Practice Note on the Sourcing of Threaded Rod Used for Foundation Bolts

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Introduction

Threaded bars are commonly used in the structural engineering industry. It is used as replacement for long bolts as well as for concrete anchors and foundation bolts. This product is not covered under New Zealand Standard AS/NZS 1252, 'High strength steel bolts with associated nuts and washers for structural engineering'. This article is intended to provide information on the appropriate standard to specify for threaded rods used for foundation bolts and the recommended verification testing.

Threaded Rod to DIN 976-1

There are a number of international standards which cover threaded bar. Threaded bar is commonly supplied to New Zealand in accordance with the European Standard DIN 976-1. In the past threaded bar has been supplied to the European Standard DIN 975. This standard is now withdrawn and the replacement standard is DIN 976-1. DIN 976-1 was revised in 2016. The technical delivery conditions for DIN 976-1:2016 is shown in table 1.

AS/NZS 5131 Foundation Bolt Requirements

Requirements for foundation bolts are covered in AS/NZS 5131 Fabrication and Erection. The chemical and mechanical properties of foundation bolts shall be to AS/NZS 4291.1. Nuts shall be supplied as a minimum equivalent to the property class of the bolt material to AS/NZS 4291.2. Thread tolerance 6g shall be specified in the construction specification with dimensional tolerances to AS 1275. Galvanizing shall be to AS/NZS 1214. Plates for attachment shall be to AS/NZS 3679.

The Australian/New Zealand standards have international equivalency. AS 4291.1:2015 is equivalent to the ISO 898-1:2013. AS/NZS 4291.2:2016 is equivalent to ISO 898-2:2012. AS 1275 was developed and is in complete alignment with ISO 965.2. AS/NZS 1214:2016 is modified from ISO 10684:2004. Threaded rod supplied to DIN 976-1:2016 is therefore considered to satisfy the chemical and mechanical properties requirements for foundation bolts in AS/NZS 5131.

Hot-dipped Galvanized Property Class 8.8 Threaded Rod to DIN 976-1

During the cleaning process for hot-dipped galvanizing, hydrogen could be absorbed in high strength steel that is severely worked hardened. The hydrogen may not be effused completely in the galvanizing bath and consequently may lead to brittle behaviour. This is known as hydrogen embrittlement. Hydrogen embrittlement is not a concern if hardness of the steel in less than 37HRC.

Property class 8.8 threaded rod manufactured in accordance with DIN 976-1 may be supplied hot-dipped galvanized to DIN EN ISO 10684. For property class 8.8 threaded rod manufactured in accordance with DIN 976-1, the thread is rolled and then heat treated to achieve the mechanical properties specified in ISO 898.1. If there is any work-hardening in thread rolling, this would be automatically removed in the preceding heat treatment process. Heat treatment will give a more or less uniform hardness over the whole rod in the range of 23-34 HRC as per ISO 898.1. Therefore, property class 8.8 threaded rod manufactured to DIN 976.1 can be Hot Dip Galvanised without any further stress relieving processes.

Table 1: Technical Delivery Conditions

Characteristic		**DIN 976-1:2002-12**	**DIN 976-1:2016-09**
General requirements		As specified in ISO 8992	ISO 8992:2005
Thread	Tolerance	6g	6g
	As specified in	DIN ISO 965-2	DIN ISO 965-2:1999-11 (ISO 965-2:1998)
Mechanical properties	Property Class	For sizes M3 up to M39: 4.8, 5.6, 5.8, 8.8, 10.9 or 12.9	For sizes M3 up to M39: 4.8, 5.6, 5.8, 8.8, 10.9 or 12.9
	As specified in	DIN EN ISO 898-1 (test programme B)	DIN EN ISO 898-1:2013-5 (ISO 898.1:2013)
Limit deviations and geometrical tolerances	Product grade	A	A
	As specified in	DIN EN ISO 4759-1	DIN EN ISO 4759-1:2001-04 (ISO 4759-1:2000)
Surface finish		As processed	As processed
		DIN EN ISO 4042 applies with regard to electroplating	DIN EN ISO 4042:2017-07 (ISO/DIS 4042:2017)
		DIN EN ISO 10683 applies with regard to zinc flake plating	DIN ISO 10683:2014-10 (ISO 10683:2014)
		Din 267-10 applies with regard to hot-dipped galvanizing	DIN EN ISO 10684:2011-09
Surface discontinuities		DIN EN 26157-3 applies with regard to limits for surface discontinuities for property classes 5.6, 8.8, 10.9 and 12.9	DIN EN 26157-3:1991-12 (ISO 6157-3:1988)
Acceptance inspection		As specified in DIN EN ISO 3269	DIN EN ISO 3209:2000-11 (ISO 3269:2000)

