NEWSLETTER

RETIRED CHARTERED ENGINEERS ASSOCIATION
WORTHING

Hon. Secretary: S. Oliver. Elphin, North Drive, Angmering, BN16 4JJ ☎ 01903 787116

FORTHCOMING EVENTS

1st Jan	Wednesday	Coffee - at Albion Inn, 110 Church Road, Hove
8th Jan	Wednesday	**Talk** - "Cathodic Protection" by R.G. Bailey, member, 2.30 p.m. Durrington C.C.
15th Jan	Wednesday	**Visit** to Vent Axia, Crawley at 2.30 p.m (see page 9)
16th Jan	Thursday	Coffee - at Three Crowns, East Preston
22nd Jan	Wednesday	Committee meeting, 2.15 p.m. Durrington C.C.
30th Jan	Thursday	Coffee - with Ladies at Beach Hotel, Worthing
5th Feb	Wednesday	Coffee - at Albion Inn, 110 Church Road, Hove
12th Feb	Wednesday	**Talk** - "SE for Supreme Effort - rebuilding class S locomotive" by G.H. Picken, member, 2.30 p.m. Durrington C.C.
20th Feb	Thursday	Coffee - at Three Crowns, East Preston
27th Feb	Thursday	Coffee - with Ladies at Beach Hotel, Worthing
5th Mar	Wednesday	Coffee - at Albion Inn, 110 Church Road, Hove
12th Mar	Wednesday	**Talk** - "Designing for the Disabled" by W.T.F. Bond member 2.30 p.m. Durrington C.C.
19th Mar	Wednesday	**Visit** to De La Rue Cash Handling, Portsmouth at 2.30 p.m see page 9 for signing up
20th Mar	Thursday	Coffee - at Three Crowns, East Preston
24th Mar	Monday	Copy date for next Newsletter
26th Mar	Wednesday	Committee meeting, 2.15 p.m. Durrington C.C.

27th Mar	Thursday	Coffee - with Ladies at Beach Hotel, Worthing
Every	Monday	Coffee at Laing's Arcade Cafe, Montague Street, Worthing

Coffee mornings commence at 10.30 a.m., except at The Beach, which is from 10.45 a.m.

Membership

We are sad to have to report the deaths of **J.W. Bailey** and **E.N. Soar.**

S.R. Renew has moved to a temporary address and his phone number is: 01903 772582.

Visit to Edwards High Vacuum, Shoreham on Wednesday 13th November, 1996 at 2.30 p.m.

Eighteen members attended this visit where we were received by Dr Alan Troup who is the Director of Technology, David Betts a senior Manufacturing Manager and Kevin Ransom who is a project leader. The visit started with a forty five minute visual presentation in the conference room explaining the structure and product range of the Company, a subsidiary of BOC plc, with a multi-million pa turnover employing some 2000 people. After an explanation of the principles of Dry, Rotary Vane and Turbo molecular vacuum pumps the meeting concentrated on the Dry pump range used by the semiconductor industry and where Edwards are world leaders technologically and in volume of sales. Manufacturing uses a most up to date concept known as demand flow technology (DFT) allied to constraint determined throughput (CDT). This considers a product's manufacture as a process incorporating "demand pull" in response to customer orders (KANBAN system) rather than the outdated MRP2 (a"supply push"concept) used previously. Data was shown on a before and after basis depicting the enormous gains made in productivity, inventory turn and cost reduction since adopting the DFT concept. We then toured a machine shop where very modern multi head computer controlled machine tools are arranged around a product where multiskilled operators are responsible for all the activities in the cell devoted to the product including quality control with each cell working on a 24 hour basis. Conformity to ISO9000 is achieved by a scheduled and separate quality audit of each manufacturing centre's tools, gauges and made parts. The investment in machine tools is high with a typical multi-head machine tool costing well in excess of £250,000; a proposition only possible by recourse to a plc of BOC's stature. We moved on to the development and test rooms and a new area using robotic assembly which is to be expanded. We visited the offices where the design, manufacturing and quality engineers share the same large room together with members of the purchasing function to ensure efficient team working supported by an integrated computer data base accessible to all. In the design section, current design technique was demonstrated using the very latest version of the IBM CADIA which allows three dimension viewing of component and assemblies from any angle or cross section and where designs are originated at the keyboard-video screen interface without recourse to pencil and paper. The

visit concluded with the President thanking Dr.Troup and his team for providing an interesting, and very professionally managed visit for Members.

Ken Wheeler

Cooch Memorial Lecture - "Untrodden Snow" by Prof. E. Laithwaite at the Worthing Library Lecture Theatre on Friday, 29th November, 2.30 p.m.

