... FROM THE EUROPEAN CONCRETE BUILDING PROJECT

Improving rebar information and supply

Figure 1: *Fixing reinforcement on the in-situ concrete building at Cardington*

This Guide provides recommendations for the more efficient supply of reinforcement by improving the transfer of information, and by re-engineering the flow of process information from the designer through to the fixer

Introduction

The European Concrete Building Project is a joint initiative aimed at improving the performance of the concrete frame industry.

The principal partners in the world's most ambitious concrete research programme are:

British Cement Association
Building Research Establishment Ltd
Construct - the Concrete Structures Group
Reinforced Concrete Council
Department of the Environment, Transport and the Regions

The programme involves the construction of a series of full-sized concrete structures in the Large Building Test Facility at Cardington, where they are being subjected to comprehensive testing of the building process and of their performance.

With support from the DETR and the Engineering and Physical Sciences Research Council, the first of these buildings, a seven-storey in-situ flat slab concrete frame, was completed in 1998. The results of investigations into all aspects of the concrete frame construction process are summarised in this series of Best Practice Guides.

These Guides are aimed at all those involved in the process of procurement, design and construction of in-situ concrete frames. They should stimulate fundamental change in this process in order to yield significant improvements in the cost, delivery time and the quality of these structures.

Key messages

Improving the flow of information between all parties involved in the rebar design, supply and construction chain will:

- Speed up the design process, and reduce the amount of re-working.
- Reduce duplication and the scope for errors in re-keying information.
- Reduce lead times with increased flexibility for change.
- Reduce waste from bending machines

Best practice

The reinforced concrete industry should:

- Use electronic exchange and sharing of rebar information. Initially this should take the form of standard ASCII formatted bending schedules, developed during this project and adopted by CITE (Construction Industry Trading Electronically) - see back page for contact details.
- Adopt reinforcement detailing by contractors using integrated rebar detailing and manufacturing information.
- Use bar-coding and text files as an automatic identification technique for the exchange of bills of quantities, test certificates, delivery notes and invoices.
- Use electronic transfer of information for the control of rebar bending and cutting machines.

Identification of current practices

To aid understanding of the information flow throughout the rebar supply chain, current practices and procedures used in the procurement of rebar have been studied and modelled, from design through manufacturing, production and supply to construction.

Consideration of case studies and discussion with the project partners has led to the development of the generic rebar process diagram summarised in Figure 2. It includes all the activities in the rebar process from design through raw material manufacture to production, supply and fixing. The diagram portrays the whole rebar process and serves as an outline for developing more detailed rebar information flow diagrams using standard modelling tools adapted to the rebar process (Figure 3).

The models developed were verified by comparing them with procedures observed at manufacturing plants, designers' offices and contractors' sites and offices.

In addition to identifying the communication paths between the various parties, the information to be transferred was examined. This involved collecting the traditional paper forms from each of the participating organisations. These were studied to highlight information to be passed between these parties and the extent of duplication that resulted from not being able to share information.

Analysis of current practices has highlighted potential areas for improvement. The main findings are summarised below.

The design process

Consultants usually feel at ease in passing design drawings to in-house or subcontractor reinforcement detailers. The detailers are treated as partners and appropriate information is passed on to them as required, without the need to wait until a complete package of calculations, sketches and general arrangement drawings is finalised. However in the approach advocated by Construct (Reference 1), in which the detailing is contractor-led, any drawings passed to contractors need to be complete. In this situation a contractor detailer cannot proceed before receiving drawings of final design from consultants.

