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Engineering and forestry *in the UK*

Forestry in the UK has undergone many changes since the formation of the Forestry Commission over 80 years ago. Geoff Freedman discusses the technical, economic and social aspects of managing and exploiting the UK's forests, and gives insights into the challenges currently facing the industry.

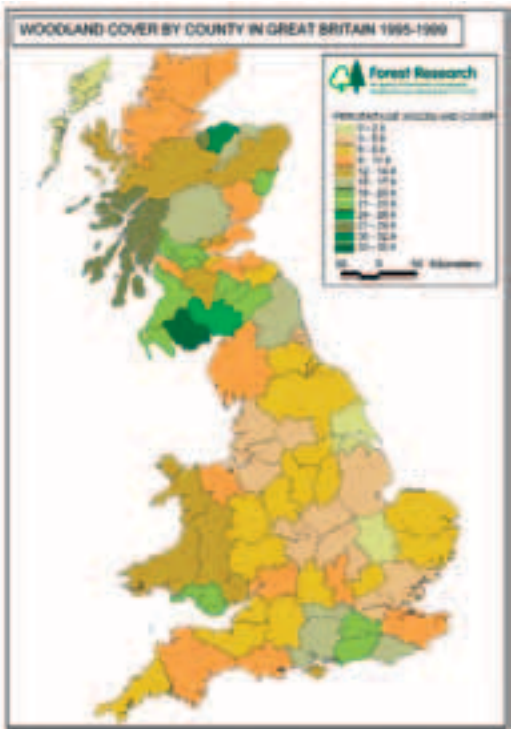
Beginnings

The First World War was almost lost because of the shortage of timber and, as a result, the Forestry Commission was formed by the government in 1919 to create a timber resource in case of further war and to save on imports. Timber was then used to provide pit props – necessary for coal production to feed the steel- and weapon-making industries. This new organisation also provided much needed rural employment for demobilised soldiers.

The major activity in the beginning was the planting of trees and so the first specialists were foresters, managed largely by retired commissioned officers. This 'building of the forests' continued and it was not until after the Second World War that the new plantations began to mature, and roads and bridges were needed for transportation of the harvested timber. During the 1950s engineers – civil and mechanical – began their specialism in forestry with many innovative ideas, as the infrastructure had to reflect the value of the industry. This meant that roads and bridges had to be of low cost while at the same time capable of taking the same weight of vehicles as the public roads. Steel joists and timber decks had been used for these bridges since about 1900, when steel beams became commercially available, but they corroded badly. Concrete had only recently shown its potential but it involved specialist design and skills to fix the reinforcement.

A typical innovative engineering idea brought an immediate solution to the building of 600 bridges very quickly and at very low cost. Following the introduction of buses for public transport, all of the uplifted tramrails from Liverpool were purchased. Sets of rails were laid side by side and concrete was poured over them to form a slab. The design was appraised by an eminent consultant 44 years ago and given approval. In May 2001, we carried out full-scale load tests at Newcastle University and concluded that those bridges, still well maintained, are suitable for the latest 44-tonne vehicles. This is indeed a tribute to the first 'forestry engineers'.

In those early days the vehicles were 20 tons and the chainsaw was only just appearing. Roads were built from gravel or as-dug rock; timber was cut and hauled to the roadside using horses and sometimes tractors. Planting was still a major operation and the Forestry Commission policy was to purchase any land that became available. This included many steep hillsides and flat bogs covered in peat. The waterlogged ground did not foster good tree growth so a policy of deep ploughing was introduced. Engineers were required to modify agricultural implements to tackle this new task.



Forest cover in Great Britain. Forests cover 2.5 million hectares, or 11% of the land area. 61% is coniferous and 39% broadleaves.

Specialist machinery arrives

During the 1960s mechanical engineering development moved fast and specialist machinery began to appear from abroad for moving timber across virgin ground. Concrete had become more sophisticated and 300 bridges were built using pre-stressed concrete. Road vehicles were becoming bigger and axle loads were increasing, so that roads began to need design rather than being built by rule of thumb. Engineers were suddenly essential for efficient forest operations.

