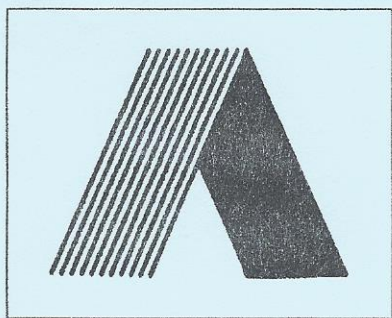
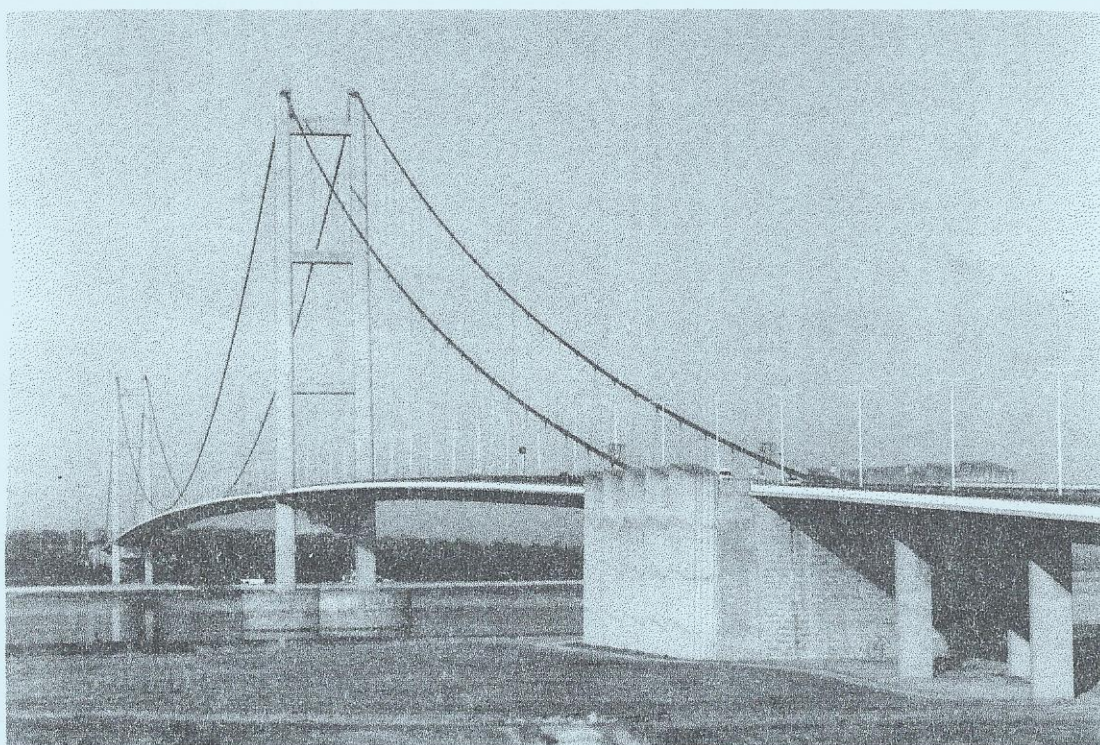




I.A.B.S.E. NEWS

BRITISH GROUP

EDITION 16 2004



THE HUMBER BRIDGE

Photograph by courtesy of ROGER EVANS – BRIDGEMASTER.

This newsletter is distributed to all members of the British Group and a single copy is sent to the secretariat of all overseas Groups.

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Mr A C E Sandberg OBE FREng
FCGI *Sandberg*
Mr P J G Wigley *Railtrack plc*

Mr C R Cockerton *Technotrade Ltd*
Mr S J Matthews *WSP*
Mr A J Pickett *Highways Agency*
Dr G P Tilly *Gifford & Partners*
Mr K R Wilson *Maunsell*

Dr C J Burgoyne *Cambridge*
Mr D K Doran *FCGI Consultant*
Mr M C O'Flynn *Taywood*
Mr W I Liddell CBE FREng
Buro Happold
Mr M J Murray *Babtie*

MEMBERS OF HONOUR OF THE BRITISH GROUP

Mr A W Hill
Mr D J Lee FREng
The Lord Hacking

*Members of Honour may attend meetings of
the Executive Committee*

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Imperial College

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Mr A M Low *Ove Arup*

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EDITORIAL

Having just completed 50 years in the industry perhaps I might be permitted to look back and make some comments on that period.