The Construct approach aims at saving time by allowing contractors the right to take decisions to rationalise reinforcement in order to achieve early

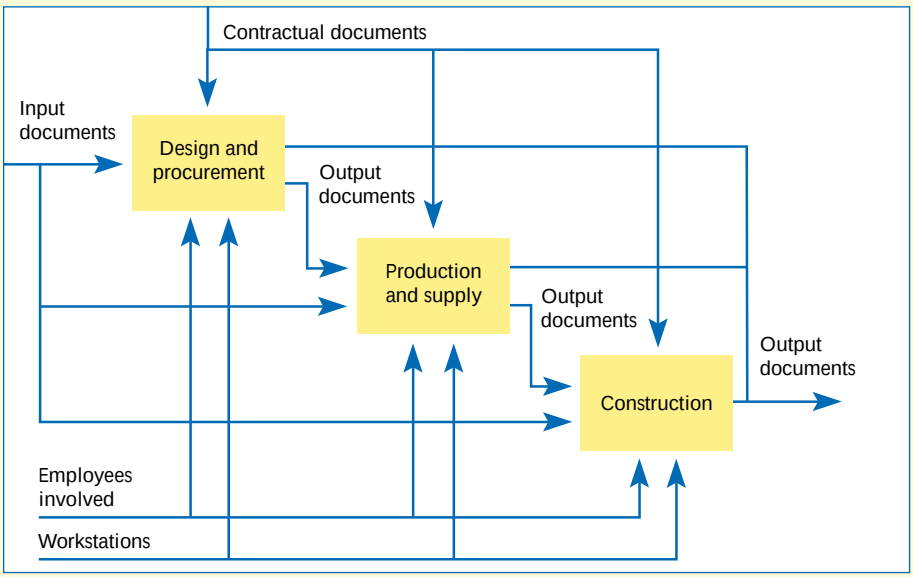

Figure 2: *A generic diagram showing rebar process information flow*

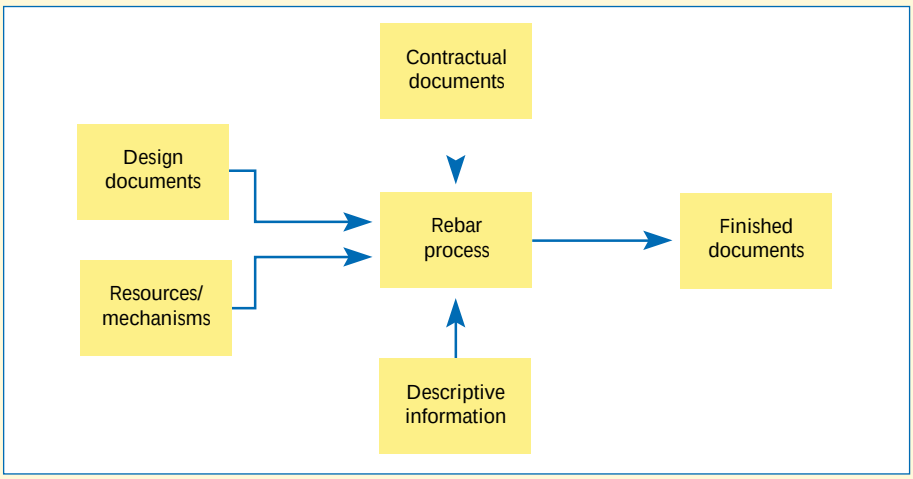

Figure 3: *Modelling tool applied to rebar processes*

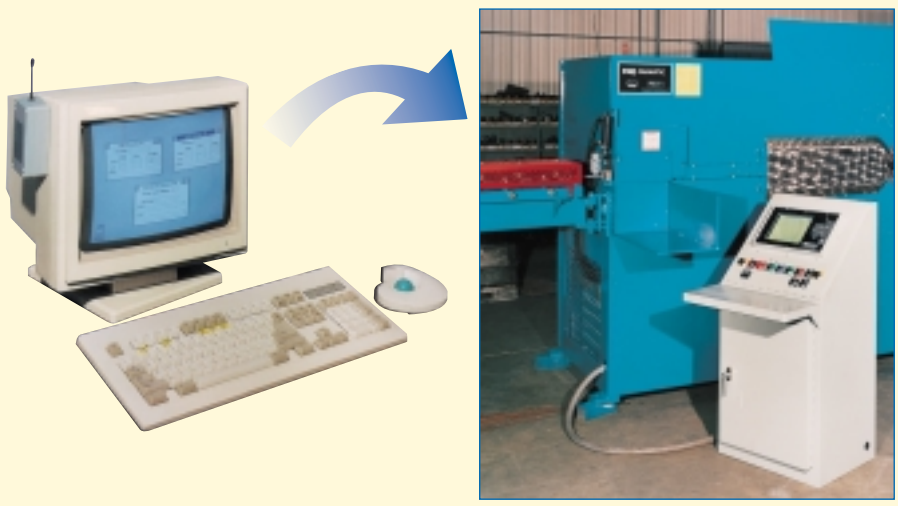

Figure 4: *A bending machine controller obtains information directly from the office database*

striking of formwork and to optimise productivity.

On any project, reinforcement drawings may be revised several times as a result of technical or human error or a change to design initiated by one of the parties involved in the construction contract. This process of revising drawings has many implications on the speed and cost of construction. Construct claims that its approach should reduce the number of times drawings are revised since the contractor participation minimises the element of change during execution of the project.

The time saved by not having to return the drawings for re-design could well compensate for time used by the consultant engineer in the preparation of complete batches of final design drawings.

In most current procurement methods the detail drawings are returned for approval and verification by the consultant engineer. This is an unnecessary step and should be replaced by an assured 'forward path' procedure.

Information technology

Software developers have traditionally thought of rebar design as a set of activities performed by one party, either the consultant, architect or detailer. Hence they often fail to address issues related to suppliers and manufacturers such as data exchange formats and the use of output information from costing, estimating and stock control activities.

Structural engineers, detailers, contractors and suppliers are all using design and detailing packages. However, because of the lack of an agreed data exchange format, they are currently unable to exchange bending schedules that are created using these packages. Most software packages produce an ASCII file format, but these formats are not standardised and hence cannot currently be exchanged throughout the industry. There is also little coherence between the detailing software

