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# The Kessock Bridge design-and-build contract, and proposals for managing similar contracts

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The Paper reviews the Kessock Bridge contract, describing the events leading up to the planning and adoption of this special form of design-and-build contract. The aims, problems and achievements are described, and proposals are put forward for modified procedures which could be adopted for managing similar projects in the future.

## Introduction

When the offshore oilfields were starting to be explored and developed, the Scottish Office undertook to improve road communications to cope with the increased traffic. A major part of the improved road system was the reconstruction of the A9 trunk road from Perth to Ardullie near Dingwall, a distance of approximately 220 km. Initially the route north of Inverness was expected to follow the old A9 route through Beauly and Dingwall, but after a detailed feasibility study by Crouch and Hogg, the Scottish Development Department decided to build a new and shorter route crossing the Black Isle with major bridges over the Beauly and Cromarty Firths. The new route was to reduce the distance to Wick and Thurso by some 23 km.

2. The Kessock Bridge, which crosses the Beauly Firth immediately north of Inverness, was designed as a cable-stayed bridge with an overall length of 1070 m, the main span of 240 m providing a headroom of 29 m over the entrance to Inverness harbour and the Caledonian Canal.

3. The original detailed design for this bridge was prepared by the consulting engineers Crouch and Hogg of Glasgow. The design was for a continuous rectangular steel box girder, with a stiffened plate deck carrying dual 7·3 m carriageways, central reserve and footways. The cross section, 4 m deep, was to be continuous over the 64 m approach and 240 m main spans, the navigation span being cable stayed from a single A-frame tower on the south side of the channel. This layout was adopted to avoid back stays over the 651 m radius horizontal curve at the northern end of the bridge.

## Early tenders

4. Tenders were invited for the foundations and piers in August 1973, but the lowest received in October exceeded the estimate by more than 100%, and several

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alternatives with concrete piles were even higher. At the time this was attributed to tendering uncertainty due to many of the boreholes not being on the designed centre line. With hindsight it is clear that the lowest tender was nevertheless keenly priced. At the time the decision was taken not to let a separate foundation contract, but to carry out an additional site investigation and trial piling, and to invite tenders for the whole bridge, when the design was complete.

5. In January 1975 tender documents were issued to eight contractors, who had already seen general arrangement drawings. At this time the estimated cost was £17·5 million. During the tender period the list of potential contractors was halved by withdrawals and the formation of a consortium of three steel fabricators.

6. In May 1975 four tenders of between £30 million and £34·8 million were received. Not only was the number of tenders low, but it was found that the steel fabricators' consortium, who submitted the lowest tender as main contractors, were also sub-contractors for steelwork to the other three tenderers. This was a great disappointment as the approach roads were progressing satisfactorily and a start was expected on the major bridge. A comparative study of the cost of recent major bridges, by the Department's engineers, clearly indicated that a suitable bridge could be built at a price nearer the estimate. Therefore, after considerable administrative and political discussion, the politically unpopular decision not to let a contract was again taken on the understanding that all possible alternative approaches to the problem would be urgently explored.

7. After discussion with various contractors, a number of offers and proposals for alternative and cheaper bridges were received. Among the offers was a proposal to build the original Crouch and Hogg design under a target price contract for approximately £25 million, and another to build a concrete cable-stayed bridge for a similar sum. The conditions under which these and others were made were so different that evaluation and comparison were impossible. Nevertheless they confirmed that several cheaper solutions were possible, although it would be difficult to select and design one which would be certain to attract keen pricing, without also attracting numerous alternatives, which would again be difficult to evaluate fairly. It therefore seemed logical to try to organize tendering for designing and building the bridge under closely defined criteria, specifications and conditions of contract.

8. In order to ensure that sufficient staff resources were available for the assessment and checking, the Department agreed to the linking of Ove Arup and Partners with Crouch and Hogg as Joint Engineers for the project.

