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ROBERT STEPHENSON SYMPOSIUM by Mike Chrimes and Peter Stephens

On 24 June the Institution of Civil Engineers hosted a joint seminar with the American Society of Civil Engineers and the Newcomen Society on *Robert Stephenson (1803-1859): the man and his works*.

Introduced by PHEW Chairman, Professor Roland Paxton, the morning session, chaired by Newcomen Society President, Sir Neil Cossons, featured presentations by four of the contributors to the forthcoming biography of Stephenson (M Bailey ed. *Robert Stephenson: The Eminent Engineer*. Ashgate, 2003). The afternoon session, chaired by ASCE President, Thomas L Jackson, looked at Stephenson's work and the development of railways from a North American perspective.

Professor Adrian Long, President of ICE, in a speech of welcome to delegates hailed the event as an example of inter-institutional cooperation, and was delighted to see international visitors from North America and Europe. He touched on achievements of engineers of the past and their popular recognition in the selection of bridge designs for the new pound coins (*HEWs in the News*). This theme was enlarged by Sir Neil and the first speaker, Michael Bailey, who compared Isambard Kingdom Brunel's success in the recent 'Greatest Briton's Poll', with the absence of Robert Stephenson from the top 100. As Michael pointed out this was a very different situation from that which pertained at the time of their deaths in 1859. Robert's funeral was almost a state occasion, Queen Victoria having granted approval for the cortège to pass through Hyde Park. He is still the only engineer other than Thomas Telford to have been buried in Westminster Abbey. He listed Robert's honours as a prelude to discussing his many accomplishments as an engineer, not least the wide range of disciplines in which he excelled.

Robert was initially trained as coal viewer and mining engineer, but in Michael's view excelled as a multidisciplinary consulting engineer, sharing offices with his associates in Great George Street. He was a distinguished railway civil engineer, locomotive engineer, water engineer, mechanical engineer, bridge designer, dock, river and coastal defence engineer, whose work was characterised by a determination to overcome any obstacles no matter how formidable. Drawing on contributions from other authors to the biography, Michael noted that even when his designs were not particularly innovative, as with his masonry bridges and viaducts, their scale and speed of construction was largely unprecedented. Notable among Stephenson's still extant



The monumental remains to Robert Stephenson from Britannia Bridge portal after the 1970s fire
© James Sutherland

works are the High Level Bridge at Newcastle and the Royal Border Bridge at Berwick-on-Tweed, carrying the railway respectively over the Rivers Tyne and Tweed. Of his great tubular bridges in North Wales, that remaining at Conwy was to be commemorated with a plaque presented by our American colleagues and unveiled during their visit later in the week.

Scale was a theme taken up by Mike Chrimes, who described Stephenson's first great civil engineering achievement – the London and Birmingham Railway. A project which dwarfed those which had preceded it, and made Stephenson's reputation, the London and Birmingham Railway presented great challenges both in terms of project control and its engineering. Mike outlined how the project was managed by Stephenson, using methods of documentation which were copied by Brunel and others, and how engineering difficulties at Primrose Hill and Kilsby Tunnels were overcome. The latter, which involved pumping water from quicksand, was the basis of his initial experience of water engineering, a theme discussed by Denis Smith.

Denis described Stephenson's water supply projects, his involvement with Fairbairn and coastal engineering, canals, Fen drainage works, and London's main drainage. He also touched on Stephenson's peculiar opposition to the Suez Canal on engineering grounds. Throughout his career Stephenson was consulted on dock and harbour projects, among which were schemes at Hull, Sunderland, Grimsby and Birkenhead.

James Sutherland followed by discussing the design of iron bridges in the Stephenson era looking particularly at the development of the compound truss girder and the tubular bridge, he explained that most engineers of the time were looking for simple arithmetical methods of design such as those developed by Eaton Hodgkinson for cast iron beams, rather than detailed analytical tools. The trussed beam, a concept which first appeared around 1839, appeared to be a 'simple' solution to the problem of extending the span of cast iron beams, but through collective myopia Stephenson and his colleagues had only a partial understanding of the forces at work, which resulted ultimately in the Dee bridge design and its failure, probably through torsion, but possibly simply in bending. From 1847, cast iron was discredited because of its brittleness and unreliability. Wrought iron became available and rapid progress was made in understanding its properties and behaviour. After discussing the evolution of the tubular girder and the rows between Fairbairn and

Stephenson, and Hodgkinson, he contrasted the ugliness of the plate girders which resulted from the tubular bridge research with the potential elegance of Wild's final prestressed design of compound girders for Stephenson's Leopold Railway in Italy.

