Welded Fabric

1.0 Introduction

Welded fabric, often referred to as mesh, is a machine welded grid arrangement of reinforcing bars or wires. BS 4483 defines welded fabric as:

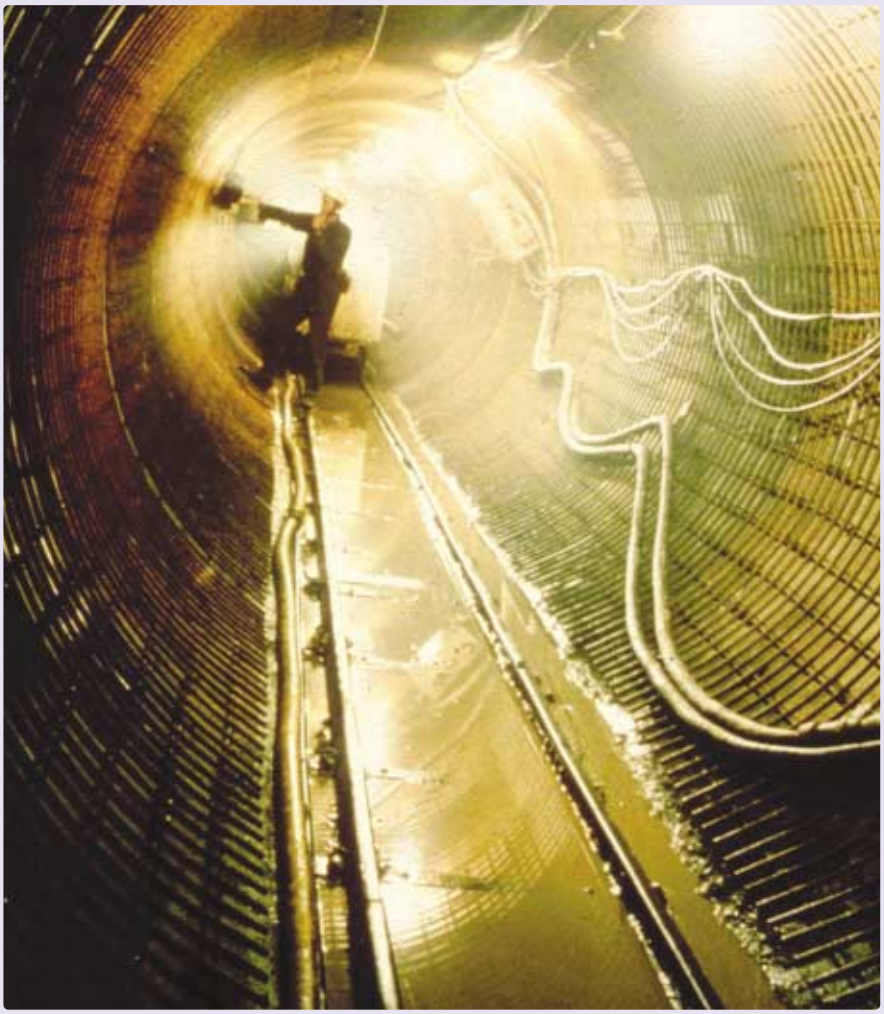
"an arrangement of longitudinal and transverse bars or wires of the same or different diameter and length, arranged substantially at right angles to each other, and factory electrical resistance welded by machine at the points of intersection."

Welded fabrics contain bars or wires, normally from 5-12mm in diameter. Some special fabrics are available in the UK containing bars up to 16mm in diameter. The wires or bars are welded together at their points of contact, to provide joints of specified shear strength.

Approximately 20-25% of all reinforcing steel used in the UK is supplied in the form of welded fabric. In some European countries, the use of welded fabric is more developed than in the UK, and the proportion of welded fabric consumed is significantly higher. Welded fabric is the most common form of pre-fabrication. Its main advantage is the speed of fixing, which can be 4 to 5 times faster than conventional loose bar. Welded fabric is particularly suitable for flat slab applications, but is also suitable for raft foundations, pile caps, retaining walls, beams and columns.

Welded fabric may be used as structural reinforcement, for example in suspended slabs, or may be used in order to control shrinkage or thermal cracking in ground supported slabs, which is its major market. Welded fabric can be substituted for loose reinforcement in most applications. Some manufacturers have the capability of supplying purpose-made fabrics designed to substitute for loose reinforcement in the most efficient way possible. Welded fabric is however not used in applications such as bridge decks, where fatigue is an important consideration.