## Design-and-build tendering

9. A detailed study was made of the requirements for design-and-build contract tendering, and the following list was drawn up.[1]

(*a*) the design criteria must be flexible enough to allow different bridge types and materials to exploit their particular advantages

(*b*) the design criteria must allow contractors to take advantage of their own expertise and to use any special erection plant or techniques which could be economically employed

(*c*) the design criteria must be clearly specified, so that no design prepared in accordance with them would be unacceptable to the client

(*d*) the conditions of tender and contract must be fair and attractive to knowledgeable and experienced contractors

(*e*) the design effort required to prepare a tender must not be excessive, bearing in mind that the cost of preparing unsuccessful tenders would not be reimbursed.

(*f*) arrangements must be made for carrying out the independent structural design check that is required before commencing construction of major bridges

(*g*) the Royal Fine Art Commission for Scotland had to be consulted before awarding the contract

(*h*) invitations to tender must be restricted to groups with adequate experience for preparing the design quickly and with sufficient experience and finance to construct the bridge if their tender was accepted

(*i*) the groups invited to tender must include a balance of steel and concrete expertise, so that designs in both materials would compete

(*j*) the tendering assessment, and final design procedures adopted, must enable work to start on site within a reasonable period

(*k*) when awarded, the contract must be manageable and acceptable in terms of public accountability.

10. In order to meet these requirements the procedures (*a*)–(*h*) were proposed.

(*a*) a tender period of five months would be allowed for the preparation of the tender design and pricing

(*b*) the contract should be divided into two stages; a design stage, for detailed design and checking, lasting about ten months; and a construction stage starting in the spring of 1979, with the duration as proposed by the tenderer

(*c*) the tender design must be accompanied by sufficient calculations to verify the adequacy of the main elements

(*d*) the tenders were to be billed with approximate quantities, and subdivided into prescribed sub-bills to simplify comparisons

(*e*) on completion of the detailed design by the contractor, the Joint Engineers would carry out the independent structural check, after which they would adopt the tender design as if it were an alternative design submitted under ordinary tendering arrangements; thus the construction contract would be managed by the Joint Engineers as a normal contract under the ICE conditions

(*f*) when the bill for the construction contract is completed and final quantities inserted, the sub-bills totals must not be changed; thus any adjustments to preliminary quantities necessary to comply with the design criteria must be compensated by changes in the rates

(*g*) during the tender assessment period all the designs would be submitted to the Royal Fine Art Commission for comment.

(*h*) the contract price would be adjusted by the application of Baxter Indices from the date of tender.

11. In June 1976 the Department advertised for firms willing to tender for the design and building of a bridge to carry the re-routed A9 across the Beauly Firth at Inverness. Sixteen applications were received and considerable difficulty was experienced in making the selection. The normal investigations were made into the financial resources of the applicants, but more importantly a series of individual meetings was arranged to explain and discuss our requirements, and to hear their reaction to the proposals and tentative timetable. In addition an assessment had to

be made of the design and contractual resources available in each group and to try to select those most likely to put forward practical and economical designs and tenders. Initially it was thought that only three or four groups would be invited to tender, but in view of the response and keenness to participate and the difficulty of making a selection, it was eventually agreed that six groups should be invited to tender.

12. The project documents (conditions for tendering, design criteria, conditions for the design contract, and conditions of contract and specification for the construction of works) were issued in October 1976, tenders being required by 28 February 1977. Subsequently, at the request of some tenderers, the period was extended to 21 March 1977. Among the design criteria were items relating to seismic forces, high winds and tidal currents, and accidental impact by ships.

13. The conditions for tendering were drafted as a compromise between reducing the design effort required to submit a tender and protecting the client against any upward revision of the price on completion of the final endorsed design. With this objective in mind the draft bills were required to be subdivided into 13 named sections. Main bill items (with approximate quantities) and rates were to be listed, so that tenders could also be readily compared. Thus designers and tenderers had to decide how much design should be undertaken to arrive at a cost which could be tendered.

14. The original design had been approved by the Royal Fine Art Commission for Scotland, and therefore it was desirable to seek their approval for any alternative bridge. They had previously suggested that the Department should make use of some form of design competition for major bridges, but this idea had never been adopted. When the new tendering arrangements were discussed, they readily agreed to offer their advice in assessing tenders. They were very anxious to see all the designs submitted, so as to judge the overall quality.

