OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

FAIR USE POLICY

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

18061

Consultant: Christopher METTEM
Backstop off: [illegible], PPD/AGRO

REPUBLIC OF GHANA

Ministry of Roads and Highways

Department of Feeder Roads

Technical report and proposal for assistance :

'Ghana Modular Timber Bridges'

1. INTRODUCTION

1.1 Terms of reference

At the request of Ghana Ministry of Roads and Highways (GMRH), UNIDO arranged through UNDP, Accra, that the consultant should visit GMRH for two weeks to undertake the following assignment:

Advise GMRH on application of wooden bridge technology for feeder roads. This will involve determining the scope of an eventual programme, the framework for material supply, component fabrication and assembling, the locations of a workshop and first bridge site plus the required technical assistance from UNIDO.

1.2 General introduction

A series of meetings were held in Accra with the Ministry of Roads and Highways (MRH), Ghana Highways Authority (GHA) , and the Department of Feeder Roads (DFR). The consultant was able to meet the PNDC Secretary, who explained the importance attached to solving the need for medium span bridges on feeder roads. Under an ongoing government programme, feeder roads are being very successfully renovated and constructed in Ghana. Twenty two contractors have been trained, each able to meet targets of 25 km of feeder road construction per annum. This benefits food and cash crop growing areas, helps the local community and brings substantial multiplier effects to rural areas. Within the feeder roads projects, strong emphasis is placed upon local-level planning; private sector encouragement; building up of DFR's management experience, and the inclusion of feeder road maintenance programmes.

Ghana Ministry of Economics and Finance has very recently undertaken to extend the feeder road programmes. It seems likely therefore that the Ghana Modular Timber Bridges Technical Proposal contained within this report will be required, in order to complement the feeder roads programmes.

demonstrably good structural performance in Britain, and is somewhat lighter. It also has a good durability record, even under tropical conditions.

In Annex 2, data sheets are given which have been compiled on seven Ghanaian hardwoods which have been shortlisted as suitable for modular timber bridges. The classifications used in these data sheets are those in the UNIDO Bridge Manual, Part 4 (ref). This should be borne in mind when interpreting the recommendations, since for example 'moderate' workability in terms of a bridge timber might well be considered 'poor' if one were considering it as a furniture timber.

2.2.4 Conclusions regarding choice of timbers:

From the classifications described above, and listed in Annex 2, the following timbers in alphabetical order are considered most suitable for timber bridge panels:

DAHOMA IROKO OPEPE

2.3 Review of medium span bridge needs on feeder toads in Ghana and applicability of modular timber bridges

2.3.1 General:

It was not possible within the scope and timescale of the visit for the consultant to travel comprehensively on feeder roads in the country, or to carry out a systematic survey of water crossings. However due to the active and current progress on feeder road development within GMRH, it was possible to draw on the experience of DFR and the ILO advisors to produce the following assessment of medium span bridge needs. The consultant was able to visit two feeder roads in the Eastern Region, and saw secondary road conditions in the area around Kumasi. These confirmed the impression that circumstances and bridge needs are similar to those which have been met by the provision of modular timber bridges elsewhere.

2.3.2 Quantification of problem:

By a conservative estimate, the number of new water crossings required on Ghana feeder roads in the next 10 years has been assessed as follows:

a) Culverts (1 culvert per 2 km) — 10 000

b) Large culverts and small bridges up to 12 m span (1 bridge per 10 km) — 2000

c) Medium and long span bridges between 12 and 50 m (1 bridge per 50 km) — 400

Substantial progress has been achieved in culvert construction, especially since the introduction of a new type of box culvert with timber decking. This allows construction of almost three new culverts at the cost of one of the old type.

prestressed ones. Bailey bridges have continued to be used until recently but they have tended to be erected by military engineers, even on civil roads, and are not always based on suitable foundations and abutments.

It appears therefore that the number of officially approved bridge construction techniques needs to be enlarged.

Simpler technology needs to be promoted alongside more sophisticated methods. An improved balance in this respect would certainly contribute to rectifying the overall balance between feeder road and bridge construction.

2.3.6 Conclusion regarding medium span bridge requirements and applicability of modular timber bridges:

ILO and Ghana government forecasts indicate that finance for feeder roads improvement in the next ten years will allow implementation of at the most 25% of the medium span bridge requirements. Even such a reduced programme, using conventional technology, would cost an estimated USD 30 to 35 million.

