Information Technology in the Reinforcement Supply Chain

1.0 Introduction

Designers, detailers, engineers, contractors, fabricators and reinforcement producers are recognising the benefits of exchanging reinforcement information via electronic means to improve supply chain efficiencies and improve on-site productivity.

Reinforcement is a major part of any concrete construction project. Effective management of this is crucial if projects are to be delivered on time and on budget. Part 9 of this Guide describes developments in the use of various forms of information technology (IT) in the reinforcement supply chain. It describes a number of case studies of major projects that have benefited from the effective implementation of coherent IT strategies.

Over recent years, the Internet and the reduction in the costs of computer hardware have made the exchange of electronic information a reality. At the same time, reinforcement standards have changed to accommodate electronic data exchange developments.

The reinforcement industry is now realising the benefits associated with electronic information exchange. Collaboration between parties in the supply chain, including CARES, is removing the traditional barriers to progress and delivering cost effective supply chain solutions. Fragmentation, bespoke solutions, inertia and high set-up costs are being avoided by this collaborative approach. Innovation without integrated information flows would be, at best, limited. The reinforcement supply chain is seeking to adopt a common approach to electronic data exchange and CARES intends to operate its certification scheme to incorporate any such developments in order to cut out wasted time and money from the key business processes.

Construction of Wembley Stadium

2.0 Electronic exchange of reinforcement information

A best practice guide produced by the Concrete Centre, Improving Rebar Information and Supply, highlighted the benefits to all parties in the rebar supply chain by the adoption of a common data exchange format to permit the exchange of electronic information. This has now become a commercial reality with the availability of a number proprietary products.

The key areas of use are:

- Reinforcement drawings and schedules transmitted by e-mail directly from the contractor/detailer to the reinforcement fabricator.
- Efficient management of 'call-offs' using bespoke software.
- Bar coded product labels, in use throughout the entire supply chain from steel mill to the reinforcement fabricator and delivery to site.
- Central storage of product test data, deposited and retrieved via a secure web based database.

3.0 Case studies

The following case studies describe the benefits of effective implementation of coherent IT strategies by firms involved in major construction projects. Firstly, the innovative integrated project team of a major project joint venture at Heathrow Airport and secondly the traditional multi-firm project teams as used at Wembley Stadium and Al Mafraq Hospital, Abu Dhabi.

It should be noted that CARES are not endorsing or recommending the use of any of the software packages referred to in this Guide as there are others available.

3.1 Heathrow airport, London, Terminal 5

The new Terminal 5 building at Heathrow Airport, commissioned by BAA,used around 150,000 tonnes of steel reinforcement. Major challenges faced the project team from a number of planning restrictions placed on the movement of materials by road and limited hours of operation.

An innovative 'lean manufacturing' approach focusing on the 'just-in-time' delivery of materials and products has been implemented to ensure the reinforcement production, fabrication and delivery was driven by the construction program and involved close working relationships between reinforcement producers, the reinforcement fabricator, designers, detailers, engineers, contractors and the client. Express and Laing O'Rourke formed a unique partnership to supply the reinforcement required and re-engineered the key business processes as described in the following sections, 3.1.1 to 3.1.4.

3.1.1 Reinforcement scheduling

The traditional way of posting or faxing reinforcement schedules was not a feasible option because of the short time interval between the development of the schedule and the need to deliver the reinforcement to site to achieve the optimum concrete pouring sequences. The use of electronic information exchange as the means of communicating reinforcement scheduling information was an important part of the business process re-engineering. Reinforcement was rationalized pre-construction using bespoke design engineering and analysis software. Thereafter, detailed reinforcement drawings produced by Laing O'Rourke, via a detailing firm, were deposited into a single drawing database for the whole project.
The accumulation of all schedule data into a single database that incorporated "version control" was accessed by all applicable users, including the detailers, site managers, engineers and reinforcement processors as well as steel producers. The absence of manual intervention ensured the accuracy of the scheduled information and expedited the ordering process. The Application Program Interfaces (API's) were developed to such an extent that they could interface various formats of exchange files. (see **Figure 1**)

3.1.2 Reinforcement processing

A significant challenge for the project team was the procurement and movement of 150,000 tonnes of reinforcing steel from the producing mills, through processing and on to site. As all steel was required to be delivered to the factory by rail, dedicated railhead facilities were established, as was a purpose built reinforcement fabrication factory at Colnbrook, adjacent to the construction site.