Manufacturing, production and supply

Manufacturers of rebar shearing and bending equipment are currently developing their products in line with developments in information technology. New machines that are more automated than previous generations are now available. They are capable of interfacing with office-generated design data. The difficulty lies with suppliers who find investing in new state-of-the-art machinery very costly both in terms of capital expenditure and workforce training. The majority of suppliers are using partially automated machines. In many cases, even those who have invested in new machines are not utilising their interface and automated capabilities.

Once set, bending machines produce reasonably accurate rebars, but the first one or two bars of each batch are taken as samples for checking the settings and are always scrapped, increasing the wastage. This would not occur if the new automated machines were used to their full capability.

Virtually all reinforcement in the UK is manufactured by CARES-approved fabricators (see back page). To date, the systems employed by the majority of these fabricators and their customers have been based on the receipt, translation, storage and transmission of hard copy documents and records. Whilst the systems employed by CARES and its approved firms have been generally sound and reliable, errors which do occur are caused by human error in the replication and transmission of data on paper. Furthermore, paper-based traceability systems in the form of order documents, test certificates or production records, involve retention and retrieval systems that are expensive and inefficient.

Use of bar-coding is currently rare and manufacturers who have adopted it have limited its use to their own purposes.

Prefabrication and assembly

It has become common practice for prefabricated wire-mesh mats and rolls, and specialist items such as shear ladders etc. to be procured from manufacturers. However, the use of cages pre-assembled off-site is rare and concentrated in certain jobs such as tunnelling and other specialised areas. Factory prefabricated cages are not favoured due to the high cost of transport and the wider responsibility for their structural performance, but there are advantages to be gained from such prefabrication.

