|  |  |
| --- | --- |
| **Annex 4 to the final report of EG2 *Ease of use***  **Section 4 *Field tests* of EC 7-2**  **2-column-version with comments**  **Still to be decided:**   * Where shall the specifications of the designer planning the tests be mentioned which are common to all field tests (e.g. location, soil type and depth)? In each section of the test, in 4.1 General or in the Section 3 Planning? We decided that this should be mentioned in Section 3 *Planning* * Shall we refer to literature? * We have to decide whether we mention that for some of the tests the results can also be used in empirical design e.g. of piles, shallow foundations … or is this textbook material? * In the section of reporting we have to mention that any deviation from the requirements given in test standards shall be justified and reported. In particular, any influence on the results shall be commented upon. * We still have to check/decide whether the informative Annexes should be part of the standard. * For DMT (4.10) Vincenzo will check the parameter which can be derived by the test. * In the section on planning it must be addressed, what to do when there are no EN- or ISO EN-standards for the tests. | |
| **Original version**  with deletions, new text and *comments*  **Section 4 Field tests ~~in soil and rock~~**  **4.1 General**  (1)P ~~When~~ Field tests ~~are conducted, they~~ shall be interpreted and evaluated in conjunction with the observations obtained ~~linked to~~ by sampling and laboratory testing ~~by excavating and drilling~~, ~~in order to collect information on the ground stratification and to obtain geotechnical parameters or direct input for design methods~~ (see also EN 1997‑1:2004, 3.3).  NOTE Recommendations for the spacing and the depth of field tests are given in 3.?.? and in Annex B.3  ~~(2)P Field tests shall be planned considering the following general points (see also Section 2):~~   * ~~geology/stratification of the ground;~~ * ~~type of structure, the possible~~~~foundation and the anticipated work during the construction;~~ * ~~type of geotechnical parameter required;~~ * ~~design method to be adopted.~~   *This is covered extensively in the section of planning*  ~~(3) The tests or combinations thereof should be selected from the following types, contained in the Parts of EN ISO 22476 and covered in this Section:~~   * ~~cone penetration test;~~ * ~~pressuremeter and dilatometer tests;~~ * ~~standard penetration test;~~ * ~~dynamic probing;~~ * ~~weight sounding test;~~ * ~~field vane test;~~ * ~~flat dilatometer test;~~ * ~~plate loading test~~.   *No list of types of tests. A reference to Table 2.1 in the informative Annex is sufficient*  NOTE: Table 2.1 gives a broad overview for the applicability of common ~~the~~ tests in different ground conditions.  ~~(4) Other complementary internationally recognised investigation methods, for instance geophysical methods, may be used.~~  *Delete - EC 7-2 should as a rule only reference to tests where there are standards.*  **~~4.2 General requirements~~**  **~~4.2.1 Planning a specific test programme~~**  ~~(1)P In addition to the recommendations given in 2.3 and the requirements given in 2.4 and 4.1 (2), the following information shall be established:~~   * ~~ground profile to be expected;~~ * ~~desired total depth of investigation;~~ * ~~elevation of ground surface and if applicable groundwater level.~~   ~~(2)P When designing the ground investigation programme, the selection of the type of field tests and of the test equipment shall aim at obtaining the best technical and economical solution for the intended purpose.   NOTE see also Table 2.1 and B.2.~~  *This is too general and already covered in the section on planning*    **~~4.2.2~~ 4.2 Execution and evaluation**  (1)P ~~For the~~ Field tests shall be executed in accordance with international standards. ~~covered in this Section, equipment and procedures shall correspond to the requirements in EN ISO 22476-1, EN ISO 22476-8, EN ISO 22476-9, EN ISO 22476-12 and EN ISO 22476-13.~~  ~~NOTE Further information on a procedure, presentation and evaluation of the weight sounding test and the flat dilatometer test can be found in CEN ISO/TS 22476-10 and CEN ISO/TS 22476-11 respectively~~.  *Can be deleted as reference to the execution standards will be given in the subsections dealing with them.*  ~~(2)P If the results obtained during the ongoing investigation do not correspond to the initial information (see Section 2) about the test site and/or the aim of the investigation, additional measures shall be considered such as:~~   * ~~additional tests;~~ * ~~changing to different test methods.~~   *This is already stated in the section on planning*  (~~3) If the desired investigation depth is not reached, the client should be informed immediately~~.  *This is already or should be stated in the section on planning*  **~~4.2.3 Evaluation~~**  ~~(1)P In evaluating the field test results, especially in establishing derived values for context of deriving geotechnical parameters/coefficients from the results, any additional information about the ground conditions e.g. from borings shall be considered~~.  *It is already stated in 4.1 (1)*  ~~(2)P Results from any sampling by drilling and excavations according to Section 3 shall be available and shall be used in evaluating the test results~~.  *Delete as contained in (1)P*  (3)P In evaluating the field test results, the possible ~~geotechnical and equipment~~ influences of equipment, ground disturbance and ground structure shall be considered ~~on the measured parameters shall be considere~~d. ~~When a soil or rock formation exhibits anisotropy, attention shall be paid to the axis of loading with respect to the anisotropy.~~  *The deleted text should go in an annex*  (4)P If correlations are used to establish derived values of geotechnical parameters or coefficients, their suitability shall be ~~considered~~ justified ~~for each particular project.~~. Local experience shall be used for confirmation, if available.  ~~(5)P When using Annexes D to K, it shall be ensured that the ground conditions of the site under investigation (soil type, uniformity coefficient, consistency index etc.) are compatible with the boundary conditions given for the correlation. Local experience shall be used for confirmation, if available.~~  *Contained in (4) P*  NOTE 1 Annexes D to K give examples of correlations for the establishment of derived values and for the application of test values to design methods.  NOTE 2 X.3 contains examples of correlations for the establishment of derived values from test results and ~~also~~ for the use of test results directly in design.  *SC7 has to decide how we deal with literature: We should refer to the Annexes in the subsection of the specific tests. We have to check, which of the Annexes we keep and which should go to EC 7-1*  **4.3 Cone penetration and piezocone penetration tests (CPT, CPTU)**  **4.3.1 ~~Objectives~~ General**  (1) The ~~objective of~~ t~~he~~ cone penetration test (CPT) is used ~~is~~ to measure d~~etermin~~e the resistance of the ground ~~soil and soft rock~~ to the penetration of a cone and the local friction on a sleeve. Cone penetration test (CPTU) will in addition provide measurements of pore water pressure.  (2) The test results can give qualitative information on the ground profile.  (3) The results of the test may be used in empirical design of pile design, shallow foundation ……*Is this ok as a standard text for empirical design?*  *Check, whether the test standard covers the dissipation test*. Yes, the standard does! *This should be checked again to avoid repetition in 4.3.2 Derived values*  ~~(2)P The CPT consists of pushing a cone penetrometer vertically into the soil using a series of push rods. The cone penetrometer shall be pushed into the soil at a constant rate of penetration. The cone penetrometer comprises the cone and if appropriate a cylindrical shaft or friction sleeve. The penetration resistance of the cone (~~*~~q~~*~~c~~~~) as well as, if appropriate, the local friction on the friction sleeve shall be measured~~.  ~~(3)P For electrical CPTs, all measurements shall be made by sensors contained in the cone penetrometer.~~  ~~(4) For mechanical CPTs, the measurements are generally made remotely.~~  ~~(5) The piezocone penetration test, CPTU, is an electrical CPT, which includes additional instrumentation to measure the pore water pressure during penetration at the level of the base of the cone.~~  *Delete – all descriptions can be found in the execution standards*  ~~(6) The CPTU results should be used mainly for the determination of a soil profile together with results from sampling by drilling and excavations according to Section 3 or in comparison with other field tests.~~  ~~(7) The results may also be used for the determination of geotechnical parameters such as the strength and deformation properties of soil and soft rock provided penetration is possible, and for direct input to design methods, generally in coarse and fine soil but also possibly in other deposits.~~  ~~(8) The results may also be used to determine the length of piles and their compressive or tensile resistance or the dimensions of shallow foundations.