Traceability

Threaded bars greater than diameter M5 should be marked at one end with the symbol denoting the property class except for threaded bars of PC4.8. The 'dot' in property class may be omitted (e.g. 88 is acceptable for PC8.8). Alternatively, clock markings as per ISO 898-1 may also be used. Marking of the manufacturer symbol is not required.

The colour coding as shown in Table 2 is also acceptable. The markings should not impair proper use of the threaded bars.

Table 2: Colour Coding for Strength Identification of Threaded Bar

Property Class	Marking
PC 4.6, 4.8	Not required
PC 5.6	Brown, RAL 8015
PC 5.8	Blue , RAL 5010
PC8.8	Yellow, RAL 1023
PC10.9	White, RAL 1013
PC12.9 Black	Black, RAL 9017

In addition, the following information should be marked on the packaging:

a) General product description – threaded bar
b) The letter M indicating ISO metric coarse pitch thread
c) The nominal diameter in mm
d) The nominal length in mm
e) Property class
f) Coating applied (if present)

Verification testing of Property Class 8.8 Threaded Rod to DIN 976-1

Verification testing is recommended to be carried out by the threaded rod distributor to provide confidence in the threaded rod conformity with the requirements of DIN 976-1. The recommended verification testing requirements are set out in appendix A of this practice note. The requirements are a modification of the verification testing for bolt assemblies described in AS/NZS 1252.2:2016 and based on recommended testing in (Fernando, 2014).

References

Fernando, S., Specification of Threaded Bar in Structural Applications, Steel Construction Volume 47 Number 1, Journal of the Australian Steel Institute, July 2014

DIN 976-1:2016-09 Fasteners – Stud bolts – Part 1: Metric Thread

SNZ, Steel Structures Standard (Incorporating Amendments 1 and 2), NZS 3404:1997 Part 1 and 2, Standards New Zealand, Wellington, 2007

SA/SNZ, High-strength steel fastener assemblies for structural engineering – Bolts, nuts and washers Part 1: Technical requirements, AS/NZS 1252.1:2016, Standards Australia / Standards New Zealand, Sydney /Wellington, 2016

SA/SNZ, High-strength steel fastener assemblies for structural engineering – Bolts, nuts and washers Part 2: Verification testing for bolt assemblies, AS/NZS 1252.2:2016, Standards Australia / Standards New Zealand, Sydney /Wellington, 2016

Appendix A

Verification testing for Property Class 8.8 threaded rod to DIN 976-1:2016

1.0 Scope

This section specifies the requirements for the verification testing that is used to provide confidence in the product's conformity with the mechanical requirements of DIN 976-1:2016.

2.0 Prerequisites for the verification testing program

The manufacturer shall have a factory production control (FPC) with a scope that complies with the requirements of ISO 9001: 2008 or 2015 (note that ISO 9001: 2015 will be the only permitted system from September 2018) and is certified by a conformity assessment body accredited by a signatory of the International Accreditation Forum Multilateral Recognition Agreement (IAF MLA).

An original or a copy of the inspection documents provided by the manufacturer or its approved representative, without any alteration, shall be provided. This documentation shall be accompanied by suitable means of identification of the product, in order to ensure the traceability between the manufacturing lot and the corresponding test certificate.

Copying of the original document is permitted, provided that

a) Traceability of product is maintained
b) The original document is available on request.

The supplier shall review the inspection or test certification for the bolt batch purchased. Checks shall include:

a) The lot or batch identification number is consistent with that indicated on the packaging for the bolts purchased
b) All tests are passed
c) The testing is within the scope of the laboratory accreditation and their accreditation is still valid.
d) The FPC is certified by a conformity assessment body accredited by an IAF MLA signatory and their accreditation is still valid.

