

A SWOT Analysis of the UK Civil Engineering Industry

Defining the context for the Agile Construction
Initiative...

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Executive Summary

A general description of the UK civil engineering sector

- The world market for civil engineering is dominated by three large domestic markets; Europe, Japan and US.
- The three large domestic markets are dominated by domestic contractors with very little penetration into these markets by foreign contractors.
- In all the three large domestic markets the markets themselves are fragmented with many contractors competing for market share.
- The international market for civil engineering is mainly in the newly industrialising countries of South East Asia (including China), South America, the Middle East and Eastern Europe.
- In both the main domestic markets and the international markets privately financed projects are becoming more important.
- Within Europe each individual country market is still dominated by home contractors, however, there is some evidence that a Europe-wide market is developing.
- There is overcapacity in the UK civil engineering market with profit margins low.
- There has been a major change in the way that UK civil engineering clients want to procure projects due to the effects of infrastructure privatisation and the introduction of the Private Finance Initiative.

Strengths and weaknesses of the UK civil engineering industry

The Environment for UK Civil Engineering

- The traditional procurement method for civil engineering contracts in the UK has been design-bid-build. There are doubts as to whether this is the best procurement method for large and complex construction projects where complex trade-offs are required between the physical design and the methods used in construction.
- The UK construction industry is beginning to speak with one voice across a range of issues. This has been brought about by the Latham Report and the subsequent establishment of the Construction Industry Board with representation from all parts of the industry including civil engineering.
- The largest UK civil engineering contractors by turnover are Tarmac and Balfour Beatty at 13th and 14th in Europe, France has the four largest, Germany three in the top ten and Italy two in the top ten. With more and more work being financed privately the leading UK civil engineering companies may not have the financial strength to compete against their bigger European rivals.
- The level of education in the UK construction industry is lower than that in its European rivals. Whilst no figures for the civil engineering sector alone are available, it is likely that the pattern is repeated here.

- The level of research and development expenditure by the UK construction industry is lower than some of its international rivals, in particular Japan and the US and very much lower than other industries.

The performance of the UK Civil Engineering sector

There is little objective evidence by which to compare performance internationally. Most of the evidence is anecdotal. There is a need for an international comparison of performance.

Company strategy

- UK civil engineering contractors have a reputation for bidding prices that are below cost in order to gain work and then attempting to cut costs by compromising on quality and increase revenue through the claims process. Clients are increasingly adopting procurement methods that do not allow additional revenue to be generated in this way.
- Some civil engineering contractors have succeeded in responding to clients new expectations and their profitability has improved.
- UK civil engineering contractors have less in-house design capabilities than their overseas rivals. This may be a disadvantage in winning turnkey projects overseas and privately financed projects at home.
- UK civil engineering contractors have been slow to start operations in Europe. With the single European market and harmonisation of specifications across Europe, this may leave them vulnerable to entry from European contractors who are already working throughout mainland Europe.
- UK civil engineering industry has been slower than other industries to exploit information technology in its main value adding processes.

The characteristics of UK civil engineering projects

- The level of integration of the design team is low compared to other countries and industries.
- Some successes have occurred in value engineering of projects but value management throughout the life of a project is not as well developed as in other countries.
- The leadership style on sites differs greatly from that seen in other countries.

Threats to the UK Civil Engineering Industry

Existing competition is intense and there is overcapacity in the market

- The UK civil engineering market is highly fragmented compared with other large scale engineering activities such as aerospace or shipbuilding. Competition between players is therefore keen and margins low.
- The overcapacity in the civil engineering market has been sustained by shareholders and banks who have been unwilling to wind up operations that have consistently underperformed over a period of years.

Civil engineering clients have a great deal of power

- UK civil engineering clients have traditionally bought on the basis of lowest price. With overcapacity and a large number of companies in the market, this has led to pressure on prices and margins.
- Separation of design and construction by clients has limited the opportunities for contractors to differentiate their offerings from one another. Low prices have therefore been achieved by passing price pressure down the supply chain rather than through innovations in product and process.

Some suppliers exert power over the contractors they supply

- Certain suppliers enjoy near monopoly conditions, others have a particular advantage with respect to certain contracts due to the economics of transporting bulk materials. These suppliers are able to resist price pressures from contractors.
- Certain suppliers of engineered products may seek to integrate forward and provide supply and fix services, taking work away from subcontractors and main contractors.
- Current management thinking promotes partnering with suppliers. Raising the performance of suppliers through partnering may backfire on contractors. With a good supply of competent suppliers and subcontractors there may be a rise in the number professional construction managers who will take work away from the traditional main contractor.

Competition from overseas is increasing

- The main threat to UK contractors in their home market is from Europe. The threat has three elements (i) the opportunities presented by PFI (ii) harmonisation of specifications carried out as part of the Single European Act, and (iii) the globalisation of infrastructure.
- There is a smaller threat from contractors outside the EU, in particular from Japan where the end of the economic miracle has left Japanese contractors short of work. However, Japanese civil engineering contractors do not export as much as those contractors involved in building or industrial work.

Falling demand for civil engineering due to the rise of alternative to construction

- There are predictions that demand for transport infrastructure will be hit by the use of IT to increase the capacity of the current infrastructure or as a substitute for travel.
- Increases in the amount of off-site manufacture will shift turnover from contractors to suppliers.

Opportunities that exist for the UK civil engineering industry

Civil Engineering Markets

- The European Union is increasingly operating like the third major home market with US and Japan being the other two. The US market is highly fragmented and may present opportunities to UK civil engineering companies.
- Newly industrialising countries have a need for infrastructure to sustain economic growth but less well developed home industries and a shortage of money to finance development. Companies that can arrange finance will find opportunities in these markets.

- Privately financed infrastructure projects represent the greatest opportunities in the UK in the foreseeable future.
- Changes in transport policies may mean that civil engineering companies will need to innovate in order to gain work.
- Changes in planning policy are promoting urban regeneration over out of town developments, this may require land reclamation and reconditioning to be carried out in order to attract potential clients back into cities.
- Environmental policies, such as the landfill tax may lead to pressure to reuse materials or look for alternative materials.

Industrial Policy and Strategy

- Research has shown the value of applying the ideas developed by the International Motor Vehicle Programme to many different industries. The civil engineering industry must look at how these ideas apply to civil engineering.
- Client expectations have changed and civil engineering companies that become more customer oriented will get more business from these clients.
- Higher client expectations and increased use of design and build and design, build, finance and operate contracts give the leading contractors the chance to increase the barriers to entry to the industry.
- Companies that make a concerted effort to develop core competencies that are value by clients will be able to differentiate themselves from their competitors.
- The UK government and the EU are both working to create research agendas to meet the specific needs of the construction industry for research and development.

Business processes

- Companies in many different industries have benefited by adopting the principles of lean thinking: specifying value, creating value streams for individual products and making value flow smoothly in response to a pull from the customer.
- Civil engineering companies need to reorganise around products and value streams in order to become lean.
- A crucial element of lean thinking is the integration of design and production, which leads to faster projects, using fewer resources and providing a better result.
- The civil engineering industry needs to make better use of IT and in concentrate on the role of IT in making value flow.

Introduction

The history of the Agile Construction Initiative

Eighteen months ago at their “Towards 200” conference, the senior managers of Balfour Beatty brought together Sir Michael Latham and Professor Andrew Graves. Sir Michael Latham’s report on the opportunities for improvement in the construction industry had just been published, and Professor Graves had recently taken up a position at the University of Bath to continue the work of the International Motor Vehicle Project (IMVP).

IMVP is the decade-long benchmarking study of the world-wide automotive industry which has yielded substantial information on the relative efficiencies of the “lean” and “mass” car producers and led to the publication of the book “The Machine that Changed the World.”

Following discussions with Sir Michael and Professor Graves, Balfour Beatty decided to join forces with University of Bath to develop a benchmarking centre for the civil engineering industry, and has secured a £600,000 grant from the government’s Innovative Manufacturing Initiative to develop the project. This has led to the establishment of the Agile Construction Initiative at the University of Bath. The objective of this project is to establish a set of data which compares civil engineering processes and provides information to drive the civil engineering industry towards world class performance.

The Analysis

In order to build up a picture of the UK civil engineering industry a number of different approaches will be used in this report. The general approach is to look at the strengths and weaknesses of the industry and then the opportunities and threats facing it. The analysis will take a fairly far-reaching look at the sector as it is one that is particularly affected by the prevailing economic and political conditions in which it operates.

The opportunities section will then try to synthesise the previous analysis into potential opportunities for the sector. This may involve a degree of “judo”, taking apparent threats and attempting to turn them into opportunities with the minimum of effort.

A general description of the UK civil engineering sector

Summary

- The world market for civil engineering is dominated by three large domestic markets; Europe, Japan and US.
- The three large domestic markets are dominated by domestic contractors with very little penetration into these markets by foreign contractors.
- In all the three large domestic markets the markets themselves are fragmented with many contractors competing for market share.
- The international market for civil engineering is mainly in the newly industrialising countries of South East Asia (including China), South America, the Middle East and Eastern Europe.
- In both the main domestic markets and the international markets privately financed projects are becoming more important.
- Within Europe each individual country market is still dominated by home contractors, however, there is some evidence that a Europe-wide market is developing.
- There is overcapacity in the UK civil engineering market with profit margins low.
- There has been a major change in the way that UK civil engineering clients want to procure projects due to the effects of infrastructure privatisation and the introduction of the Private Finance Initiative.