It was suggested to the management and senior technical staff of MRH, GHA and DFR that an alternative low cost technology, such as the UNIDO Modular Timber Bridge System, could be considered the additional means of solving this problem. It seems one of the most promising options. An additional programme of one hundred timber bridges using the UNIDO System could definitely be implemented at a much lower cost than conventional bridges. Timber bridges would have the added attraction of not involving a substantial foreign exchange component.

The conclusion reached after the senior staff seminar and the final meeting of the visit at DFR was that the modular timber bridges definitely did appear to the Ghanain staff to be suitable in principle for use on their feeder roads. It was noted that the normal width of carriageway provided by the UNIDO bridge standard designs is a single carriageway. This is satisfactory, since feeder roads are by definition 'single blade' roads. Indeed, many of the one lane feeder roads are having to be constructed or refurbished at 4.0 to 5.0 metre width. Although the consultant found that data on traffic frequencies was scant, the typical figure of twenty vehicles per day on such feeder roads appeared to prove suitable for the bridge designs.

2.4 Cost indications for modular timber bridges in Ghana

2.4.1 Principles of costing:

Throughout the consultant's visit, it was emphasised that the prototype manufacture of modular timber bridges in a particular country only gives an initial indication of the likely costs of the system under production conditions. Hence the proposals contained in this report dwell on the long-term aim of a stage-by-stage creation of bridge building capacity within Ghana, and particularly within the DFR, which seems the most appropriate part of the Ministry.

Senior staff at the seminar were naturally very keen to learn of the cost implications of using the modular timber bridge system. However it was somewhat difficult for the consultant to discern the criteria against which the staff intended that the costs should be judged. It was necessary therefore to convince them that true costings relevant to national economics could only be established by means of a pilot project. It was also suggested that during the course of this project, the cost of creating the capacity ought to be regarded as an on-cost rather than a cost to be shared by each subsequent bridge.

2.4.2 Initial indications of costs:

Notwithstanding these qualifications, on the basis of UNIDO's previous experience with the system in other regions, and in the light of information obtained by the consultant during the mission, the cost indications shown in Annex 2 were presented and discussed. These showed a bridge superstructure cost of about $US 800 per metre of span, or $US 1467 per metre for the total bridge, including the labour of modular panel manufacture, the foundation and abutment work, and the launching and completion of the deck and handrails.

2.4.3 Refinement of costings:

It was agreed that in order that the DFR management and the ILO Contracts Administrator should be able to refine these cost indications in relation to Ghanaian conditions, bills of quantities for steel and timber parts for a typical 15 m span 4 truss bridge would be provided by TRADA. These would be sent to them after the mission. Indications of staffing inputs were also requested, and these are given in Annex 3 to this report. These can be used by GMRH to establish personnel costs for any future project that may be planned.

Other information which it was agreed would be forwarded includes typical foundation and abutment designs, used for the UNIDO project in Honduras, and details of the foundations and abutments built with gabions, which have been used for a larger modular timber bridge, constucted under British aid in Cameroon.

The point was discussed that in order to have the chance of a breakthrough into the effective and widespread application of this new technology, which would be more closely related to local needs and conditions than imported steel bridge superstructures, then initially some risks on costings would have to be taken. This had proved to be the case with the labour intensive feeder roads themselves. These were considered to be very effective and valuable in the regional development of Ghana, even though at first their true costs had been unquantifiable. There is a realization at a high level within the Government of Ghana that against the direct costs of such roads, regional economic benefits, 'multiplier effects' and social benefits such as the creation of employment, have to be offset. If in order to make a feeder road effective, it is necessary to build a new bridge, or to replace an old and inadequate one, then the same arguments are applicable.

2.4.4 Relationship between need to establish costs and bridge needs:

The consultant emphasized that the full cost effectiveness of the bridges could not possibly be fairly assessed until there had been an ongoing programme involving a whole series of them, constructed over several years. The development of a bridge foundations and abutment building capability would, in its own right, be quite a major new undertaking for DFR and any contractors whose skills it might nurture. There were no comparable existing road structures of a medium capacity and cost being constructed using Ghanaian skills and labour, against which the proposals could be judged.

