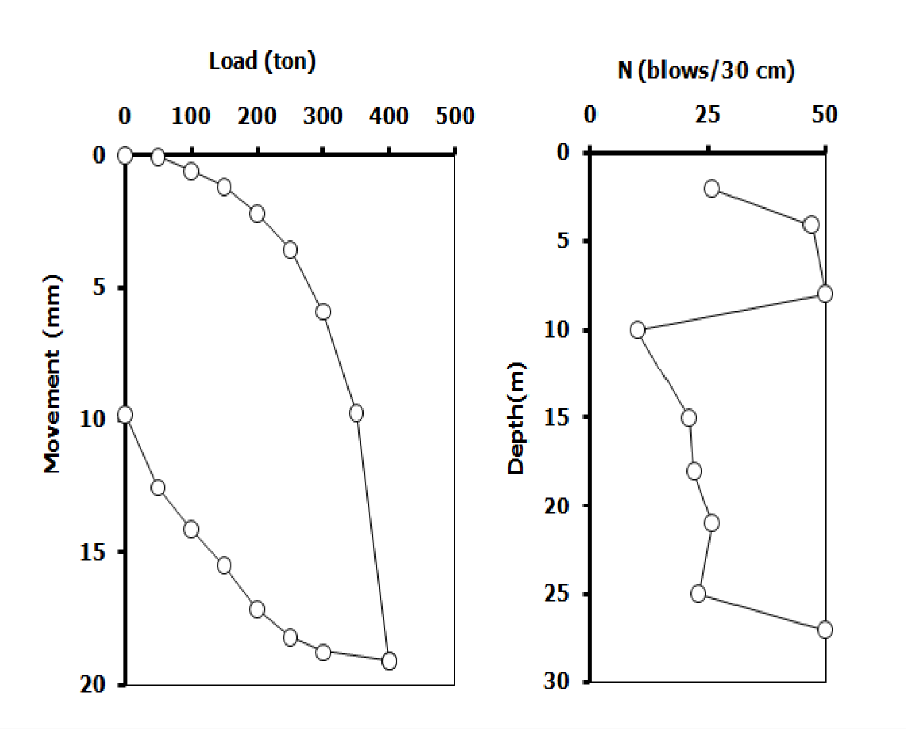
Eslami, Tajvidi & Karimpour Fard (2013)

کارایی روش های تعیین ظرفیت باربری با استفاده از مـوارد عملـی در ناحیـه شمالی خلیج فارس (WCI)

The location of research sites

Typical output of UNITEST software





Typical case pile load test and SPT test result in Khalij-e Fars Ship Yard project

3. Recent Iranian Researches on CPT & Pile

Eslami, Aflaki & Hosseini (2008-2011)

SCIENTIA IRANICA

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Scientia Iranica
Transactions A: Civil Engineering
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Evaluating CPT and CPTu based pile bearing capacity estimation methods using Urmiyeh Lake Causeway piling records

A. Eslami [a], E. Aflaki [a,*], B. Hosseini [b]

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[b] *Department of Geotechnics Civil Engineering, Islamic Azad University-Sofian Branch, Iran*

Received 23 May 2010; revised 1 June 2011; accepted 21 August 2011

KEYWORDS
Pile bearing capacity;
CPT and CPTu methods;
Dynamic testing;
Urmiyeh Lake Causeway.

Abstract Urmiyeh Lake is the largest super salt water situated in the north-west of Iran. A causeway embankment has been constructed in the narrowest part of the lake from both sides about 13.5 km, in order to connect two provincial capital cities of Tabriz and Urmiyeh of eastern and western Azerbaijan provinces to Europe through Turkey, while a 1280 m opening in between linked up by a bridge. Based on soil classification methods, utilizing CPTu data and soil sampling, the lake sediments consist of 150 m of soft and very sensitive clay. In order to evaluate the bearing capacity of driven piles of the bridge, eight long steel piles with diameters of 813 and 66 m and lengths of 75 m have been instrumented and monitored based on static and dynamic load testing program. Piezocone (CPTu) results are also available from adjacent pile locations. Results of pile capacity calculation based on direct CPT and CPTu methods demonstrate that reasonable accuracy can be achieved in reference to dynamic testing. Therefore, combination of CPTu data with dynamic testing results can be considered by engineers for predicting bearing capacity of piles in offshore and bridge structures, where the static pile load testing is difficult, time consuming and expensive in marine environment.

ارزیابی ظرفیت باربری شمع های پل میانگذر دریاچه ارومیه با استفاده از نتایج CPTu

CPTu the major source of subsoil data in this project.

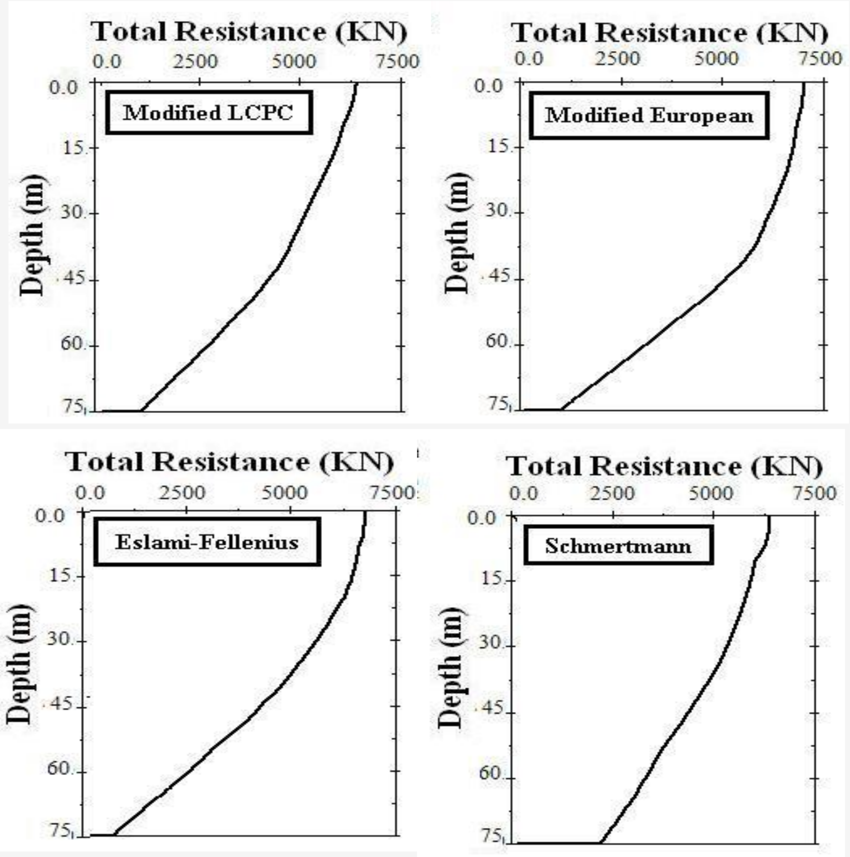
CPTu soundings were performed in 12 locations, down to 100 m below the lake-bed.

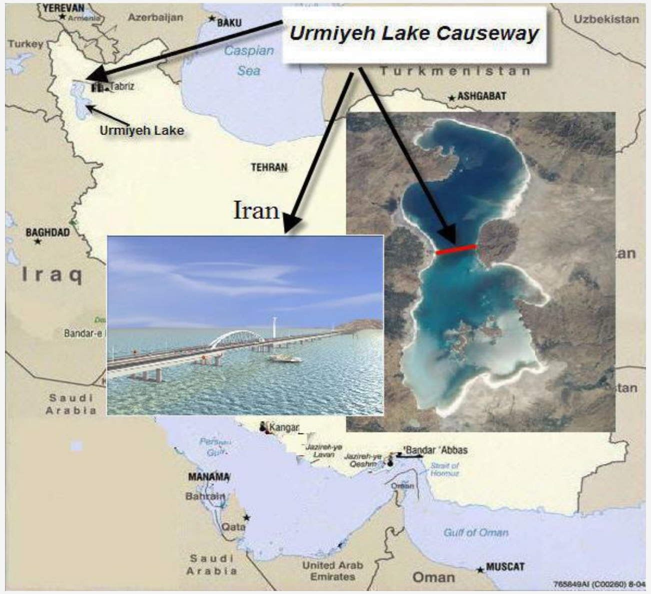
Super Soft Deposits

3. Recent Iranian Researches on CPT & Pile

Eslami, Aflaki & Hosseini (2008-2011)

ارزیابی ظرفیت بـاربری شـمع های پل میانگذر دریاچه ارومیه با استفاده از نتایج CPTu





3. Recent Iranian Researches on CPT & Pile

Asghari, Habibagahi, Ghahramani, Fakharian (2019)

International Journal of Civil Engineering
https://doi.org/10.1007/s40999-019-00443-0

RESEARCH PAPER

Check for updates

Reliability-Based Calibration of Resistance Factors in LRFD Method for Driven Pile Foundations on Inshore Regions of Iran

Seyed Ali Asghari Pari[1] · Ghassem Habibagahi[1] · Arsalan Ghahramani[1] · Kazem Fakharian[2]

Received: 21 January 2019 / Revised: 23 May 2019 / Accepted: 25 May 2019

Abstract
This paper presents the improvement of load and resistance factor design (LRFD) method for axially loaded driven piles in Iran. The LRFD method has been well developed and successfully implemented in geotechnical engineering, especially in the design of pile foundations in different parts of the world. To extend the use of this method in Iran, it is necessary to use the results of reliable local pile load tests and construction records to calibrate LRFD resistance factors regionally. To this end, we first collected a comprehensive database of static and dynamic load tests which have been performed on driven piles in fine-grained soils across Iran. Based on this database, we calculated the resistance factors for different design methods using three different methods of reliability analysis (FORM, FOSM, and MCS) and for two levels of reliability ($\beta_T = 2.33$ and 3). Finally, we used these calculations together with experience and engineering judgment to propose resistance factors for the National Building Code of Iran.

Keywords LRFD · Code calibration · Reliability analysis · Pile foundation design

کالیبراسیون ضرایب مقاومت به روش LRFD؛ شمع‌های کوبشی نواحی ساحلی ایران

3. Recent Iranian Researches on CPT & Pile

Fakharian & Khanmohammadi (2018)

Comparison of Pile Bearing Capacity from CPT and Dynamic Load Tests in Clay Considering Soil Setup

K. Fakharian, M.R. Khanmohammadi
Amirkabir University of Technology, Tehran, Iran

ABSTRACT: The CPT direct methods are vastly used to estimate the pile tip and shaft resistances in many piling projects. In driven piles embedded in clay, "soil setup" phenomenon is understood to be contributing to increase the pile bearing capacity and in particular the shaft resistance component with time. Considering "time effects" on pile shaft resistance, the question arises that how accurately CPT-based methods could estimate the bearing capacity of piles? The main objective of this paper is to compare the CPT capacity predictions with those resulted from pile Dynamic Load Tests (DLT) at End-Of-Drive (EOD) and Beginning-Of-Restrike (BOR) as well as Static Load Tests (SLT). The focus of this study has been on the field results of four "test piles" driven in North Azadegan Oilfield in Khuzestan Province, Iran. The test results show that almost all CPT-based methods have ended up in higher capacity predictions compared to EOD capacities, but generally lower than the BOR capacities. The findings of the study are useful in engineering application of offshore piling in clay deposits in which the time constraints of construction does not allow performance of dynamic load tests at different time steps. Also, setting up static load test is not feasible in such environments to measure the setup effects.

ظرفیت باربری شمع با استفاده از CPT و آزمایش بارگذاری دینامیکی در رس با لحاظ اثر گیرش خاک

3. Recent Iranian Researches on CPT & Pile

Baziar, Kashkooli, Saeedi Azizkandi (2012)

Computers and Geotechnics 45 (2012) 74–82

Contents lists available at SciVerse ScienceDirect

Computers and Geotechnics

journal homepage: www.elsevier.com/locate/compgeo

ELSEVIER

Prediction of pile shaft resistance using cone penetration tests (CPTs)

Mohammad Hassan Baziar [a,*], Armin Kashkooli [b], Alireza Saeedi-Azizkandi [b]

[a] Center of Excellence for Fundamental Studies in Structural Engineering, School of Civil Engineering, Iran University of Science and Technology, Tehran, Iran
[b] School of Civil Engineering, Iran University of Science and Technology, Tehran, Iran

A R T I C L E   I N F O

Article history:
Received 12 September 2011
Received in revised form 5 March 2012
Accepted 17 April 2012
Available online 1 June 2012

Keywords:
Pile shaft resistance
Neural network
Non-linear multi regression
Cone penetration test

A B S T R A C T

Accurately predicting pile shaft resistance when designing pile foundations is necessary for ensuring appropriate structural and serviceability performance. The scope of this research includes four main components: (I) compiling shaft resistance datasets obtained from the published literature; (II) developing two artificial neural network (ANN) and non-linear multi regression models for predicting pile shaft resistance using cone penetration test (CPT) results; (III) investigating the influence of input parameters on the resulting shaft friction and their degrees of importance; and (IV) assessing the relative accuracies of the presented models using a number of traditional methods. It is quantitatively demonstrated that the ANN and non-linear multiple regression models proposed in the current study out perform the traditional methods and can be used by engineers to accurately predict pile shaft resistance.

تخمین ظرفیت باربری جداری شمع با استفاده از CPT

3. Recent Iranian Researches on CPT & Pile

Saeedi Azizkandi, Kashkooli & Baziar (2014)

Geotech Geol Eng (2014) 32:1043–1052
DOI 10.1007/s10706-014-9779-y

ORIGINAL PAPER

Prediction of Uplift Pile Displacement Based on Cone Penetration Tests (CPT)

A. Saeedi Azizkandi · A. Kashkooli ·
M. H. Baziar

Received: 8 April 2012 / Accepted: 17 May 2014 / Published online: 25 May 2014

Abstract Accurate prediction of uplift pile displacement is necessary to ensure appropriate structural and serviceability performance of civil projects. On the other hand, in recent years, machine-learning models have been applied to many geotechnical-engineering problems, with some degrees of success. The scope of this research includes three main stages: (1) the compilation of load–displacement data sets, obtained from the published literature, (2) analysis of machine learning models that predict the uplift pile displacement based on the cone penetration test data, and the relative importance of input parameters that have been evaluated using senility analysis by the artificial neural network, In addition, this paper also examines the different selection of input parameters and internal network parameters to obtain the optimum model, (3) A parametric study has also been performed for the input parameters to study the consistency of the suggested model. The statistical parameters and parametric study obtained in this research show the superiority of the current model. It is demonstrated that machine learning models such as ANN and GP models outperform the traditional methods, and provide accurate uplift pile displacement predictions.

Keywords Uplift pile · Displacement · Cone penetration tests · Artificial neural network (ANN) · Genetic programming (GP)

1 Introduction

Pile foundations are used to transmit the superstructure load to deeper strata, when the subsurface soil is of inadequate strength. Pile foundations are often subjected to axial and lateral loads. Under the action of lateral loads and moments, some of the piles in a group, may experience uplift displacement. In compressive loading, the tip resistance of piles plays a major role in pile capacity. In contrast to the compressive loading situation, the shaft resistance capacity alone works against the piles uplift force. On the other the hand, the tensile strength of soil is quite small in comparison to its shear strength and it can be

تخمین جابجایی شمع تحت بـــار کششی با استفاده از CPT

3. Recent Iranian Researches on CPT & Pile

CPT & Pile Databases
By: Eslami & Moshfeghi

Ebrahimian & Movahed (2016)

Ships and Offshore Structures, 2016
http://dx.doi.org/10.1080/17445302.2015.1116243

Taylor & Francis
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Application of an evolutionary-based approach in evaluating pile bearing capacity using CPT results

Babak Ebrahimian[a,b,*,†] and Vahid Movahed[c]

[a]*Faculty of Civil, Water and Environmental Engineering, Abbaspour School of Engineering, Shahid Beheshti University (SBU), Tehran, Iran;* [b]*The Highest Prestigious Scientific and Professional National Foundation, Iran's National Elites Foundation (INEF), Tehran, Iran;* [c]*School of Civil Engineering, Iran University of Science and Technology, Tehran, Iran*

(*Received 3 November 2014; accepted 31 October 2015*)

Predicting ultimate axial bearing capacity of pile foundations is an important and complicated problem in geotechnical engineering. Cone penetration test (CPT) is a reliable *in situ* test widely used in the analysis and design of pile foundations. In this study, new CPT-based axial pile bearing capacity models are presented for both cohesionless and cohesive soils using evolutionary polynomial regression (EPR), a branch of evolutionary approaches. A relatively comprehensive database is gathered and divided into training and testing sub-sets to avoid over-fitting. This database includes both coarse and fine grain soils, cone tip resistance and sleeve friction of CPTs, geometry and bearing capacity of piles. The presented models are compared to some previously published ones and their preferences are demonstrated statistically and probabilistically. Proper applicability of the models in predicting axial pile bearing capacity is then confirmed by field verification, compared to analytical and empirical models available in the literature.

Keywords: pile foundation; bearing capacity; cone penetration test; evolutionary polynomial regression; statistical analysis

روش EPR در ارزیـــــابی ظرفیت بـــاربری شـــمع بـــا استفاده از CPT

3. Recent Iranian Researches on CPT & Pile

Ardalan, Eslami & Nariman-Zadeh (2008)

Contents lists available at ScienceDirect

Computers and Geotechnics

journal homepage: www.elsevier.com/locate/compgeo

Piles shaft capacity from CPT and CPTu data by polynomial neural networks and genetic algorithms

H. Ardalan [a], A. Eslami [b,*], N. Nariman-Zadeh [c]

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[b] Department of Civil Engineering, Amirkabir University of Technology, University of Guilan, Hafez street, No. 424, Tehran, Tehran 15875-4413, Iran
[c] Department of Mechanical Engineering, Faculty of Engineering, University of Guilan, Iran

A R T I C L E   I N F O

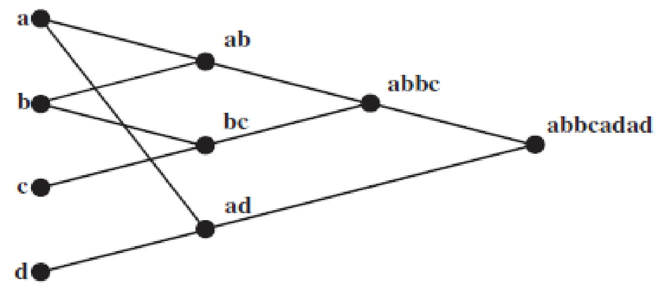
Article history:
Received 14 May 2008
Received in revised form 16 September 2008
Accepted 16 September 2008
Available online 4 November 2008

Keywords:
Pile shaft capacity
Cone penetration test (CPT)
Piezocone (CPTu)
Neural networks
GMDH
Genetic algorithm

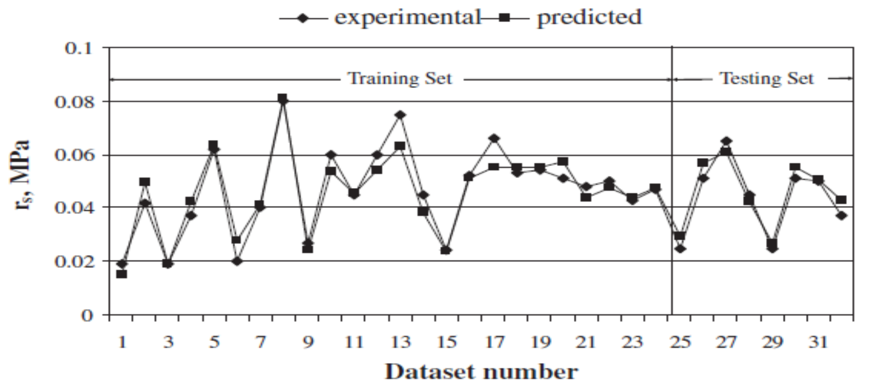
A B S T R A C T

Cone penetration test (CPT) is one of the most common in situ tests which is used for pile design because it can be realized as a model pile. The measured cone resistance (q_c) and sleeve friction (f_s) usually are employed for estimation of pile unit toe and shaft resistances, respectively. Thirty three pile case histories have been compiled including static loading tests performed in uplift, or in push with separation of shaft and toe resistances at sites which comprise CPT or CPTu sounding. Group method of data handling (GMDH) type neural networks optimized using genetic algorithms (GAs) are used to model the effects of effective cone point resistance (q_E) and cone sleeve friction (f_s) as input parameters on pile unit shaft resistance, applying some experimentally obtained training and test data. Sensitivity analysis of the obtained model has been carried out to study the influence of input parameters on model output. Some graphs have been derived from sensitivity analysis to estimate pile unit shaft resistance based on q_E and f_s. The performance of the proposed method has been compared with the other CPT and CPTu direct methods and referenced to measured piles shaft capacity. The results demonstrate that appreciable improvement in prediction of pile shaft capacity has been achieved.

ظرفیت باربری جداری شمع‌ها؛ CPT و GMDH



A generalized GMDH network structure of chromosome.



Experimental and predicted unit shaft capacities

3. Recent Iranian Researches on CPT & Pile

CPT & Pile Databases
By: Eslami & Moshfeghi

Veiskarami, Eslami & Kumar (2010- 2011)

ظرفیت باربری کف شمع کوبشی در ماسه با استفاده از روش مشخصه تنش

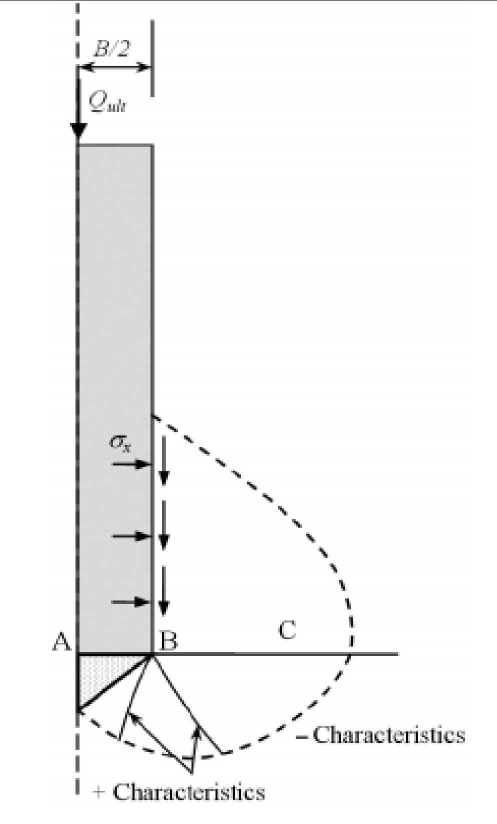
1570

End-bearing capacity of driven piles in sand using the stress characteristics method: analysis and implementation

Mehdi Veiskarami, Abolfazl Eslami, and Jyant Kumar

Abstract: The method of stress characteristics has been employed to compute the end-bearing capacity of driven piles. The dependency of the soil internal friction angle on the stress level has been incorporated to achieve more realistic predictions for the end-bearing capacity of piles. The validity of the assumption of the superposition principle while using the bearing capacity equation based on soil plasticity concepts, when applied to deep foundations, has been examined. Fourteen pile case histories were compiled with cone penetration tests (CPT) performed in the vicinity of different pile locations. The end-bearing capacity of the piles was computed using different methods, namely, static analysis, effective stress approach, direct CPT, and the proposed approach. The comparison between predictions made by different methods and measured records shows that the stress-level-based method of stress characteristics compares better with experimental data. Finally, the end-bearing capacity of driven piles in sand was expressed in terms of a general expression with the addition of a new factor that accounts for different factors contributing to the bearing capacity. The influence of the soil nonassociative flow rule has also been included to achieve more realistic results.

Key words: bearing capacity, cone penetration tests, failure, friction angles, piles, plasticity.



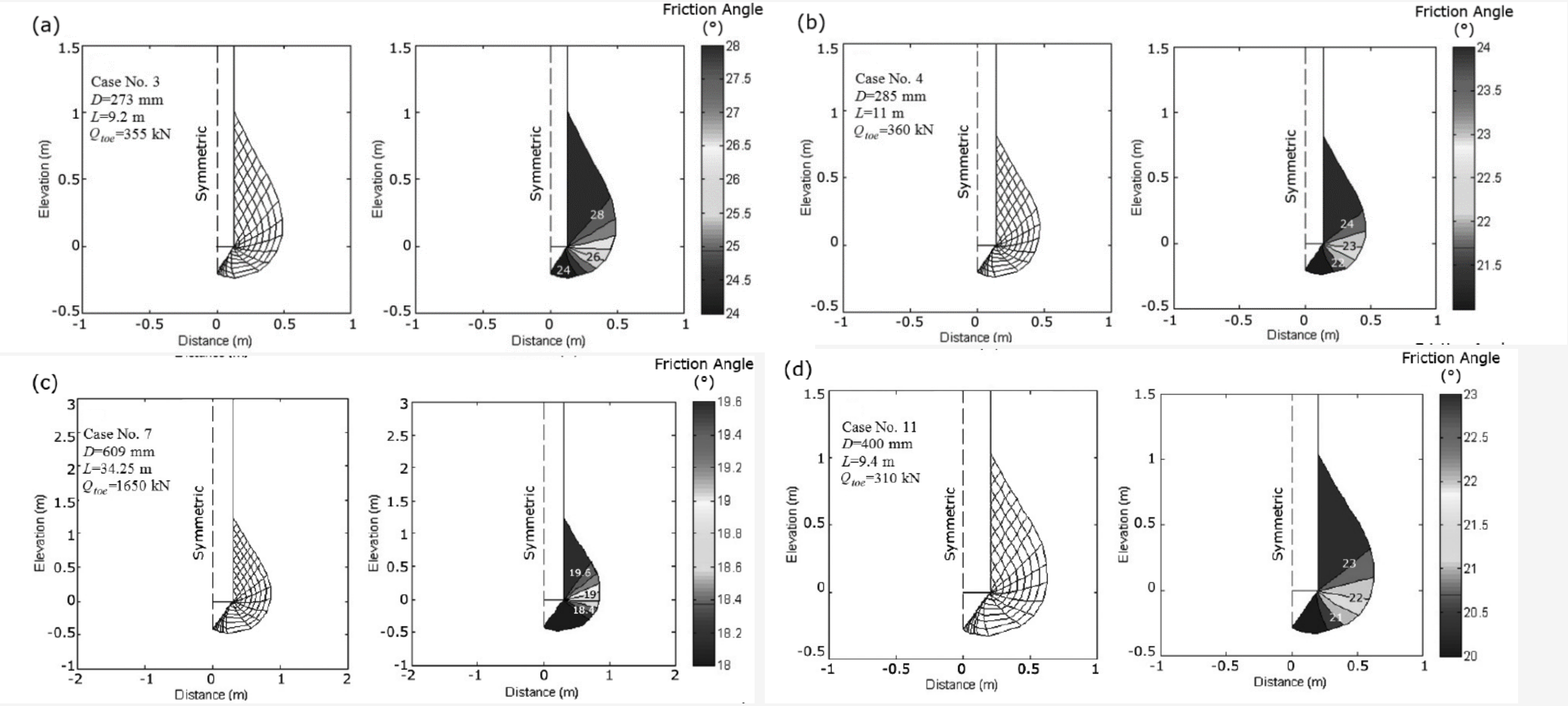
Boundary conditions of Bolton and Lau (1993) with a straight rigid cone

CPT & Pile Databases
By: Eslami & Moshfeghi

3. Recent Iranian Researches on CPT & Pile

Veiskarami, Eslami & Kumar (2010- 2011)

ظرفیت باربری کف شمع کوبشی در ماسه با استفاده از روش مشخصه تنش



Stress characteristics and variation of soil friction angle at failure

3. Recent Iranian Researches on CPT & Pile

Eslami & Mohammadi (2016)

Ships and Offshore Structures, 2016
http://dx.doi.org/10.1080/17445302.2015.1131082

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Drained soil shear strength parameters from CPTu data for marine deposits by analytical model

A. Eslami[a,*] and A. Mohammadi[b]

[a] *Department of Civil Engineering, Amirkabir University of Technology, Tehran, Iran;* [b] *M.Sc. of Geotechnical Engineering, Amirkabir University, Tehran, Iran*

(*Received 11 January 2015; accepted 8 December 2015*)

Soil shear strength parameters, i.e. cohesion (C) and friction angle (φ) are typically determined using laboratory and *in situ* tests, although some limitations are involved in laboratory tests, such as the need for considering size effects and the use of undisturbed sampling. Cone penetration testing (CPT) has been recognised as a rapid and versatile procedure to provide continuous soil records, particularly in marine environment. In this study, an analytical approach is utilised to calculate drained soil strength parameters using piezocone penetration test (CPTu) records, i.e. q_t (corrected point resistance) and f_s (sleeve friction) and the results are compared with those obtained from laboratory tests. Current methods for obtaining shear strength parameters using CPT data are based on bearing capacity and cavity expansion theories and are able to estimate only φ in sands, and undrained shear strength (S_u) in cohesive soils. In this paper, by combining bearing capacity theories and direct shear modes of failure at CPTu tip and sleeve resistances, and considering the pore water pressure at the shoulder of the piezocone (u_2), a set of equations is derived. By inputting CPTu data including q_t, f_s and u_2 at a certain depth, soil shear strength parameters can be calculated simultaneously. Finally results obtained from this method are compared with measured soil shear strength parameters, using a data bank consisting of 50 sets of CPTu sounding carried out in marine deposits at various locations around the world. The comparison between predicted and measured C and φ values indicates good consistency and low scatter for the results obtain from the proposed method. This demonstrates that the proposed method is able to predict soil shear strength parameters in difficult marine environments with acceptable accuracy.