The world market for civil engineering

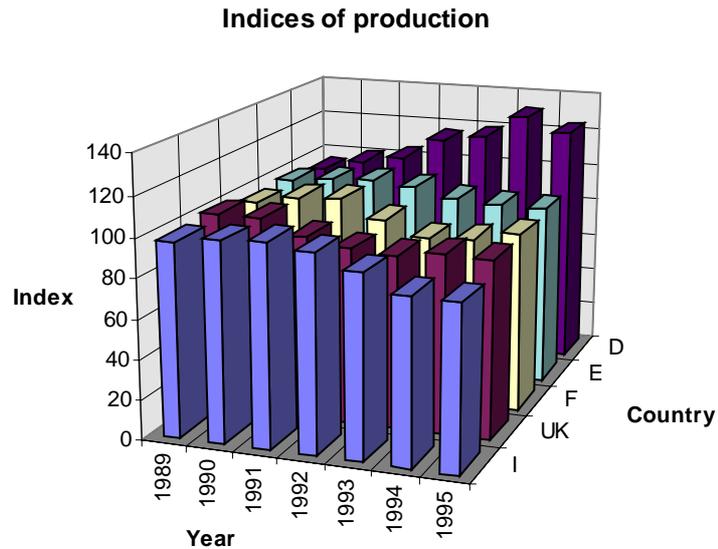
World wide, the three large domestic markets are Japan, EU and US. Table 1 shows the total size of the construction market in each geographic area. These markets are approximately the same size, however, the Japanese industry produces more output per head (in money terms at least) and the industry has a far greater share of the country's GDP. It is not easy to separate the civil engineering markets out from these figures due to differences in the way each country reports.

	Size, ECU bn	Share of GDP, %
EU	550	10
US	510	11
Japan	520	18

• Table 1 World construction markets, 1992¹

In each of these markets, the construction industry is mature with demand falling. Figure 1 shows that construction output is falling in all the major European countries except Germany, where the integration of East Germany after the collapse of the communist bloc has led to an increased demand for construction.

¹ Source: Eurostat, Panorama of EU Industry, 1995/96



• Figure 1 Falling production throughout Europe

The three large domestic construction markets are dominated by domestic contractors

The top ten contractors in each of the three main construction markets are domestic contractors according to the ENR survey of the top 225 international contractors.² The top US companies obtained revenues of \$4.7bn in Europe in 1995, but this was concentrated in process plant and industrial. All other contractors obtained revenues of \$4.3bn. The picture is repeated in the US and Japan, with the major Japanese contractors earning \$2.2bn in the US mainly from manufacturing facilities and building. Foreign contractors earnings in Japan are even lower.

All the three large domestic civil engineering markets are fragmented

The three large domestic civil engineering markets are all fragmented. The European and US markets are regionalised. In Europe 27 contractors earned revenues of over \$1bn from civil engineering in 1995. In the US 7 contractors earned revenues of over \$1bn from civil engineering in 1995, a further 14 over \$500M and 17 more over \$200M. In Japan, where the total construction market is dominated by six contractors with revenues in excess of \$9bn in 1995, the civil engineering market is more fragmented., with 5 contractors earning in excess of \$2bn from civil engineering in 1995 and a further 11 contractors earning in excess of \$1bn.

The international market for civil engineering is mainly in the newly industrialising countries

The strength of the domestic contractors in their home markets means that the main international market for civil engineering is in the newly industrialising countries (NICs) of South East Asia, the Middle East, South America and Eastern Europe. The demand for civil engineering in NICs is high as they try to develop infrastructure to support their industrialisation. Increasingly this infrastructure is being privately financed through build-operate and transfer contracts or through inward investment by overseas operators. This has

² ENR, August 26, 1996, pp37-68

opened up these markets to international contractors who have the ability to finance projects or who work for the infrastructure operators in their own domestic markets.

In both the main domestic markets and the international markets privately financed projects are becoming more important

Governments world wide are looking to private finance for infrastructure development. In advanced industrialised countries (AICs) this has come about due to pressures on government finances. Governments are under pressure to keep borrowing and spending under control in order to achieve low inflation, low interest rates and stable currencies. This pressure is particularly acute in Europe where countries are trying to meet the criteria for joining a single European currency. Other pressures on government finances come about due to high social costs incurred due to high levels of unemployment throughout the industrialised world and ageing populations.

In NICs governments are under similar pressures to control spending and borrowing, but have the need to create infrastructure to support industrialisation before the benefits of industrialisation are accrued in terms of tax revenues.

In either case, infrastructure development is increasingly being privately financed. One of the effects of this is the emergence of global infrastructure operators. Utility companies, transport companies and telecommunications companies, all of whom are major civil engineering clients are increasingly operating across international boundaries.

Within Europe home contractors still dominate but a Europe-wide market is developing

Within Europe, each home construction market is still dominated by home contractors. The top ten construction companies in France, Germany, Italy and UK are all home companies. However, the top German, French, Italian and Dutch construction companies gained earnings elsewhere in Europe of \$18.2bn. Most of this has been achieved by acquisition of medium sized-contractors and joint ventures rather than companies establishing contracting organisations from scratch. Holzmann of Germany owns Tilbury Douglas, HBG of the Netherlands owns Edmund Nuttal, GA and Kyle Stewart, Ballast Nedam of the Netherlands owns Wiltshier. In the other direction, AMEC have taken a minority stake in Spie Batignolles of France.

This trend is likely to continue as a result of the following:

1. Companies looking to acquire companies abroad to make up for falling demand at home, this is particularly true of France where there is considerable pressure on public spending.
2. More and more work will require financing. This type of work is likely to be won by large companies with the strength to obtain the necessary finance and these companies will not necessarily be home contractors.
3. The harmonisation of specifications and procurement practices that has been started as part of the Single European Market will continue and make cross border operations more straightforward.

There is over capacity in the UK civil engineering market with profit margins low

The operating margins in UK construction are historically low. The demand for construction has been sensitive to economic cycles. During the years of peak demand costs rise due to scarcity of materials and skilled labour, keeping operating margins down; during years of low

demand companies struggle to generate sufficient turnover to cover their overheads. As a result the average operating margins of the top 12 UK contractors peaked at about 3% during the late 1980s boom³. Subsequently operating margins have fallen back to less than 1% in 1993 as total output has fallen sharply.

The city wants to see restructuring in the industry to take out excess capacity and reduce overheads.⁴ However, in order to protect the restructured industry entry barriers must be raised to prevent a new clutch of contractors springing up during the next economic boom. The city sees the ending of payment mechanisms that provide the contractors with positive cash flows and low levels of capital employed as the best way to raise barriers to entry.

There has been a major change in the way that UK civil engineering clients want to procure projects

The traditional contract employed by civil engineering clients is one in which the client engages a designer who produces specifications, drawings and bills of quantities. The contractors submit bids on the basis of this information. The client generally awarded the contract to the contractor offering the lowest bid (subject to certain quality checks). The contract allows for additional revenue to be generated to compensate for certain unforeseen circumstances encountered during the execution of the contract - claims. This has led to an adversarial relationship developing between client and contractor as described by Haro Bedelian⁵ of Balfour Beatty.

“Historically, there has been a divergence of interest between the customer and the contractor. For example, the separation of design and construction has created an interface which is bedevilled with problems and which has often been exploited by contractors...The contractors strove to achieve profits not by reducing costs but by enhancing revenue. In other words, the ‘claims’ culture.”

Major civil engineering clients are increasingly looking to use contract forms that remove this separation between designing and building the project.

Traditionally, low margins were justified by the low levels of capital employed resulting from the way in which contractors were paid. Contractors were paid monthly for the work done. The work was valued by measuring the quantity of each item on the bill of quantities produced to date and multiplying it by the rate for the bill item. The subcontractors and suppliers on the other hand were paid as late as possible. The result was positive cash flow.

Clients are now turning to milestone payments with fixed payments to contractors being triggered by the achievement of a milestone of the project plan.

In addition the construction bill introduced into parliament as a response the Latham Report on the state of the construction industry seeks to ensure that suppliers and subcontractors are paid within 30 days.

Finally, the UK government has introduced the Private Finance Initiative under which private industry is invited to build and operate major items of civil engineering infrastructure. Most civil engineering contractors have set up joint venture operating companies to finance and operate the infrastructure items. These companies then engage the contracting arm of the company to design and build the infrastructure item. The operating companies are generally adopting design and build and milestone payments as the method of procurement from the contracting companies.

³ Source: New Civil Engineer: Contractors File

⁴ NatWest Securities: Strategic Assessment UK Contracting - Restructuring Required

⁵ Taken from ‘Successful major projects in a changing industry’, H M Bedelian, proc. Instn Civ. Engrs, Civ. Engng, 1996, 114, Aug, p 119

The top contractors estimate that in future between 50 and 85% of their turnover will come from privately financed projects

Pressures for change in UK civil engineering sector

Many of the issues facing the civil engineering sector are not new and many of the remedies being suggested are not new either (See Box 1). This time the remedies need to be implemented. The local nature of construction means that people in the UK will still be employed in civil engineering, however, if UK civil engineering contractors are unable to respond to the challenges then ownership of them may go abroad.

Ways to improve efficiency in Road Construction

1. Serial contracting (partnering by an earlier name).
2. More continuity of work from government.
3. More specialisation by major highways contractors.
4. More rational distribution of work (restricted tender lists)
5. Better communications between contractor, designer and client.
6. More collaborative work through earlier involvement of the contractor.
7. Better cost/benefit analysis of alternative designs.
8. Look for innovations in plant design abroad.
9. Better information on ground conditions and available materials.
10. Frank discussion at tender stage to avoid tendering mistakes.

