Measurement of Cable Band Bolt Length

1. The Contractor shall design and manufacture a calliper to measure the length of the cable band bolts during the loading of the bolt as described in Clause 3 (d) of Appendix 1/72

2. The callipers shall be designed to be operated by hand by a single person.

3. The callipers shall measure the length of the bolt to an accuracy of +/-0.025mm.

4. Measurements shall be taken over the full length of the bolt and over the unloaded length, Dimensions A and B in Fig. 1/73/1 respectively, in order that the actual load in the bolt may be calculated. All measurements require to be temperature corrected and the callipers shall be designed in such a manner that they can be calibrated to allow for temperature correction.

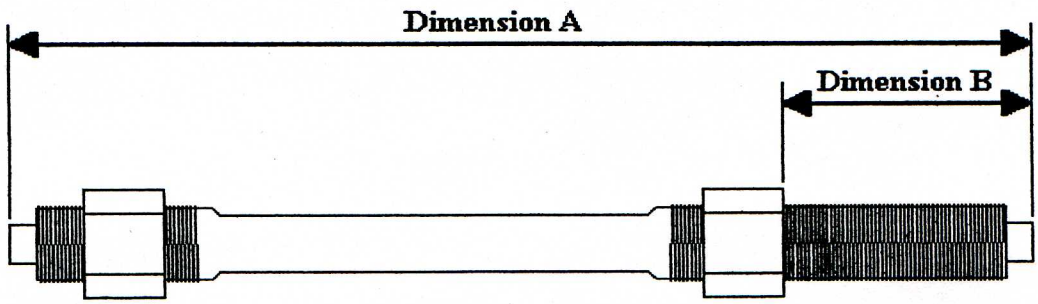

Fig. 1/73/1

5. Details of the Contractor's proposals for the calliper are to be submitted to the Engineer for approval a minimum of four weeks before the callipers are manufactured. Approval of the design and fabrication drawings shall be in accordance with Series 100 Clause 106.4 of the Specification.

6. The Contractor shall provide 1 No. calliper to the Engineer for the duration of the contract with a further two unused callipers being provided to the Forth Road Bridge upon practical completion of the contract. Callipers for the Contractor's own use during the Works shall be considered as Contractor's plant and shall be manufactured at the Contractor's own cost.

7. The Contractor shall maintain all callipers provided for the duration of the Contract.

8. Full operating and maintenance manuals shall be issued with the callipers provided to the Forth Road Bridge Joint Board.

APPENDIX 1/73 : Specification for Replacement Bolts

The following specification applies to the replacement bolts for the cable bands and the anchorage brackets.

Manufacture of Bolts

1. All components for the replacement bolts shall be manufactured from bright steel complying with BS 970 : Part 3 : 1991 and to the following grades of steel :

Cable Band Bolts	Threaded Rod	Grade 826M40X
	Nuts and Washers	Grade 826M40W
	End Caps	Grade 080M40
Anchorage Bracket Bolts	Threaded Rod	Grade 817M40V
	Nuts and Washers	Grade 605M36R
	End Caps	Grade 080M40

All the mechanical properties tabulated in BS 970 : Part.3 : 1991, including the minimum 0.2% Proof ~~Test~~ Stress, shall be met by the various steels used in the manufacture of these components. C3

Steel used to manufacture the threaded rod shall be precision ground bar in accordance with BS 970 : Part 3 : 1991, Clause 2.1.3. The tolerance for precision ground bar shall be Class B as defined in Table 3 of BS 970 : Part 3 : 1991.

2. The threads on the replacement cable band bolts shall be ISO Metric Screw Threads M39 x 3 to BS 3643 : Part 1 1981, with medium fit (6H/6g) to BS 3643 : Part 2 : 1981. Dimensional tolerances shall be checked by the Contractor by using a gauging system which complies with BS 919 : Part 3.

   The threads on the replacement anchorage bracket bolts shall be ISO Metric Screw Threads M56 x 4 to BS 3643 : Part 1 1981, with medium fit (6H/6g) to BS 3643 : Part 2 : 1981. Dimensional tolerances shall be checked by the Contractor by using a gauging system which complies with BS 919 : Part 3.

   The threads for the rods shall be rolled threads with the nuts and end caps being single point screw cut threads. The requirements for dimensional tolerances of the threads shall be met after the application of the protective coating. The extent of the threads shall be as shown on drawings 33111/B/12 and 33111/B/21.

3. Certification giving details of chemical analysis and mechanical properties for all steel used in the manufacture of the bolts shall be provided by the Contractor. All materials used in the production of the individual bolts shall be fully traceable at all stages of the manufacturing process with a full record being provided by the Contractor to the Engineer prior to the installation of the bolts in the Works.

