بسمه‌تعالی

نگرش نوین بر طراحی و اجرای پی‌های عمیق (شمع‌ها)

ظرفیت باربری محوری شمع‌ها بر مبنای قابلیت اطمینان

سارا حیدری گلفزانی

۱ آبان ۱۳۹۸

سالن همایش محل دائمی نمایشگاه های تخصصی شهرداری تهران

OUTLINE

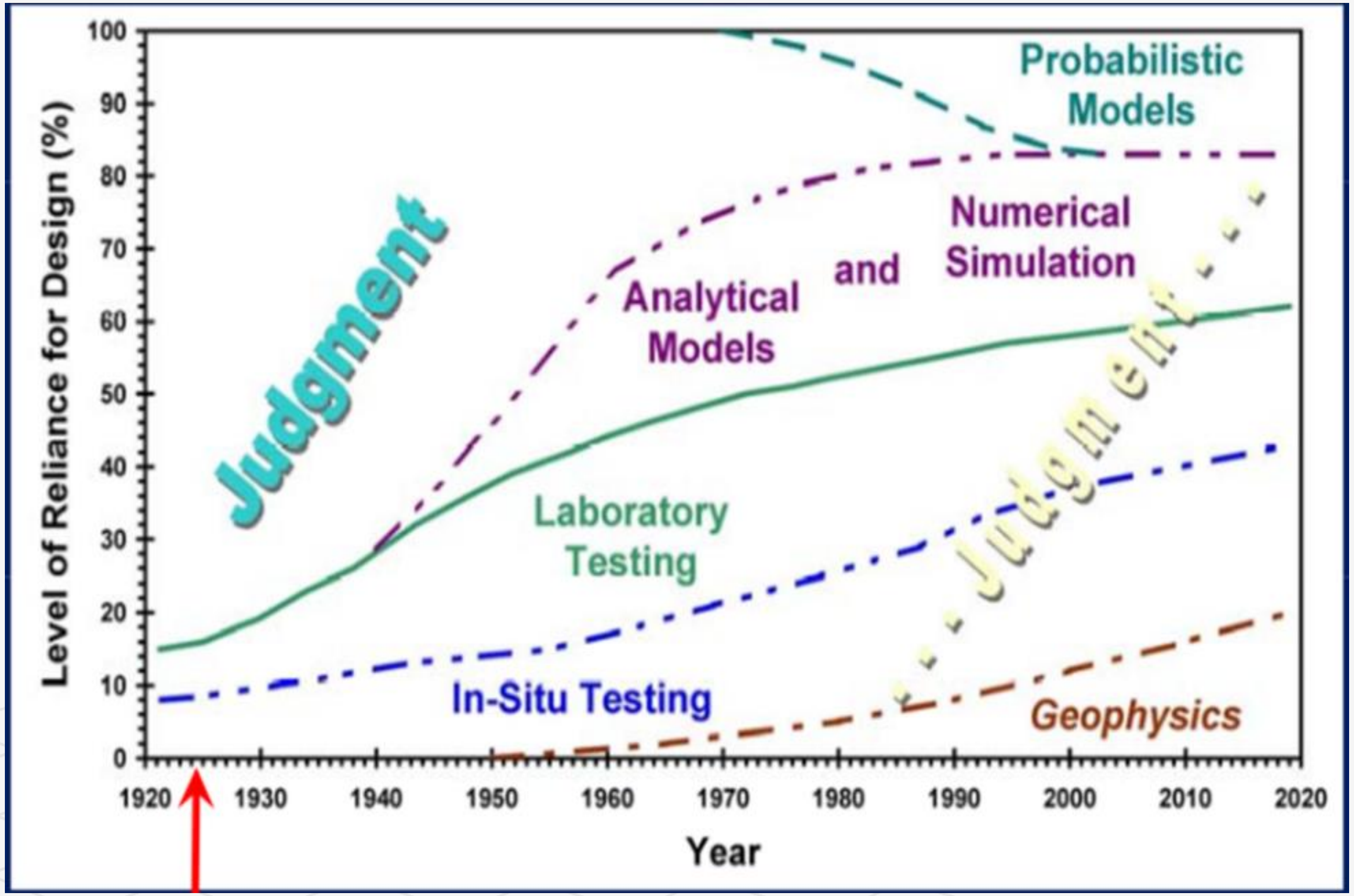
1. **Generals**
2. **Uncertainty in Geotechnical Engineering**
3. **Reliability in Pile Engineering**
4. **Probabilistic Assessment of Predictive Methods**
5. **Reliability-Based Assessment of Predictive Methods**
6. **Summary**

OUTLINE

1. **Generals**
2. Uncertainty in Geotechnical Engineering
3. Reliability in Pile Engineering
4. Probabilistic Assessment of Predictive Methods
5. Reliability-Based Assessment of Predictive Methods
6. Summary

GENERALS

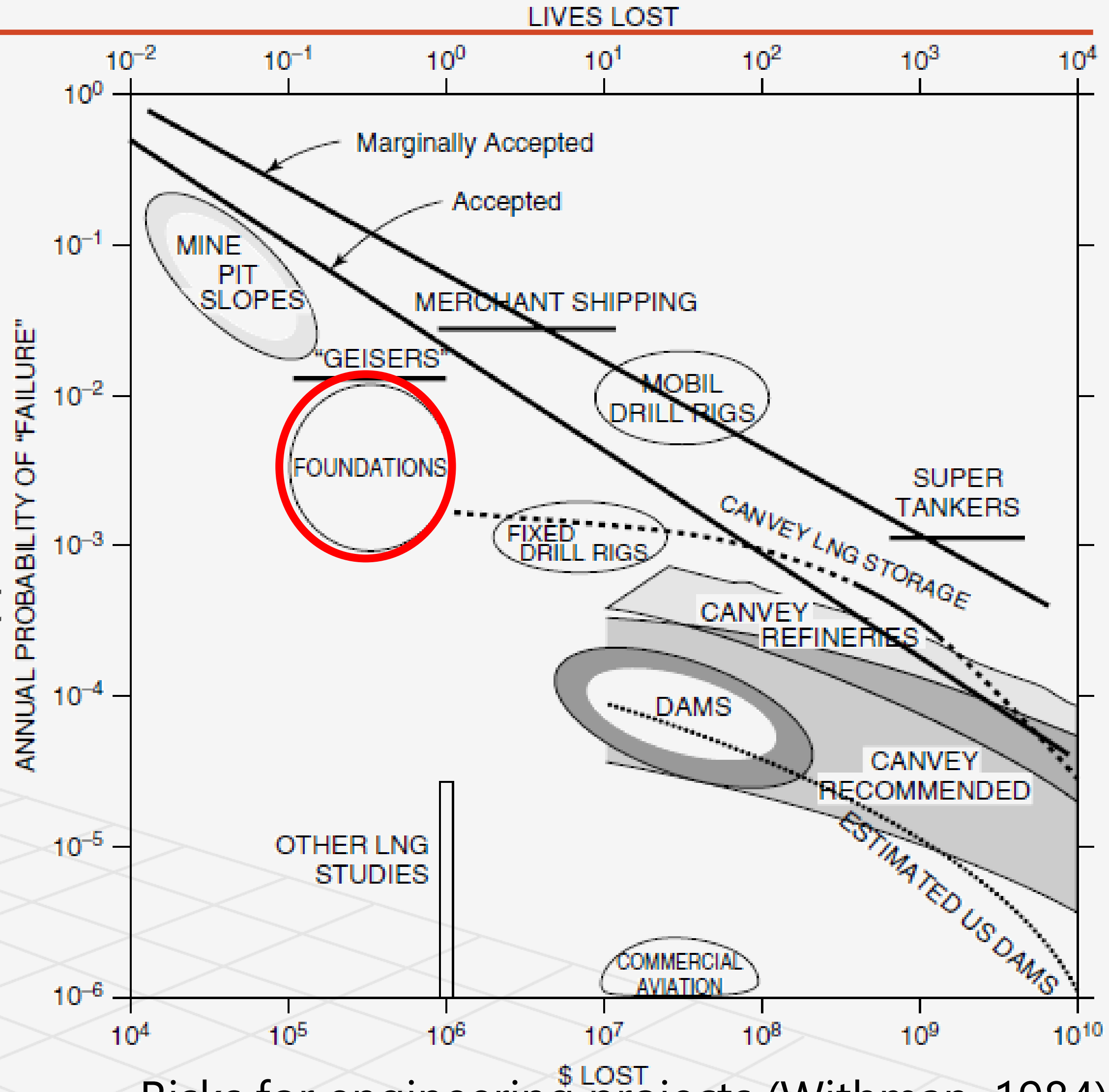
- Soil and rock; the most variable of all engineering materials.
- Uncertainties In Geotechnical designs
- Role of judgement



Evolution of geotechnical site characterization(Mayne, 2012)

GENERALS

- Risk associated with different civil facilities
- Empirical rate of failure for foundations
- Lower probabilities of failure for important facilities
- Adjustments of P_f for all causes of failure



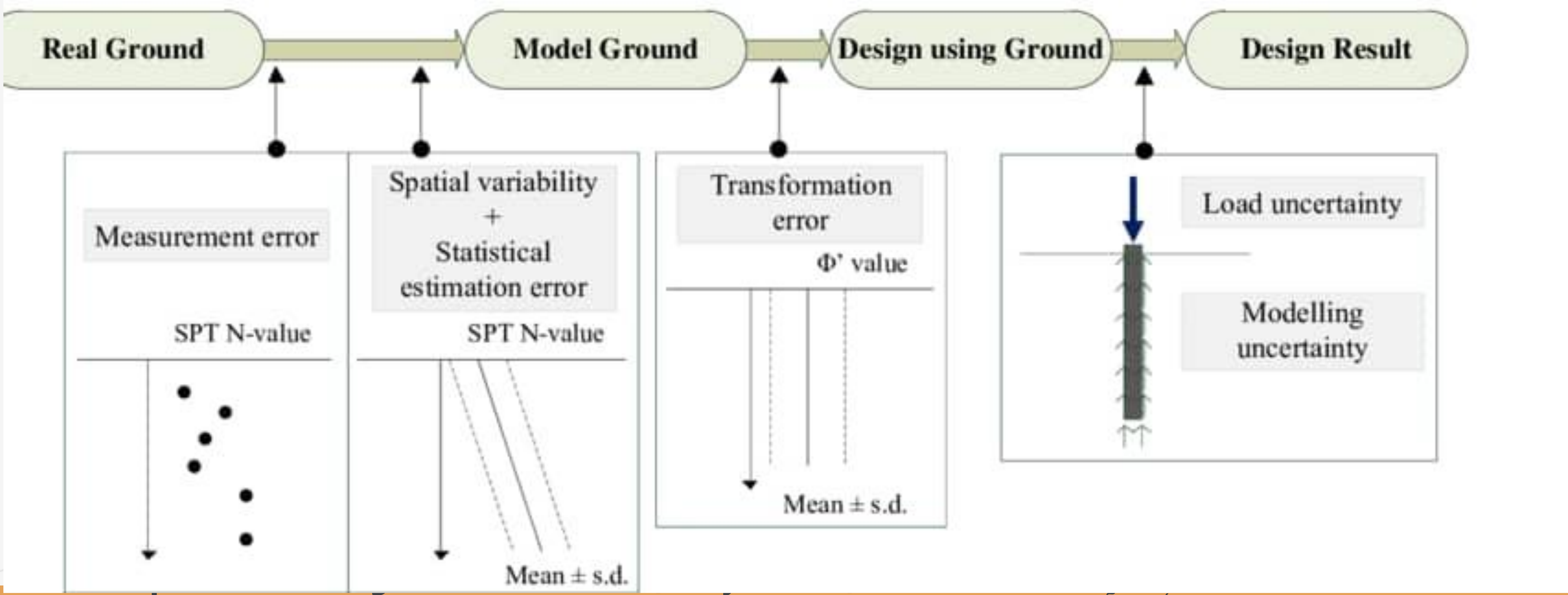
Risks for engineering projects (Withman, 1984)

OUTLINE

1. Generals
2. **Uncertainty in Geotechnical Engineering**
3. Reliability in Pile Engineering
4. Probabilistic Assessment of Predictive Methods
5. Reliability-Based Assessment of Predictive Methods
6. Summary

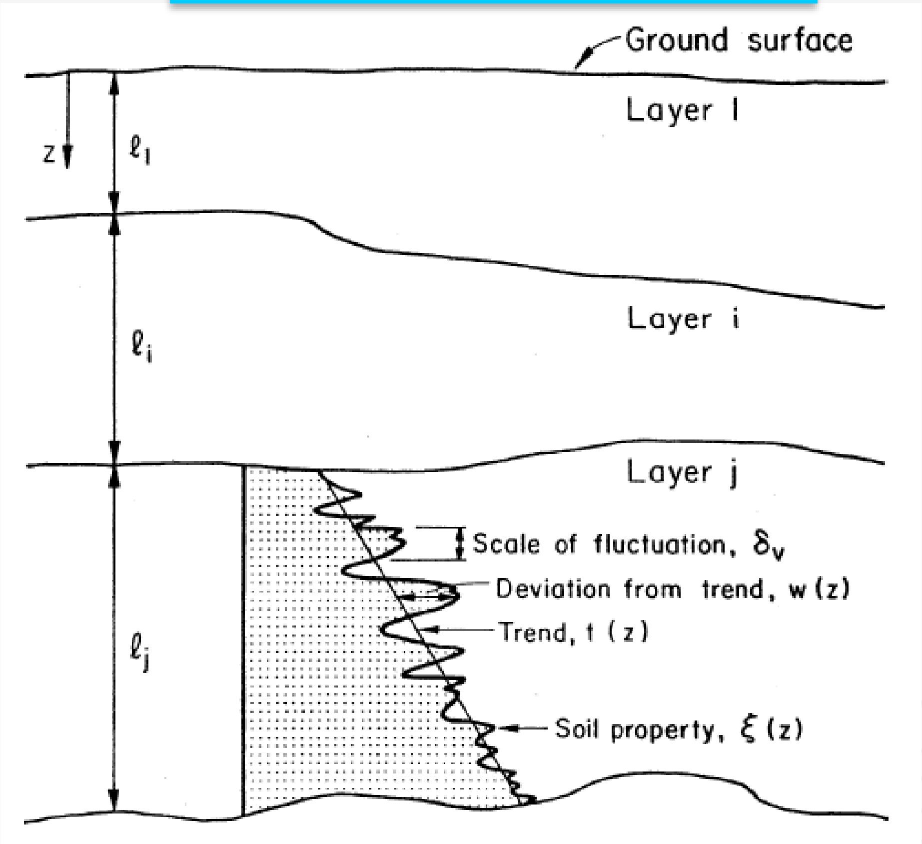
UNCERTAINTY IN GEOTECHNICAL ENGINEERING

- منابع اصلی ایجاد کننده عدم‌قطعیت در مهندسی ژئوتکنیک:
  - تغییرپذیری ذاتی،
  - خطاهای اندازه‌گیری و عدم‌قطعیت های آماری
  - عدم‌قطعیت در مدل و خطاهای ناشی از تبدیل
  - عدم‌قطعیت در بارگذاری