~~  *Delete – explanations of textbooks or should later be cover in subsection on “Derived values”*  **~~4.3.2 Specific requirements~~**  (1)P The tests shall be carried out and reported in accordance with ~~a method that conforms to~~ the requirements given in EN ISO 22476-1 for the electrical CPT and CPTU, or EN ISO 22476-12 for the mechanical CPT.  (?) In addition to the items mentioned in 3.?.? (planning section) the designer planning the tests shall specify the type of the cone*.*  ~~(2)P When planning the test programme for a project, the following items shall be decided in addition to the requirements given in 4.2.1:~~   * ~~type of required cone penetration test according to EN ISO 22476-1 or EN ISO 22476-12;~~ * ~~depth and duration of pore pressure dissipation tests, if applicable.~~   *In the planning section it will said that the designer has to provide all input values for the test. Is there any guidance for the designer for the selection of depth and duration?*  ~~(3)P Any deviation from the requirements given in EN ISO 22476-1 or  EN ISO 22476-12 shall be justified and reported. In particular, any influence on the results shall be commented upon.~~  *This is true for all tests and should be stated once in the reporting section*    **~~4.3.3 Evaluation of test results~~**  ~~(1)P In addition to the requirements given in 4.2, the field and test reports according to EN ISO 22476-1 or EN ISO 22476-12 shall be used for evaluation purposes.~~  *Repetition of 4.3.2 (1)*  ~~(2)P Possible geotechnical influences on the penetration resistance shall be considered in evaluating the test results, e.g. in clays, the cone penetration resistance corrected for pore water pressure effects, (~~*~~q~~*~~t~~~~), should be used in evaluation.~~  *This is given in 4.2.2 Derived values Is there a formula in the test standard accounting for pore pressure?Yes there is!*  **4.3.2 Derived values**  (1) CPT and CPTU results may be used to provide the following derived values:   * relative density and angle of friction of non-cohesive soils, * undrained shear strength of fine-grained soils * soils´ moduli, * permeability at specified depths and * ~~values for the unit pile resistance~~.   (2) When establishing the derived values soils type, pore water pressures and the vertical stress shall be taken into account. Examples for geotechnical values derived from CPT are given in Annexes D.1, D.2, D.4, D.5, D.6 und D.8. *We have to check whether the annexes cover the derived values mentioned above*  *The following text is all material for design and should be in EC 7-1*  **~~4.3.4 Use of test results and derived values~~**  **~~4.3.4.1 Bearing resistance and settlement of spread foundations~~**  ~~(1)P If the bearing resistance or the settlement of a spread foundation is derived from CPT results, either a semi-empirical or an analytical design method shall be used.~~  ~~NOTE See, for example, EN 1997-1:2004, Annex D or F.~~  ~~(2)P If a semi-empirical method is used, all the features of the method shall be taken into account.~~  ~~NOTE If, for instance, the semi-empirical method to determine the settlement of spread foundations from CPT results is used (see D.3), only Young’s modulus of elasticity derived from~~ *~~q~~*~~c~~ ~~is applied in this particular method as shown in the example.~~  ~~(3) If the sample analytical method for bearing resistance of Annex D in EN 1997‑1:2004 is used, the undrained shear strength of fine soil, (~~*~~c~~*~~u~~~~) may be determined for a CPT from:~~  ~~(4.1)~~  ~~Or, in the case of a CPTU, from:~~  ~~(4.2)~~  ~~where~~  *~~q~~*~~c~~~~is the cone penetration resistance~~  *~~q~~*~~t~~ ~~is the cone penetration resistance corrected for pore water pressure effects;~~  *~~N~~*~~k~~ ~~and~~ *~~N~~*~~kt~~ ~~are coefficients estimated from local experience or reliable correlations~~  *~~σ~~*~~vo~~ ~~is the initial total vertical overburden stress at the depth under consideration;~~  ~~(4) If the sample analytical method for bearing resistance calculation of Annex D of EN 1997-1:2004 is used, the angle of shearing resistance (~~*~~ϕ’~~*~~) may be determined from the cone resistance (~~*~~q~~*~~c~~~~), on the basis of local experience, taking into account depth effects, when relevant.~~  ~~NOTE 1 An example of ranges of values to estimate~~ *~~ϕ~~*~~' from~~ *~~q~~*~~c~~ ~~for quartz and feldspar sands is given in D.1, for estimating the bearing resistance of spread foundations when depth effects do not need to be taken into account.~~  ~~NOTE 2 In addition, an example for a correlation between~~*~~ϕ~~*~~’ and~~ *~~q~~*~~c~~ ~~for poorly-graded sands is given in D.2. The correlation given in D.2 should be considered as giving a conservative estimate.~~  ~~(5) More elaborate methods may also be used for determining~~*~~ϕ~~*~~’ from~~ *~~q~~*~~c~~~~, taking into account the effective vertical stress, the compressibility, and the over-consolidation ratio.~~  ~~(6) If an adjusted elasticity method is used for calculating settlements of spread foundations from CPT results, the correlation between cone resistance (~~*~~q~~*~~c~~~~) and the drained (long term) Young’s modulus of elasticity (~~*~~E~~*~~’) depends on the nature of the method: the semi-empirical elasticity method, or the theoretical elastic method.~~  ~~NOTE An adjusted elasticity method is given in EN 1997-1:2004, Annex F.~~  ~~(7) Semi-empirical methods may be used for calculating settlements in coarse soil.~~  ~~NOTE An example is given in D.3.~~  ~~(8) When a theoretical elastic method is used, the drained (long term) Young’s modulus of elasticity (~~*~~E~~*~~’) may be determined from cone resistance (~~*~~q~~*~~c~~~~), on the basis of local experience.~~  ~~NOTE An example of sample values for quartz and feldspar sands is given in D.1 to estimate a value of~~ *~~E~~*~~’ from~~ *~~q~~*~~c~~~~.~~  ~~(9) Correlations between the oedometer modulus (~~*~~E~~*~~oed~~~~) and the cone resistance (~~*~~q~~*~~c~~~~) may also be used when calculating settlements of spread foundations. The following relationship between~~ *~~E~~*~~oed~~ ~~and~~ *~~q~~*~~c~~ ~~is often adopted:~~  *~~E~~*~~oed~~ ~~=~~ *~~α~~* ~~×~~ *~~q~~*~~c~~ ~~(4.3)~~  ~~where~~  *~~α~~* ~~is a correlation factor depending on local experience.~~  ~~NOTE An example of a correlation is given in D.4.~~  ~~(10) When a theoretical elastic method is used to calculate the settlements of spread foundations, a stress dependant oedometer modulus (~~*~~E~~*~~oed~~~~), based on~~ *~~q~~*~~c~~~~, may be used.~~  ~~NOTE 1 For examples of theoretical elastic methods, see EN 1997-1:2004, Annex F.~~  ~~NOTE 2 Examples of correlations between~~ *~~q~~~~c~~* ~~and~~ *~~E~~*~~oed~~ ~~are given in D.5. The correlations given in D.5 should be considered as conservative estimates.~~  **~~4.3.4.2 Pile bearing resistance~~**  ~~(1)P If the ultimate compressive or tensile resistance of piles according to~~~~EN 1997‑1:2004, 7.6.2.3~~~~or 7.6.3.3 is derived from CPT results, calculation rules based on locally~~~~established correlations between the results of static load tests and CPT results shall be used.~~  ~~NOTE 1 An example for such correlations for coarse soil is shown in D.6.~~  ~~NOTE 2 An example is given for the assessment of the compressive resistance of a single pile on the basis of~~ *~~q~~*~~c~~~~-values from a CPT in D.7.~~  *This is all material for design and should be in EC 7-1*  **4.4 Pressuremeter tests (PMT)**  **4.4.1 ~~Objectives~~ General**  (1) The ~~objective of the~~ pressuremeter test is used to measure in-situ the deformation of soil and soft rock caused bythe expansion of a cylindrical flexible membrane under pressure.  ~~(2)P The test consists of inserting a probe containing a cylindrical flexible membrane into the ground either into a pre-formed borehole, or by self-boring or by full displacement pushing. Once at a predetermined depth the~~~~membrane is expanded under pressure and readings of pressure and expansion are recorded until a maximum expansion for the particular device is reached.~~  ~~NOTE Expansion is measured from radial displacement, or calculated from volume change of the cylindrical membrane.~~  *Delete – a descriptions can be found in the execution standards*  (3) The test ~~should~~ may be used to derive strength and/or deformation parameters of the ground at specific depths or specific pressuremeter parameters.  (4) In addition to 3.?.? (Planning section) the designer shall specify ????:  ~~(4) The results may be used to derive stress-strain curves in fine soil and soft rock.~~  *Delete – the evaluation can be found in the execution standards*  **~~4.4.2 Specific requirements~~**  ~~(1)P When planning a test programme for a project the type of pressuremeter to be used shall be specified.~~  *Delete – it is trivial*  ~~(2)P There are four different types of apparatus generally available, for which the corresponding standards shall be used:~~   * ~~pre-bored pressuremeters (PBP), e.g. the flexible dilatometer test (FDT), according to EN-ISO 22476-5;~~ * ~~the Ménard pressuremeter (MPM), a specific form of the PBP, according to EN ISO 22476-4;~~ * ~~the self-boring pressuremeter (SBP), according to EN ISO 22476-6;~~ * ~~the full-displacement pressuremeter (FDP), according to EN ISO 22476-8~~.   *See new(2)P!