



STEEL INDUSTRY
GUIDANCE NOTES

Appraisal of steel structures

When existing steel buildings are considered for change of use or alteration, or a structural survey is required for insurance purposes or after some trauma, such as a fire, appraisal and assessment will be required. For more modern structures with comprehensive drawings, and design to modern standards, this should present little difficulty. This SIGNS concentrates on older structures, which will pose more challenges. Expert advice should be sought from experienced engineers – this SIGNS presents some general guidance.

Appraisal can be considered as the total process, involving investigations of the condition of an existing structure, its form of construction, its material, connections, fire resistance and robustness. Assessment is the calculation of the structure's adequacy, based on contemporary and historical standards and based on an understanding of materials and structural behaviour.

“If it ain't broke, don't fix it”

A structure that is clearly performing adequately in its current condition and under current loads does not necessarily require remedial work. It should be remembered that the best attempt at a rigorous analysis and calculation of stresses will only be an approximation to what is actually happening. The following questions should be considered:

- Is there evidence of overall problems such as instability, undersize or missing members or connections, or gross distortion?
- Is there evidence of distress such as excessive deflection, corrosion, distortion, cracking or fracture?
- Is there evidence of activity that could produce excessive deflection or aggravate distress in the future (for example leaks to cause corrosion, exposure to aggressive chemicals or seawater, exposure to substantial dynamic or repeated loading)?
- Will continued use, or the proposed new use, increase loadings and other actions on the structure above established existing levels?

The as-built structure

Modern structures are hardly ever constructed as the initial drawings may indicate, so it would be surprising to discover that an older building was in full accord with any drawings that may exist – a thorough investigation will be essential. It is always worthwhile however to attempt to

locate any original records, and any records or subsequent investigations, alterations, remedial works etc.

The general form of construction is likely to follow the type of construction common at the time the structure was completed, so reference to historical records, reports on similar buildings and reference works that describe construction types can be helpful in identifying design practice and forms of construction. Such documents may well indicate the type of material to be expected, and identify details which may require remedial work, and help identify where detailed investigation should be focussed.

What material?

In structural applications, metals will generally be grey cast iron, wrought iron, or steel. These three materials can be distinguished principally by appearance. Dating may be helpful in corroborating visual evidence, and particularly in separating wrought iron (late 1840s to 1890s) from steel (1880s to the present day). Sampling will give definitive confirmation of material; this may be essential, especially in more recent structures where there may be stainless steel, spheroidal graphite cast iron, or cast steel. Sampling must be carefully undertaken – especially if cast iron is suspected, due to its brittle behaviour. Guidance is available (see Reference 1) on how and where samples should be taken.

Structural defects

Examination should aim to identify and record the structural condition, including:

- Distortions such as bowing, bulging, local impact damage, out-of-plumb, buckling, and bolt and rivet distortions.
- Fractures and cracks in members and connections (with particular attention to cast iron and welds).
- Corrosion

- Missing connectors (bolts, rivets, etc.).
- Defects in cast iron and welds such as blowholes and porosity.

While some of these items should be readily visible, problems arise with painted metalwork, and embedded or encased metalwork. In such cases it may be necessary to remove paintwork by blast cleaning (taking health and safety precautions as appropriate), to open up embedded or encased metalwork for closer examination or to adopt non-destructive test methods. The uncovering of metalwork may be unwelcome, but is an important step in the appraisal process as the encasement itself may have encouraged water penetration and retention, and may therefore be concealing significant defects. In some cases, the expansion of corrosion products may be revealed by cracking in the encasement. The absence of cracks should not be considered definitive, as the encasement may have been replaced without addressing the internal defects.

Structural members and connections

Careful examination of sections to establish sizes is needed, especially with built-up members and hollow sections. Hollow cast iron sections may have an eccentric void, so investigation of the thickness at intervals around the section (and at different levels to avoid drilling at the same level) is recommended. Several references provide dimensional data for older rolled sections.

Overall structural performance

In addition to the adequacy of individual members and connections to carry the self weight and externally applied loads, the structure will be required to have certain levels of robustness against disproportionate collapse. As tying requirements are relatively modern, very old structures will not have made explicit provision for this design issue. In some cases, the form of construction may provide adequate tying with no further work – in others, some strengthening work may be necessary. More modern performance requirements also include the need for fire protection, where a range of solutions are possible from intumescent coatings to encasement.

Remedial work

A whole range of solutions are possible to repair, replace, reinforce or relieve existing members. With older buildings of historical interest, it may be that the visual appearance of the remedial measures or the impact on the existing structure is of critical importance to the owners or regulators – this needs to be discussed at an early stage of development as minimal intervention may be demanded.

Key Points

- It is important to understand the characteristics and behaviour of any structural material or form of construction as a pre-requisite to the appraisal process.
- The properties of cast and wrought iron and steel are predictable, and permit structures using these materials to be re-used, adapted and upgraded.
- Wrought iron and steel are ductile materials. Cast iron is relatively brittle and weaker in tension than compression.
- The historical aspects of the use of these materials, their quality of manufacture and installation, and the design methods existing at the time, are all important considerations in the appraisal process.
- Material testing may be required to provide more quantitative information.
- Load testing may be carried out in extreme situations.
- Strengthening or upgrading of the existing structure often requires attachments formed by welding, bolting or clamping, or in some cases by composite action with other materials.
- Fire protection can be achieved by intumescent coatings, or encasement.

Further Sources of Information

1. **Bussell, M. *Appraisal of existing iron and steel structures*, P138, SCI, 1997**

2. ***Historical structural steelwork handbook*, The British Constructional Steelwork Association Ltd., 1984**