Keywords: shear strength parameters; CPTu; marine deposits; analytical approach

پارامترهای مقاومت برشی زهکشی شده خاک؛ با استفاده از کوردهــای CPTu در نهشته های دریایی

3. Recent Iranian Researches on CPT & Pile

Eslami & Mohammadi (2016)

**پارامترهای مقاومت برشی زهکشی شده خاک ؛
با استفاده از رکوردهای CPTu در نهشته های دریایی**

Input Data → **Output**

q_c, f_s, u_2 → C' , ϕ'

$$\begin{cases} C + 0.000789(1-\sin\phi)\sigma'_{v_0}\tan\left(\frac{2}{3}\phi\right)\left[\frac{q_c - \left(\frac{\sigma_{v_0} - 2\sigma_{h_0}}{3}\right)}{\left(\frac{\sigma'_{v_0} - 2\sigma'_{h_0}}{3}\right)}\right]^{1.44} = f_s \\ \left(\tan^2\left(\frac{\pi}{4}+\frac{\phi}{2}\right)e^{\pi\tan\phi} - 1\right)C\cot\phi + \bar{q}.\tan^2\left(\frac{\pi}{4}+\frac{\phi}{2}\right)e^{\pi\tan\phi} + \\ \gamma B\left[\tan^2\left(\frac{\pi}{4}+\frac{\phi}{2}\right)e^{\pi\tan\phi}+1\right]\tan\phi = q_E + N_u\Delta U \end{cases}$$

3. Recent Iranian Researches on CPT & Pile

Fateh, Eslami & Fahimifar (2015)

ظرفیت باربری شمع های پیچشی پره ای با استفاده از نتایج CPT

MARINE GEORESOURCES & GEOTECHNOLOGY
http://dx.doi.org/10.1080/1064119X.2015.1133741
Taylor & Francis
Taylor & Francis Group

Direct CPT and CPTu methods for determining bearing capacity of helical piles

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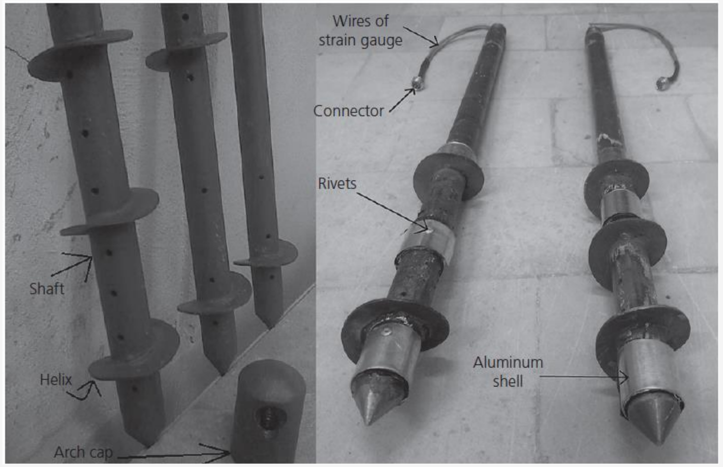
Department of Civil and Environmental Engineering, Amirkabir University of Technology (AUT), Tehran, Iran

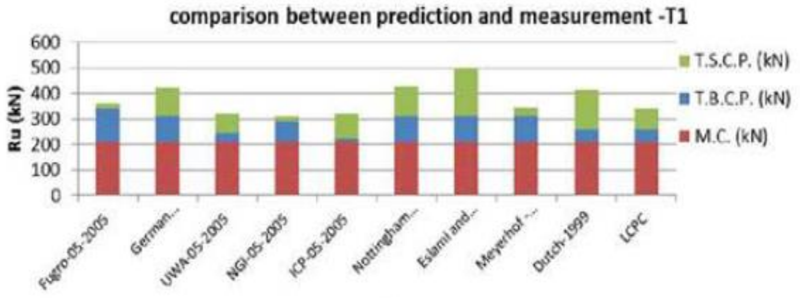
ABSTRACT

Helical piles are structural deep foundation elements, which can be categorized as torque-driven piles without any limitations to implement in marine situations. Different methods are used to predict the axial capacity of helical piles, such as static analysis, but have some limitation for this type of piles on marine conditions. In situ testing methods as supplement of static analysis have been rarely used for helical piles. In geotechnical engineering practice, the most common in situ tests particularly applicable for coastal or offshore site investigation are cone penetration test (CPT) and piezocone penetration test (CPTu). The CPT is simple, repeatable, and prepares the continuous records of soil layers. In this paper, a data bank has been compiled by collecting the results of static pile load tests on thirty-seven helical piles in ten different sites including CPT or CPTu data. Axial capacities of thirty-seven helical piles in different sites were predicted by direct CPT methods and static analysis. Accuracy estimation of ten direct CPT methods to predict the axial capacity of helical piles was investigated in this study. Comparisons have been made among predicted values and measured capacity from the pile load tests. Results indicated that the recently developed methods such as NGI-05 (2005), ICP-05 (2005), and UWA-05 (2005) predicted axial capacity of helical piles more accurately than the other methods such as Meyerhof (1983), Schmertmann (1978), Dutch (1979), LCPC (1982), or Unicone (1997). However, more investigations are required to establish better correlation between CPT data and axial capacity of helical piles.

ARTICLE HISTORY
Received 28 September 2015 Accepted 15 December 2015

KEYWORDS
Bearing capacity; direct CPT and CPTu methods; helical pile; pile load test; static analysis



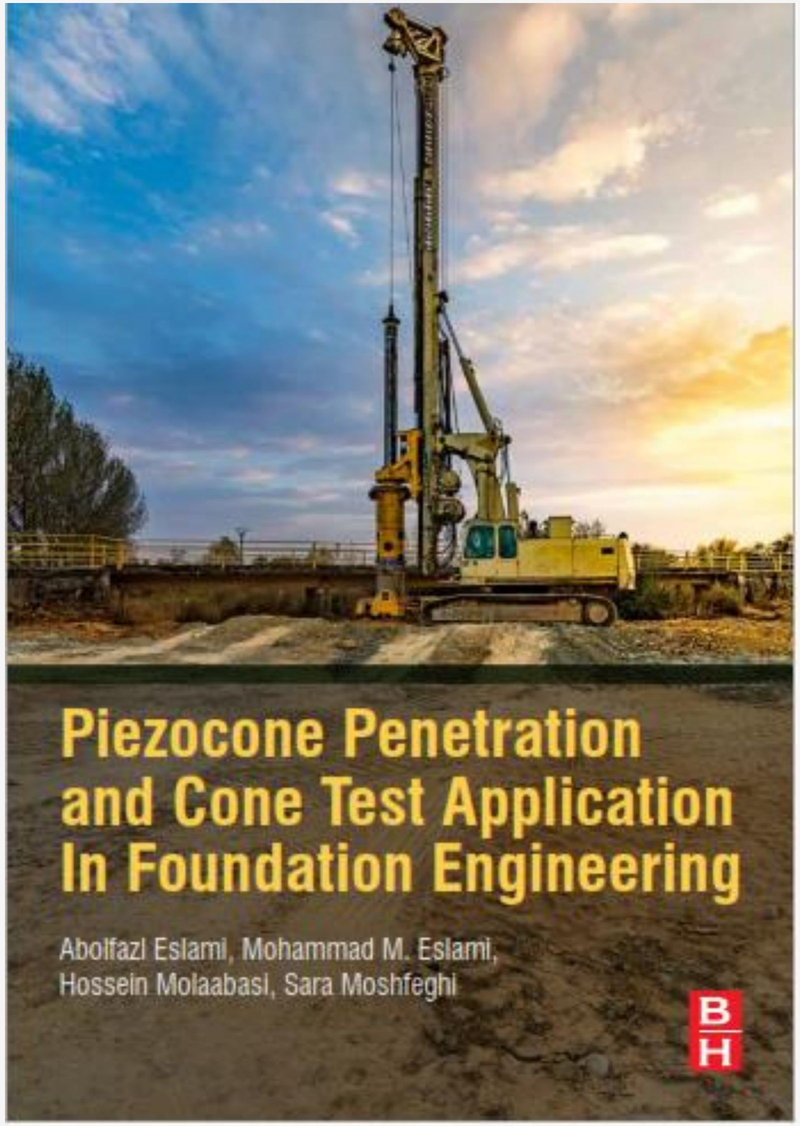


3. Recent Iranian Researches on CPT & Pile

Eslami, Moshfeghi, Mollabasi & Eslami M. (2019)

Piezocone and Cone Penetration Test Applications in Foundation Engineering

Ch. 1: Geotechnical Engineering
Ch. 2: Foundation Engineering
Ch. 3: CPT Records and Performance
Ch. 4: Geotechnical Parameters from CPT Records
Ch. 5: Soil Behavior Classification (SBC) Using CPT and CPTu Records
Ch. 6: Scale Effect and CPTu Applications for Shallow Foundations
Ch. 7: CPT & CPTu Applications for Deep Foundation Bearing Capacity
Ch. 8: CPT & CPTu: Settlement Estimation
Ch. 9: Soil improvement
Ch. 10: GMDH and Soft Computing
Ch. 11: Uncertainty and Reliability Based Approaches
Ch. 12: Case Histories and Database



4. Overview of Some CPT & Pile Databases

Databases

- **Databases are collections of data which are organized in order to facilitate access and retrieving data when they are needed.**
- **Examples of Databases in Geotechnical Engineering:**
  1. Pile loading test
  2. Pile loading test under lateral load
  3. Retaining walls and displacement due to deep excavation
  4. In-situ tests
  5. Specifications of geotechnical boreholes
  6. Settlement of shallow foundations

پایگاه داده یا بانک اطلاعاتی: مجموعه‌ای از داده‌های سازمان دهی شده به نحــوی که در مواقع نیاز به آسانی در دسترس، مورد بازیابی و شبیه‌سازی قرار گیرند.

4. Overview of Some CPT & Pile Databases

Databases

Advantages and Applications:

I. Cost saving and project execution time
II. Optimization of design methods
III. Evaluation of design methods
IV. Development of new methods
V. Improvement of geotechnical studies

بانک‌های اطلاعاتی ابزارهای کارایی در طراحی، تحلیل، توسعه و ارزیابی روش‌های تخمین ظرفیت باربری هستند.

4. Overview of Some CPT & Pile Databases

Berkeley Liquefaction Investigation

- ❑ **Records of earthquakes:**
  - ✓ Adapazari (1999) in Turkey
  - ✓ Chi Chi (1999) in Taiwan
- ❑ **Records of CPT and SPT**
- ❑ **Investigation of liquefied soils during earthquake**

peer.berkeley.edu/publications/turkey/adapazari/phase2/index.html

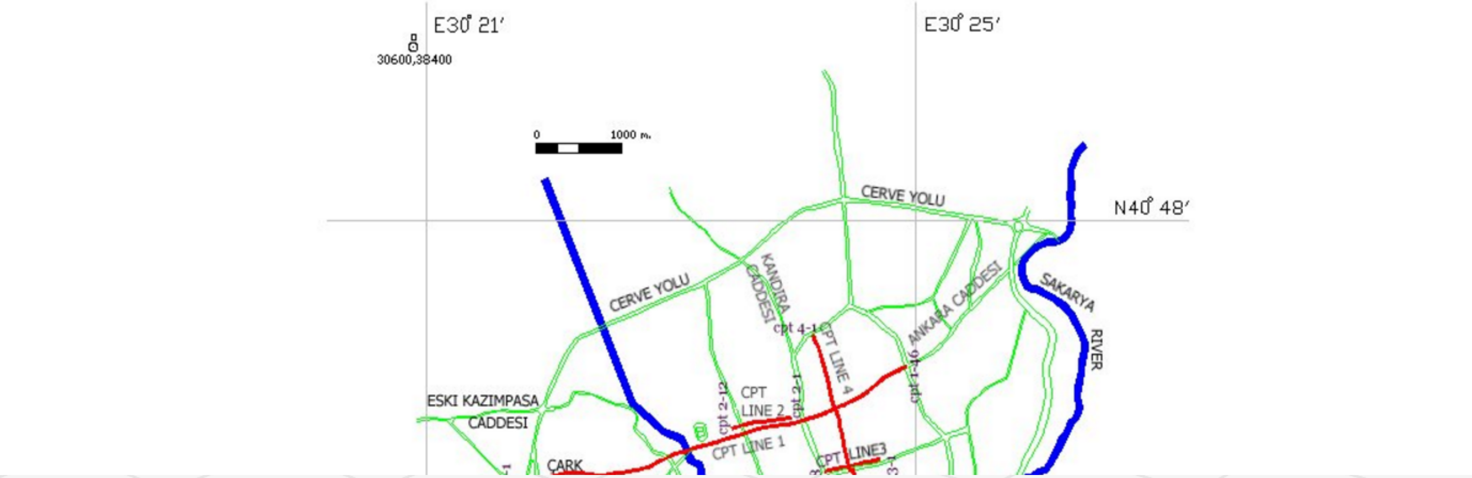
CPT Liquefaction Investigations, Adapazari, Turkey

Summary of In-Situ Tests Performed along Surveyed Lines
(see location on map below)

Line Name	Number of Soundings	Number of Borings
Line 1	46	7
Line 2	12	2
Line 3	8	2
Line 4	24	3

Description of In Situ Testing Procedures

Adapazari City Map



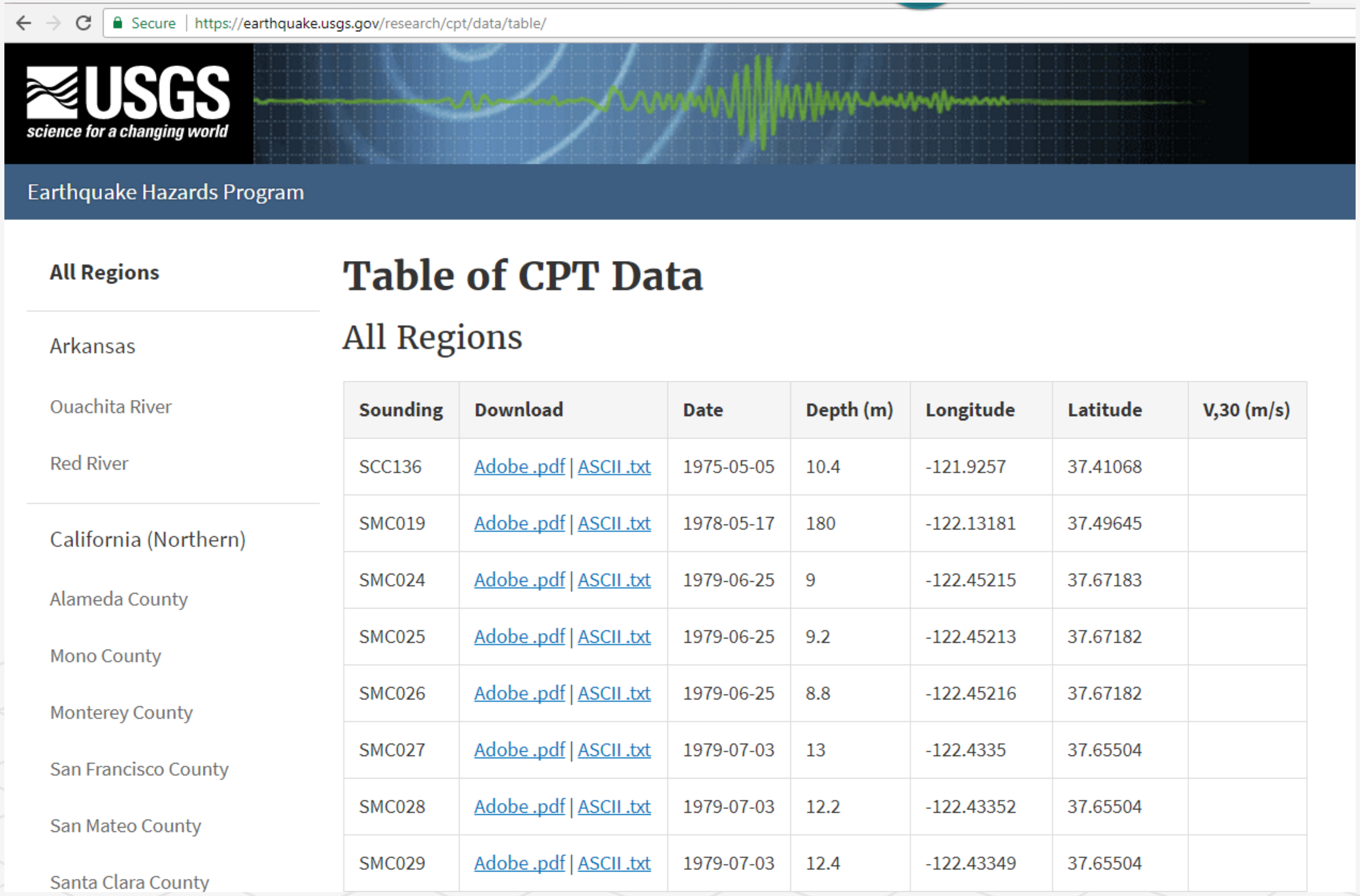
4. Overview of Some CPT & Pile Databases

USGS Earthquake Hazards Program

CPT records performed all over the North America

1500+ tests carried out from 1979 to 2011

Seismic investigation and soil liquefaction assessment

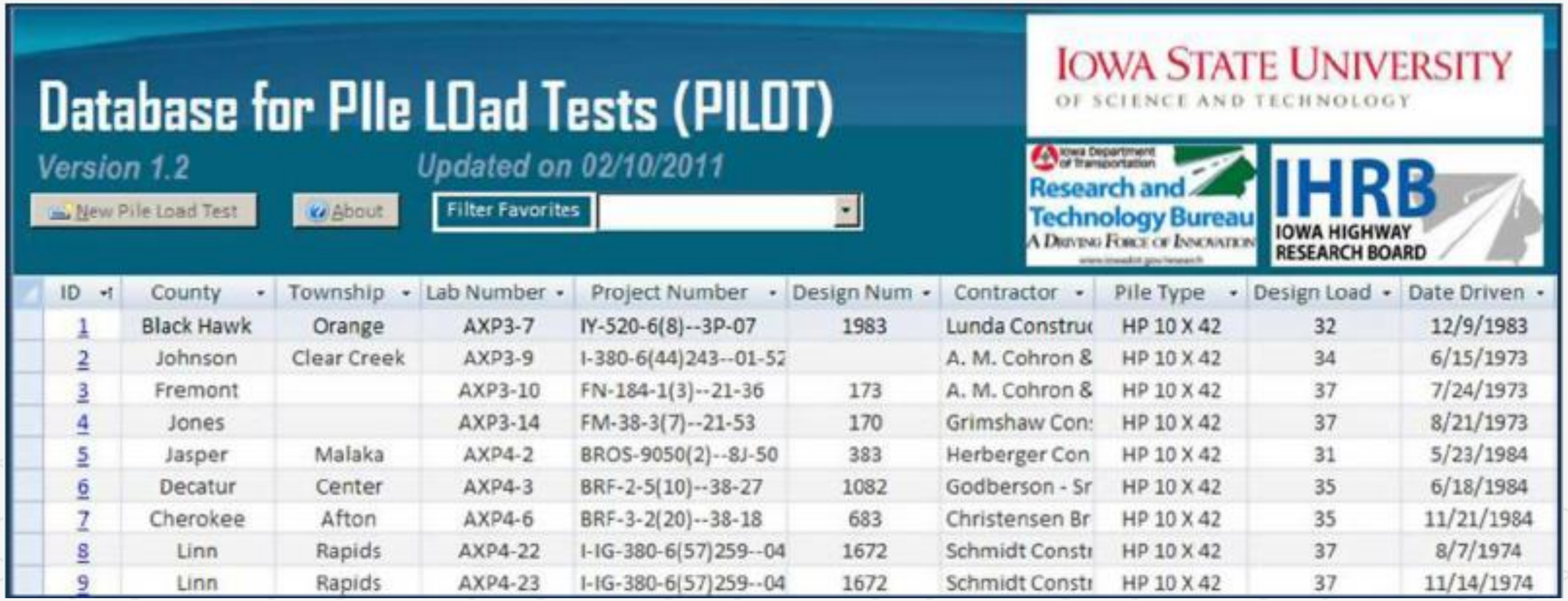


Sounding	Download	Date	Depth (m)	Longitude	Latitude	V,30 (m/s)
SCC136	Adobe .pdf | ASCII .txt	1975-05-05	10.4	-121.9257	37.41068	
SMC019	Adobe .pdf | ASCII .txt	1978-05-17	180	-122.13181	37.49645	
SMC024	Adobe .pdf | ASCII .txt	1979-06-25	9	-122.45215	37.67183	
SMC025	Adobe .pdf | ASCII .txt	1979-06-25	9.2	-122.45213	37.67182	
SMC026	Adobe .pdf | ASCII .txt	1979-06-25	8.8	-122.45216	37.67182	
SMC027	Adobe .pdf | ASCII .txt	1979-07-03	13	-122.4335	37.65504	
SMC028	Adobe .pdf | ASCII .txt	1979-07-03	12.2	-122.43352	37.65504	
SMC029	Adobe .pdf | ASCII .txt	1979-07-03	12.4	-122.43349	37.65504	

4. Overview of Some CPT & Pile Databases

Iowa State University Database-PILOT (Roling et al., 2011)

- ❑ Comprising both static and dynamic data for driven piles back to 1966
- ❑ 274 piles of various shapes driven within the state of Iowa
- ❑ Establishment of resistance factors for LRFD and a reliable construction-control method for driven piles



ID	County	Township	Lab Number	Project Number	Design Num	Contractor	Pile Type	Design Load	Date Driven
1	Black Hawk	Orange	AXP3-7	IY-520-6(8)--3P-07	1983	Lunda Construc	HP 10 X 42	32	12/9/1983
2	Johnson	Clear Creek	AXP3-9	I-380-6(44)243--01-52		A. M. Cohron &	HP 10 X 42	34	6/15/1973
3	Fremont		AXP3-10	FN-184-1(3)--21-36	173	A. M. Cohron &	HP 10 X 42	37	7/24/1973
4	Jones		AXP3-14	FM-38-3(7)--21-53	170	Grimshaw Con:	HP 10 X 42	37	8/21/1973
5	Jasper	Malaka	AXP4-2	BROS-9050(2)--8J-50	383	Herberger Con	HP 10 X 42	31	5/23/1984
6	Decatur	Center	AXP4-3	BRF-2-5(10)--38-27	1082	Godberson - Sr	HP 10 X 42	35	6/18/1984
7	Cherokee	Afton	AXP4-6	BRF-3-2(20)--38-18	683	Christensen Br	HP 10 X 42	35	11/21/1984
8	Linn	Rapids	AXP4-22	I-IG-380-6(57)259--04	1672	Schmidt Constı	HP 10 X 42	37	8/7/1974
9	Linn	Rapids	AXP4-23	I-IG-380-6(57)259--04	1672	Schmidt Constı	HP 10 X 42	37	11/14/1974

CPT & Pile Databases
By: Eslami & Moshfeghi

4. Overview of Some CPT & Pile Databases

Driven Pile Ground Vibration Case History (Hajduk et al., 2009)

- ❑ An important first step towards future examining of the environmental effects of pile driving on adjacent structures and residents

- ❑ Incorporates available data from the technical literature and data provided by professionals within the pile driving industry

Case No.[1]	Location	Pile Size	Hammer Type	Hammer	Data Points
1	Charleston, SC	HP305x79 (HP12x53)	Hydraulic	ICE 75	203
		30.5cm (12in) OEP	Hydraulic	ICE 75	7
2	Charleston, SC	30.5cm (12in) PSC	Hydraulic	ICE 75	396
3	Sullivan's Is., SC	20.3cm (8in) Timber	Air	Vulcan 6 ECH	108
4	Isle of Palms, SC	25.4cm (10in) Timber	Air	Vulcan 06	56
5	Charleston, SC	25.4cm (10in) PSC	Hydraulic	ICE 115	35
		30.5cm (12in) PSC	Hydraulic	ICE 115	72
6	Charleston, SC	HP305x79 (HP12x53)	Air	Vulcan 01	9
7	Charleston, SC	HP305x79 (HP12x53)	Vibratory	APE 200	22
		AZ 13	Vibratory	APE 200	71
		AZ 18	Vibratory	APE 200	28
8	Charleston, SC	30.5cm (12in) PSC	OED	Delmag D30-23	40
9	Charleston, SC	HP305x79 (HP12x53)	Hydraulic	Conmaco C65	7
10	Charleston, SC	HP305x79 (HP12x53)	Air	Vulcan 06	6
		30.5cm (12in) PSC	Air	Vulcan 06	18
11	Isle of Palms, SC	20.3cm (8in) Timber	Air	Vulcan 01	16
12	Sullivan's Is., SC	25.4cm (10in) PSC	Air	Vulcan 01	109
13	Kiawah Island, SC	20.3cm (8in) Timber	Air	Vulcan 06	3
14	Kiawah Island, SC	30.5cm (12in) PSC	Air	Vulcan 06	74
15	Charleston, SC	HP305x79 (HP12x53)	Air	Vulcan 06	95
16	Seabrook Is., SC	20.3cm (8in) Timber	Air	Vulcan 01	94
17	Folly Beach, SC	30.5cm (12in) PSC	Air	Vulcan 06	4
		20.3cm (8in) Timber	Air	Vulcan 06	16
18	Mt. Pleasant, SC	Fordingham 3NA	Vibratory	PVE 1420	46
19	Charleston, SC	30.5cm (12in) PSC	Hydraulic	ICE 115	5
20	Sullivan's Is., SC	25.4cm (10in) Timber	Drop	Drop Hammer	18
21	Charleston, SC	30.5cm (12in) PSC	Hydraulic	ICE 115	6
		30.5cm (12in) PSC	Hydraulic	ICE 75	143
22	Folly Beach, SC	30.5cm (12in) Timber	Drop	Drop Hammer	48
23	Sullivan's Is., SC	20.3cm (8in) Timber	Drop	Drop Hammer	38
				TOTAL	1793

4. Overview of Some CPT & Pile Databases

Pioneers in CPT and Pile Databases:

پیشگامان ارائه و توسعه بانک‌های اطلاعاتی CPT و شمع‌ها

Nottingham (1975)	Florida, USA
Meyerhof (1976, 1983)	Canada and USA
Schmertmann (1978)	FHWA Guidelines
de Ruiter & Beringen (1979)	North Sea, Europe
Bustamante & Gianesselli (1982)	LCPC, French Method
Tummay & Fakhroo (1982)	Louisiana, USA