- In common with many other professions the status of the engineer has not increased. It is a sad reflection that the numbers taking civil engineering degrees has halved and of those, 44% do not join the mainstream of civil engineering
- Too many sub-disciplines (e.g. value engineering, project management, risk management, quality assurance, durability audits etc) have been surrendered to other disciplines thus reducing the status of civil engineers

- Although several new methods of procurement are now available, most could have been encompassed within systems used years ago by major designer/contractors
- Contractually there is less *give and take* today. The available cascade of dispute resolution techniques (negotiation, conciliation, adjudication, arbitration, and litigation) is to be welcomed but it has yet to change the adversarial nature of the industry
- The technical knowledge gap between site and design office personnel has probably increased.
- Formal QA systems which came into being 20/25 years ago are still misunderstood and in many cases still regarded as a paper chase
- The time gap between completion of research into problems and new techniques and their implementation on site is still far too long
- Perhaps the possible requirement for a *licence to practice* for consultants should again be reviewed?
- Degree courses, which are now twice as long as they were in the fifties, are in danger of being dominated by management topics, perhaps to the detriment of technical matters.
- Computer techniques have revolutionised analysis, detailing and fabrication. This has encouraged innovative designs which were previously incapable of resolution. However there is concern that the use of these techniques may impair an engineer's ability to develop engineering judgement

David Doran

AIMS OF IABSE AND THE ROLE OF THE BRITISH GROUP

The International Association for Bridge and Structural Engineering (IABSE) comprises more than 4300 members in 101 countries. Founded in 1929, IABSE deals with all aspects of planning, design, execution, maintenance and repair of civil engineering structures. To fulfil its mission, IABSE organises conferences and publishes a quarterly journal, *Structural Engineering International*, as well as books and reports.

The role of the British Group in relation to IABSE is under regular review and any constructive suggestions that members may have should be addressed to the Honorary Secretary c/o the Institution of Structural Engineers.

MEMBERSHIP NEWS

New British Group members since
Newsletter No: 15

Maurice Allgrove *Tony Gee*
Andrew Beard *Mott MacDonald*
Saprava Bhattacharya
Tomas Dadeby
Elizabeth Egizabheir
Ahmed Ghallab
Omowaleola Kadeba *Leeds University*
Dr Keith Littlebury *Mobius Dynamics*
Dr Chris Luebke *Arup*
Dr Sunny Nwaubani *Surrey University*
Paolo Stellati
C S Stephens
Kim Teager *Railtrack*
Robert Wheatley *Benaïm & Associates*

Congratulations.

Awards in the Queen's New Year's Honours List

Duncan Michael FREng

*** Knighthood**

Professor Patrick Dowling FREng
FRS

*** CBE**

Professor Les Clark FREng

*** OBE**

Duncan Michael is also the recipient of a Gold medal from the Institution of Structural Engineers

Ian Liddell FREng and **Paul Westbury** (Buro Happold) on receiving the award for the best paper published in SEI (Design and construction of the Millennium Dome, UK, August 1999). Ian, together with five colleagues, was also awarded an Oscar Faber Diploma by the Institution of Structural Engineers for a presented paper describing the Dome

Professor David Nethercot FREng (Imperial College), Chairman of British Group on his election as a Vice-President of the Institution of Structural Engineers

John Hill FREng (Dr I G Doran & Partners) on his election as President of the Institution of Structural Engineers for the session 2000-2001 and also his recent election as FREng

We were saddened during the year to hear of the death of **Fritz Leonhardt** who died on 30 December 1999 at the age of 90. He was one of the giants of bridge engineering and a familiar figure at many IABSE events. A tribute to his life by Holger Svensson appeared in *The Structural Engineer* of 15 February 2000. Also, to hear of the death of **Sir Alan Harris** FREng on 26th December 2000. An obituary will appear in *The Structural Engineer*

CAMBRIDGE COLLOQUIA

The 2000 Colloquium was held at Magdalene College in July. The theme was *Making the most of our structures*; the Chairman of the Organising Committee was Stephen Matthews. It is expected that the proceedings of the meeting will be available shortly. A report on the meeting by Kathy Stansfield appeared in *The Structural Engineer* dated 17 October 2000.

The 2001 Colloquium will be held on 16th-18th July again at Magdalene College. The theme is *Achieving Design Quality*; the Chairman of the Organising Committee is Ian Firth.

PERSONALITIES

In this section we have taken the opportunity to feature our present Chairman and to pay tribute to a distinguished past holder of that office. Our thanks go to Bob Milne for much of the historical material.

DAVID NETHERCOT FREng.

I have been a life long academic – but always with a very firm eye on the practice of structural engineering. Having spent some 30 years in Universities at Cardiff, Sheffield, Nottingham and Imperial College, I remain convinced that it is not only possible but essential for those responsible for educating the next generation of practitioners and advancing the scientific aspects of our subject to be in regular, close and meaningful contact with practice.

My initial research interests in stability have, over the years, broadened to embrace several aspects of steel construction – connections, composite action, overall structural response, ultimate strength determination etc. –

and have ranged over the whole gamut from fundamental theory, numerical work, large-scale experimental studies and the development and presentation of design rules. This latter activity includes personal responsibility for drafting design documents and, latterly chairing the BSI Committee responsible for the design parts of BS 5950. The research, teaching and code writing has not been confined to the U.K., but has involved many international collaborations. These have included successfully completing a joint paper with an Australian and a Japanese co-author in the pre-fax, pre-email era, being part of the team responsible for the European Steel Design Education Programme (ESDEP) as well as membership of Technical Committees of organisations such as the European Convention for Constructional Steelwork and the North American Structural Stability Research Council. In addition, I have spoken at conferences, given lectures and visited universities, research establishments and construction sites in more than 50 countries worldwide.

