CEGB research

Structural Integrity Unit

Research Division

Central Electricity Generating Board

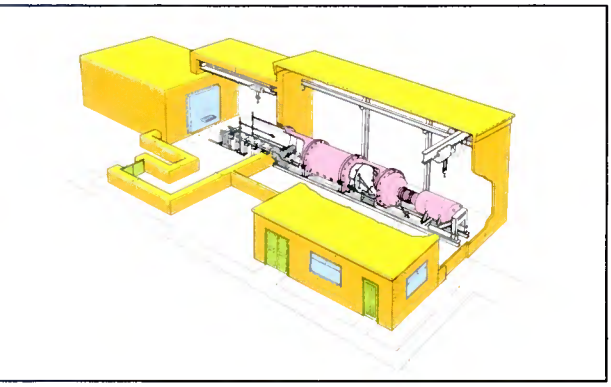






STRUCTURAL INTEGRITY UNIT SIU

Why the emphasis on structural integrity?



Horizontal Impact Facility at Winfrith used to test the strength of concrete structures.

Structural reliability of pressurised components and rotating machinery is a major factor in achieving profitability of the Board's power stations. Extended shutdown of high efficiency plant to repair defective components, particularly during peak demand, means increased expenditure as less efficient plant must be brought into operation. Losses of several £100,000's per week are incurred when a modern power plant is not available when needed.

In nuclear power stations there is the overriding consideration of safety. In all reactors a major failure of the reactor vessel, the coolant pipework, or heat exchangers cannot be tolerated.

The Structural Integrity Unit provides expertise which can be consulted on all questions concerning structural reliability. Contacts throughout the CEGB ensure that this expertise can be deployed promptly and effectively.

Breakheart Quarry is used to test components with significant stored energy.

The aim is to obtain safe and reliable operation by proper attention to design and construction of new plant. Nevertheless it is equally important that plant in service must be monitored to anticipate potential problems.

Recommended procedures and associated computer software are produced by the Unit. Engineers engaged on design and assessment work are thus able to make use of the most up to date research presented to them in simple language. Contact with British and international standards organisations ensure that concepts developed by the Structural Integrity Unit are available to a wide audience.

These advances in technology are only achieved with the support of a comprehensive and multi-disciplinary programme of fundamental research. A major contribution to this research is made by the Structural Integrity Unit in association with Universities, UKAEA, and other research organisations both in the UK and abroad. This provides the CEGB with the most up to date science to tackle its practical problems.

Cheddar Quarry used for testing behaviour of components when dropped.

Inset: *The test cells at Marchwood for testing pressure vessels.*

The major areas of expertise

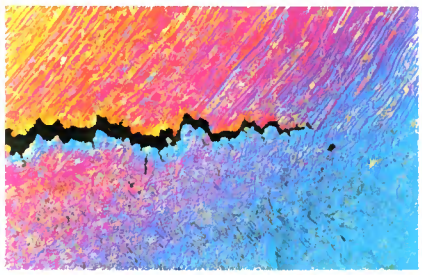
Structural analysis

The BERSAFE and BERDYNE suite of computer programs, has been developed in the Research Division to provide stress analysis of complex structures under static and dynamic loading. Special features are available for defect assessment, crack propagation and leak-before-break investigations.

Metallurgical research

Facilities are available to measure the properties of metals used in power plant. Data banks are being developed for materials already in use and there is an ongoing programme to assess materials with improved characteristics.

Fundamental research to investigate factors which determine the performance of materials is undertaken. Particular emphasis is placed on mechanisms of long term degradation. A special shielded facility is available to study the effect of radiation on materials.



Photomicrograph of a crack tip.

Defect assessment

Modern ultrasonic inspection techniques show that all welded structures contain crack-like defects. Procedures have been developed in the Unit to decide which defects are innocuous and which require remedial action.