It was also suggested that it would be fair to admit that at present, in practice, the choice was between a 'low cost' (although not 'temporary') timber bridge, and no bridge at all. In rural areas, the latter can often bring great inconvenience; waste of manpower; additional vehicle travelling time or head loading only; lost revenue from produce, and even distinct hardship.

The fact that there had been shown to be an imbalance between feeder road and bridge construction in Ghana meant that there were few alternative more conventional designs of medium span bridge design currently under construction. This makes cost comparisons even more difficult. Nevertheless, the consultant informed those present at the seminar and meetings that initial impressions of the likely economy of the modular timber bridges in Ghana are good.

2.4.5 Conclusions regarding costings:

According to the approximate figures discussed at the seminar, it seemed likely that the timber bridge superstructure would cost only about sixty percent of prefabricated steel bridging (Bailey bridge types). Also it was reported that the DFR were currently experiencing difficulty over an unacceptably high quotation for the construction of a 30 m span reinforced concrete bridge design. The expatriate contractor's tender for this bridge had been so high that it is unlikely that this structure can be built at all in the forseeable future.

As discussed above, it was agreed that DFR and ILO advisors would work on information provided by the consultant, TRADA, and UNIDO to obtain more precise cost estimates in relation to the conditions prevailing in relation to feeder roads in Ghana. From the information obtained during the consultant's visit, the costs of the actual timber, using material available locally within the country, would be very acceptable. However, the superstructure materials costs only form quite a moderate portion of the total costs of an ongoing rural or feeder roads bridging unit. It should therefore be up to the government of Ghana, at a high policy making level, to decide whether the creation of a capacity to meet the medium span bridge needs identified above is an urgent priority.

The points covered in the above discussion should be borne in mind in developing the cost estimates and in drawing conclusions from them.

2.5 Durability and maintenance of timber bridges

2.5.1 Maintenance needs in relation to timber:

During the discussions, concern was frequently expressed over the maintenance needs for timber bridges. It is of course a widely held belief that timber structures are impermanent, due to the poor impression created by badly constructed examples, and ignorance over matters such as correct choice of species, treatment and proper detailing. In addition, there is currently a strong awareness of maintenance issues in connexion with feeder roads. The topic has been given prominence by the ILO advisors and their counterparts, since earth roads, as well as bridges, require elementary but diligent maintenance. Hence there is now a better appreciation that maintenance in general is a key factor in all aspects of roads communications. Conversely, there seems to be a mistaken impression with some civil engineers that concrete structures can safely be totally neglected and left unmaintained. This is manifestly untrue.

2.5.2 Features of the design in relation to maintenance:

It was explained by the consultant that the modular timber bridge designs are permanent structures, and that they are designed as such. This entails both the use of selected naturally durable species of timber and the application of timber preservation techniques. It was verified during the mission that adequate pressure treatment facilities for timber are available within Ghana. These can of course be applied when timber bridge parts are to be made, in addition to the precaution of using durable timbers. Schedules of treatment are available for exacting applications such as bridges. A great deal of technical information on timber preservation in the tropics also exists, and this can be made available, whenever a bridge project is set up.

Modules in the system are held together by steel dowels whose heads are welded to their corresponding steel gusset plates. Also, nuts are recommended to be tack welded to their washers. There are no maintenance requirements therefore in relation to the prefabricated timber parts of the girder structure, other than keeping angles between the timber members clean from mud, plant growth and debris. Steel plates and chords require routine maintenance in the form of wire brushing and repainting with red lead oxide paint, followed by enamel.

2.5.3 Standard maintenance recommendations:

Maintenance of modular timber bridges thus entails many of the considerations applicable to any roads structure (1) , for example maintenance of drainage on road approaches and aprons; control of vegetation on embankments; clearance of waterways, and erosion protection. As regards the deck itself, this is maintained in a similar way to the deck of a prefabricated steel bridge with timber decking. Running boards can be made of a very hard and durable timber such as ekki (Lophira alata), but they must be kept in repair, and the preferred fixing method is to have them coach screwed (in countersunk holes) to the nailed laminated timber deck. Running boards fixed in this way are less likely to lift through loose nails, and are more easily removed when replacement becomes necessary.

