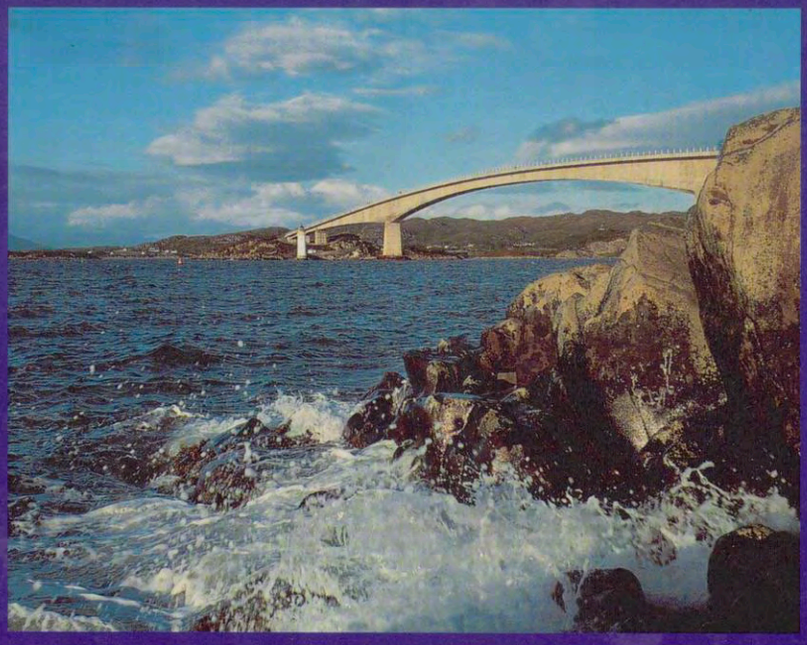
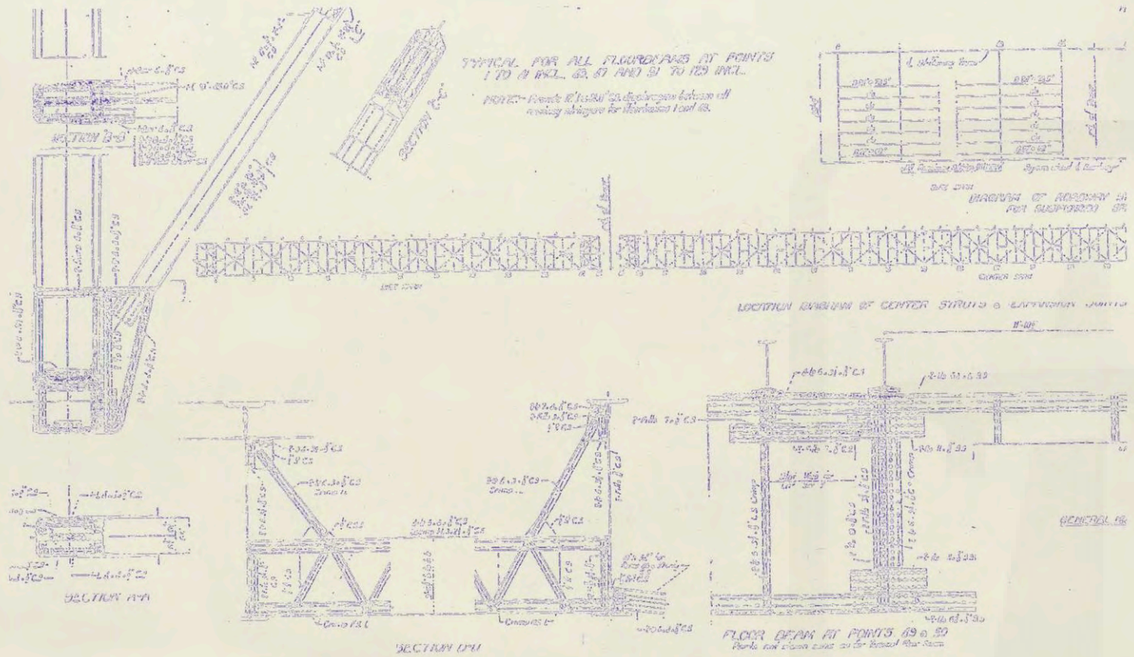
The Ministerial Opening of

the Skye Crossing



Linking the Isle of Skye with mainland Scotland



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the Opening of the Bridge to Skye

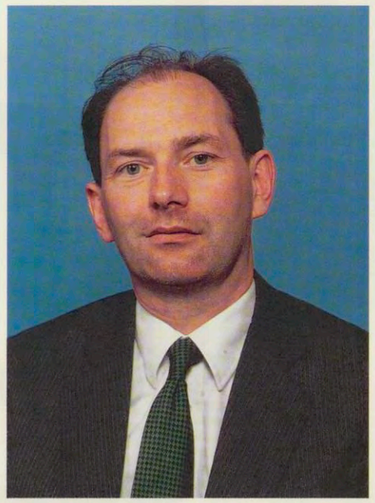
Performed by
THE SECRETARY OF STATE FOR SCOTLAND,
THE RT HON MICHAEL FORSYTH MP

MONDAY 16th OCTOBER 1995

Contents

Foreword	5
Introduction	6
A View from Skye	7
The Skye Crossing	9
The Private Finance Initiative	11
PFI - A Bridge to New Infrastructure Horizons	14
The Design Challenge	17
The History of Our Company	19
A Fitting Approach	20
Building the Bridge	25
Caring for the Environment	29

Foreword

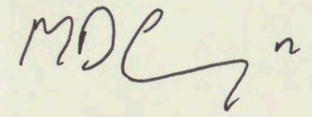


Rt Hon Michael Forsyth MP
Secretary of State for Scotland

I am delighted to participate in such a significant day in the history of Skye and the Highlands. The dream of a permanent link to the mainland has been longstanding, and it now becomes a reality. This is a major achievement for all those who have campaigned over the years and for the designers and constructors of the bridge. They have met the challenge of one of the harshest and most demanding environments to provide one of the world's longest span balanced cantilever bridges.

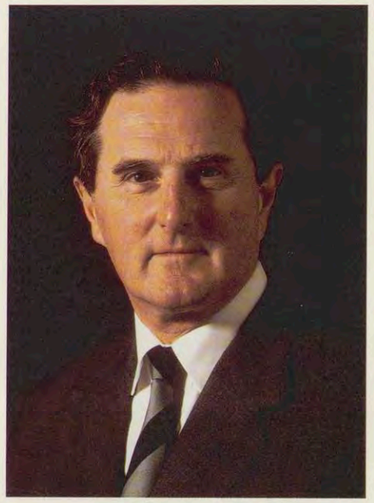
I congratulate all those whose contribution has been invaluable to the success of this project - Highland Regional Council, Skye and Lochalsh District Council, Kyleakin and Kylerhea and Kyle Community Councils, my own officials in the Scottish Office and JMP Consultants Ltd the consulting engineers, together with Skye Bridge Limited, Bank of America, Miller Civil Engineering Limited, Dykerhoff and Widmann AG, Ove Arup and Partners and Holford Associates.

I am also grateful for the sound advice from Scottish Natural Heritage, The National Trust for Scotland and finally to the Royal Fine Art Commission for Scotland. They all know the true measure of their achievement and should be confident that their work will be appreciated many times over the years to come.