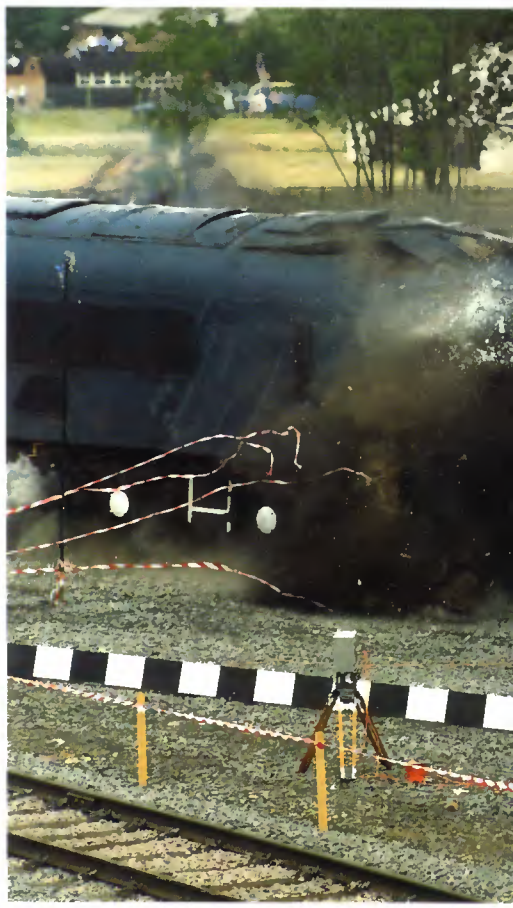
A comprehensive programme of research on post-yield fracture mechanics supports these procedures and the behaviour of cracks at high temperature is receiving increased attention.

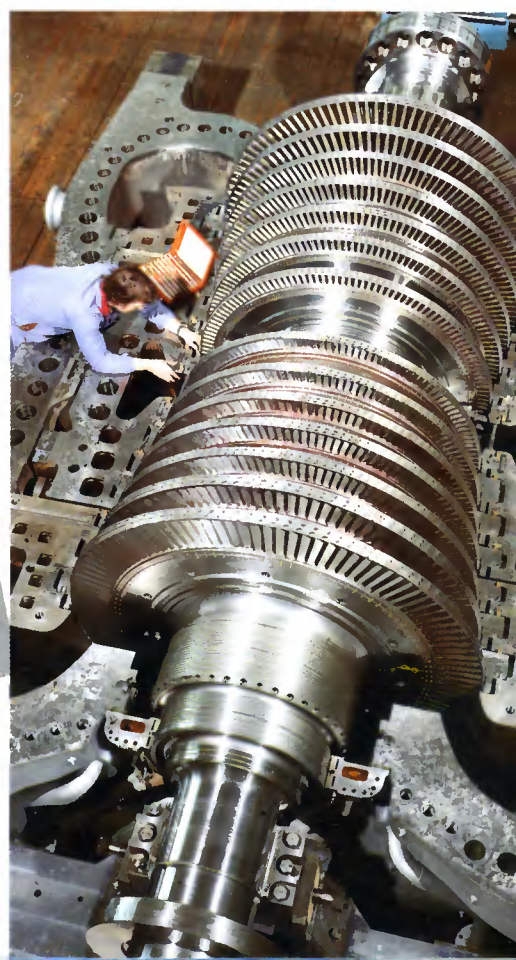
The shielded caves at Berkeley.