2.5.4 Conclusions regarding maintenance:

In concluding the discussions on maintenance, the consultant explained that the modular timber bridges are permanent, high quality designs, with many in-built features to ensure their durability. He was able to correct the impression that in industrialized countries where 'the best can be afforded (!)' timber bridges are no longer used. This is manifestly untrue. It was also pointed out that good maintenance recommendations already exist for road bridges under African conditions, and that even though these are not unfortunately universally applied, they would hold good for modular timber bridges.

It was agreed that the training programme which will be proposed for the introduction of the Ghana Modular Timber Bridges shall include a module on maintenance, expanding on the outline given above, and concluding with the presentation of maintenance documentation.

2.6 Training requirements

2.6.1 General:

Training is seen as an essential support activity which must be conceived at a national level in order that a modular timber bridge programme may be successful. It can be shown that those countries which have become most fully involved in training, have made the maximum use of the timber bridges and have gained the greatest benefit from them. On the other hand, in those situations where the more limited aim has been achieved of simply completing a demonstration or prototype bridge, on a one-off basis, there has seldom been an effective uptake of the technology once the international team has left.

Whilst the standard designs used for the bridges are relatively simple to manufacture, using prefabricated modular panels, and mild structural steel welded parts, it must be appreciated that what they entail is the production of safe and reliable structures, carrying heavy traffic loads over quite long spans. The level of skill aimed for therefore is higher than that involved in the production of, for example, low cost furniture for local markets, or the building on site of one-off timber structures such as non-prefabricated roof trusses. Once training in the technologies and skills involved in modular timber bridges has been provided, people will be found to have acquired experience in accurately made, modern designed timber structures which can be valuable for other projects too, including for example the construction of good quality timber buildings.

2.6.2 Organization and scope of services, including training:

In considering the organization and scope of support services for modular bridges, including training, it is important to recognize that the locations where bridges are required to be built are normaly rural areas. The objective of bridge projects of the type for which the UNIDO system was devised is to improve national road networks with emphasis on rural development and access roads. In Ghana, the types of road on which the bridges would be used are known as 'Feeder Roads'. The model feeder roads projects visited by the consultant during his mission appeared to be exactly the type for which the bridges are considered suitable, and on which they have been used in other countries.

Rural areas tend, by definition, to be remote from centres of industry. Hence the development of even simple industrial support for projects such as these requires careful planning with respect to location of training and manufacturing centres. In rural development projects, field workers normally have to cover a wide area of territory, and to be generalists. In the GMRH context, the most relevant field workers likely to become involved in feeder roads bridges would be the DFR Regional Engineer and his staff, plus any ILO Training Advisor that might be assigned to the Region.

The most efficient and cost effective way of providing support services to a modular bridges programme is to have one or more specialist units at a national level, providing a direct service to the field workers, and supplementing their normal supervisory and labour staffing at periods of bridge building activity. The question of how contractors are to be dealt with also needs to be resolved at this level. In relatively large countries, especially where there are differences in terrain, or economic differences between regions, plus the difficulties of transport and communications that are common in developing countries, it may be justifiable to set up more than one specialist unit, at district centres.

2.6.3 Existing institutions:

In planning such arrangements, account should be taken of institutions already available which can provide some of the specialist services required. Examples of these may include training and research organizations. It was clear in the Ghanaian context that the Forest Products Research Institute (FPRI) at Kumasi could provide some of the support. Its facilities would need strengthening for the purpose, but it has a well educated and experienced directorate and section management who could cooperate in the organization of both training and manufacturing services on the timber side.

The modular bridges also entail elements of structural steel cutting, machining, welding and fitting. Through the Chief Technical Advisor of the ILO Department of Rural Housing and Cottage Industries, contact was made with an Intermediate Technology Training Unit (ITTU), based at a Technology Training Centre (TTC) on the University of Science and Technology (UST) campus in Kumasi. It is understood that this unit is involved in metalwork machining and fitting training for small enterprises under a scheme known as GRATIS (Ghana Regional Applied Technology Information Service). This is associated with the Ghanaian Ministry of Industries. The ITTU was visited, and appeared to be a suitable organization to consider for involvement in steel parts manufacture for the modular bridges.