Rt Hon Michael Forsyth MP
Secretary of State for Scotland

Introduction

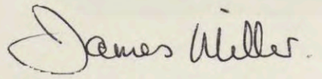


James Miller CBE
Chairman, Miller Group Limited

The Skye Bridge is a quite remarkable construction achievement. It is one of the largest and most complex structures that we have ever built. It is also remarkable for the close partnership forged between private and public sector to develop the bridge, because of its singular elegance, the beauty and romance of the environment in which it now stands and because of the sheer effort it demanded from the Miller-Dywidag team. I cannot remember any project which has proved so challenging to deliver or which has commanded such intense public interest during its construction.

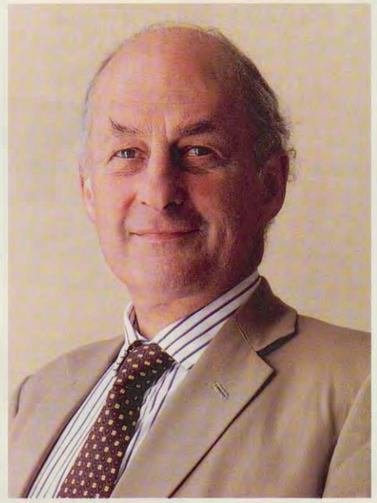
The design chosen for the main cantilevered span stretched modern construction technology to its limits and demanded constant innovation and flexibility from our team. Much of the intricate construction activity took place in harsh winter conditions during which the only access to site was by sea. John Henderson, the Miller-Dywidag Project Manager, and his team had the onerous task of building this bridge in an area of particular environmental significance and every stage of the construction was watched closely and reported upon by the world's media. They are to be commended, not only because of their achievements as engineers, but also because of their sensitivity to local feeling and their forbearance in the face of the controversy which has surrounded the project since its inception.

One other factor which sets this bridge apart from any other we have built is our continuing involvement in its life as shareholders in the development company, Skye Bridge Limited. With other projects an opening ceremony usually signals an end to our involvement; on this occasion it is a milestone in our involvement with Skye and its people. I believe the time will come, in the not too distant future, when the Skye Bridge will be recognised as one of the most outstanding and beautiful bridges in the world.



James Miller CBE
Chairman, Miller Group Limited

A View from Skye



Sir Iain Noble
Chairman, Skye Bridge Limited

Failte gu drochaid na stri, dorus ùr an Eilein Sgitheanaich. Cha tig adhartas leis fhèin ach ro thric le aimhreit tùrsach na chois.

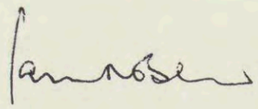
There will be few of us who will not experience a pang of emotion, nostalgic or otherwise, when we first cross over the new brig to the mainland from Skye. It may not be one of the seven wonders of the world, but it is surely one of the wonders of Skye, a technical feat of engineering by world standards, a symbol of man's presence in the Misty Isle. For that alone it is worthy of admiration and is there not majesty in the way it leaps soaring from Skye to the other shore? Farewell to ferry waiting. No more frayed tempers at the Styx.

The brig has already been the subject of world-wide debate on many issues, especially tolls, jobs and otters. But the truth is that, for many, the brig will be cheaper, taking into account summer and winter rates, and will also give valuable time savings for commercial vehicles. These diminished costs may run for about 15 - 18 years in present estimates, and a maximum of 27 years. Then the bridge will revert to the Secretary of State for Scotland and become free of charge. That is not long compared with many a house mortgage.

Controversial this project may have been, but it is time to put the past behind us. The world shall not know us as an isle of complainers, for we are a successful community with a growing population, centres of intellectual excellence, positive creative attitudes and a history to be proud of.

Our island is home to an important culture and civilization, one of those which created Europe, introduced the iron age and kept the lamp of learning alive in the dark ages. A culture rich in poetry, music and tradition, from which came the founders of Scotland, and a language which, with Latin, was used by scholars before English existed. This culture we can now export across the brig for the benefit of Europe.

The achievement of the builders is well recorded elsewhere in this publication. Let us salute them. Farewell to the ferrymen, long live nostalgia, and welcome to the new brig "Drochaid an Eilein" and a new age in Skye.



Sir Iain Noble
Chairman, Skye Bridge Limited

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Elsydel would like to congratulate Miller Dywidag on their engineering achievement and wish them every success with the operation of the bridge.

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JMP Consultants Ltd

As Consultants to the Scottish Office, and latterly as the Secretary of State's Agent, JMP has been involved with the Skye Bridge Project since 1972

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the Skye Crossing

The road to Skye was not always by Kyle of Lochalsh and Kyleakin. Originally it came down Glen Shiel and over the steep and twisting pass of Mam Ratigan climbing to a height of 800 ft and then down to Glenelg and on to Skye across the short but treacherous waters at Kylerhea.

That was the way the cattle drovers went in the 17th Century taking hardy black cattle from the outer isles and Skye to the trysts at Falkirk and Crieff and hence to the lucrative English markets. In a season they would swim as many as three thousand cattle across these treacherous waters. That was the way the soldiers came and General Wade built barracks at Berera to house the Redcoats. Here Dr Johnston and James Boswell crossed on their famous journey through the Highlands in 1723. Later Thomas Telford in his comprehensive upgrading of the Highland road system in the late 18th Century considered this to be the correct route but even he did not attempt to bridge Kylerhea.

However, in the late 19th Century all that changed with the coming of the steamers from Glasgow and Oban to Kyleakin and on to Portree and the construction of the West Highland railway line which reached Kyle of Lochalsh just a hundred years ago. The Glenelg route went into decline because the early motor cars found it easier to avoid Mam Ratigan and make the crossing at Kyleakin. It was a precarious business with the vehicle perched on planks across the thwarts of a rowing boat and later a small turntable motorboat. This continued with modest improvements until the mid 1900's and the author has vivid memories of the excitement of taking a car and caravan across the ferry in 1949.

Nevertheless, the thought of building a bridge to Skye was never far from people's minds and about the time that the first bridge was built across Loch Long at Dornie it was mooted that a low level bridge with an opening span could be built approximately on the line of the present bridge. Costs were too high however, and the matter was never taken up.

Pressure was brought to bear to provide a better service and for the first time the ferry operated on a Sunday, much to the initial displeasure of the Ministers of the Kirk who staged a token protest by sitting down on the jetty as motorists boarded the ferry on that first Sunday.

A bridge was considered again and the Scottish Council (Development and Industry) commissioned a study in 1969, the recommendations of which were that a suspension bridge should be built approximately on the line of the existing ferry. The bridge would have had a central span of

Loading Cattle at Kyleakin.
(From an early print)

By the 1960's, with the substantial improvement in the road network both on the mainland and Skye the pressure on the ferry, which had been taken over by Caledonian MacBrayne in 1935, was immense and at the height of the summer, queuing for four hours was not unusual.

1200 ft (365m) and have a clearance of 80ft (24m) for shipping. It was estimated to cost £3,000,000 and provided that a 50% grant was available, the cost could be met by tolls based on the ferry charges at that time and a traffic flow of 230,000 vehicles per year. The scheme was not taken up, but Inverness County Council decided to monitor the growth of traffic on a more formal basis and in the early 1970's several reports indicated that traffic was growing at a rate greater than the national average, so that by the mid 1990's it would be difficult to sustain a reasonable ferry service and the boats should be replaced by a bridge. In 1986 a full feasibility study was carried out which identified that traffic had grown to 300,000 vehicles per year and would reach half a million by the turn of the century.

Three possible routes for a bridge were considered as well as a line for a tunnel. The tunnel although being visually unobtrusive was rejected on the grounds of high capital and maintenance costs. Of the bridge routes the preferred line crossed the Plock and Eilean Bahn to Doctor's Rock, in fact the line ultimately chosen. Cable stayed and box girder bridges were examined and the recommendation was for a box girder bridge in concrete or steel. The study also examined the economic and social aspects of the bridge and found that some 70% of the people of Skye supported the building of a bridge and the replacement of the ferries.