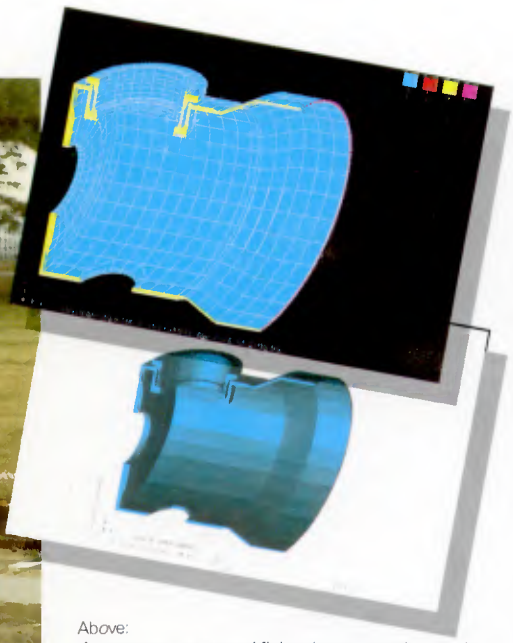
Welding technology

An extensive programme to study welding of power plant materials is in progress to ensure that fabrication procedures do not compromise component life. An important aspect is the evaluation of automatic welding processes and narrow gap techniques which are being increasingly employed in the industry. Transition welds between austenitic and ferritic steels are the subject for special study.

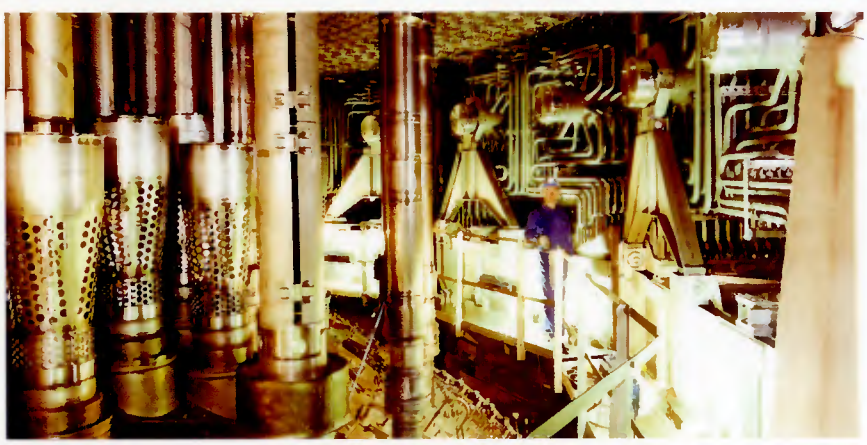
Experimental welding at Marchwood.







Above:
A computer generated finite element mesh to assist structural analysis techniques.



Top: *The ultimate test for a fuel transport flask — a 100mph impact with a railway locomotive.*

Above: *Inside an AGR reactor showing gas outlet region above the core.*

Left: *A modern steam turbine under construction showing the many discs of turbine bladec. Photograph courtesy of GEC Turbine Generators Ltd. Rugby*

Above Right: *Experimental impact of a ¼ scale fuel transport flask.*

High temperature structural mechanics

Many power station components have to operate at temperatures up to 565°C for up to 30 years. The behaviour of these structures forms an important part of the Unit's work.

Methods have been developed to evaluate stresses and strains and to predict safe working life. Simplified methods of analysis, based on shake-down criteria, are of particular interest since they replace expensive time-stepping calculations.

Plant life extension

There are strong economic reasons to continue operation of existing plant beyond nominal design life, provided this can be done without jeopardising safety and without incurring excessive costs.

For coal and oil-fired power stations methods have been developed to predict the remaining life of high temperature components in boilers, pipework and turbines.

Research into the factors affecting component life at lower temperatures has been used to extend operation of the earlier nuclear power stations. Work is now in progress which will be applied to the Advanced Gas-Cooled Reactors.

Concrete pressure vessels

The Advanced Gas-Cooled Reactors and last four of the earlier Magnox Reactors have concrete pressure vessels in place of the steel vessels of the earlier plant.

Research on the long term performance of the concrete and of the complete vessels is undertaken to provide an assurance of integrity throughout the life of the plant.

Structural dynamics

Excessive vibrations can lead to premature plant failure. A research programme investigates the factors which control vibrations in components, such as turbo-generators, nuclear pressure circuit internals and steam generator tube bundles.