Finally, and especially in view of the success which is being achieved in terms of feeder road training and project implementation, the DFR itself must not be neglected as an existing organization that would perform a key role in the implementation of bridge projects, should the decision be taken to go ahead. More senior management training, and engineering seminars can certainly be carried out at the good premises, and using the good facilities which the Department has available. The DFR contains qualified and experienced civil engineers who can form the nucleus required, particularly on the foundations, abutments and general roads and sitework side of the projects. On the other hand, it is understood that DFR does not currently construct or supervise any major road structures on a direct basis, and it will be necessary to build up this experience and confidence gradually.

It is important that new organizational arrangements which are set up to deal with new projects, such as timber road bridges, take account of, rather than interfere with, existing successful institutions and services. At the same time, the range of activities for which the new national level specialist unit(s) are set up must be those which are of direct relevance to the planned and required industrial services at field level.

2.6.4 Discussions with GHRH and ILO advisors regarding training needs:

An important point to emerge from the discussions which took place during and after the seminar was that concerning the differences in technology, and hence training needs, between timber bridges, on the one hand, and bridge construction, on the other.

These differences had become apparent in modular timber bridge projects elswhere, and the consultant was anxious to ensure that those present in the seminar appreciated them, so that training could be suitably planned from the outset.

There are two broadly different classes of skill and type of work involved in the bridge systems as a whole. These can be divided into:

1. Manufacture of the bridge modules and other pre-cut and treated timber parts.

2. Construction of foundations and abutments, and bridge launching.

The first clearly entails principally timber engineering skills, that is to say accurately controlled carpentry plus some simple metalwork. The second is essentially a civil engineering matter, involving excavation and other on-site work with mechanical plant, construction work and the handling of lifting gear and winches. Completion of the bridge again entails carpentry, but this is a relatively simple matter which never causes bottlenecks in projects.

There was considerable discussion as to whether it would be necessary in the event of a project commencing in Ghana, to train private sector contractors separately along the two lines indicated above. It then became evident from the discussions that for the forseeable future only one bridge workshop would be required, at which the modules are made for all the bridges to be constructed. This would be likely to satisfy all the needs from the sites that could be prepared, since one simple workshop can quite easily cater for one 15 m span bridge per six weeks. Sites are unlikely to be developed at a faster rate than this. In the much longer term, if there were road and bridge projects in several districts remote from one another, then perhaps production might be split.

It was noted that not only the types of skill differ between bridge making on the one hand, and site work on the other, but also the rhythms and seasonality of the work. Manufacture can proceed independently of weather conditioning (provided that sufficient timber stocks are laid up in order to be free from log shortages) whereas site work, especially at the foundation stages, is heavily dependent upon reasonably dry weather and freedom from floods.

The MRH, GHA and DFR Senior Staff present at the seminar and at the draft report discussion meeting considered that there would be difficulty in controlling contractors, and agreeing fair rates for compensation, if these had to perform both bridge manufacturing and site construction work. It was recommended therefore that project proposals ought to be developed under the assumption that during the training and inaugural period for timber modular bridges in Ghana. There would only be set up one bridge workshop. This would initially be under the control of MRH, probably under the DFR. Its location might well be in the Ashanti Region, and some form of collaborative arrangement with the Forest Products Research Institute (FPRI) might well be suitable. Contractors on the other hand could be selected, trained, and if successful given certificates of competance for all of the site work aspects, in a similar way to the DFR-based training currently in hand for Feeder Road construction.

2.6.5 Conclusions regarding organization of services, including training:

Prior to finalizing proposals for the organization of services and training, it will be necessary to have answers to the key questions:

i. What are the national development objectives with regard to the proposed new technology (in this case timber road bridges)?

ii. What regions is it proposed to serve, immediately, and in the forseeable future?

iii. What are likely to be the resource constraints (skilled manpower and experienced management; finance; equipment and facilities)?

Some partial answers to some of these points are suggested within this report, but the issues need to be addressed at a senior level by Ghanaian government and executive, in order to set a project proposal off in the correct manner.

It will then be possible to plan, draft and discuss a training programme and to draw up plans for support services in detail. It will be necessary to meet training needs for staff at several levels of responsibility, ranging from senior engineering management, through practising engineers and field staff, to artisans and construction workers of various trades.