*  (2)P The tests shall be carried out and reported in accordance with the requirements given in:   * EN-ISO 22476-5 for the pre-bored pressuremeter (PBP), e.g. the flexible dilatometer test (FDT); * EN ISO 22476-4for the Ménard pressuremeter (MPM), a specific form of the PBP; * EN ISO 22476-6 for the self-boring pressuremeter (SBP); * EN ISO 22476-8 for the full-displacement pressuremeter (FDP).   ~~NOTE The PBP and the MPM are lowered into a test hole created specifically for the pressuremeter test. The SBP is drilled into the ground using an integral cutting head at its lower end such that the probe replaces the material it removes thereby creating its own test hole. The FDP is usually pushed~~~~into the ground with an integral cone at its lower end, thereby creating its own test hole. The MPM may in some instances be pushed or driven into the ground. PBP, SBP and FDP probes may take a number of forms, in accordance with the type of installation and measuring systems.~~  *Delete – the execution can be found in the execution standards*  ~~(3) Two different basic test procedures may be used:~~   * ~~a procedure to obtain a pressuremeter modulus, (~~*~~E~~*~~M~~~~), and limit pressure, (~~*~~p~~*~~LM~~~~), that may be used in design procedures formulated for the Ménard pressuremeter; and~~ * ~~a procedure to obtain other stiffness and strength parameters.~~   *Delete – the execution can be found in the execution standards*  ~~(4)P The tests shall be carried out and reported in accordance with a test method that conforms to the requirements for the particular instrument type to be used,  (see 4.4.2 (2)P).~~  *Covered in new (2)*  ~~(5)P Any deviations from the requirements given in the corresponding standard shall be justified and in particular their influence on the results shall be commented upon~~.  *This is must be covered in the execution standard*  **~~4.4.3 Evaluation of test results~~**  *This chapter is/must be covered in the execution standard*  ~~(1)P If necessary, the applied pressure shall be corrected for membrane stiffness to obtain the true pressure applied to the cylindrical ground contact surface around the probe.~~  ~~(2)P If a radial displacement type pressuremeter is used, the displacement readings shall be converted to cavity strain and, if testing weak rock, corrected for membrane compression and thinning.~~  ~~(3)P If a volume displacement type pressuremeter is used (e.g. MPM), the volume reading shall be corrected for system expansion.~~  ~~(4)P In addition to the requirements given in 4.2, the field and test reports according to EN ISO 22476-4 EN ISO 22476-5 EN ISO 22476- 6 and EN ISO 22476-8 for the specific test type shall be used for the basis of any further evaluation.~~  ~~(5) In addition to the plots required by the individual equipment test standard, the list of additional plots in Table 4.1 should be considered.~~  *It is not within the scope of this standard to recommend additional plots. This must be covered in the execution standards.*  **~~Table 4.1 — A list of additional plots~~**   |  |  |  |  | | --- | --- | --- | --- | | **~~Probe~~** | **~~Ground type~~** | **~~Abscissa~~** | **~~Ordinate~~** | | **~~Radial displacement type~~** | | | | | ~~Self-bored,~~  ~~pushed in~~ | ~~All~~ | ~~Cavity strain for each arm~~ | ~~Applied pressure~~ | | ~~Pre-bored~~ | ~~All~~ | ~~Cavity strain for each pair of arms~~ | ~~Applied pressure~~ | | ~~Self bored~~ | ~~All~~ | ~~initial cavity strain for each arm~~ | ~~Applied pressure~~ | | ~~All~~ | ~~All~~ | ~~Cavity strain for unload- reload cycle for each arm~~ | ~~Applied pressure~~ | | ~~All~~ | ~~Clay~~ | ~~Logarithm of cavity strain for each arm~~ | ~~Applied pressure~~ | | ~~All~~ | ~~Sands~~ | ~~Natural logarithm of current cavity strain for each arm~~ | ~~Natural logarithm of effective applied pressure~~ | | **~~Volume displacement type (except MPM)~~ ~~a~~** | | | | | ~~Pre-bored~~ | ~~All~~ | ~~Volume change~~ | ~~Applied pressure~~ | | ~~Pre-bored~~ | ~~All~~ | ~~Rate of change of volume~~ | ~~Applied pressure~~ | | ~~a~~ ~~For MPM tests, the pressure is plotted as abscissa and the volume change as ordinate.~~ | | | |   **4.4.2~~4 Use of test results and~~ Derived values**  (3) The test ~~should~~ may be used to derive strength of the ground e.g.:   * the angle of shearing resistance in non-cohesive ground (ϕ’) * undrained shear strength in cohesive ground (cu)   (?) The test may be used to derive deformation parameters and stress parameters of the ground e.g.:   * horizontal stress and coefficient of earth pressure at rest (K0) * the Menard Modulus (EM),   (?) The test may be used to derive empirical design values e.g.   * bearing resistance of spread foundations, * settlements for spread foundations and * compressive resistance of a single pile.   **~~4.4.4.1 General criteria~~** *The content of this chapter must be/is covered in the execution standard*  ~~(1)P If an indirect or analytical design method is used, the geotechnical parameters of shear strength and shear modulus shall be derived from the pressuremeter curve using methods relevant for the particular test and equipment type.~~  ~~(2)P If a direct or semi-empirical design method is used, all the features of the method shall be taken into account.~~  ~~NOTE Direct foundation design procedures use directly the measurements from field tests, instead of conventional soil properties.~~  ~~(3)P If, for instance, the semi-empirical method to determine the settlement of spread foundations from MPM results is used, only the modulus (~~*~~E~~*~~M~~~~) determined from Ménard pressuremeter results shall be applied in this particular method.~~  NOTE Examples of calculations of settlements can be found in E.2. *It is design!*  **~~4.4.4.2~~ ~~Bearing resistance of spread foundations~~** *The content of this chapter must be/is covered in the execution standard or in EC7-1*  ~~(1)P If a semi-empirical method is used, then all aspects relating to the method need to be followed, in particular the specification for the pressuremeter type used in establishing the method. EN ISO 22476-4 shall be followed.~~  NOTE 1 The semi-empirical method according to Ménard is given in EN 1997-1:2004, Annex E. *It is design!*  NOTE 2 An example of the calculation of the bearing resistance is given in E.1. *It is design!*  ~~(2) If an analytical method is used, the strength of the soil may be determined using empirical and theoretical methods but only on the basis of local experience~~.  NOTE Examples of analytical methods are given in EN 1997-1:2004, Annex D.  ~~(3) The angle of shearing resistance (~~*~~ϕ~~*~~’) may be determined from an SBP test in coarse soil by theoretical methods and from FDP and PBP tests using empirical correlations but only on the basis of local experience.~~  **~~4.4.4.3 Settlement of spread foundations~~** *The content of this chapter must be/is covered in the execution standard*  ~~(1) The settlement of spread foundations may be determined from MPM tests using a semi-empirical method.~~  NOTE An example of the calculation is given in E.2. *It is design!*  ~~(2) If an analytical method is used, the stiffness of the soil may be determined using theoretical models to interpret the pressuremeter test but only on the basis of local experience.~~  ~~NOTE Examples of analytical methods are given in EN 1997-1:2004, Annex F.~~    **~~4.4.4.4 Pile bearing resistance~~** *The content of this chapter must be/is covered in the execution standard*  ~~(1) The ultimate compressive resistance of piles may be derived directly from stress controlled tests.~~  NOTE An example of the calculation of the ultimate compressive resistance is given in E.3. *It is design!*  ~~(2) When the ultimate compressive or tensile resistance of a pile is derived indirectly from pressuremeter test results, an analytical method may be applied to derive values of base and shaft resistance but only on the basis on local experience.~~  **4.5 ~~Flexible~~ Dilatometer tests ~~(FDT)~~**  **4.5.1 ~~Objectives~~ General**  (1) ~~The~~ ~~objective of the~~ ~~flexible~~ Dilatometer tests ~~is~~ may be used to measure in-situ the deformability of rock (rock dilatometer test, RDT),and soil (soil dilatometer test, SDT) from measurements of the radial expansion of a borehole section under a known uniform radial pressure applied by means of a cylindrical dilatometer probe.  (?) In addition to the items mentioned in 3.?.? (planning section) the designer planning the tests shall specify ???  ~~(2)P The test consists of inserting a cylindrical probe, having an outer expandable flexible membrane, into a borehole, and measuring, at selected time intervals or in a semi-continuous manner, the radial displacement of the borehole while inflating the probe under known radial pressure~~.  *This must be/is covered in the execution standard*  ~~(3) The RDT should be used mainly in soft and hard rock formations while the SDT should be~~ ~~used primarily in soft to stiff soil to obtain profiles of deformability variations with depth.~~  *No description where the test is applied*  ~~(4) The results of cylindrical dilatometer tests may be used to determine the deformation and creep properties in-situ when testing intact rock.~~  *Should be moved to 4.5.2 Derived values*  ~~(5) In fragile or clayey rock, and in fractured or closely jointed formations, where core recovery is poor or inadequate for the purpose of obtaining representative samples for laboratory testing, the cylindrical dilatometer test may be used for rapid index logging of boreholes and for comparisons of relative deformability of different rock strata.