The work is aimed at establishing what vibration levels are acceptable and deciding what remedial action, if any, should be taken.

Impact loads and the effect of earthquakes

Because of the need to establish absolute reliability in nuclear plant, components have to be proved to be safe under a variety of extremely improbable events. These include impact from debris resulting from failure of ancillary plant or from crashing aircraft. The component must be shown to be capable of withstanding a strong earthquake.

Another important topic is the demonstration that containers for transporting nuclear fuel elements will remain intact under extreme accident conditions.

Research and development in the CEGB

The Central Electricity Generating Board, as the major supplier of electricity in England and Wales, supports a massive research and development programme. The aim is to improve the reliability of the supply, to cut costs to the consumer, to advance safety even further and to conserve our environment as far as possible.

The scope of the R&D programme is remarkably wide. It ranges from studies of nuclear reactor physics, through many areas of chemical and engineering research to the ecology of the flora and fauna on land and in waters, which might be affected by electricity generation.

It is a highly technical programme employing over 3000 people and costing over £162M each year. Most scientific disciplines are represented.

The Research Division comprises three major laboratories, at Marchwood in Hampshire, Leatherhead in Surrey and Berkeley in Gloucestershire. A proportion of the R&D programme is also carried out in the Scientific and Technical Branches of the CEGB's Operational Engineering Division.

A CEGB Board member heads the Research Division. The research programme is managed through three Directors (Nuclear Plant, Conventional Plant and Environment), and the laboratories are under the executive control of the Director of Laboratories.

The CEGB leads the world in much of its research and encourages enquiries about all aspects of the programme.

Large test facilities for structural integrity investigation

No amount of theory can eliminate the need to undertake tests at full size or near full size, to demonstrate the validity of procedures which have been developed. Sometimes practical problems are so intractable that they can only be solved through large-scale tests.

The CEGB's Research Division has therefore made a major capital investment in large-scale structural testing facilities.

Marchwood Pressure Vessel Test Facility

Test cells at Marchwood Engineering Laboratories have been built to demonstrate that welds produced by new procedures or using new materials will give satisfactory performance in service, and will survive the imposed loads for periods up to 30 years.

The facility is capable of testing cylindrical vessels at temperatures up to 700°C and pressures up to 1200 bar. A recent development also allows end loads to be applied to the test vessels.

Breakheart Quarry

Failure tests of large pressurised components are carried out in a quarry near Berkeley Laboratories. Contained energies up to 18MJ can be accommodated. The programme includes:

(a) Test to validate defect assessment procedures.

(b) Tests on full size components to demonstrate integrity.

(c) Tests on pressurised piping systems subject to earthquake loading.

(d) Investigation of debris behaviour and pressure waves following plant failure.

Horizontal Impact Facility

The Research Department shares with the UKAEA one of the world's largest impact rigs which is located at the UKAEA's Winfrith Establishment. The facility is capable of projecting missiles, up to 2 tonnes in mass, at velocities up to 50 metres/sec. Smaller missiles can be projected at velocities up to 250m/sec.

This facility is used to study the damage caused to concrete structures and steel components when subjected to accidental impacts.