The depth into which each of the above will need to go into the various subjects which bridge building and structural timber entail will naturally depend upon their responsibilities and involvement. However Figure 1, which is based on Figure 2.1 of Part 2 of the UNIDO Bridge Manual, gives an overall design selection process chart for the bridges. This provides a good general indication of the topics concerned. Amongst these are the following:

* An appreciation of road bridge loading codes, standards and design principles

* Soils engineering and site investigation methods, surveying

* Design, supervision and safe construction of foundations, abutments, wing walls, piers and gabions

* Structural grading of timber
* Safe and effective application of timber preservation techniques
* Understanding and knowledge relating to timber drying
* Structural steelwork - grades, strengths, fabrication methods (including welding, cutting , grinding) and maintenance of tools and equipment
* Safe and efficient woodworking, machining, drilling, nailing, bolting, dowelling, use of tools and machinery setting and maintenance
* Safe and effective use of lifting and hauling gear, steel wire cables, winches, pulleys etc.
* Maintenance procedures for bridges and associated roads and drainage structures

3. PROJECT PROPOSAL

3.1 Aim

The aim of introducing the modular timber bridge technology is to enable the directorate and management of Ghana's Department of Feeder Roads, and the Highway Authority where appropriate, to have gained the experience to be able to apply modular timber bridges as a self-sufficient, labour intensive solution to medium span bridge needs in relation to their future roads programmes. UNIDO's prefabricated modular timber bridge system, established since 1973, has proven a fully cost-effective alternative to reinforced concrete, and capital-intensive steel bridges in many developing countries. With its excellent, strong, and durable timbers, good forest industries and thriving feeder roads programmes, Ghana is ideally placed to take advantage of the system.

3.2 Objectives

3.2.1 General:

Although it will clearly be necessary to build up modular timber bridge programmes gradually, it is strongly recommended by the consultant, and supported by the DFR Directorate, that the initial objectives should be planned with vision and with the long-term aim, stated above, held clearly in mind. An initial project should not therefore consist merely of building a prototype bridge, with a great deal of expatriate effort and a modicum of local training and misleading costings.

There are several important special considerations that should be included when formal project documents are drawn up for modular timber bridge projects. These projects fulfil important socio-economic aims with respect to the feeder roads of which the bridges provide a vital link. For example the rural and farming populations which are served are connected more efficiently to markets, schools and hospitals. Thus these populations are integrated into the district and national communities, whilst at the same time being able to maintain their livelihoods in the villages and small towns in which they are settled, without having to exacerbate the problems of 'urban drift'. Provision of safe, reliable and affordable road bridges, using local materials and involving national expertise and labour is an excellent way of contributing towards the solution of these prevalent problems. Officials in government and in development agencies will no doubt recognise these symptoms and the benefits outlined above, and will be able to make reference to specific studies and statistics in order to support the case. The consultant was unable, in the time available, to have lengthy discusions with UNDP or others, who would supply such information specific to Ghana.

There are opportunities to include youth and female employment opportunities in modular bridge projects. In Honduras, a female supervisory engineer served as workshop manager, including having charge of other engineers and artisans. In Cameroon, a female engineer was closely involved in bridge foundation and gabion construction, effectively serving as the resident engineer, as well as being involved in the timber engineering training and fabrication.

The objectives of the proposed initial project therefore are as follows:

3.2.2 Creation of capacity:

With respect to modular timber bridge construction, to create the capacity within the Department of Feeder Roads, to plan manage, supervise and execute projects via trained contractors, whenever and wherever they are required in future feeder road programmes.

3.2.3 Courses:

To plan, equip and conduct two modular practical and theoretical training courses, each of twelve week's duration. This to include the development and adjustment of existing material to Ghana conditions. These courses to be aimed at selected potential contractors and their staff, and to include DFR engineers and technicians.

3.2.4 Workshop:

To plan, equip and set up a modern timber bridge workshop at a location to be selected by DFR in consultation with others. To use this workshop during the conducting of the two courses mentioned above, and to associate with the courses the use of the workshop to construct two medium span (in the range of 15-18 m) modular timber bridges at locations selected by DFR.

3.2.5 Documentation and other deliverables:

To hand over training documents, a functioning workshop and maintenance recommendations for modular timber bridges, appropriate to Ghana DFR's needs.

