Visual inspection after welding

No. 6.06

Introduction
This Guidance Note gives general information about the visual inspection of welds in structural steelwork for bridges.

Scope of inspection
As explained in GN 6.01, weld quality levels are specified in EN 1090-2 (Ref 1) in relation to 'execution class'. The Standard states that EXC3 could be used for most bridge steelwork.

Visual examination is always required over the full length of all welds and it is advisable to carry this out as soon as the weld is completed to ensure there are no unacceptable surface imperfections. If surface imperfections are detected, EN 1090-2 states that the weld shall be surface tested by magnetic particle testing (or penetrant testing). The standard also defines minimum hold times after welding before supplementary NDT takes place, although it is prudent to conduct visual inspection as welding progresses to enable obvious problems to be addressed immediately.

For highway infrastructure projects, the Specification for Highway Works Series 1800 was published in August 2014 (Ref 2). The specification interprets and implements PD 6705-2 (Ref 3) and introduces the concept of Quantified Service Categories (QSC) which influences the acceptance level for visual inspection. See GN 6.01 and GN 2.12 for further explanation about QSC.

Method of visual inspection
EN 1090-2 states that visual inspection shall be conducted in accordance with EN 970 (Ref 4). That Standard is an undated reference and has been superseded by BS EN ISO 17637 (Ref 5). The Standard describes examination conditions and equipment necessary for effective visual inspection. The principal requirement being to ensure that all welds are present and in the correct location and are of the size specified on the drawings or welding procedure.

Size is specified according the convention "*z*" for leg length or "*a*" for throat thickness. UK practice to date mostly uses leg length to define weld size, however European practice uses throat thickness and the detailer needs to make it absolutely clear which convention is being used, to avoid misunderstanding.

EN 1090-2 also states that particular attention shall be paid to welded branch connections in hollow sections and emphasises the key areas for circular, square and rectangular sections where the shape and surface of welds needs careful attention.

Acceptance criteria
EN 1090-2 requires that, for EXC 3, joints the acceptance criteria for weld imperfections shall be Quality Level B to EN ISO 5817 (Ref 6), except for "Incorrect toe" and "Micro lack of fusion", which are not to be taken into account. Additional requirements for weld geometry and profile need to be specified.

For joints where an enhanced level of quality is required to meet design fatigue strength requirements, EN 1090-2 Table 17 gives additional requirements for class EXC4 as Quality Level B+. In addition, the table also gives further supplementary requirements for bridge decks. These are more stringent acceptance standards for imperfection types over and above Quality Level B.

Generally the requirements for Quality Level B+ are not practically achievable in routine production. Indeed normal welding procedure and welder qualification tests are not assessed against acceptance criteria at this level. If a higher quality level is required, this should be specified for each relevant joint detail.

Highway infrastructure projects carried out in accordance with SHW Series 1800 use Tables 18/7 and 18/8 to specify the weld acceptance criteria. These are different to those specified in EN ISO 5817 and relate to QSC to determine the detailed requirements.

EN 1090-2 suggests that non-conforming welds be judged individually and evaluation should be based on the function of the component and the characteristics of the defect in terms of type, size and location in order to determine acceptability. Reference back to the design standard may be used to support the evaluation.

The imperfections that can be determined and assessed by visual examination are size and shape, cracks, cavities, removal of slag and spatter, stray arcing, surface breaking porosity, undercut, linear misalignment. For EXC 3 cracks and cavities are not permitted, slag and spatter shall be removed, stray arcing shall be lightly ground and the visual check supplemented by MPI of the affected area. Surface breaking porosity and undercut need to be carefully measured to assess acceptability.

Linear misalignment also needs measuring and assessing against the acceptance criteria. Out of tolerance misalignment may be acceptable subject to a design check and unless there is an aesthetic reason to correct the error it is better to leave an otherwise acceptable weld rather than risk an unsatisfactory repair.

The results from inspections should be recorded formally in a report giving details of the items examined, weld identification and acceptance criteria.

Figure 1 illustrates typical weld defects.

Repair

Where a visual inspection identifies defects repair becomes necessary. In some cases this might involve a simple localised light grinding or dressing to correct the problem and it is not practical to report these.

For more substantial repairs which are reported through non-conformance and corrective action procedures, the repair is likely to involve gouging and welding. It is necessary to maintain control by implementing a repair procedure either of a generic nature or specifically developed to correct the problem. In either case, the completed repair area needs re-examination and reporting.