On financing the bridge it was found that it would appear unlikely that the costs could be met from local government road funds and only a small proportion of the capital costs, could be met using tolls equivalent to those on other esturial bridges in Scotland.

Recognising the difficulties, Highland Regional Council turned to the Scottish Office who themselves had the problem of competing projects and limited resources.

However, with a change in government policy and the encouragement to the private sector to become involved in infrastructure construction, Highland Regional Council asked the Scottish Office to take over the project as a trunk road. The private sector approached Highland Region suggesting a bridge could be privately funded. The Scottish Office concurred with this view and Highland Regional Council accepted that a bridge be provided by private finance with tolls reflecting existing ferry fares. The Scottish Office decided to run a competition for a bridge to Skye. The competition was launched in 1989. The rules were that the developer should choose whichever bridge form he preferred and whatever route, design and build the structure to the exacting requirements of the Scottish Office, and then fund it with tolls that would be no more than the cost of the ferry fares. The total cost recovered through tolls was to be limited to a fixed value at the award of tender. This value is now enshrined within the contract. When this value is reached the bridge will be toll free. The competition attracted considerable interest from the European construction industry, all of whom chose the route across the Plock and the islands and rejected as too expensive a tunnel or a crossing on the line of the ferry.

Ultimately three competitors submitted tenders for the crossing these were Trafalgar House, Morrison Construction and the winners Miller-Dywidag.

Chris Ford
JMP Consultants Limited
Secretary of State's Agent

the Private Finance Initiative

Another First

The Skye Bridge is a first in more ways than one. As well as being the first time Skye has been joined to the mainland, it is also the first privately financed road project to be completed in the UK. It is an important milestone in the Government's Private Finance Initiative, or PFI.

Since its launch in November 1992, the PFI has quickly become a key part of the Government's strategy for delivering high quality and good value across the whole range of infrastructure and services needed in a modern and competitive economy like the UK's. The PFI unleashes the resources and expertise of the private sector for the good of the whole community.

The Scottish Office has a long track-record of innovation in public sector procurement, particularly where roads are concerned. It is no surprise to discover that it has been a champion of the PFI from the outset. Today's achievements and tomorrow's exciting possibilities are built, like the Skye Bridge, on solid foundations.

Ideas: made in Scotland

Scots have been - literally - breaking new ground in road construction ever since John McAdam revolutionised road building in the early 1800s with his invention of macadamisation. In recent years, innovation in procurement and contract forms has been added to engineering innovation. The Scottish Office has led the Government's search for new ways to transfer risk and control costs.

Among the first steps down this road was the Scottish Office's Alternative Tendering Initiative (ATI). This was born of increasing dissatisfaction with poor on-site relationships.

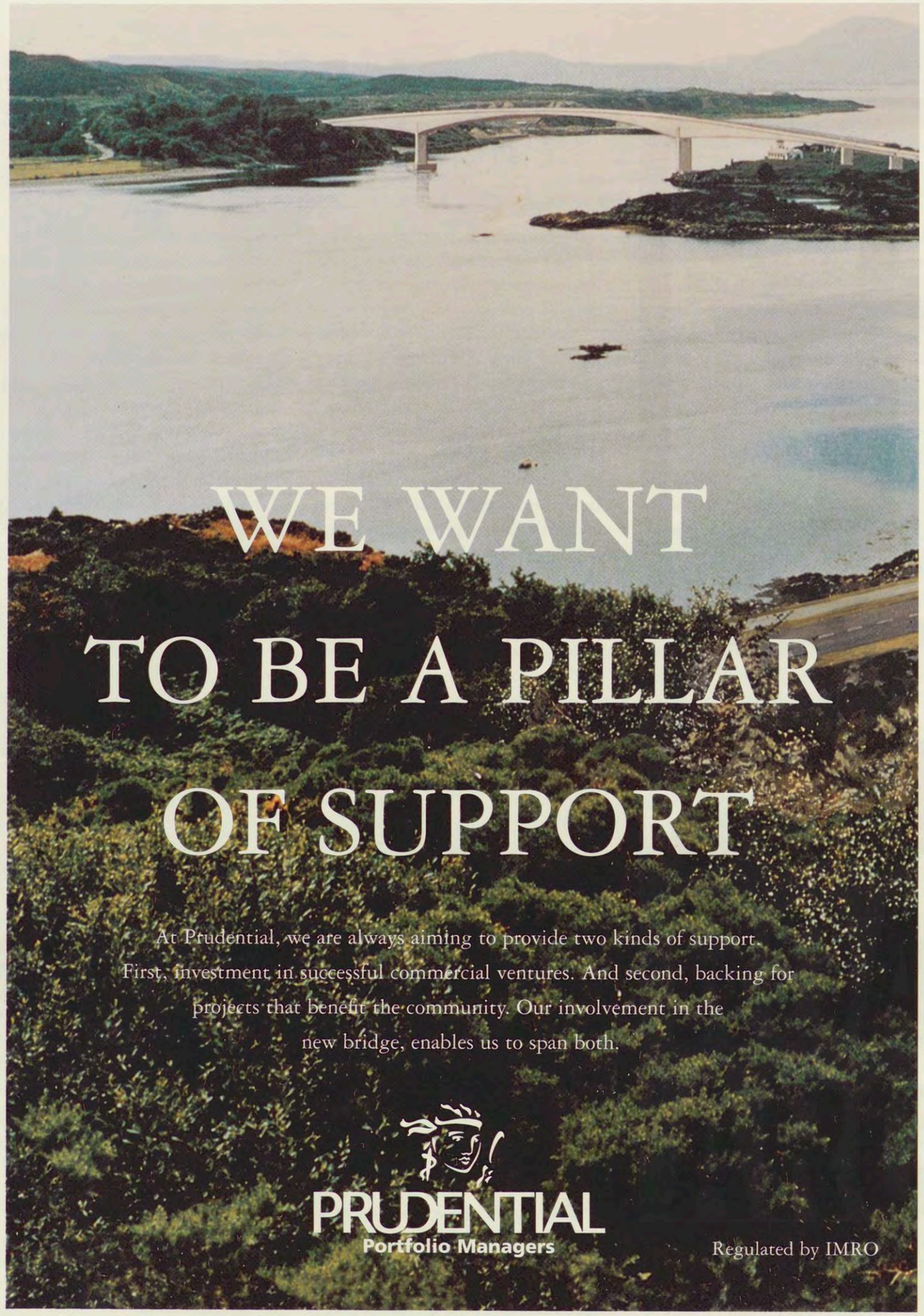
Conventional tendering placed responsibility for the design with consulting engineers working for the client and responsibility for construction of the works with the contractor. This could, and did, lead to wasted time and money. In particular, it wasted the efficiencies which a good contractor could offer, simply because it did not give contractors the opportunity to realise them.

At the heart of the new approach was the transfer of risk. The Scottish Office looked at the risks being borne by the public sector and realised that many of them could be better handled by contractors. The guiding principle should be that risk should lie where it was best managed, and the aim was to strike the right balance between cost, return and risk. The private sector could not be expected to take on risk for no return; but where it could manage the risk better, it may earn a reasonable return and provide better value for money for the taxpayer.

The result of this new thinking was new contract forms. Contracts on a 'Fixed Price Lump Sum' basis transferred the risk of cost over-runs and the reward for cost savings to the contractor. 'Design & Build' contracts allowed contractors to realise efficiencies by designing work to exploit their own strengths or specialities.