4. Overview of Some CPT & Pile Databases

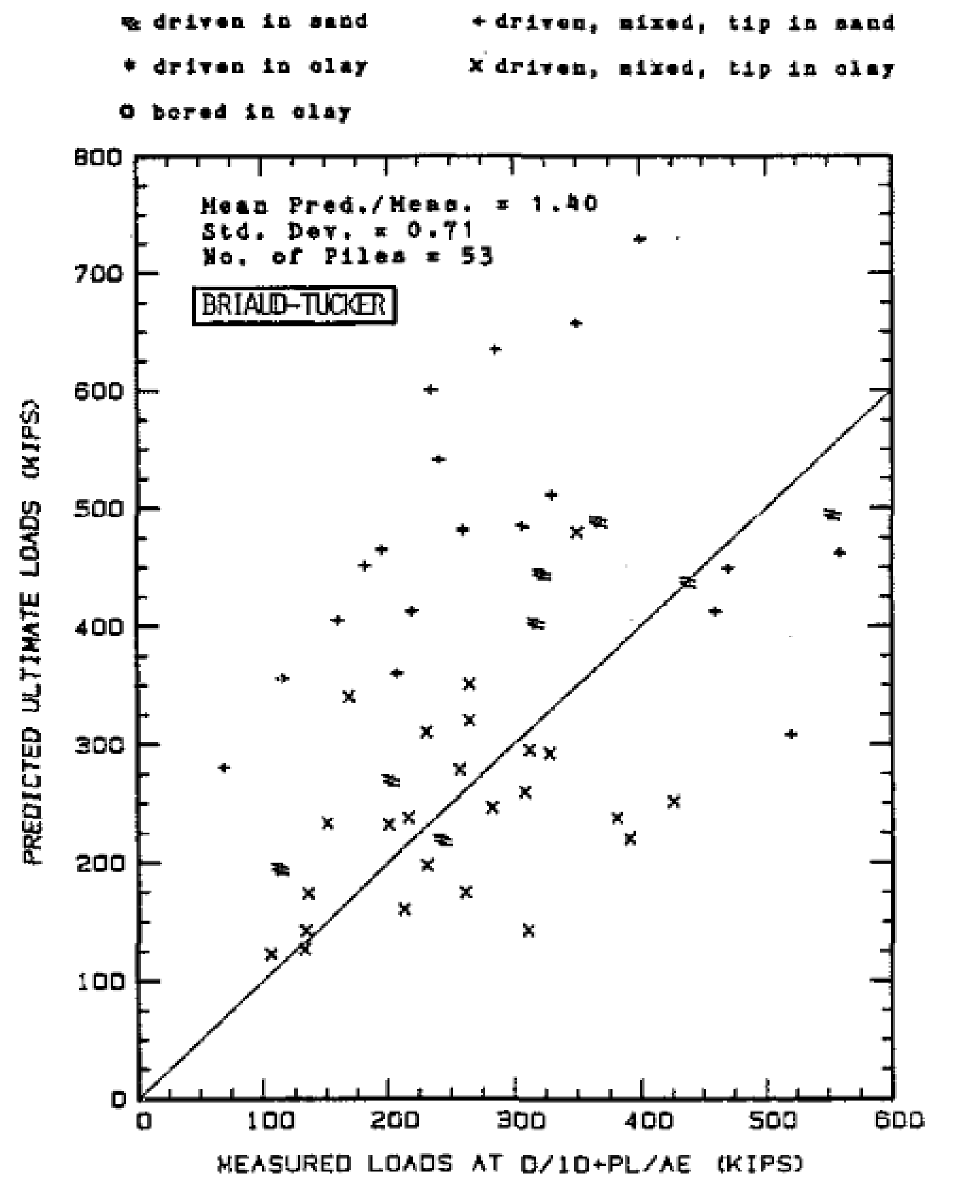
Briaud and Tucker (1988) Database

- **Evaluating Performance of 13 methods for determining the bearing capacity and settlement of piles based on the results of SPT, CPT, PMT and dynamic formulas**

- **98 case studies of steel and concrete piles with square, H, circular cross sections**

- **Pile lengths between 3 and 25 m**

- **The ultimate loads range from 307 to 2536 kN**



4. Overview of Some CPT & Pile Databases

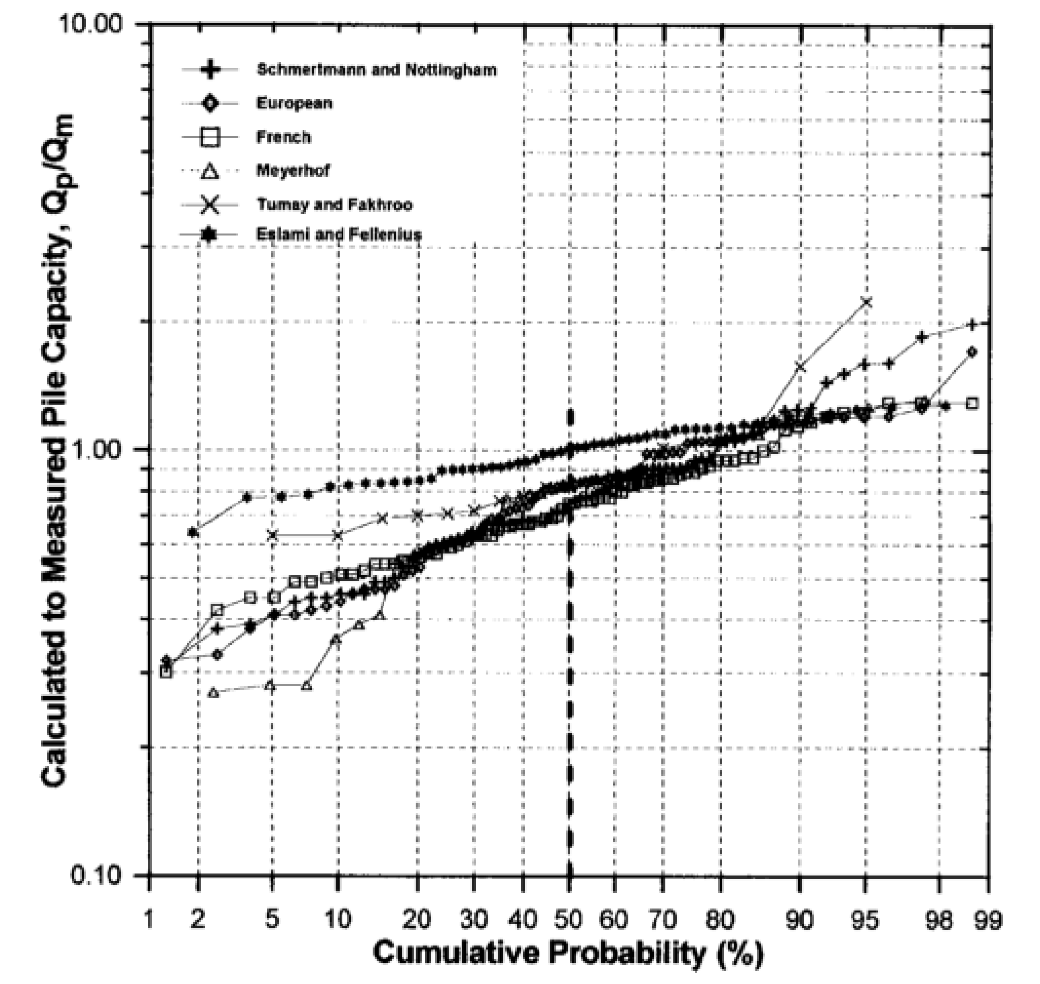
Alsamman (1995) Database

- 95 case records of axial load testing on bored piles
- 29 sites from 8 countries
- 48 loading tests in granular, 16 in cohesive and 31 in mixed soils
- The diameter of the piles is between 300 and 2130 mm
- The embedment depth of the piles is between 4.6 to 42 m

4. Overview of Some CPT & Pile Databases

Eslami and Fellenius (1997) Database

- 102 case studies from 40 sites and 13 countries
- Clay, silt and sand deposits
- Mainly square or circular in sections
- Steel and concrete materials
- Piles bearing capacity: 80 to 8000 kN

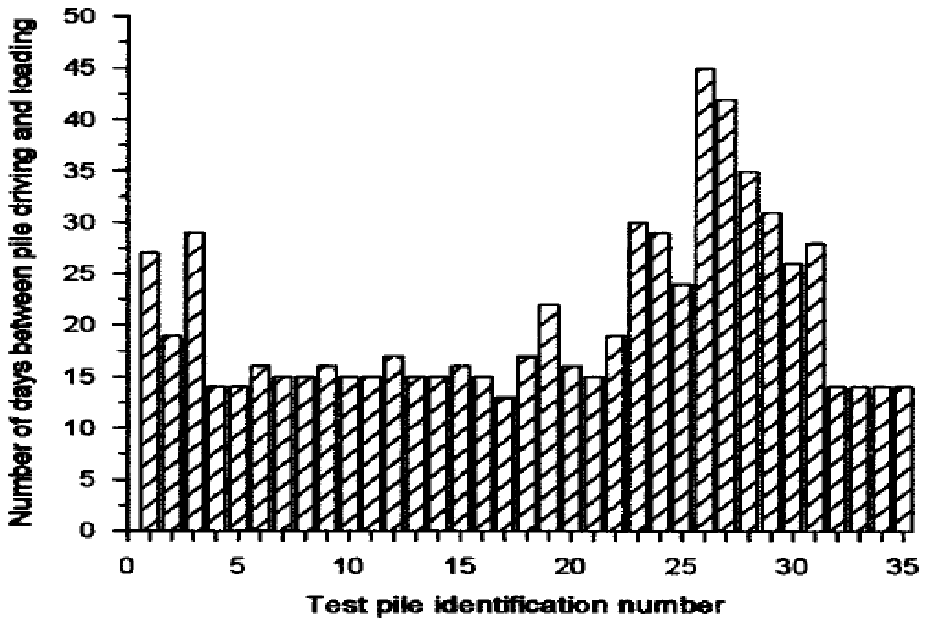


4. Overview of Some CPT & Pile Databases

Abu-Farsakh & Titi (2004) Database

- Performance of 8 CPT-based methods
- 35 prestressed square concrete piles
- The embedment length between 9 & 38 m
- The section size between 356 & 762 mm
- 29 piles driven in clay and 9 in layered soils

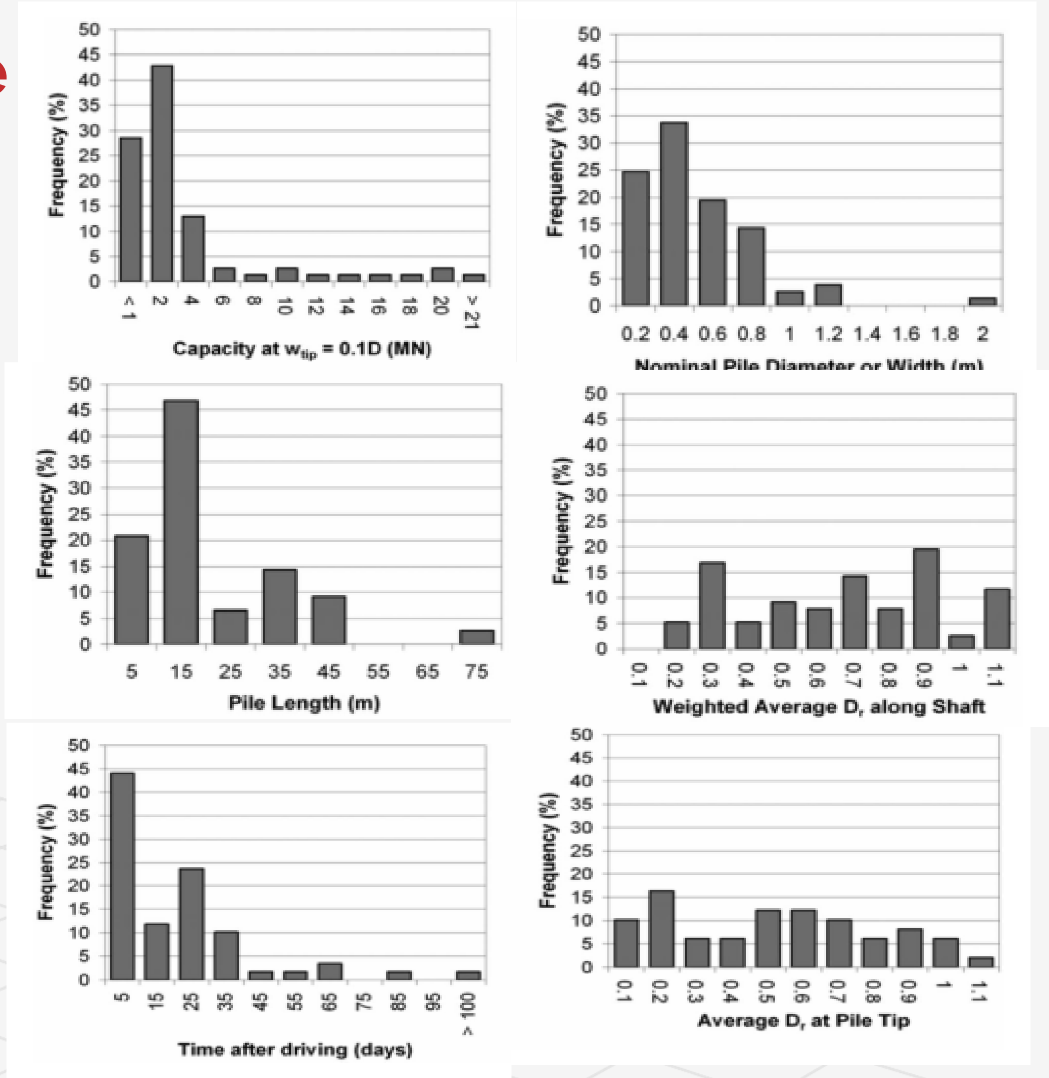
Pile size mm (in.)	Clay (number of piles)	Clay and Sand (number of piles)
356 (14)	16	2
406 (16)	4	—
457 (18)	1	1
610 (24)	2	—
762 (30)	3	6
Total	26	9



4. Overview of Some CPT & Pile Databases

UWA (Lehane et al., 2005) Database

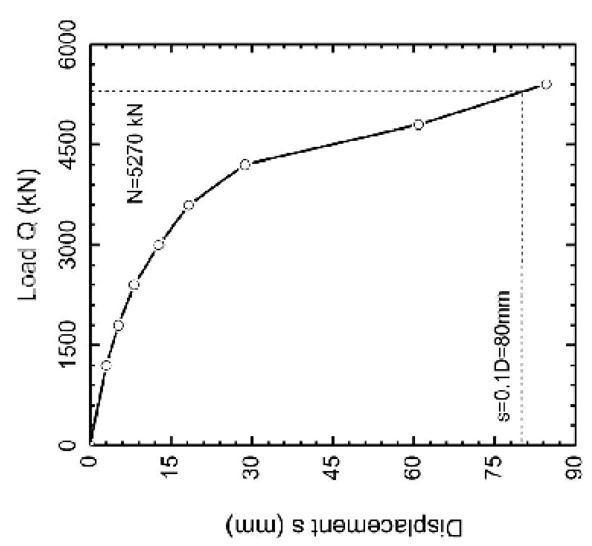
- ❑ 77 tensile and compressive loading tests
- ❑ Driven concrete piles in sand
- ❑ Piles length: 5 to 80 m (mainly 10 to 20 m)
- ❑ The diameters mainly less than 800 mm
- ❑ The bearing capacity mainly less than 5 MN



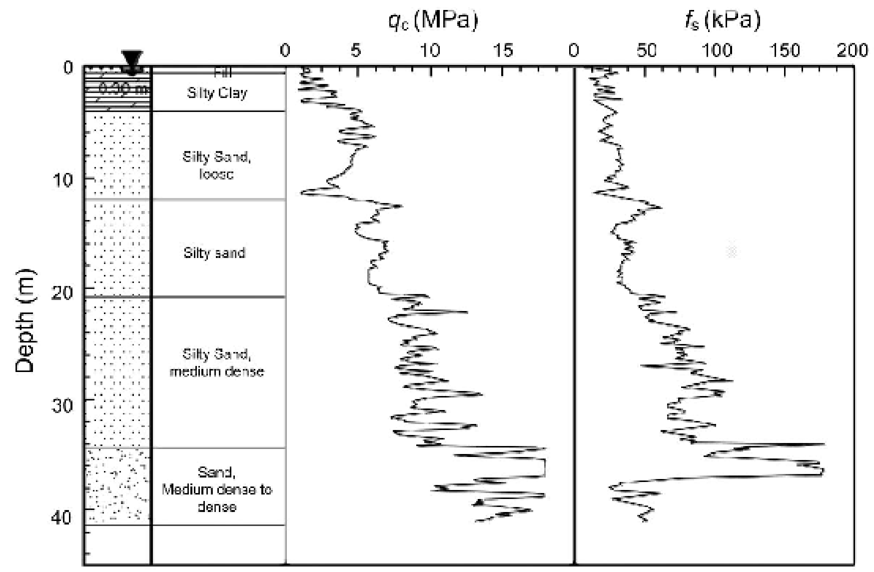
4. Overview of Some CPT & Pile Databases

ZJU-ICL Database (2015)

- Zhejiang University/Imperial College London (ZJU-ICL) database
- Developed by Yang et al. (2015)
- 115 driven piles in sand
- Openly accessible



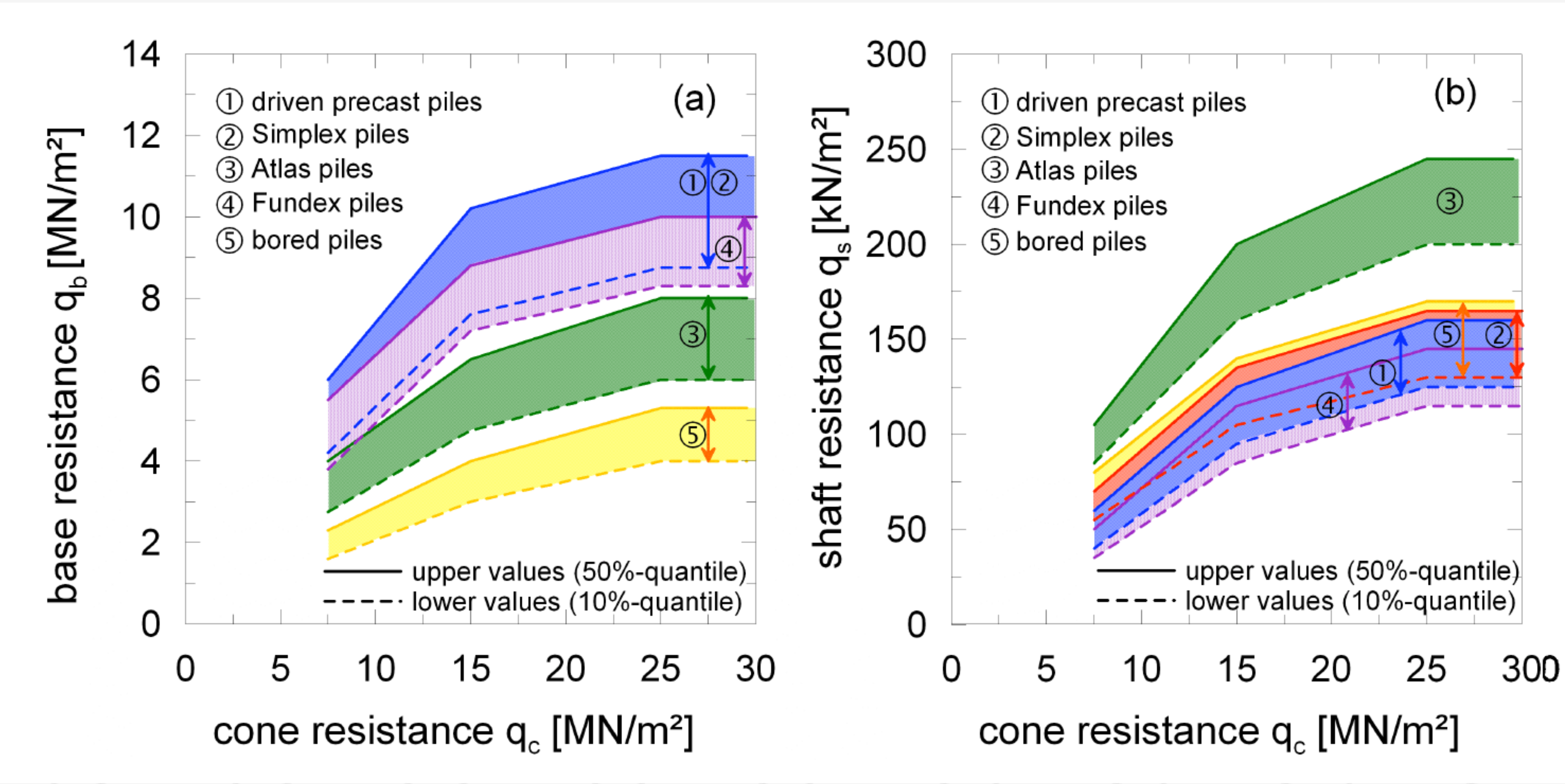
Site ID No. 3: K27, Wuhu, China

Cone penetrometer data	Detail	Description
	Site name and location	Wuhu Second Bridge over the Yangtze River Test site: K27
	Soil type(s)	Silty sand and fine sand
	Water table depth (m)	0.3
	Pile type(s)	Pre-cast Hollow Concrete (PHC)
	Type of cone penetrometer testing	Electric CPT
	Number of pile load tests	1, with 3 others at other locations
	Comments	The q_c profile has one straight line segments of 1 to 2m length where qc exceeds the 18 MPa capacity of the CPT deployed. These sections are considered as q_c = 18 MPa in the analysis performed. Interface friction angle estimated with GSD, and soil unit weight applies default value.

4. Overview of Some CPT & Pile Databases

Kempfert & Becker (2010)

- German method
- 1000 case records



Amirkabir University of Technology
Department of Civil and Environmental Engineering

AUT;GEO-CPT&PILE DATABASE

GEOTECHNICAL INFORMATION, CPT AND CPTU DATA AND PILE LOADING TESTS RECORDS

Developed by:

- Engr. Sara Moshfeghi
- Dr. Abolfazl Eslami
- Dr. S. Majdeddin MirMohammad Hosseini

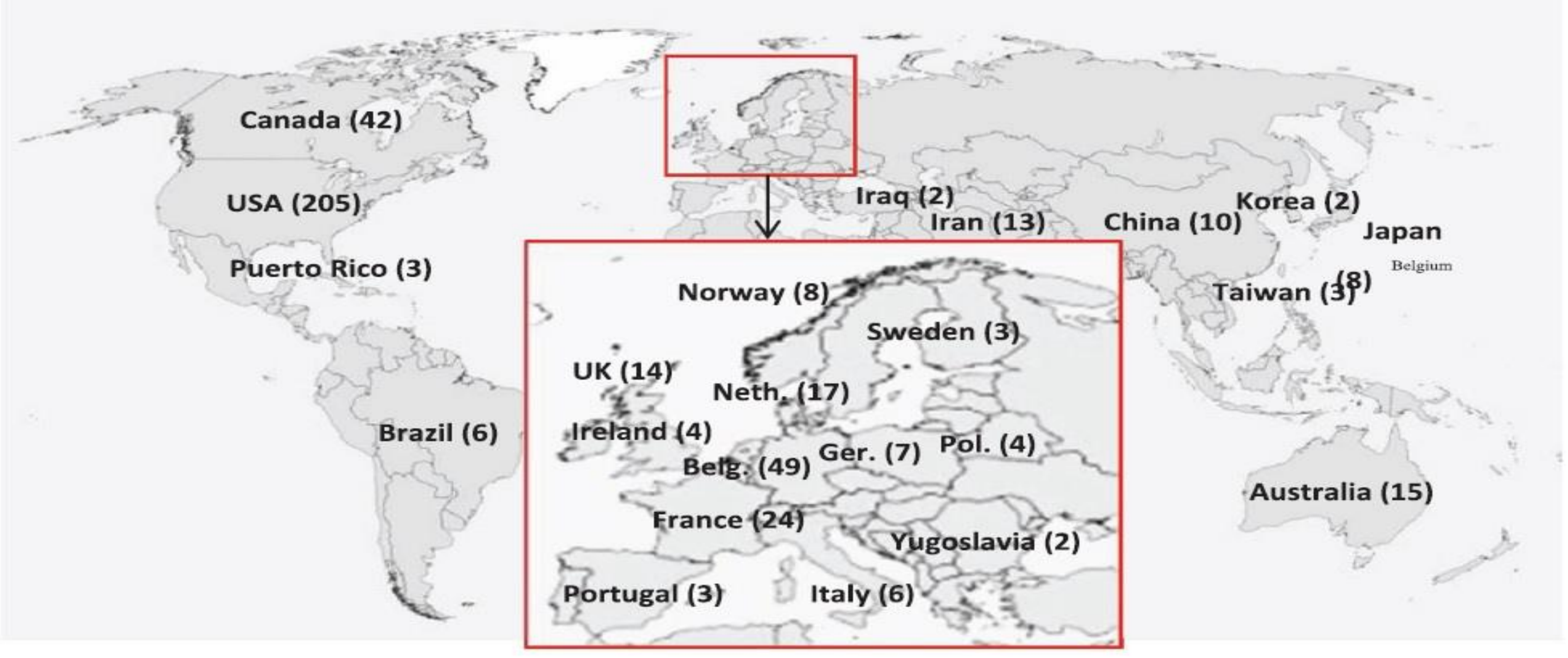
Finalized by:

- Dr. Abolfazl Eslami
- Dr. Abbas Soroush
- Engr. Sara Moshfeghi
- Engr. AmirHossein Vojgani

5. Introduction to AUT;Geo-CPT&Pile Database

توزیع جغرافیایی ۶۰۰ داده بانک اطلاعاتی دانشگاه صنعتی امیرکبیر

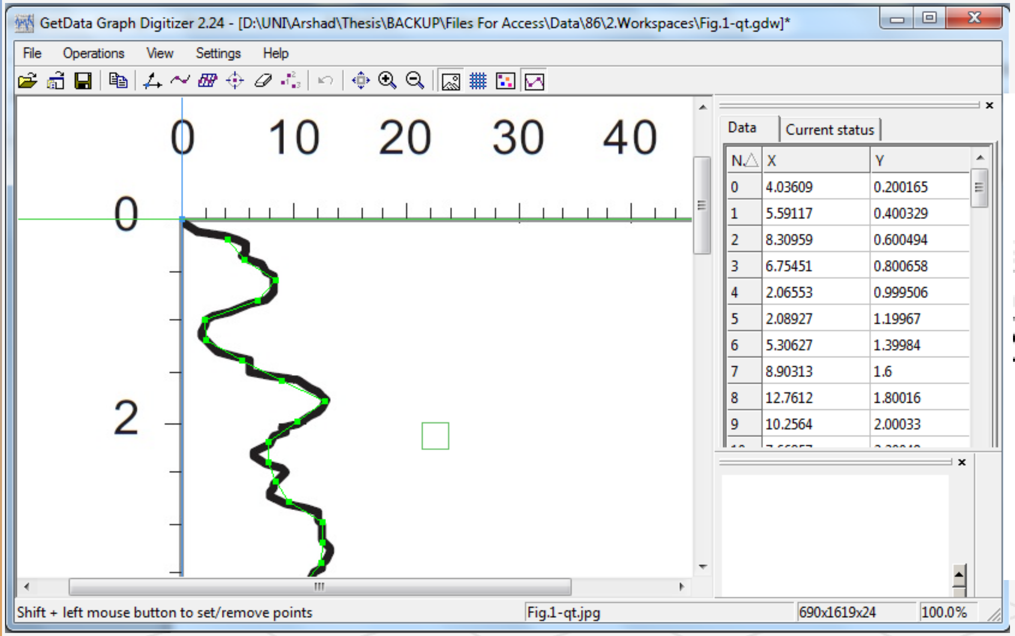
600 Records of pile axial loading tests along with adjacent CPT or CPTu profiles.