The Suez Canal was one of the themes seized upon in the discussion chaired by Sir Neil Cossons, as was the inaccuracy of Stephenson's estimates for the London and Birmingham line, but most discussion centred on the way in which Stephenson's reputation had waned as Brunel's had waxed.

Professor Henry Petroski led the afternoon session with a discussion of the characteristics of failure, postulating that on an approximate 30-year cycle civil engineering is due a bridge failure – possibly of a major cable-stayed structure. He suggested much was learned through failures and when engineers became complacent and were designing at the limits, failures were likely. He demonstrated how Stephenson was often designing at the limits of structural form – the Dee Bridge being a classic example. He suggested that despite its apparent success the Britannia Bridge would be criticised for its aesthetics and extravagant use of material, and noted Roebling's Niagara Bridge as an alternative, more economical approach.

Henry contrasted the experience of the two main transcontinental lines – the Union Pacific with no local timber for ties (sleepers) and bridges, but the benefit of the flat plains, and the Central Pacific with an abundance of timber, but the Rockies and Sierra Nevada to cross.

Alastair Mackenzie followed with a detailed account of Robert Stephenson's last great bridge design, the Victoria Bridge, Montreal, discussing the relative roles of Stephenson, his nephew George Robert, A M Ross, and T C Keefer who made the proposal on which the final design was closely based. He described construction progress on the bridge, the awful situations, particularly weather, conditions to be overcome, and the contributions of the contractors, particularly Benjamin Chaffey. He described the weaknesses in the bridge design – effectively an unventilated 2 mile tunnel, its replacement, and the site today. Again he stressed that Stephenson's involvement was all but forgotten.

The afternoon session closed with Larry Lee's whirlwind tour of early American railroads. He emphasised that the conditions in the US were very different from those Stephenson faced in Britain, and comparison was difficult, one could only speculate what Stephenson might have done. A notable feature was the frequently virgin terrain and the severe gradients on both the eastern and western seaboard. Inclined planes, horseshoes, tight curves, and switchbacks were the norm. Locomotives were soon developed with leading bogies capable of negotiating the curves and uneven track.

Structures illustrated included the first US railroad tunnel, on the Allegheny Portage Railroad of 1834 which rose up to 2,314ft, and the Baltimore and Ohio Railroad with the 80ft span masonry Carrollton Viaduct of 1829 still in use. This line used structural forms rarely seen elsewhere such as the Bollman Truss. The Canton Viaduct of 1835 was unusual as the arches had been filled from the start, with some culverts for the river it crossed.

Tom Jackson chaired the final discussion where the use of temporary timber viaducts by American engineers prior to completion of embankments was raised. This was a technique used by Stephenson on a number of his lines as it speeded up construction and allowed for consolidation of embankment materials.

Almost a hundred delegates had enjoyed a stimulating sequence of presentations which surely must have served to whet the appetite for the new publication.

ICE AWARD TO ARTHUR BELL

by Kenneth C McCrae



From left: Mrs Sanderson (Chair of Library Trust), Mrs Masterton, Gordon Masterton (ICE, Vice-President), Arthur Bell, Mrs Bell, Kenneth McCrae (a sponsor), Mrs Sloan (who restored many of the books) and Mrs Murray (Treasurer of Library Trust)

In June 1991 a party from PHEW visited the library at Westerkirk and found it in a poor and dilapidated state. The books of the Telford Bequest were in need of attention. In order to start things off a small collection was made. This seemed to give a start to things, and at the time Mr Arthur Bell who had just retired from the textile trade in Langholme took on the task of restoring the library.

In 1987 the Telford Monument was moved to a site opposite the library, partly to bring all the Telfordiana together. The monument on this site was unveiled by the Duke of Buccleuch the son of the Duke who unveiled the monument in its original site in 1927.

In 1996 due to road works the monument was moved again to a site beside the library and dedicated by Mr D Green, Vice-President. On 24 May 1997 the Duke and Duchess of Buccleuch visited the library on completion of the restoration works.