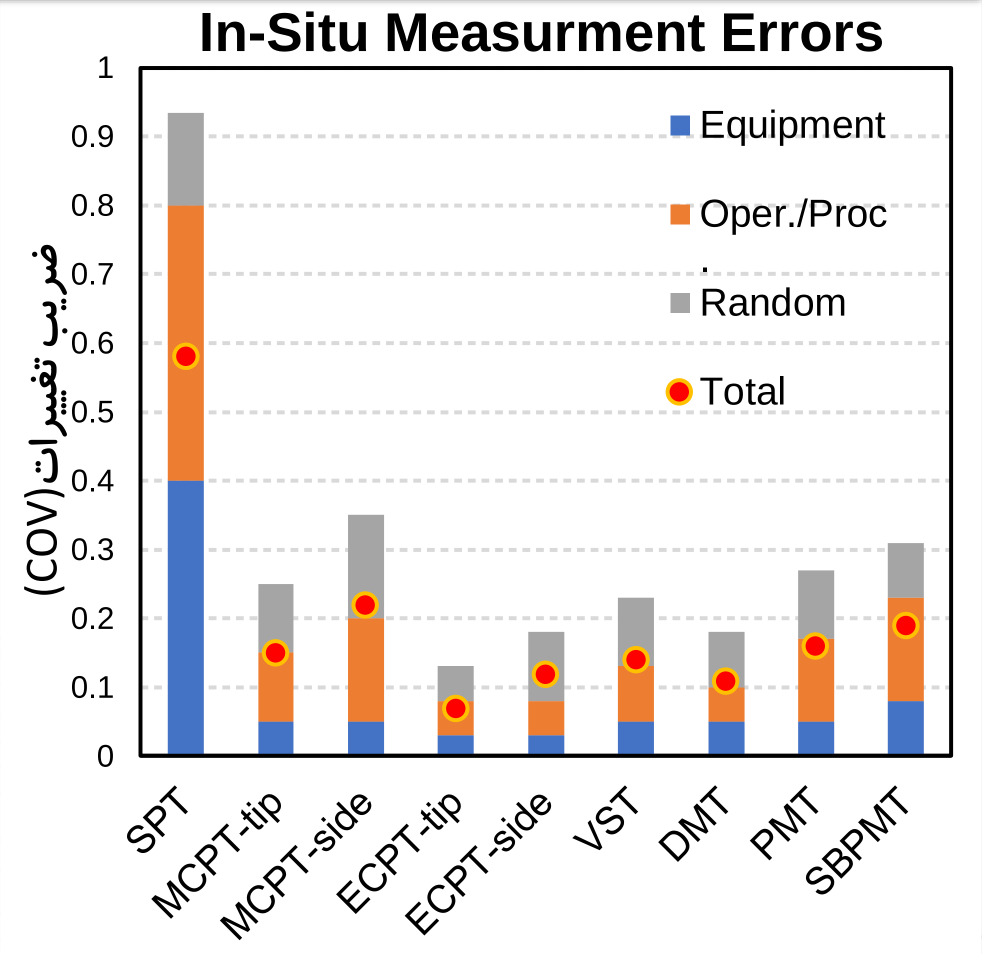
UNCERTAINTY IN GEOTECHNICAL ENGINEERING

Inherent Soil Variability



$$\xi(z) = t(z) + w(z)$$

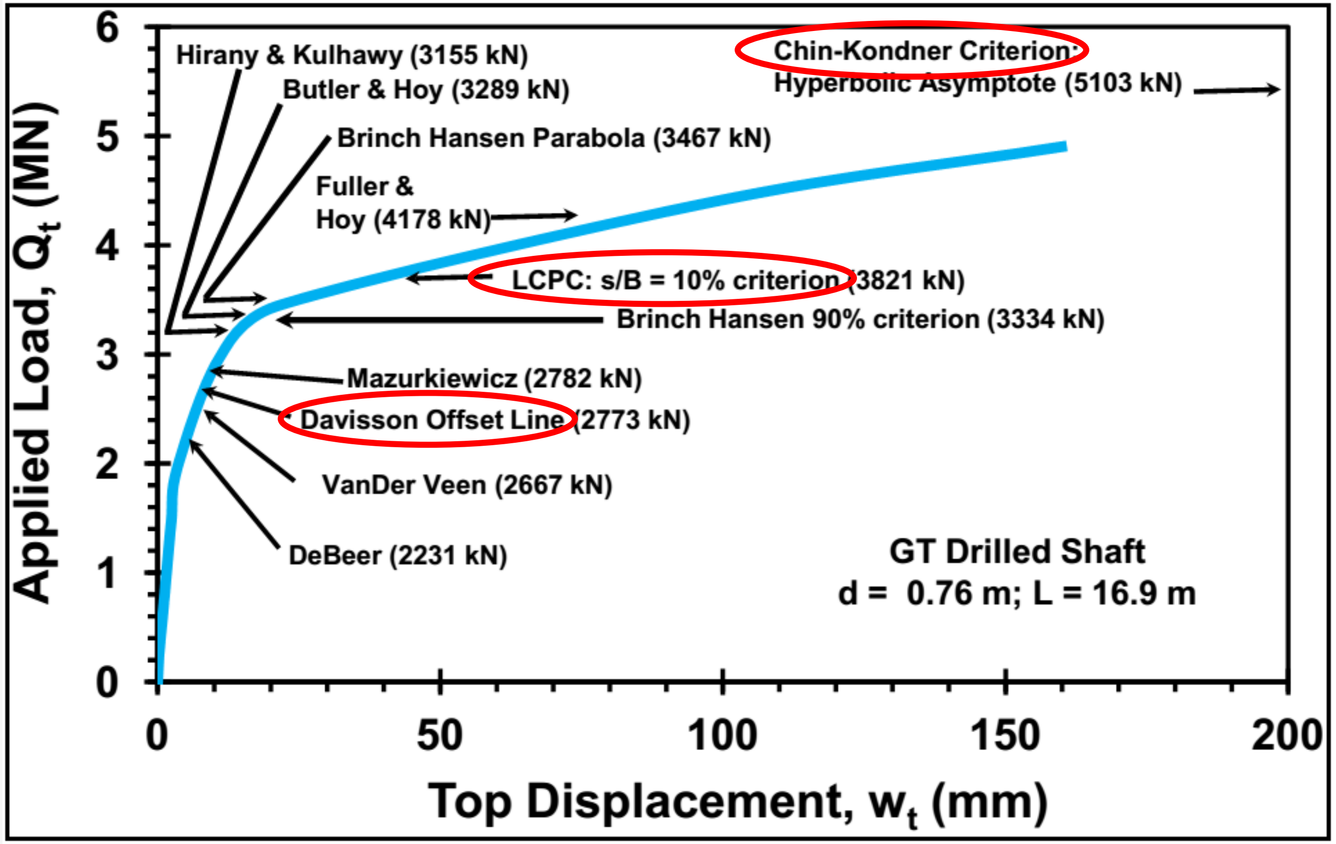
Measurement noise and random error

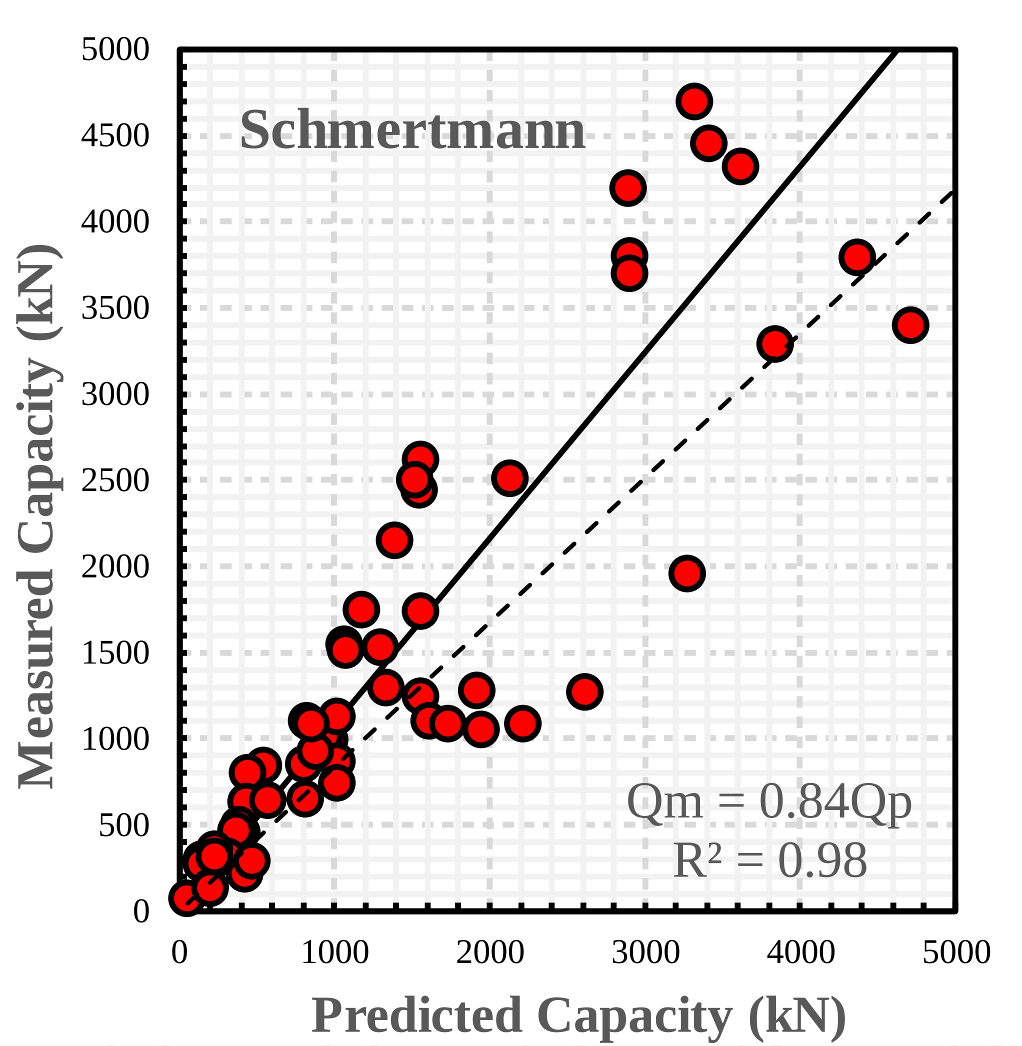


Sourced from Kulhawy and Trautmann (1996)