• Box 1 Remedies for the UK Road Construction Industry, 1966

Source: NEDO (1966), *Efficiency in Road Construction*, London: HMSO

Strengths and weaknesses of the UK civil engineering industry

Summary

The Environment for UK Civil Engineering

- The traditional procurement method for civil engineering contracts in the UK has been design-bid-build. There are doubts as to whether this is the best procurement method for large and complex construction projects where complex trade-offs are required between the physical design and the methods used in construction.
- The UK construction industry is beginning to speak with one voice across a range of issues. This has been brought about by the Latham Report and the subsequent establishment of the Construction Industry Board with representation from all parts of the industry including civil engineering.
- The largest UK civil engineering contractors by turnover are Tarmac and Balfour Beatty at 13th and 14th in Europe, France has the four largest, Germany three in the top ten and Italy two in the top ten. With more and more work being financed privately the leading UK civil engineering companies may not have the financial strength to compete against their bigger European rivals.
- The level of education in the UK construction industry is lower than that in its European rivals. Whilst no figures for the civil engineering sector alone are available, it is likely that the pattern is repeated here.
- The level of research and development expenditure by the UK construction industry is lower than some of its international rivals, in particular Japan and the US and very much lower than other industries.

The performance of the UK Civil Engineering sector

There is little objective evidence by which to compare performance internationally. Most of the evidence is anecdotal. There is a need for an international comparison of performance.

Company strategy

- UK civil engineering contractors have a reputation for bidding prices that are below cost in order to gain work and then attempting to cut costs by compromising on quality and increase revenue through the claims process. Clients are increasingly adopting procurement methods that do not allow additional revenue to be generated in this way.
- Some civil engineering contractors have succeeded in responding to clients new expectations and their profitability has improved.
- UK civil engineering contractors have less in-house design capabilities than their overseas rivals. This may be a disadvantage in winning turnkey projects overseas and privately financed projects at home.
- UK civil engineering contractors have been slow to start operations in Europe. With the single European market and harmonisation of specifications across Europe, this may leave them vulnerable to entry from European contractors who are already working throughout mainland Europe.
- UK civil engineering industry has been slower than other industries to exploit information technology in its main value adding processes.

The characteristics of UK civil engineering projects

- The level of integration of the design team is low compared to other countries and industries.
- Some successes have occurred in value engineering of projects but value management throughout the life of a project is not as well developed as in other countries.
- The leadership style on sites differs greatly from that seen in other countries. Studies need to be carried out to identify which are the most effective styles of leadership for the industry.

The environment for UK civil engineering

The traditional procurement methods are not as effective as those of competitors and those employed in other industries

A major civil engineering project is a complex undertaking, the complexity is in two dimensions; the product itself is complex in terms of the range of technologies employed, number of different systems etc., but in addition, the production environment is complex, the ground conditions may not be known fully in advance, the logistics may be complex, the weather may impact on the work. As a result the transaction between the client and the contractor is not a simple one. The client must be heavily involved in the value creation process. The structure of UK civil engineering projects and the industry in general do not reflect this reality.

The traditional project life cycle employed in UK civil engineering is the design-bid-build project. The client engages a designer to produce a design for a project. The designer produces a set of drawings and specifications and a bill of quantities detailing the expected quantities of different construction products; a number of contractors submit prices on the basis of the information provided by the designer. The lowest price is generally chosen, subject to an assessment of the contractor's competence. As the work is executed the price paid by the client reflects the actual amounts of bill of quantity items that were required to complete the project. Additional payments may be made under certain circumstances to cover the cost of work that had to be done in order to complete the project but was not included in the original specification or to compensate the contractor for additional costs incurred in overcoming problems that could not have been foreseen at the time of the tender.

In the home markets of most of our major competitors the separation between design and construction is not as acute. The UK system implies that the design is complete when the contractor is appointed. In practice the complex interaction between the 'what' and the 'how' of the construction means that this is not the case. In other countries this conflict is resolved in different ways (see Box 2).

The UK construction industry is beginning to speak with one voice

The construction industry in the UK has traditionally been characterised as being fragmented with the construction process being made up of a series of discrete activities carried out independently by different companies. The client producing a brief, the designer turning the brief into a design, the contractor bidding and then building to the design, with the whole thing being carried out with a rigid contractual framework. To protect their interests the different groups; clients, contractors, designers, subcontractors, suppliers and operatives formed their own pressure groups. These pressure groups then vied with one another to lead the industry.

"One voice for the construction industry" was the fervent cry of the then environment secretary Michael Heseltine in 1991. There followed an investigation into the construction industry under the chairmanship of Sir Michael Latham whose report "Constructing the Team" has had a

French companies are appointed earlier

In France the contractor is appointed very much earlier and on the basis of a less detailed design. The bids are assessed by professional construction economists who are able to compare bids that will take different forms and be based on different assumptions about how the project should proceed. There is no bill of quantities produced against which contractors bid.

Having been appointed earlier, the contractors have much more opportunity to influence the design of the final product. In addition, the conceptual design phase itself will have placed more emphasis on production that would have been the case on a UK project.

Japanese companies redesign the job after appointment

In public works contracts, the contractor is appointed on the basis of a tender against a detailed design. However, it accepted that the design is a definition of the “what” not the “how” and the contractor will be expected to produce a new set of design drawings. These drawings will contain a large amount of planning and constructability information.

As a result, the Japanese contractor will go to site later than his UK counterpart. The problem with going to site to early is summed up by Colin Wright, Director of Property Development of Hammerson,

“The weakness of British construction is that we all say we can start tomorrow. This means that we don’t put enough time into making sure the design is right”⁷

In addition, although the Japanese contract allows for claims, in practice they are rare. The Japanese contractor is concerned with maintaining a long-term relationship with the client and will not want to claim. There is arbitration available in cases where the project turns out to be very much more complex than expected which may result in the price being adjusted.

Box 2 Differences in the way in which contractors are appointed

significant effect on the industry ever since. The Construction Industry Board (CIB) has been set up to implement the thrust of the report. CIB contains representatives of clients, suppliers, contractors, professionals and consultants, trade contractors and subcontractors and the government. CIB has succeeded in delivering Michael Heseltine’s wish by publishing a series of guides covering the all aspects of the construction process⁶. These guides offer the real possibility of a consensus emerging on the shared values of the industry and a change from in-fighting to a concerted effort to meet its customers needs.

However, there is still some way to go. A recent analysis of the mission statements of twelve major contractors over the five year period 1987-1992⁸ found almost no reference to clients/customers, technology and public image and little reference to employees. It will be interesting to re-run this exercise in a couple of years time and see whether changes in shared values predicted earlier in this section occur in practice.

⁶ There are a total of 12 guides. The guides are being published in London by Thomas Telford. The titles include *Briefing the Team, Constructing Success, Training the Team* and *Towards a 30% Productivity Improvement in Construction*

⁷ Quoted in *Building*, 1 September 1995

⁸ Edum-Fotwe, , Price, A and Thorpe, A (1996) Analysing construction contractors’ strategic intent from mission statements, in Langford, D and Retik, A (Eds) *The Organisation and Management of Construction: Shaping Theory and Practice (Volume One)*, London: E & FN Spon

UK Civil Engineering Contractors may be too small to compete internationally

The UK has only two companies in the list of the top twenty civil engineering contractors. Balfour Beatty and Tarmac rate 13th and 14th. France has the four of the top five, Germany four in the top ten and Italy two. With the emerging importance of privately funded projects, contractors with strong financial positions are likely to dominate.

Company	Total Civil Engineering turnover, \$M
Bouygues	6,581.54
SGE	4,796.50
Phillipp Holzmann	4,369.79
GTM-Entrepose	3,460.21
Eiffage	2,223.94
Fiatimpresit	2,197.92
STRABAG	1,911.42
Bilfinger + Berger	1,877.16
Impregilo	1,753.29
Hotchtief	1,698.18
Dragados	1,649.10
FCC	1,528.53
Skansa	1,516.52
Tarmac	1,081.60
Balfour Beatty	1,077.75
HBG	981.36
Ballast Needam	881.39
Ferrovial	836.84
Ed. Zublin	775.77
Ansaldo	764.85
Total of top 20	41,963.65

• Table 2 Europe's top twenty civil engineering contractors

The workforce in UK civil engineering industry contractors is less well educated than its European counterparts

The education that construction workers in UK receive is less rigorous than those of its major European competitors (see Figure 2). In addition, in France, Germany and Spain, mathematics and literacy are compulsory and in France management and technology are also compulsory. In the UK courses have tended to be highly vocational and the lack of basic mathematical skills has been criticised. The modern apprenticeships that the UK government is currently introducing is intended to lead to NVQ level 3, in which case communications skills, problem-solving and supervision will be included in the course. Working group 6 of the Construction Industry Board regards modern apprenticeships as an important innovation and recommend that the industry supports them⁹.

⁹ Construction Industry Board(1996) *Training the Team*, London: Thomas Telford

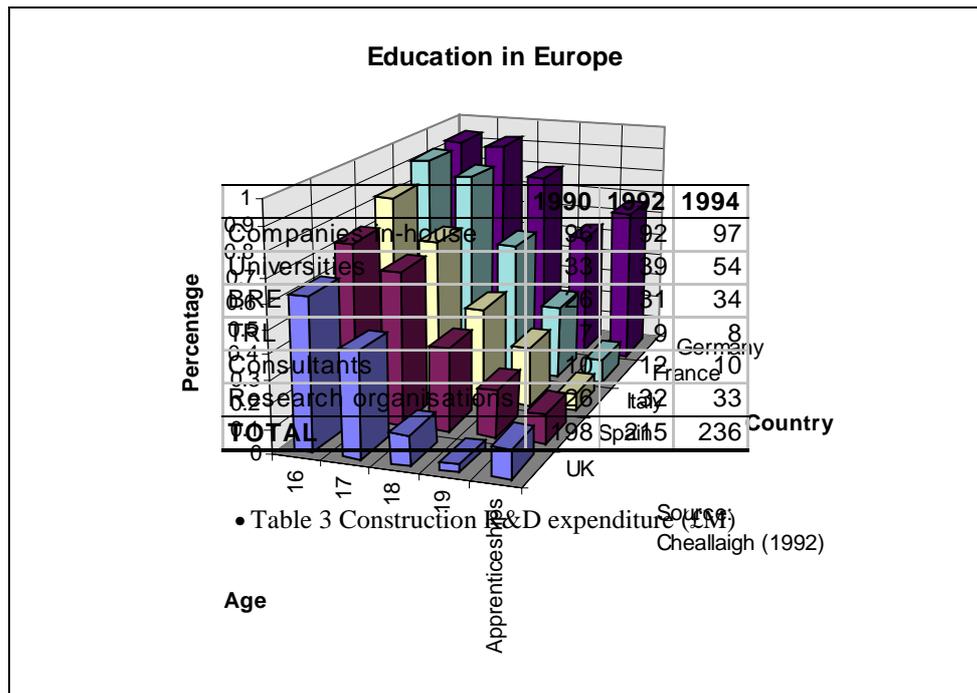


Figure 2 School Attendance in the EU, 1993

Professor Romains, CIOB president blames many of the ills of the industry on the decline in craft occupations, which he puts down to the reduction in apprenticeships, poor conditions of service and the low social esteem in which craft occupations are now held. (Construction Manager, 1996). The CITB plans to recruit 10,500 onto the new government modern apprenticeships scheme, this is considerably less than the 15,000 originally planned.