~~  *Part of this should be moved to 4.5.2 Derived values*  **~~4.5.2 Specific requirements~~**  ~~(1)P When planning a test programme for a project, the specific requirements of the device to be used shall be specified.~~  *Delete – trivial*  (2)P The tests shall be carried out and reported in accordance with ~~a test method that conforms to~~ the requirements given in EN ISO 22476-5.  ~~(3)P Any deviations from the requirements given in EN ISO 22476-5 shall be justified and in particular their influence on the results shall be commented upon.~~  *This must be/is covered in the execution standard*  **4.5.2~~4 Use of test results and~~ Derived values**  (3) The test ~~should~~ may be used to derive strength of the ground e.g.:   * the angle of shearing resistance in non-cohesive ground (ϕ’) * undrained shear strength in cohesive ground (cu)   (?) The test may be used to derive deformation parameters and stress parameters of the ground e.g.:   * horizontal stress and coefficient of earth pressure at rest (K0) * Oedometer modulus (Eoed)   (?) The test may be used to derive empirical design values e.g. – this will be checked by Vincenzo   * bearing resistance of spread foundations, * settlements for spread foundations and * compressive resistance of a single pile.   **~~4.5.3 Evaluation of test results~~**  ~~(1)P In addition to the requirements given in 4.2, the field and test reports according to EN ISO 22476-5 for the specific test type shall be used for evaluation purposes.~~  *Covered in 4.5.1 General*  ~~(2) The interpretation of flexible dilatometer tests requires that the Poisson's ratio of the soil or rock should either be known or assumed.~~  *Must be in the execution standard*  **~~4.5.4 Use of test results and derived values~~**  ~~(1) The results of dilatometer tests may be used to check the serviceability limit state of spread foundations on soil or rock through a deformation analysis.~~  ~~(2) When performing a deformation analysis, the Young's modulus of elasticity (~~*~~E~~*~~) may be taken equal to the dilatometer modulus (~~*~~E~~*~~FDT~~~~) on the assumption that the soil or rock is linearly elastic and isotropic.~~  ~~(3)P When an indirect or analytical design method is used, the geotechnical parameters of shear modulus shall be derived from the dilatometer curve using methods relevant for that particular test~~~~type~~.  *Covered in 4.5.2 Derived values*  **4.6 Standard penetration test**  **4.6.1 ~~Objectives~~ General**  (1) The ~~objectives of the~~ standard penetration test (SPT) is used to measure ~~are the determination of~~ the strength and deformation properties ~~resistance~~ of ~~soil~~ the ground at the base of a borehole ~~to~~ by the dynamic penetration of a split barrel sampler or solid cone. ~~and the to obtaining of~~ Disturbed samples may be obtained for identification purposes.  (2) The test results can give qualitative information on the ground profile.  ~~(2)P The sampler shall be driven into the soil by dropping a hammer of 63,5 kg mass onto an anvil or drive head from a height of 760 mm. The number of blows (~~*~~N~~*~~) necessary to achieve a penetration of the sampler of 300 mm (after its penetration under gravity and below a seating drive) is the penetration resistance.~~  *Execution standard*  ~~(3) The test should be used mainly for the determination of the strength and deformation properties of coarse soil.~~  *In revised (1)*  ~~(4) Valuable additional data may also be obtained in other types of soil.~~  **~~4.6.2 Specific requirements~~**  (3)P The tests shall be carried out and reported in accordance with EN ISO 22476-3.  (?) In addition to the items mentioned in 3.?.? (planning section) the designer planning the tests shall specify ???. In special cases also the limiting number of blows for the main drive in soft rock.  **4.6.2 Derived values**  (1) SPT results may be used to provide the following derived values:   * relative density and angle of friction of non-cohesive soils, * undrained shear strength of fine-grained soils (?) * soils´ moduli, * ?? Jose will check on additional derived values   (2) Type of soil, groundwater level and vertical stress shall be taken into account when establishing the derived values. Examples for geotechnical values derived from SPT are given in Annexes F.1 and F.2.  ~~(2)P Any deviation from the requirements given in EN ISO 22476-3 shall be justified and in particular its influence on the results of the test shall be commented upon.~~  *General, will be stated in Section 6 Ground investigation report*  **~~4.6.3 Evaluation of test results~~**  ~~(1)P In addition to the requirements given in 4.2, the field and test reports according to EN ISO 22476-3 shall be used for evaluation purposes.~~  *Repetition of (3)*  ~~(2)P Existing design methods of foundations based on the SPT are of empirical nature. Equipment-related operating methods have been adapted to obtain more reliable results. Therefore, the application of appropriate correction factors for interpreting the results shall be considered (see EN ISO 22476-3).~~  *Textbook*  ~~(3)P The energy ratio (~~*~~E~~*~~r~~~~) has to be known for the equipment if the results are to be used for the quantitative evaluation of foundations or for the comparison of the results.~~ *~~E~~*~~r~~ ~~is defined as the ratio of the actual energy~~ *~~E~~*~~meas~~ ~~(measured energy during calibration) delivered by the drive-weight assembly into the drive rod below the anvil, to the theoretical energy (~~*~~E~~*~~theor~~~~) as calculated for the drive-weight assembly. The measured number of blows (~~*~~N~~*~~) shall be corrected accordingly (see EN ISO 22476-3).~~  *Textbook and execution standard*  ~~(4) In sands, the energy losses due to rod length and the effect of effective overburden pressure should be taken into account accordingly (see EN ISO 22476-3:2005, A.2 and A.4).~~  ~~(5) Other corrections should be considered, such as taking into account the use of liners (see EN ISO 22476-3:2005, A.3) or the use of a solid cone.~~  *Covered in execution standard*  **~~4.6.4 Use of test results and derived values~~**  **~~4.6.4.1 General criteria~~**  ~~(1) When dealing with sands, a wide empirical experience in the use of this test is available, such as for the quantitative evaluation of the density index, the bearing resistance and the settlement of foundations, even though the results should be considered as only a rough approximation. Most of the existing methods are still based on uncorrected or partly corrected values.~~  ~~(2) There is no general agreement on the use of the SPT results in clayey soil. In principle, it should be restricted to a qualitative evaluation of the soil profile or to a qualitative estimate of the strength properties of the soil.~~  ~~(3) The SPT results may sometimes be used in a quantitative way in clayey soil under well-known local conditions, when directly correlated to other appropriate tests.~~  *Textbook*  **~~4.6.4.2 Bearing resistance of spread foundations in sands~~** *This subsection covers design*  ~~(1) If an analytical method for the calculation of bearing resistance is used, the effective angle of shearing resistance (~~*~~ϕ~~*~~') may be derived from SPT results.~~  ~~NOTE For examples of analytical methods for the calculation of bearing resistance, see EN 1997‑1:2004, Annex D.~~  ~~(2) The value of~~ *~~ϕ~~*~~’ may be derived empirically from:~~   * ~~direct correlations with SPT results;~~ * ~~correlations with density index, where the density index is derived from SPT results.~~   ~~NOTE 1 See for example F.1 and F.2.~~  ~~NOTE 2 The relationships given in F.1 can be used to determine the density index~~ *~~I~~*~~D~~ ~~from either~~ *~~N~~*~~60~~ ~~or (~~*~~N~~*~~1~~~~)~~~~60~~~~, (see EN ISO 22476-3).~~  ~~(3) The resistance of sand to deformation is often increased the longer the geological period of consolidation. This "ageing" effect is reflected in higher blow counts and should be taken into account.~~  ~~(4) Over-consolidation should be taken into account because it increases the blow counts, for the same values of~~ *~~I~~*~~D~~ ~~and~~ *~~σ~~*~~’~~~~v0~~~~.~~  ~~NOTE 1 In F.1, some sample correlations are shown by the means of which the effect of both ageing and over-consolidation can be taken into account.~~  ~~NOTE 2 When correcting for over-consolidation and ageing effects, the resultant derived~~ *~~ϕ~~*~~' values, using the density index, from the correlations in F.2 can be conservative.~~  **4.6.4.3 Settlement of spread foundations in sand** *This subsection covers design*  ~~(1) If a purely elastic design~~~~method is used, the drained Young's modulus of elasticity (~~*~~E~~*~~’) may be derived from the~~ *~~N~~*~~-values through empirical correlations.~~  ~~(2) Alternatively, the density index may be derived based on the~~ *~~N~~*~~60~~~~-value. Then an appropriate correlation may be used to obtain~~ *~~E'~~* ~~through the density index.~~  ~~(3) The direct design methods are based on comparisons of the~~ *~~N~~*~~-values and results of plate loading tests or records of measured settlements of foundations. Allowable bearing resistance for a maximum settlement of 25 mm or the settlement corresponding to a given applied pressure can be obtained through the corresponding procedures with reference to the width of the footing, its embedment in the ground and groundwater table position.