For all the work he had done towards this restoration it was decided to thank Arthur Bell by nominating him for a Companionship of the Institution of Civil Engineers. This was done and formally recognised at an informal lunch on 12 July 2003 when Mr Gordon Masterton, Vice-President, presented the award to Mr Bell.

THE CHAIRMAN'S COLUMN

by Professor Roland Paxton

(please note that an expanded version of the Chairman's Column including substantially more illustrations of the ASCE visit will be found in the E-version of this newsletter on the ice website at <http://www.ice.org.uk>)

My 52nd and last Chairman's Column starts with an account of the most ambitious historical engineering works tour ever arranged under the auspices of PHEW. It was planned by ASCE Vice-President Dr Jerry Rogers, and History and Heritage Committee Chair Professor Henry Petroski, and myself, with invaluable help in its execution from Paul Dunkerley, Michael Bailey, Keith Thomas, Andy Phillips – Welsh Assembly Government, Dewi Williams – Gwynedd Council, Jim Cornell and Dorothy Fenwick – Network Rail, Lynn Pegler and Jim Stirling – British

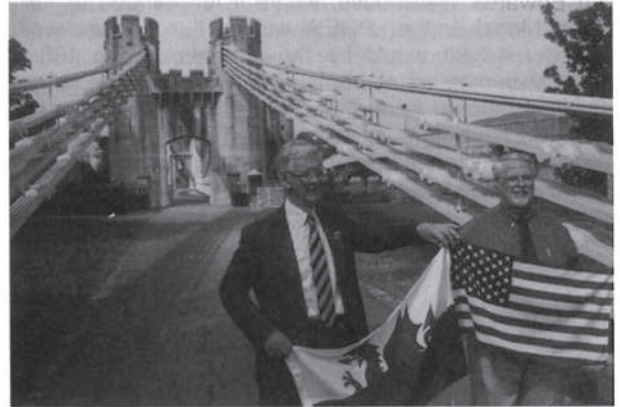
Waterways, Brian Crossley, Mike Brown, Professor Barry Clarke, the James Clerk Maxwell Foundation, the ICE North-West, Wales, North, and East and West of Scotland Regional Committees and, to Sir William McAlpine Bt. for his pre-tour buffet supper and for transporting his guests in a red, double-decker, London bus! Thank you all.

The theme of this ASCE presidential engineering landmark tour largely continued that of the Stephenson Symposium, plus visits to other notable works. Promptly, at 0900 hours on 25 June, the Manchester train hauled by the *Iron Duke* set out from Euston Station with tour members in good form. It sped through Primrose Hill tunnel and the, even today formidable-looking excavations at Tring and Blisworth, and other Stephenson landmarks, to arrive early at Piccadilly station. Here we joined our coach for the tour and made our way to the Manchester Museum of Science and Industry. At the Museum we were welcomed by Panel Member, Paul Dunkerley on behalf of ICE North-West, Bob Scott, Acting Museum Director and Michael Bailey, an Associate Trustee and our authoritative guide for the visit. Highlights of the Museum included experiencing the excellent quality of conservation of the massive warehouse complex (1830) and other railway structures. We were admitted to Water Street Station, terminus of the world's first inter-city railway, through the '1st Class' entrance of course, and enjoyed two rides along the Museum's track, as far as the main line, in a carriage hauled by a replica 1830 'Planet' locomotive built under Michael Bailey's direction. A three-hour visit to this remarkable museum was just not enough!

En route from Manchester to Llandudno, again under Michael Bailey's enthusiastic guidance, we saw the Bridgewater Canal (Brindley, c.1761), but were prevented by a traffic jam from seeing Barton Aqueduct over the Ship Canal. However, we did stop and walk along part of the infilled Sankey Brook Canal (1757) to obtain a good view of George Stephenson's, now somewhat worse for wear, 70ft tall, stone-faced brick, Sankey Viaduct (1828-1830), the massive piers of which are supported on about 200 timber piles. At the Imperial Hotel Llandudno, the party was welcomed by representatives of ICE Wales who hosted an excellent dinner with the Welsh – USA *entente cordiale* well to the fore! An air of excitement prevailed. The main parties involved in the plaquing venture on the morrow were all present. Thanks to the tremendous efforts of Panel Member, Keith Thomas, we were now on the eve of unveiling 6 fine bronze bridge plaques, three in English and three in Welsh, which had cost \$5,000 to make, recognising outstanding bridge achievements at Conwy and over the Menai Strait. The dinner concluded with an *aperitif* for the next day's visits, an informative presentation by Rick Turner of CADW on the Holyhead Road engineered by Telford from 1815-1826, as exemplified in the new publication co-authored by Rick (*Newsletter* No.98). The book's industrial archaeology coverage of this great road is excellent, but is sadly marred in Chapter 2, not least by an irrelevant repetition of some of Hadfield's misfounded allegations in *Thomas Telford's Temptation*. Hadfield posed that Telford had 'an abiding jealousy of Jessop' and had conspired to deprive him of his rightful credit in his writings. However, these allegations are incompatible with authoritative early evidence to the contrary seemingly missed by Hadfield (*Newsletter* No.60) and his book, which unfairly continues to damage Telford's reputation, should have been withdrawn.