Many of the UK engineering institutions also consider that engineer’s lack of esteem is a problem. Many writers have also suggested that the UK engineering education is too narrow producing engineers who are too inflexible and rational in outlook. This contrasts with France where the Ecole Nationale de Ponts et Chaussées (National School of Civil Engineering) is one of a small group of prestigious universities that produce many of the countries elite. Their degree courses have a considerable management element.

Investment in Research and Development is low compared to other industries

The levels of R&D in construction throughout the world are lower than in other similar industries. This reflects a number of things; the maturity of the industry, the separated nature of design and construction in most western countries and the fact that the industry has been slow to capitalise on money that is available from government.

Expenditure on research and development is starting to increase (Table 3). This has come about for a number of reasons:

1. The government and the EU have started to target the construction industry as a sector that should be receiving more funds for R&D.
2. The construction companies themselves have identified the need to do more.

1. Programmes such as the EU fourth framework, the DoE's Partners in Technology and the EPSRC's Innovative Manufacturing Initiative are forcing industry and academia to work together on R&D.¹⁰

Within the field of civil engineering very little research has been done in the UK on the construction process and how to manage it successfully. The University of Reading have built up a specialism in construction management but their work has been concentrated in building, working with BAA, Bovis and Stanhope. This contrasts with the French École Nationale des Ponts et Chaussées, which has carried out studies into the organisation of major civil engineering projects.

In Japan, where the construction companies encompass the entire construction process from development and planning to maintenance the situation is different with each of the big six construction companies having major research establishments employing between 200 and 500 people. For example, the Taisei Technology Research Centre has 166,000 sq ft of floor area and in 1987 employed 400 staff including 165 graduates. The companies see the technology centres fulfilling a number of roles including; marketing, quality (including testing suppliers' products), building the companies' capabilities through continuous improvement.

In the US the government is putting a great deal of money into civil engineering research. The research includes CONMAT, a \$2bn programme of research into high performance concrete materials and systems and superpave which is testing new road pavement construction techniques in 200 locations throughout the US.

The performance of the UK civil engineering sector

There is no reliable research into the relative performance of different countries' civil engineering sectors. What anecdotal evidence as exists is contradictory. There is a need for a comprehensive comparison of performance world wide.

The strategy of UK Civil Engineering Companies

UK civil engineering contractors are developing new strategies that will stand them in good stead internationally

The UK construction industry is shrinking and the major UK companies have responded to this a number of different ways. The factors that have affect their responses have been:

1. the company size
2. the type of ownership
3. the nature of the company's business going into the recession.

The largest companies have looked to the growing market in privately financed projects. The UK government's Private Finance Initiative now means that one of the critical success factors for a major general contractor is the ability to arrange finance and to manage the infrastructure in the long run. To obtain the necessary skills and to spread the risk, the UK contractors are creating joint venture companies to attack particular markets or projects. These joint ventures include banks, designers and foreign competitors with either funds or experience from their home markets of these kind of design, build, finance and operate projects.

¹⁰ This is helping to overcome the separation of industry and academia that Dr David Gann of the Science and Policy Research Unit at Sussex University describes as follows. "The industry thinks it knows best while researchers want to do things that industry can't use. Both sides have to have similar expectations or you won't get the value of the research flowing through to industry". (Quoted in the Financial Times, Wednesday, June 12 1996)

The smaller companies are looking to find niches. For example, Amey has targeted infrastructure maintenance gaining term contracts for both road and rail infrastructure maintenance, whilst Miller has concentrated on the water market where it feels that it can build up a long term relationship with the newly privatised water companies, learn their business and add value to it. The Morrison Construction Group has shifted its attention from tendering to negotiated work with the result that profit margins have increased from 3.3% in 1990 to 11.4% in 1996.¹¹

Most companies are reducing the range of activities that they are involved in, Tarmac and Wimpey have just completed an asset swap which saw Wimpey exchange its construction and quarry divisions for Tarmac's housing division. BICC has sold its house building business to Westbury Homes to concentrate on infrastructure projects.

Tarmac and Taylor Woodrow have put a lot of effort into building up their fee-earning businesses. Tarmac has acquired the construction managers Schal International whilst Taywood Engineering is pinning its hope on research and development and advanced IT systems.

Only Lord MacAlpine has dissented from the current received wisdom of developing core competences, warning of the dangers of specialising in a volatile market place and pointing to examples of companies that have blossomed for a few years following this strategy only to falter when the demands of the market change.

UK civil engineering contractors are responding to changes in client expectations

The response of contractors to price pressure from clients has been to attempt to bid low prices in order to win work but then to use the mechanisms contained in the civil engineering contracts to claim extra money as the work progresses.

Haro Bedelian¹² of Balfour Beatty puts this very succinctly:

“Historically, there has been a divergence of interest between the customer and the contractor. For example, the separation of design and construction has created an interface which was bedevilled with problems and which was often exploited by contractors....The divergence in interests was reflected in a ‘revenue enhancing’ contracting culture in which contractors strove to achieve profits not by reducing costs but by enhancing revenue. In other words, the ‘claims’ culture.”

UK civil engineering contractors have been slow to respond to the Single European Market

UK civil engineering contractors overseas work is concentrated in the US and the Far East. In 1995 UK contractors earned 65% of their overseas revenues in the US and the Far East, compared with only 20% of overseas earnings from Europe. This contrasts with the French who earned 50% of their overseas revenues elsewhere in Europe and the Germans with 40%¹³. With the emergence of the single European market it is important that UK contractors establish a presence on mainland Europe.

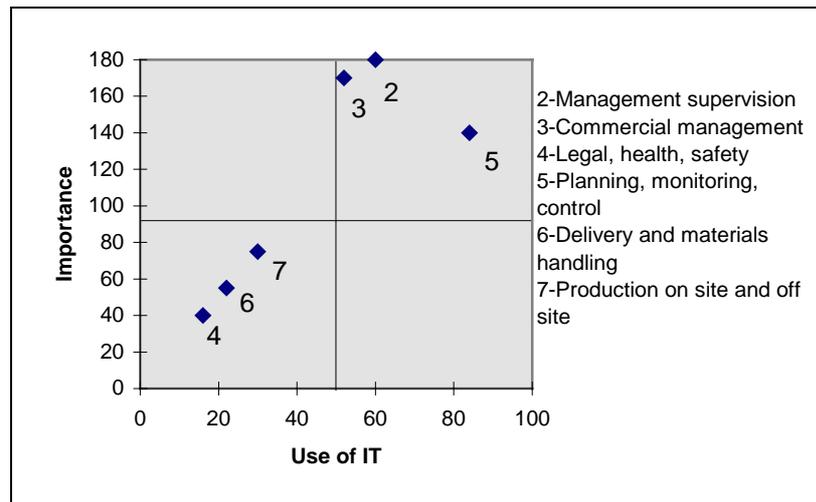
¹¹ Figures taken from a speech by Fraser Morrison, Chairman of the Morrison Construction Group to the CIB W65 International Symposium for The Organisation and Management of Construction, University of Strathclyde, 29th August 1996.

¹² Taken from “Successful major projects in a changing industry”, H M Bedelian, Proc. Instn Civ. Engrs, Civ. Engng, 1996, 114, Aug, p 119.

¹³ ENR (1996) *The Top 225 International Contractors*, ENR, 26 August 1996

Information technology is not used to improve value adding processes

The UK construction industry has failed to exploit IT to improve its key business processes. A recent state of art report from Construct-IT illustrates the problem¹⁴. The project looked at the importance placed by construction companies on the use of IT at different places in the value chain. They correlated the importance the companies placed on IT with the use made of IT in those parts of the value chain. The results are shown in Figure 3. There is a good correlation between the importance afforded to an area of IT and the use made in that area. However, two of the areas rated as highly important are support functions and two that are rated as low importance are on the main value chain.



• Figure 3 Benchmarking best practice in IT

UK civil engineering companies systems place a great deal of emphasis on the commercial function and cost control. Both of these practices are in sharp contrast to practice elsewhere. In Japan there are no complex cost accounting systems on site as cost is seen as a dependant variable. Control is applied to construction processes. If the construction process goes according to plan then cost is automatically controlled. Similarly, although Japanese public procurement contracts allow for claims they are rarely made as this would jeopardise the long term relationships that are seen to be the guarantee continuing profitability.

The organisation of UK civil engineering projects

Civil engineering projects in the UK do not have integrated design teams

UK civil engineering projects are characterised by a separation of design and construction. The designers are separated by time and psychology from the construction team. There are a number of reasons for this:

1. The design is carried out to a high level of detail before the contractor has been appointed.
2. The designer is professionally liable for the design and is not motivated to incorporate ideas from the construction team. The designer has not come up with the design but must accept liability for it.