UNCERTAINTY IN GEOTECHNICAL ENGINEERING

Model error

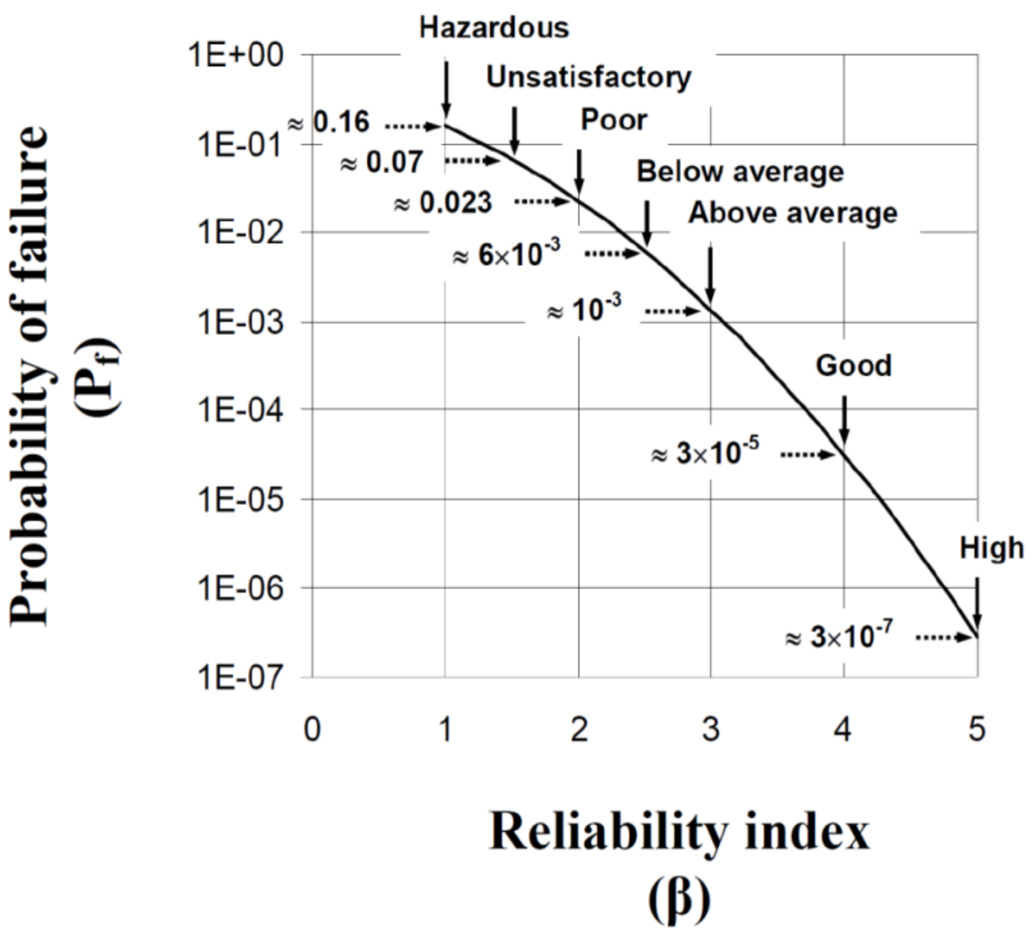




OUTLINE

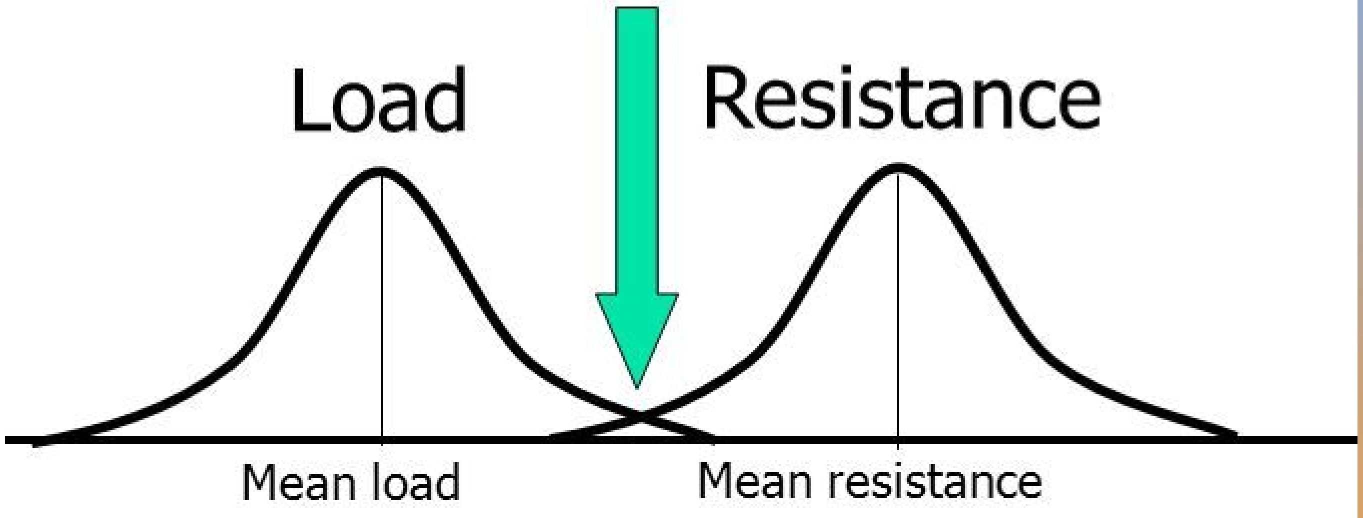
1. Generals
2. Uncertainty in Geotechnical Engineering
3. **Reliability in Pile Engineering**
4. Probabilistic Assessment of Predictive Methods
5. Reliability-Based Assessment of Predictive Methods
6. Summary

RELIABILITY IN PILE ENGINEERING



- احتمال خرابی چیست؟
- رابطه بین احتمال خرابی و ضریب قابلیت اطمینان

A very small probability that the load will be greater than the resistance



استاندارد USACE برای مقادیر مختلف شاخص قابلیت اعتماد و احتمال گسیختگی (Phoon et al., 2004)

Contents lists available at ScienceDirect

Engineering Failure Analysis

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

Assessment of Babolsar Concrete Pedestrian Bridge Failure for 1964 Flood Event and Retrofitting Practice

Abolfazl Eslami [a,*], Sara Heidarie Golafzani [b], Reza Jamshidi Chenari [b]

[a] Amirkabir University of Technology (AUT), Tehran, Iran
[b] Dept. of Civil Eng., Univ. of Guilan, Guilan, Iran

ARTICLE INFO

Article history:
Received 27 February 2016
Received in revised form 15 May 2016
Accepted 19 May 2016
Available online 24 May 2016

Keywords:
Settled (bent) bridge
Deltaic deposits
Flood event
Bearing capacity
Failure analysis
Retrofitting

ABSTRACT

The settled (bent) concrete bridge is considered as the oldest pedestrian pass over in Babolsar city of Iran along Caspian Sea shoreline. The Babolrud River bed is formed of soft deltaic deposits because of sedimentation resulting from erosion and general scour from upstream. Consequently there are geotechnical problems such as low bearing capacity, excessive settlement and instabilities. Due to the river flooding in 1964 and local scour around the foundations of the piers, the non-uniform settlement occurred beneath three piers of the middle spans of the bridge. Because of their settlements and rotation of the piers, the decks were locally bent in the support locations. Two different failure analyses were done in order to check the stability of the bridge before, during and after flooding. The results of failure analyses including deterministic method and Monte Carlo simulation, have been compared to each other. Also, a cross correlation coefficient was considered between soil shear strength parameters (i.e. c and φ). The effect of this coefficient and resistance factor was investigated on ultimate bearing capacity, factor of safety and probability of failure. Also, the rehabilitation of the bridge damaged during 1964 flooding is reviewed. The rehabilitation includes: strengthening the sub-construction, balancing and lining up the bridge deck and deck reparations. The monitoring and surveillances after three years of rehabilitation and utilization, have proved the applicability of the practices in rehabilitation of the Babolsar Pedestrian Bridge.

عدم‌قطعیت در بارگذاری

- طراحی ایمن در رویکرد یقینی
- وقوع سیلاب ۱۹۶۴
- خرابی پل
  - وجود خاک مساله‌دار
  - بار وارده بر اثر سیلاب
  - نامناسب بودن سیستم پی

Reliability Index

ضریب قابلیت اطمینان

- تحلیل‌های تصادفی؛ ابزاری مناسب برای درنظرگیری تغییرپذیری ویژگی‌های خاک
- ارائه نتایج زیر از تحلیلهای تصادفی بسته به سطح و نوع تحلیل‌های قابلیت اطمینان
  - احتمال گسیختگی یا عملکرد نامطلوب سیستم
  - ضریب قابلیت اطمینان
- ابزارهای مناسب برای تعیین ضریب قابلیت اطمینان در کارهای ژئوتکنیکی عبارتند از:
  - روش ممان دوم مرتبه اول (First Order Second Moment) یا FOSM،
  - روش‌های قابلیت اطمینان مرتبه اول (First Order Reliability Method) یا FORM و دوم (Second Order Reliability Method) یا SORM،
  - شبیه‌سازی مونت کارلو (Monte Carlo Simulation) یا MCS

OUTLINE

1. Generals
2. Uncertainty in Geotechnical Engineering
3. Reliability in Pile Engineering
4. **Probabilistic Assessment of Predictive Methods**
5. Reliability-Based Assessment of Predictive Methods
6. Summary

Probabilistic Assessment of Model Uncertainty for Predictive Methods

GEORISK
https://doi.org/10.1080/17499518.2019.1628281

Taylor & Francis
Taylor & Francis Group

Check for updates

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

Sara Heidarie Golafzani[a], Reza Jamshidi Chenari[a] and Abolfazl Eslami[b]

[a]Department of Civil Engineering, University of Guilan, Guilan, Iran; [b]Department of Civil and Environmental Engineering, Amirkabir University of Technology (AUT), Tehran, Iran

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.

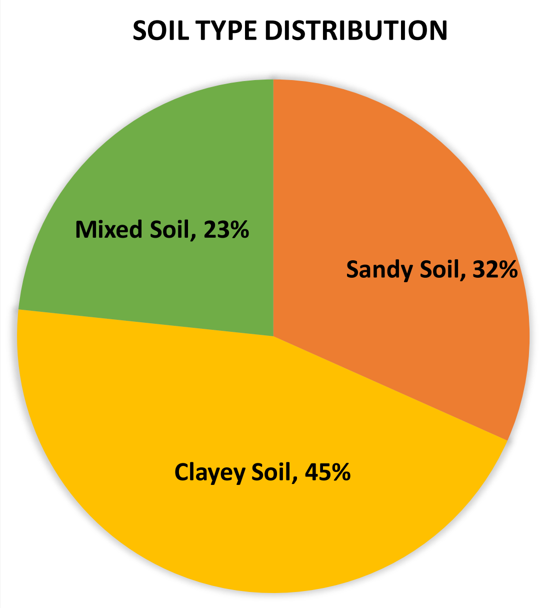
ARTICLE HISTORY
Received 11 November 2018
Accepted 2 June 2019

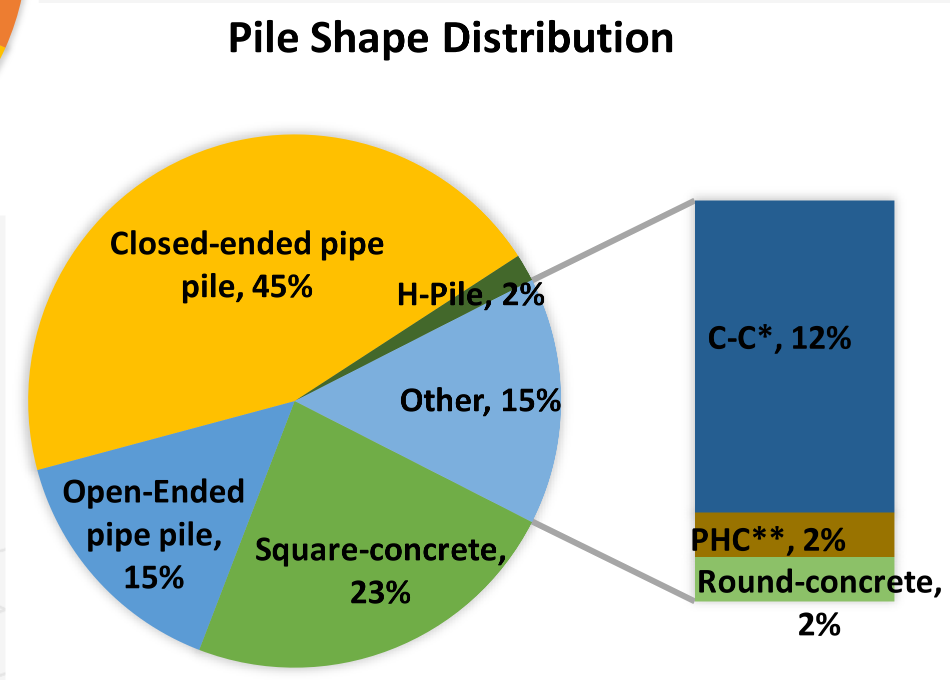
KEYWORDS
Axial pile bearing capacity; CPT; LRFD; pile foundation; reliability based design

