Foreword

This series of booklets has been produced by the Department of the Environment to increase awareness of the value of our architectural heritage and to provide information on the basic principles and methods of conservation and restoration. The titles in the series are listed on the back of each booklet.

These texts are not intended to be comprehensive technical or legal guides. The main aim is to assist architects, builders, owners and others,in understanding the guiding principles of conservation and restoration. They will facilitate the identification of the most common problems encountered in heritage buildings,and indicate the best solutions. It should be appreciated that specialised aspects of conservation and restoration will require professional expertise and more detailed information.

The Department acknowledges,with appreciation,the efforts of the authors of the individual booklets,the Irish Georgian Society who coordinated their production,the Conservation Advisory Panel established under the Operational Programme for Local Urban and Rural Development and all others involved.

Summary of Conservation Principles

- Research prior to planning work
- Minimum intervention - repair rather than replace
- Respect the setting.

Summary of Conservation Procedure

- Research and analyse history of building
- Survey building and identify original material
- Plan work according to conservation principles
- Use experts where necessary
- Record all work
- Install maintenance procedures.

Introduction

The use of cast and wrought iron was at the leading edge of building technology in the mid-19th century. Buildings such as the recently restored Turner curvilinear range of glasshouses at the National Botanic Gardens reflect the industrial age in its most advanced form,with standardised components and prefabricated elements manufactured off-site for later site assembly.

This booklet seeks to give an overview of the uses of cast and wrought iron before its general replacement by mild steel at the end of the 19th century. Advice on the identification,repair and protection of ironwork is given. For reasons of space, it is not possible to cover each issue comprehensively but an attempt is made to address the key aspects of ironwork conservation.

Brief History

Wrought Iron

Wrought iron usage dates back to 1500 BC when it was made in small furnaces blown by hand bellows. It is the iron associated with the blacksmith,decorative iron railings,anchor chains,the Menai bridge, the Eiffel Tower and Richard Turner's curvilinear glasshouses at Glasnevin in Dublin. It is tough and fibrous, equal in tension and compression and can be worked by hammering,rolling and forming. It is difficult, but not impossible, to weld. Wrought iron production/recycling has recently recommenced on a limited scale.

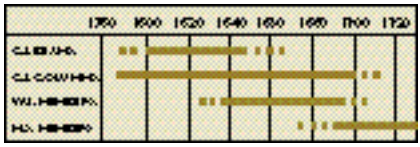
Cast Iron

Cast iron was discovered almost by accident in the fifteenth century but it was not until the 1790s that a simple, quick and relatively economical manufacturing process was developed. It can not be forged or worked but it can be melted and poured into moulds. Historic (grey) cast iron is strong in compression but weak in tension due to its crystalline structure. It is the material of old lamp standards,columns,bollards,metal casings, railings,and decorative mouldings. Grey cast iron is still made commercially today. Ductile or nodular cast iron was developed in 1947 to overcome the problem of tension stress cracking in grey cast iron.

Original decorative ironwork should be carefully preserved

Mild Steel

Mild steel is made by removing carbon from cast iron and is the modern form of commercial structural steel. It was developed by accident by Henry Bessemer in 1856 in an attempt to make wrought iron less labour and fuel intensive. It was not until 1880 that mild steel quality control problems were resolved and it then began to replace wrought iron and cast iron in structural work.



Periods of popular use of structural metalwork. C.I.= cast iron. W.I.= wrought iron M.S.= mild steel