~~  ~~NOTE The sample method for the calculation of the settlements caused by spread foundations in sand, as given in F.3, can be used.~~  **~~4.6.4.4 Pile bearing resistance in sand~~** *This subsection covers design*  ~~(1)P If the ultimate compressive or tensile resistance of piles is derived from SPT results according to EN 1997-1:2004, 7.6.2.3 or 7.6.3.3, calculation rules based on locally established correlations between the results of static load test and SPT results shall be used.~~  **4.7 Dynamic probing ~~tests~~ ~~(DP)~~**  **4.7.1 ~~Objectives~~ General**  (1) ~~The objective of the~~ Dynamic probing (DP) ~~test~~ is used to evaluate the strength and deformability properties of ground. ~~to determine the resistance of soil and soft rock in-situ to the~~ ~~dynamic penetration of a cone.~~ The results can give qualitative information on the ground profile.  (?) In addition to the items mentioned in 3.?.? (planning section) the designer planning the tests shall specify ???  ~~(2)P A hammer of a given mass and falling height shall be used to drive the cone. The penetration resistance is defined as the number of blows required to drive the penetrometer over a defined distance. A continuous record shall be provided with respect to depth. No samples are recovered.~~  ~~(3) The test results should be used particularly for the determination of a soil profile together with results from sampling by drilling and excavations according to Section 3 or as a relative comparison of other in-situ tests.~~  ~~(4) The results may also be used for the determination of the strength and deformation properties of soil, generally of the coarse type but also possibly in fine soil, through appropriate correlations.~~  ~~(5) The results can also be used to determine the depth to very dense ground layers indicating for instance the length of end bearing piles.~~  *Covered by the test standard and textbook*  **~~4.7.2 Specific requirements~~**  (~~1)P For planning the specific test programme for a project, in addition to the requirements given in 4.2.1, the type of required DP test according to EN ISO 22476‑2, shall be decided upon.~~  (3)P The tests shall be carried out and reported in accordance with EN ISO 22476-2.  ~~NOTE Five procedures are available according to EN ISO 22476-2, covering a wide range of specific work per blow: DPL, DPM, DPH, DPSH-A and DPSH-B as follows.~~   * ~~Dynamic probing light (DPL): test representing the lower end of the mass range of dynamic penetrometers. Blow count:~~ *~~N~~*~~10L~~~~.~~ * ~~Dynamic probing medium (DPM): test representing the medium mass range of dynamic penetrometers. Blow count:~~ *~~N~~*~~10M~~~~.~~ * ~~Dynamic probing heavy (DPH): test representing the medium to very heavy mass range of dynamic penetrometers. Blow count:~~ *~~N~~*~~10H~~~~.~~ * ~~Dynamic probing super heavy (DPSH-A and DPSH-B): tests representing the upper end of the mass range of~~ ~~dynamic penetrometers closely related to the dimensions of the SPT. Blow count:~~ *~~N~~*~~10SA~~~~, or~~ *~~N~~*~~20SA~~~~,~~ *~~N~~*~~10SB~~ ~~or~~ *~~N~~*~~20SB~~~~.~~   *Textbook and covered in test standard*  ~~(3)P Any deviation from the requirements given in EN ISO 22476-2 shall be justified and in particular its influence on the results of the test shall be commented upon.~~  *General, will be covered in Section 6 Ground investigation report*  ~~NOTE Deviations exist with respect to:~~   * ~~falling height and hammer mass;~~ * ~~dimensions of the cone: e.g. an area of 10 cm~~~~2~~ ~~for the DPM cone, instead of 15 cm~~~~2~~ ~~as specified in EN ISO 22476-2:2005, clause 4.~~   ~~(4) In locations with special difficulties of accessibility, lighter equipment and procedures other than those specified in EN ISO 22476-2 may be used~~.  *We have a broad variety*  **~~4.7.3 Evaluation of test results~~**  ~~(1)P In addition to the requirements given in 4.2, the field and test reports according to EN ISO 22476-2 shall be used for evaluation purposes.~~  ~~(2)P Possible geotechnical and equipment influences on the penetration resistance according to EN ISO 22476-2:2005, 5.4 shall be considered in evaluating the test results.~~  *General, will be covered in Section 6 Ground investigation report*  **4.7.24 ~~Use of test results and~~ Derived values**  (1) Results of dynamic probing may be used to provide the following derived values:   * relative density, * angle of friction and * soils´ moduli,   of non-cohesive soils.  (2) Soil type, groundwater level and vertical stress shall be taken into account when establishing the derived values. Examples for geotechnical values derived from DP are given in Annexes G.1, G.2 and G.3. Correlations between CPT and DP as well as correlations between different types of DP are given in Annexes G.4 and G.5.  ~~(1) For coarse soil, it is possible to obtain correlations with some geotechnical parameters and field tests. The correlations may be used in a quantitative evaluation for foundation design, provided the friction along the rods is negligible, or duly corrected.~~  ~~(2) For fine soil, the quantitative use of the results should be employed only under well-known local conditions and supported by specific correlations. The skin friction during the test is a factor of special concern with this type of soil and should be duly taken into account.~~  ~~(3) Several correlations have been established among the different dynamic probing tests and between them and other tests or geotechnical parameters. In some cases the friction along the rods has been eliminated or corrected, but the actual energy transmitted to the probe has not been measured. Therefore they cannot be considered valid in general.~~  *Textbook*  ~~NOTE 1 Examples of such correlations are included in Annex G.~~  ~~NOTE 2 The correlations given in Annex G should be considered as conservative estimates.~~  *Covered in 4.7.2 (2)*  ~~(4) If an analytical method for bearing resistance of spread foundations is used, the angle of shearing resistance (~~*~~ϕ~~*~~’) of coarse soil may be determined from the number of blows and the corresponding density index (~~*~~I~~*~~D~~~~) with correlations.~~  *Design*  ~~NOTE 1 An example of an analytical method is given in EN 1997-1:2004, D.4.~~  ~~NOTE 2 Such correlations for the determination of~~ *~~ϕ~~*~~' are given as examples in G.1 and G.2.~~  ~~(5) If a theoretical elastic method is applied to calculate the settlements of spread foundations, the oedometer modulus (~~*~~E~~*~~oed~~~~) derived from the number of blows may be used.~~  ~~NOTE 1 Examples of theoretical elastic methods are given in EN 1997-1:2004, Annex F.~~  *Design*  ~~NOTE 2 Corresponding examples of correlations for the determination of the oedometer modulus are given in G.3.~~  *Covered in 4.7.2 (2)*  ~~(6) If well-established correlations between ultimate compressive resistance from static pile load tests (see EN 1997-1:2004, 7.6.2.3) and cone penetration resistance (~~*~~q~~*~~c~~~~) in coarse soil are used for the design,~~ *~~q~~*~~c~~ ~~may be estimated from~~ *~~N~~*~~10~~ ~~or~~ *~~N~~*~~20~~ ~~values using established relationships.~~  *Design*  ~~NOTE 1 Examples for DPH correlations are given in G.4.~~  ~~NOTE 2 An example of correlations between the results of different dynamic probing tests is given in G.5.~~  *Covered in 4.7.2 (2)*  **~~4.8 Weight sounding test (WST)~~** *On 27 March it was decided to delete the WST because JP told us that the test would not be standardised on a European level.*  **~~4.8.1 Objectives General~~**  ~~(1) The objective of the weight sounding test (WST) is used to measure the determination of the resistance of soil in situ to the static and/or rotational penetration of a screw-shaped point.~~  ~~(2) The test results can give qualitative information on the ground profile.~~  ~~(3)P The tests shall be carried out and reported in accordance with the requirements given in CEN ISO 22476-10.~~  ~~(4) The designer planning the tests shall specify:~~   * ~~the location,~~ * ~~???? and~~ *~~(Herbert will check whether there are further specifications)~~* * ~~the depth~~   ~~of the tests.~~  ~~(2)P The weight sounding test shall be made as a static sounding in soft soil if the penetration resistance is less than 1 kN. If the resistance exceeds 1 kN, the penetrometer shall be rotated, manually or mechanically, and the number of half-turns for a given depth of penetration recorded. A continuous record is provided with respect to depth but no samples are recovered.~~  ~~NOTE Further information on a procedure, presentation and evaluation for the WST can be found in CEN ISO/TS 22476-10, (see X.3.5).~~  *~~Covered in the test standard~~*  ~~(3) The weight sounding test should primarily be used to give a continuous soil profile and an indication of the layer sequence. The penetrability in even stiff clays and dense sands is good.~~  *~~Covered in 4.8.1 (2)~~*  ~~(4) The weight sounding test may also be used to estimate the density index of coarse soil.~~  ~~(5) The results can also be used to determine the depth to very dense ground layers indicating the length of end bearing piles.~~  *~~See 8.8.2 Derived values~~*  **~~4.8.2 Specific requirements~~**  ~~(1) The tests should be carried out and reported in accordance with a recognised method.