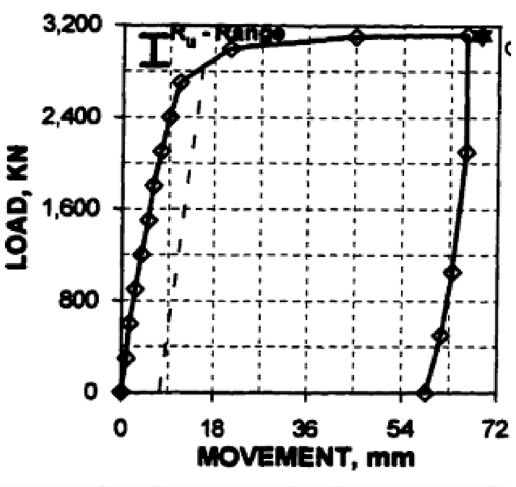


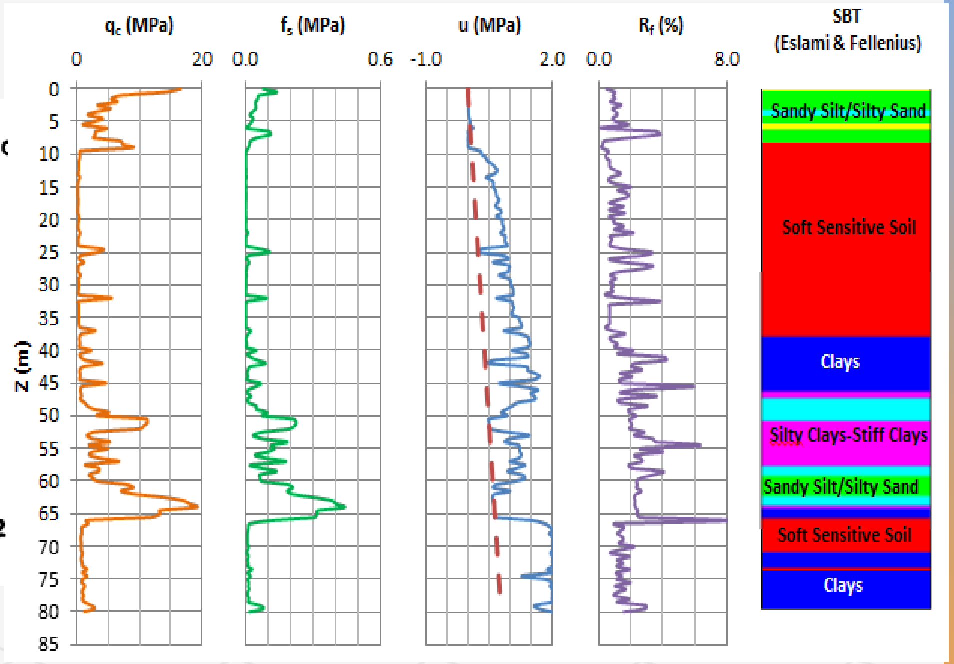
5. Introduction to AUT;Geo-CPT&Pile Database

Digitizing load-displacement diagrams derived from loading tests and CPT profiles using the GetData Graph Digitizer 2.2 software.

اطلاعات گرافیکی مندرج در بانک







5. Introduction to AUT;Geo-CPT&Pile Database

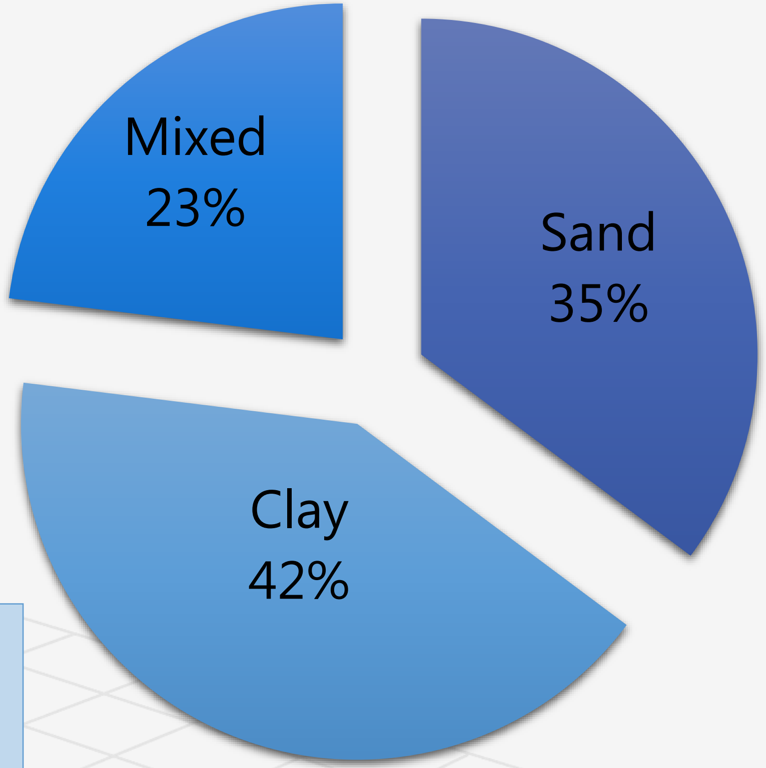
Soil Properties

مشخصات خاک

Includes a wide range of clayey, silty and sandy soils.

Classified within three categories:

- Sand
- Clay
- Mixed



Classification based on the type of soil around pile toe as well as the dominant soil type along the pile (70% of pile embedment depth)

5. Introduction to AUT;Geo-CPT&Pile Database

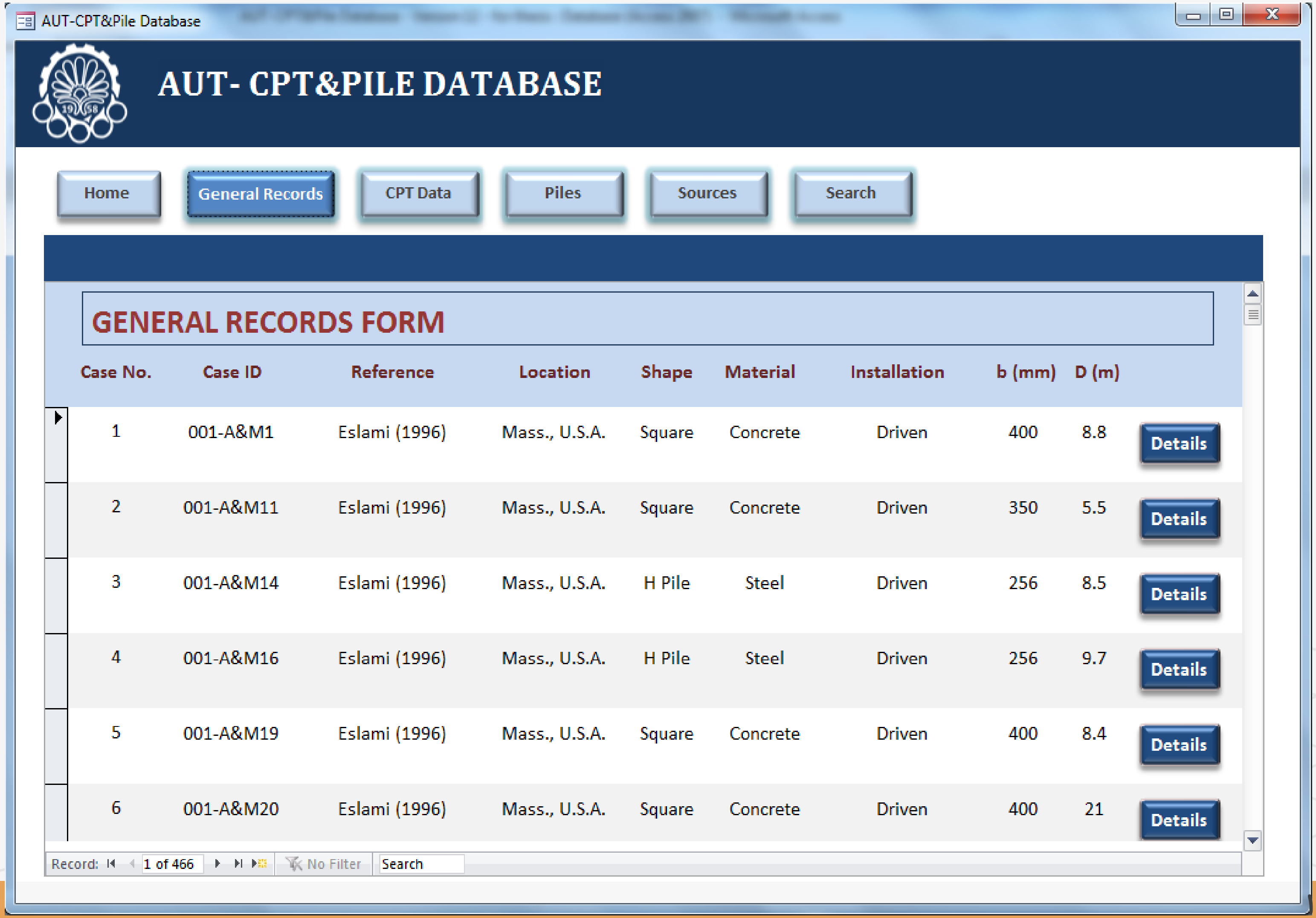
Piles Specifications

مشخصات شمع‌ها

- **Embedment Depth** → Mainly from 5 to 75 m
- **Cross Section** → Mainly from 100 to 900 mm
- **Cross Section Shape** →
  - Round
  - Square
  - Pipe
  - Triangle
- **Material** →
  - Steel
  - Concrete
  - Composite (steel and concrete)
  - CFG (Cement, Fly ash, Gravel)
- **Installation Method**
  - Driven
  - Bored
  - PGDS (Pressure Grouted Drilled Shaft)
  - APGD (Augured Pressure Grouted Displacement)
  - DCIS (Driven Cast in-situ)
  - Jacked
  - Vibro
  - CFA
  - Pressed
  - Helical
  - Atlas (DD)
  - Fundex (DD)
  - Olivier (DD)
  - Omega (DD)
  - De Waal (DD)

5. Introduction to AUT;Geo-CPT&Pile Database

Database structure-General Records Form


AUT-CPT&Pile Database

AUT- CPT&PILE DATABASE

Home | General Records | CPT Data | Piles | Sources | Search

GENERAL RECORDS FORM

Case No.	Case ID	Reference	Location	Shape	Material	Installation	b (mm)	D (m)	
1	001-A&M1	Eslami (1996)	Mass., U.S.A.	Square	Concrete	Driven	400	8.8	Details
2	001-A&M11	Eslami (1996)	Mass., U.S.A.	Square	Concrete	Driven	350	5.5	Details
3	001-A&M14	Eslami (1996)	Mass., U.S.A.	H Pile	Steel	Driven	256	8.5	Details
4	001-A&M16	Eslami (1996)	Mass., U.S.A.	H Pile	Steel	Driven	256	9.7	Details
5	001-A&M19	Eslami (1996)	Mass., U.S.A.	Square	Concrete	Driven	400	8.4	Details
6	001-A&M20	Eslami (1996)	Mass., U.S.A.	Square	Concrete	Driven	400	21	Details

Record: 1 of 466 No Filter Search

ساختار بانک اطلاعاتی

5. Introduction to AUT;Geo-CPT&Pile Database

Database structure-CPT Data Form

AUT-CPT&Pile Database

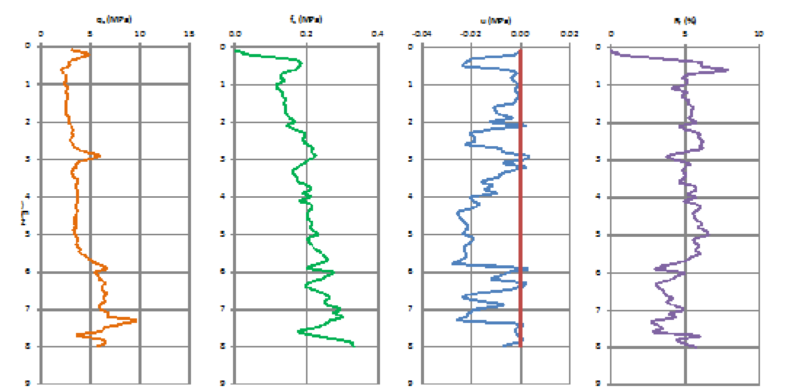
AUT- CPT&PILE DATABASE

Home | General Records | CPT Data | Piles | Sources | Search

CPT DATA

Case No: 172
CPT Depth (m): 8
Case ID: 066-ISC2T1
CPT Digitization Intervals (m): 0.1

CPT LOGS



CPT DIGITALS

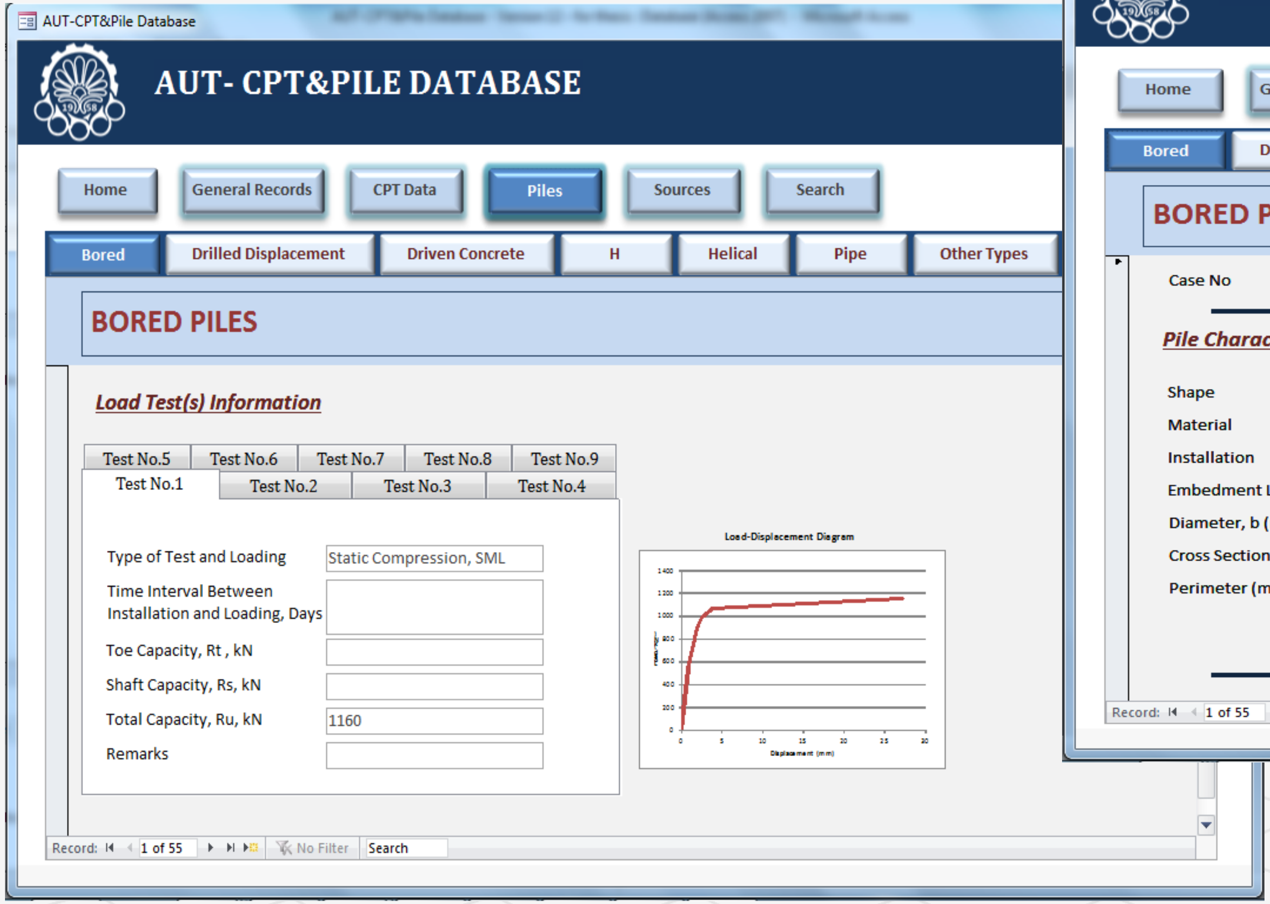
Z (m)	q_c (MPa)	f_s (MPa)	u_2 (MPa)	u_0 (MPa)	R_f (%)
0.10	3.235	0.000	0.000	0.000	0.000
0.20	4.857	0.043	-0.003	0.000	0.887
0.30	3.830	0.141	-0.019	0.000	3.689
0.40	3.003	0.183	-0.022	0.000	6.094
0.50	2.931	0.181	-0.023	0.000	6.163
0.60	2.175	0.170	-0.005	0.000	7.837
0.70	2.387	0.134	-0.002	0.000	5.607
0.80	2.633	0.128	-0.003	0.000	4.857
0.90	2.633	0.136	-0.003	0.000	5.175
1.00	2.409	0.120	-0.001	0.000	4.977
1.10	2.797	0.117	-0.002	0.000	4.185
1.20	2.551	0.130	-0.002	0.000	5.112
1.30	2.760	0.133	0.000	0.000	4.801
1.40	2.703	0.142	-0.002	0.000	5.246
1.50	2.588	0.135	-0.003	0.000	5.209
1.60	2.559	0.141	-0.010	0.000	5.528
1.70	2.635	0.142	-0.010	0.000	5.400
1.80	2.649	0.144	-0.008	0.000	5.447

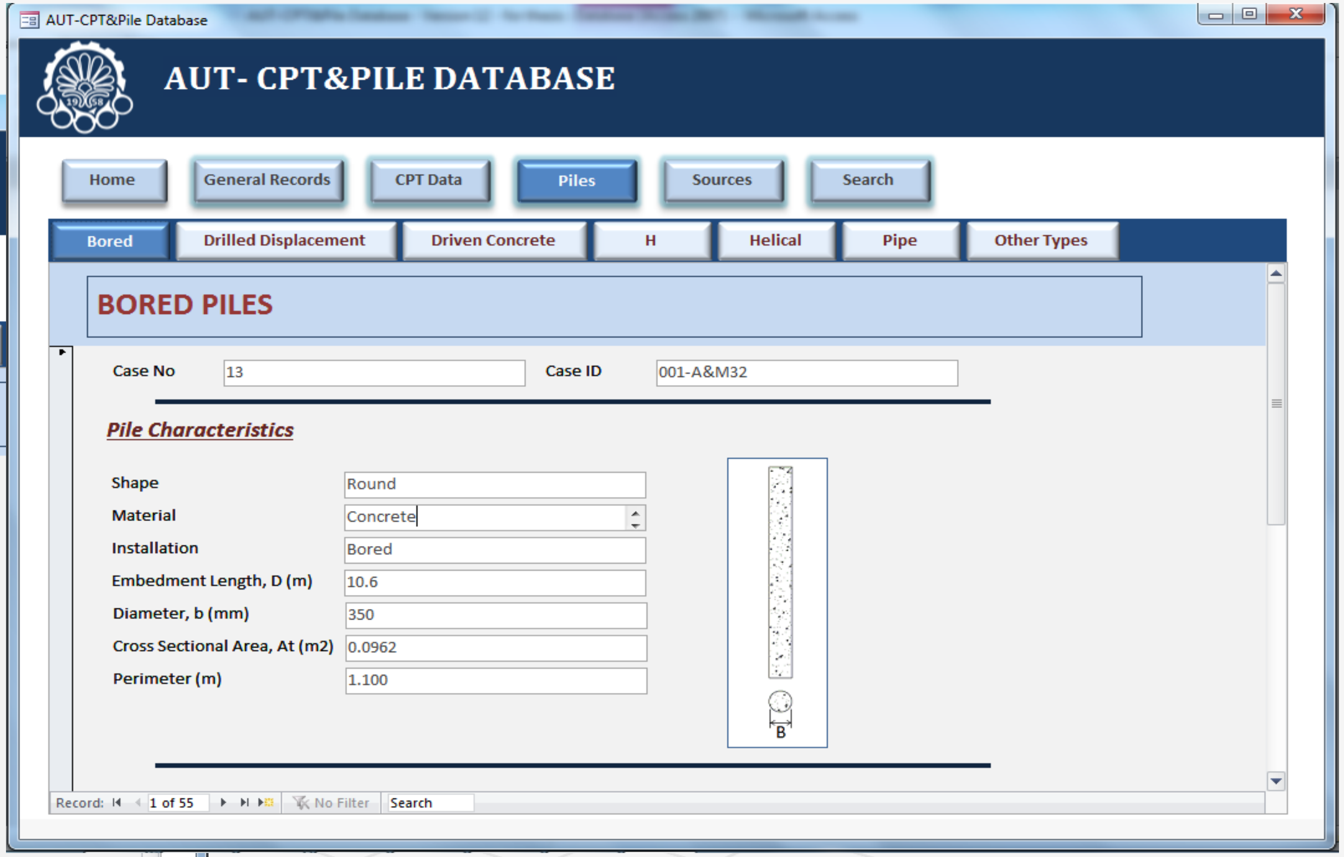
Record: 165 of 466 | No Filter | Search

ساختار بانک اطلاعاتی–
داده‌های CPT

5. Introduction to AUT;Geo-CPT&Pile Database

Database structure-Piles Information

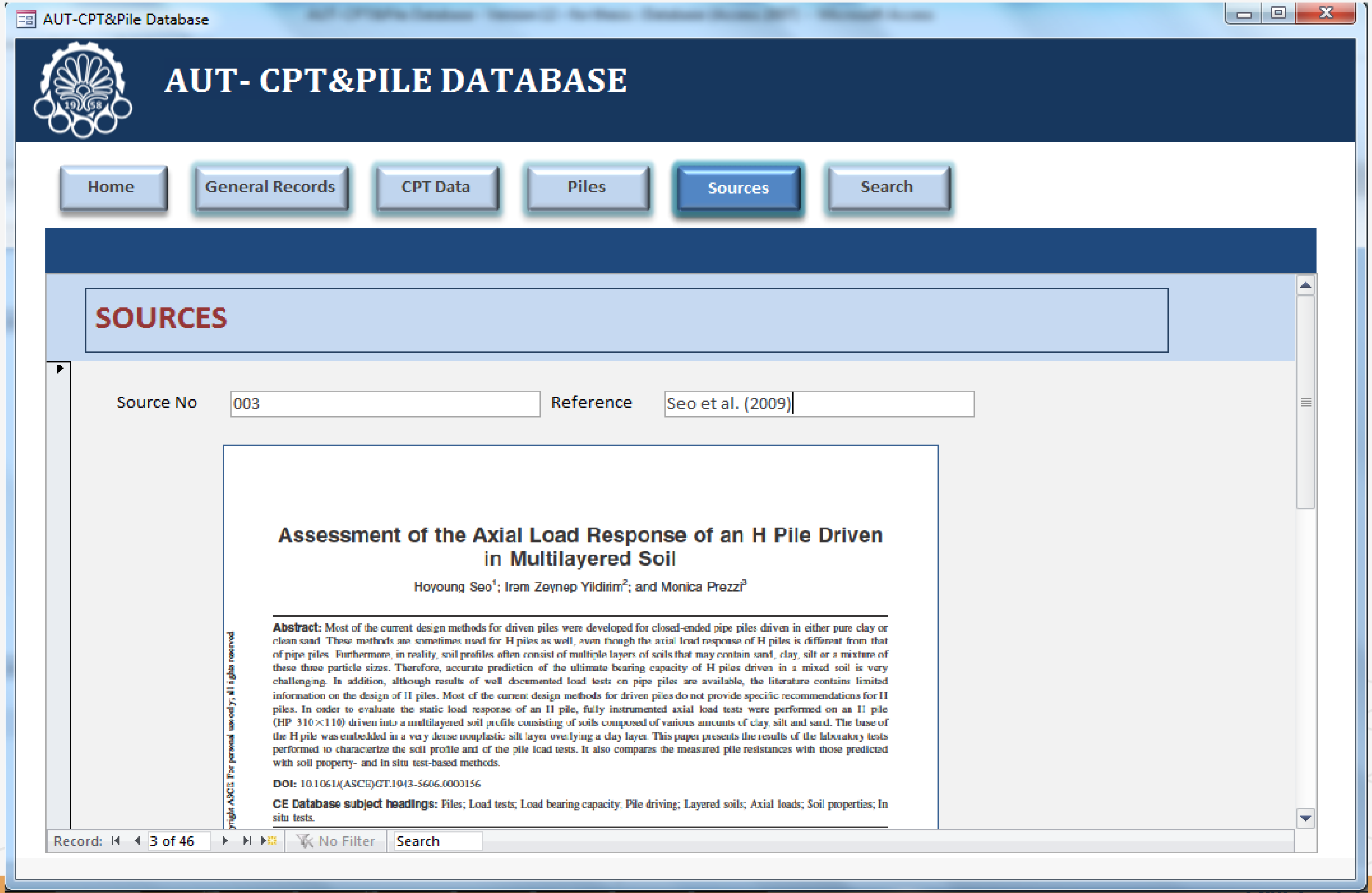




ساختار بانک اطلاعاتی–اطلاعات شمع‌ها

5. Introduction to AUT;Geo-CPT&Pile Database

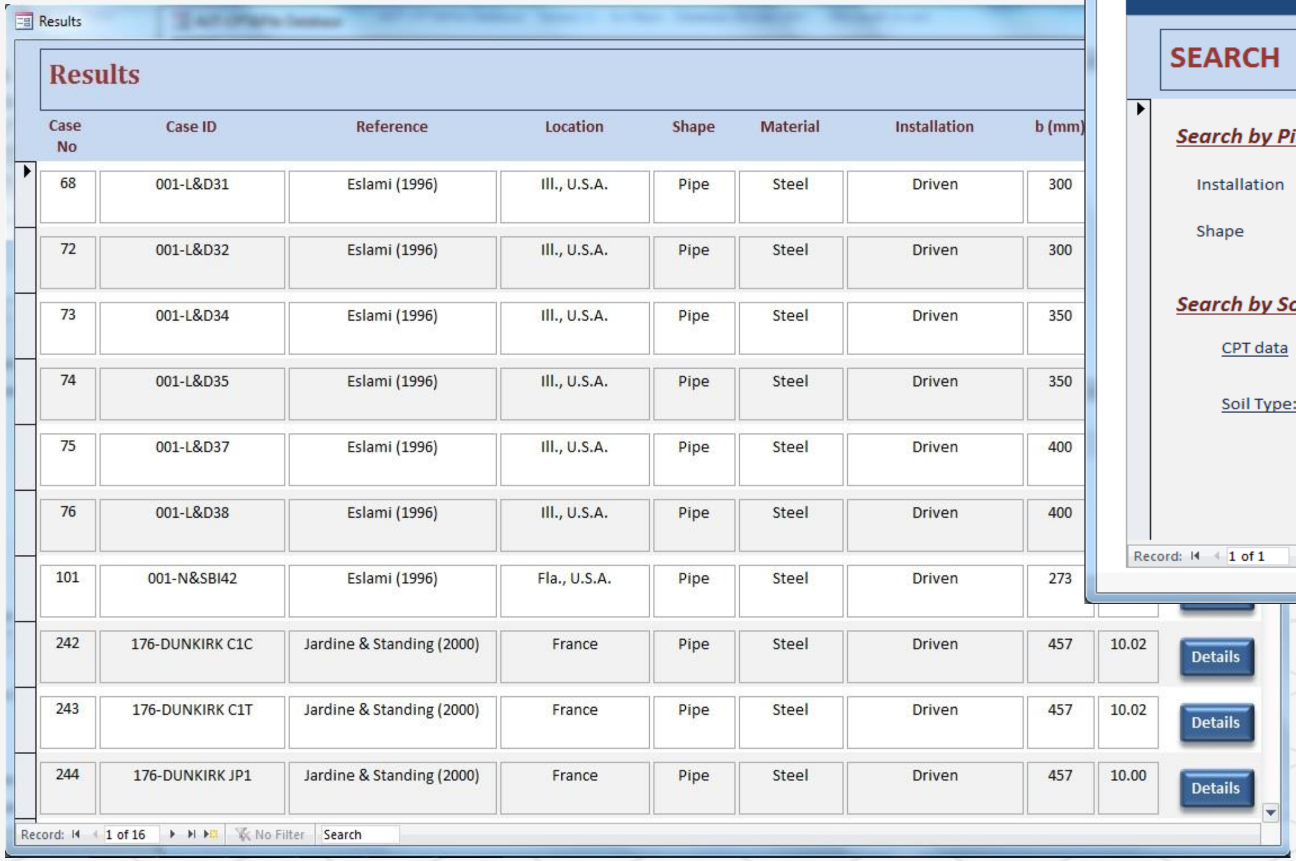
Database structure- Sources



ساختار بانک اطلاعاتی–منابع

5. Introduction to AUT;Geo-CPT&Pile Database

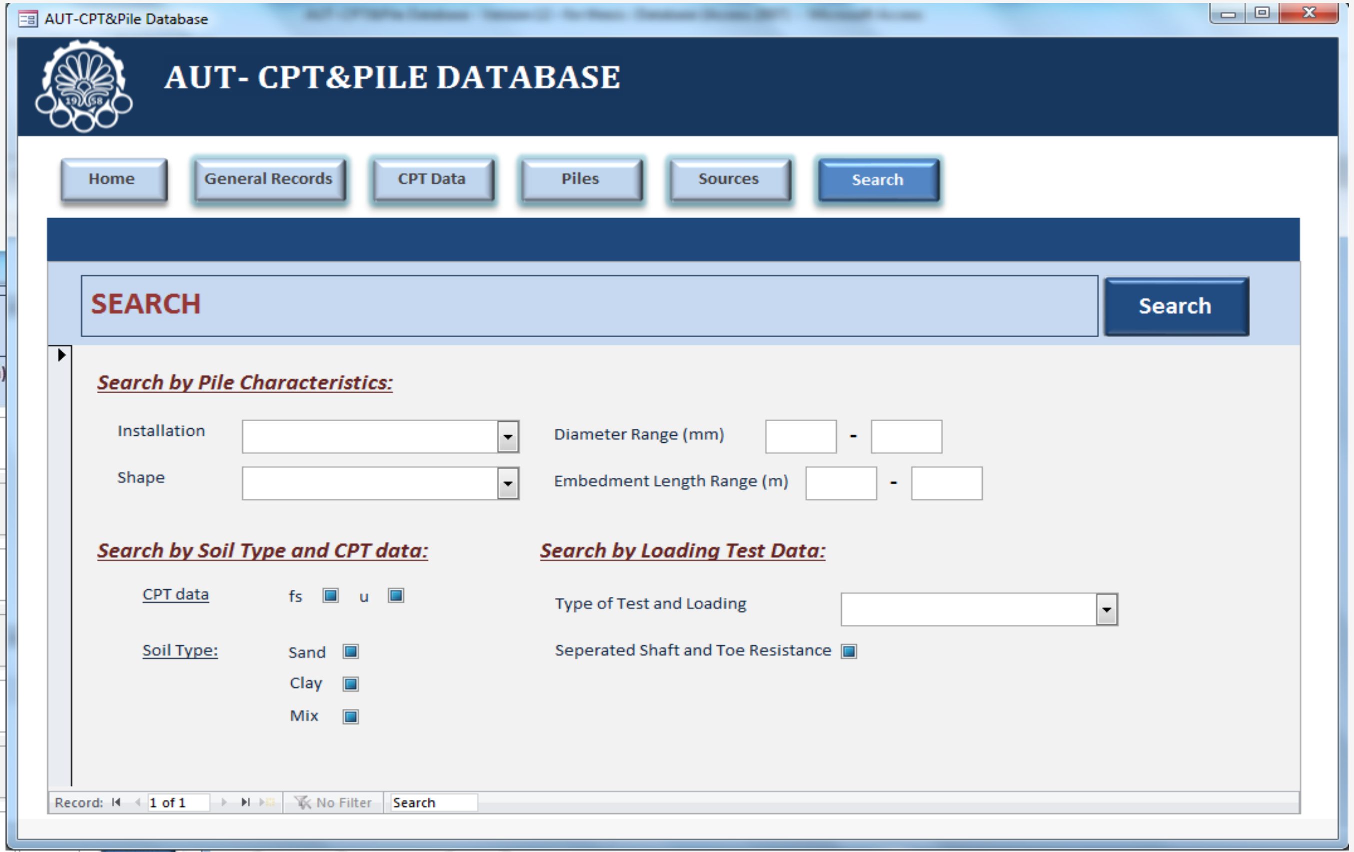
Database structure-
Search & Search Results



