Strength Tests for Structural Fixings in Concrete

In giving approval of plans involving drilled-in anchors or grouted bolts/dowels/reinforcing steel bars (the structural fixings), the Building Authority may impose a condition under item 6 of section 17(1) of the Buildings Ordinance for the carrying out of strength tests on a representative number of the structural fixings. Corresponding method statement on the strength tests is required to be submitted to the Buildings Department (BD) for agreement. Some commonly accepted method statements specifying the testing requirements, apparatus setup, testing procedures, acceptance criteria and presentation of results are provided in Appendices A to C:

Appendix A - Strength test for drilled-in anchors used for cantilevered structure/hanger/curtain wall remedial works;

Appendix B - Strength test for drilled-in anchors used for works other than cantilevered structure/hanger/curtain wall remedial works; and

Appendix C - Strength test for cementitious or polymer based grouted bolts/dowels/reinforcing bars works or steel T bolts with cast-in channels used for curtain wall/cladding works.

2. To streamline the submission process, where the tests are to be carried out in accordance with the pre-accepted method statement given in Appendix A, B or C, RSE may quote the relevant Appendix in the submitted plans for approval and submission of the method statement will not be required. If an alternative method statement other than that specified in the Appendix A, B or C is proposed, RSE is required to submit the proposed method statement of the test to BD for agreement.

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Appendix A
(PNAP APP-169)

Strength Test for Drilled-in Anchors used for Cantilevered Structure/Hanger/Curtain Wall Remedial Works

The tensile and/or shear recommended load(s) of each type of drilled-in anchors as specified by the anchor manufacturer should be verified by means of proof load test.

2. Testing requirements

(a) Sampling rate should be at least 5% or 5 numbers, whichever is more, of each type and size of the anchors installed;

(b) Each representative anchor should be tested for tensile load by tensile proof load test and/or shear load by shear proof load test as appropriate; and

(c) Test load should not be less than 1.5 times the recommended load of the anchor as specified by the anchor manufacturer.

3. Apparatus setup

Tensile proof load test

(a) An axial tensile force is applied to the test anchor by means of a loading frame acting through an attachment suitable to the test anchor;

(b) The supports of the loading frame are located on the base material in equal distance and at least 8A from the axis of the test anchor (A is the hole diameter of the test anchor or 1/4 of the embedded length, whichever is the greater);

(c) The loading frame is aligned to ensure axial application of the applied tensile force concentrically to the test anchor with suitable load measuring device is used and capable of measuring to an accuracy of 2%; and

(d) Suitable measuring equipment is fixed to the base material, independent of the loading frame, at least 12A from the axis of the test anchor and capable of measuring the relative displacement between the head of the test anchor and the base material to an accuracy of 0.02mm.

/Shear ...

Shear proof load test

(e) A shear force is applied to the test anchor by means of a loading frame acting through a steel block to the test anchor with requirements on the steel block as follows: -

(i) The steel block has a diameter equal to 5d and a thickness equal to d + 0.8mm, where d is the outside diameter of the part of the test anchor that projects from the surface of the base material;

(ii) The steel block has a clearance hole located in the centre for the test anchor with diameter as tabulated below:

Nominal diameter of test anchor, d_{nom} (mm)	6, 8	10, 12, 14, 16, 18, 20, 22, 24	27, 30
Diameter of clearance hole in the steel block (mm)	$d_{nom} + 1$	$d_{nom} + 2$	$d_{nom} + 3$

(iii) The steel block is made of quenched steel with hardness not worse than HV700 or equivalent and have radiused edges (0.4mm) where in contact with the test anchor.

(f) The steel block is located over the test anchor and directly on the surface of the base material without any interfacing. Before tightening the test anchor, the steel block is positioned so that the clearance of the projecting part of the test anchor in the bush allowed movement of the plate when the load is applied;

(g) Loading frame is aligned to ensure application of shear force parallel with the surface of the base material by a suitable rod or bar. A sheet of low friction material such as polytetrafluoroethylene (PTFE), not exceeding 2mm in thickness, is inserted between the base material and the rig. Suitable load measuring device is used and capable of measuring to an accuracy of 2%;

(h) The reaction to the load is located at a distance of at least 8A (A is the hole diameter of the test anchor or 1/4 of the embedded length, whichever is the greater) either side of the test anchor, measured at right angles to the direction of loading; and

(i) The measuring instrument is fixed to the base material, independent of the loading frame, at least 6A from the axis of the test anchor and capable of measuring the movement of the steel block parallel to the direction of the applied force to an accuracy of 0.02mm.

