Ethiopian Roads Authority







MASTER PLAN

FOR

IMPROVEMENT OF ETHIOPIAN BRIDGES

May 2011

Bridge Management Team

1 FOREWORD

This is the first in its kind Master Plan for Rehabilitation of Bridges administered by ERA. Since development and Introduction of computerized system for bridge asset management in Ethiopia, many become concerned and aware of consequences of bridge damage or collapse unless timely inspection is not performed regularly.

In this regard, since 2005, three projects for nationwide bridge and culvert inventory and inspection are implemented.

A total of 120 Mil Br was invested by the Road fund office in the past 5 years for these projects.

Currently ERA and Regional Road Authorities own a huge bridge/Culvert database that contains geographical, physical and condition data of bridge structures under their jurisdiction.

The in-house developed software for bridge asset management properly operates, analyses, and stores the collected data. And it produces multipurpose reports.

Among the reports, list of bridges prioritized for improvement based on different criteria is frequently needed by asset managers to make rehabilitation and replacement plan as well as to estimate the required budget.

In order to efficiently and effectively utilize the limited budget, a well-organized and prepared work plan is vital. In this regard, our team has prepared a 5 years plan that shows what can possibly done in the coming years in order to bring bridge structures in ERA to reasonably good and serviceable condition.

One can understand that, without timely intervention any asset especially vital road links like bridge structures could gradually deteriorate and demand higher restoration cost from year to year.

Therefore, timely allocation of sufficient budget is a back bone for implementation of bridge improvement plan.

The other important factor needed for plan implementation is assignment of skilled manpower. As it is known, in order to tackle this problem, ERA-JICA cooperation has contributed a lot in terms of capacity building through intensive trainings and provision of equipment and tools.

Now days, many Ethiopian engineers who acquired knowledge from consecutive trainings that are rendered by the cooperation scheme are working in bridge inspection, repair and construction projects either from private firms side or in ERA and RRAs.

We believe that, this Master Plan is achievable as long as the required budget is timely allocated and a capacity building works are continued in ERA district offices and at Head Quarter level.

It is our sincere hope that, this document will inspire all concerned people to pay all possible and sustainable contribution from their side during the process of implementation. Hence, we look forward to operations of the work schedule contained in the document to see improved drainage infrastructure on the road network.

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2 BACKGROUND

The preservation of the road asset including bridges and culverts is high priority task for road agencies. Deterioration that appears on roads to the degree that curtails mobility undoubtedly will follow a series of interventions to silence public outcry. But in the case bridge and other structures, unless the defects that appear develop to the extent of blocking the road, the attention it gets is very little. Due to this reason minor defects that should be corrected with simple interventions will develop to the extent of requiring major interventions. Unlike roads, bridges and culverts require very close monitoring through regular inspection as stipulated in BMS. Adherence to the BMS with clearly defined responsibility, authority and appropriate decision making mechanism are key elements for the preservation of this precious asset.

Currently bridges and culverts that require such intervention has been assessed, selected and included in this master plan for the recommended interventions. This generally can be categorized as backlog work load that should be done on the previous years. Unless a structure has become functionally obsolete, structural defects should be maintained as early as possible to avert catastrophic effects coupled with high cost of intervention.

A limited coverage of the road network and the deteriorating road infrastructure in Ethiopia in particular, has been identified as a serious hindrance in the economic development of the country. The Government has come to a clear understanding that this problem need to be solved and formulated a 10-year Road Sector Development Program in 1997 (RSDP, 1997-2007) which was divided into two five-year phases (RSDP I and RSDP II). The first phase of RSDP (1997-2002) focused on the restoration of the road network to an acceptable condition. This program, prepared by the Ethiopian Roads Authority (ERA), includes not only investment in physical infrastructure and expenditure on maintenance of existing and new infrastructure, but also investment in institutional strengthening and capacity building in order to improve road sector management. The program is jointly funded by the government and its development partners.

The Program particularly focused on the rehabilitation, upgrading of main roads, and construction of new roads. Moreover, the Program also aimed at undertaking the necessary regular maintenance on the road network. Side by side, the Program also considered major policy and institutional reforms. Target of the second phase of the Program (2002-2007) was to consolidate the achievement in the first phase; as well as to increase the network connectivity and providing a sustainable road infrastructure to the rural areas of the country.

Following the RSDP I and II programs, the on-going RSDP III was launched for 2007-10 with the objective to continue the restoration and expansion of Ethiopia's road network. Alongside the physical works, RSDP III would assist in developing stronger management and technical capacity to manage the road network and would strengthen the development of the domestic construction industry. RSDP III would also address a number of social objectives including road safety, environmental protection and HIV/AIDS prevention and mitigation. One of the programs in this part of the sector development program is institutional support to strengthen ERA, through different capacity building programs. ***This includes programs Rehabilitation and Replacement of Bridges.***

Bridge study has been launched during RSDP II. Phase I of this study provided a general inventory and prioritization of necessary remedial works including inspection, quantification and costing of required improvements. Phase II, which will be the main thrust of RSDP III, will involve detailed field investigations and design including preparation of tender documents for selected bridges, culverts and retaining structures along the Ethiopian main road network. Because of the large amounts of remedial bridge and culvert works required along the roads, the selection of those works for inclusion under future program will be guided by the need to coordinate with the priority road projects where practical, bridge and culvert works are included in all road works contracts. In addition, a lump sum amount, about Birr 135 million is allocated for bridge works.

3 INTRODUCTION

According to the 2nd nationwide bridge inventory and inspection, which was conducted in 2010, there are 4280 Bridges and 27500 Culverts found in Ethiopia. Among these structures, ERA administers 3000 Bridges and 18000 Culverts.