~~  *~~See 8.8. (3)~~*  ~~(2)P Any deviation from the requirements in the method referred to in (1) shall be justified and in particular its influence on the results of the test shall be commented upon.~~  *~~See 6. Ground investigation report~~*  ~~NOTE Further information on a procedure, presentation and evaluation for the weight sounding test can be found in CEN ISO/TS 22476-10.~~  **~~4.8.3 Evaluation of test results~~**  ~~(1)P The requirements given in 4.2 shall be followed for the evaluation of the test results.~~  ~~(2) In addition, the field and test reports, according to the method referred to in 4.8.2 (1), should be used for evaluation purposes.~~  ~~NOTE Further information on a procedure, presentation and evaluation for weight sounding test can be found in CEN ISO/TS 22476-10.~~  *~~Repetions~~*  ~~(2) The following influences can affect the evaluation of the results.~~   * ~~The variations of the resistance with depth can depend on the variations in the soil layer sequence.~~ * ~~In very soft to firm clays, the resistance is often less than 1 kN or approximately constant and less than 10 half-turns per 0,2 m of penetration.~~ * ~~As the sensitivity of the clay also influences the penetration resistance, the strength of the clay cannot be determined directly from the penetration resistance without a calibration for each site.~~ * ~~In very loose to loose sediments of silt and sand, rather low and constant penetration resistances are obtained.~~ * ~~In medium dense to dense silts and fine sands, higher (10 to 30 half-turns per 0,2 m of penetration) resistances are obtained, which remain approximately constant with depth.~~ * ~~In sand and gravel sediments, the variation in penetration resistances increases with the grain size.~~ * ~~In silty sands and coarse gravel, a high penetration resistance does not always correspond to higher density or strength and deformation properties.~~   *~~The important issues should be stated in 4.8.2 Derived values~~*  **~~4.8.24 Use of test results and Derived values~~**  ~~(1) WST results may be used to provide the following derived values:~~   * ~~relative density and angle of friction of non-cohesive soils~~ * *~~??? Herbert will check for further derived values~~*   ~~and~~   * ~~undrained shear strength in cohesive soils and~~   ~~soils´ moduli.~~  ~~.~~  ~~(2) When establishing the derived values CEN ISO/TS 22476-10 shall be taken into account. Examples for geotechnical values derived from WST are given in Annex H.~~  ~~(1)P When the bearing resistance or the settlement of a spread foundation is derived from weight sounding test results, an analytical design method shall be used.~~  ~~(2) If an analytical method for bearing resistance is used, the angle of shearing resistance~~ *~~ϕ~~*~~' may be determined from correlations with weight sounding resistance.~~  ~~NOTE Examples of analytical methods are given in EN 1997-1:2004, Annex D.~~  ~~(3) Such correlations should be based upon comparable experience, relevant to the design situation.~~  ~~NOTE Annex H presents an example correlation, derived for quartz and feldspar sands in a European region.~~  ~~(4) If an adjusted elasticity method is used for calculating settlements of spread foundations from weight sounding results, the drained (long term) Young’s modulus of elasticity (~~*~~E~~*~~’) may be determined from weight sounding resistance on the basis of local experience. In the case of quartz and feldspar sands, for example, the angle of shearing resistance (~~*~~ϕ~~*~~') may be estimated from the weight sounding resistance.~~  ~~NOTE 1 Such an adjusted elasticity method is given in EN 1997-1:2004, Annex F.~~  ~~NOTE 2 An example of a correlation to estimate the angle of shearing resistance (~~*~~ϕ~~*~~') of quartz and feldspar sands is given in Annex H.~~  ~~(5) In coarse soil, the weight sounding resistance may also be used in direct estimation of the bearing capacity of spread foundation and piles.~~  ~~(6) In fine soil, the weight sounding resistance may be used to estimate the undrained shear strength of soil, based on local experience, considering the sensitivity of the soil and water conditions in the borehole.~~  *~~This is all on design~~*  **4.9 Field vane test ~~(FVT)~~**  **4.9.1 ~~Objectives~~ General**  (1) The ~~objectives of the~~ field vane test (FVT) is used to measure ~~are the measurement of~~ the resistance to rotation in-situ of a vane installed primarily in soft fine-grained soil for the determination of the undrained shear strength and the sensitivity.  ~~(2)P The field vane test shall be carried out with a rectangular vane, consisting of four plates fixed at 90° angles to each other, pushed into the soil to the desired depth and rotated.~~  ~~(3) The field vane test may also be used for the determination of the undrained shear strength in stiff clays, silts and glacial clays. The reliability of test results varies depending on the type of soil.~~  ~~Covered in test standard~~  ~~(4) After extensive rotation of the vane, whereby the soil along the failure surface becomes thoroughly remoulded, the remoulded shear strength value can be measured and the soil’s sensitivity can be calculated.~~  ~~Covered in test standard~~  **~~4.9.2 Specific requirements~~**  (2) The tests ~~should~~ shall be carried out and reported in accordance with requirements given in EN ISO 22476-9.  ~~(2)P Any deviation from the requirements given in EN ISO 22476-9 shall be justified, and in particular its influence on the results of the test shall be commented upon.~~  (?) In addition to the items mentioned in 3.?.? (planning section) the designer planning the tests shall specify size of the vane.  **~~4.9.3 Evaluation of test results~~**  ~~(1)P In addition to the requirements given in 4.2, the field and the test reports according to EN ISO 22476-9 shall be used for evaluation purposes.~~  *Repetition of (2)*  ~~(2) The results of other field test, e.g. from CPT, SPT, WST or DP if conducted, should be available and considered.~~  *Shall be covered in 6 Ground investigation report*  **4.9.2 ~~4 Use of test results and~~ Derived values**  (1) FVT results may be used to provide the following derived values:   * undrained shear strength, * sensitivity and * values for the unit pile resistance *(check, whether we have written such information before)*   of fine-grained soils  (2) When establishing the derived values for the undrained shear strength the plasticity and the vertical stress shall be taken into account. *We were not sure, whether we are allowed to reference to literature within a standard and decided not to give formulae as in the examples for geotechnical values derived from FVT are given in Annexes I.1 to I.5.*  ~~(1)P If the bearing resistance of a spread foundation, the ultimate compressive or tensile resistance of piles or stability of slopes are derived based on vane test results, an analytical design method shall be used.~~  *Design*  ~~(2)P In order to obtain derived values for the undrained shear strength~~~~from field vane test results, the test result (~~*~~c~~*~~fv~~~~) shall be corrected based on:~~  *~~c~~*~~u~~ ~~=~~ *~~µ~~* ~~×~~ *~~c~~*~~fv~~~~. (4.4)~~  ~~The correction factor~~ *~~µ~~* ~~shall be determined based on local experience.~~  ~~(3) Existing correction factors are usually related to the liquid limit plasticity index, the effective vertical stress or the degree of consolidation.~~  ~~NOTE Annex I gives examples of such correction factors~~.  *Covered in Annex I.1*  **4.10 Flat dilatometer test (~~DMT~~)**  **4.10.1 ~~Objectives~~ General**  (1) The ~~objectives of the~~ flat dilatometer test (DMT) is used to measure ~~are the determination of the~~ in-situ strength and deformation properties of soil by expanding a thin circular steel membrane mounted flush on one face of a blade-shaped steel probe inserted vertically into the ground.  (2) The test results can give qualitative information on the ground profile.  ~~2)P The test consists of measuring the pressures when the membrane is flush with the blade and just begins to move and when the displacement in the centre of the membrane reaches 1,10 mm into the soil. The test shall be performed at selected depths or in a semi-continuous manner~~.  *Covered in the test standard*  ~~(3) The results of DMT tests may be used to obtain information on soil stratigraphy, in-situ state of stress, deformation properties and shear strength.~~  *See derived values*  ~~(4) The DMT test should primarily be used in clays, silts and sands where particles are small compared to the size of the membrane.~~  ~~NOTE Further information on a procedure, presentation and evaluation of the DMT can be found in CEN ISO/TS 22476-11, (see X.3.7).~~  *Covered in the test standard*  **~~4.10.2 Specific requirements~~**  (3) The tests should be carried out and reported in accordance withrequirements given in CEN ISO/TS 22476-11 ~~a recognised method.~~  (?) In addition to the items mentioned in 3.?.? (planning section) the designer planning the tests shall specify ???  ~~(2)P Any deviations from the requirements given in the method referred to in (1) shall be justified and in particular their influence on the results shall be commented upon.