/4. ...

4. Testing procedures

(a) Prior to the test, visual inspection is carried out for the test anchor and its surrounding area for abnormality/irregularity/defect/ crack;

(b) An initial force not exceeding 1% of the test load is applied to take up any slack in the apparatus and attachment. For case of shear proof load test, prior to application of the initial force, the test anchor is only hand-tightened and while the initial force is maintained, the test anchor is tightened to the manufacturer's recommended torque, with the initial force released afterwards;

(c) The test anchor is loaded to the test load either continuously at a rate of between $9N/(mm^2s)$ and $11N/(mm^2s)$ or incrementally by at least 10 equal increments and the readings of the load and displacement are taken;

(d) The applied load is maintained at the maximum test load for at least one hour, and the readings of load and displacement are taken at the beginning and end of this period to establish whether the tested anchor is subject to creep and relaxation of load under this maximum test load. The reading should only be taken when it has become completely stable;

(e) The applied load is then gradually released in at least 5 decrements for incremental load case or at constant rate for continuous load case, to zero;

(f) The displacement after removal of all loads (i.e. recovery of deformation) is recorded; and

(g) The tested anchor and its surrounding area are inspected and any signs of separation, plastic deformation or deleterious effect are recorded.

5. Acceptance criteria

(a) The tested anchor and its surrounding area should not have any signs of separation, plastic deformation or deleterious effect; and

(b) Recovery of the deformation after removal of all loads should be at least 80% of the total deformation at the maximum test load.

6. Presentation of results

(a) Each test is reported individually by plotting a graph of the force applied to the test anchor against displacement;

/(b) ...

(b) Description of the behaviour of the testing assembly throughout the test is required to be provided. The behaviours may include, but not limited to, the following:

(i) movement of test anchor by slipping in its pre-drilled hole;

(ii) onset of cracking in the base material;

(iii) rupture of base material, differentiating between the characteristic mode of failure in which a roughly conical block of material surrounding the test anchor is pulled away and splitting of the material through the plane of the test anchor;

(iv) tensile/shear fracture of the test anchor; and

(v) deformation of the component parts of the test anchor, e.g. thread stripping.

(c) When failure occurs before attaining the maximum test load or specified holding period, the failure load or holding time and the nature of failure should be recorded.

(10/2023)

Appendix B
(PNAP APP-169)

Strength Test for Drilled-in Anchors used for Works other than Cantilevered Structure/Hanger/Curtain Wall Remedial Works

The tensile and/or shear recommended load(s) of each type of drilled-in anchors as specified by the anchor manufacturer should be verified by means of proof load test.

2. Testing requirements

(a) Sampling rate should be at least 1% or 5 numbers, whichever is more, of each type and size of the anchors installed;

(b) Each representative anchor should be tested for tensile load by tensile proof load test and/or shear load by shear proof load test as appropriate; and

(c) Test load should not be less than 1.5 times the recommended load of the anchor as specified by the anchor manufacturer.

3. Apparatus setup

Tensile proof load test

(a) An axial tensile force is applied to the test anchor by means of a loading frame acting through an attachment suitable to the test anchor;

(b) The supports of the loading frame are located on the base material in equal distance and at least 8A from the axis of the test anchor (A is the hole diameter of the test anchor or 1/4 of the embedded length, whichever is the greater); and

(c) The loading frame is aligned to ensure axial application of the applied tensile force concentrically to the test anchor with suitable load measuring device is used and capable of measuring to an accuracy of 2%.

Shear proof load test

(d) A shear force is applied to the test anchor by means of a loading frame acting through a steel block to the test anchor with requirements on the steel block as follows: -

/(i) ...

