EC7

7.4.1 Design methods
- the results of dynamic load tests whose validity has been demonstrated by static load tests in comparable situations;

7.5.3 Dynamic load tests
(1) Dynamic load tests may be used to estimate the compressive resistance provided an adequate site investigation has been carried out and the method has been calibrated against static load tests on the same type of pile, of similar length and cross-section, and in comparable soil conditions, (see 7.6.2.4 to 7.6.2.6).

7.6.2.4 Ultimate compressive resistance from dynamic impact tests
(1) Where a dynamic impact (hammer blow) pile test [measurement of strain and acceleration versus time during the impact event (see 7.5.3(1))] is used to assess the resistance of individual compression piles, the validity of the result shall have been demonstrated by previous evidence of acceptable performance in static load tests on the same pile type of similar length and cross-section and in similar ground conditions.

EC7

7.6.2.5 Ultimate compressive resistance by applying pile driving formulae
(2) If pile driving formulae are used to assess the ultimate compressive resistance of individual piles in a foundation, the validity of the formulae shall have been demonstrated by previous experimental evidence of acceptable performance in static load tests on the same type of pile, of similar length and cross-section, and in similar ground conditions.

7.6.2.6 Ultimate compressive resistance from wave equation analysis
(2) Where wave equation analysis is used to assess the resistance of individual compression piles, the validity of the analysis shall have been demonstrated by previous evidence of acceptable performance in static load tests on the same pile type, of similar length and cross-section, and in similar ground conditions.
Correlation factors $\xi$

<table>
<thead>
<tr>
<th>$\xi$ for $n$ (n - number of tested piles)</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
</tr>
<tr>
<td>----</td>
</tr>
<tr>
<td>1.04</td>
</tr>
</tbody>
</table>

$\xi$ values in the table are derived for dynamic impact tests.

* $\xi$ values may be multiplied with a model factor of 1.0 when using static impact tests with signal matching.
* $\xi$ values should be multiplied with a model factor of 0.8 when using pile driving formula with measurement of the quasi-static pile load displacement during the impact.
* $\xi$ values should be multiplied with a model factor of 1.0 when using pile driving formula without measurement of the quasi-static pile load displacement during the impact.

**EC7 – implicit hierarchy of testing and evaluation methods with respect to assumed reliability**

**Dynamic Impact Tests**
1. Driving formula
2. Driving formula with measured elastic deformation
3. Wave equation analysis (of blow count)

**Dynamic Impact Load Test (measurements at pile top required)**
4. Evaluation by closed formula based on wave equation (e.g. CASE) utilizing empirical value for the damping
5. Evaluation by modeling of the pile in the soil by signal matching (e.g. CAPWAP), determination of skin friction distribution

**German National Application Document**

Correlation factors: $\xi = (\xi_{o,i} + \Delta\xi) \cdot \eta_D$

Correlation factors $\xi_{o,i}$ and model factors $\eta_D$ according to table A7.2

Calibration increase $\Delta\xi$ acc. to A7.2 in GNAD:

- $\Delta\xi = 0$: calibration of dynamic load tests by static load tests on same site;
- $\Delta\xi = 0.10$: calibration of dynamic load tests by static load tests on comparable site;
- $\Delta\xi = 0.40$: calibration of dynamic load tests by static load tests on comparable site; only signal matching procedures applicable
Equivalent Global Safety Factors
for Signal Matching (CAPWAP®)

Load factor : 1,35 for permanent load, 1,5 for variable load
Average 1,4 for factored action

Resistance factor $\gamma_R = 1,1$ acc. to tables A6 to A8 of EC7

Minimum
$\gamma = (1,25 + 0,0 ) * 0,85 * 1,1 * 1,4 = 1,63$

Maximum
$\gamma = (1,60 + 0,4 ) * 0,85 * 1,1 * 1,4 = 2,62$

Correlation of static and dynamic pile load test
load settlement diagrams
precast concrete piles
dense sand
L = 16 m

Ikpa steel closed end
Test piles in soft clay (lake shore)

Test piles in hard clay

Case study 3 cast-in-place-piles
Case study 3 cast-in-place-piles

Comparison dynamic load test
static load test - statnamic load test
**Offshore – wind energy**

- Project areas in German parts of North Sea and Baltic Sea

**Requirements**
- Dynamic load tests at > 10% of piles
- Minimum 2 at each geological situation
- Restrike-Tests recommended

**Offshore – wind energy**

- First activity 2005
- No enforcement of testing by authorities
- Monitoring not done because of bad weather condition

**Dynamic Pile test for Offshore Wind Turbines**

- 2005: Cabled sensors
- Since 2010 wireless
Dynamic Pile test for Offshore Wind Turbines

Requirements of BSH since 2011
(federal office for sea traffic and hydrology)

Dynamic test of axially loaded piles
Instead of calibration at static tests for piles in glacial sand a
AE = 0.1 is allowed
Monopiles: Monitoring may be required for verification of stress and fatigue

Monitoring of driving
Monitoring of driving

EMX – applied energy - control of hammer performance
CSX – max compression stress in sensor level
TSX – max tension stress in sensor level
verification of fatigue and lifetime
required by regulations
RX4 – upper bound of resistance
RX8 – lower bound of resistance
control of driving formula

Result of signal matching
Modeling of pile in the soil

RU – ultimate capacity
RS – total skin friction
RT – tip resistance
Load settlement graph
GSP

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Dynamic pile load tests - onshore and offshore, driven and cast-in-place
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„Low-Strain“ Integrity testing
Deep foundation consultancy
Vibration measurements and analysis