بررسی عملکرد روش‌های مختلف تعیین ظرفیت باربری شمع

- ضریب قابلیت اطمینان
- ضریب مقاومت
- نسبت کارایی

Probabilistic Assessment of Model Uncertainty for Predictive Methods



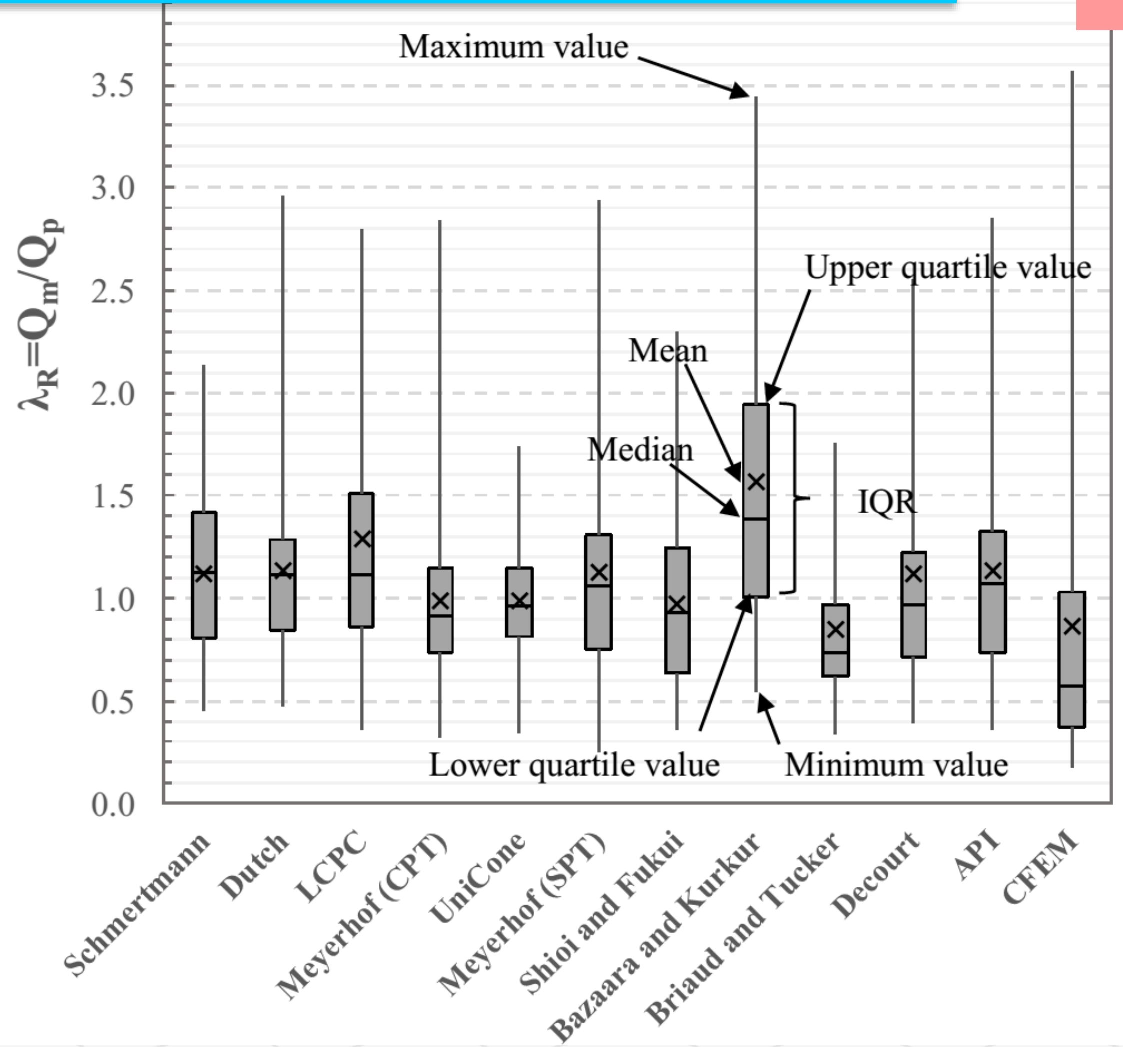


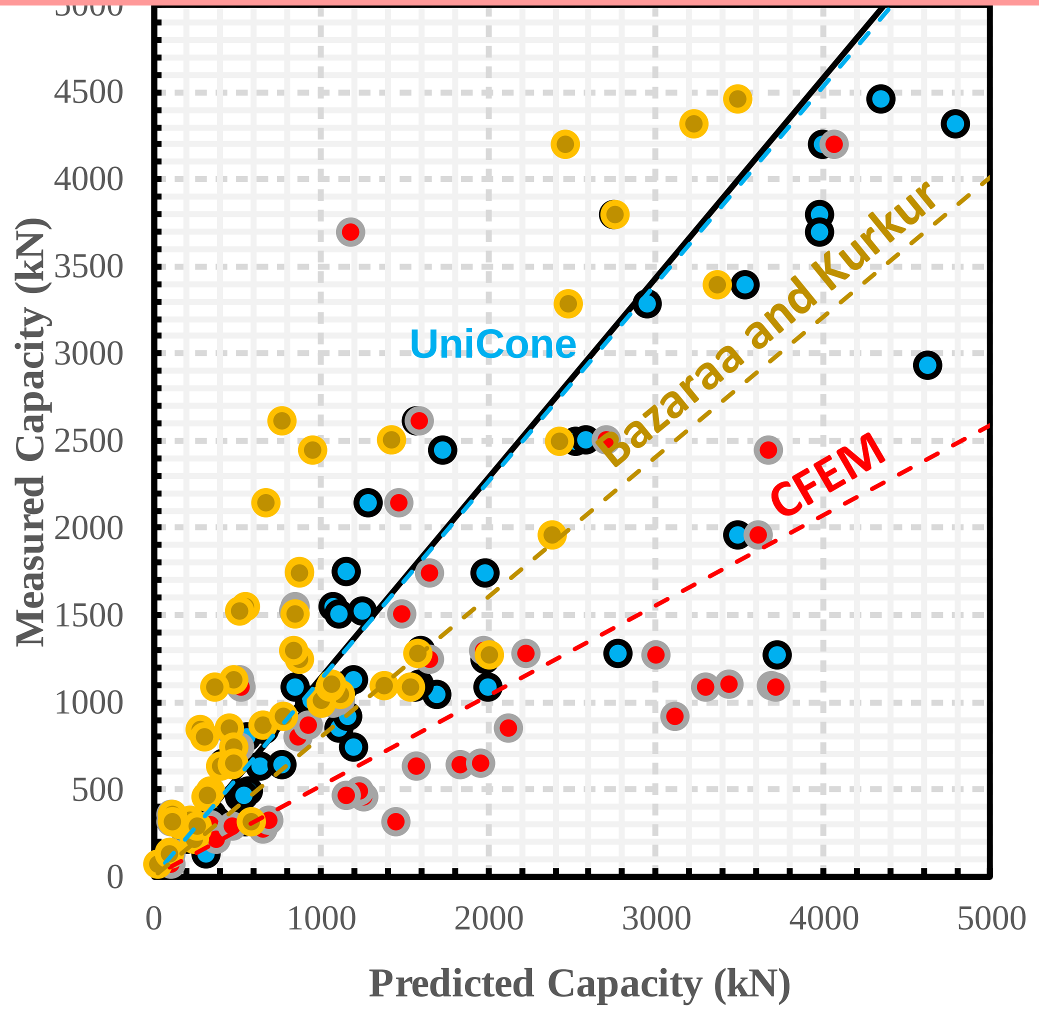
- **ارزیابی روشهای مختلف مبتنی بر تحلیل‌های استاتیکی، SPT و CPT**
- بانک داده‌ای متشکل از ۶۰ شمع
  - روش‌های تحلیل استاتیکی
    - CFEM و
    - API
  - روش‌های مبتنی بر SPT:
    - Meyerhof (1976)
    - Shioi and Fukui (1982)
    - Bazaara and Kurkur (1986)
    - Briaud and Tucker (1988)
    - Decourt (1995)
  - روش‌های مبتنی بر CPT
    - Schmertmann (1978)
    - DeRuiter and Beringen (1979)
    - Bustamante and Gianeselli (1982)
    - Meyerhof (1956, 1976, 1983)
    - UniCone (1997)

Probabilistic Assessment of Model Uncertainty for Predictive Methods

Heidarie, Eslami and Jamshidi (2019)

عملکرد هر یک از روشها در تعیین ظرفیت باربری شمعها

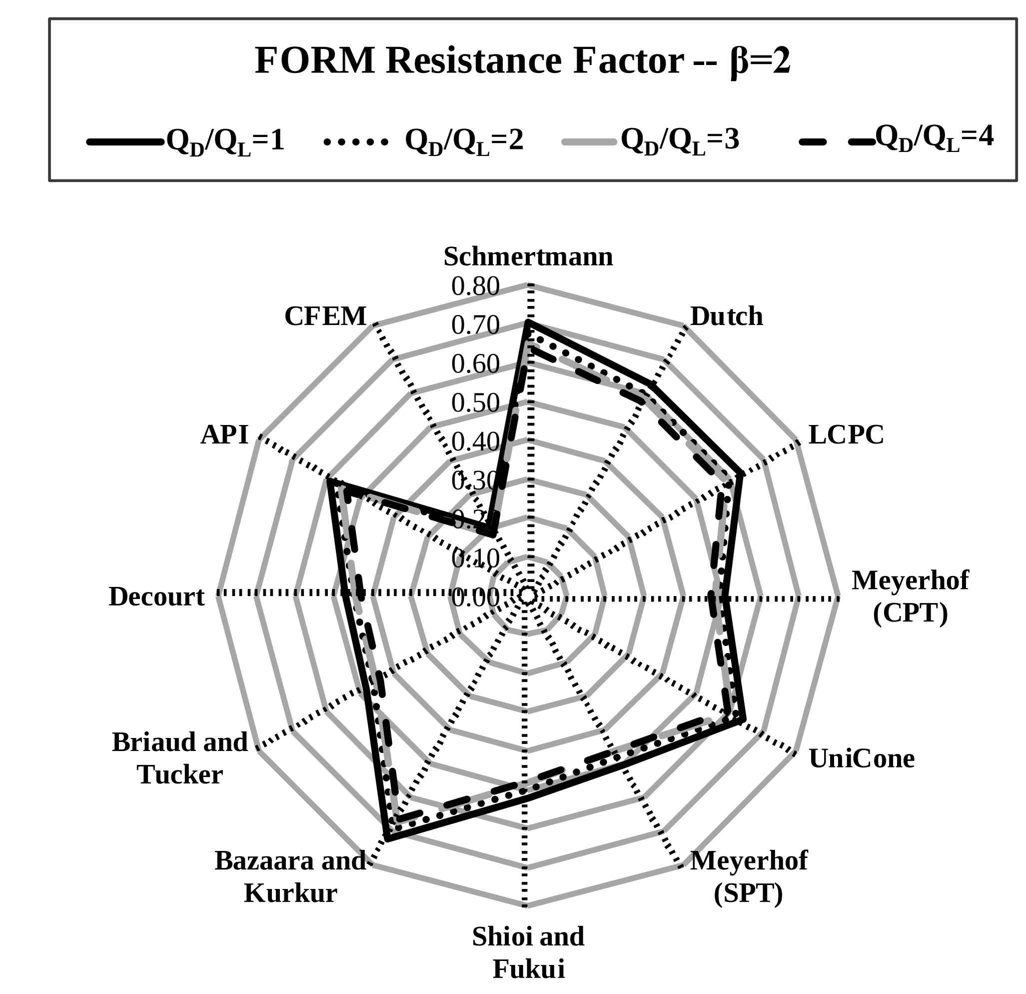


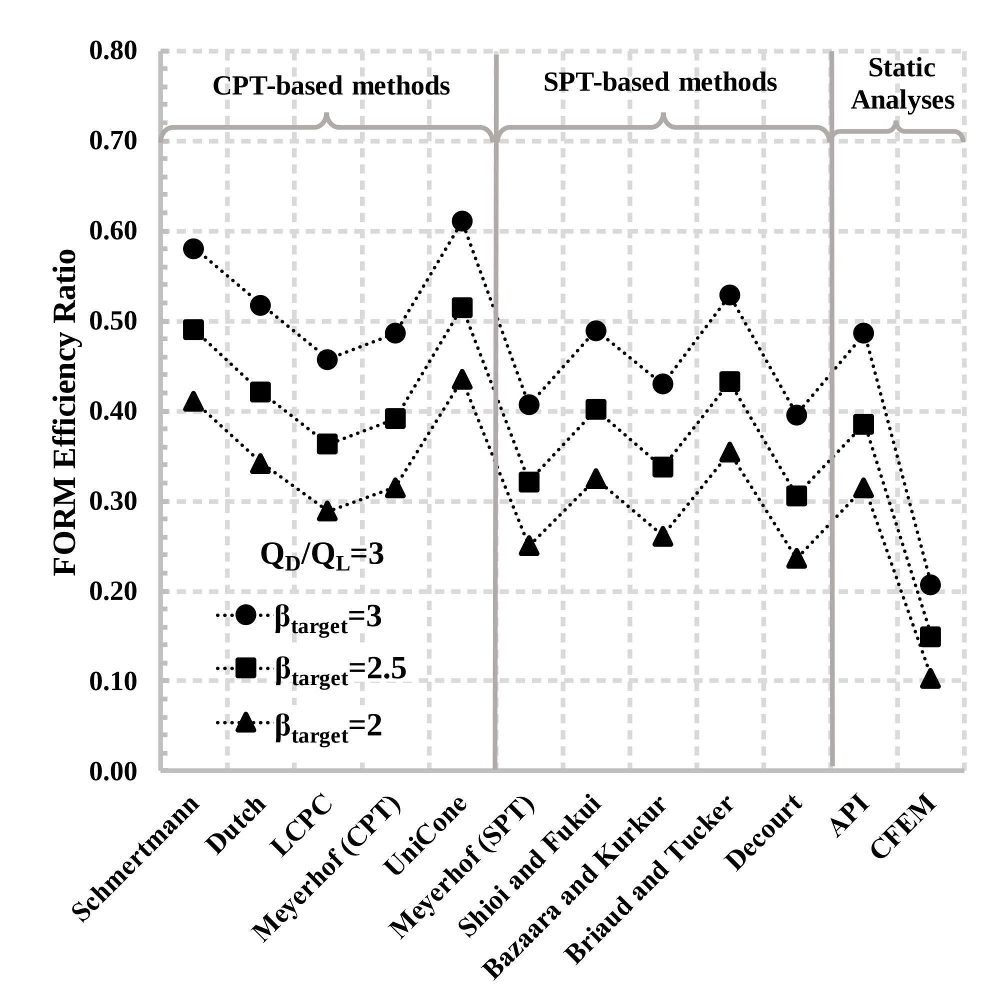


Probabilistic Assessment of Model Uncertainty for Predictive Methods

Heidarie, Eslami and Jamshidi (2019)

مقایسه عملکرد روش‌های مختلف تعیین ظرفیت باربری





Probabilistic Assessment of Model Uncertainty for Predictive Methods

Probabilistic assessment of Model Uncertainty for Prediction of Pile Foundation Bearing Capacity; Static Analysis, SPT and CPT-based Methods

Sara Heidarie Golafzani[1], Reza Jamshidi Chenari[2*], Abolfazl Eslami [3]

ABSTRACT

Geotechnical designs like other engineering disciplines are always accompanied by uncertainties. Cone penetration test (CPT), by supplying continuous and reliable records and reducing uncertainty associated with measurement errors, enhances the geotechnical designs to a more reliable level. Deep foundation design, as a major challenge of foundation engineering, is also involved with different sources of uncertainty. Moreover, the presence of various design methods, relying on different assumptions and requirements, introduce further complications to the selection of an appropriate method which leads to the wide spectrum of the predictions. Hence, a database, including 60 driven pile load test results and CPT records in vicinity of them was compiled in order to investigate the model uncertainties embedded in various predictive approaches. Investigated approaches comprising the static analyses, SPT and CPT-based methods were elucidated by means of statistical and probabilistic criteria encompassing Load and Resistance Factor Design (LRFD)-based design criteria i.e. efficiency ratio, actual factor of safety, confidence interval criterion, and five further criteria presented in radar charts. The less the occupied area of radar charts, the better the performance of the method would be. Besides, the resistance reduction factor, applied in this study, was calibrated by four different prevailing methods and results confirmed that First Order and Second Moment (FOSM) calibration method provides less accurate results in comparison to other approaches. Eventually, among common available predictive methods, CPT-based methods perform better than others and result in cost-effective and optimized trends.

Keywords: Uncertainty; Bearing Capacity; CPT; LRFD; Reliability; Driven piles; SPT; Static analysis.

