VOLUME 5 — MECHANICAL FASTENERS (BOLTING)

(Expanded – BS EN 1090-2:2018 + BS EN 14399 + BS EN 15048)

(All organization names replaced with XXXXXX)

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1. GENERAL REQUIREMENTS

1.1 Standards

All mechanical fasteners used in structural steelwork shall comply with the latest editions of:

- **BS EN 1090-2:2018** – Execution of steel structures
- **BS EN 14399 (Parts 1–10)** – High-strength structural bolting assemblies for preloading
- **BS EN 15048-1** – Non-preloaded structural bolting assemblies
- **BS EN ISO 898-1** – Mechanical properties of fasteners
- **BS EN ISO 4014 / 4017** – Hexagon bolts
- **BS EN ISO 4032** – Hexagon nuts
- **BS EN ISO 7089 / 7090** – Washers
- **BS EN ISO 10684** – Hot-dip galvanized fasteners

All bolts shall be CE/UKCA marked.

1.2 Execution Classes

Bolting requirements vary by Execution Class:

Execution Class	Bolt Type	Inspection Level
EXC1	Non-preloaded (EN 15048)	Basic
EXC2	Non-preloaded (EN 15048)	Standard
EXC3	Preloaded (EN 14399)	Enhanced
EXC4	Preloaded (EN 14399)	Full inspection

1.3 Traceability

- EXC1–EXC2 → Batch traceability
- EXC3–EXC4 → Full traceability (bolt, nut, washer sets)

Each assembly must remain together as supplied by the manufacturer.

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2. TYPES OF BOLTING ASSEMBLIES

2.1 Non-Preloaded Bolting Assemblies (BS EN 15048-1)

Used for:

- Simple shear connections
- Bracing connections
- Secondary steelwork
- Purlins and cladding rails

Grades

- 4.6
- 8.8

Characteristics

- No preloading
- Standard tightening
- Slip not considered in design

2.2 Preloaded Bolting Assemblies (BS EN 14399)

Used for:

- Slip-resistant connections
- Moment connections
- High-stress joints
- Fatigue-sensitive structures

Grades

- 8.8/10
- 10.9

Types

- HR (Heavy hexagon)
- HV (European standard)
- HRC (Tension control bolts)

- SB (Structural bolts)

Characteristics

- Preloaded to a specified tension
- Slip resistance considered in design
- Requires calibrated tightening method

2.3 Washers

Washers shall comply with:

- **BS EN ISO 7089** – Plain washers
- **BS EN ISO 7090** – Chamfered washers

Washers shall:

- Be used under both bolt head and nut
- Be of the same strength class as the bolt
- Be flat and free from burrs

2.4 Nuts

Nuts shall comply with:

- **BS EN ISO 4032**
- Strength class matching bolt grade

Nuts shall be:

- Lubricated
- Free from cracks
- Marked with grade and manufacturer

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3. HOLE TYPES & TOLERANCES

3.1 Hole Types

- **Standard holes**
- **Oversized holes**
- **Short-slotted holes**
- **Long-slotted holes**

- **Countersunk holes** (special applications)

3.2 Hole Tolerances (BS EN 1090-2 Table 11)

Hole Type	Tolerance
Standard	+1.0 mm
Oversized	+3.0 mm
Short-slotted	+2.0 mm (slot length per design)
Long-slotted	+3.0 mm (slot length per design)

Slotted holes require plate washers or special washers.

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4. SURFACE CONDITIONS FOR SLIP-RESISTANT JOINTS

4.1 Slip Factors

Slip factors shall comply with **BS EN 1090-2 Table 18**:

Class	Surface Treatment	Slip Factor (μ)
Class A	Cleaned, as-rolled	0.30
Class B	Blast-cleaned	0.40
Class C	Zinc-silicate coating	0.50
Class D	Grit-blasted + coating	0.60

Slip-resistant joints require:

- No paint on faying surfaces (unless approved Class C/D)
- No oil, grease, or moisture
- No mill scale

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5. TIGHTENING METHODS

5.1 General

Tightening shall be performed using one of the following methods:

- Torque method
- Combined method

- Angle-controlled method
- Direct tension indicator (DTI) method
- HRC (tension control bolt) method

5.2 Torque Method

Steps:

1. Snug-tighten all bolts
2. Apply final torque using calibrated wrench
3. Verify torque

Torque values shall be per manufacturer recommendations.

5.3 Combined Method

1. Snug-tighten
2. Apply specified torque
3. Apply specified angle of rotation

Used for high-accuracy applications.

5.4 Angle-Controlled Method

1. Snug-tighten
2. Rotate nut by specified angle (e.g., 60°, 90°, 120°)

Angle depends on bolt diameter and length.

5.5 Direct Tension Indicator (DTI) Method

DTI washers shall comply with:

- **BS EN 14399-9**

Tightening is complete when:

- Gaps between protrusions meet feeler gauge requirements

5.6 HRC (Tension Control Bolts)

HRC bolts shall comply with:

- **BS EN 14399-10**

Tightening is complete when:

- The spline shears off at the designed torque

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6. INSTALLATION REQUIREMENTS

6.1 Bolt Assembly

Bolts, nuts, and washers shall:

- Be supplied as matched sets
- Not be mixed between manufacturers
- Not be interchanged between batches

6.2 Bolt Insertion

Bolts shall be inserted:

- From the least accessible side
- With washers under both head and nut
- With threads fully engaged

6.3 Snug-Tightening

Snug-tightening shall:

- Bring all plies into firm contact
- Remove gaps
- Be performed before final tightening

6.4 Final Tightening

Final tightening shall:

- Follow the selected method
- Be performed in a star pattern
- Avoid inducing distortion

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7. INSPECTION & TESTING

7.1 Inspection Levels

Execution Class	Inspection Level
EXC1	Visual only
EXC2	Visual + random torque checks
EXC3	Visual + systematic torque checks
EXC4	Full inspection + documentation

7.2 Inspection Items

Inspect:

- Bolt grade
- Bolt length
- Washer placement
- Nut orientation
- Hole alignment
- Surface condition
- Tightening sequence
- Final tension

7.3 Testing Methods

- Torque wrench verification
- DTI feeler gauge test
- HRC spline shear verification
- Random bolt removal (EXC4)

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8. NON-CONFORMING BOLTS

8.1 Causes

- Incorrect grade
- Incorrect tightening
- Damaged threads

- Missing washers
- Incorrect hole size
- Slippage in slip-resistant joints

8.2 Corrective Actions

- Remove and replace bolt
- Ream hole if required
- Re-tighten entire joint
- Re-inspect

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9. DOCUMENTATION

9.1 Required Records

- Bolt batch certificates
- Calibration certificates
- Tightening logs
- Inspection reports
- NCRs
- As-built bolt maps

9.2 Retention Period

Minimum **10 years**.