¹⁴ Construct IT Benchmarking best practice in IT

3. The designer's education includes little on the management and operation of construction sites. This can lead to designs that are difficult to construct.
4. The designer often goes on to act as the clients representative on site. This can put them into opposition with the construction team, making co-operation over design issues difficult to achieve.

There needs to be a reassessment of the way in which the different parties are organised and in particular a recognition that there is no way to win at the expense of another party on the project, there must be a recognition of the shared destiny of the parties.

There have been some successes in value engineering but value management is not well established

The role of the contractor in value engineering of projects is acknowledged. Even under traditional contracting many clients have encouraged contractors to propose design alternatives to cut costs. There are many examples of successful cost savings alternative designs that contractors have proposed^{15,16}. However, problems exist in terms of assigning design liability and in sharing the financial gains from these alternative designs. This can mean that there is a lack of motivation to search for and approve alternatives.

The leadership style in UK civil engineering differs from that seen in Japan and US

The style of management employed on site differs from country to country. This is a function of a number of factors; the amount of the work that is subcontracted, the type of contract employed, the education of the workforce and the management and the nature of employment of the workforce.

The Japanese construction site is characterised by an orderly approach and the use of teams. The teams start the day with exercises and tool box talks. The purpose of the toolbox talks is to ensure that the teams understand exactly what is expected of them that day. The engineers and the foremen attend daily meetings to discuss problems, negotiate interfaces and to discuss the following day's work. Instructions are posted on simple chalk boards or white boards and updated daily. Achievement of the daily planned work is of paramount importance.

In the US the management of labour is done by construction staff. Foremen are engaged by the construction company and then they in turn engage their men. The foremen decide on the composition of the gang and hire and fire as the nature of the work changes. The foremen then report to a construction supervisor. The project manager must show strong leadership to manage the interface between this labour organisation and the designers. The foremen are expected to carry out many of the measurement and control tasks that would be carried out by engineers in the UK. The motivation to achieve the plan comes from the foremen and then the men. The foremen must get the work done in order to be re-employed on another job, the men must get the job in order to be re-employed by the foremen. (See Box 3 Comparison of UK and US supervision).

Research is needed to understand the relationship between leadership style and the effectiveness of a site.

A comparative study of the simultaneous construction of two Kodak process plants in the UK and US found that the US workers were 42% more productive. Most of this was put down to the better "bell to bell" working of the US workers. The UK workers were estimated to work

¹⁵ The replacement of bored piles with driven piles reduced costs on the A13 contract. *New Civil Engineer*, 21 November 1996, p26

¹⁶ Design alternatives proposed by the contractor saved at least £1.5M on the A74(M) contract, including not deciding on finished road levels until well through the earthworks programme. *New Civil Engineer*, 15 June 1995

60% of the time paid, compared with 90% on the US site. The time on the UK site was lost in travelling and washing up at the beginning and end of the day and at coffee meals breaks. The UK workers would travel to canteen for coffee breaks, where as the US workers would drink at the work face. The difference in working style was put down to the accountability of the US supervisors who recruited their own teams and whose employment prospects depended on the performance of their teams.

NEDO (1990) *Comparative study of simultaneous construction of tow Kodak Pet plants built in the UK and USA*, London: NEDO

Box 3 Comparison of UK and US supervision

Threats to the UK civil engineering industry

Summary

Existing competition is intense and there is overcapacity in the market

- The UK civil engineering market is highly fragmented compared with other large scale engineering activities such as aerospace or shipbuilding. Competition between players is therefore keen and margins low.
- The overcapacity in the civil engineering market has been sustained by shareholders and banks who have been unwilling to wind up operations that have consistently underperformed over a period of years.

Civil engineering clients have a great deal of power

- UK civil engineering clients have traditionally bought on the basis of lowest price. With overcapacity and a large number of companies in the market, this has led to pressure on prices and margins.
- Separation of design and construction by clients has limited the opportunities for contractors to differentiate their offerings from one another. Low prices have therefore been achieved by passing price pressure down the supply chain rather than through innovations in product and process.

Some suppliers exert power over the contractors they supply

- Certain suppliers enjoy near monopoly conditions, others have a particular advantage with respect to certain contracts due to the economics of transporting bulk materials. These suppliers are able to resist price pressures from contractors.
- Certain suppliers of engineered products may seek to integrate forward, and provide supply and fix services, taking work away from subcontractors and main contractors.
- Current management thinking promotes partnering with suppliers. Raising the performance of suppliers through partnering may backfire on contractors. With a good supply of competent suppliers and subcontractors there may be a rise of professional construction managers who will take work away from the traditional main contractor.

Competition from overseas is increasing

- The main threat to UK contractors in their home market is from Europe. The threat has three elements; (i) the opportunities presented by PFI, (ii) harmonisation of specifications carried out as part of the Single European Act, and (iii) the globalisation of infrastructure.
- There is a smaller threat from contractors outside the EU, in particular from Japan where the end of the economic miracle has left Japanese contractors short of work. However, Japanese civil engineering contractors do not export as much as those contractors involved in building or industrial work.

Falling demand for civil engineering due to the rise of alternative to construction

- There are predictions that demand for transport infrastructure will be hit by the use of IT to increase the capacity of the current infrastructure or as a substitute for travel.

- Increases in the amount of off-site manufacture will shift turnover from contractors to suppliers.

Existing competition is intense and there is overcapacity in the market

The UK civil engineering industry has a large number of similar sized contractors competing largely on price, in a market place that is shrinking. Barriers to exit would appear to be low with low levels of investment in capital equipment, however, a number of the major companies have remained in the industry despite a run of poor results. Some of these companies have been kept in businesses by their banks who see this as the only way to recover their investments in them, others still have large family shareholdings who are reluctant to wind them up, the remainder have been bought by overseas contractors seeking an entrance into the UK or European markets.¹⁷

Civil engineering clients have a great deal of power

The civil engineering market in the UK up until the last ten years was dominated by customers from central and local government. Different government departments and privatised companies were responsible for the investment in infrastructure that makes up a high proportion of the civil engineering market. The spending of these departments was controlled by the Treasury and subject to change according to the prevailing economic conditions. With all government spending coming under increasing scrutiny in the 1970's and 1980's due to other pressures on government spending (in particular welfare spending), pressure was kept on the civil engineering industry to keep prices down. The way that government fixed capital budgets meant that the emphasis was on reducing construction costs, rather than whole life cycle costs.

Historically, quality has not been an issue, with clients accepting incomplete projects and the contractor staying on for extended periods to complete outstanding work. With very little opportunity to differentiate their work on quality, contractors kept cutting costs throughout this period and passed the downward pressure on prices down the supply chain to suppliers and subcontractors.

Since the early 1980's many infrastructure owners have been privatised; the water industry, the power industry, telecommunications, the rail industry and the gas industry have all been privatised. These clients now have access to capital throughout the economic cycle and will be more interested in minimising life cycle costs, rather than construction costs. This offers the civil engineering industry the opportunity to compete on a basis other than price. However, the danger is that the damage done to the industry by years of costs cutting, will mean that new entrants will be able to profit from these opportunities better than the existing UK civil engineering contractors.

Some suppliers exert power over the contractors they supply

Bulk materials and aggregates

The suppliers of bulk materials and aggregates have enjoyed more power than other suppliers. The costs involved in transporting these materials have always meant that local suppliers have an advantage when bidding for work. There have been cases of local price fixing agreements to maintain margin and share out turnover. In some cases the supplier has the choice of contractor for a particular contract, since he/she is the only viable source of supply.

Some of the major aggregates companies have tried to gain greater coverage by developing super-quarries with huge cost advantages over small local quarries.

¹⁷ The future of Costain has been the subject of speculation for some time. The company was saved this year by the Malaysian construction and investment group Intria Berhad, which took a 40% stake in the company, Financial Times, 5 July 1996. The group was already part owned by a Kuwait and a Saudi Arabian company.

In order to secure long term security of supply, the contractors may employ a number of strategies:

1. Buy the supply companies. However, this may cause problems when working away from areas covered by the in house suppliers.
2. Mobilise their total buying power. Threats to withdraw other business if suppliers attempt to exploit local monopoly situations.
3. Develop alternative supplies; including dealing directly with local landowners for certain materials, cleaning contaminated material and re-using, investigating the use of re-cycled materials in place of primary materials.

The suppliers will always be tempted to exploit their monopolistic position and there will always be contracts that will fall outside the geographic area of the partnership.

Complex engineered components and systems

The specialist trade contractor is a key feature of building. In civil engineering there are less specialist trades. However, there are areas such as communications and variable messages signs where the main contractor will have very little practical experience of the work and will engage a specialist trade contractor. In these areas, there is an opportunity for the supplier to command higher margins in return for managing the risk associated with that area of supply.

Suppliers for whom the construction industry is not the main customer

There are areas of supply, for instance the supply of rail, where the civil engineering industry is a minor customer of a major supplier. In these areas the industry has little power and must accept the supply schedules and prices dictated by the suppliers main business.

Will partnering make things worse?

The Construction Industry Board is promoting partnering as a way to improve performance in construction. However, partnering is difficult to achieve where there is imbalance of power between customer and supplier. A supplier may enter into a partnership when times are tough in order to maintain turnover and price. However, when the industry picks up, suppliers with a powerful position will be tempted to leave the partnership and take their chances on the open market where they may make bigger margins.

One of the advantages claimed for partnerships is the improvement brought about in the performance of suppliers. This may backfire on main contractors who try partnering. It would be possible to imagine the main contractors moving towards the auto industry model, where they limit their sphere of activity to design and project management, orchestrating the final assembly of a number of specialist trade contractors work at site. The danger in this is that the barriers to entry for foreign competitors will be reduced greatly through this approach. With reliable trade contractors the foreign competitor need only bring finance and a project management team to win very large contracts in the UK. This effect can be seen with the success of Bovis as an international construction manager in building.