## Receipt of tenders

15. On 21 March 1977 six tenders were received, ranging from £17·25 million to £24·8 million. The tenders are summarized in Fig. 1. The lowest tender was £13 million less than that received in May 1975, and this difference is increased to more than £20 million if a Baxter-type adjustment is made for inflation over the 22 month interval.

16. Six copies of the tender drawings, bills and calculations were required and these were distributed to enable the Joint Engineers and the Department to study and assess submissions. For the presentation to the Royal Fine Art Commission a contoured site model of the Firth was prepared with a slot into which could be fitted models of the different bridges (Fig. 2). Separate small-scale models of each bridge were built to fit into this slot to show how the different bridges would blend into the landscape. The sizes of the bridge and site contours are such that the bridge is visible from considerable distances and thus a small-scale model was suitable for judging the environmental impact. Tenderers submitted perspective sketches which were also shown to the Commissioners.

17. During the assessment period, the Joint Engineers studied the calculations submitted and made some checks to establish that the designs either broadly complied with the design criteria or could be readily modified to do so.

18. Before the letting of the contract a price was negotiated with the tenderers for increasing the thickness of the deck plate and trough stiffeners. This decision was taken by the Department's engineers to provide greater security against pos-

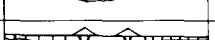
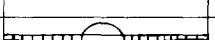
| Tenderer | Sketch | Cost, £million |
|---|---|---|
| Cleveland Bridge/RDL (Dr Homberg and THES) |  | 17.255 |
| Laing(Maunsell) |  | 18.312 |
| McAlpine/Dyckerhoff & Widman |  | 19.140 |
| Monk/MAN/McGregor/Clarke Chapman(Atkins) |  | 19.527 |
| Wimpey/Clarke Chapman/Highland Fabricators (Babtie & Leonhardt) |  | 20.812 |
| Taylor Woodrow/Campenon Bernard |  | 24.850 |

*Fig. 1. Kessock Bridge, analysis of tenders, March 1977*

sible fatigue damage. The deck plate design as submitted complied with the design criteria, but as doubts had been recently raised as to the fatigue life of orthotropic steel decks, it was thought prudent to increase stiffness.

19. The contract was let on 21 June 1977 to a consortium of the Cleveland Bridge and Engineering Co. Ltd and Redpath Dorman Long, with the superstructure to be designed by Dr-Ing Homberg in conjunction with Cleveland Bridge and Engineering, and the substructure and foundations designed by Trafalgar House Engineering Services (THES). The programme submitted by the tenderers, who were required to state their own completion date, envisaged a total contract duration of four years. The design was to be completed, checked and endorsed in 44 weeks to enable work on site to commence in the spring of 1978.

20. Many views have been put forward to explain the large differences between the two sets of tenders. At the time of the first, inflation was very high and there was still a fair amount of work in hand, whereas in 1977 both inflation and capital investment had been reduced. It is also true that only one consortium of steel fabricators priced the steelwork in the first four tenders, and thus the competitive element was partially eliminated. It is also worth referring to a letter from the contractors involved in preparing both tenders.[2] The essential points were that the new design involved greatly simplified fabrication and erection and a reduction of some 30% in steel tonnages, i.e. from 10 300 to 7230. It was estimated that erection costs would be reduced by over 35%. In fairness it should be said that the tonnages of the completed design have risen, partly due to changes required to fully comply with the British steel design rules, and partly due to the additional plate thicknesses ordered after submission of tenders. The final amount was approximately 8800 t, giving a saving of 1500 t or 14·5% less than the original design. The main span of the original design was to be supported by fan cables from a single tower on the south side, and thus being rather like half a longer-span bridge, might be expected to be heavier and thus more costly. This arrangement was adopted to provide a 651 m radius at the north end, it being thought that the northern back stays would be seriously displaced by the curved approach spans. The bridge as built has a standard minimum radius of 511 m and has towers at both ends of the main span. It should also be mentioned that the twin-towered, multi-cable-stayed bridge is a much better long-term maintenance proposition, in that individual cables can be replaced without completely closing the bridge.