Typical Elements

Wrought Iron

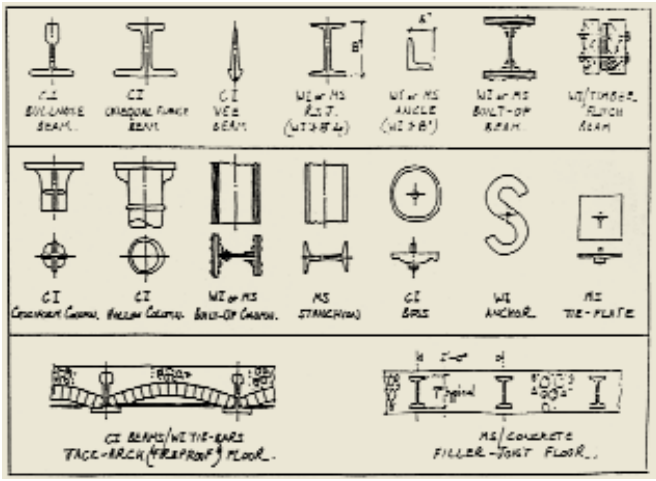
Wrought iron was used extensively for railings and gates in the 18th and 19th centuries. It reached its peak as a structural building material for glasshouses,bridges,and large span railway station roofs and exhibition buildings in the latter half of the 19th century before it was displaced by the use of cheaper mild steel. Wrought iron's fibrous nature and the inclusion of slag by virtue of its hand made process,make it malleable and relatively easy to work into different shapes by various techniques. The square, circular or rectangular bars were usually connected by carpentry type joints,such as mortice and tenon and/or halving and pinning,to provide the basic railing,gate or roof structure. Decorative elements,such as spear heads, leaves and scrolls, were then attached by means of heat or forge welding or rivets. The use of gilding and different coloured paints was not uncommon in Ireland. The use of black as the 'correct' railing colour dates only from the late Victorian period.

Cast Iron

Cast iron was used for simple geometrically shaped columns from the end of the eighteenth century. Such columns were often circular, square, hexagonal or octagonal in shape, with a hollow central section. Classical style column capitals and bases were used to facilitate structural connections by means of simple sockets,spigots and/or wrought iron bolts. Cast iron was very good in compression. Cast iron beams tend to look oversized and visually 'heavy'compared to wrought iron or mild steel beams. This is because old grey cast iron is weak in tension and the foundry tried to compensate for this deficiency by increasing the thickness of the bottom flange of the beam. Traditional grey cast iron can not be forged or mechanically worked either hot or cold.

Steel

In 1889 the Eiffel Tower was built in wrought iron, but in the same year the Forth railway bridge was constructed in mild steel. From that time onwards mild steel became the dominant iron for large and small structures. Today, when someone buys wrought iron metalwork they are most likely purchasing mild steel which has been hammered and forged to give it a wrought iron look.



Common structural forms. C.I.= cast iron. W.I.= wrought iron M.S.= mild steel

However, wrought iron and mild steel are different irons with similar but different chemical and physical properties.

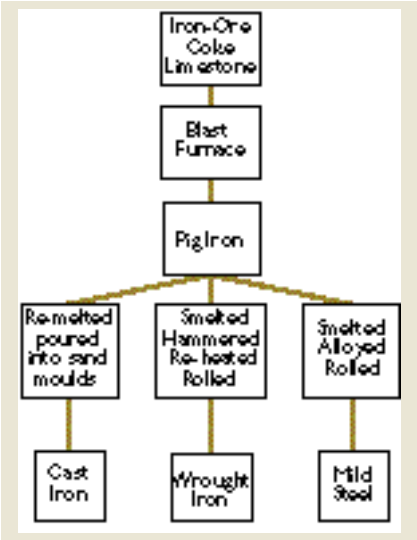
Today, there are many different forms of steel developed for specific applications,such as stainless steel, but they have a limited role to play in the conservation of 18th and 19th century ironwork.

Common Problems and Solutions

1. Identification of Irons

The most common problem is to distinguish what type of iron has been used. The different methods of manufacture, strengths and applications are the key to distinguishing between wrought iron,cast iron and mild steel. The date of the structure will help considerably in identifying the type of iron.

Traditionally, wrought iron was generally used in tension while cast iron was mainly used in compression. The mould line, bulkiness and sandy surface (from the sand mould) will indicate cast iron. Wrought iron may be made up of riveted sections,and have a hand beaten or smooth rolled surface. If a fracture has occurred,the fibrous laminated type structure of wrought iron is clearly different from the crystalline structure of cast iron. The use of mild steel was not common until the 1880s. A metallurgical test on supplied samples by Forbairt or Material Ireland, U.C.D.,will determine the precise iron used where precision and quality assurance are required for exacting conservation work.