During the 1970s, purpose-built forwarders arrived from Scandinavia (forwarders are the vehicles that pick up cut logs from the harvesting site and transport them to the forest roadside); this transformed the economics of forestry. Engineers were required to modify these machines for UK use on soft ground and a network of sophisticated specialist workshops was built around the country to adapt, service and maintain this hydraulically driven equipment. Road vehicles had now reached 38 tons and roads had to be built to accommodate them. The same developments continued during the 1980s but, in addition, the specialised harvester (the machines that fell, trim and cut trees) began to arrive.

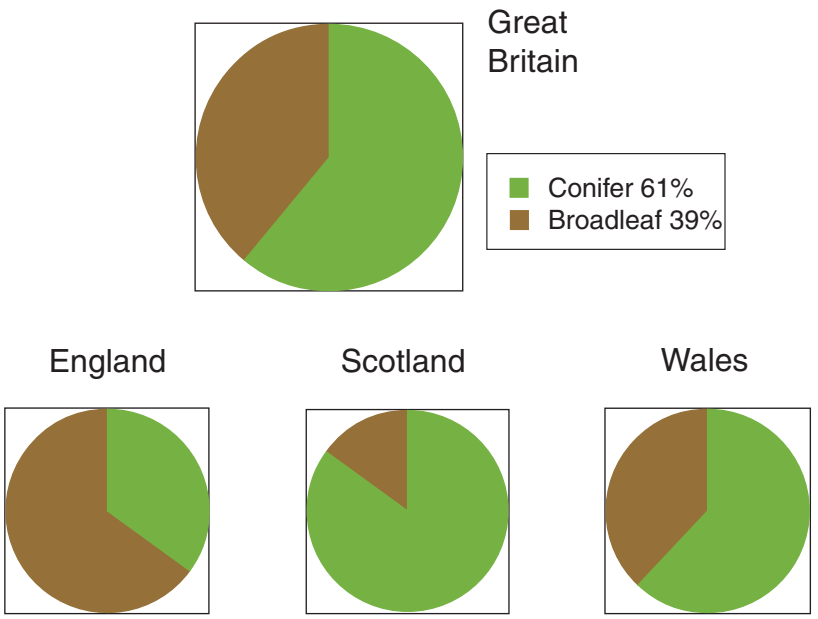
Recognition and policy-making

During the 1980s, a need was seen for forestry engineers to be recognised as specialists working within the agricultural industry and so the Forestry Engineering Group (FEG) was born, as a specialist group within the Institution of Agricultural Engineers (IAgrE). To date, we have held about 20 major conferences and are responsible for approximately 200 papers representing the thinking of the industry in the UK.

Many industry advances have been helped along through FEG Symposia and much knowledge has been disseminated to smaller units in the industry. This was important because during the 1980s the private sector, encouraged by government tax breaks, began to grow significantly and now comprises 50% of production forestry in the UK. Today FEG is still the only professional body representing engineering in forestry in the UK.

During the 1990s, government policy regarding the primary aims of public-sector forestry gradually changed, from simply providing a timber resource to increasing the social and recreational benefits of forestry combined with the environmental benefits that trees provide. Engineers have therefore taken on new remits to help fulfil the policies of multi-purpose forestry, for example:

- equipment must now minimise ground damage;
- ploughing is now outlawed;
- runoff from roads cannot enter drains directly;
- roads must not scar a hillside;
- bridges must not pollute the aesthetic or the river;
- treetop walks and visitor centres are seen as better value than commercial forestry.



Types of forest in Great Britain

Compacting a forest road to provide a smooth sealed surface

It is important to keep forest roads well graded.

Transport challenges

The industry is changing and facing new challenges. The 44-tonne vehicles are now well catered for in the forest but minor public roads, just outside the forest in the rural areas, are breaking up under the severe use. Last year the Forestry Engineering Group took a DTI ITS (International Technology Service) Mission to Sweden and Norway to look at their solutions to this problem and as a result, our proposals for the UK are now before the Minister for Transport in Scotland. One solution in the report is to convert minor public tarred roads to gravel roads which will be more easily maintained when damaged by large forestry vehicles. The industry does need to carry larger and fewer loads, as in Finland and Sweden. The introduction of 60-tonne timber lorries on selected routes between forests and mills could reduce pollution and improve economics.