The President welcomed Members, their Ladies and Guests to the meeting and introduced the speaker, Professor Eric Laithwaite adding that Professor Laithwaite was one of the countries most eminent engineers. He was Professor Emeritus of Electrical Engineering at Imperial College and Visiting Professor of Electrical Engineering at the University of Sussex having a career which started at the Royal Aircraft Establishment, Farnborough in 1943. He has been associated with several "firsts" such as the world's first commercially produced computer, the tracked hovercraft and the development of the linear induction motor. Going into the unknown invariably brings problems of a special kind as the subject of his lecture called UNTRODDEN SNOW revealed.

Professor Laithwaite commenced with several hilarious anecdotes recalling his time at the RAE. After the war he decided upon an academic career gaining successive degrees at Manchester University with a Doctorate in 1964. His early work was devoted to the development of the linear induction motor as a more practical successor to the previously attempted DC version and described with slides the early versions, of which BBC archival film exists, and recounted his experiences at that time. He moved on to show how little we know about some engineering artifacts as demonstrated by their behavior which seemed at odds with conventional theoretical analysis. He was drawn by analogy to Alice in Wonderland and the pursuit of the White Rabbit, in his case the behavior of gyroscopes and the apparent mass transfer without the application of a force in a gyroscopic top when the rotating mass was rotating about its bearing. After much research he has shown that gyroscopic devices are three dimensional in behavior with an analysis which is very difficult to grasp. He concluded with some demonstrations of spinning devices which included an act of levitation caused by spinning a magnetic gyroscopic top above a flat permanent magnet.**

The Vice President, David Lewis gave the vote of thanks to Professor Laithwaite on behalf of the Members of the Association.

Before closing the meeting the President invited Mr. Conrad Coome to join him at the rostrum to receive the prize awarded annually to the most outstanding student in the Engineering Faculty of the University of Brighton. Mr.Coome in acceptance said that he was completing his Master's degree in civil engineering (MEng), that he would like to work in research and development upon qualifying and thanked the Association for their interest.

Ken Wheeler

** The Levitron can be obtained from the Science Museum catalogue sales at Swindon, item number OA27718 price £39.95 Telephone 0990 353433 .

The talk foreseen at the meeting on 11th December, 1996 by **A.S. Whitaker** entitled **Bridges 1999** has been postponed, due to incapacity of the author, and we hope he will be able to present it in the future, when he has recovered. Our President presented the talk detailed below.

Bridges and Things Structural - Talk by K.J. Wheeler, member, at the Durrington Community Centre on 11th December, 1996

That engineers can learn more by the mistakes of the past than by the successes is as true today as it ever was. This talk is about CONCEPTUAL FAILURE ANALYSIS, that in design one should look for all possible modes of failure including those that may be introduced by design changes as a project progresses. Four landmark bridge failures which used different construction concepts show a time interval between each of approximately 30 years. From the Dee trussed bridge of 1846 through to the Milford Haven box girder bridge of 1970 and if the 30 years is other than a statistical freak, then perhaps we are due for a new bridge failure around the year 2000. In what follows we trace a path from ancient times to the present. The fundamental problems facing designers have not changed. The concept of say a structure is a product of the mind but the efficacy depends upon progressively more advanced scientific and mathematical knowledge, these days expressed through computer solutions based on sound fundamental principles or so it would seem, for most design activity is still conducted in conditions of relative ignorance of the full behavior of the system or artifact being processed.

One paradigm is the mindset associated with the" state of the art" typified by codes of practice which truly cannot be employed to deal with extrapolation beyond current boundaries and engineers are continually striving to exceed such boundaries for that is the path of progress but alas in many cases ignoring the fundamental principles by which the current state of the art was derived and the limitations to extrapolation shown up by such principles. Indeed the difference between "common" and "formal" knowledge is that the principles may well form part of the common, but formal implies a scientific understanding of the constraints that apply when such principles are exercised. Having formal knowledge may be considered as the definition of being an expert. For example, that a cantilever beam with a rectangular cross section bends more readily when loaded at right angles to the thinner dimension is a case of common knowledge, but to determine the deflection for specific dimensions, loading and material requires formal knowledge.

This text uses structural engineering as its vehicle because of its long historical record. Adequate design often reflects the need to provide for redundancy, that is an alternative load path for a structure suffering failure of one of its elements. In fact, the presence of provision for redundancy either intended or by accident has saved many a reputation. One example where this was not present occurred in the design of a hung precast concrete ceiling at a railway station in New Jersey, USA in 1983. The ceiling was suspended by wire

cables from a roof. The cables were adequate to support the ceiling in total but local additional loading during servicing caused one cable to fail. The re-distributed load through the remaining cables exceeded their capacity causing rapid progressive failure of the fifty ton ceiling which fell to the floor below killing two pedestrians.