4. Each bolt shall have a unique identification number with the history of its manufacture and loading being recorded. The identification shall be hard stamped or engraved on the bolt in the location shown on drawings. The identification number shall be applied before the application of the protective coating.

C3

5. Threaded rods shall have a factory applied protective coating of cadmium plating with a chromate conversion coating on top in accordance with BS 1706:1990 classification code Fe/Cd 25 c 2C. The minimum thickness of cadmium plating coating shall be 25 microns. Any process required to prepare the steel surface prior to plating shall be agreed with the Engineer a minimum of four weeks prior to commencement of the works. Pickling processes will not be allowed.

6. All nuts, washers and end caps for both the Cable Band Bolts and the Anchorage Bracket Bolts shall have a factory applied protective coating of cadmium plating, with no conversion coating, in accordance with BS 1706:1990 classification code Fe/Cd 25. The minimum thickness of cadmium plating coating shall be 25 microns. Any process required to prepare the steel surface prior to plating shall be agreed with the Engineer a minimum of four weeks prior to commencement of the works. Pickling processes will not be allowed.

7. All plated components shall be free from visible defects such as unplated areas, blisters and nodules. The surface of all nuts, washers and end caps shall be suitable for application of a protective paint system as detailed in Appendix 19/1.

8. The Contractor shall take due account of the material properties of each component before applying the heat treatment specified in Clause 9 below. The Tensile Strength in accordance with BS 970: Part 3: 1991 is as follows:

Tensile Strength (N/mm^2)

Cable Band Bolts	Threaded Rod	1150-1300
	Nuts and Washers	1075-1225
	End Caps	625-725
Anchorage Bracket Bolts	Threaded Rod	1000-1150
	Nuts and Washers	700-850
	End Caps	625-775

9. Before and after the application of the cadmium plating the bolts shall be heat treated as follows:

a) Threaded rods, nuts, washers and end caps shall be heat treated before cadmium plating for a minimum of 3 hours at a temperature range of 190°C to 220°C. The duration of heat treatment shall be measured from the time that all items in the oven have attained the specified temperature.

b) Threaded rods, nuts, washers and end caps shall be heat treated immediately after cadmium plating to relieve hydrogen embrittlement for a minimum of 24 hours at a temperature range of 190°C to 220°C. The duration of heat treatment shall be measured from the time that all items in the oven have attained the specified temperature.

c) The Contractor shall record and provide a chart for each complete bolt assembly (i.e. the threaded rod, nuts, washers, and end caps) plotting the temperature of each item against time for both heat treatment processes. This information shall be passed to the Engineer a minimum of four weeks before the bolt is installed in the Works.

d) The post-coating heat treatment shall be carried out prior to the application of the chromate conversion coating.

10. Details of the bolts assemblies are shown on contract drawings 33111/B/12 and 33111/B/21.

11. The Contractor's manufacturing processes for all the components of the replacement bolts shall be compatible with the heat treatment specified in Clause 9 above. The Contractor shall ensure that the properties of the steel are not adversely affected by the heat treatment referred to in Clause 9 above.

12. The Contractor shall ensure that components manufactured from tempered steel are not heated above a temperature of 50^0C below the tempering temperature.

13. The Contractor shall ensure that the steel properties produced during the manufacturing processes for all the bolts are consistent throughout the length of the bolt.

14. The Contractor shall undertake impact tests using either the Charpy test method or the Izod test method as approved by the Engineer. The frequency of the testing shall be as shown in Table 1/73/1. The Contractor shall submit his proposals for impact testing to the Engineer for approval a minimum of four weeks prior to commencing the tests. The test samples shall meet the following requirements:

a) Charpy value: 28 Joules min. at a temperature of -20°C.

b) Izod value: 34 Joules min. at a temperature of -20°C.

Testing of Bolts

1. The Contractor shall manufacture and undertake impact tests and tensile tests to failure of 10 No. of each size of replacement bolt as stated in Table 1/73/1. The bolts tensile tested shall be fully assembled with their washers and nuts. The threaded rods, nuts and washers forming the bolt shall be cadmium plated and fully heat treated in accordance with this specification. The samples for the impact tests shall be taken from the fully treated threaded rods under the length dimensioned 'B' in Figure 1/73/1 unless otherwise approved by the Engineer. No bolts for inclusion in the Works shall be manufactured (including the production of the steel) until the results of these tests have been approved by the Engineer in writing. The object of the tensile tests is to establish the stress/strain curves for the bolts in order that the load induced in the bolt on-site can be verified by measurement of their length. The tensile tests shall be carried out with the bolts at a constant temperature with 7 No. tests being undertaken at 20°C and the other 3 No. bolts being tested at -20°C as stated in Table 1/73/1.