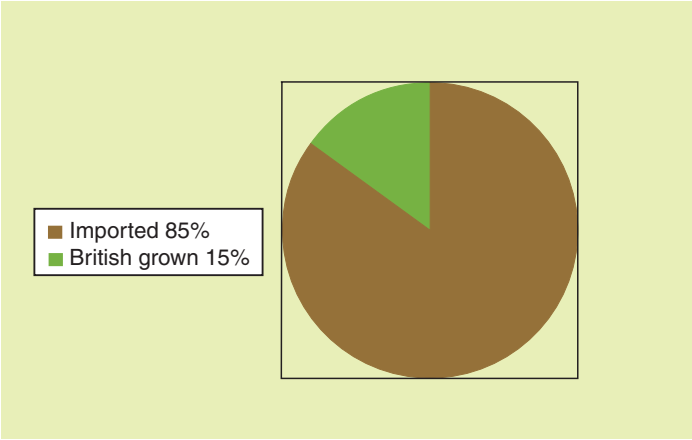
The economics of the forestry industry in the UK are so finely balanced that any advantage given to a competitor can make imports so much less expensive that it significantly affects the home market. Trees in the UK grow faster than in Scandinavia and therefore have lower density, thus are of poorer structural capacity, so we already find it difficult to compete in the structural market. Furthermore, because distances from forest to market are long the economic model hinges around the cost of transport. Sweden and Finland use 60-tonne vehicles and because they had them before joining the EEC, they have been allowed to continue to use them, thus providing these producers with an unfair transport cost advantage. There are no plans for allowing 60-tonne vehicles for general use in Europe but there are precedents of heavier vehicles being allowed on designated routes. If such an exemption were made for UK timber transport, the cost of taking trees to pulp and saw mills could be reduced and competitiveness increased.

The 60-tonne vehicles would be 24 metres long – 6 metres longer than the maximum allowed for general Construction and Use vehicles in the UK. However, the axle loads would be no greater than those allowed at present, therefore damage would not increase. This is a very important issue as damage is directly proportional to the 4th power of the wheel load, so a small increase in axle load can cause disproportionate damage to forest and public roads. The geometry of roads could present a problem but these larger vehicles would only be introduced selectively and most roads will handle the increased length of these articulated vehicles.

At the moment all timber is loaded at roadside, transported along the forest roads and then along public roads to market. If 60 tonnes were permitted, it is likely that double handling of timber would become economic. This means that specialised vehicles could transport timber through the forest to a loading area and the large 60-tonne lorries would then take it on the public roads.

Timber for construction

The timber industry in this country is centred around paper-making and chipboard production because this is what Sitka spruce, the main product of



Supply and consumption of timber in the UK

our forests, is most suited to. The structural timber market is presently only penetrated by home-produced timber by about 10%, partly because Sitka spruce is not of the required quality (as mentioned earlier). This is, therefore, the biggest potential growth area in the UK, but engineering needs to be added to this poor-quality timber. Production from our forests has doubled over the last 10 years and is set to double again in the next 10 but there are no ready markets.

We in Forestry Civil Engineering have taken on the challenge by initiating 'InTeC' (Innovative Timber Engineering in the Countryside) which will research new high-tech structural uses for timber by adding engineering. We are doing this in partnership with the Building Research Establishment, Timber Research and Development Association, working together with universities.

InTeC is proposed to be a 5-year applied research programme to find new ways to use home-grown timber for structures. Year 1 is complete and was very much a desk study of what has been happening elsewhere internationally and what needs to be done in the UK. Subsequent years will be a collection of specific research projects focused on producing something of value for a client. Much of the research is liable to be assimilation of current work completed elsewhere, adjusted to meet UK codes and available tree species. The first focus will be on highway structures because of their high profile and greater public exposure. If the public accepts timber for major structures, then architects and engineers will be more likely to use the material.

A low-cost lorry bridge

A more unusual timber bridge

The most important historic influences came from the USA and Canada in the 1970s when they began a major research effort into using their traditional construction material in a more sophisticated structural way. Many years ago, timber was available in vast quantities and in large sections which were easily utilised for structures. The modern engineering movements are employing smaller timbers and adding engineering to enhance their capabilities. Glue-laminated beams are common but, being expensive, only fulfil the needs of specialist markets.

The main challenge was to composite smaller sections more cost effectively. That was first done by the Canadians, who mechanically stress-laminated joists using steel post-tensioning bars. Timber slabs were produced for bridge decks at very competitive costs and this is one of the core activities of the InTeC initiative in the UK. It is a simple idea with an immediate market and is being exploited in many countries throughout the developed world.