Since 2002, thanks to the in-house developed Bridge Management System (BMS) software, ERA radically transformed in bridge asset management from almost absence of organized bridge asset information to the systematic bridge asset management practice, which is born through challenging efforts truly paid to introduce concept of bridge asset management and develop & implement the computer aided BMS. This task was technically and financially was assisted by JICA.

After having developed BMS software by individually initiated ERA bridge Engineer and prepared the bridge Inspection manual by JICA experts, the first nationwide bridge inventory and inspection was conducted in 2005-2006, which was a new practice in the sector.

This historical nationwide bridge inventory and inspection project has established the bridge and culvert asset database that contains wide range of information concerning geographical, physical, historical and service condition of bridge and culvert structures.

All the collected bridge data at the site, by using standard formats for the purpose, entered in to the BMS software where storage could be made and data analysis processed. The software, after analyzing the data, produces multipurpose reports such as list of prioritized bridges for improvement; estimation of the required budget for the improvement implementation; historical data with pictures, drawings, videos; many kind of information that might be asked by professionals or stake holders.

Owning and using of this kind of modern systematic bridge asset management system, makes ERA one of the few road agencies in Africa pioneers in implementing BMS. Moreover, ERA is proud to use this software which is developed by own engineers designed by considering the all round local need in bridge matters and easy available of programmer for the software maintenance need.

In order to widely introduce the concept and necessity of bridge asset management, a series of trainings are given to Engineers drawn from ERA, Regional Road Authorities, and private firms in the past 8 years in cooperation with JICA. The trainings which are focused in Bridge Inspection, Repair and management organized under the Capacity building programs. As many as 500 Engineers have participated in the trainings and received knowledge on the mentioned courses.

Now days, better than ever, Ethiopian engineers are well aware of the need for preserving bridge asset from unpredictable damages and collapses by making timely inspection. In this regard, ERA has launched regular bridge inspection program that

enforces to make detail inspection at 3 years interval and visual inspection every year for each bridge and culvert structure.

In the 2nd round nationwide bridge inspection program, about 150 engineers from the contracted private firms and ERA District offices have involved most of them are passed through the capacity building trainings mentioned above.

The purpose of this Master Plan, which is the first in its kind, is to present the bridge rehabilitation need for the coming few years in more organized and long term plan as well as to indicate the required budget.

It is true that, needs for improvement of Ethiopian bridge generally considered along with the need for rehabilitation and expansion of the country`s road network which is well discussed and planed in the RSDP, which was launched in 1997. But, unlike to the road sections that are defined name by name, bridges to be improved were not identified individually due to absence of the said bridge database and information.

Despite that, a number of bridges which were already known as defective could be included for replacement and rehabilitation along the road rehabilitation projects. As a result, many drainage structures are improved. Consequently, after acquiring nationwide bridge database, a prioritization activity and formulation of bridge rehabilitation projects took place in order to handover the implementation to own force and private firms. In this regard, a number of bridges identified for improvement and added in to the ongoing projects and handed over the own force. Some others recommended for further study and replacement design.

Updating of the BMS database after completion of the bridge improvement works here and there, shows how condition of bridge structures is improving from year to year. Condition of bridge structures classified as GOOD, FAIR and BAD. However the bridge asset management and improvement works are being implemented as discussed above, preparing of a Master Plan in more organized way become necessary so that the ERA management can assist and provide the required resource for future short and long term plan of bridge structures rehabilitation.

Availability of the MP assists the decision making body to see clearly what kind of intervention should be done in the future by considering the available budget and capacity. On the other hand, it serves as input to prioritize needs of sectors development demanding pouring of resource at nationwide level.

Therefore, this MP is prepared in considering the mentioned facts as well as it shows time schedule for improvement implementation by considering the work load and the capacity.

Finally, it should be noted by all stakeholders that, for proper implementation of the MP and the desired improvement works, a capacity building works must not be neglected such as provision of trainings to professionals engaged in the sector and establish engineers retaining incentives in the regulatory body.

4 OBJECTIVES OF THE MASTERPLAN

The bridge and culvert stock on the road network hold the significant part of the road investment and should be preserved as part of the overall road asset. Bridges and culverts on the road network should be monitored through close inspection and their condition should be kept to the level that insures the structure safe and operational.

By virtue of their service and the demand of users, bridge structures have to be safe and operational under any circumstance. Unlike pavements such structures shouldn't sustain severe damage that could disrupt the transportation system and compromise the safety of passengers.

Even though this should be supported by a clear policy that stipulates level of service regarding the operational and safety of bridges and culverts, they should be structural sound condition throughout their design life. Any condition that makes them less safe and operational should be rectified urgently.

The main target of this master plan is to identify backlog in the preservation of the bridge and culvert asset on the road network and bring their performance to good condition within the specified 5 year time.

The Master plan for the rehabilitation and replacement of bridges and culverts will contribute to the implementation of effective and planned annual bridge improvement programs. It will provide an integrated plan until 2015, for the rehabilitation /replacement of Bridge/Culvert structures to improve the efficiency and safety of the road network specifically, the study will result in

- Building and updating a database of bridge/culvert structures;
- Developing a comprehensive prioritized list of all major bridge/culvert structures describing detailed remedy actions required for each structure, and
- Prepare an investment plan for rehabilitation and replacement of bridges and culverts under the Federal Road Network up to the year 2015.The Study will produce plans for efficient management of capital investment projects for rehabilitation or replacement of bridge and culvert structures as well as for the mobilization of resources required for these investments. In this regard, the direct beneficiaries represented by government are organization under the *Ministry Transport* such as Ethiopian Roads Authority, Road Transport Authority, and Office of Road Fund (ORF). The ultimate beneficiaries of the outcomes of the study include at large the road users who stand to benefit from the implementation of the recommendations of the Master Plan with regard to the efficient operation of these structures.
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5 EXECUTIVE SUMMARY

5.1 General

Bridge rehabilitation/replacement master plan provides a "road map" to the future improvement and development of the bridge infrastructure in the country. It is a key guide for ERA and the Government in determining the funding of future improvements. The bridge master plan provides recommendations and serves as solid tool to assist the implementing bodies in the preparation of annual plans and the corresponding budget.