There was extensive use of bar coding to ensure effective stock control and product traceability.
The build up of material information began in the steel mill, where bar codes on bundle labels provided full production and consignment details. This information was posted to the T5JV database, enabling accurate stock control at the railhead and factory.

Reinforcement production planning

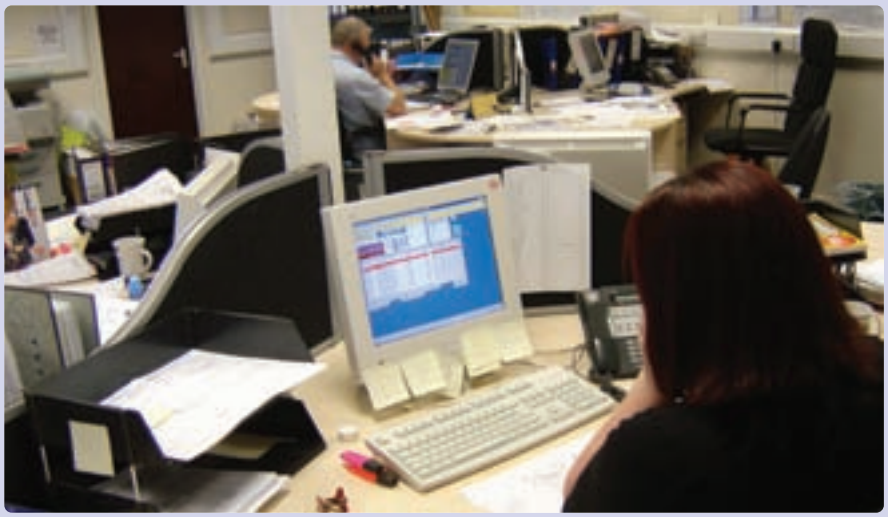

Figure 1 Courtesy of Express Reinforcements Ltd

Reinforcement data

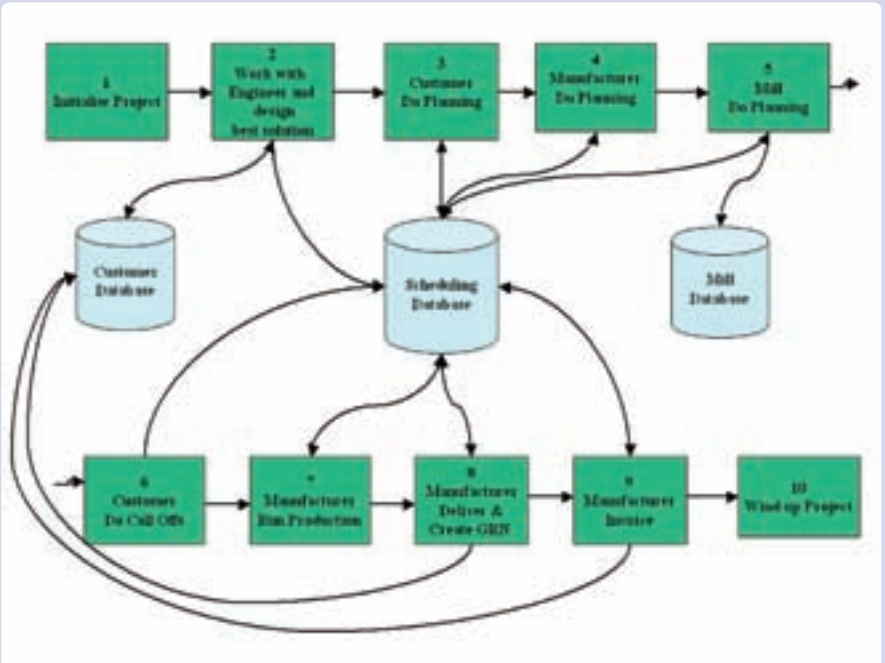

Figure 2 Courtesy of Express O'Rourke JV Ltd

In the factory, the use of similarly bar coded labels for both production and dispatch to site made it possible to track the full path of each as it moved through the factory.

The single T5JV database of information enabled the generation of various user interfaces to facilitate site planning, package call-offs, production planning as well as raw material planning. By involving the full supply chain in the process, full traceability from hot metal to site was ensured, i.e. from material test certificate, through each individual bar mark to the relevant call-off and associated invoice. The various parties throughout the supply chain used this information to ensure that no data was out of sequence and that the cost of duplication was avoided throughout the full supply chain process.