Installation of Welded Fabric on a Major Contract



Courtesy of ROM

In the UK, welded fabric is manufactured by specialist companies. Many of these manufacturers are also fabricators of cut and bent reinforcement. It may be supplied direct from the manufacturers, or via stockholders.

The CARES scheme for the reinforcement of concrete includes a quality and operations assessment schedule for the manufacture of welded fabric. As with standard reinforcing bar products, this scheme, provides specifiers and purchasers with an independent verification of material and product quality.

2.0 Welded fabric products

BS 4483, Steel fabric for the reinforcement of concrete, distinguishes between standard and purpose-made fabrics. A standard fabric has a defined mesh arrangement and wire sizes. A purpose made fabric may be specified by the customer, and may have non-standard mesh arrangements and wire sizes.

2.1 Standard Fabrics

Within the UK, the requirements for welded fabric are specified in BS 4483. **Figure 1**, taken from the standard shows the notation used for the geometrical arrangement of a welded fabric.

BS 4483 lists the range of standard fabrics (**Table 1**). This includes four different types of fabrics, for use in different design situations:

Type A: These are called square mesh fabrics, and have the same diameter reinforcement in both longitudinal and transverse directions. The spacing is 200mm centres in both directions. These are used where the same area of reinforcement is required in both directions, typically in slabs and walls. These are the most widely used welded fabrics.

Type B: These are called structural mesh fabrics and are used where the main reinforcement is in one direction. Only a minimum reinforcement area according to the design code is supplied in the transverse direction. The spacing of the transverse wires is greater, and the transverse wire sizes may be different to the longitudinal wires.

Type C: These are called long meshes and are used where reinforcement is only required in one direction. The transverse wires are only to hold the fabric together. They do not perform a structural function.

Type D: This is wrapping fabric and is mainly used for fire protection, and for links in beam cages.

Standard fabrics are designated by their mesh type, and the area of the longitudinal reinforcement contained within, measured in mm²/m. Thus A252 is an A type mesh, with a nominal area of longitudinal wires of 252 mm²/m.

The standard size of welded fabric sheets is 4.8m x 2.4m. Merchant size sheets are also available in a standard size of 3.6 x 2.0m. Special fabrics may be manufactured up to sizes of 12.0 x 3.3m.

Fabric Notation

KEY

- L is the length of the longitudinal wires (which are not necessarily the longer wires in the sheet)
- B is the length of the cross wires
- 0_1 and 0_2 are the overhangs of the longitudinal wires
- 0_3 and 0_4 are the side overhangs of the cross wires
- P_L is the pitch of the longitudinal wires
- P_C is the pitch of the cross wires