Results

Case No	Case ID	Reference	Location	Shape	Material	Installation	b (mm)		
68	001-L&D31	Eslami (1996)	Ill., U.S.A.	Pipe	Steel	Driven	300		
72	001-L&D32	Eslami (1996)	Ill., U.S.A.	Pipe	Steel	Driven	300		
73	001-L&D34	Eslami (1996)	Ill., U.S.A.	Pipe	Steel	Driven	350		
74	001-L&D35	Eslami (1996)	Ill., U.S.A.	Pipe	Steel	Driven	350		
75	001-L&D37	Eslami (1996)	Ill., U.S.A.	Pipe	Steel	Driven	400		
76	001-L&D38	Eslami (1996)	Ill., U.S.A.	Pipe	Steel	Driven	400		
101	001-N&SBI42	Eslami (1996)	Fla., U.S.A.	Pipe	Steel	Driven	273		
242	176-DUNKIRK C1C	Jardine & Standing (2000)	France	Pipe	Steel	Driven	457	10.02	Details
243	176-DUNKIRK C1T	Jardine & Standing (2000)	France	Pipe	Steel	Driven	457	10.02	Details
244	176-DUNKIRK JP1	Jardine & Standing (2000)	France	Pipe	Steel	Driven	457	10.00	Details

Record: 1 of 16 No Filter Search

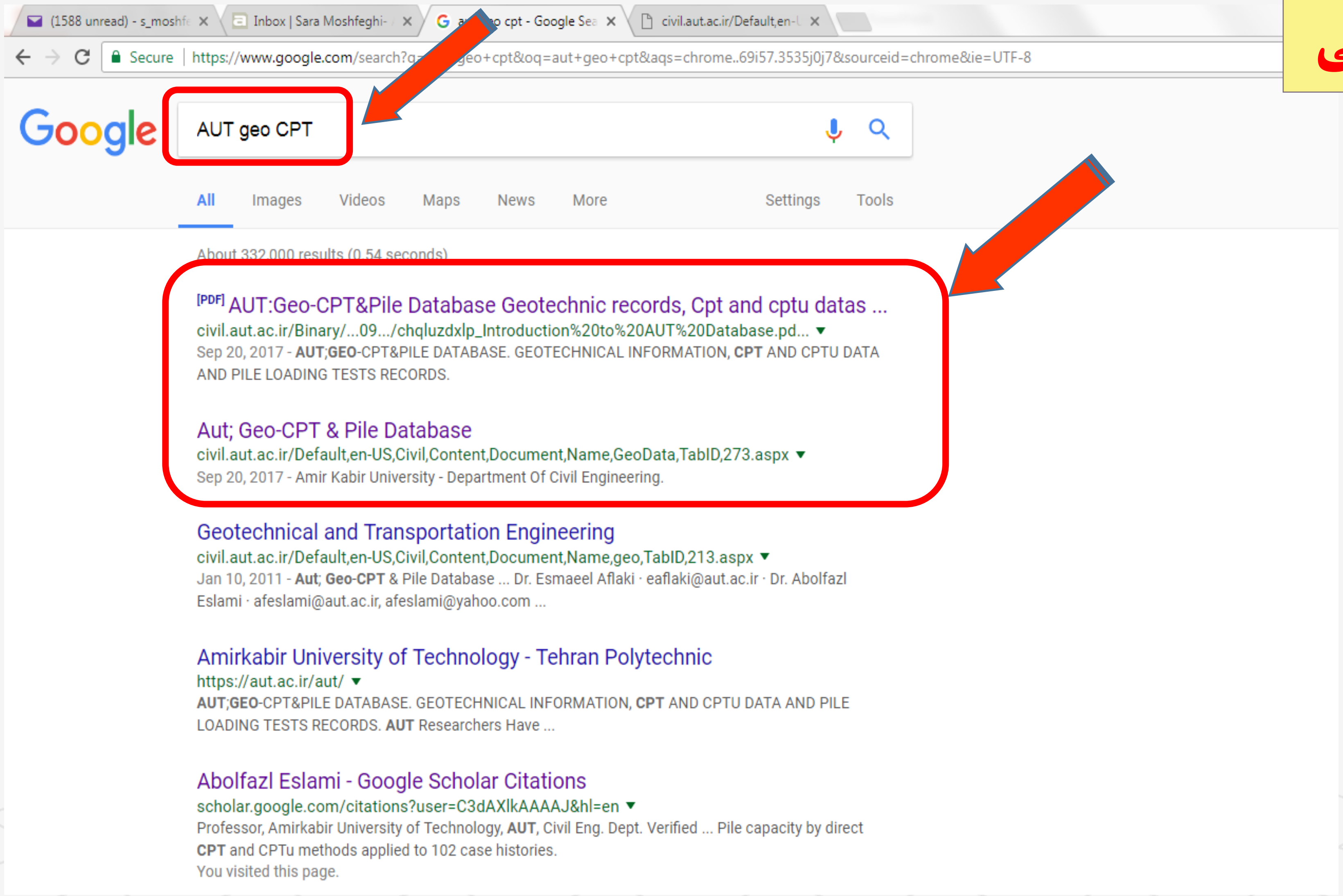


ساختار بانک اطلاعاتی – جستجو

5. Introduction to AUT;Geo-CPT&Pile Database

Access?

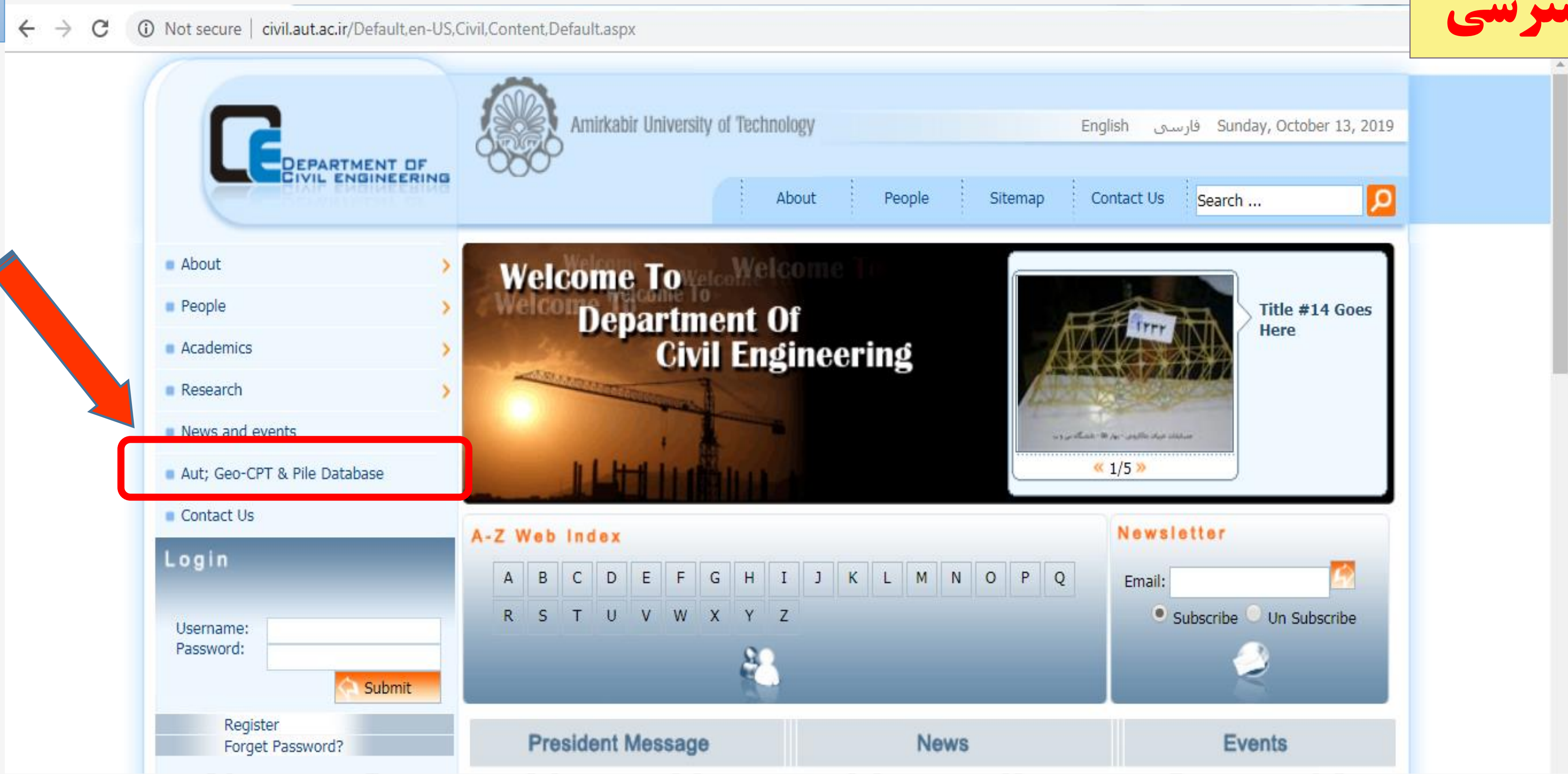
چگونگی دسترسی



5. Introduction to AUT;Geo-CPT&Pile Database

Access?

چگونگی دسترسی

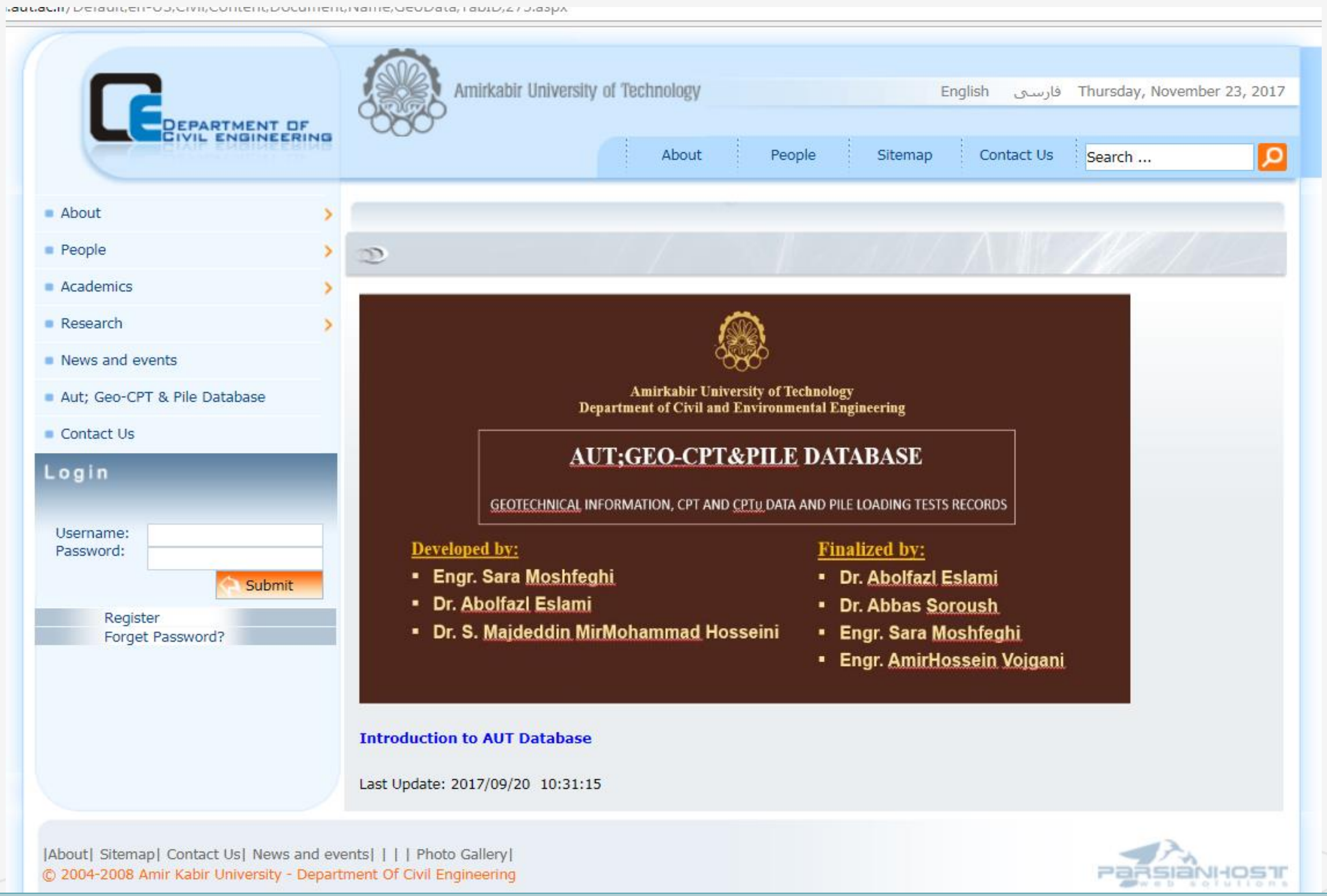


http://aut.ac.ir/aut/
http://civil.aut.ac.ir/Default,en-US,Civil,Content,Document,Name,GeoData,TabID,273.aspx

5. Introduction to AUT;Geo-CPT&Pile Database

Access?

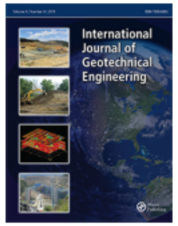
چگونگی دسترسی



http://aut.ac.ir/aut/
http://civil.aut.ac.ir/Default,en-US,Civil,Content,Document,Name,GeoData,TabID,273.aspx

6. Typical Implementations

Moshfeghi & Eslami (2015-2019)



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International Journal of Geotechnical Engineering

ISSN: 1938-6362 (Print) 1939-7879 (Online) Journal homepage: http://www.tandfonline.com/loi/yjge20

Study on pile ultimate capacity criteria and CPT-based direct methods

Sara Moshfeghi and Abolfazl Eslami*

Due to the variety of current Cone Penetration Test (CPT)-based methods of estimating the pile bearing capacity, for optimum design, it is necessary to evaluate the performance of such methods in various geotechnical conditions. Geotechnical databases including piling and *in situ* testing records have been recognised as useful tools for analysis, design and economical construction. In order to evaluate current CPT-based pile bearing capacity methods, AUT-CPT and Pile database has been compiled including 450 full scale pile load tests and CPT sounding records. This database consists of different pile types with a relatively wide range of geometries and various soil conditions. Forty-three records of piles driven in sand deposits were then employed to evaluate effects of ultimate capacity interpretation criteria from load displacement diagrams. The Brinch Hansen 80% criterion and the load at the displacement of 10% of the pile diameter were compared to estimated capacities from 10 CPT-based design methods currently used in practice. The Brinch Hansen 80% criterion and the load at the displacement of 10% of the pile diameter lead to reasonable results, the Brinch Hansen 80% criterion showed less scatter. For evaluating the accuracy and the precision of CPT-based methods, the results were compared to estimated capacities. Methods with the best performance are introduced. Generally, comparisons indicate that the CPT-based methods mainly predict the pile capacity with reasonable accuracy.

Keywords: Ultimate pile bearing capacity, Direct CPT method, Load test, Failure criterion, Database

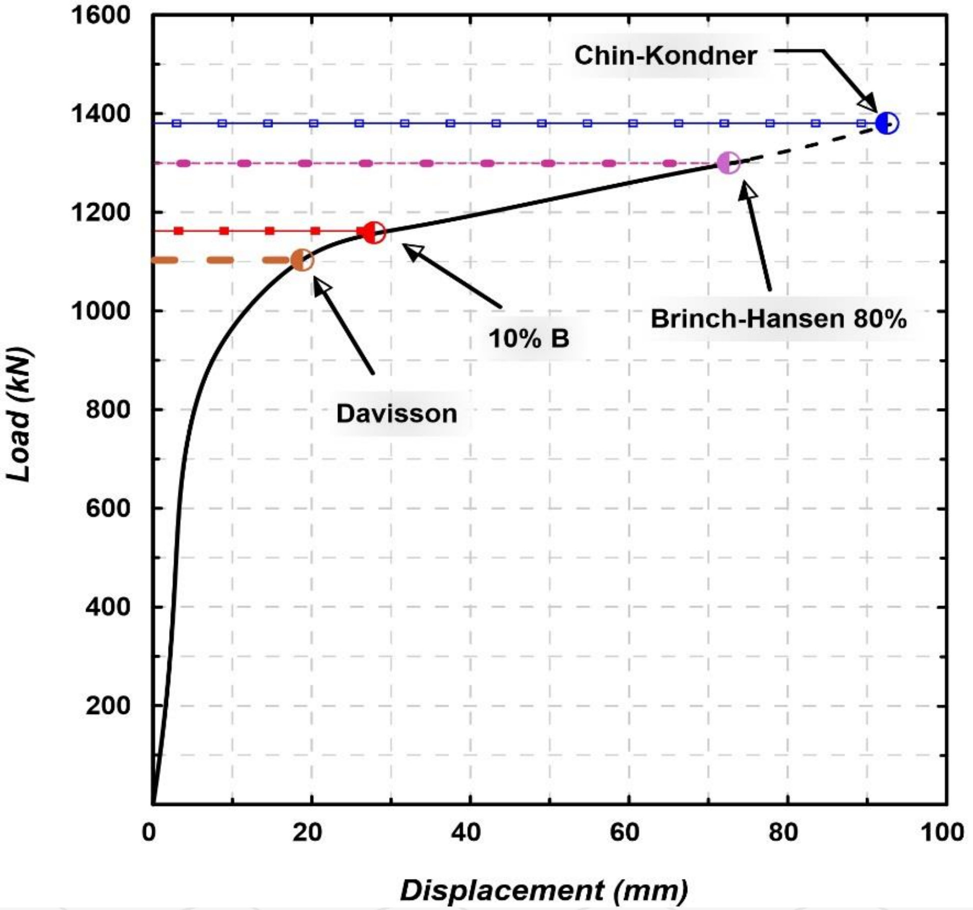
- ❑ شامل ۴۳ مورد عملی شمع و CPT
- ❑ انطباق پذیری روش‌های تفسیر نمودار بارگذاری شمع
- ❑ ارزیابی ظرفیت باربری کششی و فشاری شمع

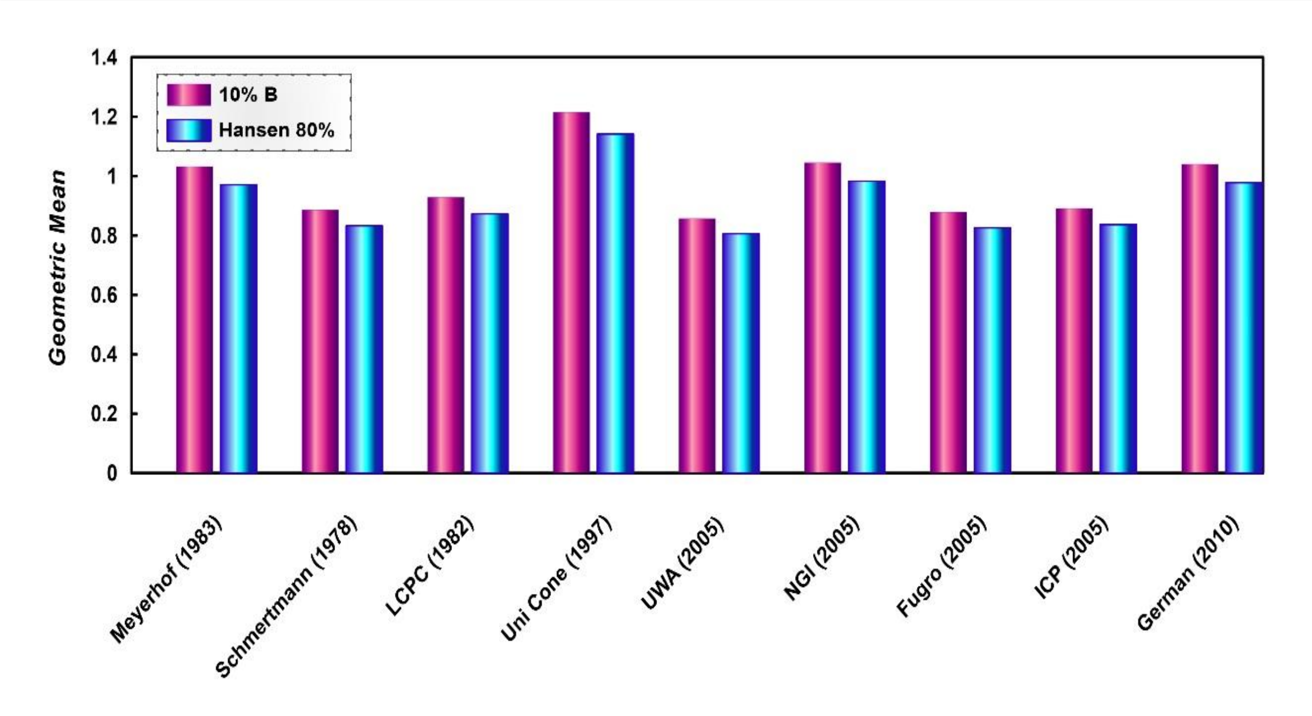
6. Typical Implementations

CPT & Pile Databases
By: Eslami & Moshfeghi

Moshfeghi & Eslami (2015-2019)

بررسی روش های تفسیر نمودار بارگــذاری شمع ها و انطبــاق پــذیری نتــایج آنهــا بــا روش‌های مبتنی بر CPT

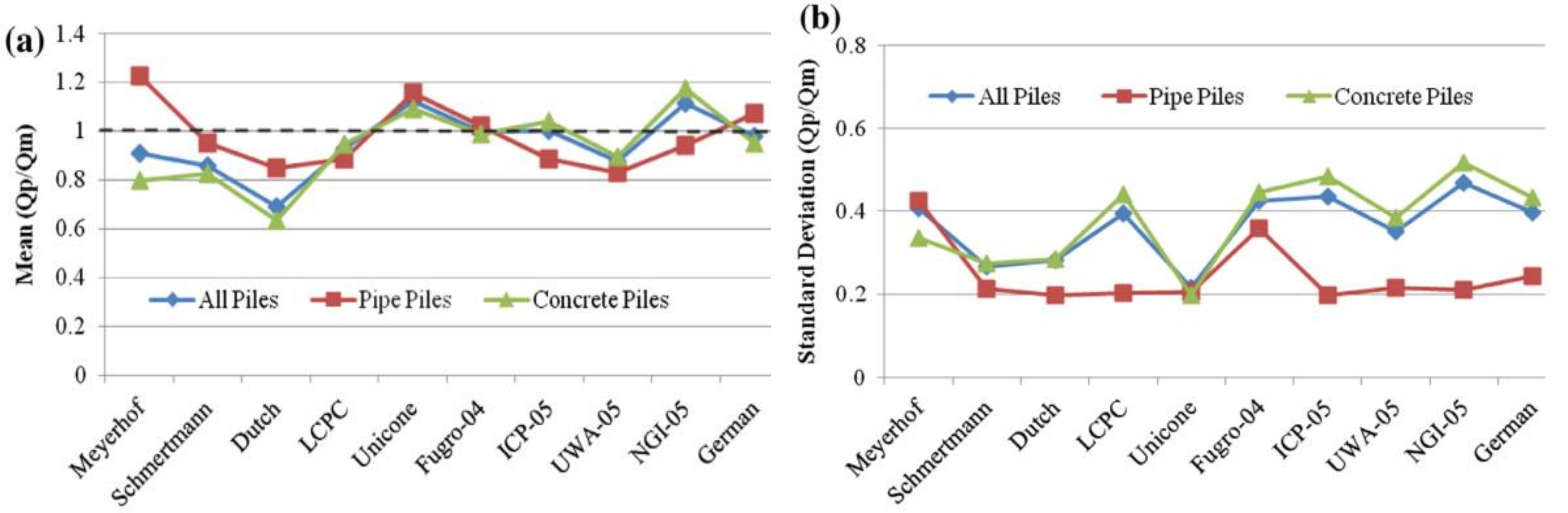




6. Typical Implementations

Moshfeghi & Eslami (2015-2019)

روش های تعیین ظرفیت باربری کششـــی و فشـــاری شمع با استفاده از CPT و CPTu



6. Typical Implementations

Moshfeghi & Eslami (2015-2019)

GEORISK
https://doi.org/10.1080/17499518.2018.1478105

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Failure analysis of CPT-based direct methods for axial capacity of driven piles in sand

S. Moshfeghi and A. Eslami

Department of Civil and Environmental Engineering, Amirkabir University of Technology, AUT, (Tehran Polytechnic), Tehran, Iran

ABSTRACT
Due to variety of current pile bearing capacity methods based on cone penetration test (CPT) measurements, there is always a need for evaluating performance of existing methods to make proper choices of methods as well as safety factors for optimum design. In this regard, geotechnical databases are known as useful tools which facilitate evaluation of existing methods. This paper deals with axial bearing capacity of driven piles in sand using CPT-based methods. A database of seventy-six records is employed to analyze different criteria of interpreting static pile load test results to select the most consistent approach with the CPT-based methods. Then, performance of nine commonly used direct CPT-based methods was evaluated. Finally, via a failure probability and cost optimisation approach, optimum safety factors are presented and discussed. Analysis of different failure criteria shows that the Hansen 80% criterion leads to more consistent results with the CPT-based methods. In addition, almost all of the investigated methods showed promising performance. The attained safety factors range from 1.6 to 3.1 for all records, 1.4 to 3.1 for piles in compression, and 1.4 to 2.2 for the piles in tension. Then, efficiency of methods was evaluated and the methods with higher efficiency are introduced.