Bridges: test-beds for innovation

The Scottish Office's first 'Design & Build' contract was for another important bridge, also in the Highlands and Islands of Scotland: the Kessock Bridge, just north of Inverness. Since then, much has been learned and contract conditions developed to change the old adversarial relationships to the new constructive partnering approach. Over 20 schemes with a total value exceeding £300 million have been tendered in these new ways.



These have included projects such as the A9 Dornoch Bridge, the A90 Brechin Bypass and the M8 St James Interchange. When it was tendered, the last of these was the largest 'Design & Build' road contract in Great Britain. The £30 million project had a cost over-run of just one half of one percent. This can be compared with the 28% over-spend noted by the Public Accounts Committee on conventional contracts, and the benefits of this method of procurement are obvious.

Beyond cost control

Better control of costs, though, was not enough. The Government wanted to find a way of presenting its projects as investment opportunities and creating incentives for keen financial management. A combination of new legislation (the New Roads and Street Works Act of 1991) and the coming of the PFI provided the answers. This Act made it possible for the private sector to propose and carry out privately financed road schemes. The contract for the Skye Bridge is the first such scheme in the UK. Under the New Roads and Street Works Act, the Miller-Dywidag joint venture agreed to design, build, finance and operate the bridge in return for the right to collect tolls on the bridge until it has recovered an agreed total sum.

The Skye Crossing under construction

The Skye Bridge is the UK's first DBFO (Design, Build, Finance and Operate) road scheme. In fact, the idea pre-dated the PFI, its origins being in a proposal by local residents and subsequently a feasibility study carried out by Highland Regional Council. The bridge would have been unable to find a place in the public procurement programme for years to come: instead, it has been designed, built, financed and opened with private finance, and when the costs of construction are covered, it will be free of tolls.

Private finance: the future

This record of innovation has not stopped with the Skye Bridge. While it was being built, the principles of private finance have been developed further. The Scottish Office is examing new ways in which private finance can bring substantial benefits to Scotland's people and its economy.

Scottish Office Industry Department

PFI - A Bridge to New Infrastructure Horizons

Although started prior to the Chancellor's Autumn 1992 statement launching the Private Finance Initiative, the Skye Bridge is rightly regarded as being the first PFI project in Scotland and is an excellent example of what the PFI approach can achieve by combining public and private sectors in the delivery of a great infrastructure project which neither sector could have delivered on its own.

It is important to recognise this success and the factors contributing to it at a time when much criticism has been levelled at the PFI. That criticism however, may, in large measure, reflect an imperfect understanding, among certain members in the construction industry, that the PFI has brought fundamental change to the way in which the public sector procures infrastructure projects.

What has changed is that the Government now seeks to take infrastructure projects "off its balance sheet" by ensuring that the financial risk is assumed as far as possible by the private sector, the latter being remunerated from revenues generated by projects over their lifetimes. This is largely uncharted water for all concerned. It must be navigated carefully and this, among other considerations, has caused delays to projects coming forward. On maps of the world, cartographers used to put on parts which were then unexplored "here there be dragons". The same may be said of the deep waters of the PFI in its new applications and guises.

What lessons does Skye Bridge teach us for the PFI process? The first lesson is that there is to be no such thing as a standard PFI contract. Although the experience gained on the Dartford Tunnel and second Severn projects was invaluable it had to be re-engineered to meet the particular requirements for the Skye Bridge. The second lesson is that the problems of allocation of risk and reward in PFI Projects will increase in subtlety as PFI applications expand beyond bridges and roads (where risk can be readily recognised and revenues readily measured) to areas such as delivery of infrastructure services in hospitals, water and sewerage, education or even prisons. Much more sophisticated techniques of measuring the use of resources and the efficiency of design will be required, for example, in an NHS Trust hospital concession than in the case of a toll bridge and modesty forbids discussion of the proper basis upon which one measures the efficiency of a sewerage system!

The lawyer on a PFI transaction will, however, find a positive attraction in abandoning prescribed forms of contract and "can't do that" reactions and engaging with the open-ended challenge to his forensic and analytical skills which is involved in the successful design and conclusion of a PFI project.

The PFI is about allocating risk to the party which can best manage it. Checking what those risks are, analysing their nature, and documenting their allocation is the essential role of the PFI lawyer in conjunction with the other professional advisers. He has to seek out the intentions of the parties as to such matters and to ensure that the contractual documentation, at the end of the day, reflects those intentions.

The successful PFI lawyer will need to call on his old skills in construction law, company law, joint ventures, employment, banking and environmental law and, applying his skills of analysis, lateral thought and contract negotiation, apply these to maximum efficiency in this new environment.

The continued development of PFI in Scotland must encompass the art of the possible. It can be foreseen that the private sector will criticise the public sector for imposing "equity risks" but paying "lenders rewards". The Treasury does not accept that criticism, but potential players in the PFI market will need to be continually aware of the new legal environment they are entering into and to remember always (to parody the Scriptures) that it profits a company nothing to gain a PFI project but to bankrupt the company.

However, for imaginative operators who can undertake a proper legal analysis of the risk profile and obtain contractual documentation which secures an appropriate risk allocation, the prospects will be exciting.

Paul W Hally
Shepherd & Wedderburn WS

FOR THE FIRST TIME SINCE THE ICE AGE, THE ISLE OF SKYE IS LINKED TO THE MAINLAND.

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DYWIDAG

the Design Challenge

The new connection between the mainland and the Isle of Skye, the 2,400m crossing, consists of approach roads and two bridges; the 200m long Carrich Viaduct connecting the mainland with the two small islands, Eilean Dubh and Eilean Bahn, and the main Skye Bridge spanning the 400m wide navigational channel.

From the beginning of the planning process for the Skye Crossing the following criteria were of primary importance:

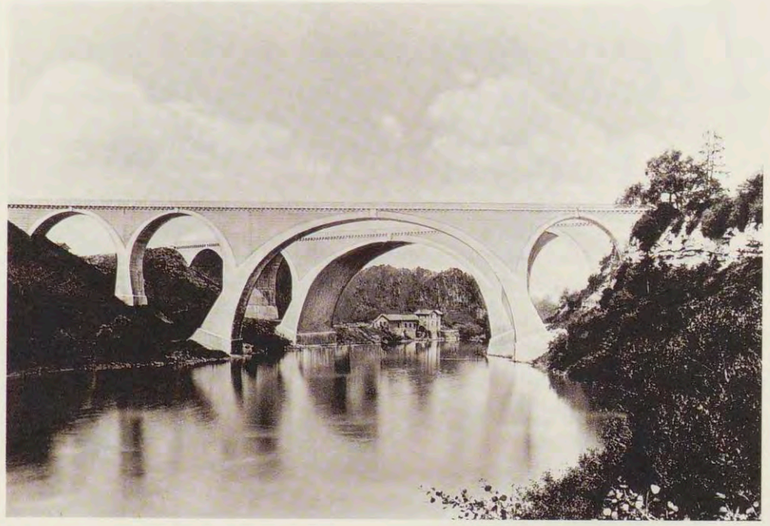
- integration in the surrounding landscape and seascape;
- appearance from near and distant viewpoints;
- durability;
- long term maintenance.

Various types of bridges, such as steel trusses, concrete arches, cable-stayed and concrete beams with a range of alternative solutions for the main piers or pylons, were considered during the design competition.

Main Bridge Design

The 400m navigation channel is spanned by a symmetrical frame with a main opening of 250m and sidespans of 125m. Both main piers are founded at a depth of some 12m below the water surface. Although the rock pressure is very high, due to the unbalanced moments under construction and the specified ship impact loads, the strength of the Torridonian sandstone permits a flat foundation. As a result of the adopted construction, the foundation consists of a prefabricated 17m diameter caisson and a foundation slab, cast in-situ after placing the caissons in the planned position, anchored with rock anchors and dewatered.