~~  *Covered in 6 Ground investigation report*  ~~NOTE Further information on a procedure, presentation and evaluation of the DMT can be found in CEN ISO/TS 22476-11~~  **~~4.10.3 Evaluation of test results~~**  ~~(1)P The requirements given in 4.2, shall be followed for the evaluation of the test results.~~  ~~(2) In addition the field and test reports, according to the method referred to in 4.10.2 (1), should be used for evaluation purposes.~~  ~~NOTE Further information on a procedure, presentation and evaluation of the DMT can be found in CEN ISO/TS 22476-11~~  **4.10.2 ~~4 Use of test results and~~ Derived values**  (1) DMT results may be used to provide the following derived values:   * in-situ stress *(check, whether it is mentioned in the standard*) * coefficient of consolidation and permeability for fine-grained soils *(check, whether it is mentioned in the standard*) * angle of friction of non-cohesive soils, * undrained shear strength of fine-grained soils * soils´ moduli *(Vincenzo will check the derived values mentioned in the test standard)*   (2) An example for geotechnical values derived from DMT is given in Annex J.  (3) The results of the test may be used in empirical design of spread foundations and pile foundations. See ??? *(This paragraph must be considered for other tests too)*  **~~4.10.4.1 Bearing resistance and settlement of spread foundations~~** *this is design*  ~~(1)P If the bearing resistance of spread foundations is derived from DMT results, an analytical design method shall be used.~~  ~~(2) If an analytical method is used, the derived value of the undrained shear strength (~~*~~c~~*~~u~~~~) of non-cemented clays, for which the DMT test results show material index~~ *~~I~~*~~DMT~~~~< 0,8, may be determined using the following relationship:~~  *~~c~~*~~u~~ ~~= 0,22~~ *~~σ~~*~~'~~~~v0~~ ~~× (0,5~~ *~~K~~*~~DMT~~~~)~~~~1,25~~ ~~(4.5)~~  ~~where~~  *~~K~~*~~DMT~~ ~~is the horizontal stress index or any other well documented relationship based on local experience.~~  ~~NOTE Examples of analytical methods are given in EN 1997-1:2004, Annex D.~~  ~~(3) If applying an adjusted elasticity method, the one-dimensional settlement of spread foundations may be calculated using values of the one-dimensional tangent modulus (~~*~~E~~*~~oed~~~~) determined from results of DMT tests. In fine soil, such procedures should be applied only when the sum of the effective overburden pressure and the stress increase induced by the foundation load is less than the pre-consolidation pressure.~~  ~~NOTE 1 Such an adjusted elasticity method is given in EN 1997-1:2004, Annex F.~~  ~~NOTE 2 An example of such a determination of settlements is shown in Annex J.~~  **~~4.10.4.2 Pile bearing resistance~~** *this is design*  ~~(1)P If the ultimate compressive or tensile resistance of piles is derived from DMT results, an analytical calculation method shall be applied to derive the values of base and shaft resistance.~~  **4.11 Plate loading test ~~(PLT)~~**  **4.11.1 ~~Objectives~~ General**  (1) The ~~objective of the~~ plate loading test (PLT) is used to measure ~~the determination of~~ the vertical deformation and strength properties of ground ~~soil and rock masses~~ in-situ by recording the load and the corresponding settlement when a rigid plate ~~modelling a foundation~~ is loading the ground.  ~~(2)P The plate loading test shall be carried out on a thoroughly levelled and undisturbed~~~~surface either at ground level or on the bottom of an excavation at a certain depth or the bottom of a large diameter borehole, an exploration shaft or gallery.~~  *See test standard*  ~~(3) The test is applied in all soils, fills and rock but normally should not be used for very soft fine soil~~.  *See test standard*  **~~4.11.2 Specific requirements~~**  (2)P The test shall be carried out and reported in accordance with EN ISO 22476‑13.  (?) In addition to the items mentioned in 3.?.? (planning section) the designer planning the tests shall specify   * size of the plate * the loading sequence   of the test.  ~~(2)P Any deviation from the requirements given in EN ISO 22476-13 shall be justified and in particular its influence on the results shall be commented upon.~~  ~~NOTE Deviations exist, for example with respect to plate size and test procedure (incremental loading, constant rate of deformation~~).  *See 6 Ground investigation report*  **~~4.11.3 Evaluation of test results~~**  ~~(1)P In addition to the requirements given in 4.2, the field and the test reports according to EN ISO 22476-13 shall be used for evaluation purposes.~~  **4.11.2 ~~4 Use of test results and~~ Derived values**  ~~(1) The results of a PLT may be used to predict the behaviour of spread foundations~~. *design*  ~~(2) For deriving geotechnical parameters of a homogeneous layer (for use in indirect design methods), the layer should have a thickness beneath the plate of at least two times the width or diameter of the plate.~~  ~~(3) Results of a PLT may only be used for direct design methods if:~~   * ~~the size of the plate has been chosen considering the width of the planned spread foundation (in which case the observations are transformed directly);~~ * ~~a homogeneous layer up to two times the width of the planned spread foundation exists (in which case the results of smaller sized plates – not considering the planned foundation width – are used to transform the results on an empirical basis to the actual foundation size).~~   ~~(4) If an analytical design method for bearing resistance is used, the undrained shear strength (~~*~~c~~*~~u~~~~) may be derived from a PLT conducted at a constant rate of penetration, sufficiently fast to practically preclude any drainage~~.  *Covered in test standard*   1. PLT results may be used to provide the following derived values:  * undrained shear strength of fine-grained soils * drained strength of coarse grained soils * soils´ moduli, * ???.  1. Examples of geotechnical values derived from PLT are given in Annexes K.1, K.2 and K.3. 2. The results of the test may be used in empirical design of spread foundations and for compaction control of earthworks. See ??? *(This paragraph must be considered for other tests too)*   ~~NOTE 1 Examples of analytical design methods for bearing resistance are given in EN 1997-1:2004, Annex D.~~  ~~NOTE 2 An example of a relationship used for deriving the value of~~ *~~c~~*~~u~~ ~~is given in K.1.~~  ~~(5) If an adjusted elasticity method for settlement evaluation is used, the Young's modulus of elasticity (~~*~~E~~*~~) may be derived from the plate settlement modulus (~~*~~E~~*~~PLT~~~~), based on established experience.~~  ~~NOTE 1 Such an adjusted elasticity method for settlement evaluation is given in EN 1997-1:2004, Annex F.~~  ~~NOTE 2 The determination of~~ *~~E~~*~~PLT~~ ~~is shown in K.2.~~  ~~(6) The coefficient of sub-grade reaction (~~*~~k~~*~~s~~~~) for evaluating deformations may be derived from results of an incremental loading test.~~  ~~NOTE An example of the calculation of~~ *~~k~~*~~s~~ ~~is given in K.3.~~  ~~(7) For direct design, the results of PLT may be transferred directly to the foundation problem without using any geotechnical parameters.~~  ~~(8) Settlements of footings in sand may be derived from PLT results.~~  ~~NOTE An example is given in K.4.~~  *This is all design* | **New streamlined version**  new text and *with comments*  **Section 4 Field tests**  **4.1 General**  (1)P Field tests shall be interpreted and evaluated in conjunction with the observations obtained by sampling and laboratory testing (see also EN 1997‑1:2004, 3.3).  NOTE Recommendations for the spacing and the depth of field tests are given in 3.?.? and in Annex B.3  NOTE: Table 2.1 gives a broad overview for the applicability of common tests in different ground conditions. *Do we keep the table in EC 7-2? It is textbook!*  **4.2 Execution and evaluation**  (1)P Field tests shall be executed in accordance with international standards.  (3)P In evaluating the field test results, the possible influences of equipment, ground disturbance and ground structure shall be considered.  (4)P If correlations are used to establish derived values of geotechnical parameters or coefficients, their suitability shall be justified. Local experience shall be used for confirmation, if available.  NOTE 1 Annexes D to K give examples of correlations for the establishment of derived values and for the application of test values to design methods.  NOTE 2 X.3 contains examples of correlations for the establishment of derived values from test results and ~~also~~ for the use of test results directly in design.  *SC7 has to decide how we deal with literature: We should refer to the Annexes in the subsection of the specific tests. We have to check, which of the Annexes we keep and which should go to EC 7-1*  **4.3 Cone penetration and piezocone penetration tests**  **4.3.1 General**  (1) Thecone penetration test (CPT) is used ~~is~~ to measure the resistance of the ground to the penetration of a cone and the local friction on a sleeve. Cone penetration test (CPTU) will in addition provide measurements of pore water pressure.  (2) The test results can give qualitative information on the ground profile.  (3) The results of the test may be used in empirical design of pile design, shallow foundation …… *Ok as standard text for empirical design? Or is this textbook?