On Thursday the 26 June, the plaque unveiling ceremonies were performed in sunshine at each bridge by ASCE President Tom Jackson and myself (representing ICE President Professor Adrian Long), in the presence of numerous civic dignitaries, officials and well-wishers. Media

interest took the form of radio interviews and press coverage. Articles and photographs at the Conwy events, with the Welsh and American flags much in evidence, appeared in the *Daily Post*, *Railstaff* and, rather splendidly, on the front cover of *ASCE News*.



Conwy Bridge. ASCE President Jackson and myself with unveiling flags
© Roland Paxton



Menai Bridge plaques and ICE 'movers and shakers' in Wales. Keith Thomas in shirtsleeves!
© Jerry Rogers

The plaques are intended to inform the public of the details, persons responsible and significance of the bridges by recognising them as INTERNATIONAL HISTORIC CIVIL ENGINEERING LANDMARKS (IHCELS). Twenty-five years ago, in the discussion on my Newcomen Society paper, '*Menai Bridge and its influence ...*', attention was drawn to the lack of adequate explanatory plaques at the bridges. On behalf of PHEW I put cases to ASCE for IHCEL designations for Menai and Conwy suspension bridges and, with Panel Technical Secretary Peter Stephens' help, Conwy tubular bridge. The Conwy suspension bridge plaque, for example, reads:

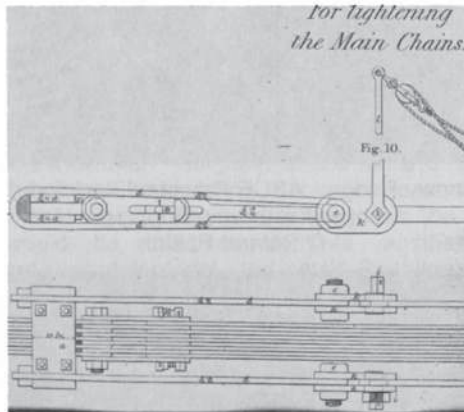
CONWY SUSPENSION BRIDGE

ERECTED 1822-26. SPAN 327FT. DECK REPLACED & STRENGTHENED WITH SIDE TRUSSES 1896. CLOSED TO VEHICULAR TRAFFIC 1958

ENGINEERS: T. TELFORD (1822-34) & W.A. PROVIS (1822-50)
IRONWORK: W. HAZLEDINE, T. RHODES. MASONRY: J. WILSON

THIS WAS THE MAJOR STRUCTURE ON THE STRATEGICALLY IMPORTANT HOLYHEAD TO CHESTER ROAD. CONWY SUSPENSION BRIDGE, TELFORD'S MOST DRAMATIC CREATION IN THE GOTHIC STYLE, WAS BUILT WITH THE IDENTICAL TECHNOLOGY DEVELOPED FOR THE LARGER MENAI BRIDGE (1818-26) AND STILL HAS ITS ORIGINAL IRON CHAINS.