An overview of the process is shown in **Figure 2**

3.1.3 Quality Assurance

The technology of making use of bar code scanners to follow the process of raw material receipts through to delivery to site has various advantages. These advantages far outweigh the initial investment costs. From the time of steel making onwards, all production information was built into the bar codes of the identification labels used. These bar codes were scanned as required and the data was sent electronically to the steelmill database. Upon receipt at the reinforcement fabrication factory the bundle labels were scanned and the delivery data, including cast information, updated the stock records. Throughout all processing stages in the factory the production labels were scanned to maintain product traceability and provide factory performance indicators, including operator, machine and delivery data. This technology enabled the database to be updated with regards to all events in the procurement cycle with 'real-time' information. Not only was traceability in place but management of the factory was more effective as the status of production was monitored and 'real-time' productivity reports of the produced material and also manpower and machines was obtained. Furthermore errors in deliveries were minimized and early warning signals triggered faster responses to various problems or queries (see **Figure 3**).

Use of bar coded product labels

Figure 3 Courtesy of Express O'Rourke JV Ltd

3.1.4 Computer aided manufacturing

Computer aided manufacturing in the reinforcement processing industry has come a long way over recent years. Traditionally the downloading of information to the manufacturing equipment was seen as automation. The production software used in this case, ARMA+, turned the factory into a homogeneous manageable unit, making optimum use of the various resources available. These process control systems had the flexibility to run the production unit as a fully optimized, lean manufacturing solution. Again, all parties in the business process had access to the information via the single T5JV project database that enabled early action to be taken on external procedures and decisions.

This case study demonstrates that optimization has progressed from the saving of raw material and now focuses on the whole business, managing all business processes from pre-manufacturing through to installation on site ensuring the optimum use of design, planning, manpower, machines, raw material, deliveries and installation. This approach not only streamlines the reinforcing process but has a positive knock-on effect on the whole construction process. (see **Figure 4**)

3.2 Wembley Stadium, London

Traditional construction project teams consist of a number of independent firms that each have their own information technology systems designed for their own business processes but cannot easily communicate with external firms. Constructive Technologies have developed a fully integrated electronic solution for reinforcement management under the 'Steelpac' brand name that facilitates effective electronic information exchange between firms. Pivotal to the whole process was the use of the Steelpac SITE tool that gave the contractor control of his reinforcement requirements, featuring change management, bar coded delivery and redundant material control. Steelpac SITE standardized the file formats to facilitate electronic exchange of information between all parties in the construction project using two file formats, .SDI (Steelpac data interchange) and .SOI (Steelpac order interchange).

Reinforcement detailing for the 18,000 tonne Wembley Stadium project was carried out in the UK and South Africa using several different detailing packages including SteelPac RCD, Cads

Computer aided manufacturing

Figure 4 Courtesy of Express O'Rourke JV Ltd

RC and Prokon, all of which were able to produce reinforcement schedules in the SteelPac SDI format. Schedules were then issued through SteelPac RCS to be fully validated and to ensure any errors were identified at the detailing stage. The reinforcement schedules was then issued to the construction team from concrete frame contractor, using Steelpac SITE. By using these electronic schedules, reinforcing bar schedules to BS 8666 or BS 4466 were automatically validated and any errors identified. There were also specific instructions for steel fixers, along with efficient and effective bar schedule revisions.

When the contractor placed his steel order from Steelpac SITE, a SteelPac Order Interchange (SOI), file was generated and sent to the reinforcement fabricator. The SOI file was then imported directly into the fabricators production system saving time and avoiding the risk of transcription errors. This allowed the execution of the order to commence immediately, resulting in shorter lead times and efficient scheduling of deliveries. The reinforcement fabricator achieved improved schedule input time, fewer errors, and avoidance of delays between the receipt of reinforcing bar schedule and delivery of material to site. The program also provided improved analysis of cutting and bending requirements, production planning, execution and delivery. In addition, it enabled an effective solution for the receipt of shape code 99's, producing a fully dimensioned drawing on the production labels.

The system was fully networked across all firms involved in the construction project allowing all relevant personnel, project management, engineers and quantity surveyors 24-hour access to 'real-time' data.