ارزیابی با استفاده از معیارهای آماری و احتمالاتی

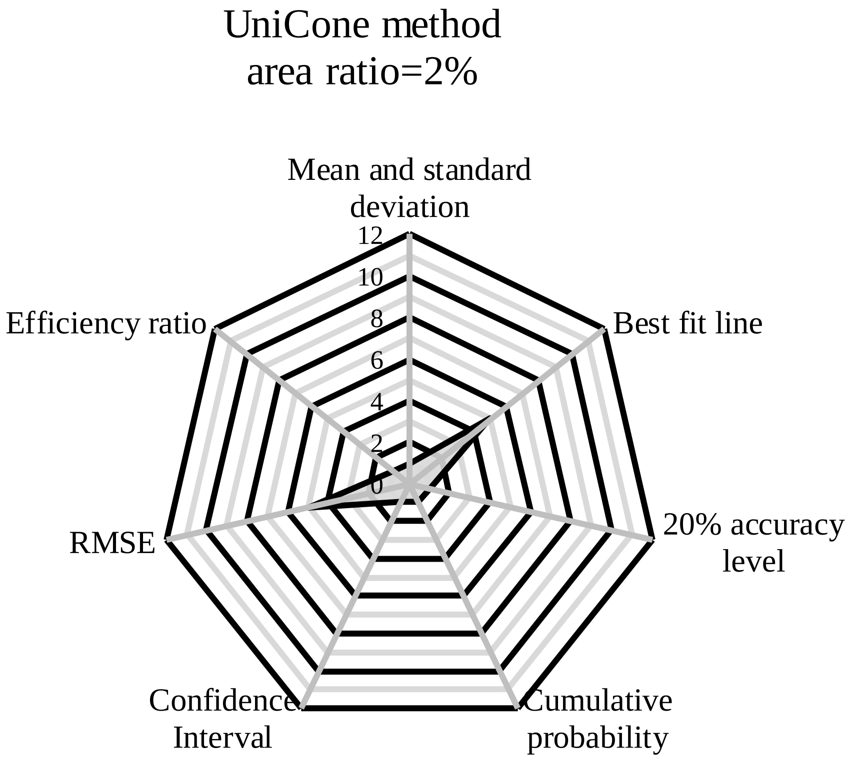
- میانگین و پراکندگی پارامتر مدل
- برازش بهترین خط
- تابع توزیع تجمعی
- تابع چگالی احتمال
- خطای مدل
- فاصله اطمینان
- نسبت کارایی

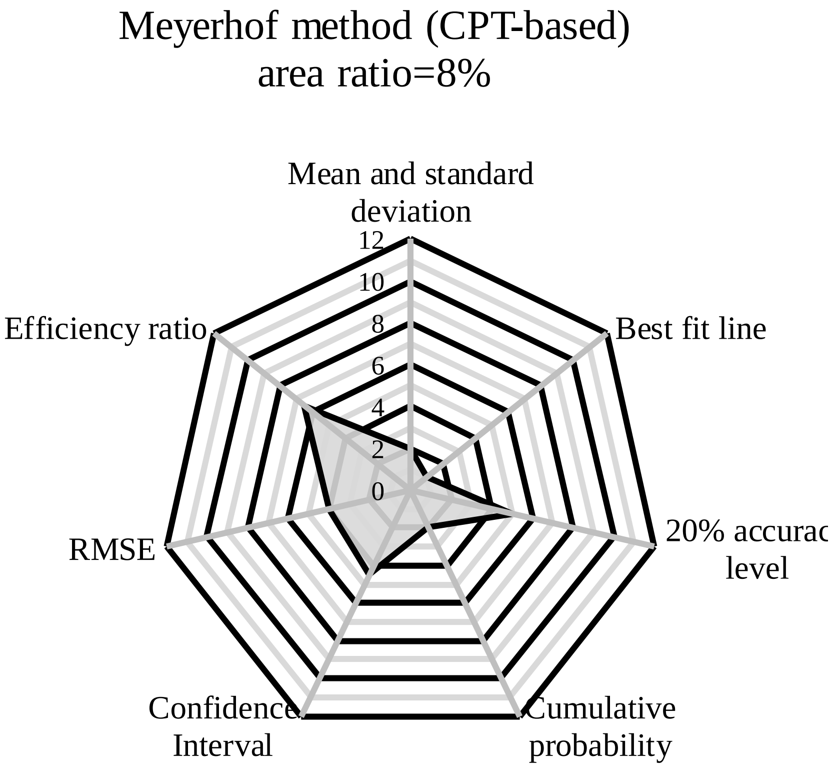
Probabilistic Assessment of Model Uncertainty for Predictive Methods

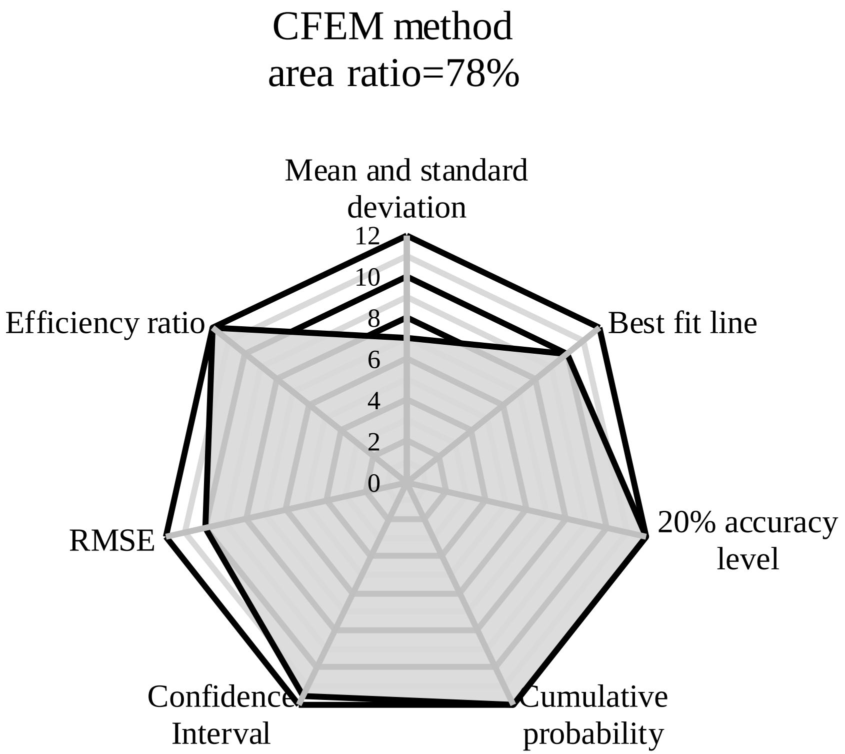
Heidarie, Eslami and Jamshidi (2019)

ارزیابی روش‌ها بر مبنای پارامترهای آماری و احتمالاتی

- رتبه‌بندی روش‌ها از ۱ برای بهترین عملکرد تا ۱۲ برای عملکرد ضعیف



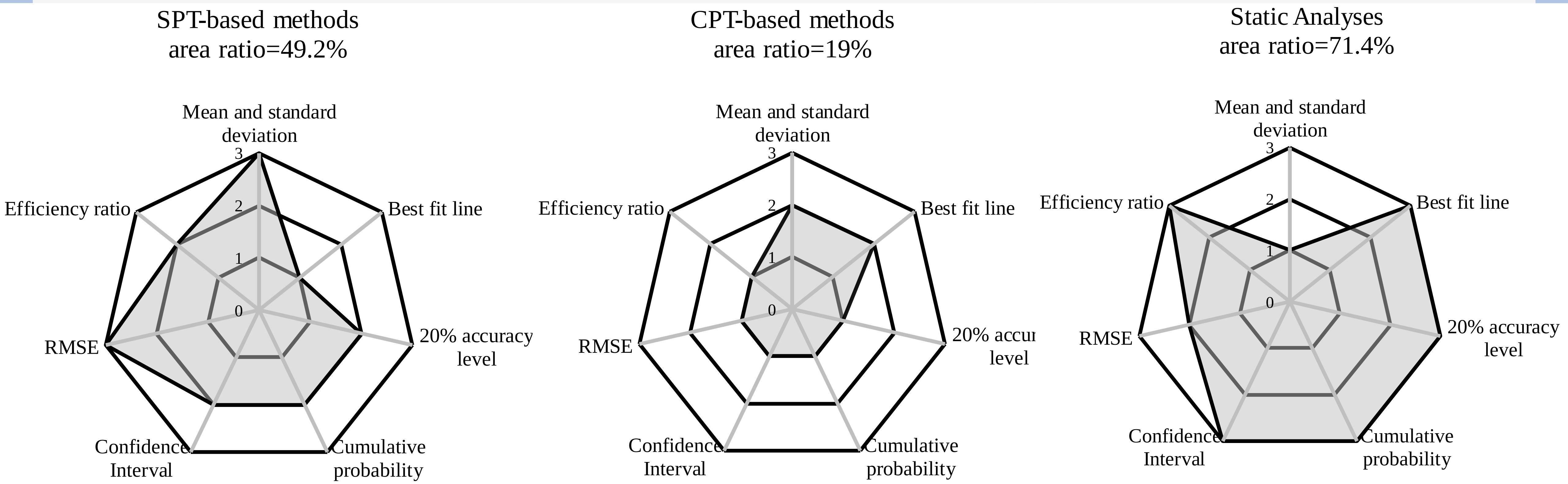




Probabilistic Assessment of Model Uncertainty for Predictive Methods

Heidarie, Eslami and Jamshidi (2019)

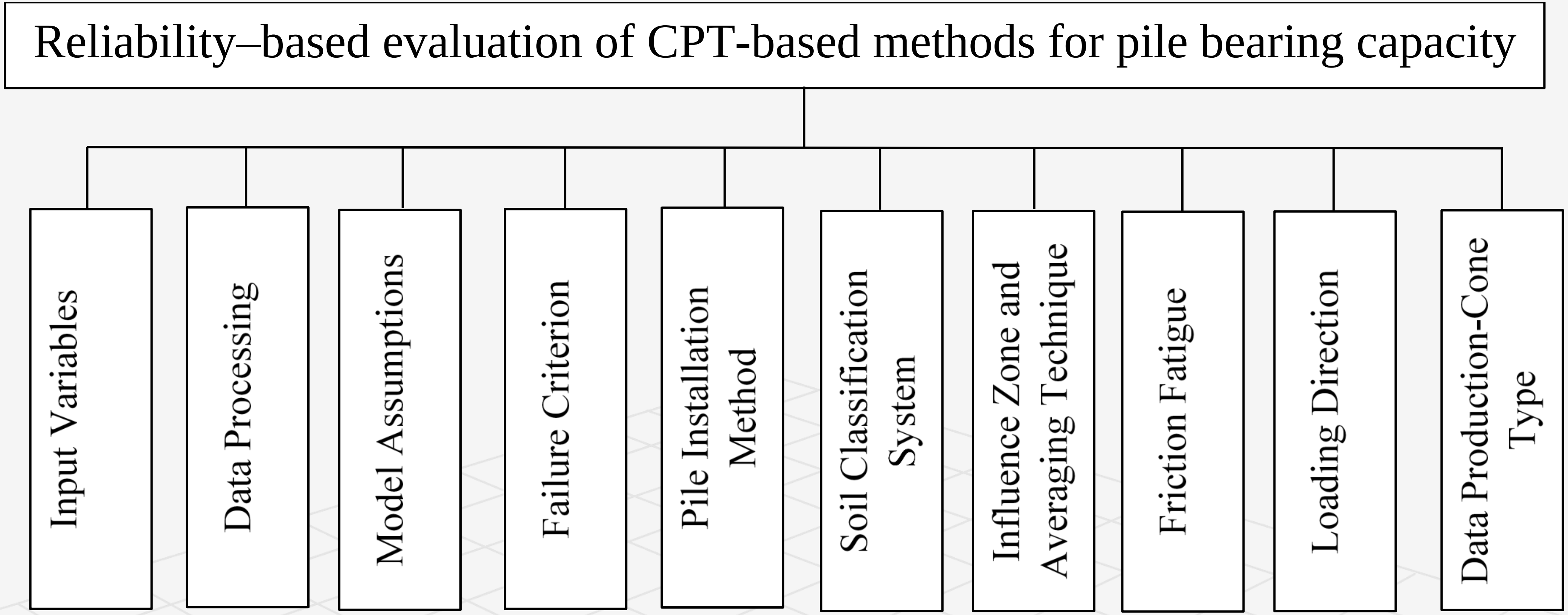
ارزیابی رویکردهای مختلف تخمین ظرفیت باربری شمع‌ها بر مبنای پارامترهای آماری و احتمالاتی