One of the RSDP goals is to develop and manage the road network in the country in the most efficient manner that satisfies road users Sustainable road infrastructure can be achieved through maintained asset preservation programs. The specific objectives of this study are to:

(i) Prepare a Master Plan for the rehabilitation/replacement of bridge/culvert structures on the Federal road network (a dynamic plan demonstrating what interventions need to be done on each of the concerned structures taking into consideration the defects sustained, at what time and cost) and

(ii) Prepare a feasible investment projects for the top priority bridge/culvert structure identified under the study to facilitate the mobilization of resources for implementation of works.

Master Plan for the replacement and rehabilitation of bridges and culverts is important given the resource constraints. It is necessary to have in place a master plan that enables the prioritization of appropriate and timely interventions in the different Bridges and Culverts. Such a plan will equally address the issues of timely resources mobilization. Resource is very limited and the available resource should be deployed where it brings the maximum benefit in terms economy and other social benefits. Beside this prioritization in the case of bridges and culverts is highly related to the safety of rode users and have significant importance. This prioritization process will involve elaborate capacity and resource analyses which take into account the probability and the impacts of failure of the structures as well as the risks of safety and variability on their performance and resilience. The prioritization process conducted mainly from the technical aspect of the current condition of the structures.

Bridge rehabilitation/replacement works have been carried at several locations on the road work ever since ERA established as a responsible body for roads and bridges. Most of such actions were materialized after the damage on the bridges reached to critical level and become life threatening and requiring more cost than the cost required for earlier interventions.

After the implementation of BMS and responsible body for monitoring and evaluation of the bridge stock in the country, the number of such drastic measures is expected to

drop rapidly and give away to more comprehensive risk analysis approach to determine the type of intervention, cost and timing in order to minimize cost and ensure public safety.

It is common practice that most of the bridges are designed for a life of hundred years. As long as there is no change in the design parameters, most bridges serve more than the design life. However due some changes in the loading and the environment or errors introduced at the design and construction stage, an earlier premature structural/functional failure could happen. Such premature failures are usually aggravated by lack of frequent routine/periodic maintenance.

The bridge and culvert stock on the road network hold the significant part of the road investment and should be preserved as part of the overall road asset. Safety and serviceability are the major essence of the intervention proposed in this master plan. The bridges and culverts on the road network should be monitored through close inspection and their condition should be kept to the level that insures the structure safe and operational.

The management of bridges and other structures should be supported by a clear policy that stipulates level of service regarding the serviceability and safety. The overall management of bridges and other structures should be guided this policy. It is known that ERA has road maintenance policy which also incorporates bridges. However bridges are very weak link in the road network and deserve specially attention unlike roads. For this either this unique attributes of bridges should be incorporated in the policy or a separate policy should be formulated and implemented.

The main target of this master plan is to identify backlog in the preservation of the bridge and culvert asset on the road network and bring their performance to good condition within the specified 5 year time. ERA has planned to improve the condition bridges and culverts to safe and serviceable condition.

The prioritization process has been conducted based on BMS and other known standard parameters applicable to facilitate the selection process. The recommendation of bridge specialists regarding the overall condition of a structure is a governing factor for the prioritization task rather than the general parameters set for the process.

5.2 Summary of Bridge Stock

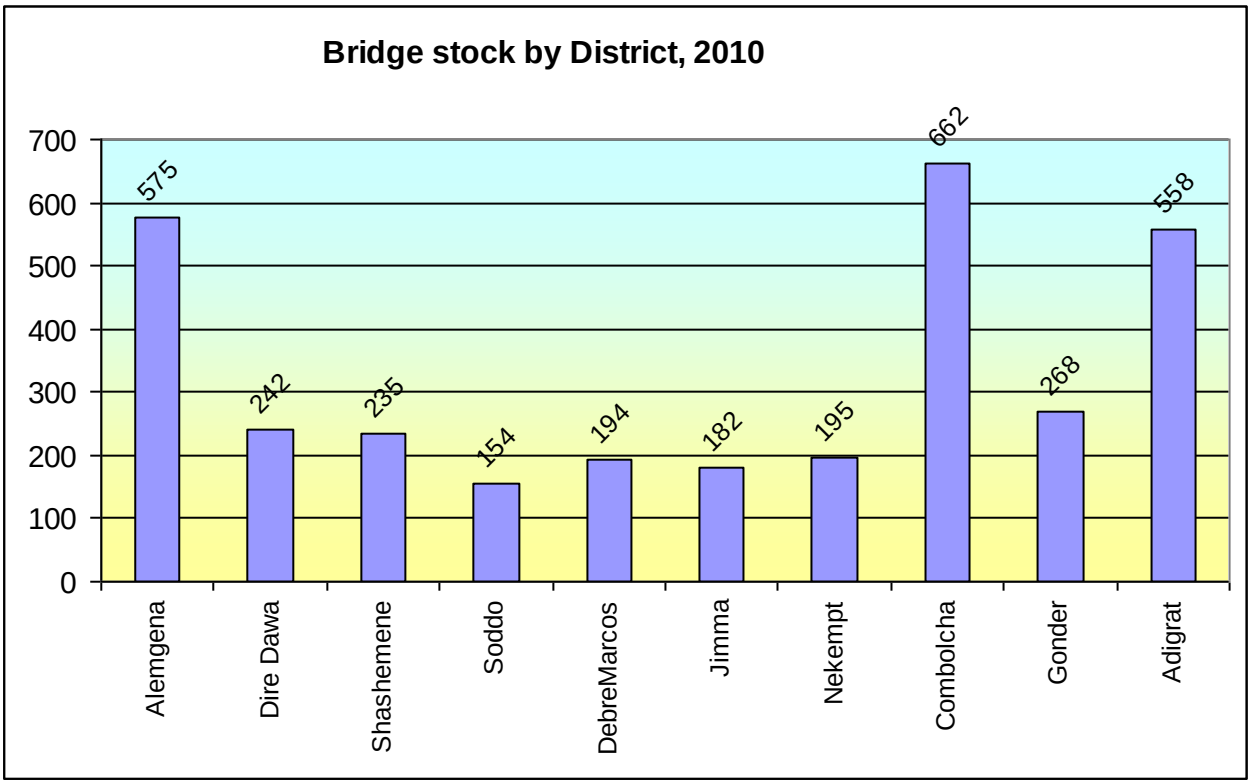
In preparation of this Master Plan, more than 3200 bridges and about 19000 Culverts , which are registered in latest inventory program. The bridge stock considers bridge structures length of 4.0 mt and more. The remaining Hugh number of drainage structures is considered as Culvert.