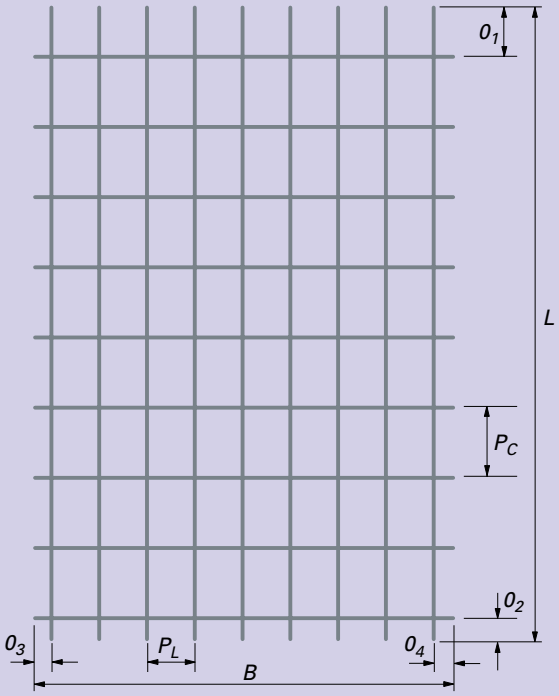


Figure 1

Preferred Range of Standard Fabric Types

Fabric Reference	Longitudinal Wires			Transverse Wires			Mass (kg/m²)
	Nominal wire size (mm)	Pitch (mm)	Area (mm²/m)	Nominal wire size (mm)	Pitch (mm)	Area (mm²/m)	
Square Mesh							
A393	10	200	393	10	200	393	6.16
A252	8	200	252	8	200	252	3.95
A193	7	200	193	7	200	193	3.02
A142	6	200	142	6	200	142	2.22
A98	5	200	98	5	200	98	1.54
Structural Mesh							
B1131	12	100	1131	8	200	252	10.9
B785	10	100	785	8	200	252	8.14
B503	8	100	503	8	200	252	5.93
B385	7	100	385	7	200	193	4.53
B283	6	100	283	7	200	193	3.73
B196	5	100	196	7	200	193	3.05
Long Mesh							
C785	10	100	785	6	400	70.8	6.72
C636	9	100	636	6	400	70.8	5.55
C503	8	100	503	5	400	49	4.34
C385	7	100	385	5	400	49	3.41
C283	6	100	283	5	400	49	2.61
Wrapping Mesh							
D98	5	200	98	5	200	98	1.54
D49	2.5	100	49	2.5	100	49	0.77
Stock sheet	Length 4.8m			Width 2.4m			Area 11.52 m²

Table 1

Example of Ribbed Cold Rolled Wire

Figure 2 Courtesy of R-Tech Services

BS 4483 curently allows for bars and wires used for the longitudinal and transverse reinforcement in welded fabrics to be to the following specifications:

BS 4482
BS 4449 Grade 460A or 460B

(Note: BS4483 is currently under review by the British Standards Institute. Any changes made will result in an amendment to this guide, which in turn will be published on the CARES website and also in pdf format.)

The only exception is for D49 wrapping mesh, where a 2.5mm wire with a minimum yield strength of 250 N/mm^2 is specified.

BS 4482 is specifically for the manufacture of cold reduced wire for the reinforcement of concrete. The standard allows for plain, indented or ribbed wires to be produced, with different bond classifications. Only one grade of steel is included in BS 4482, which is broadly similar to grade 460A of BS 4449, but with a more restricted chemical analysis, reduced ductility requirements, and no fatigue specification. Wire sizes included in BS 4482 are 5 to 12mm.

In practice, almost all of the welded fabric used in the UK is made of cold rolled wire produced to BS 4482. The majority of this material, approximately 95%, is produced by the cold rolling process route (see Part 2 of this Guide). This material is ribbed, with three rows of transverse ribs, giving Type 2 bond characteristics. This is illustrated in **Figure 2** showing also the CARES mark of producer identity.

A small proportion of welded fabric produced in the UK is made from plain wire, which has been drawn, rather than rolled. This product is currently in use but is to be excluded from the European design code (known as EC2), due to be published in 2004. The use of indented wire in welded fabric is very rare in the UK. Hot rolled bar is not normally incorporated into welded fabric in the UK, although this is common practice in some European countries.

For standard fabrics, the same steel type and grade must be used in both directions (longitudinal and transverse wires).

It is a requirement of BS 4483, that all fabric should be electrical resistance welded. A minimum weld shear strength is specified of 25% of the nominal tensile yield strength of the smaller wire at the welded intersection. In addition, the welded wires must meet the tensile and rebend properties specified in the parent material specification (i.e. BS 4482 or BS 4449).

2.2 Purpose-made fabrics

In addition to the standard fabrics listed in Table 1, BS 4483 also makes provision for purpose-made fabrics. These may have any combination of wire sizes and spacing in either direction. In addition, bars or wires in these fabrics may be staggered. It is an important requirement that the same grade of reinforcing steel should be used in each direction.

