Testing times for couplers

The use of mechanical couplers for joining reinforcing bars is increasing not only in the UK market but globally. In addition the number of suppliers in the market and the different types of couplers available are also increasing. Against this background there are a number of initiatives to standardise the testing and performance of couplers. Tony Franks of R-TECH Services, and chairman of the BSI committee ISE/104-1 on reinforcing steels, reports.

(Photo: Ancon.)

Examples of different coupler types.

The use of mechanical couplers for joining reinforcing bars is an established technology, which is continuing to develop in terms of the types of couplers available and their performance. The supply of couplers is a global business and because of the diversity of design codes, specifications and construction practice, standardisation of the specification and testing of coupler performance has been slow.

The types of couplers available can best be categorised by the way in which the joint is made between the coupler and the reinforcing steel as follows:

- threaded cold swaged steel sleeve with/without screwed steel inserts
- threaded steel sleeve with/without screwed steel inserts
- hot forged end-deformed bars
- lock shear-bolt steel sleeve with/without epoxy resin injection.

With all coupler systems, the joint (or splice) is made either in the fabricator's works or on the construction site. Therefore there is a requirement for control of both the coupler manufacturing operation, and also the production of the splice itself, which will normally require some end preparation of the bar.

The main performance characteristics required of a coupler are as follows:

- Failure load – failure of the coupled joint can occur by stripping of threads, failure of the coupler itself or premature failure of the bar, within the coupled joint. In general terms the minimum failure load of the reinforcing bar specification must be met.
- Ductility – it is not possible to measure the elongation to fracture across a coupled joint as has been conventional for testing of reinforcing steel. However, it is possible to measure the uniform elongation of the bar away from the coupled joint.
- Slip – the permanent slip across the joint is restricted in order to limit cracking of the concrete bonded to the coupler. For instance, BS 8110[1] limits slip across the coupled joint to a maximum of 0.1mm after loading to 60% of the nominal yield load of the reinforcing bar.
- Failure location – some coupler systems are designed to always give a failure of the parent bar away from the coupler itself.
- Fatigue – within the UK, fatigue performance of coupled joints is specified in BS 5400 Part 10[2]. This recognises two classes: D and R. Class D couplers are for applications with limited fatigue loading where the coupler has been included in the original design and additional reinforcement has been used to reduce the dynamic stresses. Class R couplers are subject to fatigue loading and require approval to the Highways Agency *Design Manual for Roads and Bridges*[3].
- Cyclic loading – in some countries there are requirements for assessment against low cycle reverse loading to simulate seismic conditions.

(Photo: R-TECH Services.)

Testing of a mechanical splice.

Standards development – the current UK position

For many years, coupled joints in the UK have been specified to meet the requirements of the BS 8110 design code. This specified two criteria:

- When tested, an assembly consisting of the size, grade and profile of the reinforcing steel to be used and the precise type of coupler to be used, the permanent elongation after loading to $0.6f_y$ should not exceed 0.1mm.
- The ultimate tensile strength of the coupled bar should exceed the specified characteristic yield strength by the percentage specified in the reinforcing steel Standard.

Eurocode 2[4] contains no specific performance criteria for mechanical couplers. This currently leaves a significant gap in the specification of couplers in the UK.

Within the UK, couplers for nuclear construction have been specified to a BNFL (now Sellafield) Technical Standard A.0391[5]. This specification includes initial type tests of a coupler system and ongoing production tests. In addition to the normal failure load and slip tests, a number of additional requirements are included:

- the failure load must exceed the measured yield strength of the reference bar by more than 15% and less than 35%

(Photo: Dextra.)

Couplers on a cage for a bored pile.

(Photo: Erico.)

Above: 32mm MBT couplers in place. Below: Complex testing of coupled joint.

- the permanent slip after loading to 300MPa ($0.6f_y$) shall not exceed 0.1mm
- the strain across the joint should not exceed the measured strain across the unspliced bar by more than 40% for all loads up to $0.9f_y$
- the UTS of the joint shall not be less than the load required to produce 2% strain in the reference bar
- the failure shall occur by breaking of the bar away from the coupler.

The BNFL specification provides for three classes of couplers, namely A, B and C, depending on the requirements against the various performance criteria listed above.

Although BS 5400 and BS 8110 make reference to the performance of mechanical couplers, there is currently no available Standard to specify how couplers should be made, tested and certified. UK CARES, recognising this deficiency, introduced its own scheme for product certification of couplers[6–8]. It has three schemes based on the end application as follows:

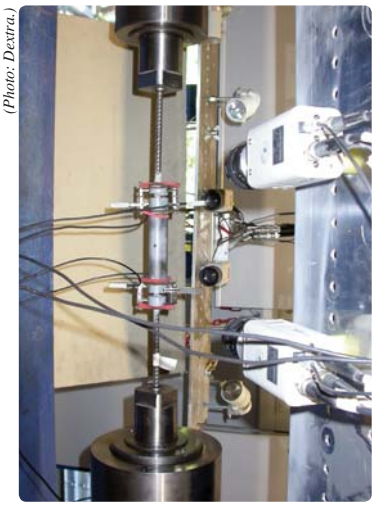
- Appendix TA1-A. This covers couplers for design to BS 5400 Part 10 (ie, fatigue design for bridge applications).
- Appendix TA1-B. This covers couplers applied to BS 8110 or Eurocode 2.
- Appendix TA1-C. This covers couplers to the BNFL specification.

These technical appendices cover the requirement of the coupler system. In addition, CARES has an additional set of requirements to cover the fabricators making the spliced joint[7].

Standards development – ISO 15835

In 2009, ISO published ISO 15835[9]. Part 1 covers requirements for reinforcement couplers for mechanical splicing of bars. Part 2 covers the test methods. Due to the global diversity in design codes, applications and experience with mechanical couplers, the ISO Standard is deliberately inclusive, and incorporates a number of options for the specification of the various performance characteristics. It is for this reason, as well as the limited UK experience with some of the tests, that the ISO Standard has not been adopted within British Standards.

(Photo: Dextra.)



Some aspects of the ISO Standard of which the UK has no or limited experience include:

- measurement of slip under load, after multiple (three) loading cycles
- measurement of ductility under static forces, by means of a uniform elongation measurement away from the coupled joint
- if the coupler consists of more than one load transferring part, slip measurements being taken between each load-bearing part
- measurement of high cycle fatigue performance by determination of an S–N diagram
- measurement of properties under low cycle reverse loading in the elastic-plastic range
- a certification system for couplers.

Standards development – UK

Work is currently underway by BSI committee ISE/104-1 to develop a new British Standard for couplers. This will draw on the requirements and test methods of the ISO Standard but tailored to the requirements of the UK market. It is hoped that all interested parties, designers, manufacturers, fabricators, test laboratories and certification bodies will have an active involvement in the development of this Standard, to ensure that it meets the needs of the UK. ●

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