Completing the main span



An early Dywidag bridge over the Iller, Kempten 1904 / 1906

In order to reduce the stresses in the legs of the frame caused by restraint of the long term shortening of the superstructure, the stiffness of these legs was minimized and the free length of the piers increased to 27.9m by founding them on the foundation slab and leaving a gap between the piers and the mass concrete within the caisson.

The bridge has two traffic lanes with a foot/cycle path on both sides of the carriageway. The main dimensions of the cross-section - 12.5m construction depth at the piers, 4.7m at mid-span - result from the statical and structural requirements. However, the complicated detailed geometry of the cross section was determined by aesthetic considerations. The relevant features are:

A chamfer, cutting the bottom corners of the box section at 45 degrees. At the pier, the height of the web is reduced by 1.60m and the width of the bottom from 6.30m to 3.70m. The chamfer tapers to zero at a distance of 70m either side from the pier axes. An inclined flare, above the chamfer, tapering from 2.30m depth at the pier to 0.15m at a distance of 70m either side from the pier axes. Texturing of the outer web surface with a ribbed wood-textured surface contrasting starkly with the smooth surface finish of flare and chamfer. 1.20m deep, slight inclined fascia panels to accentuate the line of the bridge deck. The connection of the bridge deck with the top of the pier.

The completed structure shows that the desired effects have indeed been achieved and that the strong lines of the deck, the chamfer, the flare and texturing combine to create a surprising interplay of light and shade - a constantly changing image within a constantly changing landscape.

The development in the construction of concrete bridges of this type in the specific features of the Skye Bridge can be best seen when compared with similar bridges - the Bendorf Bridge over the Rhine built in 1962 and the Schweich Bridge over the Mosel built in 1972. To accommodate the longitudinal displacements due to shrinkage, a movement joint was located at mid-span in the case of the Bendorf, a movable bearing under a pier in the case of the Schweich. The avoidance of such joints or bearings in the exposed marine environment was an important feature of the Skye Bridge design and only possible by using a slender monolithic frame structure.

From the first preliminary design to the last construction drawing, the design of the Skye Bridge was a great challenge for everybody concerned and it has pushed free cantilever concrete bridge construction to a new limit.

Joachim Winkler
Designer Representative Miller-Dywidag

the History of our Company

Dyckerhoff & Widmann AG are based in Munich, Germany, they are pioneers in the concrete field and have produced many of the finest structures worldwide. More commonly referred to as DYWIDAG, an abbreviation of their full name, they are one half of the joint venture to build the bridge to Skye.

Dywidag created the basis for concrete technology which was being developed in the 1800's. This was achieved by carefully grading the particle size of gravel and sand, adding small amounts of cement and the minimum quantity of water possible. Only after the development of this process of concrete production did the use of concrete for load-bearing systems become possible.

The development of prestressed concrete construction is inseparably connected with the name of Dyckerhoff and Widmann. The free cantilever construction method opened up new possibilities for large scale bridge construction. The introduction of light weight concrete meant that the further fields of application were open to concrete construction as can be seen by the Skye Bridge.

Dywidag were also behind the idea which brought about a revolution in large scale hall construction. Shells are used all over the world as northlight roof buildings for many large industrial sites.

All over the world, structures designed to meet the most exacting demands are convincing proof of Dyckerhoff and Widmann's outstanding technical knowledge; more than 600 free cantilever bridges, large scale cable stayed bridges in Europe, the USA and Asia, the world's largest aircraft hanger in Frankfurt and the world's largest ski jump in Oberstdof.

A Fitting Approach

Ove Arup & Partners

Ove Arup has been a member of the design team for the Skye Crossing and as such has been involved in a number of different elements. They have undertaken the detailed design of the approach roads to the scheme, the geotechnical investigation and design for all of the scheme including the bridge foundation, the study of the hydrographic effects, the collection of traffic information and the checking of the design of both the main and secondary bridges.

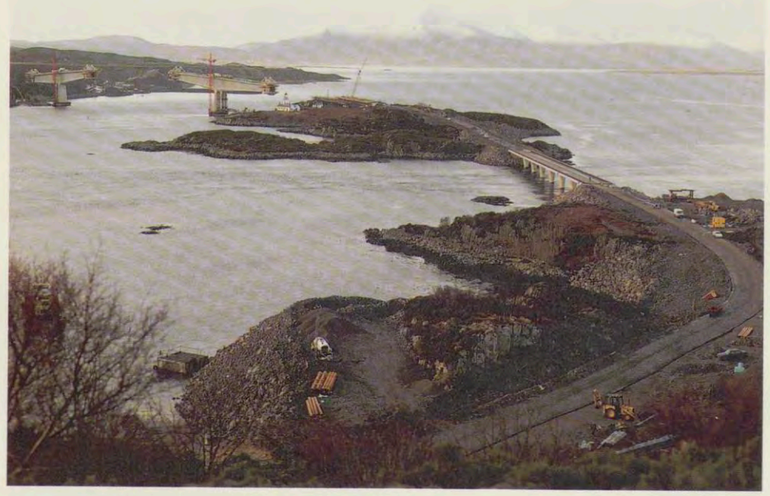
All the work was carried out in Ove Arups' Edinburgh office, apart from the design check which was carried out in our London office. Ove Arup is one of the largest firms of multi-disciplinary consulting engineers in the UK and brought all its considerable experience and skill into the production of the design of this exciting and challenging project.

The Scheme

The total length of the new road from the roundabout on Skye to the new junction in Lochalsh is 2.4km. Of this some 800m, is taken up by the main and secondary bridges. The engineering design of the road brought particular challenges as it was an important aspect of the design that, as well as conforming to present day highway design standards, the new road should reflect the nature of the roads that already exist in the area.

The design of the bridge foundations was carried out after detailed consideration of the geological information obtained from the site investigation. The caissons have been located on platforms constructed within the very strong sandstone bedrock on the edge of the navigation channel. The platforms were formed in some 10m water by bulk blasting and machine excavation. In order to ensure a sound formation and negligible settlement, loose rock and blasted rock debris was removed naturally by divers.

The formation was then systematically surveyed by geotechnical engineers from Ove Arup using the diver's CCTV system before underwater concentrating created a level platform for the caisson. A similar approach was adopted for the foundations on the secondary crossing where precast piers were located on blasted platforms in the rock.



Construction of the approach to the Carrich Viaduct

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Building the deck of the Secondary Bridge

Road Design

The road has been designed to a design speed of 70 kph. It is a 7.3m 2-lane single carriageway and on the seaward side has a 2.0m wide cycleway and footpath. This path runs for the full length of the road crossing including the main and secondary bridges. There is a junction at either end of the road, the one at Lochalsh being a crossroad at the ferry slipway and on Skye a roundabout has been built to take the three roads, from the bridge, Broadford and Kyleakin.

The horizontal alignment has radii of 270mm and crossfalls of 5% to match the design speed. The main crossing has a navigation clearance of 30m above mean high water springs, a requirement of the Ministry of Defence. In order to bring the road down from the bridge as quickly as possible, to ground level, particularly in crossing Eilean Bahn and Eilean Dubh, grades of 8% have been used. Three dimensional computer techniques were used extensively in the design of the road. An extensive 3-D model of the ground was first surveyed, then fed into computers on which the design was then modelled. From this Ove Arup were able to generate perspective views of the completed scheme. As well as being used to check the safety of the design these provided very valuable pictures as to how the new road would fit into the surrounding terrain.