Galileo was the first to provide a scientific basis for structures albeit in the mediaeval mathematics of the day. His reputation had gone before him and he was called upon to provide solutions to certain engineering problems of the day and he provides paradigms which are just as important to us today. It had been in his time the practice for centuries before to support marble columns on trestles before their erection in temples, to keep them clean and allow sculpting to take place. On many occasions supporting a column placed horizontally with a trestle at each extreme, in the manner of a simply supported beam, caused the column to fracture at mid-span. The chosen solution was to place an additional trestle at mid-span but in some cases this proved of no avail because the column still fractured at the same point. Galileo showed because one of the end trestles sunk the result was the same bending moment being applied to the resultant cantilever. Galileo's corollary was that the system represented by the original simply supported beam was quite distinct from a failure analysis that should be accorded to a beam supported in three places. Galileo was approached by shipbuilders who were building bigger ships by scaling up existing examples only to have them fail structurally. The problems of scale effect had been known for centuries and Galileo was the first to articulate and formulate rational strength-of-materials solutions which stood for over a hundred years in spite of a flawed analysis on the load carrying capacity of a cantilever beam. Galileo was the first to suggest that theoretically derived formulae be subject to experimental confirmation but strangely this was not done in the case of the cantilever resulting in a solution under strength by a ratio of three to one and masked in practice by applying a large factor of safety thus providing an example that a person of Galileo's reputation did not always get it right.

In conceptual failure analysis seven paradigmatic criteria emerge and these are:

1. Critical failure mode not identified
2. Inadequate design theory available
3. Incorrect design assumptions applied
4. Wrong appreciation of initial and service conditions
5. Arithmetical errors with parametric data
6. Scale effects and the extrapolation of the existing design envelope
7. Design changes introduced during work in progress

One would have thought that these criteria are always considered in design but experience shows that this is not the case. Engineers are known to rely on what has proved to be successful previously when extrapolating a design concept rather than going back to first principles.

A selection of examples identified with the paradigms above begins with the Robert Stevenson's railway bridge crossing the River Dee at Chester in 1846. Bridge design is always finding that solution capable of spanning the gap with its usually unique terrain with economy of construction and often where the span required exceeds that attempted previously but still using methods represented by the state of the art. Stevenson's solution was to use cast iron girder beams where the tensile loads in the lower face were relieved by the use of wrought iron tension bars to mitigate the poor tensile qualities of cast iron. These bars were of necessity along the the side face of the girder and such trussed girder bridges had previously been successful

on smaller spans. After completion the wooden decking supported between the lower flanges of the girders were, as an afterthought, covered with ballast to prevent falling cinders from locomotive fireboxes igniting the timbers thus further reducing the safety factor. In 1847 with a locomotive and four carriages travelling over the bridge, the out of plane tensile forces in the bars coupled with the compressive ones induced in the girders produced torsional buckling of the girders (a failure mode apparently not considered) causing the decking and crossbeams to fall into the river with the locomotive and carriages resulting in five deaths.

The Hartland Center Stadium in the USA covered around 2.4 acres. The bid accepted by the authorities was one where the designers proposed a spaceframe truss comprising inverted interconnecting pyramids supporting on the top face a flat roof panel. The designers had produced a computer program which treated the spaceframe as a statically determinant structure where each member was either a strut or a tie and where the minimum material use with its consequent effect on weight and cost could be demonstrated. For the spaceframe, by definition, all the reactions at a node must pass through a common point and difficulty must have arisen in the detail design when the connections at the nodal points were displaced resulting in certain struts receiving bending moments, a situation built into the construction at odds with the computer analysis. The structure collapsed under a snow load on the roof whose magnitude was within the design parameters fortunately when the Stadium, which had recently housed 5000 spectators,was empty.

Across the Atrium of the Hyatt Regency Hotel in Kansas City a series of suspended walkways (bridges) were built connecting a section of the building to the other parts of the hotel and these walkways were presented as a novel feature keeping the floor of the atrium clear of pedestrian traffic passing between the two sections. In the arrangement one walkway serving a higher storey was suspended directly above another connecting a lower level. The design had common vertical suspension rods passing through and connected to the upper walkway crossbeams terminating at the lower walkway crossbeams. The crossbeams were connected to the vertical rods by threaded portions each with a washer and threaded nut making a seating on the beam's underside to take the vertical load. It transpired that when all material was on site and erection commenced someone queried how it was possible to thread a nut halfway along a rod whose outside diameter exceeded the core of the thread. The solution offered was to cut the rods and suspend the top walkway directly and in turn suspend the lower walkway from the upper walkway crossbeam using a thread at each end of the rod. Calculations showed that the crossbeams were capable of taking the bending moment due to the upper and lower rods no longer being in line and this modification was accepted by the design office as the solution to the problem. What was overlooked was the elementary fact that rods to the upper crossbeams would now have to support the loading of the lower walkway in addition to that of the upper one. At a busy function when all walkways were loaded with revellers the upper vertical rods at one end of the walkway pulled through the crossbeam. The remaining upper rods progressively collapsed and some 167 people were killed.