Achieving best practice in rebar information and supply

- In addition to their effort in developing state-of-the-art machinery, manufacturers of reinforcement cutting and bending equipment should think of ways in which their older machines can be upgraded. These then should be able to handle electronic data interchange over networks or via data saving devices, floppy disks etc. in a similar manner to the controller units of newer machines (Figure 4).
- Fabricators should automate information transfer in their plant. With the new generation of equipment it is possible to transfer bending schedule data from detailers' computers directly to shearing and bending machines. This feature needs to be fully exploited, and this requires a standard data exchange format. This view is supported by members of Construction Industry Trading Electronically (CITE). As a first step towards rebar process automation, a proposed ASCII format has been developed as part of this project for the standardisation of bending schedule information exchange. The format has been adopted by CITE as an industry standard and CITE members will be encouraged to use it.
- Traditionally, steel-framed structures are detailed by the nominated fabricator, and this is provided for in the Association of Consulting Engineers (ACE) agreement. In 1995 new ACE agreements were introduced to encourage specialist concrete contractors to detail reinforced concrete structures in a similar way. This approach was further promoted by the publication of the Construct document on contractor-led detailing (Reference 1).
- Designers and contractors should agree on which procurement method is best and adopt that approach. An assured 'forward path' approach is needed in which a job delegated to a second party moves on to the third and following parties in the chain and does not return unnecessarily.
- The proposed data exchange format adopted by CITE should be seen as a starting point. There is scope for a more sophisticated standardised data exchange format to be developed in the future to cope with graphic information, and with the use of object-orientated programming.
- New standardised formats for electronic data exchange will remove the element of duplication that is associated with the traditional paper forms currently used, and permit rapid electronic transfer of the most commonly exchanged items (i.e. bending schedules and test certificates).
- Automatic identification (AI) of materials should be applied

systematically throughout the rebar industry. The application of bar-coding as an AI tool will streamline the flow of both the materials themselves and the information concerning them through the supply chain.

- There should be more commitment, within the CARES-approved supply chain for reinforcement, to the use of electronic systems for material traceability, processing and supply to site.
- An organisation should be set up to promote the integration of information in the rebar process throughout the reinforcement industry. CARES, RCC, CITE and Construct could together play an invaluable role in promoting the industry's future IT activities and fostering the development and implementation of an integrated information system based on object-oriented process modelling. These organisations should take account of other initiatives (e.g. that from the International Association for Interoperability, IAI, see below).

Quality assurance

CARES certification is designed to improve the consistency of raw material and derived products such as cut and bent reinforcement, ensuring that at all stages the material consistently meets the requirements of the relevant standard or specification, allowing a reduction in costly and time consuming site testing. The certification rules also provide for full traceability of material from the hot metal through to the construction site.

Certification rules allow the use of electronic systems throughout the approved supply chain. CARES therefore intends to encourage the adoption of electronic systems for material ordering, production and supply, initially seeking to work with a small number of committed designers, contractors and fabricators to trial its use. CARES recognises that the adoption of the recommendations of this Guide will greatly assist this drive towards electronic trading.

This Best Practice Guide is based on research report, *Improving rebar information and supply (IRIS)* by A. Kalian, T. Thorpe and S. Austin. BRE report published by CRC Ltd. (020 7505 6622).

Reference

1. CONSTRUCT. *A guide to contractor detailing of reinforcement in concrete.* Crowthorne, BCA, 1997. Ref. CSG/001.

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- Improving concrete frame construction
- Concreting for improved speed and efficiency
- Early age strength assessment of concrete on site
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Research partners for this Guide

Loughborough University
Building Research Establishment Ltd
Reinforced Concrete Council
CARES (Certification Authority for Reinforcing Steel)
CITE (Construction Industry Trading Electronically)
UKSA (Reinforcement Manufacturers Product Group)
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John Doyle Construction
R O'Rourke and Sons Engineering Ltd
Buro Happold

97.504
First published 2000
ISBN 0 7210 1555 7
Price group A

Published by the British Cement Association on behalf of the project partners.

British Cement Association
Century House
Telford Avenue
Crowthorne, Berkshire RG45 6YS
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