(i) The steel block has a diameter equal to 5d and a thickness equal to d + 0.8mm, where d is the outside diameter of the part of the test anchor that projects from the surface of the base material;

(ii) The steel block has a clearance hole located in the centre for the test anchor with diameter as tabulated below:

Nominal diameter of test anchor, d_{nom} (mm)	6, 8	10, 12, 14, 16, 18, 20, 22, 24	27, 30
Diameter of clearance hole in the steel block (mm)	d_{nom} + 1	d_{nom} + 2	d_{nom} + 3

(iii) The steel block is made of quenched steel with hardness not worse than HV700 or equivalent and have radiused edges (0.4mm) where in contact with the test anchor.

(e) The steel block is located over the test anchor and directly on the surface of the base material without any interfacing. Before tightening the test anchor, the steel block is positioned so that the clearance of the projecting part of the test anchor in the bush allowed movement of the plate when the load is applied;

(f) Loading frame is aligned to ensure application of shear force parallel with the surface of the base material by a suitable rod or bar. A sheet of low friction material such as polytetrafluoroethylene (PTFE), not exceeding 2mm in thickness, is inserted between the base material and the rig. Suitable load measuring device is used and capable of measuring to an accuracy of 2%; and

(g) The reaction to the load is located at a distance of at least 8A (A is the hole diameter of the test anchor or 1/4 of the embedded length, whichever is the greater) either side of the test anchor, measured at right angles to the direction of loading.

4. Testing procedures

(a) Prior to the test, visual inspection is carried out for the test anchor and its surrounding area for abnormality/irregularity/defect/ crack;

(b) An initial force not exceeding 1% of the test load is applied to take up any slack in the apparatus and attachment. For case of shear proof load test, prior to application of the initial force, the test anchor is only hand-tightened and while the initial force is maintained, the test anchor is tightened to the manufacturer's recommended torque, with the initial force released afterwards;

/(c) ...

(c) The test anchor is loaded at a constant rate to the maximum test load and maintained for at least 2 minutes;

(d) The applied load is then gradually released at a constant rate; and

(e) The tested anchor and its surrounding area are inspected and any signs of separation, plastic deformation or deleterious effect are recorded.

5. Acceptance criteria

(a) The tested anchor and its surrounding area should not have any signs of separation, plastic deformation or deleterious effect.

6. Presentation of results

(a) Description of the behaviour of the testing assembly throughout the test is required to be provided. The behaviours may include, but not limited to, the following:

(i) movement of test anchor by slipping in its pre-drilled hole;

(ii) onset of cracking in the base material;

(iii) rupture of base material, differentiating between the characteristic mode of failure in which a roughly conical block of material surrounding the test anchor is pulled away and splitting of the material through the plane of the test anchor;

(iv) tensile/shear fracture of the test anchor; and

(v) deformation of the component parts of the test anchor, e.g. thread stripping.

(b) When failure occurs before attaining the maximum test load or specified holding period, the failure load or holding time and the nature of failure should be recorded.

Appendix C
(PNAP APP-169)

Strength Test for Cementitious or Polymer Based Grouted Bolts/Dowels/Reinforcing Bars Works or Steel T Bolts with Cast-in Channels used for Curtain Wall/Cladding Works

The tensile and/or shear recommended load(s) of each type of grouted bolts/dowels/reinforcing bars/T bolts with cast-in channels as specified by the manufacturer should be verified by means of proof load test.

2. Testing requirements

(a) Sampling rate should be at least 1% or 5 numbers, whichever is more, of each type, size and embedment of the grouted bolts/dowels/reinforcing bars installed or each type and size of the assemblies of T bolts with cast-in channels (Assembly);

(b) Each representative grouted bolt/dowel/reinforcing bar or Assembly should be tested for tensile load by tensile proof load test and/or shear load by shear proof load test as appropriate; and

(c) Test load should not be less than 1.5 times the recommended load as specified by the manufacturer.

3. Apparatus setup

Tensile proof load test

(a) An axial tensile force is applied to the test grouted bolt/dowel/reinforcing bar/Assembly by means of a loading frame acting through an attachment suitable to the test bolt/dowel/reinforcing bar/Assembly;

(b) The supports of the loading frame are located on the base material in equal distance and at least 8A from the axis of the test grouted bolt/dowel/reinforcing bar (A is the maximum diameter of the test grouted bolt/dowel/reinforcing bar or 1/4 of the embedded length, whichever is the greater) or $2h_{ef}$ from the axis of the test Assembly (h_{ef} is the effective embedment depth of the cast-in channels); and

(c) The loading frame is aligned to ensure axial application of the applied tensile force concentrically to the test grouted bolt/dowel/reinforcing bar/Assembly with suitable load measuring device is used and capable of measuring to an accuracy of 2%.