Figure 5 shows the reinforcing schedule generated using SteelPac

Reinforcing schedule generated using SteelPac

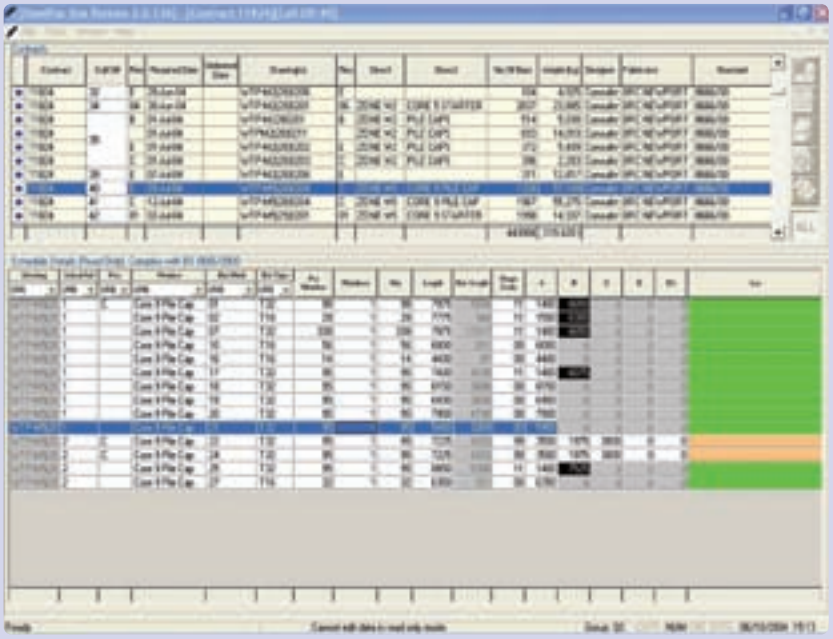

Figure 5 Courtesy of Constructive Technologies Group

3.3 Al Mafraq Hospital Abu Dhabi

The Al Mafraq Hospital (**figure 6**) is situated on a prominent site in Abu Dhabi close to the future Abu Dhabi Central Business District. Surrounded by an environmentally sensitive landscape design, the 745-bed hospital is distinguished architecturally by four prominent patient towers designed in a bold, contemporary style that expresses the state-of-the-art healthcare taking place within.

The hospital is being built by a JV between Al Habtoor Leighton/ and Murray & Roberts and will contain an estimated 20,000 Tonnes of reinforcing steel from CARES approved sources.

In this construction, Constructive Technologies SteelPac products are being used by the entire supply chain, Detailers, Contractors and Supplier, to manage and integrate the entire reinforcement process.

The reinforcement processes are described below:

Stock Process – (SteelPac ERP)

1. Stock Rebar arrives in the Rebar Processing Factory and is booked in tagged and bar code scanned.
2. Material test certificates, MTC's, are scanned into an electronic format and attached to the stock received in the database and Cast Numbers are entered.

Detailing Process – (SteelPac RCD & SteelPac RCS)

1. Using structural, MEP and reinforcement drawings the detailer produces Co-ordinated Rebar Drawings with Automatic BBS from SteelPac RCD.
2. Drawings in AutoCAD and BBS in SteelPac SDI format are issued to the consultant via SteelPac RCS for approval.

Ordering Process – (SteelPac SITE)

1. Once Drawings are approved Contractor uses SteelPac SITE to order cut and bent rebar from electronic BBS.
2. The call off is created and automatically sent via email to the Rebar Processing facility via the SteelPac SOI format taking into account any revisions to bars and/or shapes, where applicable.

Production Process – (SteelPac ERP)

1. The electronic call off that can contain part or multiple BBS is received by the Rebar processing facility and imported into SteelPac ERP.
2. Bar Coded Rebar Tags are printed from the imported Call off, removing any risk of human error.
3. SteelPac ERP then manages the complete production process and workflow through the factory by:
   i. Proving information on required stock and off cuts required for production.
   ii. Allocation of Stock and off cuts to bar marks via bar code scanning ensuring full traceability with cast numbers.
   iii. Communication to Rebar Production equipment via downloading and bar code for cutting and bending process.
   iv. Automatic Stock reduction and new off cut introduction including off cut tags ensuring traceability of cast numbers from stock to off cut to scrap.
   v. Bar coded delivery and loading process ensuring what is ordered is loaded ready for delivery.
   vi. Full delivery reconciliation including printing of delivery notes with automatic MTC's.
   vii. Creation and sending via email of electronic pre delivery message format that contains cast numbers with embedded electronic MTC's within the pre delivery SteelPac file format.