Purpose Made Welded Fabric Showing Flying Ends

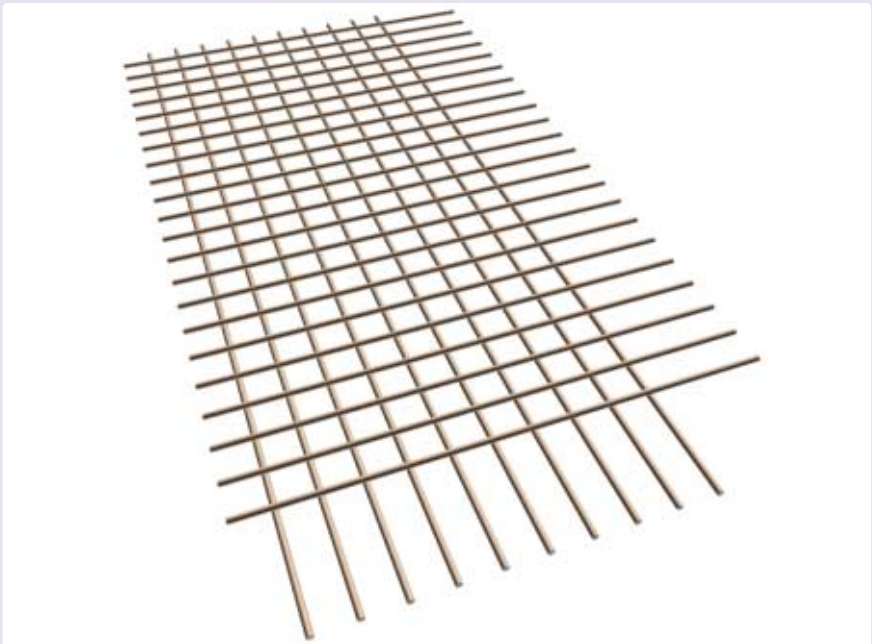


Figure 3 Courtesy of ROM

Manufacturers may use different terms to describe purpose-made fabrics. In practice, they may be sub-divided into two categories. These are:

a) Special fabrics (also called semi-standard or scheduled fabrics).

b) Bespoke fabrics (also called detailed fabric mats).

Special fabrics consist of the standard wire size combinations, but with non-standard sheet dimensions or overhangs. A particular group of products in this category are fabrics with so-called flying ends (**Figure 3**).

These fabrics are designed so that less steel is provided in the lapped area between sheets. The lap length is designed to dive a minimum 40d lap, i.e. in excess of that required for grade C25 concrete. The use of flying ends eases congestion, and prevents encroachment of the reinforcement into the concrete cover, which could occur if standard fabrics are lapped. As an alternative, some manufacturers incorporate finer wires into the edge of the fabric to assist with lapping.

Bespoke fabric is a more complex arrangement in which a whole range of different combinations of wire sizes, spacings and lengths can be specified, and bars or wires are often staggered. These products are tailor made for each contract as a replacement for conventional loose bar and they are often referred to as bar mats.

These bespoke fabrics tend to be in the larger wire sizes (12 and 16mm), and they may be made by arc welding techniques, rather than electric resistance welding. In this case, the fabrics are not strictly made to BS 4483, which covers only electric resistance welding. Welding in such products is conducted to the requirements of BS 7123.

Bespoke fabrics are appropriate on contracts where there is a high degree of repeatability, and generally manufacturers would require a minimum tonnage order for commercial viability. Those fabricators who supply purpose-made fabric will generally provide the design assistance required to advise customers on appropriate specification.