The Japanese model of partnering includes cross-ownership. In order to keep out new entrants, it may be that this will have to be a feature of partnerships in the UK civil engineering industry.

Competition from overseas is increasing

Barriers to entry in the civil engineering market are low. Contractors exist with very low levels of fixed assets. The volatility of the market has led to a well developed hire market for capital

equipment. Over the past twenty years a number of new companies have been started by staff from existing companies breaking away. Some are now well established.

Civil engineering remains a localised industry. Even within Europe, where the Single European Act is leading to harmonisation of specifications and procurement procedures, the top ten contractors in each country are domestic contractors. However, a number of European contractors are doing work throughout Europe, through a combination of setting up local subsidiaries and through acquisition.

With the move to design, build, finance and operate contracts the opportunities for overseas companies have improved further. Many of these companies have greater financial security and experience of DBFO contracts elsewhere. There are a large number of European companies involved in the PFI; Dragados, Philip Holzman, GTM, HBG, SGE are all involved in bidding for DBFO road or rail projects.

Howard Seymour of stockbroker BZW foresees a two tier contracting market, with the larger companies making money from investments in PFI projects, with the remainder providing services to these companies as niche players or competing for the remaining smaller traditionally financed projects. He warns that unless the larger companies acquire the required skills in financing PFI projects, then they will lose out to overseas contractors.¹⁸

The Japanese have moved slowly into the UK market (See Box 4). Most have concentrated on servicing existing Japanese clients with building requirements in the UK. The most interesting move is by Kumagai Gumi who have bought Arnold Project Services, a move that reflects the fact that Japanese construction companies are used to handling the full construction process from development and concept through to maintenance.

The slowing of Japanese economic growth is predicted to hit the construction industry particularly badly. The Japanese contractors are concentrating their efforts on South East Asia and the US at present, however, if they target Europe, they may well use the UK to get a toe hold as they have other industries.

Shimuzu	100 staff in UK, turnover in 1995 £23M
Kajima	160 staff in UK, turnover in 1995 £40-50M, with £5M from civil engineering. (Kajima also have a large number of staff in the Netherlands and is looking to establish a Europe wide presence)
Taisei	20 staff servicing Japanese clients in UK
Takenaka	15 staff, turnover £35M, servicing Japanese clients in UK
Ohbayashi	9 staff
Kumagai Gumi	Bought Arnold Project Services

Source: Building, 12 July 1996

- Box 4 The Japanese in the UK

Substitute products

One of the major threats to UK civil engineering is the drastic reduction in the road building programme. Whilst this is largely due to economic and environmental considerations, however

¹⁸ Quoted by Nick Barrett in the New Civil Engineering Contractors File, July 1996, page 6

it has prompted research into alternatives to road building. Some of the alternatives, such as light rail will promote other civil engineering work. However, much of the research will result in alternatives to civil engineering.

The US have a national automated highway project looking at automatic control of vehicles to increase the carrying capacity of roads. As vehicles join the highway they are organised into small groups of vehicles that then travel together under automatic control, greatly increasing the carrying capacity of the roads.

At a more detailed level many commentators have been predicting the increased use of off-site manufactured components in construction for many years. This may lead to a reduction in the turnover of the main contractors and subcontractors with the work shifting to manufacturers and suppliers. In civil engineering the opportunities for substitution are less than in building with little opportunity for substitution in the areas of earthworks and roadworks, but there may be opportunities in structures and other areas such as finishings.

Opportunities that exist for the UK civil engineering industry

Summary

Civil Engineering Markets

- The European Union is increasingly operating like the third major home market with US and Japan being the other two. The US market is highly fragmented and may present opportunities to UK civil engineering companies.
- Newly industrialising countries have a need for infrastructure to sustain economic growth but less well developed home industries and a shortage of money to finance development. Companies that can arrange finance will find opportunities in these markets.
- Privately financed infrastructure projects represent the greatest opportunities in the UK in the foreseeable future.
- Changes in transport policies may mean that civil engineering companies will need to innovate in order to gain work.
- Changes in planning policy are promoting urban regeneration over out of town developments. This may require land reclamation and reconditioning to be carried out in order to attract potential clients back into cities.
- Environmental policies, such as the landfill tax may lead to pressure to reuse materials or look for alternative materials.

Industrial Policy and Strategy

- Research has shown the value of applying the ideas developed by the International Motor Vehicle Programme to many different industries. The civil engineering industry must look at how these ideas apply to civil engineering.
- Client expectations have changed and civil engineering companies that become more customer oriented will get more business from these clients.
- Higher client expectations and increased use of design and build and design, build, finance and operate contracts gives the leading contractors the chance to increase the barriers to entry in the industry.
- Companies that make a concerted effort to develop core competencies that are value by clients will be able to differentiate themselves from their competitors.
- The UK government and the EU are both working to create research agendas to meet the specific needs of the construction industry for research and development.

Business processes

- Companies in many different industries have benefited by adopting the principles of lean thinking: specifying value, creating value streams for individual products and making value flow smoothly in response to a pull from the customer.
- Civil engineering companies need to reorganise around products and value streams in order to become lean.

- A crucial element of lean thinking is the integration of design and production, which leads to faster projects, using fewer resources and providing a better result.
- The civil engineering industry needs to make better use of IT and in concentrate on the role of IT in making value flow.

Civil Engineering Markets

European Union

The European Union after the Single European Act is an increasingly open market. Specifications and procurement methods are being harmonised making it increasingly viable for contractors to work throughout the EU. A number of European contractors are already operating widely through a combination of setting up subsidiaries, joint ventures and acquisitions. The UK contractors have been slow to move into Europe, their traditional export markets being the US, Middle East, Far East and the old British Empire. However, Amec have recently bought a stake in Spie Batignoles, the French Contractor and a Tarmac Joint Venture has been awarded the contract to build the Copenhagen Metro.

The European Union is also funding an increasing amount of infrastructure work through its various structural aid programmes. It is estimated that 30% of European Infrastructure development is now partially funded by the EU. In addition, the ownership and operation of infrastructure is becoming increasingly pan-European. UK civil engineering industry needs to be able to react and offer a corresponding pan-European construction service to these clients.

United States

The US civil engineering industry is highly fragmented with many medium sized regional companies sharing the market. This may offer opportunities for UK contractors to expand into the US. This is particularly true of those contractors who are able to arrange finance for projects.

Newly industrialising countries

Newly industrialising countries (NICs) have much higher demand for infrastructure as a proportion of gross domestic product (GDP) than the advanced industrialised countries (AICs). In NICs infrastructure can represent as much as 20% of GDP compared to 6-7% for established countries. The NICs are also less likely to have a developed home construction industry and therefore ease of entry is high. This is reflected in the ranking produced by the US Department of Commerce on the attractiveness of worldwide construction markets. These rankings are not directly applicable to UK as the ease of entry is from a US perspective, but they are a useful guide.

By size of import market	By ease of entry	Combined ranking
Japan	China	Japan
Germany	Guatemala	Germany
Netherlands	Ecuador	Netherlands
France	Ukraine	Canada
Belgium	Singapore	Singapore
Canada	Ireland	Belgium
Saudi Arab	Portugal	France
South Korea	Mexico	South Korea
Austria	Morocco	China
Sweden	Australia	Italy
Singapore	Hong Kong	United Kingdom

• Table 4 Markets for building products¹⁹

Privately financed infrastructure projects

The Private Finance Initiative (PFI) in the UK is part a growing trend throughout the world to encourage private financing of infrastructure projects. This innovation offers the contractors the opportunity to start to create value for customers rather than simply seek to control costs. The PFI company is creating an asset that will generate a revenue stream. The size of the revenue stream will be affected by the quality of the asset created. This is marked contrast to previous public procurement of infrastructure projects where the effectiveness of the assets were rarely evaluated and even if they were the contractors and designers did not share in the value created.

The PFI companies may introduce long term relationships with preferred contractors opening the way to long term monitoring of the performance of designs with respect to maintenance, leading to improvements in infrastructure design. In addition, the PFI companies may push contractors to innovate in other areas. For instance if payments to PFI road companies are related to congestion on the roads, then the contractor may need to look into adding value through controlling the entry of vehicles onto the motorway, or through improved signing.

Changes in transport policies

There has been a sea change in the attitude of government to road transport. The government road building budget, already planned to decline in money terms year on year, has been further cut at each of the last four budgets. The public have protested against a number of major new road schemes, causing millions of pounds to be spent on security measures.

The Department of Transport's recent green paper on transport²⁰ has stressed the need for future spending on transport to be in line with the principle of sustainability, by which it means the following:

“Development that meets the needs of the present without compromising the ability of future generations to meet their own needs.”

In practical terms this means the following:

1. New road building will concentrate on the building of bypasses, which command the greatest public support.
2. DoT will support schemes to reduce congestion through better management of traffic, for example variable message signs and variable speed limits.

¹⁹ From WORLD BUILDING PRODUCTS (BLD) - BMR9406 US Department of Commerce, International Trade Administration. This is a market analysis based on figures for 1994. The report includes all building materials, not just construction and not limited to civil engineering.

²⁰ Transport the Way Forward, Green Paper, Department of Transport, London: HMSO

The European Union in its White Paper, The Citizen's Network, sets out a similar vision. The centre piece of the European Union plans is the Trans European Network. This outlines the additional major links to give a comprehensive and even coverage to Europe by roads that will mean that no region is disadvantaged in terms of transport links. Table 5 shows the additional road links that are planned.

Country	Existing links, km	Planned links, km
Germany	8,600	1,400
France	8,085	4,015
Spain	6,100	4,159
United Kingdom	2,720	1,195
Italy	6,000	1,776
Ireland	709	1,067

Table 5 Trans European Network

The European Union also emphasizes the needs for integration of modes of transport and the role of telematics²¹ in transport, including pre-travel information, satellite positioning and guidance, dynamic route information and automatic tolls. American Airlines have shown the value of controlling the information infrastructure associated with air transport, consistently making more profit from its reservations system than from operating aircraft²².