At Llanfair P.G., under Keith Thomas's expert guidance we visited the Telford two-storey toll house and railway station. It was here that I learned from Shaun McLoughlin that Menai Bridge Community Heritage Trust had received an offer of financial support to staff a Heritage Centre at John Edwards Warehouse, where it is intended to tell the story of Menai Bridge. PHEW wishes this venture well. A wonderful exhibit would be the spanner with a 10ft long handle shown to us at Menai Bridge Toll House, together with an octagonal head link cross-bolt of the type it was thought to have tightened. In fact, this spanner is of even greater interest. It operated an eccentric chuck used with links with elongated eyes and wedges to tighten the suspension chains into position. (see figure)



Menai Bridge. 10ft spanner used for tightening suspension chains, c.1825
© Roland Paxton

After the ceremonies we continued our coach tour along the Holyhead Road, designated and signed as an *Historic Route* in 1998 under Keith Thomas's direction (*Newsletter* Nos.78 & 80). The road is retained in part of the Nant Ffrancon pass by Telford's remarkable retaining walls tastefully preserved in 1998, also under Keith's direction, by the Welsh Office and which won our *Historic Bridge Award*. At Bettws-y-Coed, we saw the 105ft span, prefabricated cast iron, Waterloo Bridge, with its ornamental facades commemorating the famous battle. (Telford/Hazledine).

Then on to the 1007ft long, 121ft high (max), Pontcysyllte Aqueduct 'the supreme structural achievement of the canal age'¹ designed and constructed by Telford and Hazledine with Jessop's approval, arriving at Chester in good time for Panel Member Brian Crossley to act as our cicerone for an evening walk in the City and on part of its Roman wall, from which we saw an amphitheatre site and other Roman works. We noted that in the 13th and 14th centuries Edward I employed 'Richard the Engineer' of Chester on, castle-building in North Wales, rebuilding the city's weir and a major element of the cathedral. He also designed a floating bridge built on the east coast of England which was towed to Berwick-on-Tweed to assist in the invasion of Scotland – an unfriendly act indeed!

On 27 June a grey and wet start to the long journey to Edinburgh began well with an early visit to the Anderton Boat Lift, near Northwich. It was designed and built by Edwin Clark in 1875 to overcome a height distance of 50ft between the River Weaver and the Trent and Mersey Canal. At the newly completed visitor centre, Martin Clark, British Waterways, gave an excellent overview of the lift's history and refurbishment. This was an uplifting visit for me as I had not only given the project a strong letter of support on behalf of the Panel at its funding stage, but also presided over its *Historic Bridge and Infrastructure Award* win in 2002 (*Newsletter* No.96). This piston lift had been included in the tour to contrast with the new 'Falkirk Wheel' rotating arm boat-lift experience on the morrow.

After a brief bow to the 'Angel of the North' at Gateshead, where the party was joined by our guide Mike Brown of the Robert Stephenson Trust, we proceeded the Stephenson works at South Street, Newcastle, where the 'Rocket' and many other locomotives were designed and built. Here we met with ICE North Chairman Professor Barry Clarke and others and enjoyed conducted tours through the workshops and offices. After lunch Professor Clarke took us to the Millennium Bridge and High Level Bridge (Stephenson). Then north again, via Berwick-on-Tweed with the Royal Border Bridge (Stephenson) in the distance, to Heriot-Watt University's Conference Centre.

After dinner at Heriot-Watt the party was welcomed to the School of the Built Environment by its Head, Professor John Swaffield, who made some well-received remarks about the value of teaching history. We then looked over the ICE's fascinating collection of several hundred artefacts, ranging from Telford relics to a quarter scale model of a Forth Bridge skew-back and a Menai Bridge link, under the guidance of Museum Committee members.

Saturday 28 June, the last day of the tour, commenced with a visit to another Telford masterpiece, the 106ft tall, Dean Bridge, Edinburgh. The strong hollow-box form of its 90ft spans and mode of construction were described, and its superb quality Craigleith stone-work viewed from beneath. Then to the James Clerk Maxwell Foundation at 14 India Street where the party was shown over the fine Georgian house, in which 'the father of modern physics' was born in 1831, by Trustee Professor David Ritchie. We were impressed by Einstein's testimonial that 'the special theory of relativity owes its origins to Maxwell's equations of the electromagnetic field'. The building which contains a fascinating museum of Maxwell artefacts is partly occupied by the International Centre for Mathematical Sciences. It is also used by PHEW and others for meetings and lectures.



Edinburgh, 14 India Street.
ASCE party at James Clerk Maxwell's birthplace
© Roland Paxton



Forth Bridge. ASCE party on top of North Queensferry cantilever
© Roland Paxton

The party then continued on to the Forth Bridges Visitor Centre for lunch as guests of its trustees, Dorothy Fenwick and others from Network Rail and Balfour Beatty, and a visit to the top of the North Queensferry cantilever of the Forth Rail Bridge to see its refurbishment. The day concluded with the dedication of the IHCEL Forth & Clyde Canal Millennium Link plaque (*Newsletter* No.87), a boat trip on the 'Falkirk Wheel' with its 35m arms and a memorable farewell dinner hosted by both ICE Scottish Regions and British Waterways, Scotland.