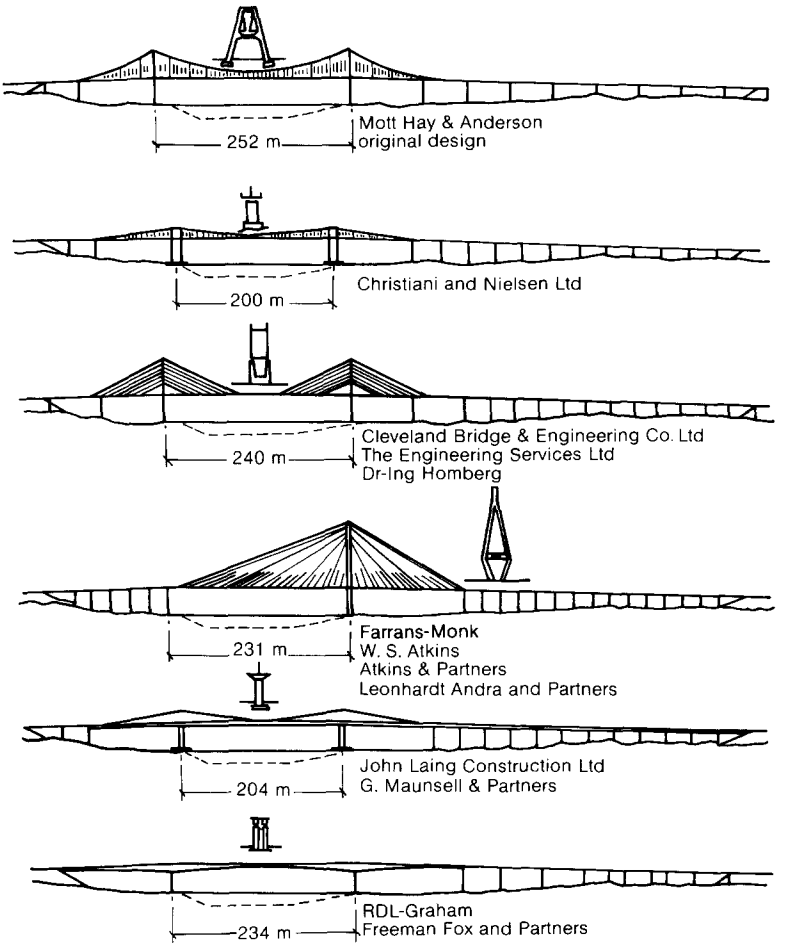



*Fig. 2. Foyle Bridge alternative designs, August 1979*

## Contract management

21. During the design period the contract was under the Department's direct control, with the contractor's designers and the consultants reporting progress at monthly meetings. As parts of the design were completed, the Joint Engineers carried out their design checks and drawings were endorsed. Independent design checks are required for any major bridge built in the UK; thus the endorsement procedure was a way of obtaining the check.

22. Originally it was thought that the whole design would be completed, checked and endorsed by the end of the 44 week design contract period, but for various reasons this was not achieved. However, sufficient progress was made to enable construction to commence as planned in April 1978. Actually the contrac-

tor first arrived on site in the autumn of 1977 to supervise additional boreholes required for the detailed design of foundations and temporary works. Early in 1978 the specified dredging was undertaken to improve the channel through the navigation span and into Inverness harbour.

23. The foundation design was by Trafalgar House Engineering Services and the check by Ove Arup and Partners. The superstructure design was by Dr-Ing Homberg with assistance by Cleveland Bridge and Engineering, and the check by Crouch and Hogg. In addition to this broad division of design and checking, there was frequent consultation between the Joint Engineers and the design offices. The main delays in completing the design were due to the problems of adjusting the design, originally conceived under West German rules for the Rees bridge over the Rhine, to comply with British loadings and design rules. These problems were further aggravated by postal and translation delays. Complications were also caused by the decision to increase deck plate thicknesses, which in turn increased dead loadings on cross and main girders, cables and towers. It is interesting to note that all the checks and endorsements for the Foyle Bridge were completed in a period of about twelve months. In this case there was no adaptation of a design to comply with different rules. Although it was envisaged that the design would be completed and endorsed during the first eleven months, there was no real penalty for a failure to do so, and relatively little inconvenience was caused by these delays.