The Tay Bridge disaster in 1897 is best known by engineers. Designed by Thomas Bouch to span the Firth of Tay as part of the North British Railway's drive for a direct rail connection from London to Dundee and beyond, it formed part of a multiple scheme to bridge the Tay and then in turn the Firth of Forth. At the design stage Bouch had asked the Astronomer Royal, Sir George Airy, what value of wind loading he should allow for in designing the bridge and Airy said 10 pounds per square foot, a quite inadequate figure which Bouch factored for safety. During construction sub-standard workmanship in the casting of the supports and in assembly on site

also contributed to the disaster on that stormy night. Bouch who had been knighted for his bridge before the disaster died a broken man. The Tay Bridge was rebuilt shortly afterwards and the design of the Forth Bridge was placed in the hands of (Sir) Benjamin Baker and (Sir) John Fowler who had to determine what maximum wind loading to allow for and there is a story that on the island of Inchgarvie in the middle of the Firth, Baker set up a wind gauge to determine the wind speed and from this a value for dynamic air pressure. This is a mystery as the formulae for dynamic air pressure as a function of wind velocity was not known at that time (which for 100mph winds equates to 34 pounds per square foot). In the event Baker designed for 55 pounds per square foot plus a safety factor and after his success with the bridge spent the latter part of his life trying to establish the true factors of safety in his design.

If one reviews these examples against the paradigmatic criteria given earlier its seems that with the notable exception of the Forth Bridge, sometimes more than one failure possibility had not been considered.

William Morris was an artist of considerable talent and whose contribution to society is perhaps best known for wall paper and furnishing patterns perpetuated today once said of the Forth Bridge "The supremist example of all ugliness". There has been another William Morris who later became Lord Nuffield who is less well known and arguably contributed more to this country and its citizens than the the former whose statement shows that some non-engineers are possibly unaware of what does constitute beauty. In the Forth Bridge the balance of scale between the main towers and the suspended spans for a structure designed to perform a service in the most adverse conditions is aesthetically pleasing. Designed in the wake of the Tay disaster and using the limited design knowledge of the day it was in the first instance a concept devised in the mind of two engineers who committed their ideas to paper and then subjected those ideas to rigorous theoretical analysis in the shadow of the Tay disaster. The above examples show that the use of conceptual failure analysis which implies developing a design from first principles should be encouraged in new entrants to the profession.

Ken Wheeler

Spring Break to Monschau 19th to 23rd May, 1997

There are still a number of vacancies for Double bookings, and two Singles are still available. We have decided therefore to open up the bookings to relatives and friends, so if any are interested will they please contact Woods Travel Ltd direct, Tel. No. 01243 868080 to make reservations. You are also reminded that it is advisable to obtain and complete Form E111 to cover free or reduced cost for emergency medical treatment in most European countries. The forms are available from the Post Office in a booklet entitled "Health advice for Travellers" and it also contains instructions on how to fill in the Form E111.

John Fowler

Visit to Vent Axia, Fleming Way, Crawley on Wednesday 15th January, 1997 at 2.30 p.m.

Even fan systems are high tech these days and this should prove to be an interesting visit. We will be met by Mr. David Vincent, who is the Technical Director, and the visit starts promptly at 2.30 pm. Limited car parking facilities are being made available to us; the entrance is in Fleming Way as shown on the map. Members intending to come along please reply to Ken Wheeler by Tuesday, 14th January 1997.

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To: K.J. Wheeler, 14 Musgrave Avenue, East Grinstead RH19 4BS Tel: 01342 321291
I wish to participate in the visit to **Vent-Axia** on Wednesday, 15th January 1997 at 2.30 p.m.

Full Name .....(Block capitals)

Address .....

.....

Phone No..... **Applications by 14th January, 1997**

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Visit to De La Rue Cash Handling, Portsmouth on Wednesday, 19th March, 1997 at 2.30 p.m.

This visit is understood to involve two sites devoted to the development and manufacture of cash handling machinery respectively and we will be received by Mr. Roger Prowen, the Engineering Director. Will members intending to visit advise Ken Wheeler by the 10th March 1997. Those responding will receive detailed instructions by post.

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To: K.J. Wheeler, 14 Musgrave Avenue, East Grinstead RH19 4BS Tel: 01342 321291
I wish to participate in the visit to **De La Rue Systems Ltd** on Wednesday, 19th March 1997 at 2.30 p.m.

Full Name .....(Block capitals)

Address .....

.....

Phone No..... **Applications by 10th March, 1997**

*I can provide ....seats in my car from ..... * I would like a lift.....

*Complete as appropriate

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