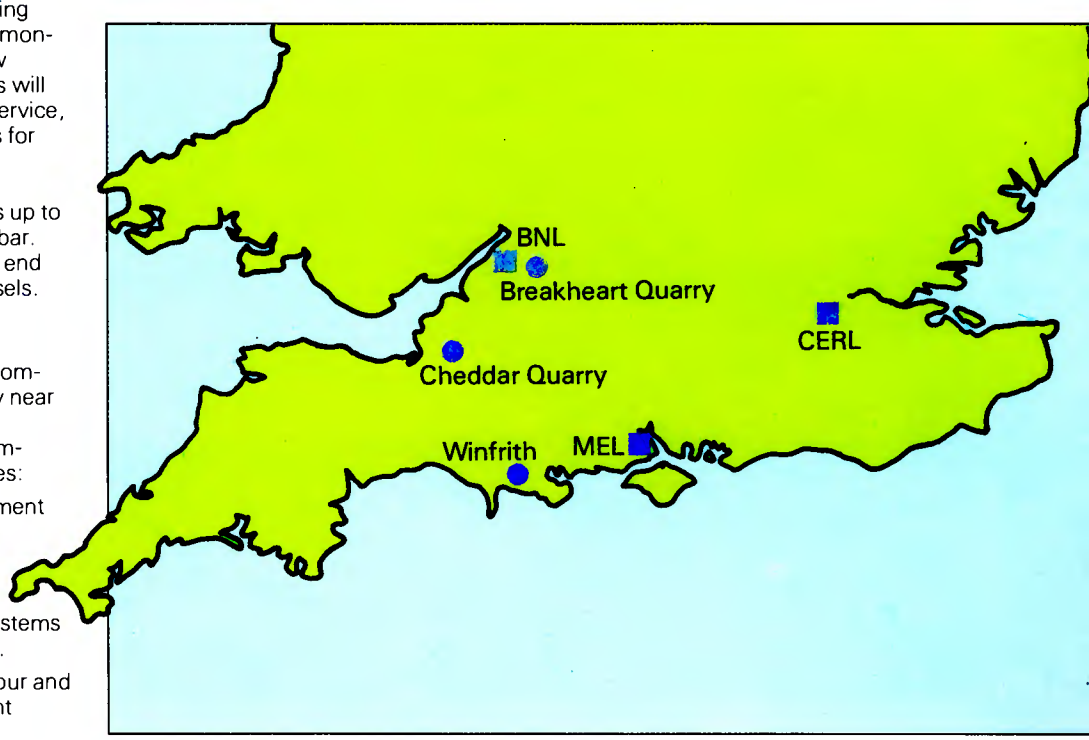
Cheddar Quarry

The Structural Integrity Unit can make full use of the Cheddar Quarry, operated by the Transmission Division of the CEGB.

The Unit uses the quarry for:

(a) Demonstrating that flasks for transport of spent nuclear fuel will survive extreme accidents.

(b) Investigating the safety of civil engineering structures under impact loads.



Addresses

Research Division

Head Office:
Courtenay House
18 Warwick Lane
LONDON EC4P 4EB
Tel. 01-634 5111

Berkeley Nuclear Laboratories
BERKELEY
Gloucestershire GL13 9PB
Tel. 0453 810451

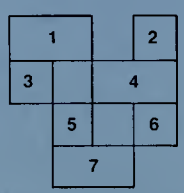
Central Electricity Research Laboratories
Kelvin Avenue
LEATHERHEAD
Surrey KT22 7SE
Tel. 0372 374488

Marchwood Engineering Laboratories
Marchwood
SOUTHAMPTON
Hampshire SO4 4ZB
Tel. 0703 663232

Further information about the CEGB's Structural Integrity Unit and the services it offers can be obtained from:

The Structural Integrity Unit Manager
Berkeley Nuclear Laboratories
BERKELEY
Gloucestershire GL13 9PB
Tel. 0453 810451

Front Cover:



1 *Berkeley Nuclear Laboratories — the centre for structural analysis.*
2 *Use of a scanning electron microscope.*
3 *Preparing a pressure vessel for testing at Marchwood.*
4 *Central Electricity Research Laboratories — the centre for materials research.*
5 *Inside of a power station furnace showing water-cooled tubes.*
6 *Simulating the effect of earthquakes in tubes.*
7 *Marchwood Engineering Laboratories — the centre for welding research.*

Further information on all aspects of the CEGB's Research programme can be obtained from:

The Divisional Public Relations Office
c/o Marchwood Engineering Laboratories
Marchwood
Southampton
Hampshire SO4 4ZB
Tel. 0703 663232

Published by the Divisional Public Relations Unit.
Printed by Chichester Press Limited.