/Shear ...

Shear proof load test

(d) A shear force is applied to the test grouted bolt/dowel/reinforcing bar/Assembly by means of a loading frame acting through a steel block to the test grouted bolt/dowel/reinforcing bar/Assembly with requirements on the steel block as follows: -

(i) The steel block has a diameter equal to 5d and a thickness equal to d + 0.8mm, where d is the outside diameter of the part of the test grouted bolt/dowel/reinforcing bar/T bolt that projects from the surface of the base material;

(ii) The steel block has a clearance hole located in the centre for the test grouted bolt/dowel/reinforcing bar/T bolt with diameter as tabulated below:

Nominal diameter of test grouted bolt/dowel/reinforcing bar/T bolt, d_{nom} (mm)	6, 8	10, 12, 14, 16, 18, 20, 22, 24	27, 30
Diameter of clearance hole in the steel block (mm)	$d_{nom} + 1$	$d_{nom} + 2$	$d_{nom} + 3$

(iii) The steel block is made of quenched steel with hardness not worse than HV700 or equivalent and have radiused edges (0.4mm) where in contact with the test bolt/dowel/reinforcing bar/T bolt.

(e) The steel block is located over the test grouted bolt/dowel/reinforcing bar/Assembly and directly on the surface of the base material without any interfacing. The steel block is positioned so that the clearance of the projecting part of the test grouted bolt/dowel/reinforcing bar/Assembly in the bush allowed movement of the plate when the load is applied;

(f) Loading frame is aligned to ensure application of shear force parallel with the surface of the base material by a suitable rod or bar. A sheet of low friction material such as polytetrafluoroethylene (PTFE), not exceeding 2mm in thickness, is inserted between the base material and the rig. Suitable load measuring device is used and capable of measuring to an accuracy of 2%; and

(g) The reaction to the load is located at a distance of at least 8A (A is the hole diameter of the test grouted bolt/dowel/reinforcing bar or 1/4 of the embedded length, whichever is the greater) or $2h_{ef}$ (h_{ef} is the effective embedment depth of the cast-in channel) either side of the test grouted bolt/dowel/reinforcing bar/Assembly, measured at right angles to the direction of loading.

/4. ...

4. Testing procedures

(a) Prior to the test, visual inspection is carried out for the test grouted bolt/dowel/reinforcing bar/Assembly and its surrounding area for abnormality/irregularity/defect/crack;

(b) An initial force not exceeding 1% of the test load is applied to take up any slack in the apparatus and attachment;

(c) The test grouted bolt/dowel/reinforcing bar/Assembly is loaded at a constant rate to the maximum test load and maintained for at least 2 minutes;

(d) The applied load is then gradually released at a constant rate; and

(e) The tested grouted bolt/dowel/reinforcing bar/Assembly and its surrounding area are inspected and any signs of separation, plastic deformation or deleterious effect are recorded.

5. Acceptance criteria

(a) The tested grouted bolts/dowels/reinforcing bars/Assemblies should not show any signs of separation, plastic deformation or deleterious effect.

6. Presentation of results

(a) Description of the behaviour of the testing assembly throughout the test is required to be provided. The behaviours may include, but not limited to, the following:

(i) movement of test grouted bolt/dowel/reinforcing bar by slipping in its pre-drilled hole;

(ii) onset of cracking in the base material;

(iii) rupture of base material, differentiating between the characteristic mode of failure in which a roughly conical block of material surrounding the test grouted bolt/dowel/ reinforcing bar/Assembly is pulled away and splitting of the material through the plane of the test grouted bolt/dowel/ reinforcing bar/Assembly;

(iv) tensile/shear fracture of the test bolt/dowel/reinforcing bar/ Assembly;

(v) deformation of the test grouted bolt/dowel/reinforcing bar or the component parts of the test Assembly; and

(vi) failure or rebar/anchor legs attached to the cast-in channel.

/(b) ...

(b) When failure occurs before attaining the maximum test load or specified holding period, the failure load or holding time and the nature of failure should be recorded.

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