3.3 Work programme for first bridges

3.3.1 Schedule:

A typical project schedule for a modular timber bridge is given as Figure 2. This represents the consultant's assessment of the needs, in the light of previous experience. It indicates 'milestone' dates by which major activities must be completed in order for others to proceed.

3.3.2 Main activities:

The main general activities and the elapsed times for each are given below. However it should be noted that a better idea of timescales can be obtained from the Gantt chart (Figure 2), since some are not full-time activities during the periods concerned, and some activities may be permitted to overlap in calender time.

1. Mobilization of personnel and familiarization 2 months

2. Preparation of bills of quantities for jigs, steel parts, equipment and expendables and obtaining and selecting quotations from suppliers — 3 months

3. Shipping, clearance from port and delivery — 3 months

4. Construction of foundations and abutments — 4 months

5. Sawing, drying, machining, preservation and re-drying of timber parts — 4 months

6. Modular panel manufacture, completion of steel parts — 2 months

7. Arrangements for bridge launching, supply to site, logistics, delivery of erection equipment etc. — 1 month

8. Launching bridge — 2 weeks

9. Completion of decking, handrails etc. — 3 weeks

10. Clearing and making good the site — 2 weeks

3.3.3 Total elapsed time:

Although some of these major activities overlap, it can be stated that in practice for the first few bridges in a country, it is unrealistic to expect completion in under one year from the start of serious work on a project. This needs to be borne in mind in planning the training needs.

3.3.4 Need for Government and official support:

Full government support and commitment is required in order to ensure that undue delays are not caused by, for example, difficulties over import and customs clearance of project equipment; licenses and payments for timber supplies and contractors; construction of foundations and abutments.

3.3.5 Conclusion regarding project proposal and initial bridge programme:

Provided that there is a definite commitment on the part of GMRH, two bridges, for example, could just as easily be built within only about fourteen months, rather than one in twelve months. Thereafter, an ongoing bridge programme is driven only by the rate at which the structures need to be called up in relation to road development and the rate of support structures construction. Hence the size, scope and geographical locations of trained contractors, particularly those on the civil engineering side, needs to be carefully worked out in relation to feeder road development plans.

It is essential to bear in mind the stated aim and objectives given at the start of this proposal, in the view of which the construction of one or two bridges is to be regarded as a by-product of the creation of the capacity within Ghana MRH, DFR, to manage and execute via trained contractors, the construction of their future medium span bridges.

Thus the activities to put in hand a work programme for the first bridges should not commence until training plans relating to both a bridge superstructure and a foundations and abutments programme are thoroughly established and underway.

AFZELIA

Botanical name	Afzelia bipindensis (and other spp.)
Pilot name	Doussie
Ghanaian names	Apa, Papao
Density	Upper
Strength group	S3
Workability	Moderate
Shrinkage	Low
Natural durability	Good
Amenability to Preservative Treatment	Sapwood Moderately resistant, Heartwood very resistant
Observations	Good reputation for external applications, and having good joinery qualities. Logs said to be obtainable, by some of sawmills visited. Should be given trial for modular wooden bridges, if available.

DANTA

Botanical name	Nesogordonia papaverifera
Pilot name	Kotibe
Ghanaian name	Danta
Density	Upper
Strength group	S4
Workability	Good
Shrinkage	Moderate
Natural durability	Good
Amenability to Preservative Treatment	Sapwood Moderately resistant, heartwood very resistant
Observations	Traditionally used for lorry bodies and floors, boat building and external joinery. Appears suitable for bridge modules, but some doubt about availability and price.

DABOMA

Botanical name	Piptadeniastrum africanum
Pilot name	Dabema
Ghanaian name	Dahoma
Density	Upper
Strength group	S4
Workability	Moderate
Shrinkage	Moderate
Natural durability	Good
Amenability to Preservative Treatment	Sapwood Moderately resistant, Heartwood very resistant
Observations	Recommended for external structural applications rather than fine joinery etc., due to unpleasant smell and woolly grain. Recently used for 24m span modular bridge in Cameroon, where it was selected to demonstrate utility of a plentiful, commercially less accepted species. On offer at all sawmills visited in Kumasi.

