

MAJOR CAST METAL COMPONENTS

Introduction

Contemporary structures (buildings and bridges) may utilise cast metal components for a variety of reasons and applications. These include the ability to be shaped for structural or aesthetic purposes and to transfer loads at the interface between differing structural components. Applications include bridge bearings, cable hangers, node junctions and generally for ease of fabrication in volumetrically complex shapes.

Some of these components are required to accommodate movement: between two castings or a casting and another component. Movement may be linear or rotational; it may be occasional or fluctuate in a regular or irregular manner. It may be of a nature that could give rise to fatigue damage.

The design of castings requires special care because of the manner in which they are made; each designed cast is unique and ensuring the integrity of the final product requires specialist skills in design, material specification, control of the casting process, machining, construction and assembly on site. The structural qualities of interest in the final product may be strength, ductility, toughness, weldability and machineability. All these metallurgical properties are affected by the mix chemistry and by the rates of product cooling post casting and possibly by later heat treatment. Pre-service non destructive examination may be essential. The technology involved is beyond the normal skills in structural engineering so it is essential that proper advice is sought on product procurement. This is particularly important when the product dimensions are 'thick'.

This note is written to highlight the key aspects of using cast metal components so as to avoid unintended consequences which are detrimental to the component's life and performance. Further information can be found in the references quoted at the end.

Managing the risks

Adopting the '3Ps' (People, Process and Product) approach to risk management will allow a comprehensive assessment of the issues.

People

Having a competent team involved with the design and specification of the cast metal component will ensure that the necessary skills and experience are brought to bear. If this competence is lacking within the design office advice should be sought, at an early stage in the design, from specialists e.g. contractors, foundries, fabricators, materials consultants. It is important that this is done before committed design decisions are made. It is equally important that those involved with the fabrication are also competent. The structural designer has a key role in placing the requisite quality standards in the context of the consequences of failure.

Process

There are a number of aspects to the process of the design and procurement of cast metal components that can give rise to problems if not managed appropriately. These include:

Element	Sub-element	Comment
Design		
	Function	It is essential for the design intent to be clear and fully understood; this should consider the fabrication, use and maintenance phases and the consequences of failure.
	Toughness	The consequences of a fracture may be catastrophic so the definition of requisite toughness is essential. The risk of fracture can be exacerbated by internal flaws and by shrinkage stresses at re-entrant corners.

	Movement	Apart from the primary linear and/or rotational movements it is necessary to give thought as to whether any secondary movements may arise, perhaps unintended, and their likely significance.
	Loads	The nature of the loading is critical to performance: deviation from expected thrust-lines, fluctuating loads and load reversals can all have a disproportionate effect in certain circumstances.
	Shape/size	The shape of the casting, and experience in the chosen configuration and size, will be key to success. Modifying the shape can reduce the risk of shrinkage cracking. Modifying thickness can render the cooling process more even. Advice may need to be taken from competent fabricators/ foundries.
	Accuracy	Accuracy of casting has an effect upon performance and cost. The necessary accuracy will depend upon an interaction of assembly tolerances, movement characteristics, need to limit /allow movements.
	Mock-up	Mock-ups can identify many difficulties prior to commitment with the production run. They are a good insurance policy.
	Experience	Experience of casting configuration/sequence and size; extrapolation issues
	Material	See below under 'Product' The need for an understanding of the metallurgical and manufacturing aspects of cast steel including heat treatment, cooling rates, crack generators, toughness and ductility
	Information	
	Review	
Procurement		
	Responsibility	The contract must be clear as to which party is responsible for the design and production of the component and its metallurgical characteristics. This is particularly important in 'D&B' contract routes.
	Competency	The contract should stipulate requirements regarding the competency of those engaged to manufacture, fabricate and erect the components.
	Sub-contracting	If the fabrication and erection process is sub-contracted this procedure should be undertaken in a controlled manner, to the designer's approval.
	Time	Adequate time must be allowed at all the various stages of approval, fabrication, testing and inspection.
Supervision/Testing		
	Inspection	Casting may be subject to internal flaws and an appropriate NDE regime should be specified
	Testing	Specimens need to be taken from the same heat as the casting, for chemical and strength analysis. Other specimens may need to be subject to the same heat treatment (if used) for strength and fracture toughness testing.

Process risks

Product

Finally, the product itself. Cast metal components generally require greater basic consideration of the manufacturing stage than say rolled steel components which are well covered by established BSs. It is vital that the various requirements are considered and covered in the procurement Specification. This should be specific as to:

Aspect	Issue	Comment
Product	Metallurgy	Achieving adequate strength, toughness and weldability at an economic price is a balance between material chemistry and subsequent casting technique and heat treatment.
	Source	The composition of the metal will be important to the integrity of the product and its certification through an acknowledged QA route will be essential.
	Inspection	Sufficient non destructive inspection opportunities should be stipulated under guidance from the designer to assure both general quality and assurance of product reliability relative to its duty in service
	Testing	The material should be tested (considering both non destructive and sample destructive testing) such that the designer can be satisfied as to its integrity.

Product control

Summary

Cast metal components can often offer significant architectural and engineering benefits. However, it is important that their particular characteristics and requirements are appreciated and acted upon. This note is designed to act as an initial briefing to draw out some of the key issues.

References

1	'Castings in Construction', P172, The Steel Construction Institute, 1996.
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