24. Under the conditions of contract, as soon as the drawings were endorsed, the design was adopted by the Joint Engineers, and construction proceeded under ICE Conditions of Contract (5th edn), as if the design had been prepared by the consultants or was an alternative submitted with a normal tender. Thus the management and supervision of the contract followed the usual pattern and precedents. Costs for site supervision were reimbursed in the normal way.

## Construction

25. After extensive temporary works the construction of foundations progressed satisfactorily with few unforeseen problems. However, although the design of the approach spans was completed in time, there were serious delays in commencing deck fabrication and erection. This was started initially at the south end, and later from the north abutment also, progressing by cantilevering after the first spans eventually to meet in the centre of the navigation span. Thus every stage of deck erection was on the critical path, and had to be completed before the next bay could be started.

26. As erection proceeded, it gradually became evident that the rate of erection achieved would never catch up with the programme. Bearing in mind that there was a liquidated damages clause in the contract, the contractor eventually decided that a seven-day working week should be adopted. Previously the men travelled home each weekend, and effectively only worked four and half days per week, less after allowing for stoppages due to weather. The new system divided the increased work-force into three gangs, with two on site and one at home; thus each man worked for 14 days, followed by one week's rest. This system, which was introduced in the spring of 1981, worked well for several months, with the rate of erection more than doubling, until further delays occurred due to a shortage of fabricated units from Darlington. Some delays were also caused by local strikes and adverse weather.

27. One carriageway was opened to two-way traffic on 19 July 1982, and on 6 August Her Majesty the Queen Mother officially opened the bridge.

## Preliminary review of the contract

28. In reviewing the contract at this stage the Author is convinced that the decision to reject the 1975 tenders was fully justified, although it met with severe criticism from those anxious to see the new route completed. Although completion was delayed by two or three years, it is probable that the actual saving on the bridge would be approximately £20 million, allowing for inflation on both tenders. If, however, design-and-build tendering had been adopted initially, there would have been no delay and possibly a saving of time, as well as a substantial cash saving.

29. As with any large contract, claims for extensions of time and additional payments for various reasons are still being examined. It is difficult and improper for the Author to express any views as to the probable outcome of the various claims under consideration, but because the contractor was responsible for the design and tendered his own time for completion, it seems unlikely that the claims settlement will be greater with this type of contract, than with a normal contract for a project of this magntiude. Had the contract been let as a target-price contract at £25 million, it is inevitable that this would be widely known and site labour would have been even more difficult to manage. These difficulties would have resulted in increased costs to the client.

## The Foyle Bridge

30. The Department of the Environment for Northern Ireland, having observed the efforts to build the Kessock Bridge, elected to adopt the design-and-build type of contract for the Foyle Bridge in Londonderry. This is a similiar, but shorter, crossing of a navigable waterway, and it seemed likely that if tendered in the same way, some of the Kessock designs could be readily adapted. Their own consultant had previously been commissioned to design a self-anchored prestressed concrete suspension bridge, and this was offered as an option for pricing. After a similar advertisement and selection process, five consortia were issued with documents and five tenders were received in August 1979. None chose to price the original design, which had of course been conceived in very different circumstances. Four of the designs were based on designs submitted for Kessock, and one was based on the Friarton Bridge built near Perth in Scotland. Tendering was complicated by the terrorist activity in Ulster and eventually a tender for £15·7 million (which was not the lowest) was accepted, and the contract let to a consortium of Redpath Dorman Long and Graham Contracts. The bridge has twin steel box girders over the main spans and prestressed concrete approaches. Work is proceeding on this scheme, with completion expected in 1983 (Fig. 2).

## Contracts for large bridges

31. The introduction of design-and-build tendering for major bridges in the UK has been criticized, in some quarters, as detracting from the authority and prestige of consultants, but the Author does not accept this point of view. It seems evident that in these days of increasing complexity a single consultant cannot adequately develop alternative schemes without close liaison with a number of different contractors, who will contribute their full expertise only when they are sure that their rivals will not benefit from their hard-earned knowledge. In normal tendering for a consultant's scheme, there is provision for offering alternative designs and prices, but experience has shown that such alternatives are reluctantly

accepted, even though they may offer significant savings. It is the usual practice to deduct all the additional costs of checking and delays from the gross saving, and then, unless a significant saving remains, the alternative is rejected. Similar problems have occurred recently at the Orwell Bridge at Ipswich, Ballachulish Bridge at Fort William, and the Tweed Bridge at Berwick. Overseas, competitive design and building contracts are frequently used for major bridges; for example, for the replacement Danube bridge in Vienna and the Sunshine Skyway Bridge in Florida.