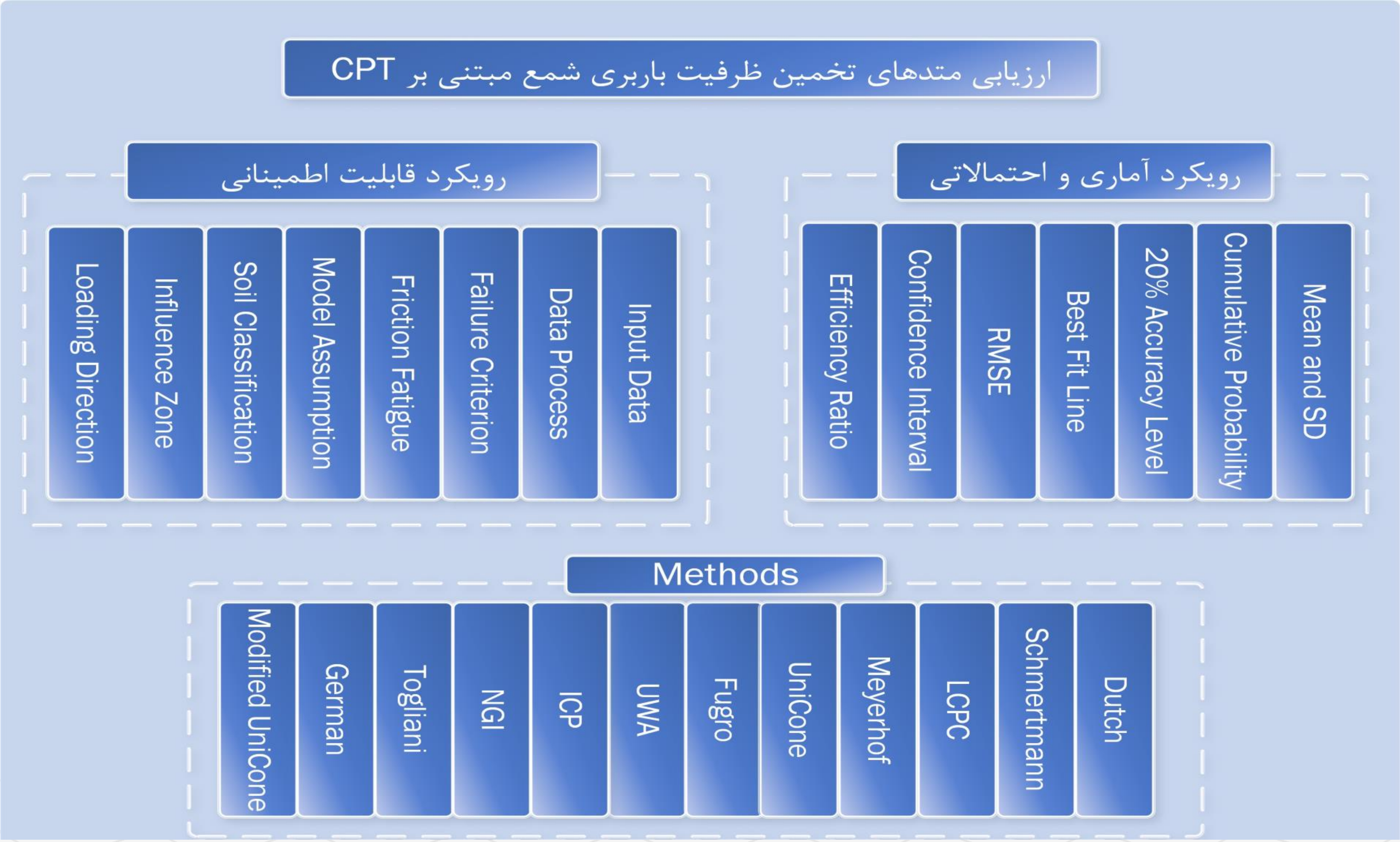
OUTLINE

Reliability-Based Assessment of Predictive Methods

طبقه‌بندی معیارهای مورد استفاده در ارزیابی‌های با رویکرد قابلیت اطمینانی

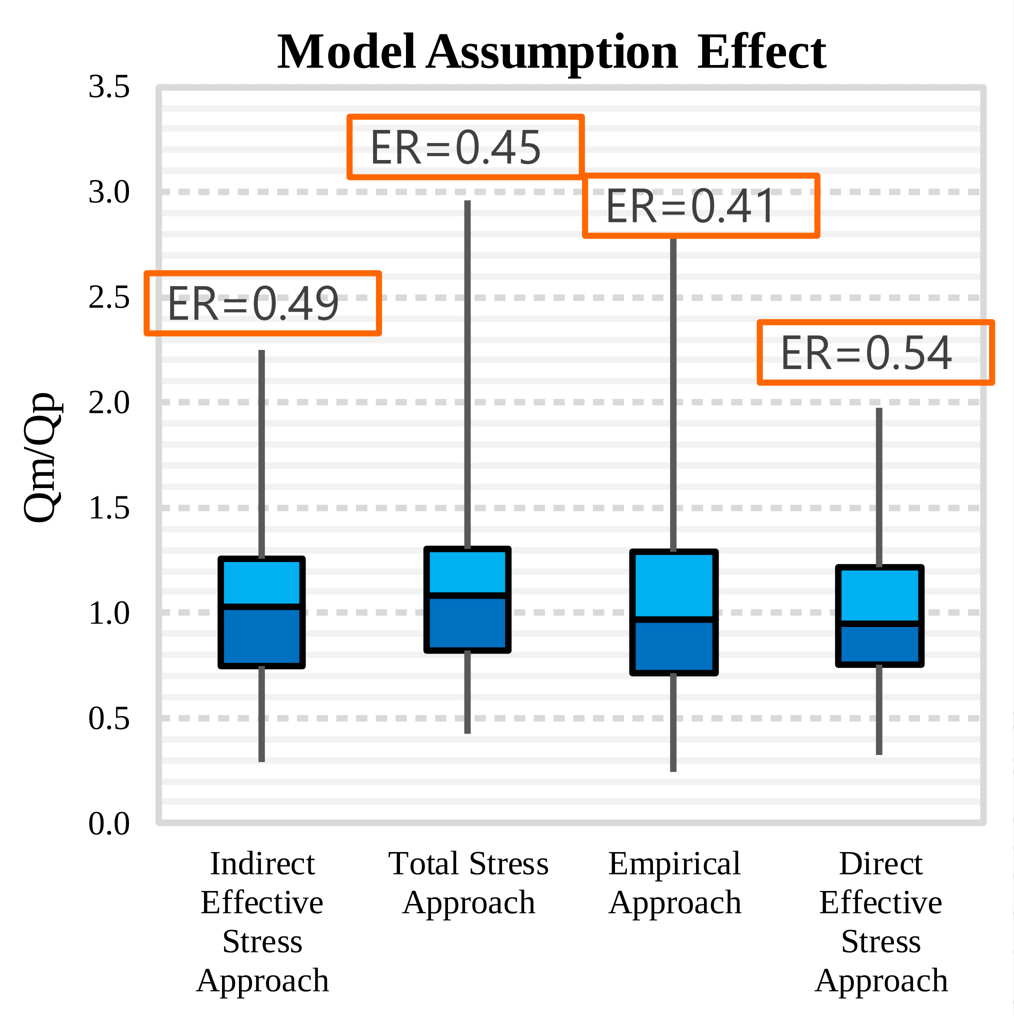


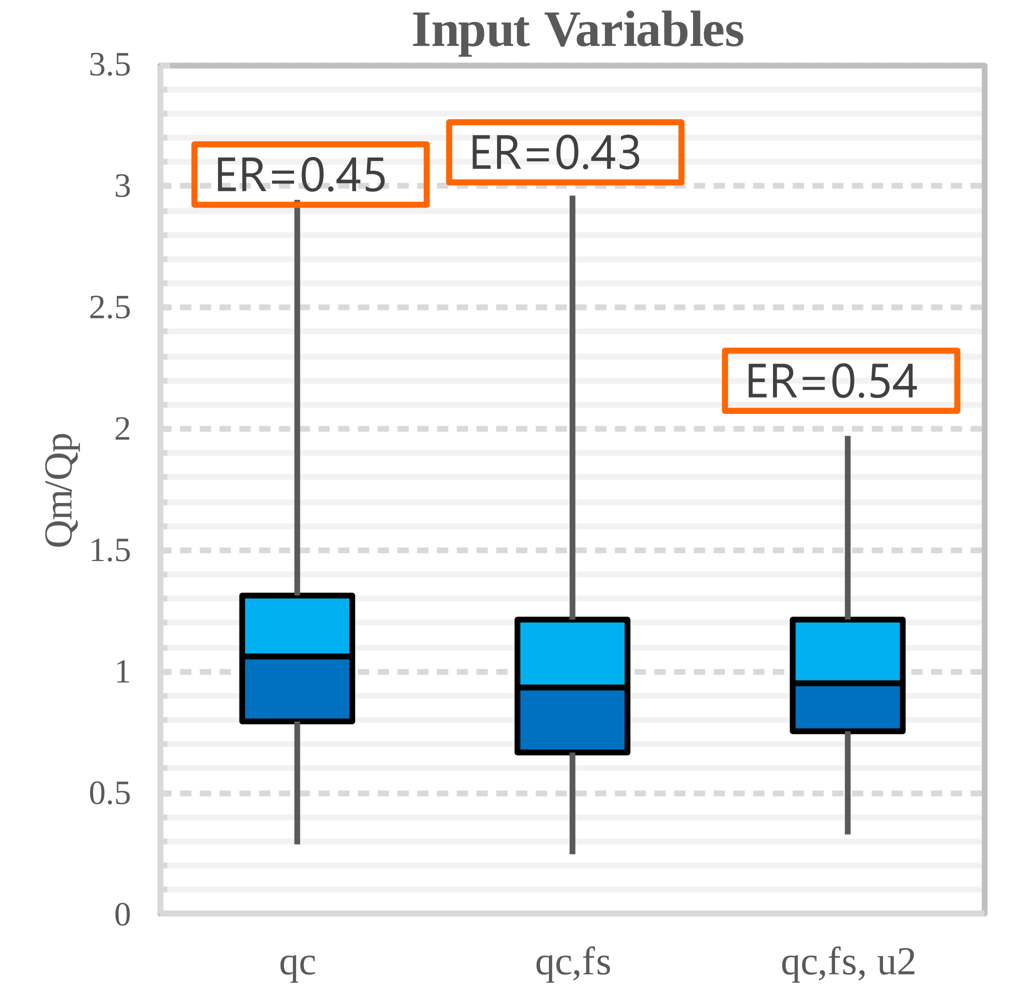
Reliability-Based Assessment of Predictive Methods



Reliability-Based Assessment of Predictive Methods

- بررسی تاثیر تعداد داده‌های ورودی
- بررسی فرضیات مدل

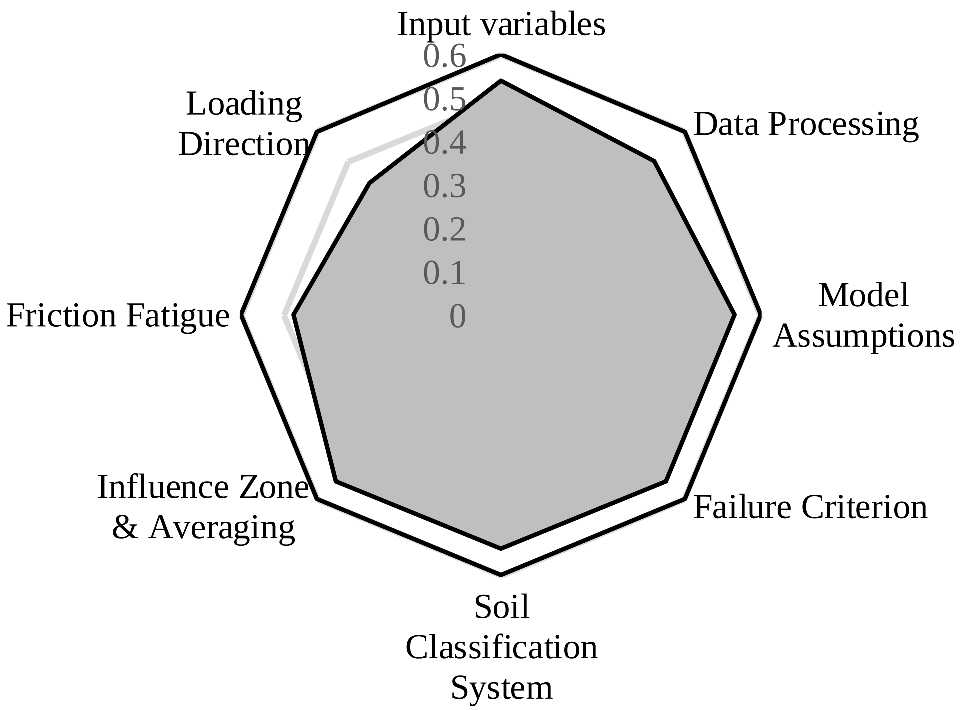




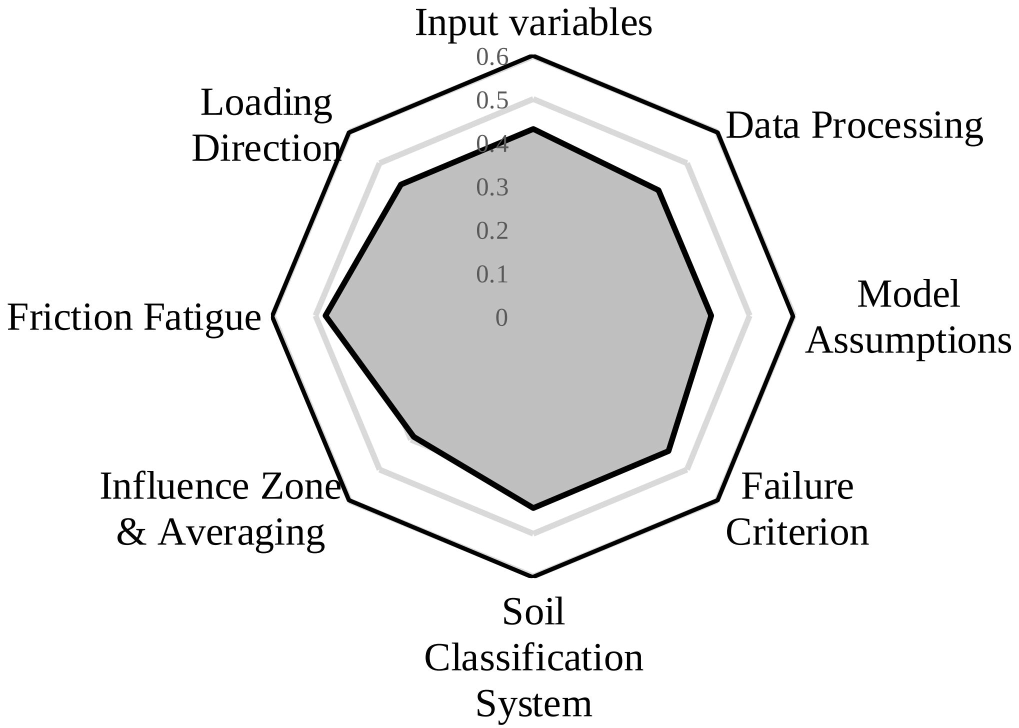
Reliability-Based Assessment of Predictive Methods