Starting from the junction at Lochalsh, the road winds along the Plock of Kyle. A principle aim was to keep the road in rock cutting to minimise its intrusion on the surrounding area, particularly when seen from Skye and Kyleakin. There are two major rock cuttings on the Plock, the first up to 12.0m deep behind the Lochalsh Hotel and the next, to the west of Lochalsh is up to 20m deep. The first cutting has been formed with steep pre-split slopes to suit available land take. Where necessary, retaining structures and rock bolting have been carried out to ensure the stability of the slope. The western cutting has rock faces which have been bulk blasted, rather than engineered, to leave a finish which is similar to the natural rugged appearance of the rock in the surrounding areas. In time this will weather to match existing rock faces in the area. The third rock cutting contains the Toll Plaza area before the road passes onto embankment as it approaches the secondary bridge.

After crossing the secondary bridge on to the two islands, the road keeps close to ground level before starting to climb at the southern end of Eilean Bahn onto the main bridge. On the other side of the bridge, the road drops down onto Doctor's Rock to end at a roundabout, where the road splits to Kyleakin and to Broadford. This section of the road provides spectacular views of the Cuillins on Skye and looking up to Loch Duich.

The road has been provided with street lighting from Lochalsh out to the Toll Plaza and at the roundabout on Skye. There are no lights on the intervening section over the secondary crossing, Eilean Bahn, Eilean Dubh and the main crossing consistent with that of a rural road. Traffic signs have been provided on Skye in both English and Gaelic.

On the Plock of Kyle and on the two small islands where the road is on an embankment, a masonry wall has been constructed on the outside edge of the verges on either side of the road. This wall has two functions. The first is to provide a safety barrier to contain traffic in the event of an accident. The second is to prevent otters from being able to have access on to the road. The wall is 1.4m high and on the outer face the joint mortar has been finished flush with the masonry so otters are unable to get a toe hold and climb the wall.

The use of masonry as a safety barrier is a first in Scotland following trials in the UK to achieve a design standard and it replaces the more familiar corrugated beam barrier or tensioned wire rope.

So otters can pass safely from one side of the road to the other, provision has been made by building 1.2m diameter pipes through the embankments. The siting of these has been agreed in consultation with Mr Jim Green, an expert on otters acting on behalf of Scottish Natural Heritage. Two otter pipes are provided on the islands and two on the Plock of Kyle.

In addition to designing the road, Ove Arup have also been responsible for designing the bridge services. These have included closed circuit television cameras for supervising the road. In the event of hold ups or accidents there are three cameras, one on the Skye end of the road, one mid-span on the main crossing and one on Eilean Bahn. In addition there is a meteorological station which measures wind speed and direction and air and road surface temperature. All this information is fed back to the Crossing Control centre where an operator can monitor events on a TV screen and computer VDU.

This has been a very exciting project for Ove Arup to be involved in. Not least has been the challenge of overcoming the environmental concerns and the completed road has met all of these and produced a scheme which epitomises the character of the country through which it is passing. In this respect it matches the Scottish Office's new proposed policies of "Fitting Roads" in the countryside and it provides a very fitting approach on to the Isle of Skye.

Alistair Smith
Ove Arup & Partners

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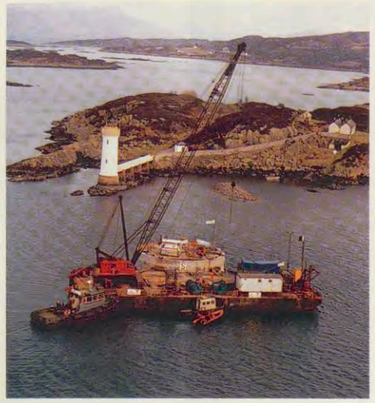
Building the Bridge



Placing the south caisson

Miller Civil Engineering Limited, half of the joint venture which built the bridge to Skye has substantial experience in contributing to infrastructure projects including roads, bridges, tunnelling, water, drainage and rail projects throughout the UK.

Part of The Miller Group, Scotland's largest independent construction group, Miller Civil Engineering has a long track record in bridge and road construction. They were responsible for building the Friarton Bridge in Perth, and more recently two sections of the M74, totalling £35 million in value. Miller Civil Engineering are currently upgrading the A1 to dual carriageway between Tranent and Haddington and are building the new M66 ring road around Manchester.

The Skye Bridge has proved to be a challenging and complex construction project, stretching modern construction technology to its limits and exciting enormous public interest throughout its production.

The construction of the Skye Crossing began in July 1992, slightly later than anticipated following a delay to accommodate the findings of a Public Inquiry held in January of that year.

A construction base was established in a quarry near Kyleakin and this served as the centre of operations for the next three years. Critically, the location gave access to the foreshore. For most of the next 24 months, the bridge would only be accessible from the sea and the ability to land and berth craft near the site was essential.

The first construction operation was the casting of the foundation caissons; hollow, open-topped cylinders, which would eventually form the marine supports of the main bridge. The caissons, which weighed 2,300 tonnes were manufactured at Kishorn. The Kishorn dry dock, formed from a deep natural harbour in Loch Kishorn, was last employed during the 1970s when Howard Doris used the facility to construct the Ninian Central Platform, at the time the largest concrete oil production platform in the world. The approach by road to the Kishorn Dock was more than 31 miles but the route by sea to the bridge site was only 10 miles.

The caissons were constructed during the first four months of the contract and for the early months of their lives they were technically floating structures. As a result they were christened by the Miller-Dywidag site team. The north caisson was called Lena after the daughter of one of the German engineers working on the project and the south caisson was called Janette, named after a student who had worked at Kishorn during the construction period.

While the construction of the caissons progressed at Kishorn, the sea bed at Lochalsh was being prepared to receive them. Initially, a dredger moved bulk rock and a team of divers completed the final trimming and removal of loose material by hand.

The divers worked in harsh conditions, at depths of 15 metres and with currents of up to 5 knots which made work at times impossible. Having cleared the sea bed, the divers installed concrete landing pads using underwater tremmie techniques. A special concrete mix was developed to avoid segregation of the concrete in water. Because of the water depths, divers were only permitted to work for one hour under water at a time before returning to the surface. Teams often worked round the clock, diving during the darkness of night and using underwater floodlighting to guide them.

During spring 1993 the caissons were towed to site and secured on the sea bed. This operation required particular tidal

Building the pier table above the foundation

conditions and a suitable weather window in order to be undertaken safely and successfully. The caissons had to be placed on the sea bed in a precise and demanding operation which required the structures to be lowered on to the landing pads, using the natural tidal conditions in the Kyle of Lochalsh, to within a tolerance of 100mm. The team managed to place them within 30mm in an operation lasting 24 hours. The placing of the caissons marked the first of many milestones in the construction of the Skye Bridge.

The next scheduled activity was the construction of the piers above the foundation caissons to the underside of the main deck. This was done in sections or 'lifts'. The formwork, or shuttering, which formed the mould for the concrete, was raised as each section was completed. In total 620 cubic metres of concrete were poured to construct each pier.

At the same time, auxiliary or temporary piers were being constructed. These would perform a vital function in supporting the bridge deck and provide stability during the superstructure construction. The construction technique, known as 'free cantilevering', involved building the deck of the bridge out from the supports one section at a time on either side of the pier alternately. Theoretically, this could have rotated the pier table and the auxiliary piers were necessary to prevent any movement during construction.

The balanced cantilever process

The construction of the superstructure began in winter 1993. Pier tables - the section of deck immediately above and spanning the permanent and temporary piers were constructed in four separate concrete pouring operations, two for the base, one for the walls and one for the deck. The concrete had to be pumped 35 metres vertically to where the construction was taking place. Up to 300 cubic metres of concrete were poured at any time, in a continuous operation. The pier table structures were designed as reinforced concrete with steel as dense as that used in the construction of a nuclear power station.