32. Professor Leonhardt has commented on some of these matters.[3] He said that it was competition among design engineers which had brought about so much progress and many innovations to bridge building in West Germany. In the discussion on the above reference, attention was drawn to the inevitable waste of design work, but Professor Leonhardt, while agreeing that there was some waste, nevertheless continued to advocate competitive design for large projects. He stressed the need to organize the competitions in such a way that the advantages are preserved, while keeping the costs within reason. In the discussion several speakers warned of the danger of competition with regard to design fees, and the Author would agree that any such proposal should be rejected. Indeed the normal percentage method of calculating fees is very open to criticism, because the more effort and skill devoted to a project, the cheaper it is likely to be, and the smaller the fee will be. This must be a real disincentive against extra efforts on behalf of a client. In a design-and-build contract, the main competition is in the construction cost, with the design only representing a small percentage of the total. The interests of the successful designer could be protected by specifying that the standard fees be included in the tender price and be paid to the design consultant.

33. From the Author's experience with the Kessock Bridge and his knowledge of the Foyle Bridge, he is convinced that in the UK and elsewhere, one should advocate the use of design-and-build contracts for major bridges. In the case of Kessock Bridge, as explained, these procedures were hastily drawn up as a way out of a dilemma, and with hindsight there is no doubt that improvements could and should be made for future contracts.

## Future contracts

34. Based on the experience of Kessock Bridge and discussions with many engineers and contractors, the following proposals for the conduct of a future design-and-build contract are suggested (§§ 35–55).

35. Projects should be selected which are of sufficient size and importance to attract adequate competition.

36. Projects selected should be those which offer a wide variety of possible solutions, and especially those where alternative structural materials could be used.

37. The decision to use a design-and-build contract should be taken early in the planning stages, thus avoiding the cost of preparing the client's detailed design. Detailed thought about possible designs is, however, necessary in order to draft the design criteria.

38. The client should appoint a consulting engineer or engineers of sufficient size so that they will have the necessary resources to handle the peaks of work, and be of such standing that their judgements will be impartial and respected.

39. The consulting engineer should outline a whole series of possible solutions in various structural materials and bear these in mind when drafting the design criteria and the site investigation contract.

40. The site investigation must be more thorough than usual, as tenderers need to have sufficient information to prepare designs and plan temporary works. It must be remembered that flexibility in the location of piers is to be encouraged whenever possible.

41. A large project of this nature is likely to have a considerable impact on the environment, and therefore it is desirable that the client has the benefit of impartial advice in these matters. The Royal Fine Art Commission for Scotland have offered their help in Scotland, and perhaps similiar arrangements could be made elsewhere.

42. The first public stage of such a contract should be an advertisement describing the project to be built and the type of contract planned. Applications should be invited from consortia of experienced designers and contractors with a proven capability of undertaking this type of work. It should be made clear that the client and his advisers will make a very careful two-stage selection before two or three consortia are invited to submit firm proposals and tenders. It should also be made clear that there will be no appeal against non-selection at either stage. In making the initial selection the importance of experience in designing to British codes and working under British contract and labour laws should be stressed.

43. The applicants should be required to submit details of their financial and technical resources, together with an outline of their practical experience. These should be screened to eliminate those not meeting the basic requirements. The remainder should be interviewed and be given an opportunity to discuss the project before a final selection is made. The number selected can vary depending on the circumstances, but normally six should be adequate.

44. The selected applicants should then be supplied with full details of the contract, including the final contract documents. The drafting of the design criteria is critical. They must be drafted so as to permit as wide a range of solutions as possible, but also to make clear any restrictions or reservations which might prejudice selection. Bridges should be designed to comply with current codes and specifications. Alignments, widths and clearances must be carefully defined, particularly with reference to permitted variations. They should be given a period of four or five months to study the problems and prepare outline schemes for submission by a predetermined date. At this stage no detailed calculations would be required. The amount of design required should be roughly equivalent to a consultant's 20% report stage.