Flow chart of the manufacture of metalwor k

2. Corrosion of Iron

The most serious problem with iron is corrosion. The presence of water and oxygen causes corrosion. Good detailing, regular maintenance and quality paint application are essential if corrosion is to be kept under control. Painting is the most practical way of protecting ironwork.

Iron corrodes to form rust which is loosely adherent and many times the volume of the original iron. As a result,'corrosion jacking' takes place which pushes off the adjacent paintwork,and in restricted locations,such as where crevice corrosion is occur ring, other metal sections can be jacked or displaced causing considerable damage. Wrought iron corrodes more slowly than mild steel.

If a building/structure is severely corroded, dismantling in the reverse order to construction should be considered. The advantages of such an approach are significant. A clear understanding of the structure and its condition will be gained, defective parts easily revealed,and cleaning and painting can be car ried out in dr y workshop conditions. A tagging system for every component is required so that the building elements can go back in their right location during re-erection. Use drawings, photographs and/or a video to record the work in progress.

3. Manufacturing defects

Ironwork can have defects dating from the time of its manufacture. The quality control of 19th century cast iron foundries was variable. Defects were concealed by a surface application of wax and iron filings. These defects will become apparent when old cast iron is cleaned back to bare metal in preparation for painting. Cast iron has good corrosion resistance.

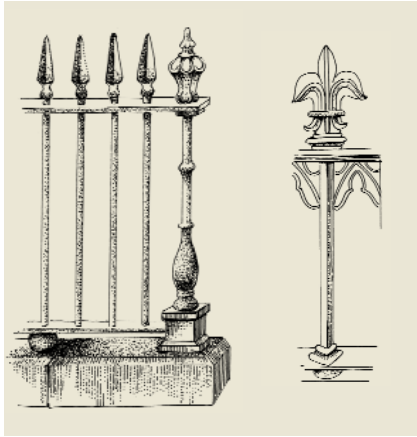
Wrought iron has a higher elastic (bending) limit than cast iron and,as a result,does not fracture very easily under stress. In extreme situations it may suffer fatigue failure following repeated severe bending.

Mild steel,after 1880,had good quality control and would seldom have manufacturing defects. It is,however, more susceptible to corrosion than cast or wrought iron.

4. Damaged or missing elements
In-situ repair for smaller elements is possible. A special proprietary system of cast iron repair (used mainly in heavy engineering) is available from Metlab Ltd. but it is expensive for building/structural purposes. Where it is not a structural item,a strap, stud or dowel may be used for cast iron repair. Where a structural cast iron item has cracked or fractured,the original component can be used for re-casting a new component. If additional strength and tension resistance are required,ductile cast iron should be used in lieu of standard grey cast iron.

Wrought iron structures or railings can be welded despite the contrary view put forward in most construction books. However, it does require specially skilled welders. Slag occlusions and the fibrous nature of wrought iron make it difficult but not impossible to make structurally sound welds. Professional advice should be sought. Replacement wrought iron from recycled material is available from Britain. (See Chris Topp and Ironbridge in Sources of Information).

5. Railings and Balconies
For external ironwork, such as railings and balconies, remove all rust deposits. A needle gun is useful for reaching into awkward corners and general rust removal. Quickly follow by the application of two coats of red lead rust inhibitor. The next coat should be a micaceous iron oxide (M10) and,if the surface is rough,allow for two thin coats. A final two coats of an epoxy urethane finish will give good resistance to corrosion. A minimum dry film thickness (D.F.T.) of 250 microns is needed for good protection. The paints used in an overall paint system must be compatible and preferably from the same supplier. Strict supervision of painting contractors to ensure compliance with the specification is vital. The use of old lead based paints for reasons of 'authentic' appearance to finishing coats is not recommended on the grounds of health, safety and environment. Colour and gloss/sheen levels can be reproduced in quality modern paints which will give better protection to metalwork.