As a past Chairman of the Joint Board of Moderators, I was closely associated with the initiative to assist the Ministry of Construction in China establish a broadly similar University Accreditation operation.

Because of this international interest and activity, it was inevitable that I would be drawn into the work of IABSE. This has included service as Vice Chairman and Chairman of Working Commission 2, responsible for steel, composite and timber construction and now extends to being Vice Chairman of the Technical Committee. It is of interest to recall that I first met our President-elect, Professor M Ito, during my first visit to Japan as a Japan Society for the

Promotion of Science Visiting Fellow in 1980. Being a "Westerner" in that country 20 years ago was a less straightforward experience than it is nowadays but an abiding memory is of the ingenuity of my hosts in ensuring that I coped not only with not being able to converse in Japanese but also of being incapable of recognising a street sign, train destination, subway station name etc.

To me, the value of belonging to IABSE has always been that it has brought something extra. In the U.K. we are well provided for with professional bodies and networks within our own specialisms. However, the combination of genuinely worldwide coverage and no allegiance to any particular structural material or form provides opportunities for a type of discussion, personal development and education not duplicated elsewhere. As a relatively modest but nonetheless important and above all interesting component of my professional life, IABSE can be thoroughly recommended.

WILLIAM HENDERSON

The British Group has always supported the international work of IABSE. When Dr William Henderson succeeded Sir Hubert Shirley Smith as Chairman of the Group in 1969 he was determined not only to continue this support but also to develop IABSE's technical work in the UK. Dr Henderson realized that any developments need to complement rather than compete with the work of the UK Institutions. Under his guidance two main events were promoted – an Annual Lecture by a prominent personality (not necessarily an engineer) and a residential Colloquium on a topic of interest, for

which different views were currently under debate.

The first Annual Lecture was given by the then President of IABSE Professor Bruno Thurliman (Switzerland) who spoke on the *evolution of structural design*. Since then a distinguished list of speakers from both the UK and overseas has been built up. This has included the current President (Klaus H Ostenfeld in 1988) and culminating in 2000 with Professor John Burland FREng FRS (Imperial College). This year Martin Didier (SNCF France) will lecture on the steel bridges of the Mediterranean high speed line.

Henderson's piece-de-resistance was the concept of the Colloquium where a gathering of about 25 UK and overseas engineers could each make a contribution to a topic in an air of informality and with shared experiences. Cambridge was the chosen venue and through the good offices of Professor Jacques Heyman the first Colloquium (on highway bridge loading) was held at the CU Engineering Laboratories in 1975. Accommodation was provided at Pembroke College later to become the venue for many Colloquia.

In recent years, the event has been reduced from 3 days to 2 with a loss of some of the visits of interest and the opportunity to wander along the backs. The Colloquium dinner has been an opportunity for a speaker to be provocative and stimulate more debate. Jacques Heyman, David Quinion, Sam Thorburn and Lord Hacking are but a few who have graced that position.

The Institution library holds proceedings of many of these Colloquia. Dr Henderson's original concept has been retained and such events still form part of the Group's

annual programme. Bill died in 1980 and as tribute to his life the Colloquia now bear his name.

JOINT IABSE / I STRUCT E MEETING

A half day meeting was held on 22 May 2000 to discuss the topic *Implementation of Eurocodes in the UK*. This meeting was a follow-up to the Henderson Colloquium held at Cambridge in 1999. The joint meeting was fully reported in *The Structural Engineer* of 4 July 2000. In this connection it should be noted that the report of the committee chaired by Professor Les Clark FREng to review the *Future Evolution of Structural Design Codes in Construction* is now available through IStructE.

ANNUAL LECTURE

The IABSE British Group Annual Lecture was presented by the distinguished geotechnical engineer Professor John Burland FREng FRS on Thursday 7 December 2000. His topic was *A tale of two towers* and dealt with Pisa and the Houses of Parliament Clock Tower (more commonly known as Big Ben!) This was followed by a dinner at the Institution. A full report of the lecture by Peter Harris (Maunsell) will appear in *The Structural Engineer*.

The 2001 Lecture (provisional date 6 December) will be given by M Didier Martin (SNCF) *The design of the steel railway bridges of the Mediterranean high speed line*.

WIDE SPAN ENCLOSURES

The name Ted Happold is synonymous with the engineering of lightweight structures and it was fitting that the

International Symposium on widespan enclosures held at Bath University from 26 to 28 April 2000 was dedicated to his memory. It was appropriate that speakers and participants from many primary disciplines came to take part as Ted Happold was a passionate believer in the joint education of architects, engineers and other professionals in the construction industry. He would have been delighted with the outcome of the symposium, where so many friends from around the world met to discuss a subject to which he had contributed so much. The British Group was pleased to support the meeting.

The format took the form of six sessions:

- Form and structure
- Form and environment
- The Millennium Dome Greenwich
- Construction of widespan enclosures
- Recent retractable-roof stadia and other projects
- Atria environment and construction

The symposium posed two questions:

- How are engineering and materials technology used to produce better quality widespan enclosures that offer better environmental and architectural quality for less resources?
- What are the likely future design, construction and operational developments that will allow the evolution of new building forms in response to tomorrow's architectural and engineering challenges?