*  *Check, whether the test standard covers the dissipation test*. Yes, the standard does! *This should be checked again to avoid repetition in 4.3.2 Derived values*  (1)P The tests shall be carried out and reported in accordance with the requirements given in EN ISO 22476-1 for the electrical CPT and CPTU, or EN ISO 22476-12 for the mechanical CPT.  (3) In addition to the items mentioned in 3.?.? (planning section) the designer planning the tests shall specify the type of the cone.  **4.3.2 Derived values**  (1) CPT and CPTU results may be used to provide the following derived values:   * relative density and angle of friction of non-cohesive soils, * undrained shear strength of fine-grained soils * soils´ moduli, * permeability at specified depths and   (2) When establishing the derived values soils type, pore water pressures and the vertical stress shall be taken into account. Examples for geotechnical values derived from CPT are given in Annexes D.1, D.2, D.4, D.5, D.6 und D.8. *We have to check whether the annexes cover the derived values mentioned above and whether such examples are allowed in standards as they get an “official” status!*  **4.4 Pressuremeter tests**  **4.4.1 General**  (1) The pressuremeter test (PMT) is used to measure in-situ the deformation of soil and soft rock caused bythe expansion of a cylindrical flexible membrane under pressure.  (3) The test may be used to derive strength and/or deformation parameters of the ground at specific depths or specific pressuremeter parameters.  (4) In addition to the points mentioned in 3.?.? (Planning section?) the designer shall specify the type of the pressuremeter.  (2)P The tests shall be carried out and reported in accordance with the requirements given in:   * EN-ISO 22476-5 for the pre-bored pressuremeter (PBP), e.g. the flexible dilatometer test (FDT); * EN ISO 22476-4for the Ménard pressuremeter (MPM), a specific form of the PBP; * EN ISO 22476-6 for the self-boring pressuremeter (SBP); * EN ISO 22476-8 for the full-displacement pressuremeter (FDP).   **4.4.2 Derived values**  (3) The test ~~should~~ may be used to derive strength of the ground e.g.:   * the angle of shearing resistance in non-cohesive ground (ϕ’) * undrained shear strength in cohesive ground (cu)   (?) The test may be used to derive deformation parameters and stress parameters of the ground e.g.:   * horizontal stress and coefficient of earth pressure at rest (K0) * the Menard Modulus (EM),   (?) The test may be used to derive empirical design values e.g.   * bearing resistance of spread foundations, * settlements for spread foundations and * compressive resistance of a single pile.   *Isn´t this textbook?*  **4.5 Dilatometer tests**  **4.5.1 General**  (1) Dilatometer tests ~~is~~ may be used to measure in-situ the deformability of rock (rock dilatometer test, RDT),and soil (soil dilatometer test, SDT) from measurements of the radial expansion of a borehole section under a known uniform radial pressure applied by means of a cylindrical dilatometer probe.  (?) In addition to the items mentioned in 3.?.? (planning section) the designer shall specify the type of the dilatometer.  (2)P The tests shall be carried out and reported in accordance with the requirements given in EN ISO 22476-5.  **4.5.2 Derived values**  (3) The test ~~should~~ may be used to derive strength of the ground e.g.:   * the angle of shearing resistance in non-cohesive ground (ϕ’) * undrained shear strength in cohesive ground (cu)   (?) The test may be used to derive deformation parameters and stress parameters of the ground e.g.:   * horizontal stress and coefficient of earth pressure at rest (K0) * Oedometer modulus (Eoed)   (?) The test may be used to derive empirical design values e.g. – this will be checked by Vincenzo   * bearing resistance of spread foundations, * settlements for spread foundations and * compressive resistance of a single pile.   *Isn´t this textbook?*  **4.6 Standard penetration tests**  **4.6.1 General**  (1) The standard penetration test (SPT) is used to measure the strength and deformation properties of the ground at the base of a borehole by the dynamic penetration of a split barrel sampler or solid cone. Disturbed samples may be obtained for identification purposes.  (2) The test results can give qualitative information on the ground profile.  (3)P The tests shall be carried out and reported in accordance with EN ISO 22476-3.  (4) In addition to the items mentioned in 3.?.? (planning section) the designer planning the tests shall specify ????. In special cases also the limiting number of blows for the main drive in soft rock.  **4.6.2 Derived values**  (1) SPT results may be used to provide the following derived values:   * relative density and angle of friction of non-cohesive soils, * undrained shear strength of fine-grained soils (?) * soils´ moduli, * ?? Jose will check on additional derived values   (2) Type of soil, groundwater level and vertical stress shall be taken into account when establishing the derived values. Examples for geotechnical values derived from SPT are given in Annexes F.1 and F.2.  **4.7 Dynamic probing**  **4.7.1 General**  (1) Dynamic probing (DP) is used to evaluate the strength and deformability properties of ground. The results can give qualitative information on the ground profile.  (2) In addition to the items mentioned in 3.?.? (planning section) the designer planning the probing shall specify the test procedures.  **4.7.2 Derived values**  (1) Results of dynamic probing may be used to provide the following derived values:   * relative density, * angle of friction and * soils´ moduli,   of non-cohesive soils.  (2) Soil type, groundwater level and vertical stress shall be taken into account when establishing the derived values. Examples for geotechnical values derived from DP are given in Annexes G.1, G.2 and G.3. Correlations between CPT and DP as well as correlations between different types of DP are given in Annexes G.4 and G.5.  **4.9 Field vane tests**  **4.9.1 General**  (1) The field vane test (FVT) is used to measure the resistance to rotation in-situ of a vane installed primarily in soft fine-grained soil for the determination of the undrained shear strength and the sensitivity.  (2) The tests shall be carried out and reported in accordance with requirements given in EN ISO 22476-9.  (3) In addition to the items mentioned in 3.?.? (planning section) the designer shall specify size of the vane.    **4.9.2 Derived values**  (1) FVT results may be used to provide the following derived values:   * undrained shear strength and * sensitivity   of fine-grained soils  (2) When establishing the derived values for the undrained shear strength the plasticity and the vertical stress shall be taken into account. *We were not sure, whether we are allowed to reference to literature within a standard and decided not to give formulae as in the examples for geotechnical values derived from FVT are given in Annexes I.1 to I.5.*  (3) The results of the tests may also be used in empirical design of piles, shallow foundations …???  **4.10 Flat dilatometer tests**  **4.10.1 General**  (1) The flat dilatometer test (DMT) is used to measure in-situ strength and deformation properties of soil by expanding a thin circular steel membrane mounted flush on one face of a blade-shaped steel probe inserted vertically into the ground.  (2) The test results can give qualitative information on the ground profile.  (3) The tests should be carried out and reported in accordance withrequirements given in CEN ISO/TS 22476-11~~.~~  (4) In addition to the items mentioned in 3.?.? (planning section) the designer shall specify ????  **4.10.2 Derived values**  (1) DMT results may be used to provide the following derived values:   * in-situ stress *(check, whether it is mentioned in the standard*) * coefficient of consolidation and permeability for fine-grained soils *(check, whether it is mentioned in the standard*) * angle of friction of non-cohesive soils, * undrained shear strength of fine-grained soils * soils´ moduli *(Vincenzo will check the derived values mentioned in the test standard)*   (2) An example for geotechnical values derived from DMT is given in Annex J.  (3) The results of the test may be used in empirical design of spread foundations and pile foundations. See ??? *(This paragraph must be considered for other tests too)*  **4.11 Plate loading test**  **4.11.1 General**  (1) The plate loading test (PLT) is used to measure the vertical deformation and strength properties of ground in-situ by recording the load and the corresponding settlement when a rigid plate is loading the ground.  (2)P The test shall be carried out and reported in accordance with EN ISO 22476‑13.  (?) In addition to the items mentioned in 3.?.? (planning section) the designer planning the tests shall specify   * size of the plate * the loading sequence   of the test.  **4.11.2 Derived values**   1. PLT results may be used to provide the following derived values:  * undrained shear strength of fine-grained soils * drained strength of coarse grained soils * soils´ moduli, * ???.  1. Examples of geotechnical values derived from PLT are given in Annexes K.1, K.2 and K.3. 2. The results of the test may be used in empirical design of spread foundations and for compaction control of earthworks. See ??? *(This paragraph must be considered for other tests too)* |