List of all bridges in each district prioritized by improvement recommendation presented at the end.

Districts	Bridge stock in 2006 , 1st round Nationwide Inventory	Bridge Stock in 2010, 2nd round Nationwide Inventory	Growth
Alemgena	559	575	16
Dire Dawa	237	242	5
Shashemene	171	235	64
Soddo	103	154	51
DebreMarcos	167	194	27
Jimma	158	182	24
Nekempt	175	195	20
Combolcha	626	662	36
Gonder	219	268	49
Adigrat	539	558	19
	2954	3265	311

10.5% increment

More than 300 bridges which are constructed in the past 4 years added to the central bridge database. Most of these bridges appeared due to alignment of roads in the road network improvement programs. There are also some Road segments are transferred from Regional Road Authorities to ERA.

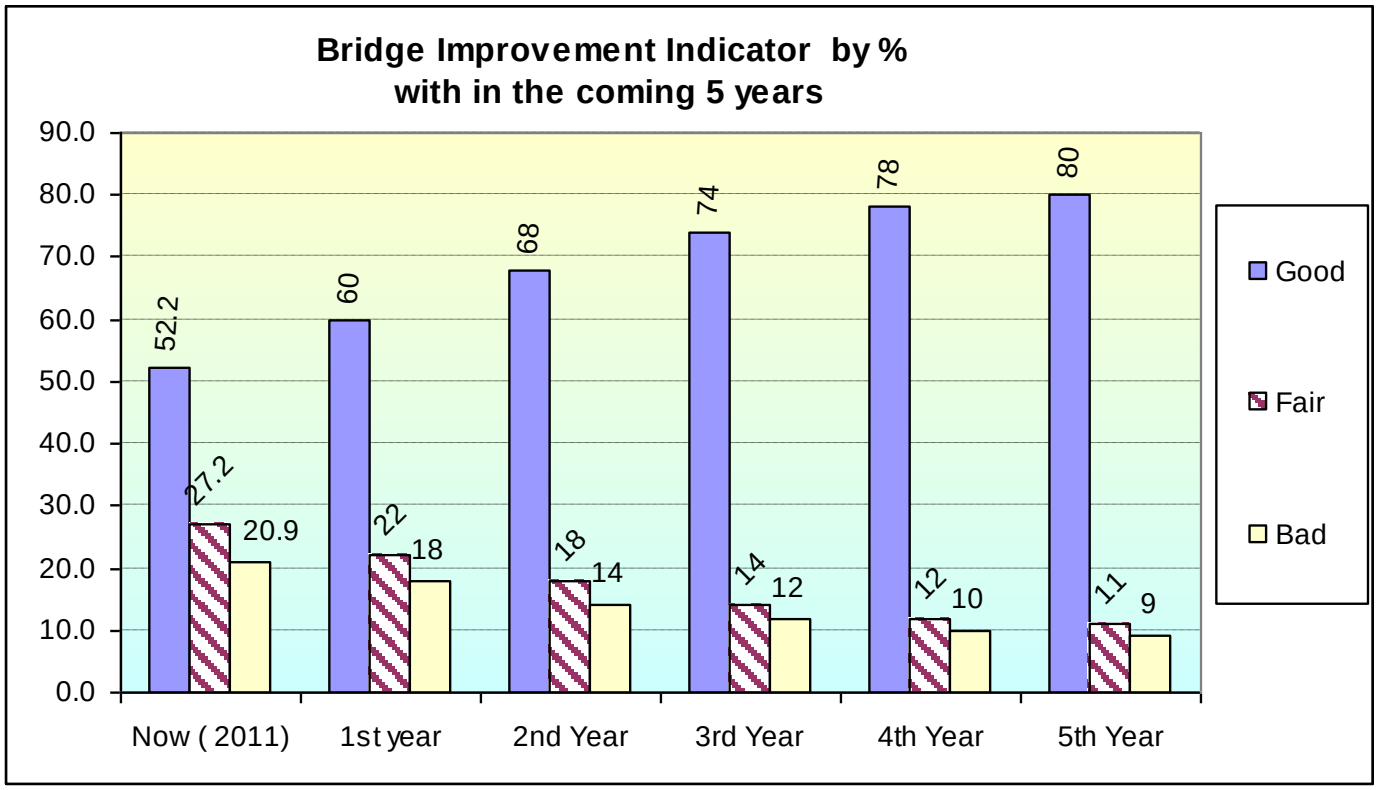


5.3 Summary of Bridge Condition

In the 2nd round nationwide bridge inventory, 3265 bridges are registered. Among them only about half of the stock found in reliable service condition, which means they need only visual regular inspection. The remaining stock need either detail inspection for maintenance action in near future or 1 bridge out of 5 may need replacement in long term plan.