ARTICLE HISTORY
Received 1 July 2016
Accepted 13 April 2018

KEYWORDS
Database; CPT; pile bearing capacity; load test; failure interpretation criterion; optimum safety factor; probability of failure

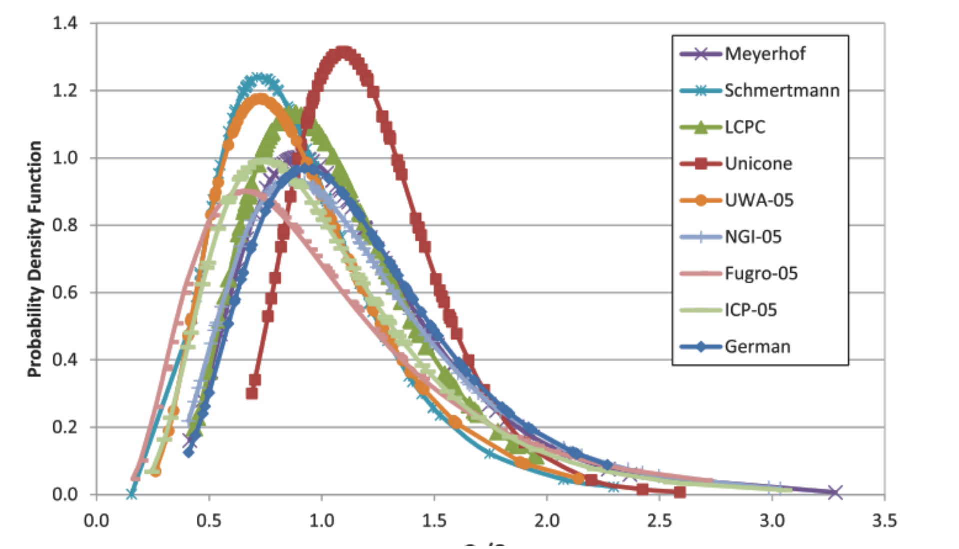
ارزیابی متدهای تعیین ظرفیت باربری مبتنی بر CPT:

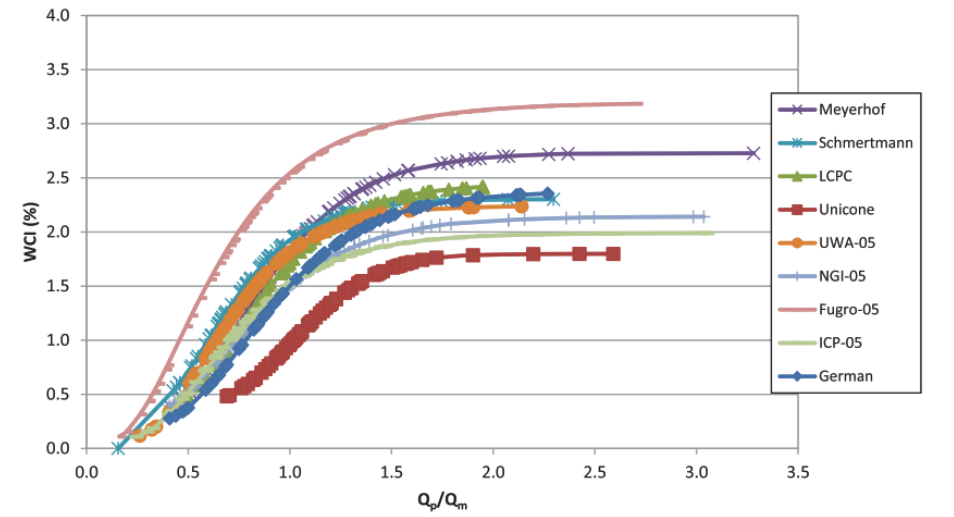
- ❑ ۷۶ مورد عملی شمع های کوبشی در ماسه
- ❑ تحلیل گسیختگی
- ❑ تعیین ضرایب اطمینان بهینه و کارایی روش‌ها

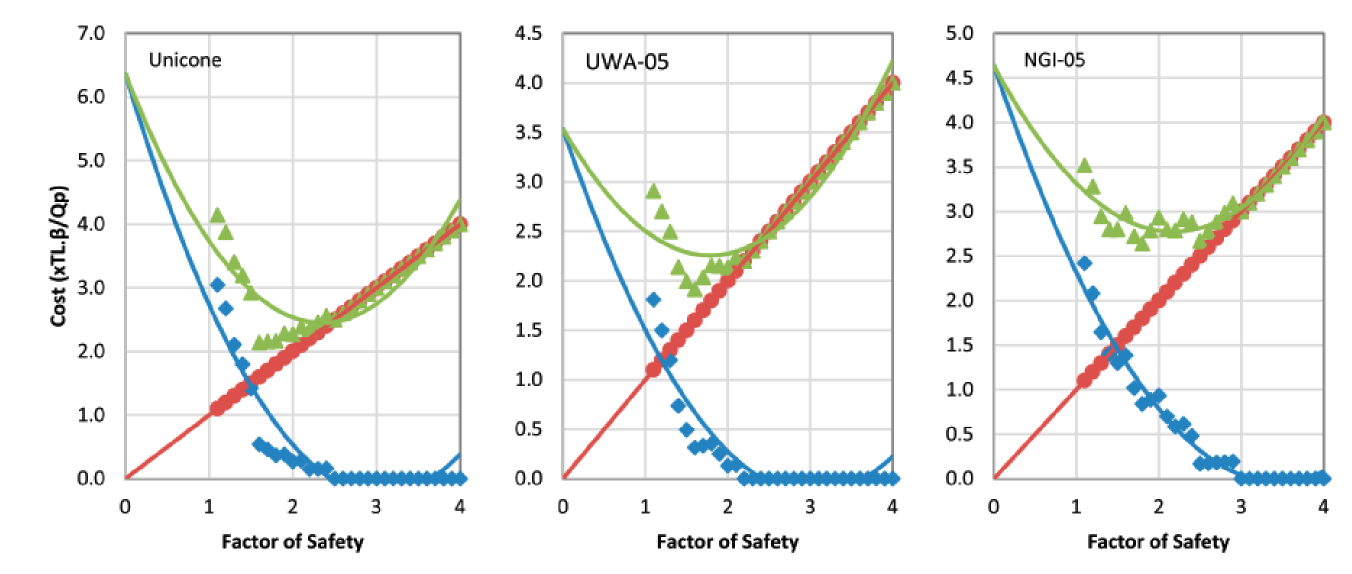
6. Typical Implementations

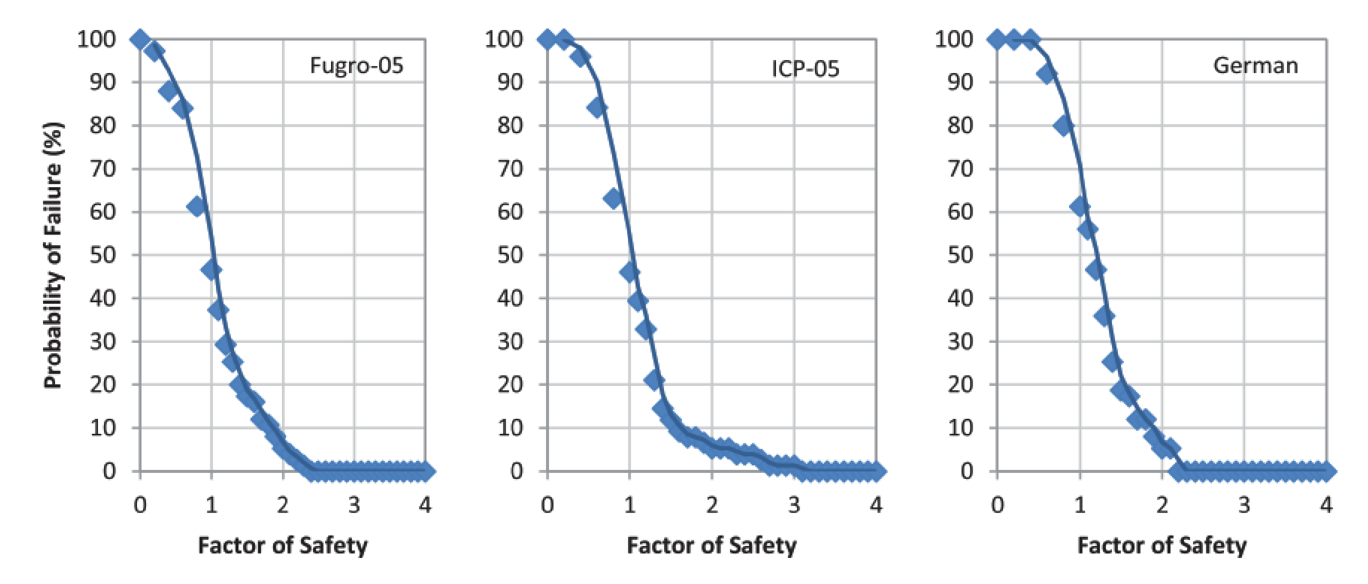
تعیین ضرایب اطمینان بهینه و کارایی روش هــای مبتنی بر CPT

Moshfeghi & Eslami (2015-2019)









6. Typical Implementations

Moshfeghi & Eslami (2015-2019)

تعیین ضرایب اطمینان بهینه و کارایی روش هــای مبتنی بر CPT

Method	FS_{opt}
Meyerhof-1976	2.4
Schmertman-1978	1.5-2.3
Dutch-1979	1.4, 1.5
LCPC-1982	2.0
Unicone-1997	1.6-2.5
UWA-2005	1.7, 2.2
NGI-2005	1.8,2.5
Fugro-2005	2.4
ICP-2005	1.6-3.1
German-2010	2.2

Method	Safety Factor					Min. S.F. for Risk=0
	1.5	2	2.5	3	3.5	
Meyerhof-1976	15.9	5.7	0	0	0	2.4
Schmertman-1978	5.7	2.3	0	0	0	2.3
Dutch-1979	0	0	0	0	0	1.5
LCPC-1982	15.9	0	0	0	0	2
Unicone-1997	17.0	2.3	0	0	0	2.5
UWA-2005	7.9	1.1	0	0	0	2.2
NGI-2005	15.7	7.9	1.1	0	0	3
Fugro-2005	14.6	4.5	0	0	0	2.4
ICP-2005	12.4	4.5	3.4	1.1	0	3.1
German-2010	16.8	4.5	0	0	0	2.2

6. Typical Implementations

CPT & Pile Databases
By: Eslami & Moshfeghi

Moshfeghi & Eslami (2015-2019)

MARINE GEORESOURCES & GEOTECHNOLOGY
https://doi.org/10.1080/1064119X.2018.1448493

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Reliability-based assessment of drilled displacement piles bearing capacity using CPT records

S. Moshfeghi and A. Eslami

Department of Civil and Environmental Engineering, Amirkabir University of Technology, AUT, (Tehran Polytechnic), Tehran, Iran

ABSTRACT
Drilled displacement piles (DDPs) are known as an alternative to conventional foundations in coastal areas, given the elimination of environmental impacts and difficulties caused by installation process of driven piles and more consistency with environment. Despite increasing employment of these piles, the extent of research works does not yet suffice the requisites to reach a routine design. This paper aims to analyze six cone penetration test (CPT)-based methods of determining the bearing capacity of DDP. The statistical and reliability-based approaches were used in two parts of assessing performance of the methods with respect to soil–pile characteristics followed by evaluating reliability of the prediction outcome. A database is compiled including 65 DDP load tests with adjacent CPT profiles. Performance of the methods are analyzed. Finally, a reliability parameter, i.e., confidence interval, is introduced to demonstrate a more realistic insight into the evaluations by expressing performance of the methods in terms of a range for possible average values of the predictions ratios, rather than simply an arithmetic mean. The study reveals that the commonly used CPT-based methods which have not been specifically developed for DDP show great potential for design. The results indicate that the investigated methods can have promising performance if some modifications are applied.

ARTICLE HISTORY
Received 10 November 2017
Accepted 1 March 2018

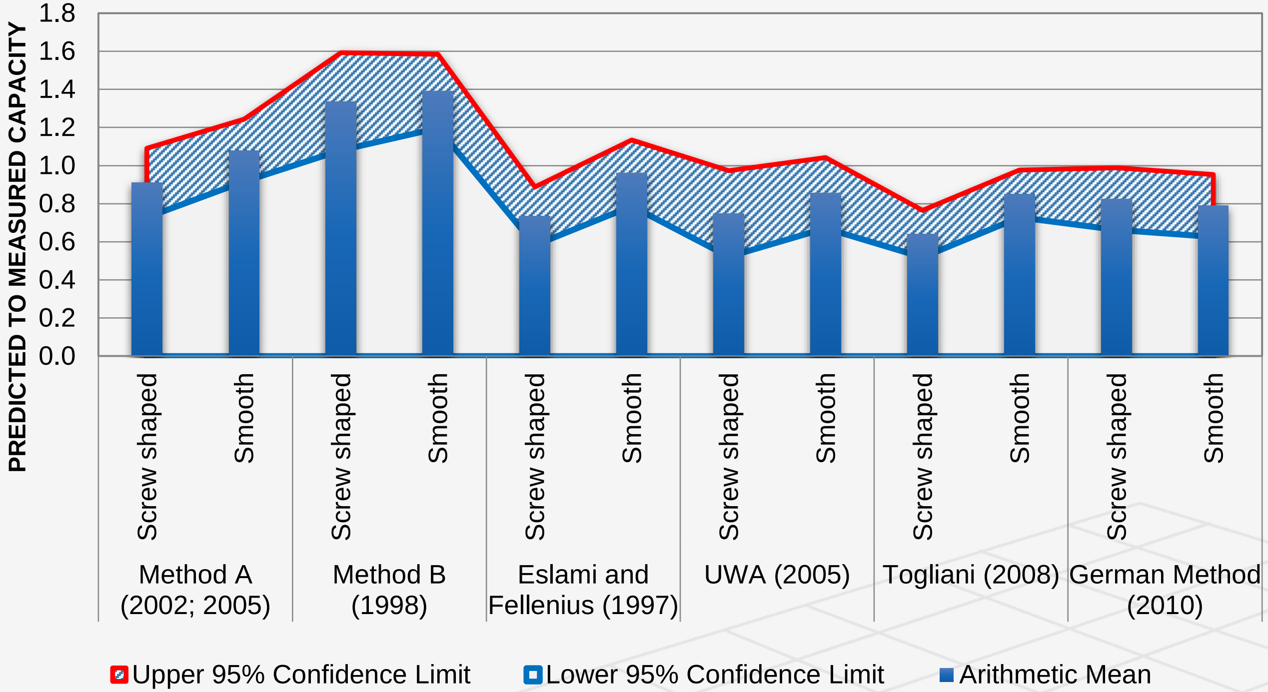
KEYWORDS
Bearing capacity; confidence interval; CPT methods; drilled displacement pile (DDP); reliability-based evaluation

ارزیابی کاربرد روش هــای مبتنی بر CPT در شمع‌های جابجایی–جایگزینی

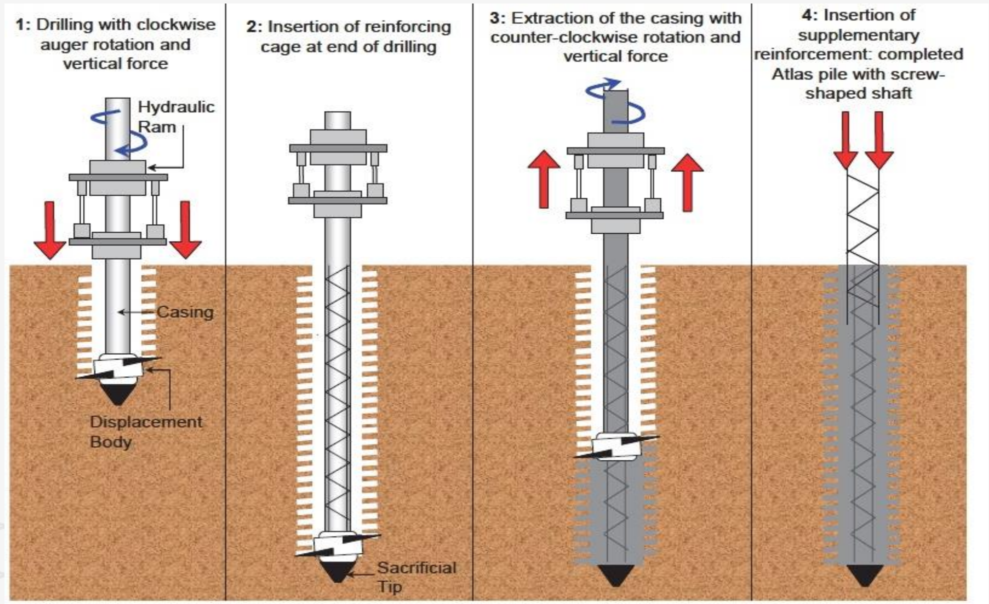
6. Typical Implementations

Moshfeghi & Eslami (2015-2019)

ارزیابی کاربرد روش های مبتنی بـــر CPT در شمع‌های جابجایی–جایگزینی



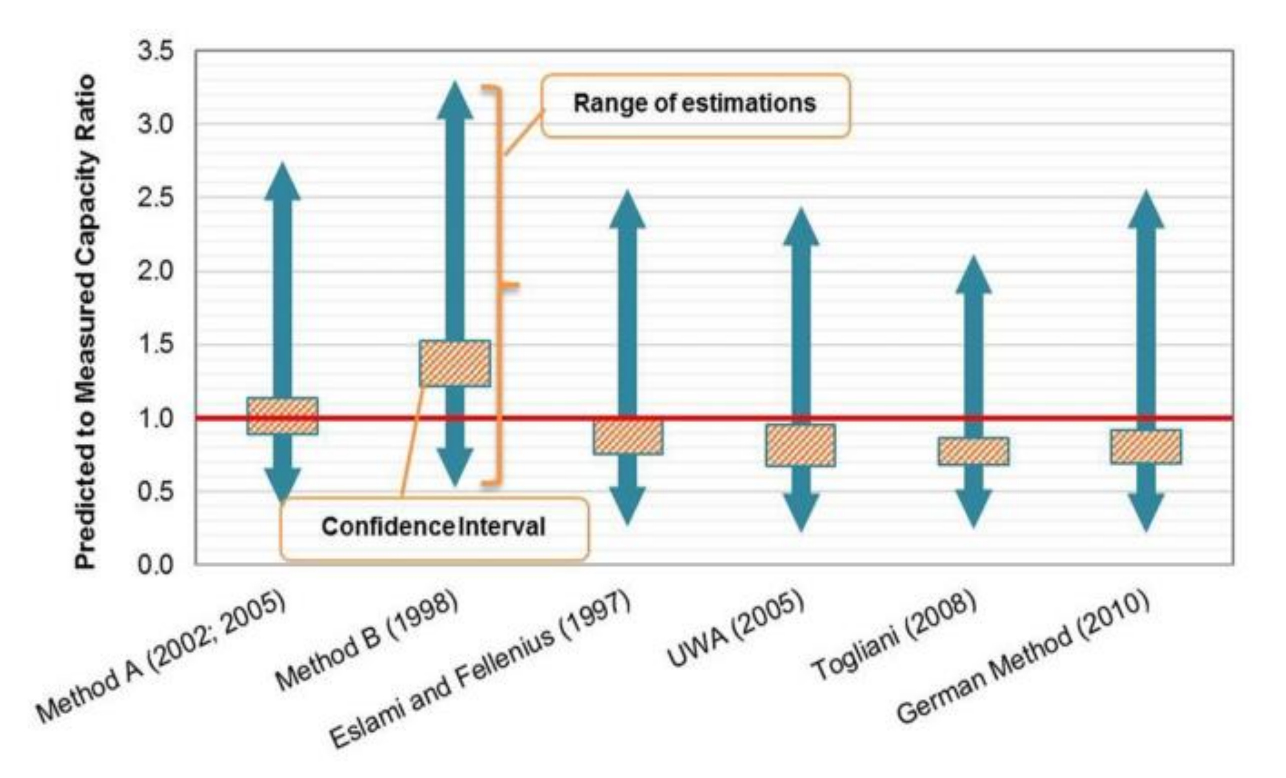
Evaluation results of CPT-based methods based on shaft shapes

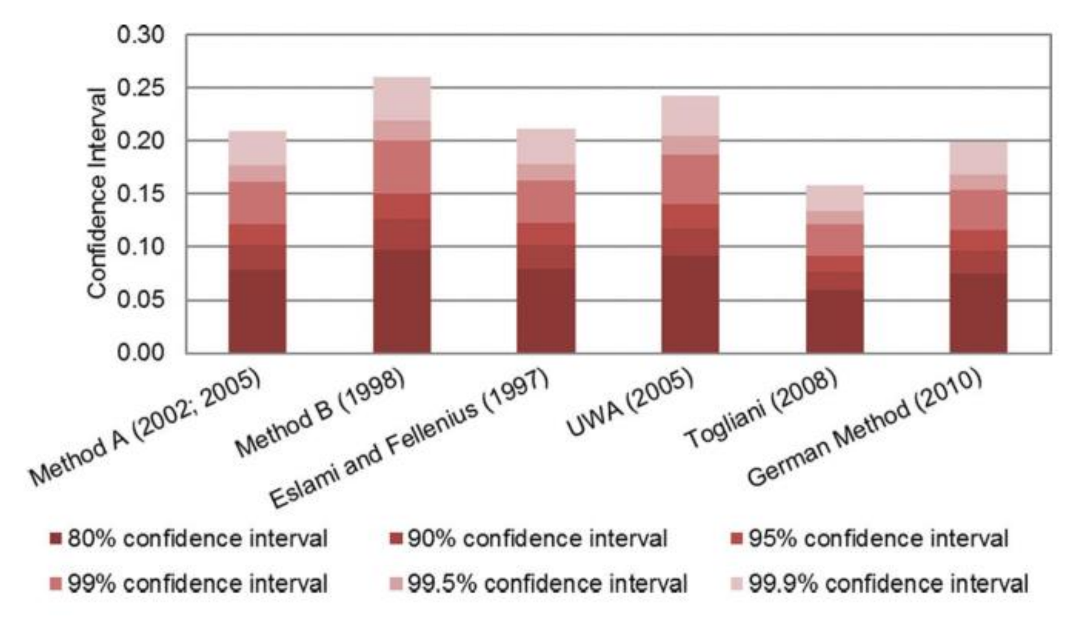


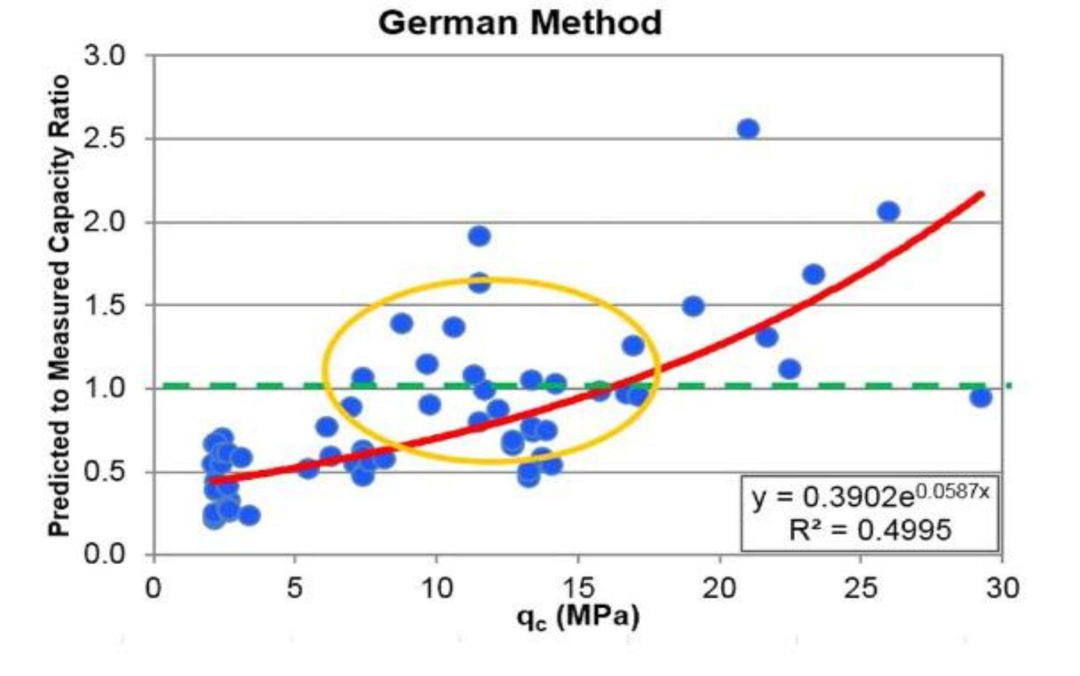
Drilling displacement procedure of Atlas piles (Basu et al., 2010)

6. Typical Implementations

Moshfeghi & Eslami (2015-2019)







6. Typical Implementations

CPT & Pile Databases
By: Eslami & Moshfeghi

Eslami & Valikhah (2017-2019)

توزیع مقاومت کف و جدار شمع در عمق مبتنی بر نتایج CPT (۱۶ مورد شمع کوبشی و درجاریز)