Besides the Millennium Dome the projects discussed included the Eden Project, the Olympic Stadium in Sydney, the Millennium Stadium in Cardiff and the Great Court Roof for

the British Museum. Papers were also presented on lightweight structures in the USA, Germany and Japan.

The dinner at the historic Pump Room attracted Nick Raynsford, Minister for Construction. The symposium was rounded off with a visit to the Dome in Greenwich.

The 29 papers presented are available as a bound set from Bath university (please contact Professor Michael Barnes).

Bob Milne

LUCERNE 2000 ANNUAL MEETINGS AND CONGRESS

As a welcome gesture the Honorary Secretaries of national groups were invited to the Congress. A reflection on the visit, by Bob Milne, appears below together with a personal note from Keith Wilson (Maunsell)

IABSE Congresses are grand affairs and Lucerne 2000 was no exception. Attended by nearly 1000 people the meeting was off to an excellent start - presentation of the International Award of Merit, the IABSE Prize and a special Millennium Award; a musical programme and an introduction to the Congress theme. As well as the delegates and the accompanying persons the opening ceremony was attended by national and local authorities together with the 'great and the good' of Lucerne.

Once the opening ceremony was over the delegates were immediately plunged into the technicalities of the theme - *Structural engineering for meeting urban transportation challenges*. The printed report contained more than 350 two page abstracts of each accepted paper with

the full text on a accompanying CD-ROM, the first time IABSE has tried this method. Congratulations are due to Keith Wilson (Maunsell) who was the UK representative on the Scientific Committee responsible for drawing up the technical programme and the hard work that that entailed. Having been involved in two IABSE symposia (1981 and 1994) organised by the British Group I appreciate the difficulties and problems that arise.

The format of the Congress was a plenary session beginning with a keynote address presenting an overview of the main aspects related to each theme, followed by parallel sessions with a main speaker before selected oral presentations. As usual there were poster presentations with authors present at given times for discussion of their work. A BASAAR (Briefings about structural applications and research) was held to allow the Working Commissions to contribute to the programme by providing a forum for informal discussion. Finally there was a commercial exhibition.

As usual, the Congress was preceded by the Annual Meetings - a chance to meet old friends and make new ones as well as dealing with the business of the Association. On duty at 8.00am for a meeting of the Publications Committee on Saturday 16 September then again at 8.00am for a meeting of National Group Chairmen with the President on Monday 18 September followed by the Permanent Committee. Sunday was the only free day giving a chance to walk around the historic town of Lucerne.

Surprisingly, the consensus at the Publications Committee was a desire for a higher proportion of science and technology (R&D) papers for SEI. Perhaps not so surprising when one

realised that most of those present had academic and research backgrounds!

National Groups are organised in many different ways. In the British Group there seems to be more accountability of the UK representatives on the various international committees than in some of the other groups. Although the President's meeting with the National Group's Chairmen is 'advisory' it is the one meeting where National Groups, as such, can put forward their ideas for discussion. The Permanent Committee meeting is, by and large, a formal endorsement of work already carried out. The National Group Chairman's meeting was squeezed in before the Permanent Committee meeting and once again ran out of time. If this meeting is to be given the importance it deserves it should be scheduled with enough time for discussion.

It would be remiss not to mention the excellent social programme and technical tours. The late Ted Happold once remarked that you were attracted to a conference by its technical content but you remembered the event by the quality of the social events. In this context Lucerne was outstanding. From the President's reception to those attending the annual meetings, through the Mayor's reception in the Town Hall and the State reception and boat party to the Congress dinner, it would be difficult to improve their hospitality.

Finally a vote of thanks go to Anton Steffen (Switzerland) and the members of his organising committee for the excellence of the arrangements.

Bob Milne

LUCERNE CONGRESS,
SEPTEMBER 2000

My wife and I arrived in Switzerland on Friday evening because, as a member of the conference Scientific Committee, I had a final briefing meeting on the Saturday morning. With the briefing completed, we were able to explore both the city and lake for the remainder of the weekend. Lucerne is beautifully situated at the end of one arm of Lake Lucerne and is an ideal location for relaxing when not rushing from one conference session to another! We were fortunate, too, in having fine sunny weather when we needed it.

The new conference centre on the lake-side certainly makes an impressive architectural statement and provides a topic of conversation. I think that it integrates with its surroundings very well from a distance, but is less successful close-up. Having lived with planning the technical content of the conference for the past 3 years, it was satisfying to see it all come to fruition. There were a few technical hitches at the first session, but thankfully these had been resolved by the time I chaired the plenary session on Tuesday morning. However, there were still anxious moments when, 10 minutes before the session was due to begin, two of the speakers had not turned up and neither of them had deposited their slides the previous day. Fortunately they arrived just in time, with their slides and I chaired a full session. The chairman's life is made much easier when speakers follow their instructions, but perhaps you only realise this when you experience the other side!