In this Master Plan, presumably possible improvement of bridge condition in the next years is presented. Assuming that the required budget will be allocated, capacity building works will be achieved and all concerned managers dedicate themselves for follow up of the implementation, at the end of 5th year only 9 % of the bridge stock would be considered as `BAD` condition which will have first priority for improvement in consecutive years.

In this regard, after 5 years 80% of ERA`s bridges will found in `GOOD ` condition.



5.4 Summary of Budget requirement

In order to implement the Bridge rehabilitation Master Plan, about 400 Mil Br is required. This amount is distributed for 5 fiscal years. This amount is estimated only for repair works ranging from minor repair to partial replacement.

For those bridges requiring full replacement, separate budget may be requested for detail design, construction and supervision.

The budget estimation is prepared based on the damage quantity collected in 2nd round nationwide bridge condition survey, special recommendation of inspectors, and the given priority for each bridge by road class and traffic volume.

District	Distribution of estimated budget for bridges improvement, Br					
	1st year	2nd year	3rd year	4th year	5th year	Total required Budget estimate, Br
Alemgena	8,738,052	18,468,613	10,051,814	23,174,412	10,649,880	71,082,771
Dire Dawa	9,425,757	11,834,240	1,129,549	500,000	700,000	23,589,546
Shashemene	9,472,156	21,799,091	16,803,576	2,123,519	3,750,324	53,948,666
Soddo	8,105,456	16,614,163	3,641,163	4,100,468	1,927,333	34,388,584
DebreMarcos	8,662,750	18,137,500	7,794,500	8,791,000	11,297,750	44,683,500
Jimma	4,049,750	15,255,750	4,472,000	4,009,250	2,884,125	20,754,875
Nekempt	4,817,250	13,000,000	3,580,500	3,270,750	4,318,000	18,986,500
Combolcha	51,787,857	14,629,311	2,267,181	3,140,000	3,800,000	75,624,349
Gonder	7,988,779	11,561,755	1,440,000	1,420,000	1,420,000	23,858,590
Adigrat	8,114,543	14,302,183	6,013,454	3,622,524	2,900,000	27,952,704
Total	**121,162,350**	**155,602,607**	**57,193,737**	**54,151,923**	**43,647,412**	**394,870,084**

The above shown total budget is anticipated to be sufficient to improve ERA`s bridges from the current status which is only ***52.2% in GOOD condition to 80%*** with in 5 years period. The estimated budget includes the necessary cost for improvement of Culverts as well. The estimated budget may be adjusted based on the price inflation if any starting this period.

6 ROAD AND BRIDGE CONSTRUCTION HISTORY IN ETHIOPIA

Like in any other country, movement on roads in ancient Ethiopia was done on trails and foot paths in addition to the traditional shoulder porter age, animals like mules, donkeys, horses and camels were used as a means of transportation. Historic chronicles of 17th , and 18th , centuries show that there were a number of small roads (rails and foot paths) in use in various small kingdoms of the country. These routes served the trade and expansion of both Christian and Islam Religions.

Prior to the 17th century, there were efforts in bridge constructions. One of which is the narrow bridge on the gorge in the upper course of the Blue Nile River, downstream of the Tis-Isat Falls. This bridge is existent to date. This effort in bridge construction indicates that there were also road construction activities at the time although the roads were of rudimentary standards. It is believed that in the 18th century, especially during the reign of Emperor Tewodros, planned road building efforts, although the technology was primitive, and was also made. It was however limited in extent and conceived in strategic rather than economic terms.

Emperor Yohannes IV, who succeeded Tewodros, was also engaged in road construction. But due to the danger of invasion by Egyptians, Derbush and Turkish, the Emperor was not able to achieve his desires.

Between the years 1896 and 1936, that is prior to the second Italian occupation, great success was made in Road Construction. Especially Emperor Menilik II was a successful road builder participating himself in the construction. By this time the road from Eritrea to Addis Ababa and in 1903 the road from Addis Ababa to Addis Alem were constructed, and it was also during this time that the first Asphalt roads appeared in Addis Ababa.

6.1 Road and Bridge Construction during the Italian occupation (1936-1941)

During this period, the Italians continued the Road Development Program that had been initiated by the Imperial Ethiopian Government. But the roads built by them were established to meet the requirements of the Military Control rather than to promote the overall development of the country's economy. Moreover, the roads built by the Italians lacked most of the modern location, design and construction features desirable for present day high speed traffic.

The roads and trails built and improved during the brief span of 5 years Italian occupation were about 6,000 km. This was done by utilizing large quantities of forced labor of Ethiopian Nationals and some imported Italian Professionals. Almost, without exception, these roads consisted of a 3 to 4 meter wide telford based constructed from hand set stones. Approximately 2500km were given a single

asphalt surface treatment. Drainage structures were usually of stone masonry and at least there tunnels were built. However, when Ethiopia regained independence , the Italians in their fleeing attempt almost undid what they created during the occupation, by blasting bridges and dynamiting roads.

6.2 Road and Bridge development during 1941-1951

From the time the Italian Administration packed off to home to the eventual creation of the Imperial Highway Authority (IHA) road Construction or maintenance activity was almost subsided for stagnation period of one decade.

The first epoch of the post-war period was characterized by reorganizing the destroyed governmental organizations and systems. During this period, considerable stagnation in the whole range of social and economic sectors, of which the road Sub-Sector was one, prevailed.