The special design features incorporated to enhance the Bridge's aesthetic appearance presented a further challenge. Incorporating these features into the building of the structure required a high degree of control and quality of workmanship.

The technical demands of the construction of the superstructure were a challenge to the highly skilled workforce, but the construction team also had to endure the vagaries of an extraordinarily harsh winter. The construction area was then only accessible by sea, and high winds, driving rain and rough sea states put an added strain on an operation which was dependent on vital supply line logistics.

The piers, however, were completed within the revised programme in the Summer of 1994 and work commenced on the free cantilevering process which would create the dramatic arch which now spans the Kyle of Lochalsh. The deck of the Skye Bridge grew from each pier table section by section, using two pairs of form travellers to support and form the in-situ concrete bridge deck.

In total there were one hundred and seven pours of concrete, the largest being over 100 cubic metres. The segments varied in length up to five metres. The first segment was poured on 19th July 1994 and the centre and final section was poured on 29th July 1995. A degree of rivalry arose between the two teams constructing the north and south sides of the deck as they competed to see which side could complete a section in the shortest possible time.

During the late summer of 1995, the final finishing activities such as footpaths, surfacing, street lighting and landscaping were completed to allow opening to traffic by the Secretary of State for Scotland.

The Carrich Viaduct

The Skye Crossing incorporates two bridges, the main cantilevered span, the Skye Bridge, and a smaller bridge, known as the Carrich Viaduct, the structure which connects the mainland to the island of Eilean Bahn.

The piers for the Carrich Viaduct were pre-fabricated on a temporary jetty on Skye. It had been proposed that these piers should be cast in position in the sea but the hostile weather and sea conditions persuaded the constructors that there was a better option. It was to first create the piers and then drop them into place. Again, divers prepared the sea bed to receive the piers and all seven piers were lifted into place within one week during September 1993. The piers weighed up to 380 tonnes and were up to 22 metres in height.

Work on the deck of the Carrich Viaduct began in October 1993. The segments which would form the deck for the bridge were cast in a covered facility on the Plock of Kyle and incrementally launched over the seven already constructed piers. Each segment was 15m long and required 130 cubic metres of concrete in construction. The operation took place between October 1993 and May 1994. However the covered working environment provided ideal working conditions even during the rigours of a west coast winter.

The work on the island of Eilean Bahn and Eilean Dubh proved to be extremely sensitive because the islands were known to be otter habitats. Extensive research had been carried out to identify where otters lived on the islands and their traditional runs. This research was used to determine how construction on the island should proceed and to incorporate any otter protection measures into the design of the roadway.

During construction, one otter holt which lay in the line of the road had to be relocated. Otters are itinerant creatures, often living in up to 15 different holts. To ensure that this particular habitat was not occupied at the time, a radio, playing music was left by the holt for 24 hours before work began.

The causeways also incorporated five special otter tunnels. The research had identified all otter habitats and tracks and the tunnels would allow the otters unimpeded access along traditional routes. One thousand seven hundred metres of dry stone wall was built to keep the otters away from the main carriageway.

John Henderson
Project Manager, Miller-Dywidag

Building the Carrich Viaduct

HOLFORD ASSOCIATES

ARCHITECTS · PLANNING · LANDSCAPE
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Prepared the Environmental Statement, Design and Supervision of Landscape and Environmental Mitigation Measures for the Skye Crossing.

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Caring for the Environment

Holford Associates were appointed by the Miller-Dywidag joint venture at the start of the project to advise on, design and manage the environmental, architectural and landscape issues involved in the Skye Crossing.

The scenery and wildlife of the area are of international importance and it was recognised at the outset that great care would be required to minimise any adverse impact that might be caused by the bridge construction.

Due to the perceived importance of the project and its wide environmental implications an Environmental Statement was prepared on behalf of the joint venture. This addressed key topics such as noise, visual, landscape, archaeological, wildlife and community effects both during and on completion of the project, requiring the input of several specialist consultants and advice from Scottish Natural Heritage.

Having established the key environmental features of the area the joint venture were advised on actions to avoid or mitigate identified adverse effects.

Further detailed work was done on two rare plants (a seaweed and a liverwort) and an internationally protected species, the otter.

It was established that protecting the plants could be achieved by fairly straightforward protection measures i.e. temporary fencing, but that complex and extensive work would be required to safeguard the large local population of otters.

Construction of the Otter Wall

Otters

It was known that the road would cross several otter tracks and interfere with resting places (holts) and grooming pools and measures to protect or replace these were developed. Tunnels were installed under the road to maintain the most frequently used tracks as close to their original position as was feasible, with new holts and freshwater pools being built to replace those which were affected by construction. These are designed to allow the otters to maintain their territorial habits with relatively little disturbance. Of even greater importance, however, was the need to reduce the risk of otter mortalities by traffic once the bridge and approach roads opened. Several methods were considered in consultation with the Vincent Wildlife Trust, Scottish Natural Heritage and JMP, the Secretary of State's Agent. Simultaneously, investigation was undertaken to devise ways of reducing the intrusiveness of the safety features required for a modern road including crash barriers, rock trap fences and cyclist safety barriers. Recent research had shown that a stone wall, if carefully designed, could fulfil all these purposes and could also be effective as an otter barrier. A wall with smooth outer face and built of stone obtained from the road excavations was therefore selected as the most attractive and serviceable solution and aligned to maintain key views. The use of this locally won rock has achieved a significant level of visual unity and

reduced the extent of metal vehicular barriers to the bridge structures.

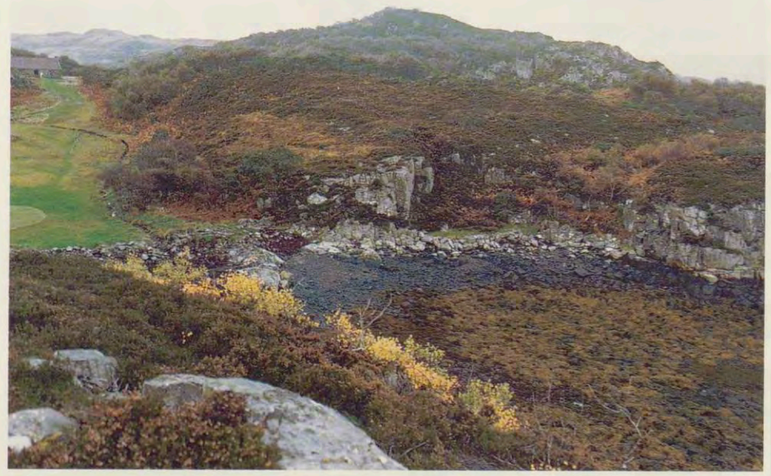
The Toll Buildings

The design of the buildings evolved from the special requirements of the project, temporary but solid and a wish to provide ancillary buildings in keeping with this individual bridge solution. The system of tolling is complicated by the need to allow for operation by a single person at night and during quiet periods and for the provision of a toilet and snack facilities. Building materials have been chosen to reflect the character of the site and the temporary nature of the buildings. The walls, doors and windows are of untreated oak which will age to give a weatherbeaten appearance while the roofs are of copper which should quickly form a green patina.

The extensive glazing of the Crossing centre is designed to give operational staff a comprehensive view of the Toll Plaza and the idiosyncratic shape of the toll booth is intended to provide the toll operators with good sightlines past the ancillary accommodation.