Fabric-Welding Machine

Figure 4 Courtesy of Schlatter

Cross Section of an Electric Resistance Weld

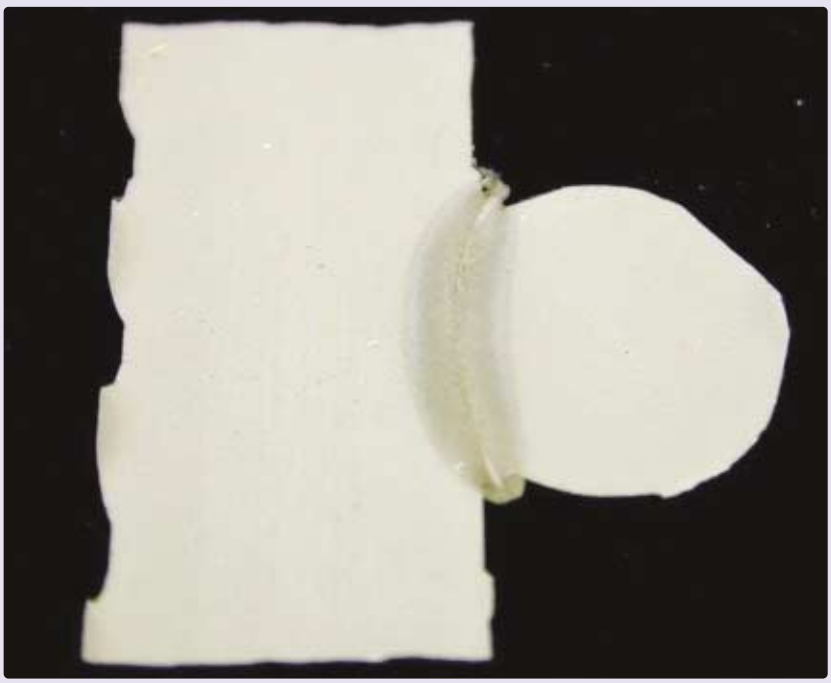


Figure 5 Courtesy of R-Tech Services

3.0 Process Routes

The manufacturing process route for bar and wire to BS4449 or BS 4482 has been described in Part 2 of this Guide. Since welded fabric is produced only in sizes up to 16mm diameter, the feedstock for the fabric making process is normally reinforcing bar in coil. Fabric manufacturers in the UK normally have their own cold rolling operation, in which plain hot rolled rod is rolled to ribbed wire. The coil may be fed directly into the fabric-welding machine from spools, for both the longitudinal and transverse wires. This is the common method for standard fabrics. Alternatively, the wire may be straightened off-line, usually by decoiling, and cut to length. The cut lengths are then fed to the welding machine from hoppers. A standard welding machine may have up to 24 longitudinal wires. The spacing of both transverse and longitudinal wires is adjustable. A typical fabric welding making machine is shown in **Figure 4**.

The longitudinal and transverse wires are fed into position under the welding heads, which consist of Cu/Cr electrodes. These clamp the wires, and then pass the welding current. The electrical resistance at the interface between the two wires causes local heating due to the Joule effect. The combination of the heat produced and the pressure applied produces a solid-state weld i.e. where no melting of material takes place. An example of a typical electric resistance weld is given in **Figure 5**. The process is fully automated, and a modern machine may weld at a rate of 120 transverse wires per minute, with up to 24 welds per wire.

After welding, coil fed fabrics are sheared to length, and then stacked. Normally each alternate sheet is inverted, in order to nest the sheets, so that the volume for transportation is reduced. After stacking, bundles are tied, normally with tying wire, labelled, and then despatched. Bundles are normally 1.5 tonnes in weight. They are generally wire tied. It is important that the bundles are lifted with slings, not by the ties, which are not designed for this purpose.

4.0 Testing

In addition to testing conducted on the constituent wires, welded fabric is tested according to the requirements of BS 4483 for tensile properties, rebend properties and weld shear strength.

The test unit is 50 tonnes of the same type of fabric from a single welding machine. Tests are performed on two longitudinal wires and two transverse wires from the batch. The tensile properties are measured on samples containing at least one welded intersection in the gauge length. This ensures that the presence of the weld has not led to deterioration in the properties of the parent wire.

As with the parent materials, there is a requirement for the long-term quality level to be assessed. The characteristic value of yield strength measured over 3 months production must meet the long-term characteristic requirement. Under the CARES Product Certification Scheme, the results are verified by CARES. Where material is not covered by such a third party product certification scheme, BS 4483 requires that welded fabric be subject to a more extensive batch testing regime.

The shear test requirement of BS 4483, is that the shear strength of a weld should exceed 25% of the nominal tensile yield strength of the smaller wire in a combination. In certain circumstances, shear strengths of up to 70% of the nominal yield strength may be specified.

If required by the customer, manufacturers of welded fabric may issue a certificate of conformity for the batch, although the CARES approved status of fabric producers obviates the need for such a provision, as this capability is required by CARES and is audited at regular intervals.

5.0 Bending of fabric

Sheets of welded fabric, containing wires up to 12mm diameter, can be bent by the fabricator. The shape codes applied to the bending of fabric in BS 8666, or BS4466, are the same as those for the bending of bar. Almost all shapes can be supplied in fabric, but care must be taken when specifying "closed" shapes.