Meanwhile, the Imperial Ethiopian Government had entrusted its Ministry of Communications and Public Works with the prodigious job of maintaining and building roads with conditions being what they were, this government agency was unable to cope up with the rehabilitation work due to shortages in funding and experienced personnel in the fields of engineering and Administration. Thus, no significant construction and maintenance of highways was carried out during this period.

Ethiopia's difficult terrain cleft in numerous places by canyons of great depth and high mountain ranges has often rendered communication impossible. The presence of these natural landscapes, coupled with the then lack of adequate equipment and trained technicians stimulated the Imperial Ethiopian Government to found an agency solely responsible for the building and maintaining of the nation's highways. It was realized that without an adequate system of Highways, social retardation and economic retrogression were inevitable.

This self-evident situation led the government to create a climate of belief that good roads would enhance its reconstruction and development plans. Hence, there was a need for the establishment of an independent governmental body with a legal personality and the capacity to borrow from international organizations. Out of this consciousness was born the Imperial Highway Authority (IHA) by proclamation No. 115/1951 as Semi-Autonomous Agency.

The objective to be accomplished was portrayed by the words. "The Authority shall have the duty or developing and maintaining the Highway Systems of our Empire".

The specific duties were to Plan, Design, Construct and Maintain Highways, Roads and Bridges throughout the Empire. Steps were immediately taken to make the newborn organization a reality.

The paper took shape on February 27,1951. This was the day a contract Agreement was signed between the fledgling organization and the Bureau of Public Roads of the UNITED States Department of Commerce. The Bureau provided engineers and specialists to plan the construction and maintenance of Highways in Ethiopia. Having founded a national road policy by the establishment of the IHA, the imperial Ethiopian Government needed financial help to carry out the job through. The sum of US $ 5,000,000 was borrowed from the International Bank for Reconstruction and Development (IBRD) mainly for the purchase of American Road Building Equipment and Supplies.

The Imperial Ethiopian Government supplemented this IBRD Loan with Eth. Birr 23,000,000 in initializing the Authority's program.

The Ethiopian Roads Authority when established in 1951, Mr. Joneal Humbard, an American engineer, was named as Director of the Authority and a member of the Board of Commissioners. At the initial stage the Authority took control of some 6400kms of roads.

In 1963 , for the first time, an Ethiopian Dr. Haile Giorgis Workneh took over the position of the Director with few other Ethiopians deputized in important positions. As IHA continued recruiting Ethiopians with required educational background, the Ethiopianization of key positions has progressed .

6.3 Ethiopian Highway Development Programs

6.3.1 First Highway Program (1951-1957)

A programmed development of road started in 1951 when IHA launched its First Highway program that extended up to 1957. Then a comprehensive study and budget estimation was done for 12 road reconstruction projects. Under this scheme, three roads were identified as primary reconstruction projects in order to open the roads for year-round travel.

This program was designed to achieve in 3 years period. According to the 3rd annual report of IHA, the program involved a total capital investment of Birr 77 Million and largely consisted of the reconstruction and maintenance of 1525 km of badly damaged and 2686 km of all weather roads respectively. The roads constructed include:- Addis-Asseb (860) Addis-Jimma (355km)and Addis-Nekempt (331km) . In addition maintenance and repair works were carried out on the Addis – Adigrat, Addis-Blue Nile and Addis – Shashemene main highways of the country.

6.3.2 Second Highway Program (1957-1966)

The Second Highway program was launched in 1957 with plan to improve 4500km of main highways, Construction of 800 km new roads. And improvement of 1000km of other existing roads. A total sum of Birr 110 million was earmarked for financing the program.

6.3.3 Third Highway Program (1965-1968)

The purpose of the program was an extension of the objectives of the First and Second Highway Programs. The Authority embarked upon a fourfold approach, i.e, carrying out construction of roads and bridges, asphalting of existing roads and carrying out surveys for future road construction. The program involved a total outlay of Birr 60 Million which went into the construction of 700 km of primary and secondary roads, 1000 km of feeder roads and 1040 km if asphalt surfacing works.

6.3.4 Fourth Highway Program (1968-1973)

The program included the construction of 820 km of new, primary and secondary roads. Unlike the pervious programs, the Fourth Highway Program involved four feasibility studies of future road works, technical assistance and advisory services in the reorganization of the Authority, It also included expert assistance in the area of engineering, operation and maintenance, overseas training with practical orientation for equipment superintendents, foremen and mechanics and others. Out of the total program of 2246km, 1600km were completed.

6.3.5 Fifth Highway Program (1947-1976)

Under this program great emphasis was given to the construction of feeder road network to support the agricultural development, strengthening the institutional capability of the Road Agency and providing assistance to the local contracting industry. The program covered the construction of 539 km feeder road and 322 km of asphalt surfacing projects. It also involved the purchase of road maintenance equipment with Birr 14 million and further strengthening of the organization and developing the domestic construction industry.

6.3.6 Sixth Highway Program (1976-1978)

The program envisaged the rehabilitation of 284 km of primary roads, gravel rehabilitation of 280 km of secondary roads, construction of 809 km of new gravel feeder road, 657 km of service-to traffic and 1660 km of rural roads.

Unlike the pervious programs, the Fifth and Sixth Highway programs shifted emphasis to the construction of relatively lower standard roads in conjunction with agricultural projects such as the Minimum package program, the Coffee processing projects, and the Amibara Irrigation projects. Under these two programs, the construction of the Butajira-Ziway, Asela Dodola. Agaro-Ghera, Gelemso-Mechara. Dejen-Mota. Sodo-Bulki. Nekempte-Bedele and Bonga-Mizan Teferi roads were carried out. One of the most important features of the two programs was that local contractors managed to successfully participate in road works contracts with the assistance of the government and the International Development Association (IDA). The new roads built under the two programs contributed to stimulating agricultural development and expanding social service coverage.