Having responsibility as chairman for certain sessions meant that the decision of which of the parallel sessions to

attend is made for you. This sometimes means that you cannot get to a presentation that you particularly want to hear. In the event there were only one or two clashes between papers that I was interested in. Another consequence of being assigned to particular sessions is that you can end up attending ones which you would not normally choose, and then being surprised by the usefulness of its content. For me the session on Information Technology for Infrastructure Management was a case in point.

The BASAAR sessions were perhaps the least successful from my point of view because the locations and the amplification were not good and it was very difficult to hear the speakers. However, the special session with Toni Ruttimann describing his work in South and Central America, was particularly interesting both from a humanitarian point of view and technically. Do we get too involved with analysis and satisfying ever more restrictive planning conditions and miss (or at least delay) providing the infrastructure that we need? Perhaps the main message of the conference was that in constructing infrastructure works in urban areas the challenge is not in the structural analysis, but in conceiving structures which can be constructed quickly with minimum impact on people and existing transportation systems in the immediate vicinity.

Although the technical programme was very full, there were many opportunities to meet friends and colleagues. The evening boat trip was excellent as was the official banquet on the Wednesday evening, but for my wife and I the highlight was the post-congress mountain hike in bright sunshine along the Swiss-Italian border

overlooking Lakes Locarno and Lugano – a fitting climax to a very interesting and absorbing week.

Keith Wilson. (Maunsell)

RAILTRACK MIDLANDS ZONE CAMBRIAN LINES STRUCTURES UPGRADE 1996-2000

A BRIEF SUMMARY OF THE WORKS UNDERTAKEN TO THE TIMBER STRUCTURES

BACKGROUND

The Cambrian lines are predominantly single track railway connecting Aberystwyth and Pwllheli on the west coast of Wales with Shrewsbury in the east. The railway was originally built by several different private companies in the late 1860's eventually coming under the control of the Cambrian Railways company until 1923 when ownership passed to the Great Western Railway (GWR). Due to the limited finances of the companies originally constructing the railway and the remote nature of a much of the route, extensive use was made of timber (mainly pitch pine) to construct a large number of bridges and viaducts along the route. As the route follows predominantly river valleys and coastline, there are numerous crossings of both rivers and tidal estuaries.

Maintenance of these structures has meant that timber was retained at a large number of locations with major refurbishments being undertaken by the GWR in the late 1920's. Maintenance by British Railways (BR) since 1948 had also been on a like for like basis. However, the 1960's saw the possibility of line closure under the

Beeching plan which resulted in a reduced level of maintenance and the introduction of cheaper alternative timber members in the form of Douglas Fir. Public lobbying and the acceptance that the railway provides a social need in the area meant that the route did not close. Investment by BR in new signalling equipment in the 1980's in the form of Radio Electronic Tokenless Block (RETB) reduced operating costs. Structural maintenance during this time was on a localised small scale replacement of individual seriously decayed timber members.

Privatisation of BR in 1994 led to the creation of Railtrack as the infrastructure owner and maintainer. Inspection reports for the structures on the Cambrian lines indicated that the extent of the timber decay was such that serious operational difficulties would have been encountered if a programme of heavy repairs and refurbishment was not undertaken. This was to form the basis for a period of investment of about £10m over four years.

SUMMARY OF WORKS UNDERTAKEN

West of Shrewsbury there were, in 1996, 14 separate timber structures. These all carried a single track railway over river estuaries, tidal inlets, rivers or flood openings. The structures were all of a similar design with the track being supported on longitudinal support timbers resting on timber decking. Each span is about 6.5m with individual timber piles supporting a crosshead onto which main span beams are supported. The track support timbers rest on corbels. The main span beams are in pairs or groups of four. Edge girders supporting handrailing are provided in a simple structural form. Timbers are connected together

by steel straps clamping the main span beams onto the corbels which in turn are connected to the crossheads by straps. Due to the harsh marine environment, not only had the timbers decayed but the metalwork had corroded in many places. The proposed works consisted of the replacement of the badly decayed and failed timbers with new hardwood (greenheart) together and the provision of new metal ties.

Access to these sites is such that considerable use of road/rail equipment was made both for transportation and as a means of lifting at individual bridges.

The size of the structures varied from 3 spans up to 113 at Barmouth (the largest timber viaduct in Europe).

Additional lateral sway strengthening works have been carried out at the majority of sites to allow locomotive-hauled services to operate again along the route to Aberystwyth. (The route to the north over Barmouth Viaduct to Pwllheli is still currently barred to locomotives until works to all the spans at Barmouth is completed. So far, 49 out of 113 have been strengthened or replaced).

Design Development – Repair and Refurbishment Vs Replacement.

Following detailed inspection works undertaken at each structure it became apparent that extensive works were required to all the timber structures if the railway was to continue to operate. In order to ensure short term operability and safety, speed restrictions and axle loadings were imposed on all structures. This effectively reduced the railway west of Welshpool to "sprinter only" operations (diesel multiple units).

Locomotives were barred from using the line. (The route has a Route Availability rating of 5; in effect a maximum axle loading of 21.5 tonnes).

Consequently, if Railtrack and Central Trains are not to suffer serious performance penalties, remedial measures were required at all the structures as a matter of urgency.