EKKI

Botanical name	Lophira alata
Pilot name	Ekki
Ghanaian name	Kaku
Density	High
Strength group	S1
Workability	Moderate
Shrinkage	High
Natural durability	Good
Amenability to Preservative Treatment	Sapwood Permeable, Heartwood very resistant
Observations	Recommended for heavy structural uses. Durable and resistant to wear. In Europe ekki (or azobe as it is known on the Continent) is favoured for mechanically laminated bridge structures, in which it has been employed for spans up to 73 metres. For modular wooden bridges it is rather too heavy and strong, the strength of the steel parts becomes more critical than that of the timber. At TRADA, demonstration modules have been made with 'ekki', proving that it can be dowelled and nailed (with pre-drilling). A good timber for running boards. Still in plentiful supply, although only better equipped sawmills are prepared to cut it.

IROKO

Botanical name	Chlorophora excelsa (and occasionally C. regia)
Pilot name	Iroko
Ghanaian name	Odum
Density	Upper
Strength group	S4
Workability	Moderate
Shrinkage	Moderate
Natural durability	Good
Amenability to Preservative Treatment	Sapwood Permeable, Heartwood very resistant
Observations	Iroko would probably be the first choice amongst Ghanain timbers for the modular wooden bridges, especially for the modules themselves. However it is a valuable export timber, and is potentially becoming short in supply. Traditionally a sacred wood in Ghana, reserved for important applications requiring if durability and other desirable properties. Great experience of structural use of iroko in UK, including glulam bridges and Thames Barrier arches.

NIANGON

Botanical name	Tarrietia utilis
Pilot name	Niangon
Ghanaian name	Nyankom
Density	Medium
Strength group	S5
Workability	Good
Shrinkage	Moderate
Natural durability	Good
Amenability to Preservative Treatment	Sapwood Moderately resistant, Heartwood very resistant
Observations	Classified as a good general purpose timber, indicated as suitable for carpentry and joinory. Would have sufficient strength and durability for bridge modules but may be more expensive than alternatives for use within Ghana, due to demand on export markets, including use as peeler logs to produce veneer and plywood for overseas markets.

OPEPE

Botanical name	Nauclea diderrichii
Pilot name	Bilinga
Ghanaian name	Kusia
Density	Upper
Strength group	S4
Workability	Good
Shrinkage	Moderate
Natural durability	Good
Amenability to Preservative Treatment	Sapwood Permeable, Heartwood moderately resistant
Observations	Highly recommended for modular wooden bridges, especially for the modules themselves. One of the best Ghanaian timbers for bridge building. TRADA experience of use of this timber in UK for industrial and agricultural building frames.

ANNEX 1
COST INDICATIONS

Cost indications for a 15 m, four truss modular timber bridge, part assembled in Ghana

Timber	Cost, $US
Dahoma, Kussia or similar timber Approximately 22.5 m^3 required	3000
Pressure treatment, using CCA or creosote	750
Steel	
Mild steel flats, plate and rods, grade 43A	1250
Galvanized nuts, bolts, washers, nails, coach screws	2000
Welding expendables	200
Foundations and abutments	
Concrete bases, r.c. pier caps (including cement and aggregate)	4000*
Reinforcing bars, formwork, wire etc.	800
TOTAL Materials costs	12000

*Alternative, using gabion construction $3000 approx., assuming rock fill in vicinity of site, free of charge or at cost of transportation.

Cost indications to equip a modular timber bridge workshop and launching team

Workshop equipment	Cost, $US
Combined surface planer and thicknesser	
Radial arm cross-cut saw	
Set of arc welding equipment	
Heavy duty electric drill and drill stand	
Heavy duty portable electric saw	

TOTALS: $US

Bridge:	Materials	12000)	= 1467 per metre including support-
	Labour	10000)	structures and labour
Project:	Workshop	25000)	
	Prototypes	4000)	
	Launching	15000)	

GRAND TOTAL $US 66000

ANNEX 2

Typical plant requirements for foundations and abutment construction and for launching a modular timber bridge

1 Bulldozer D6

1 Front end loader

4 Tippers

2 Vibrator rollers

1 Concrete mixer

1 Bowser

1 Water pump and hose

1 Vibrating poker

1 flat bed lorry

1 pick up

Fuel, oil, tyres and spares for vehicles and plant.

ADMINISTRATIVE REGIONS
OF GHANA