John Hackett of the Federation of Civil Engineering Contractors²³ identifies the following value adding opportunities offered by these policies.

- Telematics.
- Cost increases in return for optimal maintenance (for example during holiday times) paid for by reductions in congestion.
- Cost premiums in return for environmental performance, for example whisper concrete and porous asphalt.

The US government requires all states to develop multimodal transport plans to ensure that transportation choices are available to all. The Mid-Ohio Regional Planning Commission have got as far as putting together a feasibility plan for a Multimodal Transportation Terminal (MMTT) in the city of Columbus²⁴. This facility includes car parking, a rail station, bus station and interchange. The interchange includes facilities for :- inter city rail, interstate highway traffic, local buses, long-distance buses, pedestrians and cycles, taxis and mini-cabs and a planned light rail system. There are hundreds of cities world wide that would benefit from this type of facility.

Urban regeneration

The Department of Environment has also started to stress the need for sustainable development. In the case of the DoE this means that it will favour development in existing urban areas, rather than green field sites. This policy doesn't apply simply to retail development but also employment leisure, higher education, health services and other land uses.

²¹ Telematics is defined by the EU as the strategic use of IT in transport, healthcare and other applications. Telematics is information provision via emerging information and communications infrastructure. (Source: Research and Technical development activities of the EU - Annual Report 1995)

²² McFarlan (1984) Information Technology changes to way you compete, *Harvard Business Review*, 62, No. 5

²³ Quoted in the Contract Journal, Roads Supplement, June 1996

²⁴ Multimodal Transportation Terminal Feasibility Study, Columbus, OH

This policy suggests the following opportunities for civil engineering contractors:

- Land reclamation, including the rehabilitation of contaminated land.
- Improvements to the urban transport infrastructure; the cost per km of these developments being higher than green fields sites.
- Urban transport systems, such as trams, guided buses and light rail transport systems.
- Edge of town transport interchanges, where the population which still lives predominantly in the suburbs and periphery park their private cars and change to public transport.

The emphasis on urban regeneration will require the contractors to work closely with local government to produce development plans and transport plans.

The environment

The government has introduced a landfill tax. This will increase pressure on producers of waste to look for alternative uses for this waste. Civil engineering is a major consumer of bulk materials and is an industry that will be targeted by other industries seeking to find a use for their waste materials (see Box 5). At the A13, Balfour Beatty worked with Hyder to develop a method of processing material originally designated as unsuitable so that it could be used for embankment construction²⁵. The Hyder resident engineer believes that these kind of initiatives will become the norm on civil engineering schemes in the future.

The Transport Research Laboratory has conducted trial into the use of scrap tyres in filter drains. A report on the trials concludes the following:

“With the introduction of a landfill tax in the near future, alternative uses for waste materials, in particular scrap tyres, are urgently required. It is recommended that consideration is given to the specifying of scrap tyres as a alternative filter drain material.”

Carswell, J and Jenkins, E J (1996) Re-use of scrap tyres in highway drainage, TRL Report 200

Box 5 Re-use of scrap tyres in highway drainage

Industrial Policy and Strategy

Lean thinking/value management

The International Motor Vehicle Programme (IMVP) showed how car assembly companies could dramatically improve their performance by adopting the “lean production” pioneered by Toyota. In the book *Lean Thinking*, James Womack and Dan Jones show examples of the success of lean thinking in industries other than car making. They present five principles of lean thinking that can be applied to any industry. UK civil engineering companies must investigate how to apply these principles to civil engineering projects, in particular by defining the value of the products that they produce, identifying the value streams that lead to the creation of this value and making this value flow smoothly and without interruption to the customer.

Customer orientation

The civil engineering industry is changing. Clients expectations are changing. They will no longer put up with contractors bidding low and then using their skills in operating contracts to bring the final revenue up to a level where they can make a profit on the project. The new

²⁵ This initiative is described in more detail in the *New Civil Engineer*, 21 November 1996, p26.

paradigm is summed up by Graham Matthews, project services director of BAA, he says that client must,

“...create an environment where the design process can flourish. Break down the barriers between those with design ownership and encourage everyone to participate fully... If you can create a design roundtable where everyone communicates directly with each other, the reward will be a team playing the same music and a design that will be integrated and owned by all”²⁶

Civil engineering companies must respond. They must understand the needs of the customers and develop strategies that meet them. With privatisation, there are now clients around with money to invest in civil engineering projects. But, they will not do so unless they are sure that the outcome will be favourable and the process will run smoothly.

Raising entry barriers

The move from design-bid-build contracts to design and build contracts gives the contractor the opportunity to differentiate his or her product. The successful contractor in the future must start to build intellectual property leading to a high percentage of process innovations, high relative product quality and relative service quality, market these capabilities aggressively and reinvest in the acquisition of new intellectual property through research and development.

Developing core competencies

Civil engineering companies must start to identify and manage their core competencies. These core competencies will be engines that lead to product differentiation and the raising of entry barriers to the industry. Some core competencies will be related to fundamental construction processes, others may relate to the management of design, or the financing of projects. In either case, they will be related to value adding activities, that is, activities that lead directly to product or service characteristics that the customer values.

Training and development

The UK has the least developed system of technical training of any of the major European countries. The traditional in-company apprenticeships and training schemes that used to train construction workers have largely disappeared as companies first subcontracted large amounts of work and then passed price pressure from clients down to the subcontractors. The subcontractors have neither the infrastructure nor the money to train new generations of workers. This situation needs to be reversed and the industry should embrace the current government initiatives in this area, in particular NVQs, Investors in People and Modern Apprenticeships.

Research and development

The construction industry in the UK has been behind other industries in making use of the research and development support available from the UK government and the European Union. However, this beginning to change. The UK Department of Environment has just published a consultation document on research and development priorities based on the Latham Report's findings. The EU has a number of programmes related to civil engineering, in particular BRITE/EURAM and TRANSPORT. The UK government wants a specific construction research agenda included in the next EU research programme (the Fifth Framework).

Individual civil engineering companies must start to set their own research agendas. These need to be based on a technology strategy that looks at the contribution of different processes to customer value. The companies need to plot different construction disciplines and support

²⁶ Quoted in Building, 5 November, 1993

functions on to a strategic grid. They must use the grid to promote research and development programmes that will lead to world class performance in the areas that the customer values most (Figure 4).

Value to customer	High	Develop or partner	Stay ahead
	Low	Buy in	Drop or redeploy
		Low	High
		Performance relative to competition	

• Figure 4 Technology strategy

Once the mapping has been carried out, the research and development agenda can be set.

1. Where the customer value is high and performance is world class, research and development is needed to maintain leadership. Competitor performance needs to be tracked to set challenging research goals to stay ahead.
2. Where the customer value is high but performance is below world class, there are two possible responses, initiate research and development to attain world class performance or find a partner who is world class and build a close relationship with them.
3. Where the customer value is low but performance is world class, the response is to either drop the technology or look for alternative markets that value the technology more highly.
4. Where the customer value is low and performance is low the technology should be outsourced.

Of course, this situation is never static. The customer value must be tracked through marketing and the companies position must be tracked through benchmarking.

Government are targeting research on business processes

The industry has long been aware that the methods of procurement it uses are ineffective. The traditional contracts lead to behaviour by individual companies that runs contrary to the needs of the end customer. This situation is finally being addressed. The concept of business processes is being introduced to the construction industry. The Department of Environment has a business processes business plan, there is a CRISP²⁷ Process Theme Group developing research priorities in the area of business processes and there is an IMI²⁸ project developing a generic process map for the construction industry. The most effective set of business processes needs to be identified and then contractual forms built that support these. Until the work on business processes is complete, however, it is inappropriate to focus on contractual forms. Business processes are discussed in detail in the next section.

²⁷ The Construction Research and Innovation Strategy Panel is a government sponsored group who are defining research priorities for the UK construction industry

²⁸ The Innovation Manufacturing Initiative is a new form of government assisted research, all IMI projects must have at least 50% industry funding. The PROCESS^{protocol} project involves University of Salford, Alfred McAlpine, Engineering Technology, BAAplc, BT, EDM Architects, Waterman Partnership and Boulton and Paul Ltd.

Business processes

Adoption of “lean thinking”

The phrase “lean production” was coined by the International Motor Vehicle Programme to describe a fundamentally different approach to production developed by Toyota. In their best selling book, *The Machine that Changed the World*, the researchers presented a wealth of benchmark data that showed that lean production is a better way to organise production. The research showed clearly that organisations that employ lean production use less to achieve more than their mass production rivals; less space, less time, fewer people and less materials, with fewer customer reported defects and less waste resulting. Subsequent work has shown that the philosophy underlying lean production is transferable to other industries and that it leads to the same high performance in these new industries.²⁹

Reorganise around products and value streams

There are five principles of lean thinking. First companies must clearly specify *value*. They must then identify all the value-creating activities for a specific product along a *value stream*. They must then make the value *flow* smoothly along the value stream without interruptions. They must get the customer to *pull* the product through the value stream and finally pursue *perfection*.

The construction industry must carry out this exercise as a matter of urgency. In doing so it must take account of a number of characteristics of the industry:

1. Value must be defined in terms of the operation of the civil engineering product. Companies must see beyond the current design standards and consider the way that the infrastructure operator profits from the use of the construction product.
2. The value stream must be put together without regard to the organisations that will execute different activities. The value stream must be constructed for the benefit of the end customer and not be dictated by current practice and custom in the industry.
3. The value stream must lead to a specific product that is of value to the customer, this runs contrary to current subcontracting practice which is focused on grouping activities of similar types, rather activities that all contribute to a specific product.