Consideration was made as to the cost effectiveness of full scale replacement versus extensive refurbishment using suitable timber. The GWR had undertaken a similar programme of refurbishment works in the late 1920's generally using pitch pine for main structural timbers.

The lack of suitable adjacent accesses to many of these structures and the general remoteness of the area contributed to the decision to undertake extensive refurbishment works. Detailed costings were prepared to compare full re-construction against refurbishment. Inspections had shown that the majority of piles to be in fair to good condition and thus not in need of full replacement. Therefore, as new structures were not required at the majority of the locations, refurbishment with timber appeared to be more cost effective than replacement in more conventional materials such as steel and concrete.

It is also worth noting that maintenance of the timbers is relatively infrequent – no painting required. A large number of timber members installed in the late 1920's were not significantly decayed. These in turn had replaced the original 1860's members. A life of 60+ years could thus be expected from pitch pine.

However, as pitch pine is now no longer as easily available the decision

was made to use a hardwood – greenheart instead. Small scale use of greenheart had been made in localised repairs undertaken in 1980's and had performed well. The timber is well suited to the harsh marine environment that exists along the coast of this part of Wales.

Initially it was proposed to only replace the worst decayed timbers but this was found to be time consuming in both splitting apart the timbers and then matching new to old. As a result, it was decided to renew pairs of span beams together. In this way, the relative stiffness of span remained constant as problems could arise with different stiffnesses beneath each rail as a result of mixing hard and soft wood sections.

The works were designed and specified by Cass Hayward and Partners under various contracts let by both Railtrack Midlands and contractor Birse Rail. Installation works were undertaken by a number of contractors again working for Railtrack Midlands and Birse rail between 1996 and 2000. The main contractors were Seastructures from Plymouth, Wrekin Construction from Shifnal and GTRM, Railtrack's infrastructure maintenance contractor for Cambrian lines.

Greenheart timber was obtained from Aitken and Howard in Scotland who imported the material from managed forests in British Guyana.

Working methods developed during each contract resulting in the recently completed works to Barmouth Viaduct. Extensive scaffolding and temporary support systems enabled full structural span beams to be replaced in a three night sequence when trains were not running.

The majority of the works,

(particularly large scale deck replacement and upgrading of longitudinal timbers supporting the permanent way) had to be undertaken in sympathy with an extensive programme of track possessions.

All the timber viaduct replacement works have now been completed at a cost to Railtrack in excess of £8m. Full line speed operation has now been restored over all bridges and locomotive restrictions removed from the line to Aberystwyth. As replacement works at Barmouth Viaduct are only about 50% completed locomotive access over the structure will not be possible until this remaining work is undertaken. Further works are planned for 2001-2002.

The work on the timber viaducts together with other significant operations along the route have been the most extensive civil engineering investment in this line since its original construction.

Shaun Winfield (Railtrack)

A NEW ALUMINIUM HIGHWAY GANTRY

David R. Morris

*Engineering Manager, Civil &
Structural Department
EarthTech-Reid Crowther, Haywards
Heath, UK*

Abstract

A new aluminium gantry has been designed by Brown & Root and a prototype commissioned and built by Advanced Aluminium Solutions Ltd. The gantry exploits the structural design advantages offered by extrusions. A system of components

connected using alloy pin and collar fasteners is suitable for manual handling, and facilitates rapid assembly. The gantry is light enough to allow the pre-installation of signal equipment on long span superstructures prior to lifting the entire span to its permanent location.

Background

With an anticipated increase in demand for gantries, the Highways Agency invited teams of engineers and architects to develop new gantry designs. Brown & Root teamed up with Yee Associates, and one of the ideas proposed was for an aluminium gantry. The idea has been followed through by Brown & Root, and a commercial company (Advanced Aluminium Solutions Ltd) has been established to market and manufacture this new product.

Benefits and Costs of Extrusions

Aluminium lends itself to innovation in design. Ingenious interconnecting sections abound in the glazing, display and motor industries particularly. A designer of civil engineering applications can find a great deal to inspire new applications by talking to experienced extrusion manufacturers. The aluminium extrusion industry has a wealth of experience, which is indicated by the fact that it is impossible to put a number to the dies in existence. With aluminium alloy extrusions, engineers have freedom to design the most suitable structural system from scratch. Although there is a tendency for individual extrusions to be linear prismatic members, designers commonly produce large asymmetric members from a series of smaller extrusions. With rare exceptions, the only limitation is in the skill and imagination of the designer.

Design effort was employed to create a series of extrusions, which could be used together, and connected with mechanical fasteners. The new gantry design comprises a schedule of components (cut and drilled), which are connected on assembly jigs to ensure that the geometry of the final structure is maintained.