An extensive and well-maintained highway system not only benefits the country economically but also socially and administratively as well. Economic benefits resulting from highway improvements are discernable first in the direct reduction in transportation costs and in the stimulation of regional economic activities. The ability to move goods and services from the center of production to the market areas is an advantage largely anticipated from good roads.

In E.R.A. history, major highway construction works were dominated by international contractors between 1960 and 1970. The major roads from Awash to Mille, Agaro to Bedelle, Dilla to Moyale and Nekemte to Ghimbi were built by these foreign contractors with the assistance from donors, specifically the World Bank and KFW.

Between 1972 and 1976, the domestic construction industry had started to develop and became active to same extent in the road construction sector. Unfortunately, their development was impeded by the adverse policy environment created by the Dergue Regime.

In its history, ever since mid 1975, ERA's Force Account construction capacity expanded and executed major projects such as :

- The rehabilitation of the Addis-Awash-Mille road with World Bank and Government funding.
- The construction of feeder roads and service to traffic roads such as the Bonga-Mizan, Gore-Tepi and Gore-Gambella.
- The construction and rehabilitation of run-ways like Bahirdar, Diredawa, Debrezeit , Assab and Bole Airports.

6.3.7 The 1st Road Sector Program (1979-1982)

The first road sector program covered both main and Rural Roads and had as its main objective the extension of the feeder and rural road network to support agricultural development plan and increased social service coverage and the upgrading of the existing heavily trafficked section of the primary and secondary road network. It also included strengthening of the organization and assisting the domestic road construction industry. The program covered the construction of 272km of rural roads, 944 km of service-to traffic roads and 1732 km of feeder roads, asphalt surfacing of 596 of gravel roads, the asphalt overlay of 502 km of existing paved roads and the rehabilitation of 73 km primary and secondary roads. One of the major components of the FRSP was to build up the domestic construction industry and strengthen institutional capability of ETCA through.

6.3.8 The 2nd Road Sector Program (1984-1987)

The most significant advance in the road planning process began to become noticeable with the launching of a comprehensive sector program both for main and rural roads. The accomplishment of the Second Sector Program was the asphalt overlay of 97 km of paved roads, the asphalt surfacing of 118km of gravel roads construction of 386 km of feeder

roads such as Nekempt-Bure, Gore-Tepi, Injibara-Beles, Holeta-Muger , Mota-Bahardar , Mizan-Tepi: Shishinda-Tepi and the asphalt overlaying of the Addis Awash- Mille road was completed successfully, with greater use of force account construction. The program also included 1626 km of Rural Roads and 196 km of service to traffic roads and the equipping of construction brigades for airfields, seaports and city roads plus the development of manpower resource and the maintenance of the road network

The Road Rehabilitation project (RRP), followed the completion of the Second Road Sector Program, with the primary objective of improving the bearing capacity, geometry, safety and riding quality on sections between Mille and Assab on the Addis Ababa- Assab road.

This was followed by the road component of the Emergency Recovery and Reconstruction Program (ERRP).

6.4 New Era for Road development

6.4.1 General

After 1991, Ethiopia embarked on a comprehensive economic reform program putting in place the conditions for transition from a command based economy to a market oriented one. In 1993, as part of its reforms administration of rural roads has been assigned to Regional self-Governments and highways to ERA as part of the central Government's responsibility.

Based on the fact that, to improve general scenario of road infrastructure, a ten years Road Sector Development Program (RSDP) has been prepared. This program envisaged to be financed mainly by donor community.

6.4.2 Road Sector Development Program (RSDP)

Road transport is the dominant mode and accounts for more than 95 percent of motorized inter-urban freight and passenger movements. Yet, Ethiopia has to its size and population a limited road network, currently about 44,359 km, hampering economic development especially in the rural areas. The overall classified network in good condition is about 53 percent.

The Government, in recognition of the crucial role the road sector plays for the economic development of the country; has set out a Road Sector Development Program (RSDP) to speed up the improvement and expansion of the road network. The program provides a comprehensive approach of integrating the implementation of key road investments with major policy and institutional reforms. The objective of the RSDP is to restore Ethiopia's road network, which has become an obstacle to the sustainability of the economic development program, and to develop institutional capacity of the road agencies to manage properly the networks.

RSDP is divided into three phases (RSDP I, RSDP II and RSDP III). The program is started by launching the first phase -RSDP I in 1997, which ended in June 2002 in which RSDP II is also concluded in June 2007. Various donors including the World Bank, European

Union, ADB, NDF, BADEA, OFID, Governments of Japan, Germany, U.K., Ireland, the Road Fund and the Government of Ethiopia have been committed to the Program implementation through provision of the required funding. During RSDP II, an important partner, the Saudi Fund for Development has also joined in financing the RSDP.

RSDP was officially launched in September 1997 and it ended in June 2007. The Program involves a number of components including civil works, capacity building, and policy issues with a view to bring about remarkable changes in the prevailing poor state of road network and improve the efficiency of the transport system in order to support the economy. Investment priority criterion for selection of projects to be included in the RSDP had been clearly predetermined during program preparation and has been strictly followed during implementation. Consistent to this criterion, both Government and donor-funded projects have been under implementation since the launch of RSDP.