This will mean fundamental changes to the way that construction is carried out. The potential reward is an increased demand for civil engineering projects. When the value that they add to the customers business is clear and the process of the delivering value is smooth and responsive, clients will procure more projects.

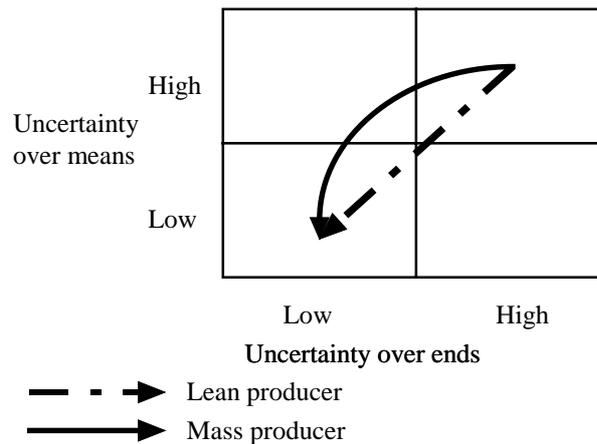
Integrated design and production

One of the key features of lean thinking is the integration of design and production. The design of a complex product has two dimensions of uncertainty; uncertainty about what is required, and uncertainty over how to produce it. Under traditional civil engineering contracts these are addressed in sequence, first the product is defined by the designer, then the production process is defined by the contractor. This is the same as the traditional design process in a mass production company (Figure 5). In a lean producer, however, both dimensions are addressed simultaneously. This has a number of benefits:

1. It reduces the time taken to produce the product by a third.
2. It reduces the amount of engineering effort required by a half.

²⁹ James Womack and Dan Jones (1996) *Lean Thinking*, New York: Simon and Schuster

- 3. It reduces the cost of the final product, which is designed for ease of production.



• Figure 5 The project as a process of means/ends negotiation

A practical example of lean construction

There have been a limited number of examples of lean thinking applied to construction, though not necessarily civil engineering. The most notable examples being in manufacturing and housing. The silicon chip manufacturer Intel replaces its main product range every three or four years, this involves building a whole new fabrication facility capable of producing silicon chips with twice the density of components as the previous generation of silicon chip. This has led to spiralling construction costs for fabrication plants. Intel’s response was to apply what it knew about lean thinking to the construction of a new fabrication plant. The results were impressive (see Box 6). Intel got a new plant construction on time and to budget that produced silicon chips with a higher yield (lower error rate) than previous plants.

A US house builder applied lean thinking to his business and achieved a transformation. He realised that 78 percent of the market for people moving house were not available to him as they were people who moved into second hand houses. On investigation, he found that the reason lay in the customer’s perception of value. The house buyer is concerned not only with the property that they are moving into but in the process on moving, including specifying what they wanted, negotiating with the house-builder, arranging finance, and furnishing the house. Many felt that the “hassle” involved in buying a new house far outweighed the advantages of owning a new property. The house builder completely redesigned his offering to provide a one stop, smooth procedure that covered all aspects of the purchase and move.

THE PROJECT

Design and construct the worlds largest semiconductor factory. The total project cost would be about \$1.8 billion, a third of that in the facility design and construction. It would include a better than state-of-the-art sub-micron fabrication plant (FAB)

THE CHALLENGE

Overcome a combination of challenges that previously were thought insurmountable, such as:

- Build it on the same site with an operating semiconductor FAB, while that facility was maintained in production.
- Build it fast. Time-to-market was everything to the success of the factory. The aim was to design and build it in half the time it previous took to build a previous plant half the size.
- Build-in the highest degree of flexibility for future process modifications.

THE APPROACH

Set aside all preconceptions of how a project is accomplished. Start with the objectives, goals, and milestones of the project. Build upon these to construct the systems and build the team required. Remove all barriers to quick and decisive communications and decision making. Assemble a highly skilled, empowered and energized project staff. Then re-invent everything, bottom up.

THE TEAM

The project Team had to be fully inclusive. Key parties to the Team would include: the Owners Process Design and Construction Project Management Staff; the Engineering and Architectural Design Staff; the Construction Staff , including all the major contractors and sub-contractors; the Authorities Having Jurisdiction and major equipment suppliers

THE RESULT

- Significant improvements in project quality. The client has publicly reported that the facility has achieved greater product yield (less reject) than their original best
- Dramatic reduction in design and construction time. The facility was completed on-time, to the very aggressive schedule.
- On budget performance of the project plus reduction of cost on a sister facility constructed after this project, due to lessons learned from this one.
- No project issues escalated above the Project Manager. The majority of issues are resolved at the trenches of the working-groups.

Box 6 An example of an Agile Construction Project³⁰

Make better use of IT

The building industry has placed a lot of emphasis on the use of IT in the design of complex buildings. First 2-D computer aided design (CAD), then 3-D CAD and latterly 5-D CAD (with the addition of time and cost) have been talked about. However, the use of information technology throughout the value chain is the key to success in civil engineering. The problems of civil engineering are evenly distributed between the design (what) and the logistics (how) of the project. Information technology in civil engineering must reflect this, with emphasis being placed on the supply and control of materials.

“The construction industry’s use of information technology now compares poorly with other sectors. For example, over the past ten years the food industry has been revolutionised by the ability of the food retailers to harness information technology

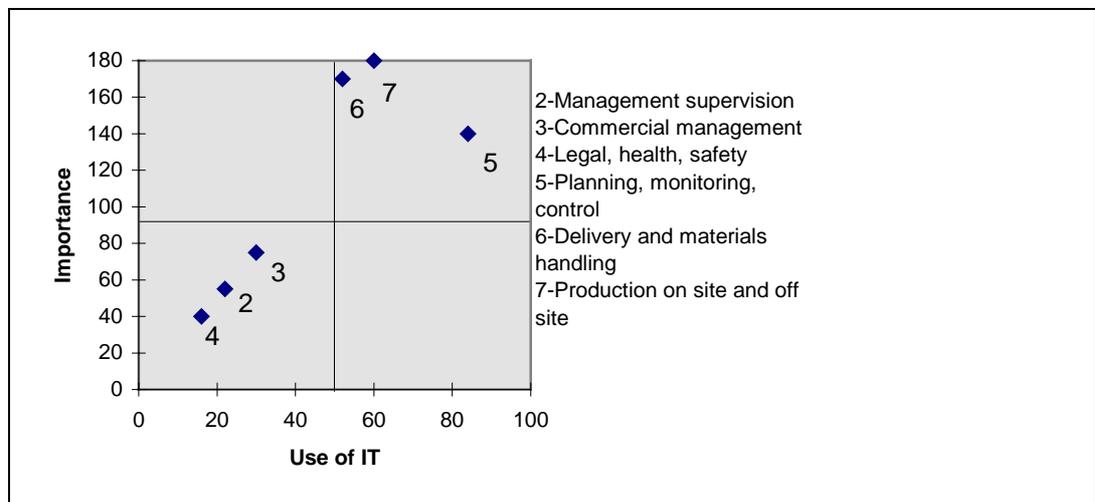
³⁰ Taken from: Greg Howell, Robert Miles, Charlie Fehlig & Glenn Ballard (1996) *Beyond Partnering: Toward A New Approach To Project Management?* in the Proceedings of the Fourth IGLC conference, Birmingham, UK, August 1996

effectively. It was previously a fragmented industry at the mercy of the food manufacturers. Now the tables have turned. The industry is dominated by a handful of retailers that exert considerable power over the manufacturers. Information technology played a pivotal role in this revolution, in much better control of stock, materials and deliveries, and in providing up-to-the minute information on what was profitable and what was not”

Haro Bedelian, Managing Director, Balfour Beatty Limited³¹

This revolution has taken the industry from one that in the later 1970s suffered from low margins, with the major companies in severe difficulties after years of price cutting, to one which now enjoy high margins and a reputation for quality and service.

If the construction industry is to achieve the sort of transformation that Haro Bedelian foresees, then the importance and use needs to be brought in line with the contribution of the area to value adding. On this basis the Construct IT best practice chart³² would look like Figure 6.



• Figure 6 Aligning IT with the value chain

³¹ Quoted in Proc. Instn Civ. Engrs, Civ. Engng, 1996, 114, Aug, p 118

³² See Figure 4 Technology strategy Figure 3 Benchmarking best practice in IT earlier in the report.

Conclusions

The construction industry has many of the characteristics now being promoted by researchers as the critical success factor for the future. The industry can be fast and flexible, assembling an array of skills quickly and mobilising them to meet the needs of a particular client. However, the industry has a number of difficulties:

- Basic skill levels amongst operatives are low.
- Teamwork amongst partners (designers, contractors, suppliers, subcontractors and client) is poor.
- Contracts used are divisive and promote adversarial behaviour.
- There is a lack of investment in innovation.
- There is a lack of control over the main construction operations.

The response of the industry needs to be fast and decisive.

- Become fast and flexible during concept development, design and planning.
- Introduce the ideas of lean production to the construction site.
- Develop strategic capabilities and market them aggressively.
- Invest in skills.
- Operate in a way that promotes cooperation to meet the needs of the customer; don't operate in a way that promotes the self-interest of the individual partners.

The ACI research agenda supports these aims through:

- Research into the value management process.
- Business process analysis and re-engineering.
- Benchmarking the industry and documenting best practice.
- Life cycle assessment to understand the needs of the customer.

The civil engineering contractor holds the dominant position in the value chain and must start to exert leadership for the good of everyone in the chain. In the words of David Coles of KPMG,

“They need to be more inventive instead of waiting for the client to come up with the ideas”³³

When they do, the UK civil engineering industry will be in a position to capitalise on the opportunities that still exist worldwide, if they fail to do so then they will be quickly acquired by their foreign competitors and the UK will have lost control of another industrial sector

³³ Quoted in New Civil Engineer, Contractors File, July 1996