The Landscape

The underlying geology of the area is Torridonian sandstone which has a covering of peat varying from a few inches to several feet. The sandstone is extremely durable but heavily faulted and this has resulted in a rugged landscape with many rock outcrops and a coastline formed from remarkably



The natural environment

unweathered boulders creating a very sharply defined margin between the high water level and the vegetation above.

The existing vegetation is dominated by heather, gorse and bracken with scrub woodland on the mainland and on the islands. There are two prominent stands of Scots pine, in Kyle behind the Lochalsh Hotel and at the bridge embankment on Skye and the contractor's working corridor has been restricted to avoid impact on surrounding vegetation.

The landscaping proposals aim to minimise the visual intrusion of the approach roads and to reinstate the original vegetation pattern. The methods used include the following:

- The protection of important habitats;
- The retention of existing vegetation in close proximity of the road;
- The re-use of existing vegetation;
- The use of plants of native provenance including material grown from seeds and cuttings harvested from the road corridor.

A planting contractor has been appointed and extensive tree and shrub planting will commence in November 1995 with ongoing establishment and maintenance in subsequent years.

It is intended that, by close co-operation and good working practice, the road corridor, its cuttings and embankments will be re-vegetated. The initial scar associated with major construction works such as this, will rapidly recover to provide typical west Highland habitats both for plants and wildlife.

Holford Associates

Skye Bridge Opening

October 1995

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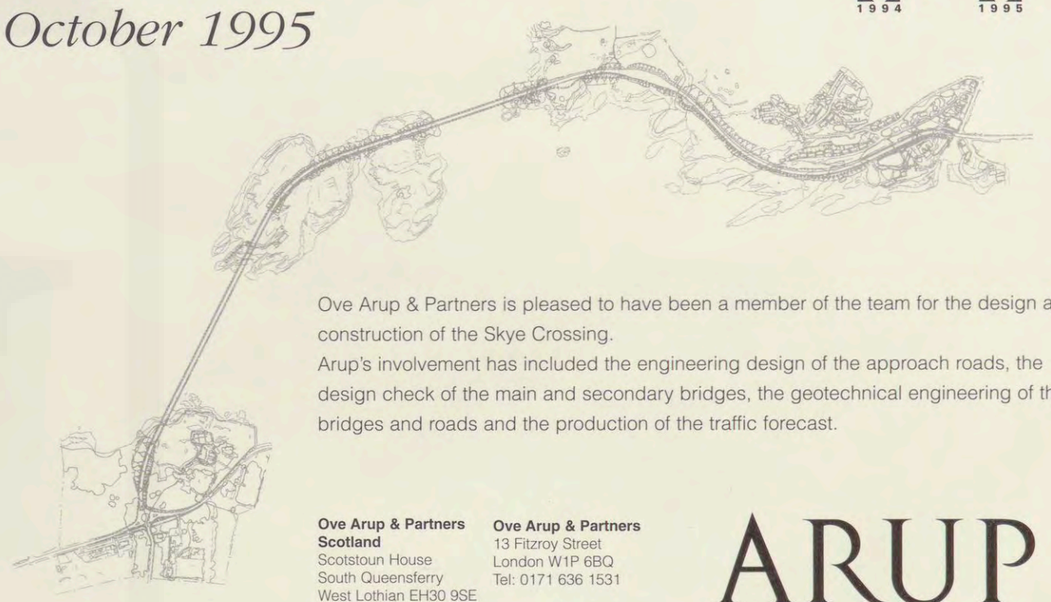

Ove Arup & Partners is pleased to have been a member of the team for the design and construction of the Skye Crossing.
Arup's involvement has included the engineering design of the approach roads, the design check of the main and secondary bridges, the geotechnical engineering of the bridges and roads and the production of the traffic forecast.

Ove Arup & Partners Scotland
Scotstoun House
South Queensferry
West Lothian EH30 9SE
Tel: 0131 331 1999

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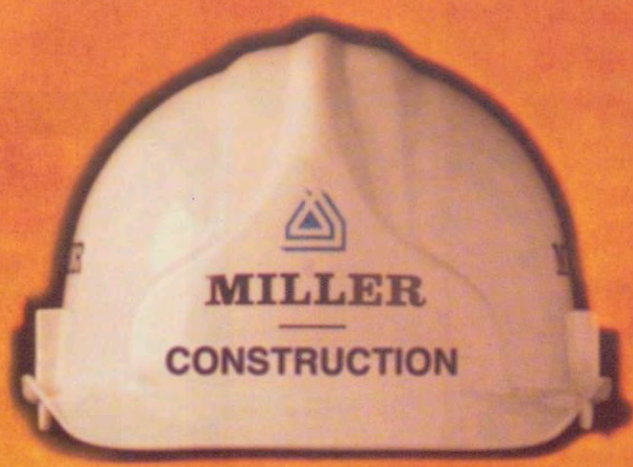

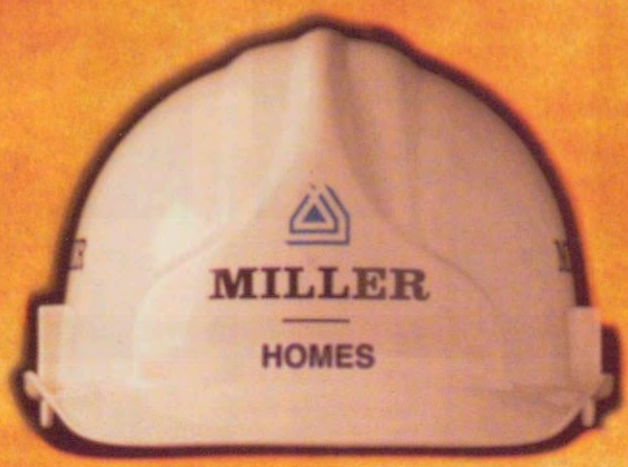

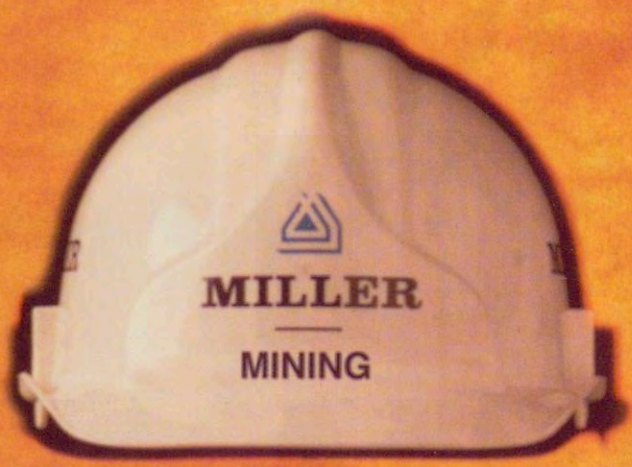

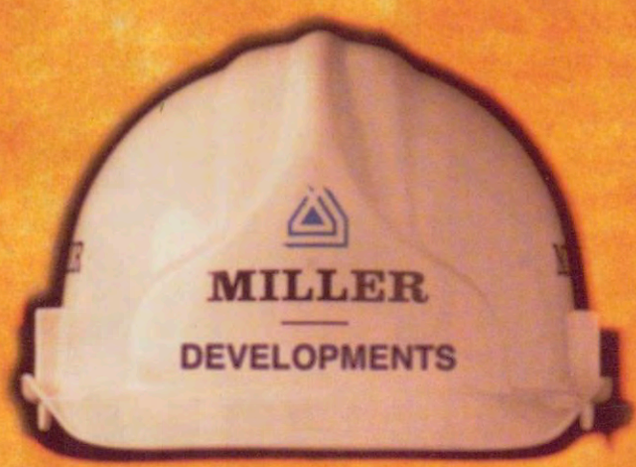

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