Delivery Process – (SteelPac SITE)

1. Prior to delivery the contractor imports the pre delivery message that reconciles what was ordered against what is about to be delivered, enabling the contractor to view from the software the cast numbers and electronic MTC's that have been used in the production of his order. The contractor can also plan cranes and fixing resource on site ready for the bars to be delivered.
2. When the Rebar arrives on site the contractor uses a bar code scanner and scans each bundle of steel completing the delivery reconciliation process and also stores the GPS co-ordinates of the bundle of Rebar on site.
3. The Rebar can be located on site via the SteelPac SITE Maps application showing the exact position of the Rebar via a satellite image as well as using the scanner to direct you to the location of the Rebar on site.
4. After inspection of the Rebar by the engineer SteelPac is also updated that the material is approved and ready for fixing.

Al Mafraq Hospital Abu Dhabi

Figure 6 Courtesy of Constructive Technologies Group

4.0 CARES product test data depository

CARES, reinforcement producers, reinforcement fabricators and a software development firm have developed a secure website to allow the electronic exchange of product test data between the reinforcement producer and fabricator. It will result in the reduction of paper 'Test Certificates' traditionally sent by the steel producer to reinforcement fabricator, although it will enable these to be provided to the construction client if required.

The secure website receives an electronic copy of the product test data, normally documented on a paper 'Test Certificate,' for each cast of steel when it is dispatched from the steel producer's works. The product test data is stored on the CARES reinforcing steel product test database and accessed via a secure website, i.e. each user has a username and password allocated by CARES, to permit access only to data relevant to them.

A number of successful trials between steel producers and reinforcement fabricators have been completed and the system is available to all CARES approved firms. Feedback from the trials indicates there has been a significant reduction in the volume of documents forwarded from the reinforcing steel producer to the purchaser and a reduction in the time spent validating, storing and retrieving product test data.

The system is operated and maintained by CARES and provide benefits to the purchasers of reinforcing steels supplied by the CARES approved supply chain.

5.0 CARES list of approved manufacturers

The scope of approval of each approved firm is given on the CARES website, www.ukcares.com. In addition the product marking, often referred to as the bar mark, is shown for each producer of reinforcing steel products covered by their CARES certificate of approval. Before choosing a CARES approved supplier it is important to ensure the scope of certification covers the products or services required by the purchaser. It is only the approved scope that is supported by assessment and continued audit.

Firms may have an approved scope that covers a number of categories and the complete scope of approval is detailed on the firm's certificate of approval that may be obtained from the firm or from the CARES office. The CARES certificate number is displayed in this list and on certificates of approval and, where appropriate, on product labels attached to products supplied by an approved firm. CARES certificates of approval are updated as required and reissued annually.

Should there are any doubts concerning the scope of approval of a firm then the CARES List of Approved Firms should be consulted, www.ukcares.com, or alternatively the CARES office can be contacted for verification, contact details are given below.

6.0 Future developments

Technology companies are working to extend the full product traceability into the Steel Fixing process. When fixing commences it will be possible to scan the tag and select the fixing team and fixer installing the Rebar. Upon completion of fixing the bar mark will be scanned again to synchronise the main project database and provide valuable productivity data for each structural element of Rebar installed taking factory practices and management reporting capabilities to the construction site.

New developments in communication technology, including 3D modeling and wireless technologies, will soon allow open ended, permanent information to be stored on site for future measurement and bench marking. Although wireless technology in terms of 'on-product-memory' is available it is still relatively expensive and it may be some time before it is used on a large scale in the reinforcement supply chain. However as a solution to have meaningful sources of data available on site for the use of various disciplines it opens exciting avenues at a relatively low cost. The current generation of available systems are already being used in the macro management of post construction in other parts of the world. More visionary firms are needed to develop these products into useable tools for the future.

7.0 References:

1. CONSTRUCT. A guide to contractor detailing of reinforcement in concrete. **Crowthorne, BCA, 1997. Ref. CSG/001**
2. Improving rebar information and supply (IRIS) by **A. Kalian, T. Thorpe and S. Austin**. Available from the Concrete Centre.

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