Inspection personnel

All inspection to ensure the quality of the completed welding should be carried out by appropriately qualified, capable and experienced personnel. EN ISO 17637 recommends qualification in accordance with EN ISO 9712 (Ref 7) or an equivalent standard at an appropriate level relevant to the industry sector. In any case, visual inspection personnel should be familiar with relevant standards, rules and specifications, be informed about the welding procedure used and have good vision which should be checked every twelve months.

In many cases, the services of an independent testing organization will be engaged, in addition to the inspection carried out by the fabricator. This independent organisation will normally place an inspector at the works on a full- or part-time basis to monitor the inspection carried out by the fabricator as part of the production process, and also to carry out verification testing in parallel.

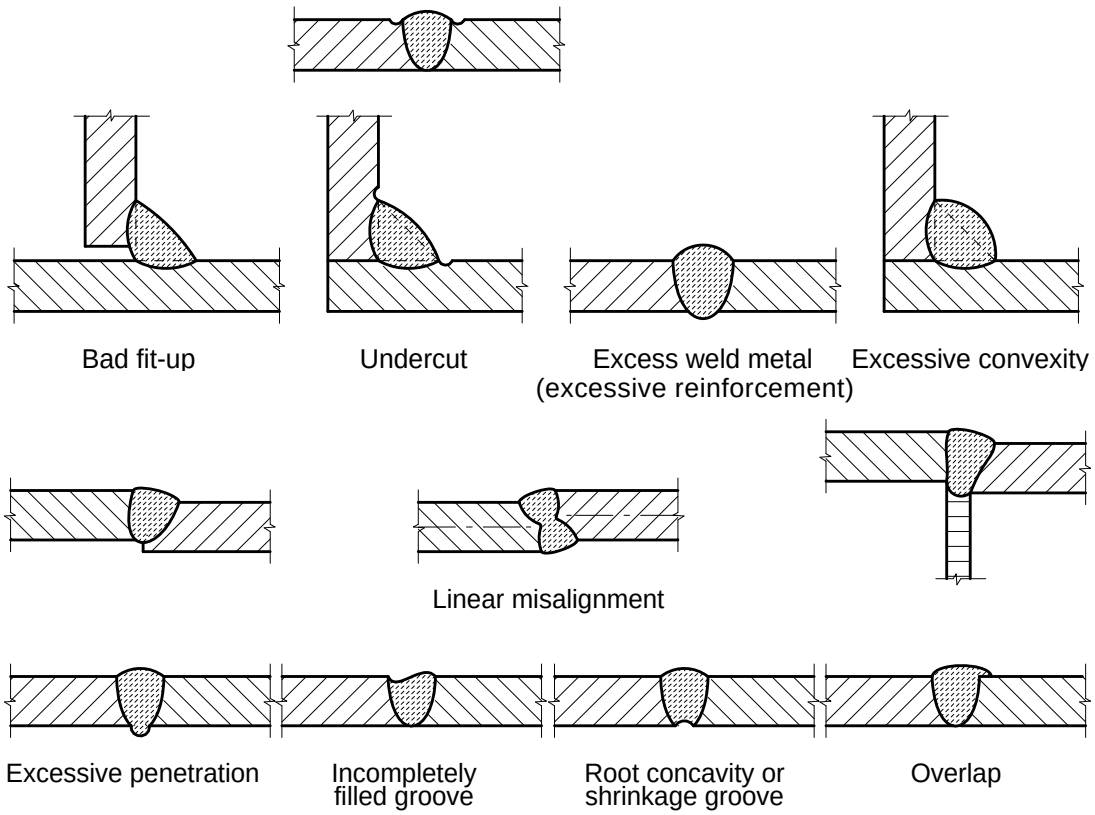

Figure 1 *Typical weld defects or discontinuities*

References

1. EN 1090-2: 2008+A1:2011 Execution of steel structures and aluminium structures. Technical requirements for steel structures.
2. Manual of Contract Documents for Highway works. Volume 1 Specification for Highway Works. Series 1800 Structural steelwork. Amendment - August 2014, TSO.
3. PD 6705-2: 2010+A1:2013 Structural use of steel and aluminium. Part 2: Recommendations for the execution of steel bridges to BS EN 1090-2.
4. EN 970: 1997, Non-destructive examination of fusion welds - Visual examination. *Superseded, withdrawn.*
5. EN ISO 17637: 2011 Non-destructive of welds. Visual testing of fusion welded joints.
6. EN ISO 5817: 2014, Welding. Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded). Quality levels for imperfections.
7. EN ISO 9712: 2012 Non-destructive testing. Qualification and certification of NDT personnel.