مقایسه عملکرد دو روش تخمین ظرفیت باربری شمع با توجه به معیارهای اصلی

UniCone method
Area Ratio=73%



TOGLIANI METHOD
Area Ratio=51%

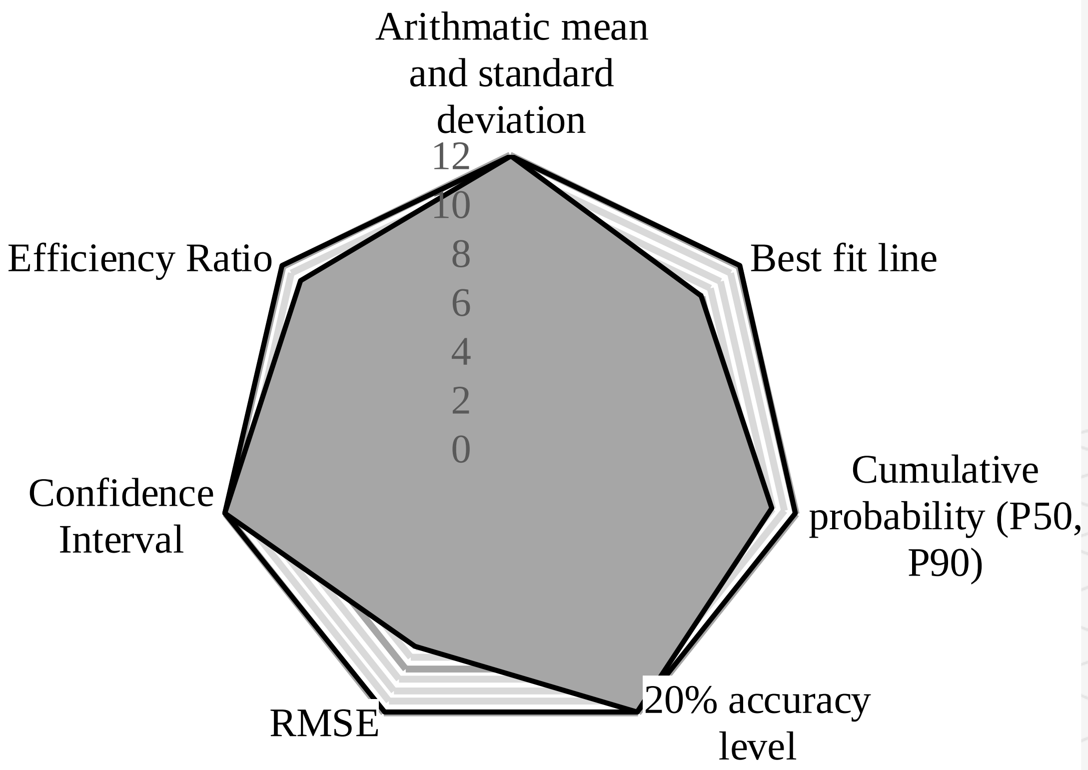


Reliability-Based Assessment of Predictive Methods

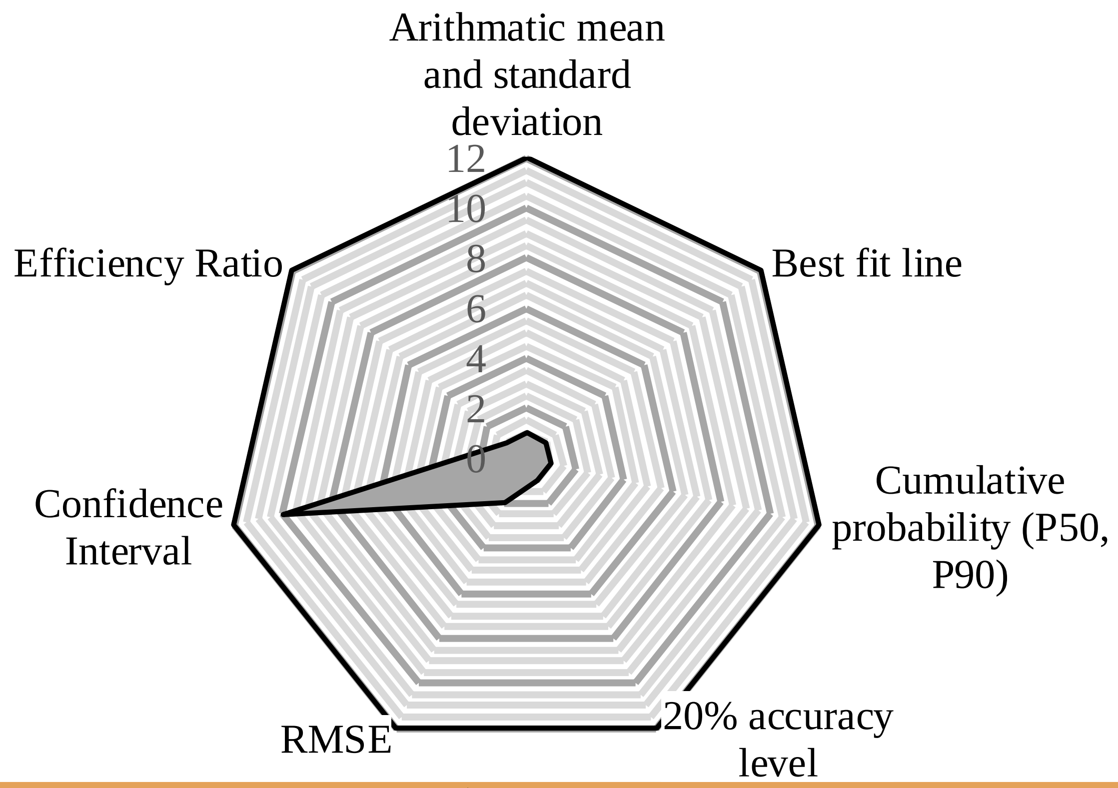
مقایسه عملکرد دو روش تخمین ظرفیت باربری شمع با توجه به معیارهای آماری-احتمالاتی

- رتبه‌بندی روش‌ها از ۱۲ برای بهترین عملکرد تا ۱ برای عملکرد ضعیف

UniCone method
Area Ratio=84%

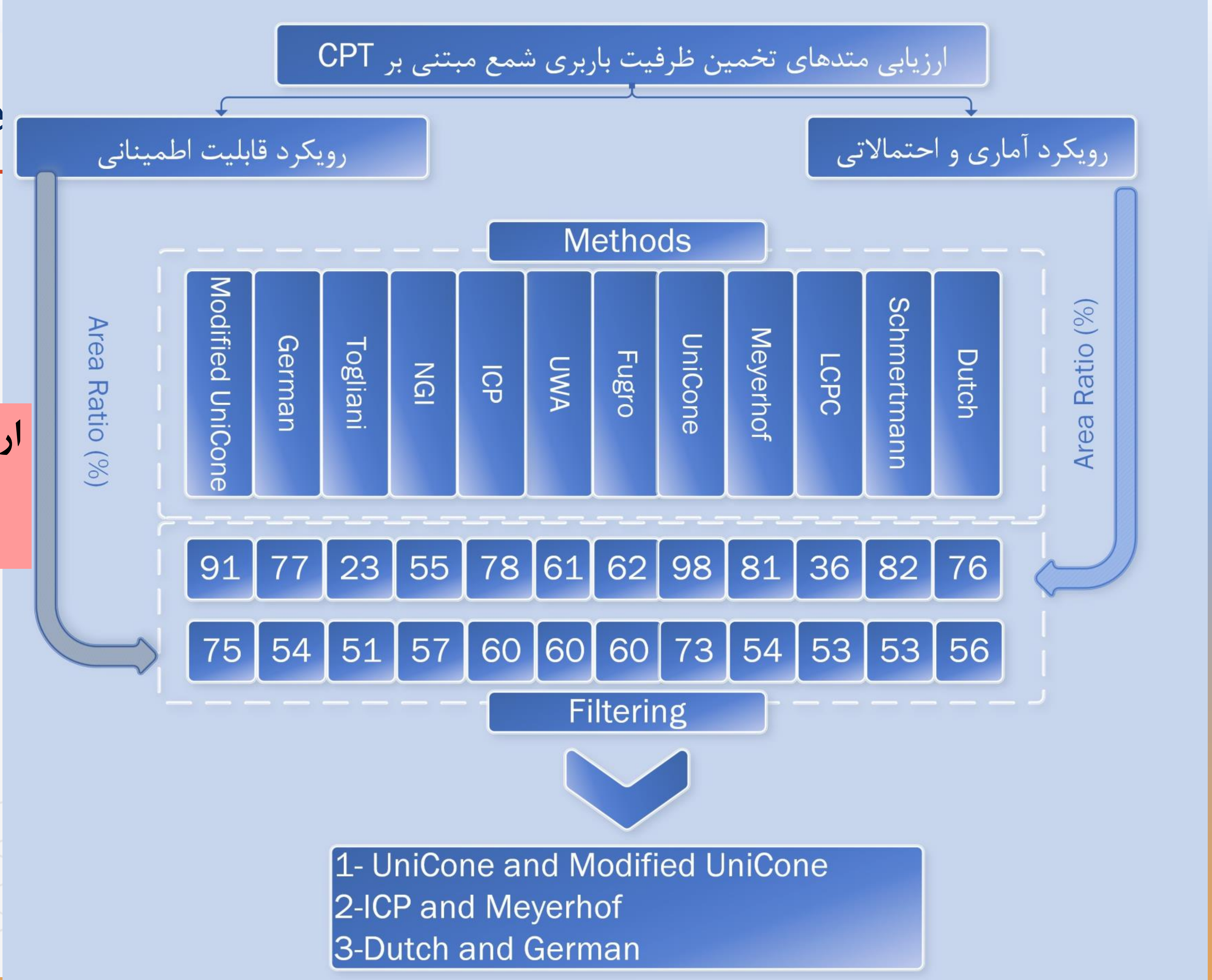


Togliani method
Area Ratio=23%

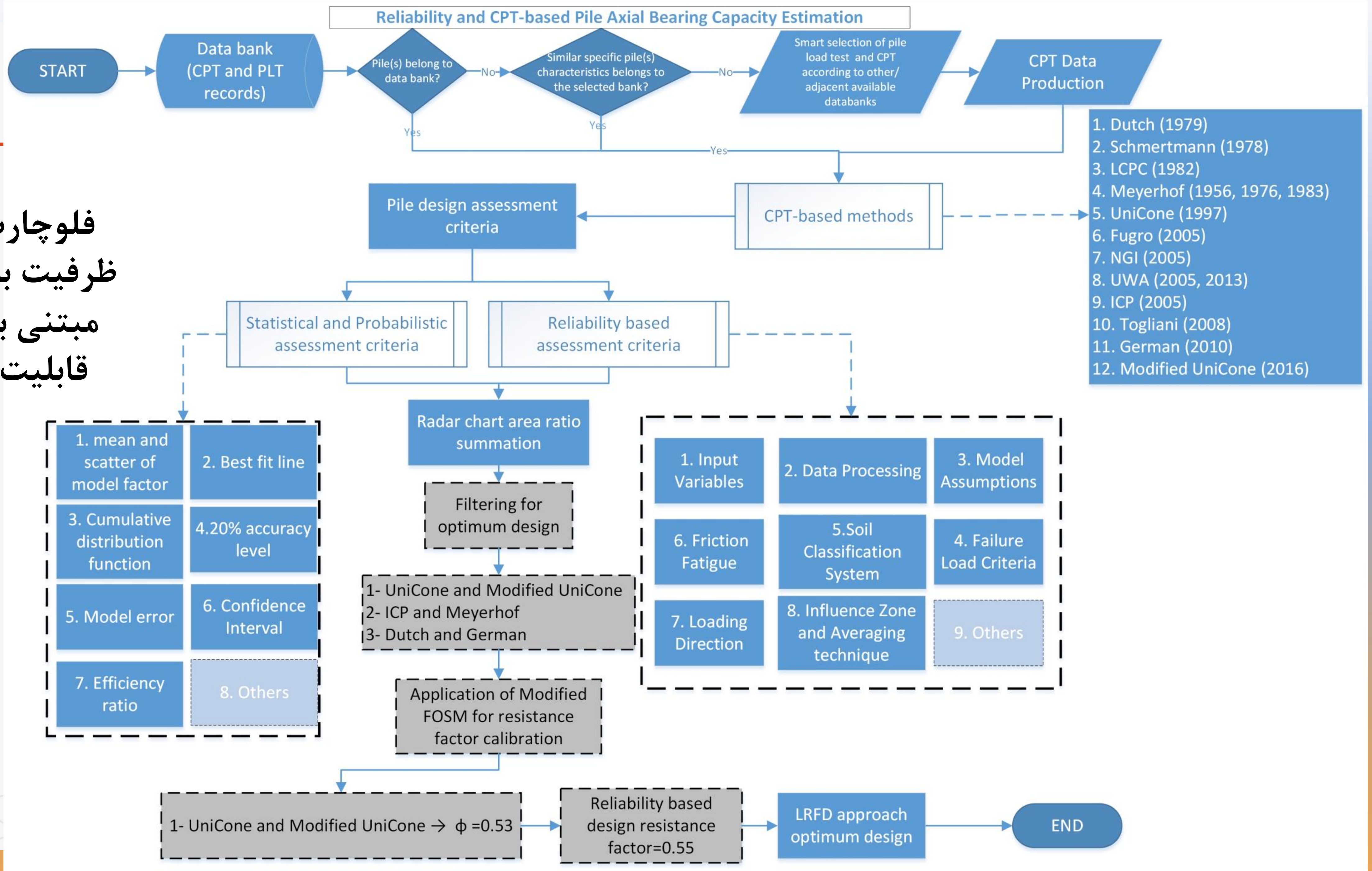


Reliability-Based Assessme

ارزیابی روشهای مبتنی بر CPT با توجه به
- **رویکرد آماری-احتمالاتی**
- **رویکرد قابلیت اطمینانی**