2. In addition to the above tests the Contractor shall undertake at his own expense 1 No. additional impact test and tensile test of the complete bolt assembly for each separate production run of either the threaded rods or nuts. The properties of the bolt shall be the same as the bolts in the approved tests in item 1 above. The test results shall be passed to the Engineer a minimum of four weeks before the inclusion of the bolts from this production run in the Works.

3. The Engineer shall select at random additional bolts for impact testing and tensile testing. The number of bolts selected for this purpose shall be as stated in Table 1/73/1. The Contractor shall arrange to have the bolts tested on an individual basis at the same laboratory as the original bolt testing with the results being passed to the Engineer. The bolts tested shall have the same properties as the original test bolts.

4. Should any of the additional bolts tested in the opinion of the Engineer fail to meet the required standard the production run shall be discarded unless further tests prove to the satisfaction of the Engineer that the bolts in the particular production run are satisfactory for inclusion in the Works. The cost of all additional tests and the production of all replacement bolts shall be borne by the Contractor.

5. In addition to the impact tests and tensile tests on the bolts, a minimum of 5 No. nuts for each bolt diameter shall be proof load tested in accordance with BS EN 20898-6 : 1992 Clause 8.1. The nuts to be tested shall be cadmium plated and fully heat treated in accordance with this specification. No bolts for inclusion in the Works shall be manufactured (including the production of the steel) until the results of these tests have been approved by the Engineer in writing.

6. Testing shall be carried out to confirm the thickness of cadmium plating and chromate coating on each item of the bolt assembly. The Contractor shall test the threaded rods, nuts washers and end caps in accordance with Clause 8 of BS 1706:1990.

   The Contractor shall test a minimum of 1% of the total number of each item with samples being selected from throughout the production run. Where the rods, etc. are coated in batches a representative sample shall be tested from each batch unless otherwise agreed by the Engineer.

   Where test samples fail to meet the specified coating thickness further samples shall be tested to prove to the satisfaction of the Engineer that the items are satisfactory for inclusion in the Works. Where after further testing items continue to fail to meet the specification the whole batch of components shall be discarded and replaced by new components at the Contractor's expense.

   Individual test samples which fail to meet the specification shall be replaced at the Contractor's expense unless otherwise agreed by the Engineer.

   The Contractor is permitted to use sacrificial pieces of similar material and size to the component in question to fulfil the testing requirements for the chromate coating provided the sacrificial piece has undergone the same coating and heat treatment.

7. General testing of the materials used to manufacture the bolts shall be in accordance with BS 970 : Part 3 : 1991.

8. The Contractor shall submit a method statement and a detailed schedule for all the inspection and testing of the bolt components required by this Specification for the approval of the Engineer a minimum of four weeks prior to the testing commencing. The Contractor shall inform the Engineer of the date the testing will be undertaken a minimum of one week before the tests are undertaken and arrange access for the Engineer or his representatives to witness the tests All laboratories carrying out testing shall have a NAMAS accreditation.

9. The Contractor shall ensure that all testing is completed and certificates of compliance with the requirements are provided to the Engineer for approval a minimum of one week prior to any bolt assembly being included in the Works. No bolt or component shall be included in the Works without the full certification and the written approval of the Engineer.

Appendix 1/73 continues on additional page: Page 3.61A

10. The Contractor shall undertake a Hardness Test by a method approved by the Engineer on both ends of each fully manufactured threaded rod immediately prior to the pre-coating heat treatment for the cadmium plating, referred to in Clause 9. above. The Contractor shall ensure that his proposed method of Hardness Testing has no detrimental effects on the properties of the threaded rod and shall submit his proposals for testing to the Engineer for approval a minimum of four weeks prior to the tests commencing.

Table 1/73/1

Test	Cable Band Bolts	Anchorage Bracket Bolts
Initial Tensile Test	7 No. @ 20°C 3 No. @ -20°C	7 No. @ 20°C 3 No. @ -20°C
Initial Impact Test	10 No.	10 No.
Additional Tensile Test	25 No. @ 20°C	20 No. @ 20°C
Additional Impact Test	25 No.	20 No.
Production Run Tensile Test	1 No. per run @ 20°C	1 No. per run @ 20°C
Production Run Impact Test	1 No. per run	1 No. per run
Nut proof Load Test	5 No.	5 No.
Protective Coating Test	Min. 1% or one sample per batch, whichever is greater	Min. 1% or one sample per batch, whichever is greater

General

10. In addition to the bolts for testing and inclusion in the Works the Contractor shall manufacture and deliver to the Forth Road Bridge Joint Board additional spare bolts as detailed in the Bill of Quantities for future use.

11. All bolts shall be packaged, stored, handled and transported in such a manner that the protective coating shall remain clean and undamaged. Bolts with damaged protective coatings shall be replaced or the coatings made good to the satisfaction of the Engineer by the Contractor at no cost to the Client.