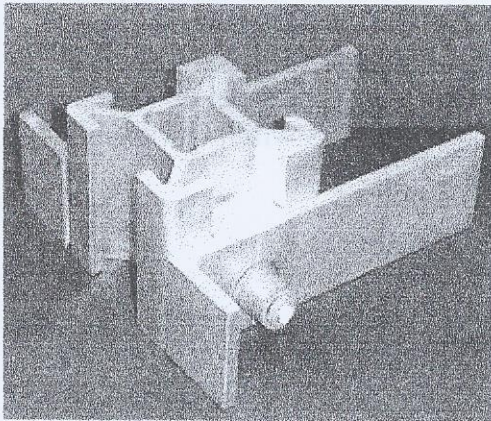
The cost of aluminium extrusions is approximately £2 per kg. The cost of cutting and drilling the aluminium components is modest, and 4 men achieved the assembly of a full 15m span prototype superstructure in less than a day.

Fabricated steel trusses in hollow section costs typically £2.0 to £2.5 per kg. Aluminium structures also have the added bonus of a residual material value beyond the design life of the structure. Aluminium is a valuable material, which can be re-cycled. The current recycle value of aluminium is approximately £1 per kg.

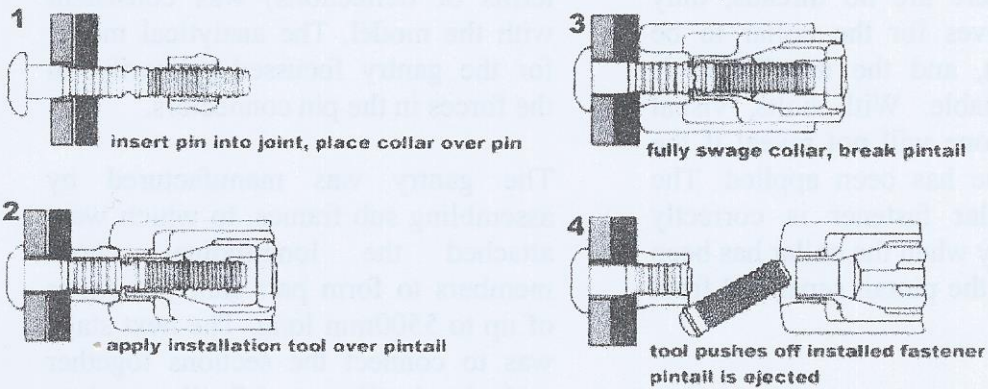
Structural Connections

The crux of the design is in the structural connection between the main vertical and chord members. Welded joints offer significant advantages in steel fabrication, as connections can be fitted and welded neatly, and with the full strength of the parent material. With aluminium, however, a different approach to connections is required. Welding techniques (MIG, TIG etc) can be used, but the heat affected zones around welds mean a reduction of aluminium strength of up to 50%.

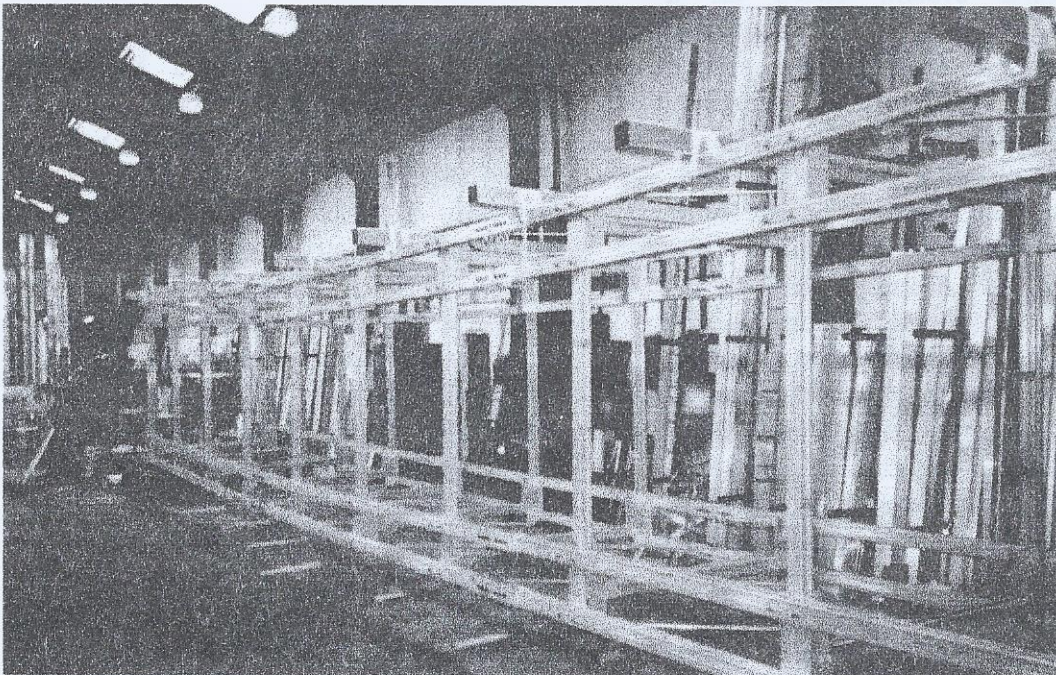
There are alternatives to welding, for example friction stir welding (where the heat input to the weld, and hence strength reduction for the alloy is very



Connection system using the new extrusions with pin and collar fastener



Installation of the pin and collar fastening



Prototype 15m span vierendeel gantry

much less. The aerospace industry has used riveted connections for aluminium in aircraft for many years. Bolted connections, both ordinary and high strength friction grip are available.