Geotech Geol Eng
DOI 10.1007/s10706-017-0287-8

CrossMark

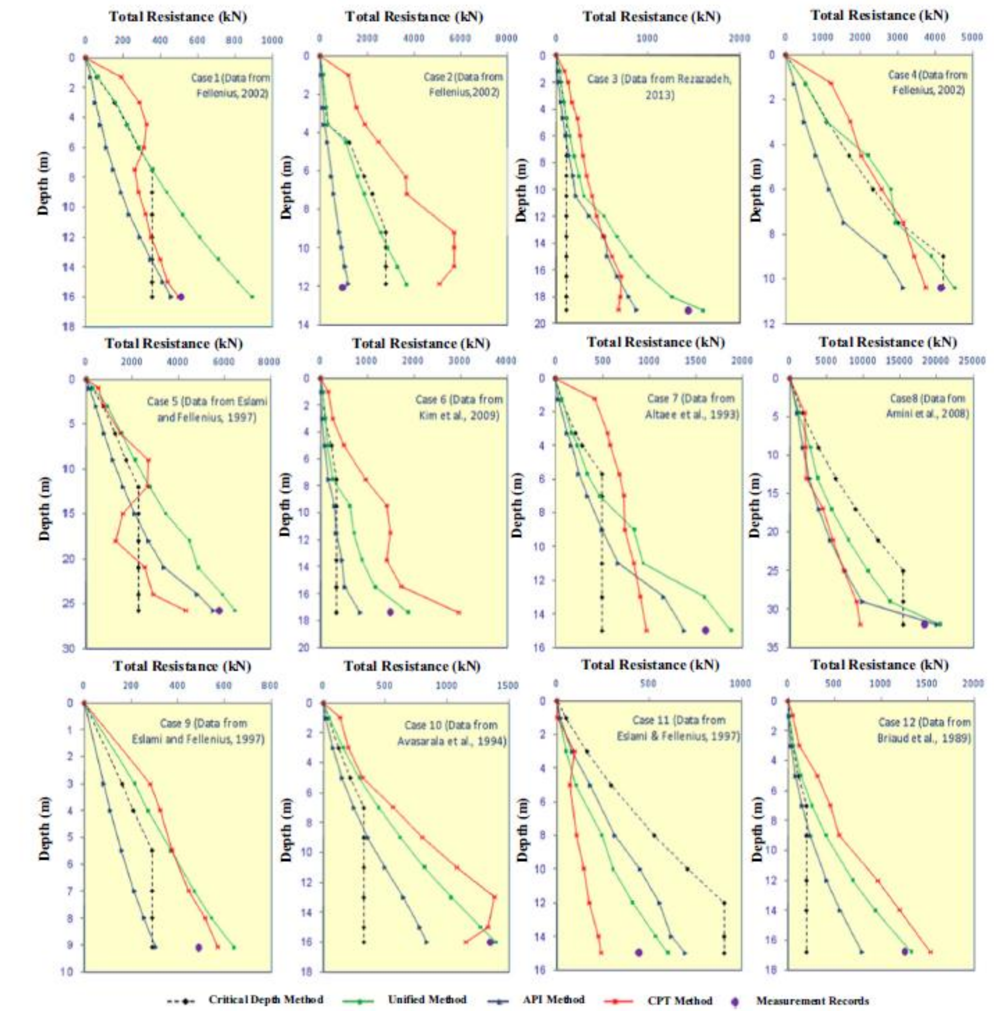
ORIGINAL PAPER

CPT-Based Investigation for Pile Toe and Shaft Resistances Distribution

A. Eslami · F. Valikhah · M. Veiskarami · M. Salehi

Received: 16 April 2016 / Accepted: 22 June 2017

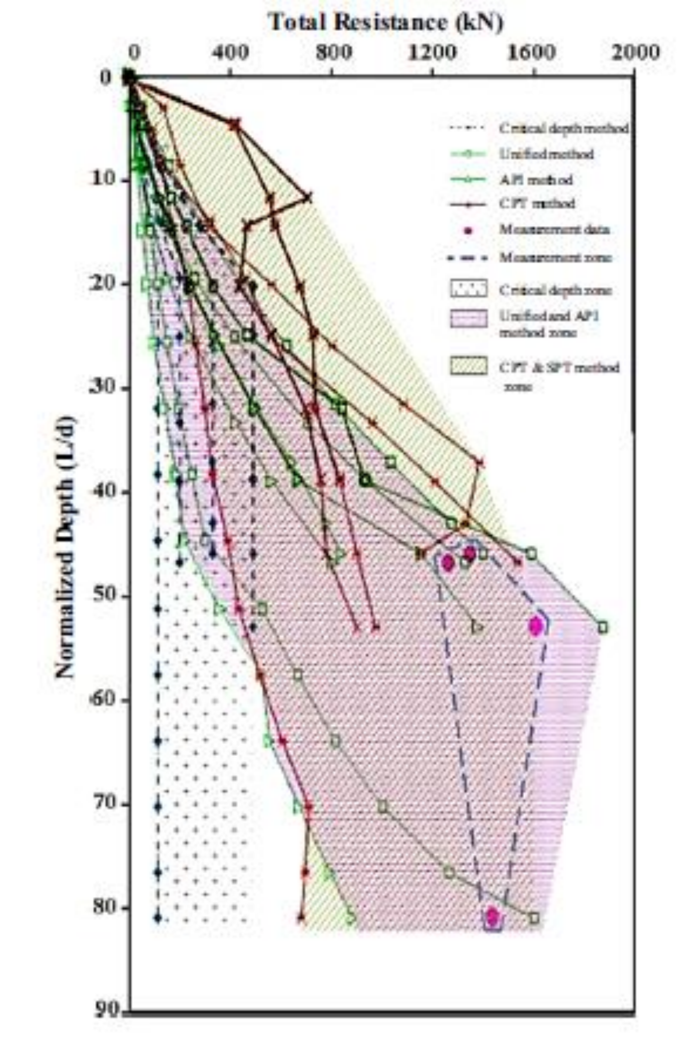
Abstract The true distribution of both pile shaft and toe resistances along depth, has been an important issue in geotechnical engineering. Twenty four pile load test case records of deep foundation projects, where CPT, Cone Penetration Test, soundings were also advanced close to piles locations, throughout the world have been compiled for investigations and analyses. The geomaterial at these sites are homogenous, including sandy, clayey and silty soils. Four different methods for determining pile bearing capacity comprising the method based on critical depth concept, recommended approaches by CFEM, Canadian Foundation Engineering Manual 2006 (Unified method), American Petroleum Institute (API), and CPT-based methods are presented, compared and discussed. In addition, the influence of factors such as soil friction angle variations, calculated from q_c, cone tip resistance, and overburden stress, are taken into account to perform indirect calculations. Direct and indirect CPT-based calculations on the pile capacity are studied to investigate the actual pile toe and shaft resistances distribution along depth. The comparisons reveal that in practice and in observations from full scale tests, shaft and toe resistances follow a nonlinear and gradual trend beyond the certain depth. However, it is not in agreement with conventional linear-constant or relatively linear distribution concept and some recommended codes.



6. Typical Implementations

Eslami & Valikhah (2017-2019)

توزیع مقاومت کف و جدار شمع در عمق مبتنی بر نتایج CPT– بررسی تئوری عمق بحرانی



Comparison of the results reveals that bearing capacity at the critical depth, **is neither linear-constant, nor linear** as suggested by Unified codes.

Rather, the calculations in direct methods including CPT-based and UniCone show that bearing capacity gradually varies with depth and have a **gradual decreasing trend.**

Total pile resistance distribution versus normalized pile geometry (L/d) for cases No. 3, 7, 10, 12

6. Typical Implementations

Valikhah & Eslami (2017-2019)

رفتار بار–جابجایی شمع‌های کوبشی مبتنی بر نتایج CPT
(۹۸ مورد شمع کوبشی)

International Journal of Civil Engineering
https://doi.org/10.1007/s40999-018-0388-7

RESEARCH PAPER

CrossMark

Load–Displacement Behavior of Driven Piles in Sand Using CPT-Based Stress and Strain Fields

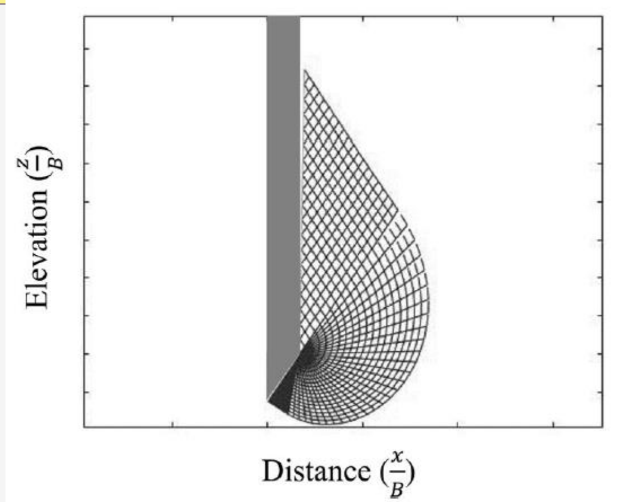
Fatemeh Valikhah[1] · Abolfazl Eslami[1] · Mehdi Veiskarami[2]

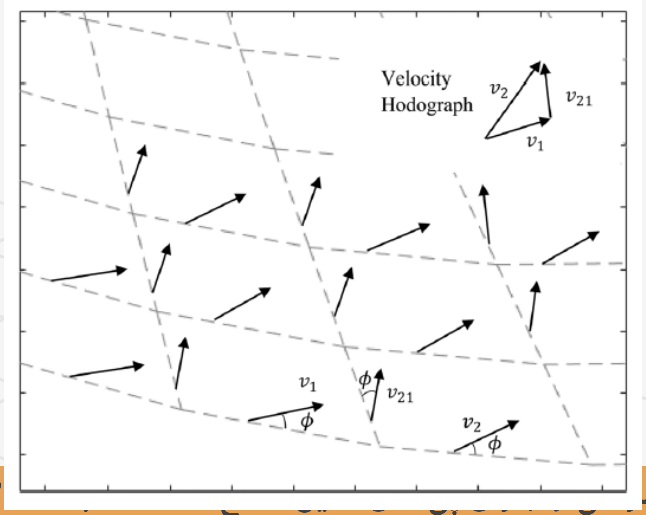
Received: 24 September 2018 / Revised: 24 November 2018 / Accepted: 10 December 2018

Abstract

The bearing capacity of piles is often estimated by a variety of methods such as the limit equilibrium or the limit analysis. In contrast, the load–displacement behavior, which should not be disregarded in common practices, cannot be obtained as simply as the bearing capacity. The reason is its dependency on the stress and the strain (or the displacement) fields around the pile. In the current work, attempt has been made to predict the load–displacement behavior of driven piles in sand by direct and indirect implementation of the cone penetration test (CPT) data into the displacement field. CPT often serves as a very successful in situ test which provides a close link between the soil resistance and the bearing capacity, although it brings no direct information. A rather simple procedure is presented to indirectly use the CPT data to find the stress and strain fields. While the pattern of the failure mechanism has been obtained by the method of stress characteristics, the displacement (and strain) field has been found by the kinematics of the failure mechanism. The proposed procedure has been calibrated and verified by 98 case histories including pile load test results in conjunction with CPT data. Comparisons made by this new method show that the CPT-based method of stress characteristics can be successfully used in load–displacement prediction of driven piles.

Keywords Pile · CPT · Load–displacement · Stress characteristics method · Displacement field

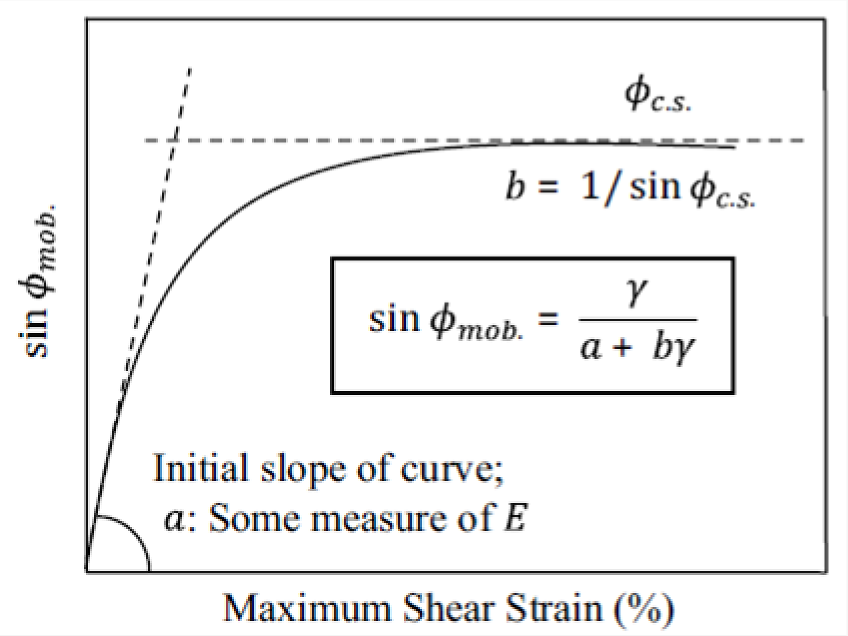




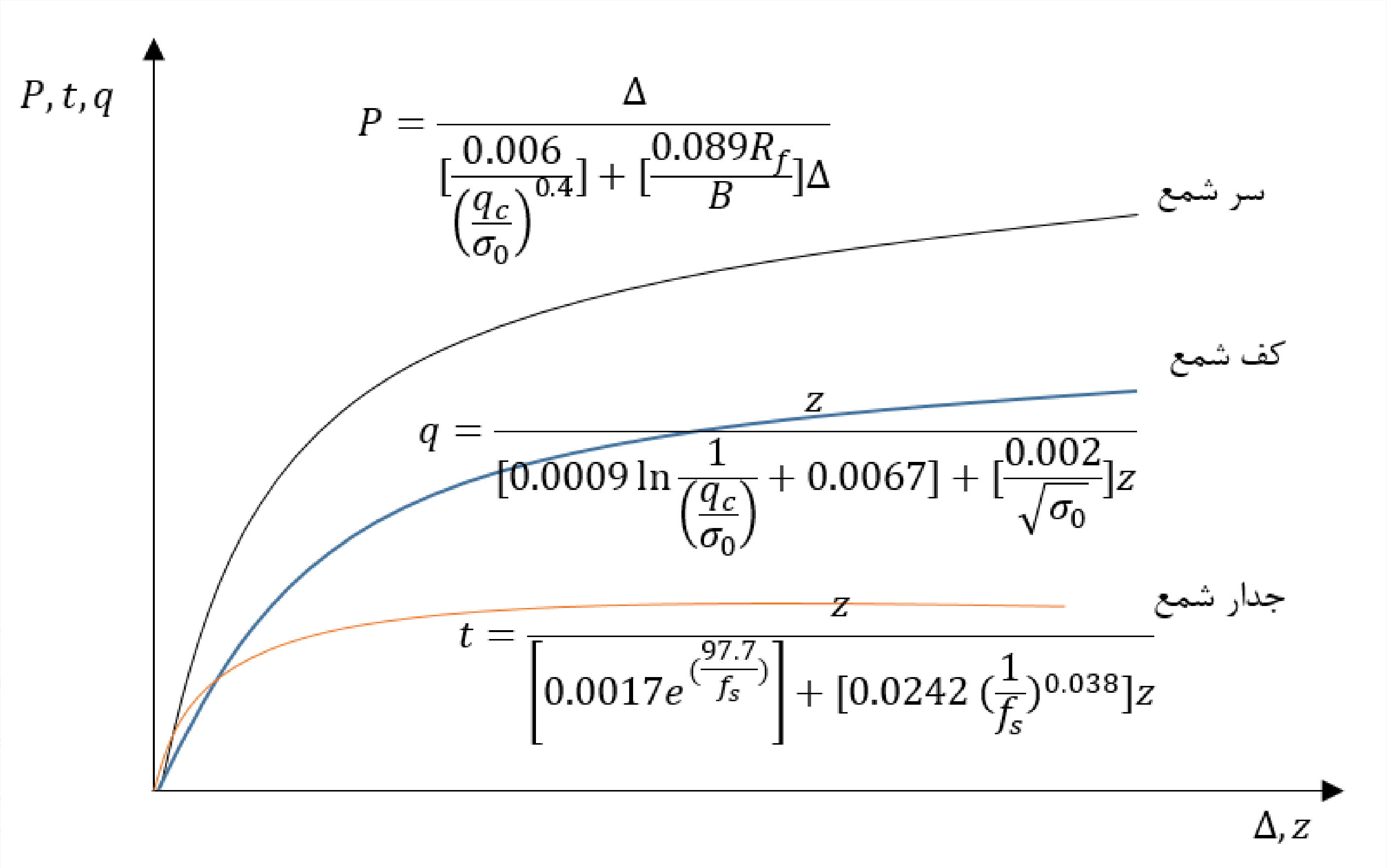
6. Typical Implementations

Valikhah & Eslami (2017-2019)

رفتار بار–جابجایی شمع‌های کوبشی مبتنی بر نتایج CPT



Hyperbolic relation between $\sin\phi_{mob.}$ and maximum shear strain



6. Typical Implementations

Valikhah & Eslami (2017-2019)

روش مبتنی بر نتایج CPT برای تخمین نشست پی‌ها (۴۶ مورد پی سطحی)

Arabian Journal for Science and Engineering
https://doi.org/10.1007/s13369-019-04034-y

RESEARCH ARTICLE - CIVIL ENGINEERING

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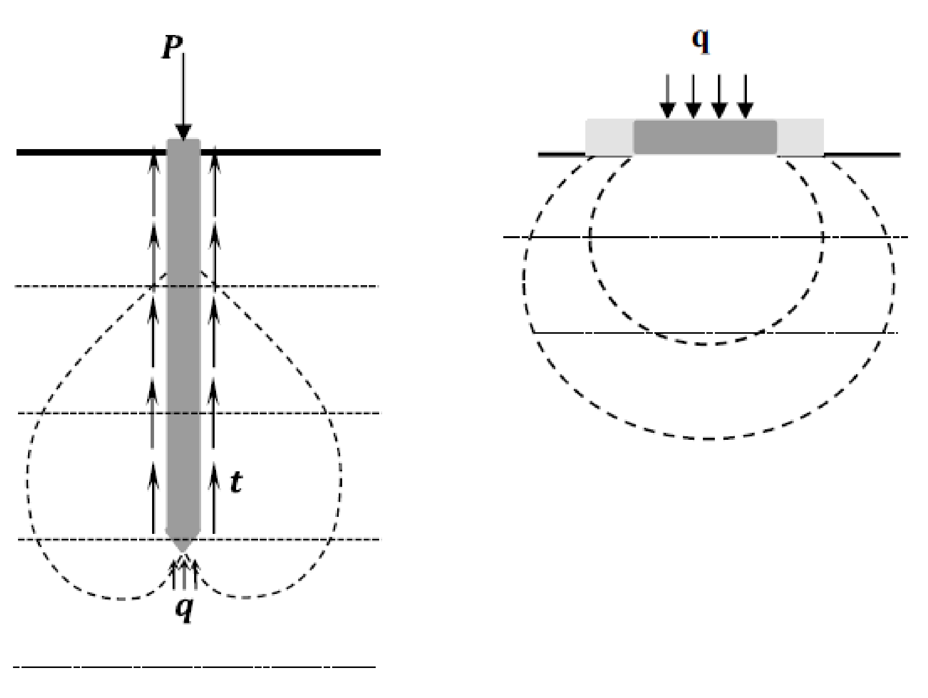
CPT-Based Nonlinear Stress–Strain Approach for Evaluating Foundation Settlement: Analytical and Numerical Analysis

Fatemeh Valikhah[1] · Abolfazl Eslami[1]

Received: 9 May 2019 / Accepted: 16 July 2019

Abstract
Due to complexities in soil–foundation interaction and nonlinear behavior of subsoil, considerable uncertainty is involved in the foundation settlement evaluation. In the present paper, a new analytical approach is proposed to estimate the foundation settlement based on soil behavior classification charts developed from CPT records. The approach is founded on the Janbu nonlinear stress–strain method. However, instead of using fixed parameters in the Janbu method, the variable coefficients are used depending on geomaterial properties. Also, in the proposed approach, the scale effect is taken into account for foundation width considering soil stiffness. The proposed procedure is calibrated and verified by a data bank containing 46 case histories including 22 square, 17 circular and 7 rectangular foundations with widths varying between 0.3 and 2.4 m in conjunction with CPT data. Furthermore, the numerical finite difference analysis using a CPT-based stress characteristics method is carried out to validate the proposed approach for the prediction of foundation settlement. The accuracy of the calculations done by the proposed and some available common methods is investigated. Comparisons based on statistical and probabilistic methods apparently reveal that the proposed approach calculates the foundation settlement promisingly.

Keywords Nonlinear stress–strain · Settlement · CPT data · Stiffness modulus · Analytical and numerical analysis · Data bank



Valikhah & Eslami (2017-2019)

روش مبتنی بر نتایج CPT برای تخمین نشست پی‌ها

Janbu (1967) Method for Foundation Settlement Estimation:

$$\varepsilon = \frac{\Delta H}{H}$$

$$\varepsilon = \frac{1}{mj}\left[\left(\frac{\sigma'_0 + \Delta\sigma'}{100}\right)^j - \left(\frac{\sigma'_0}{100}\right)^j\right]$$

Range of modulus number (m) and stress exponent (j) for different soils in Janbu approach

Soil type		Modulus number	Stress exponent (j)
Till, very dense to dense		300–1000	1
Gravel		40–400	1
Sand	Dense	250–400	0.5
	Compact	150–250	0.5
	Loose	100–150	0.5
Silt	Dense	80–200	0.5
	Compact	60–80	0.5
	Loose	40–60	0.5
Silty clay and clayey silt	Hard, stiff	20–60	0
	Stiff, firm	10–20	0
	Soft	5–10	0
Soft marine clays and organic clays		5–20	0
Peat		1–5	0

Malekdoost and Eslami (2011):

$$j = \frac{q_c\left[1 + \left(0.05\log q_c\right) \times R_f^2\right]}{5^{\log q_c}\left(11\sqrt{R_f} + R_f^2\right)}$$

$$m = \alpha q_c$$

$$\alpha = 2$$

6. Typical Implementations

Valikhah & Eslami (2017-2019)

روش مبتنی بر نتایج CPT برای تخمین نشست پی‌ها

$$\varepsilon = \frac{\Delta H}{H}$$

$$\varepsilon = \frac{1}{mj}\left[\left(\frac{\sigma'_0 + \Delta\sigma'}{100}\right)^j - \left(\frac{\sigma'_0}{100}\right)^j\right]$$

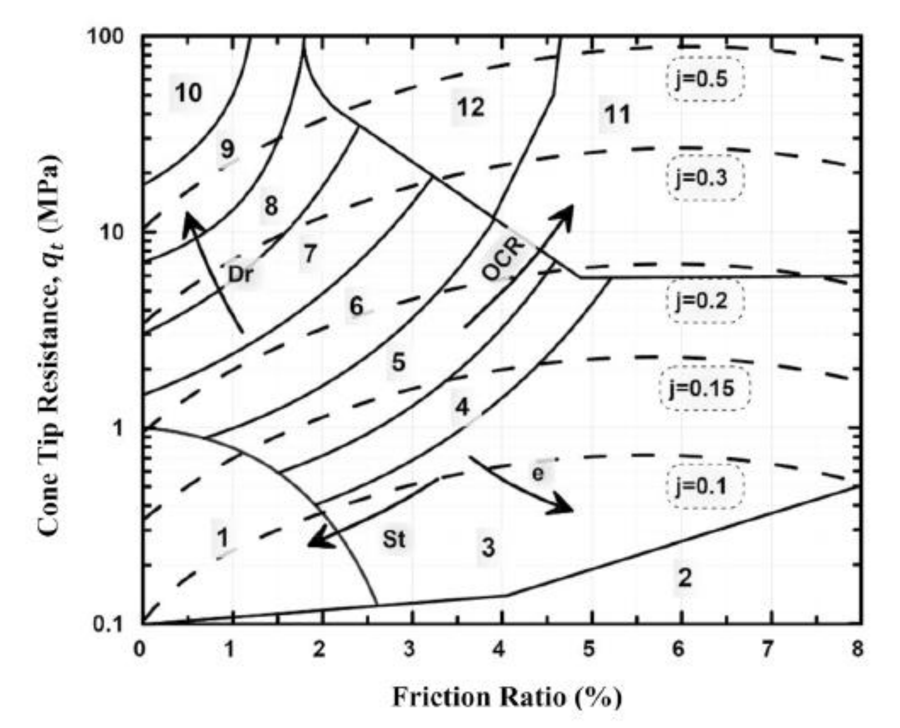
$$m = \alpha q_c$$

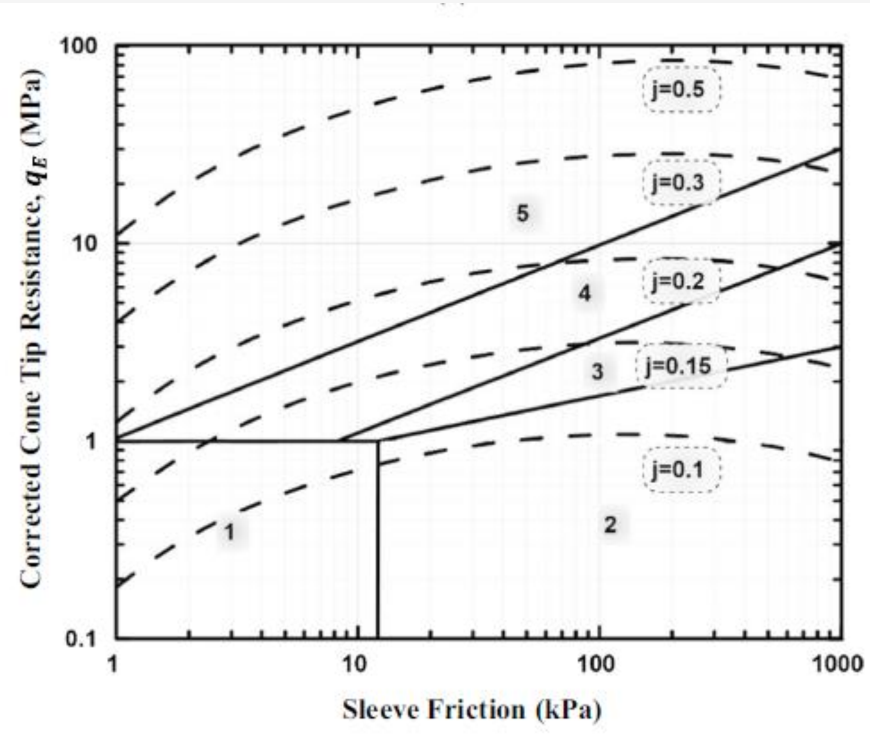
$$\alpha = 0.25b \times \left(\frac{2B+1}{3B}\right)^3$$

$$j = \frac{q_c}{x + yq_c}$$

$$x = 0.02R_f + 0.5$$

$$y = 7.53(\sigma'_0)^{-0.25}$$





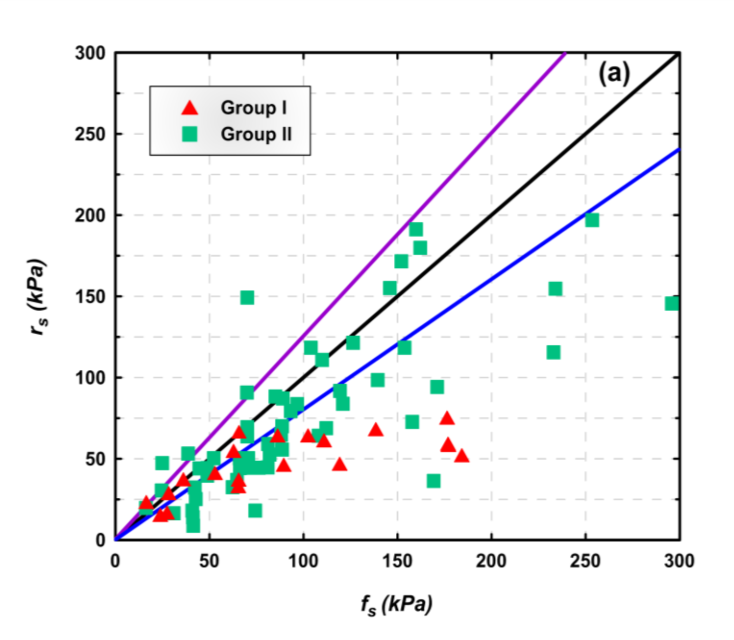
6. Typical Implementations

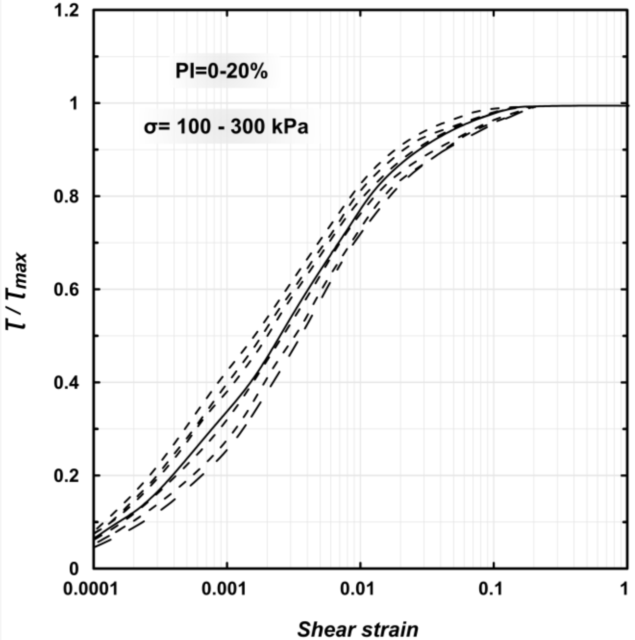
Eslami, Lotfi, Infante, Moshfeghi & Eslami (2019)

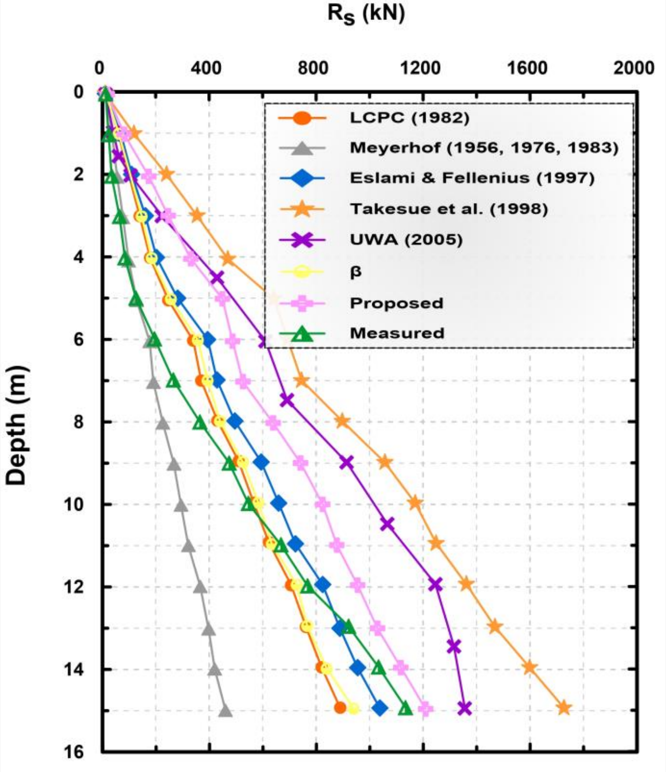
تعیین ظرفیت باربری جداری شمع ها با استفاده از نتایج CPT با لحاظ آثار ابعادی (f_s-r_s)

$$\gamma_{Pile} = 0.0255\,(V_{Pile})^{0.61}.(D_{Pile})^{0.5}$$

$$r_{s(z)} = k_z\,.k.\,f_{s(z)}$$







6. Typical Implementations

Heidarie, Jamshidi, Eslami (2019a)

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https://doi.org/10.1080/17499518.2019.1628281

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Reliability based assessment of axial pile bearing capacity: static analysis, SPT and CPT-based methods

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ABSTRACT

Since piles are one of the major geotechnical foundation systems, estimation of their axial bearing capacity is of great importance. Employing different design methods, resulting in a wide range of bearing capacity estimations, complicates the selection of an appropriate design scheme and confirms the existence of model error along with the inherent soil variability in bearing capacity prediction. This paper tends to evaluate different predictive methods in Reliability-Based Design (RBD) framework. In this regard, different static analyses, SPT and CPT-based methods are considered to evaluate which approaches collectively and which method individually, have more reliable predictions for compiled data bank. In order to assess reliability indices and resistance factors, two approaches have been considered, i.e. First Order Second Moment method (FOSM) and First Order Reliability Method (FORM). To investigate the reliability indices for different methods in both RBD approaches, various safety factors and loading ratios have been considered. Also, the Load and Resistance Factor Design (LRFD) resistance factors are calibrated for different target reliability indices and loading ratios. Results show that CPT-based methods are more reliable among other methods. Furthermore, the estimated efficiency ratio, i.e. the ratio of resistance factor to resistance bias factor, confirms this agreement.