45. The amount and form of the material submitted should be closely controlled to prevent anyone gaining an unfair advantage by making an excessively lavish presentation.

46. The report should include approximate quantities for the main items, and a budget price which could be judged in comparison with the other proposals and estimates prepared by the client's engineers.

47. All schemes should be presented to the Royal Fine Art Commission for their comments, and the models for this should be made by the same modelmaker, and be designed to fit into a contoured model of the surrounding terrain.

48. Assessment and selection of those invited to compete in the final tendering should be by a panel composed of the client's own engineers and the consultants. Selection should be declared to depend upon the following factors in (a) technical quality of the proposal, including maintenance implications, i.e. the client's long-term interest; (b) comments by the Royal Fine Art Commission; (c) assessment of the construction proposals and programme; (d) budget price and the consultant's

estimate. It should be emphasized that assessment will not at this stage depend primarily upon budget price, or the consultant's estimate.

49. It is important that any novel construction techniques or long-term advantages should be described in detail. It should be emphasized that any such features disclosed would be treated as strictly confidential, and would not be disclosed to any other consortium, except by mutual agreement.

50. As the final selection is being made, the consulting engineers should study the foundation proposals to see if a further site investigation is desirable. If thought necessary, the client should let a contract, and make the information obtained available to all the final-stage tenderers.

51. As only two or three groups would be invited to submit final tenders, the consulting engineers would be able to set up special teams, each under the direct control of a different partner, to commence detailed checking as the final designs are being prepared. This arrangement would overcome the fears that a scheme might incur substantial additional costs due to differences in the interpretation of the codes and criteria. It would of course be necessary to ensure that confidentiality was rigidly maintained. In this way it should be possible to have final designs prepared and largely checked by the final tender date. Thus when the contract is awarded there should be little delay before site work commences.

52. The final designs would be submitted with accurate bills, fully priced. Thus the final selection would be solely on the tender price—aesthetics, serviceability and all other aspects having been dealt with before the final tendering. The final tender should also include a commitment to complete the construction within the period forecast in the initial proposal.

53. The final tenderers would of course have devoted much time and effort to the preparation of their designs, and the client would have had the benefit of having two or three alternatives accurately priced. Therefore it would be reasonable to suggest that a premium of, say, £100 000 should be paid to the one or two unsuccessful tenderers in the final stage.

54. When the contract is let, the successful design should be fully checked and certified by the consulting engineers, who will then adopt it. Thus the construction contract can be managed and supervised as usual.

55. The duration of stage II design and tendering should be 9–12 months, but this should be fixed after discussion with the tenderers.

## Conclusion

56. The Author has had numerous discussions on design-and-build contracts, and he is convinced that the majority of those with direct experience are satisfied that there are significant advantages to be gained by the adoption of this form of contract for the building of large bridges, and probably for other major structures as well. Doubts and reservations have been expressed, but a review of major post-war bridges makes it clear that the normal consultant's design is not always economical. It is widely acknowledged that the cost of a major bridge depends more upon the cost of temporary works and labour needed in erection, than upon the cost of the material incorporated in the permanent structure. Therefore, to arrive at an overall economical solution to a complex problem, it is essential to draw upon the best constructional expertise, and to consider the plant available to individual contractors.

57. In the past many major bridges have been built under 'cost plus' contracts. These may have been satisfactory between the two World Wars, but recently trade

union negotiators have been seen to take advantage of the knowledge that extra costs are reimbursable by the client.

58. The series of cheaper alternative bridges which have been tendered in recent years show that the client's engineer often fails to arrive at the most economical solution. However, this is not surprising, as the breadth of knowledge and experience required to evaluate a wide range of major structures is unlikely to be available within a single organization.

59. Judging by the Kessock and Foyle Bridges there seems to be no doubt that very satisfactory and very economical bridges can be built by design-and-build contract. However, care must be taken that they are only used for contracts prestigious enough to attract the expertise and competition which can ensure success. The Author does not advise their indiscriminate use, and certainly does not wish to see a general departure from the traditional role for civil engineering consultants in the UK.

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61. The views expressed in this Paper are those of the Author, and do not necessarily represent those of the Scottish Development Department.

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