The main connection method adopted was to combine a simple and efficient set of interconnecting extrusions, fixed with heavy-duty alloy pin and collar fasteners ('Huck' fasteners).

This fastener system was chosen because it cannot be loosened by vibration (there are no threads, only parallel grooves for the collar to be swaged into), and the installation is fast and reliable. With bolts, visual inspection alone will not reveal if the correct torque has been applied. The pin and collar fastener is correctly installed, only when the collar has been swaged, and the pintail separated from the shank.

Superstructure

A structural system based on a Vierendeel girder was adopted for two main reasons. Firstly, the simple arrangement of vertical members (rather than diagonals) presents an uncluttered appearance to road users. Information on gantries needs to be presented clearly without the distraction of a preponderance of structural members. Secondly, the arrangement of members in the truss should not impede the installation of signals. The vertical members over the carriageway are spaced at 1.83m intervals, to accommodate standard matrix signals over the centre of each lane.

When compared to more common diagonally braced trusses, the Vierendeel girder deflects more under the same applied loads. However, as

long as the minimum headroom is provided, the depth of the truss is not generally critical for gantries, and deeper structural depths can be used to keep the deflections within acceptable limits.

Prototype Gantry

Brown & Root designed, and Advanced Aluminium Solutions Ltd have built and tested a 15m span prototype gantry, to demonstrate that the structural system was practical to build, and that the performance (in terms of deflections) was consistent with the model. The analytical model for the gantry focussed primarily on the forces in the pin connectors.

The gantry was manufactured by assembling sub frames, to which were attached the longitudinal chord members to form part gantry sections of up to 5500mm long. The next stage was to connect the sections together with chord splices, and finally attach to the support legs.

The prototype was tested on 7th September 2000 at Service Metals Factory in Braintree, Essex. The superstructure (weighing 2 tons) was loaded with up to 8 tons of steel, uniformly distributed along the span. The braced gantry carried 7 tons loading with a deflection of only 44mm at mid-span. The vierendeel gantry carried 8 tons, prior to initial structural failure. The analysis predicted both the mode (shearing of the shank of a single fastener) and the ultimate load (8 tons) at failure. After the fastener sheared, the gantry continued to support the 8 tons loading. The mid-span deflection immediately prior to failure was nearly three times the value predicted by the analysis (109mm). The hole tolerances for the main moment resisting

connections (and the chord splices) were almost certainly responsible for this.

Future developments

As a result of this observation, three changes to the gantry were proposed:

- a) The gantry should be fabricated with a flat horizontal profile (i.e. with the splice joints should be made straight). Fabrication is much simpler, and the splice joints more robust using this method.
- b) The gantry precamber should be introduced by loading the gantry uniformly in an upside down configuration until the midspan deflection matches the required precamber.
- c) Simple cross bracing should be introduced in the panels above the handrail. This will lock in the precamber, and make the gantry sufficiently rigid under vertical loading. The benefit of only bracing the panel above

the handrail, is that the motorway matrix signals can be attached and maintained free from obstruction by bracing.

During the course of meetings between the manufacturer, designer, and Highways Agency, additional equipment and facilities were accommodated into the design. The structural system has proved to be very tolerant of changes in the design, and straightforward to manufacture and assemble.

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STRUCTURAL ENGINEERING INTERNATIONAL

May I remind all members of the ongoing opportunity to have articles published in *SEI*. The journal continues to grow in stature and is an excellent show-case for British engineering. The rules for publishing a paper are relatively simple and I would be pleased to hear from anyone who may wish to provide such material. Many articles, such as project profiles, are only two to four pages in length so the demand on authors is not all that great.

Before embarking on an article it is prudent to submit to Zurich, for consideration, a 100/200 word synopsis.

If I can help in any way please contact me as below.

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INTERNATIONAL REPRESENTATION

A recent meeting of the Executive Committee noted that several Working Commissions were devoid of UK members. As a result, a number of proposals were made to fill vacancies. These will be forwarded to Zurich for ratification.

CALENDAR 2001-2002

- 21 March 2001 IStructE *Young Researchers' Conference*
- 21-23 March 2001 IABSE Conference *Safety Risk and Reliability – Trends in Engineering* - Malta
- 6-8 June 2001 *Information and Communication Technology in Building and Civil Engineering* - Espoo Finland
- Easter vacation lecture (April) *Hi-tech through the ages- Lessons from Engineering History*
- 12-14 June 2001 IABSE Conference on *Cable Supported Bridges* - Seoul Korea
- 16-18 July 2001 Henderson Colloquium on *Achieving built design quality* - Magdalene College. Cambridge
- 29-31 August 2001 IABSE Conference *Innovative Wooden Structures and Bridges* - Lahti Finland
- 6 December 2001 (prov) IABSE British Group Annual Lecture *The Design of the Steel Railway Bridges of the Mediterranean High-speed Line* by Didier Martin (SCNF, France). This will be preceded by the AGM and followed by the Annual Dinner.

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