Railings *Detail of decorative railing*

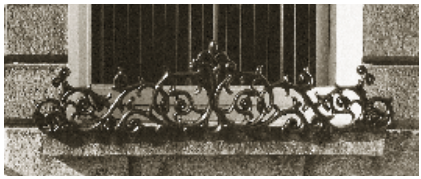
Ironwork housed in masonry
Where ironwork is housed into masonry, abrasive cleaning will be necessary to remove

completely all corrosion prior to painting and re-setting. While lead was traditionally used to socket-in metalwork,its heat in the molten state will damage the paint system on the iron. Consideration should be given to using an epoxy resin compatible with the paint finish for best corrosion resistance at the vulnerable ironwork/masonry connection point.

6. General painting of ironwork

Apart from structural integrity, the surface preparation of ironwork and the application of a quality paint system are the most important considerations in the conservation of cast and wrought iron. Choose a test area which includes the various types and shapes of iron so that a cleaning/painting system can be selected which allows for these variables. The surface roughness of the ironwork will be a key factor in determining the type and number of coats of paint. Specialist metal fillers may be used on cast and wrought iron to fill surface defects.

Mechanical wire brushing or abrasive blast cleaning give best results and may be used on cast and wrought iron, but careful selection of mechanical brushes and abrasive grits is essential. Painting by brush is superior to spray painting on rough surfaces. The damp Irish climate is not conducive to a good paint finish. External painting should be avoided in the months November to February inclusive, due to the high relative humidity during this period. More thinner coats of paint are better than fewer thicker coats.



Well-maintained decorative ironwork.

Procedur e

The type and extent of repairs worth carrying out to ironwork depends on the merit of the item or building in terms of uniqueness,quality of design,technological importance and workmanship. The primary concern must be to stop deterioration and stabilise the condition of the ironwork.

In the case of a structure/building you should seek professional advice so as to consider adequately the architectural and structural aspects of the project prior to carrying out any work. Such professionals would carry out an assessment covering such aspects as: how the building/structure was put together, how it is functioning,check vulnerable parts for corrosion,check water traps, inspect all rivets and bolts,check for structural movement and fractures,carry out load tests for strength,and structural calculations for stresses.

Repair should be on the basis of minimal disturbance, retention of as much original material as possible and the use of traditional materials and techniques where feasible. The process of restoration/repair should be recorded.

Maintenance

Annual inspections of ironwork is recommended to check for corrosion and defects. Professional help should be sought where specialist architecture or engineering aspects apply. Good paintwork is basic maintenance.

Dos and Don'ts

Do
- identify iron type prior to commencing work
- take precautions if removing lead-based paint
- repair rather than replace if possible
- insist on accurate detail if replacement is necessary
- record the work carried out.

Don't
- start painting before testing the proposed cleaning/paint system on a small area.
- forget that regular inspection,and maintenance, will keep ironwork in good condition,and save money.

Sources of Information

The Office of Public Works - 51 St.Stephens Green,Dublin 2
Tel. 01 661 3111

General Paints,Celbridge, Co. Kildare
Tel. 01 628 8224

Forbairt Paints Division,Dublin 9
Tel.01 808 2000

Material Ireland, U.C.D.,Dublin
Tel.01 706 1990

The Welding Institute, Abingdon Hall, Abingdon, Cambridge, CG1 6AL,England

Chris Topp & Co.,Blacksmiths,Carlton Husthwaite,Thirsk,North Yorkshire, England

Ironbridge George Museum,Ironbridge, Telford,Shropshire,TF8 7AW,

Select Bibliography

Ashurst,John and Nicola. *Practical Building Conservation,Vol.4: Metals* (English Heritage). Aldershot,1988.

Ciria Report III. *Structural Renovation of Traditional Buildings*. Rome, 1986.

Jagard and Drury. *Architectural Building Construction*. Cambridge, 1935.

Richardson,Clive. 'Guide to Structural Surveys' (*The Architects Journal*). London, 1985.