3.0 Definition of Manufacturing lot or manufacturing batch

A quantity of fasteners of a single designation, including product grade, property class and size (one thread diameter and one length), manufactured from bar, wire, rod or flat product from a single cast, processed through the same or similar steps at the same time or over a continuous time period from a process with factory production control, including the same heat treatment and/or coating process, if any.

4.0 Minimum sampling and testing plan for verification testing

The minimum sampling and testing plan for verification testing is indicated in Table A1 for dimensional characteristics and Table A2 for mechanical characteristics.

Table A1: Plan for Verification testing - Mechanical Characteristics

Dimensional characteristic	Testing Standard	Sample Size	Acceptance no. (Ac)
Threaded Rod			
All sizes			
Extension under proof load	Proof load test ISO 898-1/AS4291.1	1	0
Breaking load	Breaking load (wedge*) test ISO 898-1/AS4291.1	1	0
Decarburization	Decarburization test ISO 898-1/AS4291.1	1	0
>M24			
Tensile strength, Rm	Tensile test ISO 898-1/AS4291.1	1	0
Stress at permanent set limit, Rp,0.2	Tensile test ISO 898-1/AS4291.1	1	0
% Elongation after fracture, A	Tensile test ISO 898-1/AS4291.1	1	0
Impact strength	Impact test ISO 898-1/AS4291.1	1	0

Notes: * Threaded wedge with thread tolerance 4H is used. Wedge angle M16, 6^0, all other sizes 4°.

5.0 Traceability of components

The identification number of the manufacturing lots, including the number of units, of the assembly lot to which the verification testing applies, shall be identified both on the test report and on all packaging for the entire assembly lot for the purpose of traceability of components.

6.0 Sampling, testing and assessment

Sampling, testing and assessment shall be undertaken in the following steps:

(a) Select samples at random from the assembly lot
(b) For each characteristic listed in table A1 and A2, carry out the inspection or test on the number of samples required.
(c) Record the number of nonconforming characteristics.
(d) For any characteristic, if the number of nonconforming test results is greater than the acceptance number (Ac), then reject the assembly lot.

7.0 Re-testing in case of non-conforming product

Where a test indicates that an assembly lot is nonconforming, a sample of additional items, of the sample size specified in Table 2, for the number of non-conformances, shall be taken from the assembly lot and tested for the particular nonconforming parameter(s).

If the additional test(s) result demonstrate conformance, then the assembly lot shall be deemed to comply, and all of the additional results included in the records.

If any of the additional test result(s) demonstrate nonconformance, then the assembly lot shall be rejected as nonconforming and the supplier shall take steps to ensure the manufacturer is informed and the nonconforming assembly lot is not put into the market. The supplier shall have written procedures specifying the processing of nonconforming product.

Table A2: Minimum sampling and testing plan for verification testing - re-testing after initial tests indicate lot is non-conforming

Initial test sample size = 1	
Sample size	**Acceptance No. (Ac)**
1 (initial sample)	0
10	1
25	2
Lot to be rejected	3

8.0 Testing laboratory

Testing shall be performed in New Zealand by a laboratory that has a quality management system with a suitable scope that complies with the requirements of ISO 9001:2008 or 2015 and is certified by a certification body accredited by JAS-NZ, IANZ or an equivalent approved body. Testing shall be carried out by competent personnel for the tests specified.

9.0 Verification test report

The following minimum information shall be included on all supplied test reports:

a) Date of testing
b) Printed name, position and signature of the person authorizing the report, with date of issue
c) Identification number of the manufacturing lot sufficient to allow traceability
d) Number of items tested
e) Designation of threaded rod, nuts and washers
f) Coating or surface finish
g) Test results in accordance with DIN 976-1 and this specification

10.0 Supplier Declaration of Conformity

A Supplier's declaration of conformity (SDoC) shall be provided. The issued SDoC shall include the following:

a) Statement from the supplier that the bolt assembly type(s) covered by the SDoC complies with the requirements of DIN 976-1:2016 and this specification.
b) Test report numbers for the verification testing carried out under the responsibility of the supplier