CPNI
Centre for the Protection of National Infrastructure

TESTING SOIL CONDITIONS FOR VEHICLE SECURITY BARRIER TESTS - SUMMARY

This summary guidance note provides advice and considerations on determining the soil conditions when testing Vehicle Security Barriers (VSBs) installed in soil and are based on the requirements of:
ISO IWA 14-1:2013 Vehicle Security Barriers - Part 1: Performance requirement, vehicle impact test method and performance rating; and
ASTM F2656-07 Standard Test Method for Vehicle Crash Testing of Perimeter Barriers.

Specification of soil conditions

For VSBs installed in soil, both IWA 14-1:2013 Section 6.4.4 and F2656-07 Clause 7.2.2 require the degree of compaction, in terms of soil density, to be measured. F2656-07 states that the density shall not be less than 90% of the maximum dry density. It also specifies the dimensions of the area to be backfilled in relation to the size of the foundation.

In addition to the soil grade and degree of compaction, IWA 14-1:2013 also requires measurements of the bearing capacity and moisture content of the soil. It also states that the density and moisture content measurements are to be made not less than 72 hours before the test. Suggested gradings for the soil can be found in EN 12767:2007 Passive safety of support structures for road equipment. Requirements, classification and test methods Annex A, F2656-07 and AASHTO M147-65 Standard Specification for Materials for Aggregate and Soil-Aggregate Sub-base, Base, and Surface Courses.

Alternatively, it is permissible to use a soil that replicates site specific conditions where the VSB is to be installed. If testing is conducted to replicate site soil conditions, laboratory tests should be completed to assess the in-situ density before excavation and after re-compaction to ensure that the original in-situ density conditions have been achieved.

Test Standards

The in-situ density of the soil can be determined either by using a nuclear, or non-nuclear, density gauge or by the sand replacement test method. The test procedures are detailed in the following documents:

- ASTM D1556-07 Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method.
- ASTM D2922-05: Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth). Replaced by ASTM D6938-10 Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

- BS 1377-9:1990 Methods for test for soils for civil engineering purposes. In-situ tests.

In order to ascertain the degree of compaction that has been achieved, it is necessary to know the maximum wet density for the soil which is determined from the optimum moisture content test. If a nuclear (or non-nuclear) gauge is used, it will need to be verified against the sand replacement method and when used to automatically calculate the relative compaction, the gauge must be programed with the maximum wet density for the soil.

BS1377-9 also details the methodology for determining the bearing capacity or California Bearing Ratio (CBR) of the soil. The Dynamic Cone Penetrometer (DCP) is another acceptable method for determining the soil CBR; the equipment and test procedure are outlined in the Design Manual for Roads and Bridges, Volume 7, Section 3, Part 2 HD29/08.

The procedures for finding the maximum wet density and moisture content for the soil are detailed in:

- AASHTO T99: Standard Method of Test for Moisture-Density Relations of Soils Using a 2.5kg (5.5lb) Rammer and a 305mm (12in.) Drop.
- AASHTO T180: Standard Method of Test for Moisture-Density Relations of Soils Using a 4.54kg (10lb) Rammer and a 457mm (18in.) Drop.
- BS 1377-4:1990 Methods of test for soils for civil engineering purposes. Compaction-related tests.
- BS EN 1097-5:2008 Tests for mechanical and physical properties of aggregates. Determination of the water content by drying in a ventilated oven.

Alternative Approach

To reduce the amount of soil testing and to provide a standard soil for all VSB tests, one recommendation is that a stockpile of suitable material is obtained and checked for compliance. This material is then reused for each VSB installation. If this approach is adopted, a standard procedure for clearing all test debris and natural in-situ soil must be established and regular checks of the moisture / density relationship and grading will need to be made and compared to the original measurements to ensure continued compliance. The stockpiled material will also need to be sheeted to prevent loss of fines and be maintained at the correct moisture content to ensure future compaction criteria are met.

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