ARTICLE HISTORY
Received 11 November 2018
Accepted 2 June 2019

KEYWORDS
Axial pile bearing capacity; CPT; LRFD; pile foundation; reliability based design

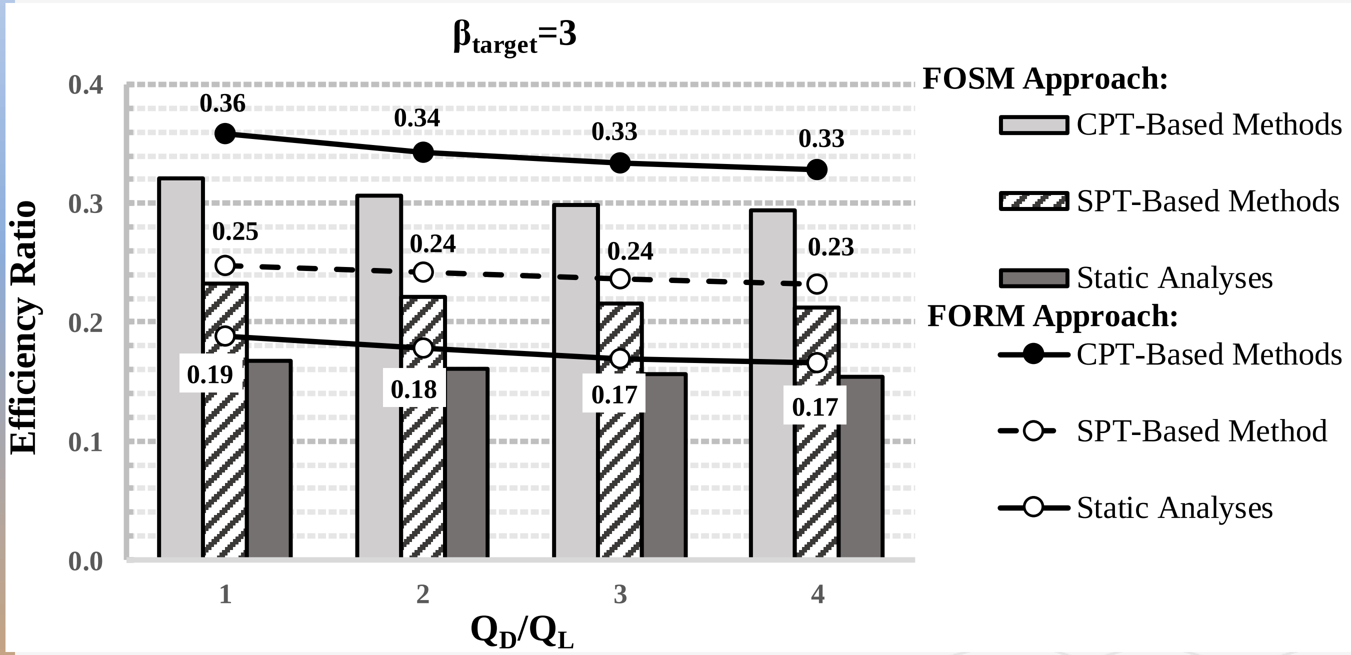
ارزیـــابی احتمـــالاتی عـــدم قطعیت مدل برای روش‌هــای تعیین ظرفیت باربری شمع‌ها

CPT & Pile Databases
By: Eslami & Moshfeghi

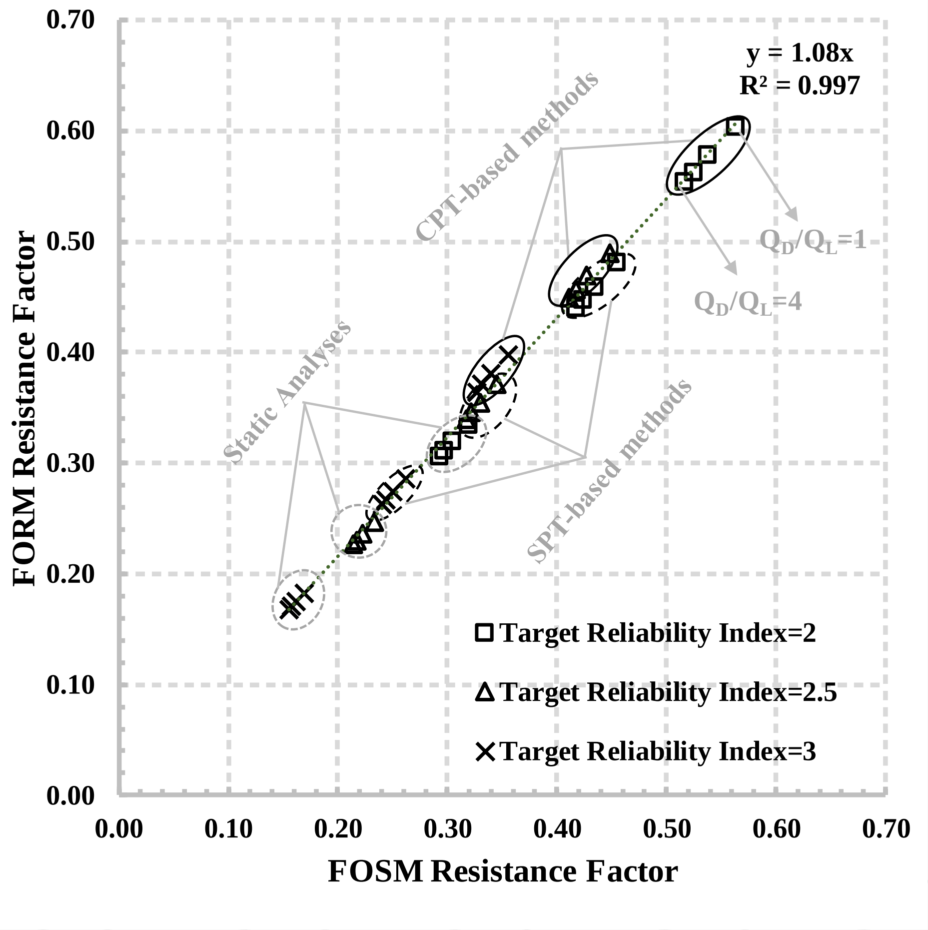
6. Typical Implementations

Heidarie, Jamshidi, Eslami (2019a)

ارزیابی احتمالاتی عدم قطعیت مدل برای روش‌های تعیین ظرفیت باربری شمع‌ها



مقایسه عملکرد رویکردهای مختلف تخمین ظرفیت باربری شمع

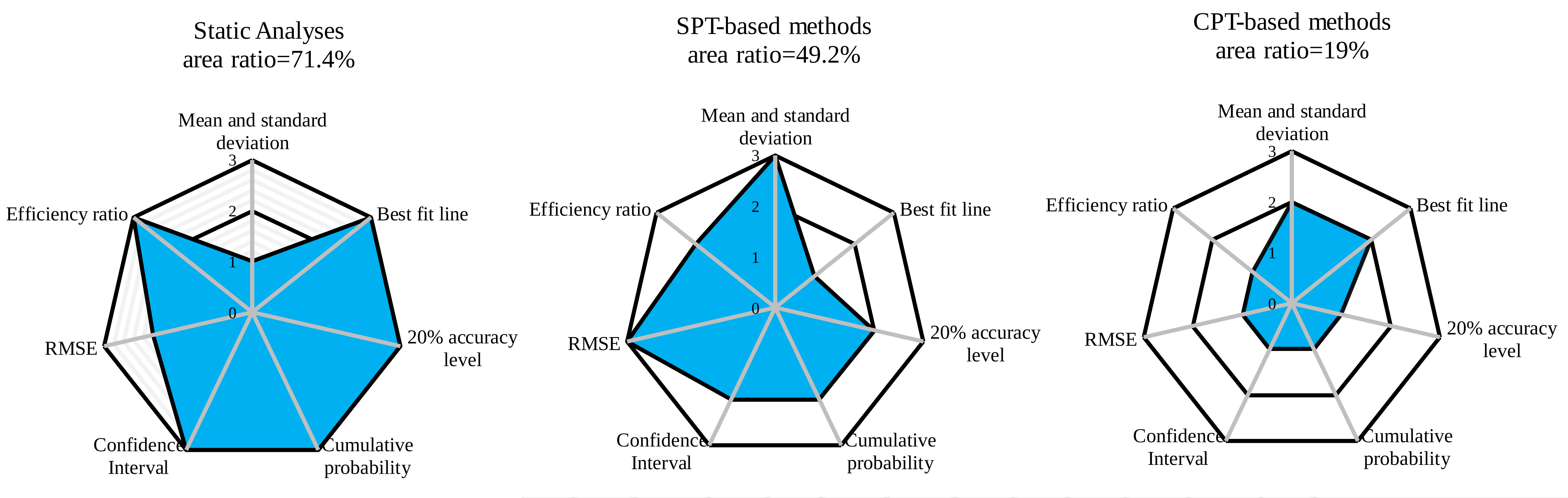


بررسی پارامترهای موثر بر ضریب مقاومت

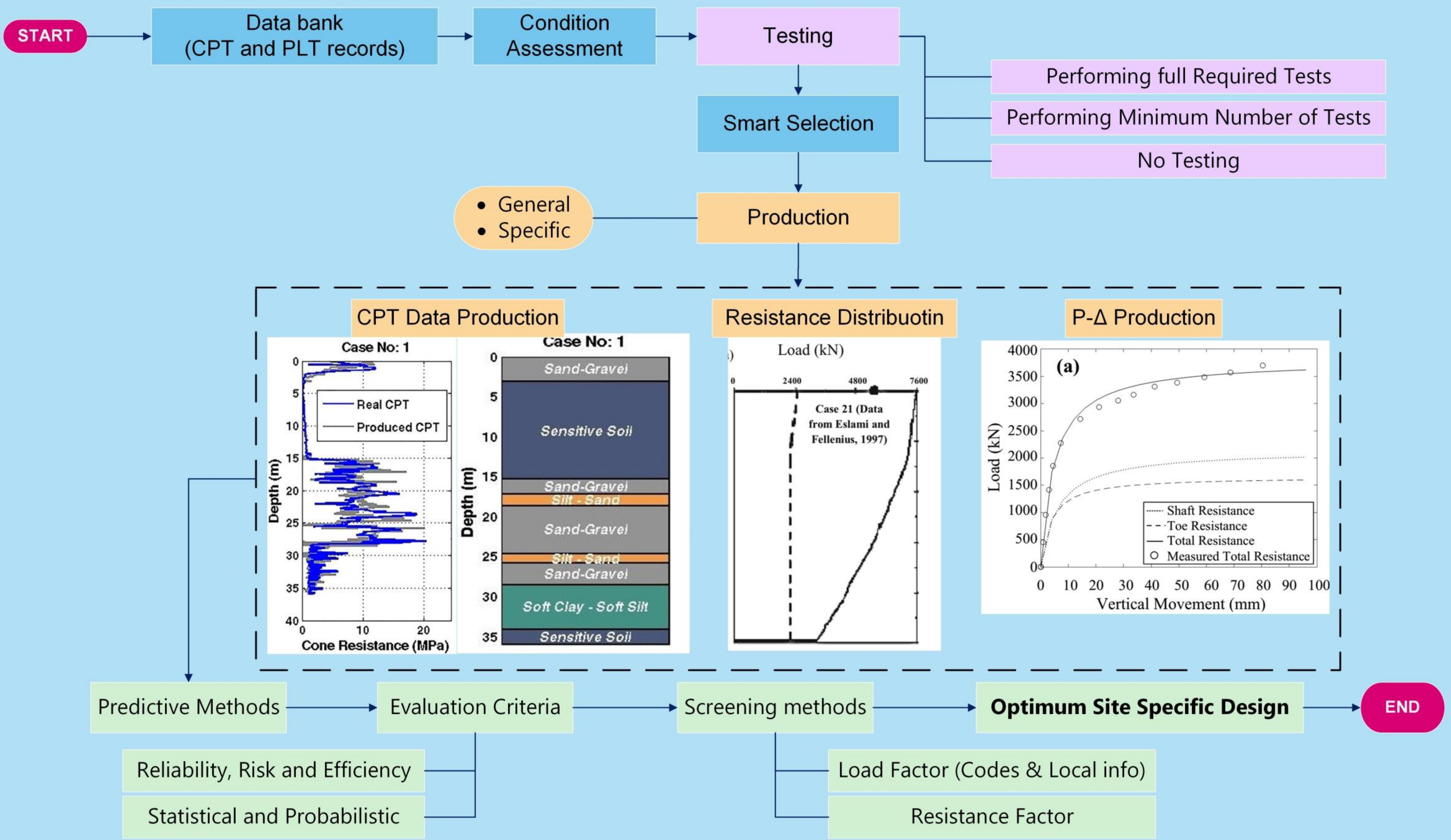
6. Typical Implementations

Heidarie, Jamshidi, Eslami (2019b)

ارزیابی احتمالاتی عدم قطعیت مدل برای روش‌های تعیین ظرفیت باربری شمع‌ها



Data-Based Pile Design



6. Typical Implementations

Eslami, Moshfeghi, Heidari, Valikhah (2019)- Fellenius Issue

Geotechnical Engineering Journal of the SEAGS & AGSSEA Vol. 50 No. 2 June 2019 ISSN 0046-5828

AUT: Geo-CPT&Pile Database
Updates and Implementations for Pile Geotechnical Design

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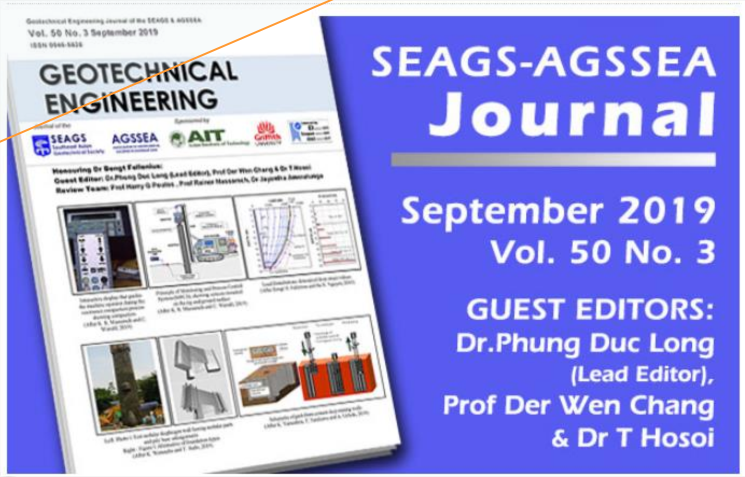
B. H. Fellenius ISSUE

ABSTRACT: Due to uncertainties in geomaterial properties and modelling, a detailed and precise data source can significantly improve reliability indices. Accordingly, to facilitate quantifying the uncertainties, there are currently several databases in the realm of piling and CPT. AUT (Amirkabir University of Technology): Geo-CPT&Pile Database was initially developed in 2015 by 466 case records including pile and CPT records. At present, it is updated to the total number of 600 case records which is partly accessible online. Aiming at pile performance-based design, risk analyses and evaluation of optimum safety factor have been examined based on value engineering by Wasted Capacity Index (WCI). Subsequently, the performance of direct and indirect CPT methods for pile bearing capacity estimation has been assessed focusing on reliability-based approaches. In addition, a methodology was employed to predict the load-displacement and bearing capacity of driven piles interactively. Finally, an algorithm is implemented for pile geotechnical performance-based design through a selected database considering probabilistic, reliability and risk assessments.

KEYWORDS: AUT: Geo-CPT & Pile Database, Pile Capacity, CPT-based Methods, Performance-Based Design (PBD)

AGSSEA Association of Geotechnical Societies in Southeast Asia
SEAGS Southeast Asian Geotechnical Society



7. Concluding Remarks

1. CPT and Pile (Past):

- Provides continuous records with depth
- Cone penetrometer is considered as a model pile
- Direct and indirect approaches for bearing capacity
- Bearing capacity methods: more than 28 currently used

PAST

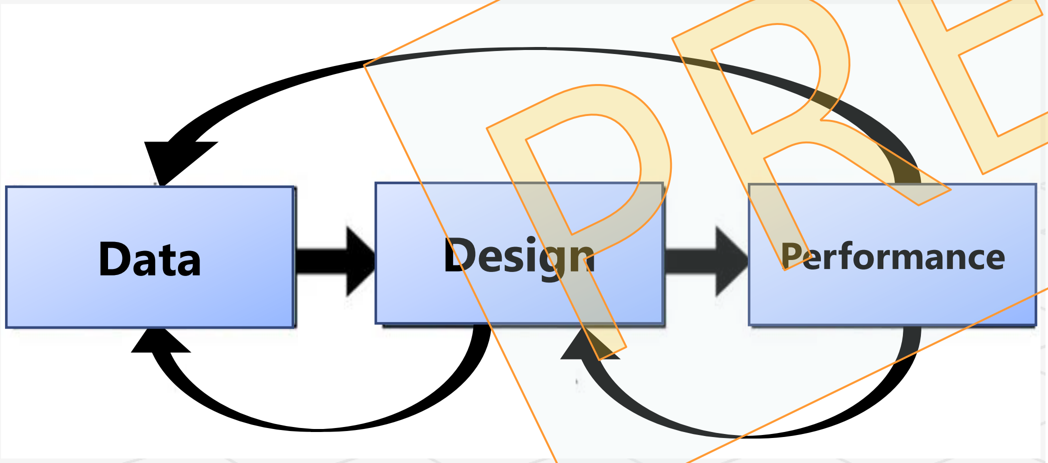
روش‌های کلاسیک طراحی ژئوتکنیکی شمع‌ها بر مبنای نتایج CPT: خطی

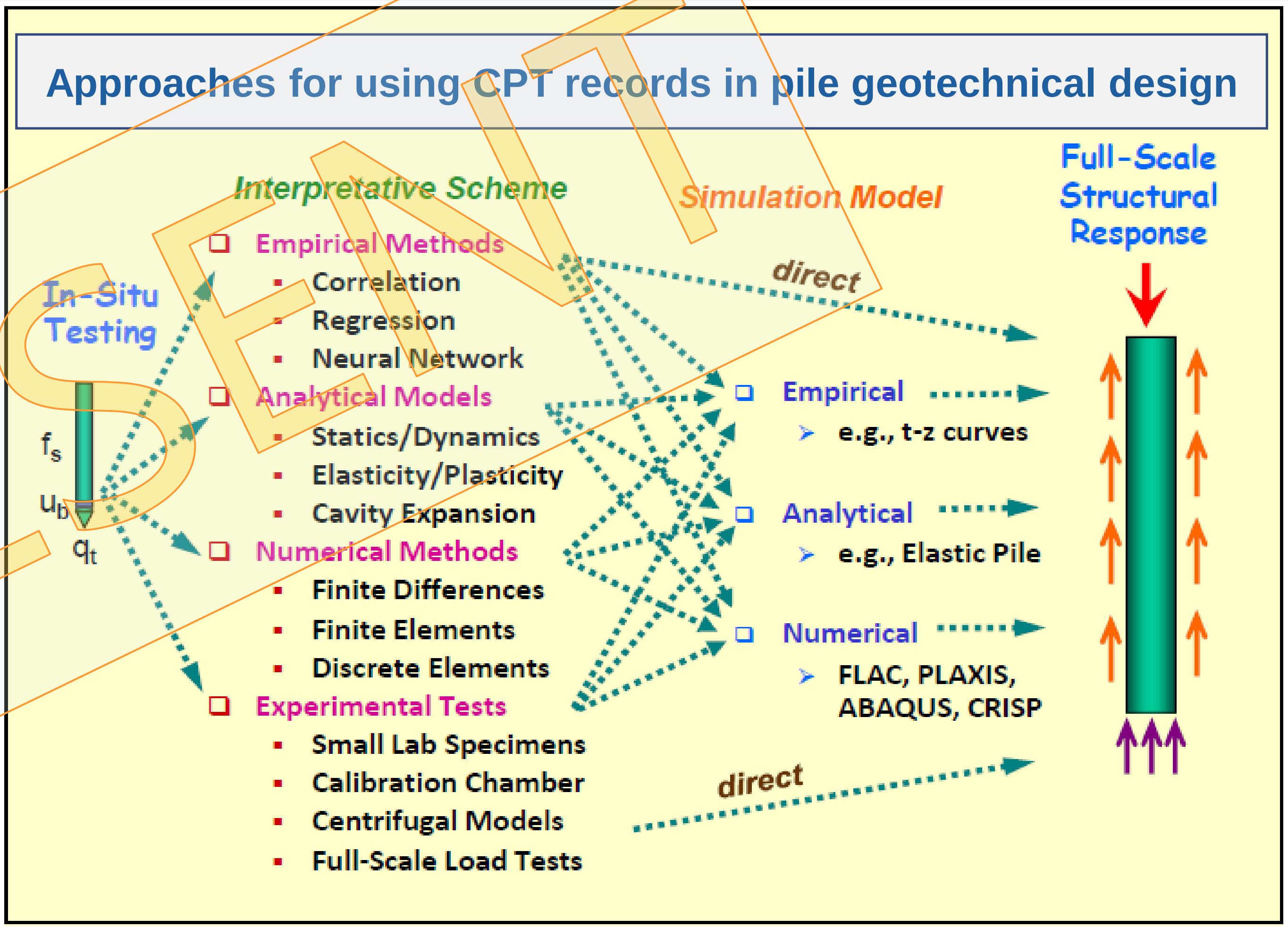
7. Concluding Remarks

2. CPT & CPTu: Pile Geotechnical Design (Present):

روش‌های جاری طراحی ژئــوتکنیکی شمع‌ها بر مبنای نتایج CPT و CPTu:

متد مشاهده‌ای و چرخه طراحی



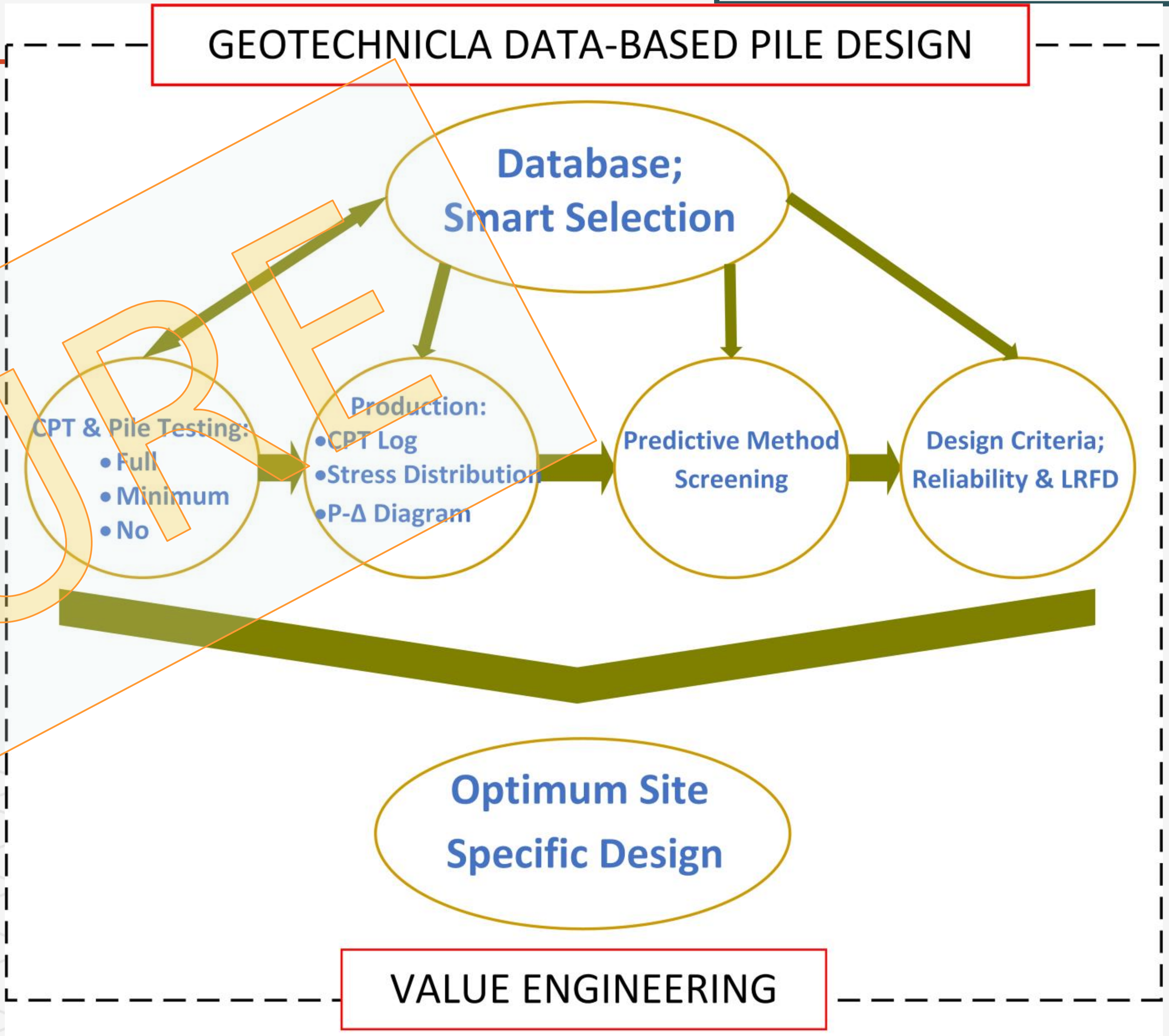


7. Concluding Remarks

3. New trends (Future):

Data-based approach in design

چشم انداز آتی طراحی ژئوتکنیکی شمع‌ها بر مبنای نتایج CPT و CPTu: مبتنی بر پایگاه داده‌ها



با تشکر از همراهی و توجه شما

THANKS FOR YOUR ATTENTION

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