Much valuable work has been done by Michael Ritter of the United States Department of Agriculture (USDA) and he has taken the technology to Australia where Keith Crews has taken the structural use of timber to a new level. The Nordic Timber Council, through Otto Kleppe and Eric Aashiem, are developing major structures along similar lines. They have recently built some very impressive cost-effective bridges over motorways, competing with steel and concrete and winning hands-down on aesthetic and environmental grounds.

Although highway structures will provide a high-profile use for timber, the building industry has the potential to use it in large quantities. To this end one early project connected to InTeC is the 'New Age Flitch Beam' being developed by the Timber Research and Development Association (TRADA) in conjunction with suppliers, manufacturers and Forestry Civil Engineering. Flitch beams are composites of steel plates and timber joists and have been around for a hundred years, but the new research employs a unique shot-fired doweling system to replace the original time-consuming and costly bolting. This project is nearing completion and will have immediate application for timber-frame houses. Large spans will be possible at lower costs than by simply using more timber, and connections will be revolutionised. Ongoing evaluation will no doubt find many new applications for this innovative idea.

New projects and resources

InTeC has evaluated about a dozen possible projects to develop the use of timber in ways new to the UK. The majority involve compositing with other materials but basic uses, for example telephone boxes, pillar boxes, road signs, crash barriers and commercial buildings, are all on the agenda. Separate projects will be set up and finance will have to be found from industry, although it is hoped that government departments can be persuaded to help in the initial stages.

Scottish Enterprise is helping forestry through a 'cluster industry' status, established a year ago, and one main project is to set up a centre of excellence for timber engineering in a university. This will ensure that young engineers and architects are introduced

to timber in a positive and constructive way which has previously been lacking in the education system in the UK. The undergraduate courses will be complemented by research in the same university and it is planned to offer training all the way to vocational level, to ensure that the skills needed to build and design timber structures are readily available.

The indigenous UK species of trees either grow too slowly to compete commercially or will not grow at all because the ground has been allowed to acidify through centuries of peat bog. Foreign species had to be found which would flourish in those adverse conditions and in the harsh climate with high winds. Sitka spruce from Newfoundland has been the most successful but, as discussed above, is not a good structural material with allowable bending stresses of about 4 N/mm^2.

Work has been going on in the UK's excellent forestry research centres to look at modifying trees to improve their density and growth rates. The work has been inconclusive and will probably not make significant inroads into UK forestry. Even if something significant were developed it would take a 50-year growth cycle before the benefits could be realised. There is already a healthy research programme in all aspects of establishing forests but little effort goes into improving timber engineering. The wisest investment in research in the near future will be in engineering the timber resource by developing ways of adding value to the presently maturing crop.

Forestry in the UK has come through many changes this century and, although it will always have a commercial arm, it is likely that the state sector will become dedicated to social forestry as has happened in the USA. Plantations will provide a resource and jobs but as society becomes more affluent, the forests offer an unparalleled opportunity to provide recreation and conservation areas. The environmental issues will gain momentum because biomass is the one controllable carbon sink, and although our forests are small in global terms, every country must provide its share. As new engineering methods of pelletising timber to enable it to be automatically fed into a heating boiler are developed, timber will become a useful fuel. This will further enhance the benefits of forestry by reducing the fossil fuel requirement.

> …forests offer an unparalleled opportunity to provide recreation and conservation areas …

Engineers continue to give the forestry industry a valuable service by introducing science and technology whenever and wherever required. The convocation in Helsinki earlier this year, organised by the international Council of Academies of Engineering and Technological Sciences (CAETS), showed how much added value engineers are bringing to the industry worldwide. Forestry is now a sophisticated materials-handling operation, requiring expert project management and continued technological input – surely the domain of engineering. ■

Web site

The Forestry Commission:
http://www.forestry.gov.uk

Geoff Freedman worked with consultants and contractors before joining the Forestry Commission in 1975. He is a fellow of both the Institutes of Civil and Agricultural Engineers and is President of the latter. He is currently one of the leading design consultants in the UK for a wide range of rural structures. He is active in allied applied research, for example he is chairman of Innovative Timber Engineering in the Countryside and leader of a DTI project on road specifications. Email: geoff.freedman@forestry.gsi.gov.uk