'Falkirk Wheel', Forth and Clyde Canal.
ASCE President Jackson and Professor Fleming
unveiling IHCEL plaque
© Roland Paxton

Abroad, I recently revisited the \$5.6m Philadelphia Water Works Interpretive Center project (*Newsletter* No.88) under the enthusiastic guidance of Ed Grusheski – General Manager of Philadelphia Water Department, Mark Thompson – Architect, David Cornelius – Engineer and Ursula Reed – Fund Raiser. Within the historic buildings, dating from 1812, and flood range of the river thus the engineering input, everything salvable has been professionally conserved. In addition to evocative displays in the reclaimed space, a class-room, river balconies, esplanade, Water Lab and a small theatre have been created.

'*Water in the World*' will be the main theme of the Center's exhibits with focus on the urban watershed and the incredible history of the site. A most appropriate re-use for this world class historic engineering landmark! The grand opening of the Center is to be on 19 September. Congratulations to all concerned on a magnificent achievement. 100,000 visitors are expected annually. PHEW wishes this remarkable venture into public education on water matters past, present and future many participants and visitors and every success.

And finally, I close my last 'Chairman's Column' by thanking Newsletter Editor, Dr Bob Otter, Mike Chrimes and Paul Parkes for their wonderful encouragement and support in producing it over the past 13 years.

¹ Paxton, R.A. (Art.) 'Thomas Telford', *The Biographical Dictionary of Civil Engineers*. London, Thomas Telford, 2002.

PROPOSED EMAIL DISCUSSION GROUP by Mike Chrimes

CIVIL-ENGINEERING-HERITAGE-
L@KNOWLEDGELISTS.ICE.ORG.UK

ICE Have established an email discussion group intended to provide a forum for those interested in historical and

conservation issues in civil and structural engineering, and construction generally.

It is intended that, through the exchange of emails among group members, knowledge and experience can be freely exchanged and ideas discussed. Although the history of civil engineering scarcely exists as an academic discipline, an enormous body of knowledge exists among engineers, and other researchers, regarding the development of civil engineering and construction techniques of the past. Frequently one comes across a form of construction in an old structure which prompts the questions such as 'Why was this designed in this way?', 'Do other examples exist?' Group members will be able to broaden their usual circle of advice on such questions.

It is intended to develop the group internationally to facilitate exchange of experience and also the understanding of how civil engineering has evolved in parallel over centuries. The launch of this group coincides with the establishment by ICE and IStructE of CARE, a register of engineers accredited in conservation. This group will hopefully provide a forum for engineers on the register. Contributions to the group will appear in your Inbox for you to read and answer, respond, delete or archive.

If you would like to register for the group please email:

LISTSERV@KNOWLEDGELISTS.ICE.ORG.UK

sending the following message on one line:

SUBSCRIBE CIVIL-ENGINEERING-HERITAGE-L (your)
First Name Last Name.

This will enable you to register. Ensure that there is no other text in the body of the message e.g. your courtesies greeting. The subject header field should be left blank. The system should respond with a welcome message and further details including an option to de-register whenever you wish. It also advises how you can receive mail on a digest only basis. Alternatively e-mail mike.chrimes@ice.org.uk and he can register you.

Please note this forum is not intended for promotional material. If it is felt a group member is abusing the list they will be removed

THE HISTORY OF BUILDING TECHNOLOGY – A PROPOSED ELECTRONIC NEWSLETTER by Randy Swanson

During the ICCH Conference in Madrid last January, many of the American attendees met for a brief dinner and information discussion concerning the establishment of a North American organisation addressing the History of Building Technology (HBT). It quickly became clear at that meeting that it was premature to initiate a formal academic society, but that improved communications between scholars was certainly needed.

This spring, John Ochsendorf (MIT), Tom Peters (Lehigh), myself (UNC Charlotte) and others have been discussing how we might initiate and maintain a venue to further our scholarly interaction, research, publications, and friendships. We believe that a modest grassroots beginning is best. To this end, we will be working to provide a semi-annual electronic newsletter that will facilitate a wide range of exchange between scholars interested in the History of Building Technology.