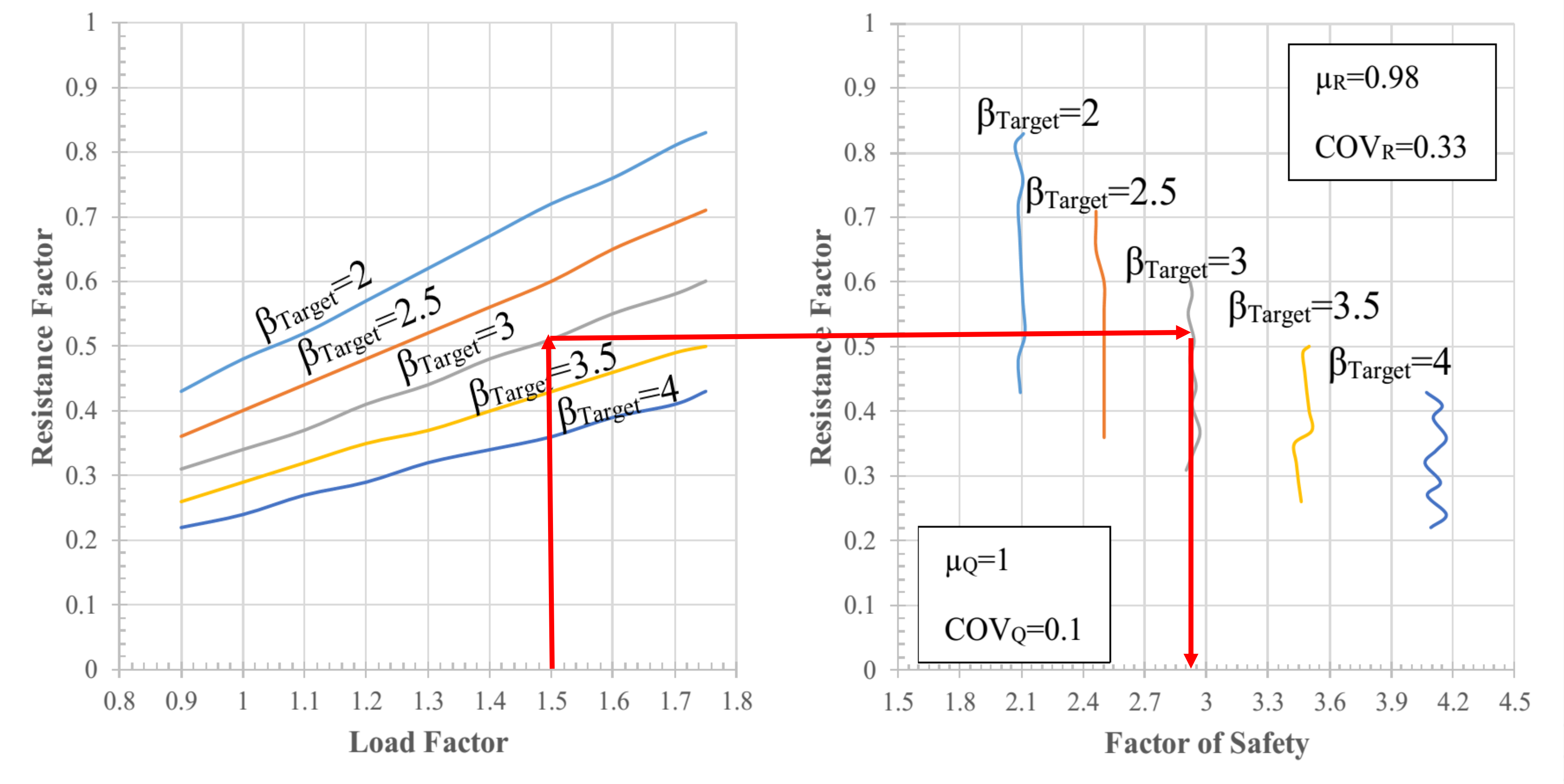


فلوچارت تخمین ظرفیت باربری شمع مبتنی بر CPT و قابلیت اطمینان



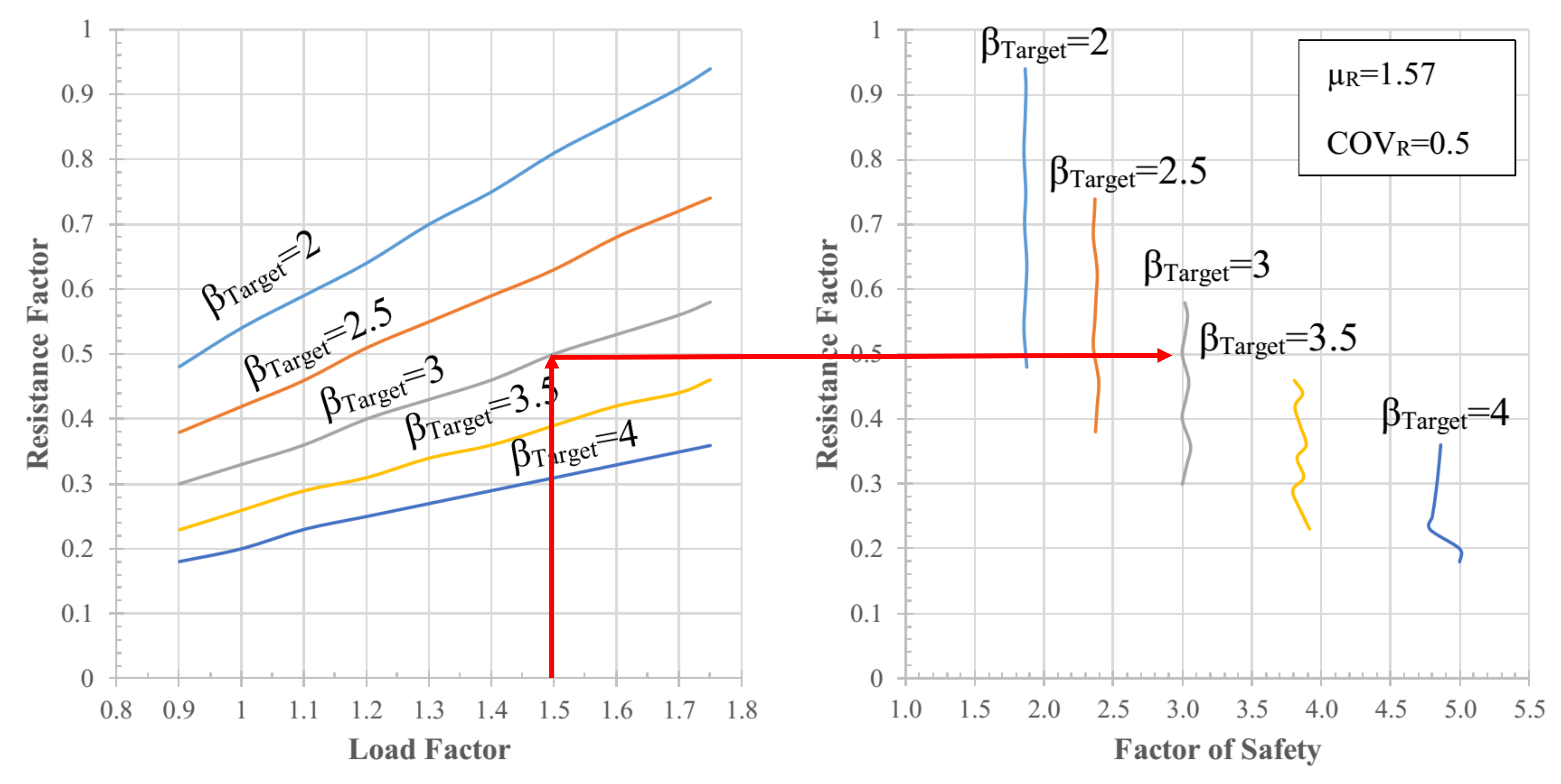
Reliability-Based Assessment of Predictive Methods

بررسی اثر ضریب بار بر روی ضریب مقاومت برای یک روش تخمین بهینه



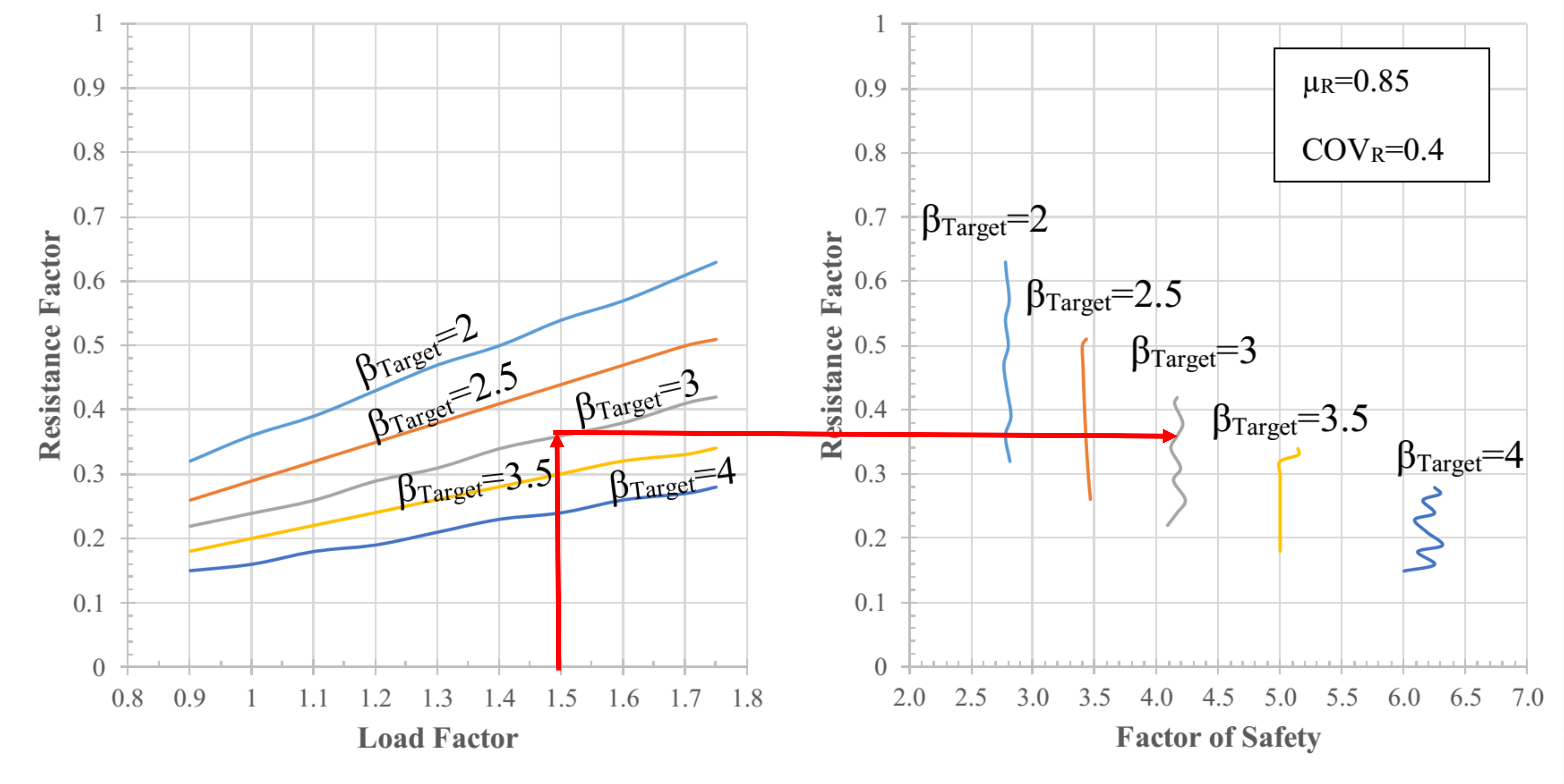
Reliability-Based Assessment of Predictive Methods

بررسی اثر ضریب بار بر روی ضریب مقاومت برای یک روش تخمین دست پایین



Reliability-Based Assessment of Predictive Methods

بررسی اثر ضریب بار بر روی ضریب مقاومت برای یک روش تخمین دست بالا



OUTLINE

1. Generals
2. Uncertainty in Geotechnical Engineering
3. Reliability in Pile Engineering
4. Probabilistic Assessment of Model Uncertainty for Predictive methods
5. Reliability-based assessment of Predictive methods
6. **Summary**

SUMMARY

- عدم قطعیت؛ **جزء جدایی ناپذیر** طراحی‌های ژئوتکنیکی
- منابع عدم‌قطعیت در مهندسی؛ **تغییرپذیری ذاتی خاک**، **خطاهای اندازه‌گیری** و **خطاهای مدل**
- استفاده از ۷ معیار آماری-احتمالاتی، به منظور بررسی عدم‌قطعیت مدل در روش‌های مختلف تخمین ظرفیت باربری محوری شمع
    - مقایسه میانگین و پراکندگی پارامتر مدل
    - برازش بهترین خط
    - تابع توزیع تجمعی
    - تابع چگالی احتمال
    - خطای مدل
    - فاصله اطمینان
    - نسبت کارایی

SUMMARY

- برتری روش‌های مبتنی بر **آزمایش‌های درجا** نسبت به **روش‌های تحلیل استاتیکی** در تخمین ظرفیت باربری شمع
- برتری **روش‌های مبتنی بر CPT** در مقایسه با **روش‌های مبتنی بر SPT** در تخمین ظرفیت باربری محوری شمع
- ارائه ۸ **معیار اصلی** در ارزیابی روشهای مبتنی بر CPT
  - پارامترهای ورودی در هر روش
  - پردازش داده ها
  - فرضیات مدل
  - بار نهایی
  - نحوه در نظرگیری طبقه‌بندی خاک
  - استهلاک اصطکاک جداری
  - جهت بارگذاری
  - ناحیه تاثیر و تکنیک میانگین‌گیری

References

Allen, T.M., 2005. Development of geotechnical resistance factors and downdrag load factors for LRFD foundation strength limit state design: Reference manual. US Department of Transportation, Federal Highway Administration, National Highway Institute.

Beacher, G. B. & Christian, J. T. 2003. Reliability and Statistics in Geotechnical Engineering. Wiely. ISBN0-471-49833-5.

Eslami, A. & Fellenius, B. H. 1997. Pile Capacity by Direct CPT and CPTu Methods Applied to 102 Case Histories. Canadian Geotechnical Journal, 34, 886-904.

Heidarie Golafzani, S., Jamshidi Chenari, R., and Eslami, A., 2019. Reliability Based Assessment of Axial Pile Bearing Capacity: Static analysis, SPT and CPT-based Methods, Georisk: Assessment and management of Risk for Engineered Systems and Geohazards, DOI:10.1080/17499518.2019.1628281.

Heidarie Golafzani, S., Eslami, A., and Jamshidi Chenari, R., (2019b) " Probabilistic Assessment of Model Uncertainty for Prediction of Pile Foundation Bearing Capacity; Static Analysis, SPT and CPT-based Methods" under review for Geotechnical and Geological Engineering

Jamshidi Chenari, R., Kamyab Farahbakhsh, H., Heidarie Golafzani, S. and Eslami, A., 2018. Non-stationary realisation of CPT data: considering lithological and inherent heterogeneity. Georisk: Assessment and Management of Risk for Engineered Systems and Geohazards, pp.1-14.

References

Fenton, G. A. & Griffiths, D. V. 2008. Risk Assessment in Geotechnical Engineering, Wiley.

Moshfeghi, S. and Eslami, A., 2018. Study on pile ultimate capacity criteria and CPT-based direct methods. International Journal of Geotechnical Engineering, 12(1), pp.28-39.

Moshfeghi, S. and Eslami, A., 2018. Failure analysis of CPT-based direct methods for axial capacity of driven piles in sand. Georisk: Assessment and Management of Risk for Engineered Systems and Geohazards, pp.1-19.

Niazi, F.S. and Mayne, P.W., 2018. Deep foundation analysis from cone penetrometers–a reappraisal. In IFCEE 2018 (pp. 53-62).

Phoon, K.-K. & Kulhawy, F. H. 1999. Characterization of Geotechnical Variability. Canadian Geotechnical Journal, 36, 612-624.

Phoon, K.-K. & Kulhawy, F. H. 1999. Evaluation of Geotechnical Property Variability. Canadian Geotechnical Journal, 36, 625-639.

Paikowsky, S.G., Birgisson, B., McVay, M., Nguyen, T., Kuo, C., Baecher, G.B., Ayyub, B., Stenersen, K., O’Malley, K., Chernauskas, L. and O’Neill, M., 2004. Load and resistance factor design for deep foundations, NCHRP Report 507. Transportation Research Board of the National Academies, Washington DC.

Whitman, R. V. 1984. Evaluating Calculated Risk in Geotechnical Engineering. Journal of Geotechnical Engineering, 110, 143-188.

با تشکر از توجه شما