Bending of Fabric Reinforcement

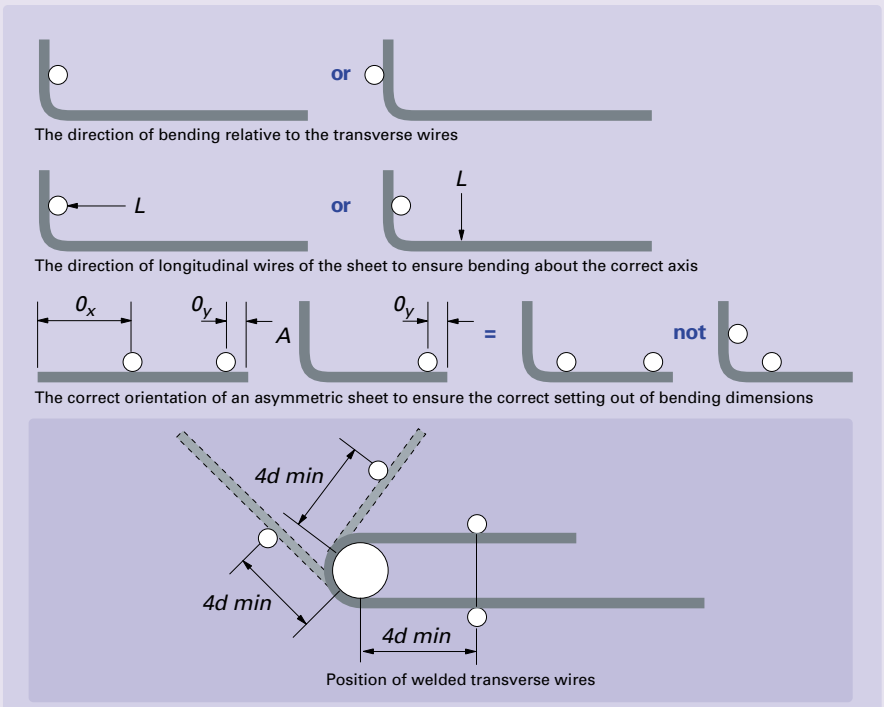


Figure 6

5.1 Scheduling

BS 8666 gives requirements for the scheduling of standard and purpose-made fabric.

Standard fabrics are ordered by their designation in BS 4483, e.g. A193. If a specific grade of bar or wire is required, then this is added after the standard designation, using the notation of BS 8666 or BS 4466 (see part 4 of the Guide). For example A193T would specify that the wire complies with grade 460A or B of BS 4449.

Where bent fabric is to be scheduled, a sketch should be included on the schedule to show the orientation of the bend with respect to the welds. For example, the transverse wires may be on the inside or outside of the bend (**Figure 6**). BS 8666 specifically requires that bends are at least 4 wire diameters away from the nearest welded intersection.

6.0 The CARES scheme for welded fabric

The operation of the CARES schemes has been described in Part 1 of this Guide. The scheme operates in a similar way for welded fabric to that described for reinforcing bars, incorporating quality systems assessment, independent product testing, and full traceability throughout the supply chain.

The CARES list of approved manufacturers, which appears on the CARES web-site (www.ukcares.com), includes a list of approved manufacturers of welded fabric, along with details of their scope of approval.

As with the other schemes, specification of CARES approved welded fabric gives specifiers and users the confidence that the material complies with the purchase specification. The requirements for costly batch acceptance testing are avoided.

7.0 Handling of fabric.

It is vitally important, both from a quality and safety point of view that reinforcing fabric is handled correctly at all points in the supply chain but particularly from delivery vehicles at construction sites. Poor handling can damage wires and the welds between them and create problems when fixing. From a safety point of view, the movement of reinforcement fabric should be the subject of risk assessment and safe system of work. It is not the purpose of this guide to expand on this. A code of practice for users, hauliers and suppliers has been produced by the UK fabric producers however, under their trade association, IRPA (**Figure 7**). A copy of this can be obtained via any CARES approved reinforcement fabricator.

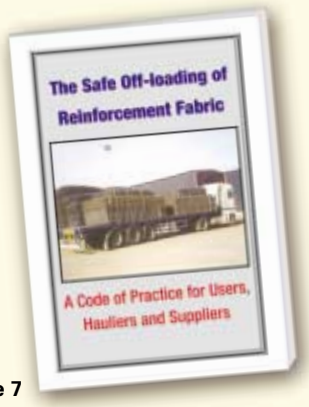


Figure 7

8.0 References

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2. "Economic assembly of reinforcement" **D F H Bennett, L A M MacDonald, BCA, Wexham Springs 1992**

3. "Concrete industrial ground floors - a guide to their design and construction" Concrete Society Technical Report 34. **Concrete Society, Slough 1994**

4. "Steel for the reinforcement of concrete Appendix 4. Quality and operations schedule for welded fabric to BS 4483" **UK CARES Jan 2002**

5. **BRITISH STANDARDS INSTITUTION. BS 4482:1985** "Cold reduced steel wire for the reinforcement of concrete" London pp 12

6. **BRITISH STANDARDS INSTITUTION. BS 4449:1997** "Carbon steel bars for the reinforcement of concrete" London pp 19

7. "Eurocode 2: Design of concrete structures-Part 1: General rules and rules for buildings" **prEN1992-1-1 Final Draft**

8. "The safe off-loading of reinforcement fabric- a code of practice for users, hauliers and suppliers" **IRPA**

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