As a result of the investment, the share of road network in good condition has improved from 22 per cent in 1997 to 53 percent in 2008**.**

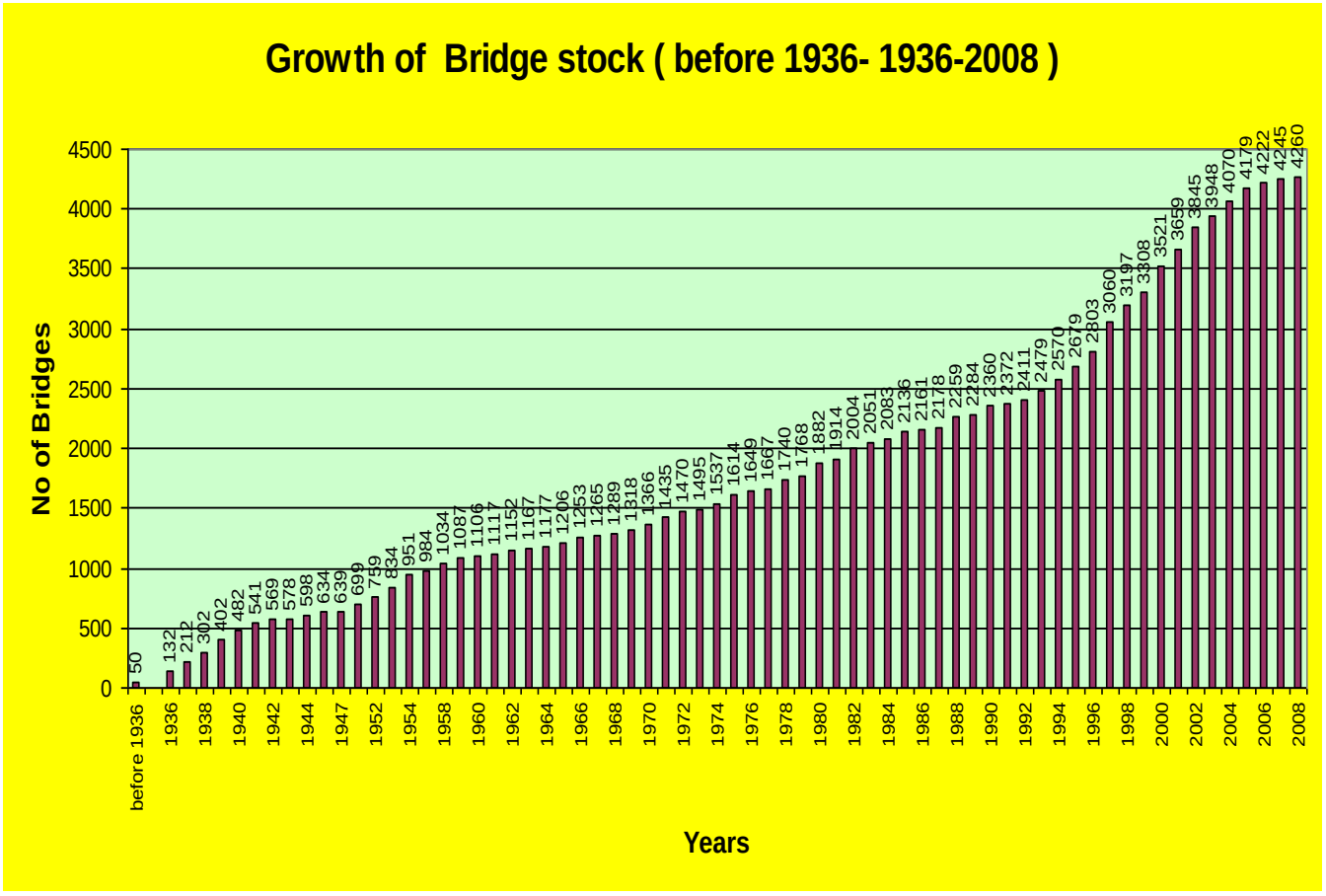
Some improvements have also been realized in the quality of regional roads especially in terms of reduction of the share of roads in poor condition. Apart from road condition improvement, rural accessibility has also improved due to the construction of new link roads and rural roads as well as community roads.

The total road network of the country has reached to 44,359 km (excluding community roads) as of June 2008. With a total land area of 1.1 million sq. km, the current road density is 40.3 km per 1000 sq. km. Overall road network in Ethiopia has been increasing on the average by 5% each year between 1997 and 2008. The road network in the year 1997, (i.e. at the time of the launching of the RSDP) was 26,550 km.

6.4.3 Rehabilitation and Replacement of Bridges under RSDP

Bridges and structures, which are found along the road stretches, need to be properly managed and should receive appropriate intervention in order to enable them to cater for the increasing traffic. Most of the existing bridges and structures are highly deteriorated or even if some of them look sound they are narrow and cannot serve efficiently the modern big size trucks. Because of the above reason, some bridges and structures have been proposed to be replaced or maintained.

During the 11 years period, about Birr 275.3 million was allocated for bridges and culverts rehabilitation and replacement. Most of the bridges identified for maintenance/reconstruction under RSDP are financed from Government treasury. The Road Fund is also financing emergency bridge maintenance when deemed necessary and also the bridge condition survey on a national scale. The World Bank through the Emergency Recovery Program has made available funds for rehabilitating various structures located within the Dire Dawa – Duri - Dewele road. The total sum of money disbursed for this category amounted to Birr 191.9 million.


Growth of Bridge stock (before 1936- 1936-2008)
No of Bridges
Years
0
500
1000
1500
2000
2500
3000
3500
4000
4500
50
132
212
302
402
482
541
569
578
598
634
639
699
759
834
951
984
1034
1087
1106
1117
1152
1167
1177
1206
1253
1265
1289
1318
1366
1435
1470
1495
1537
1614
1649
1667
1740
1768
1882
1914
2004
2051
2083
2136
2161
2178
2259
2284
2360
2372
2411
2479
2570
2679
2803
3060
3197
3308
3521
3659
3845
3948
4070
4179
4222
4245
4260
before 1936
1936
1938
1940
1942
1944
1947
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1954
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1960
1962
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1966
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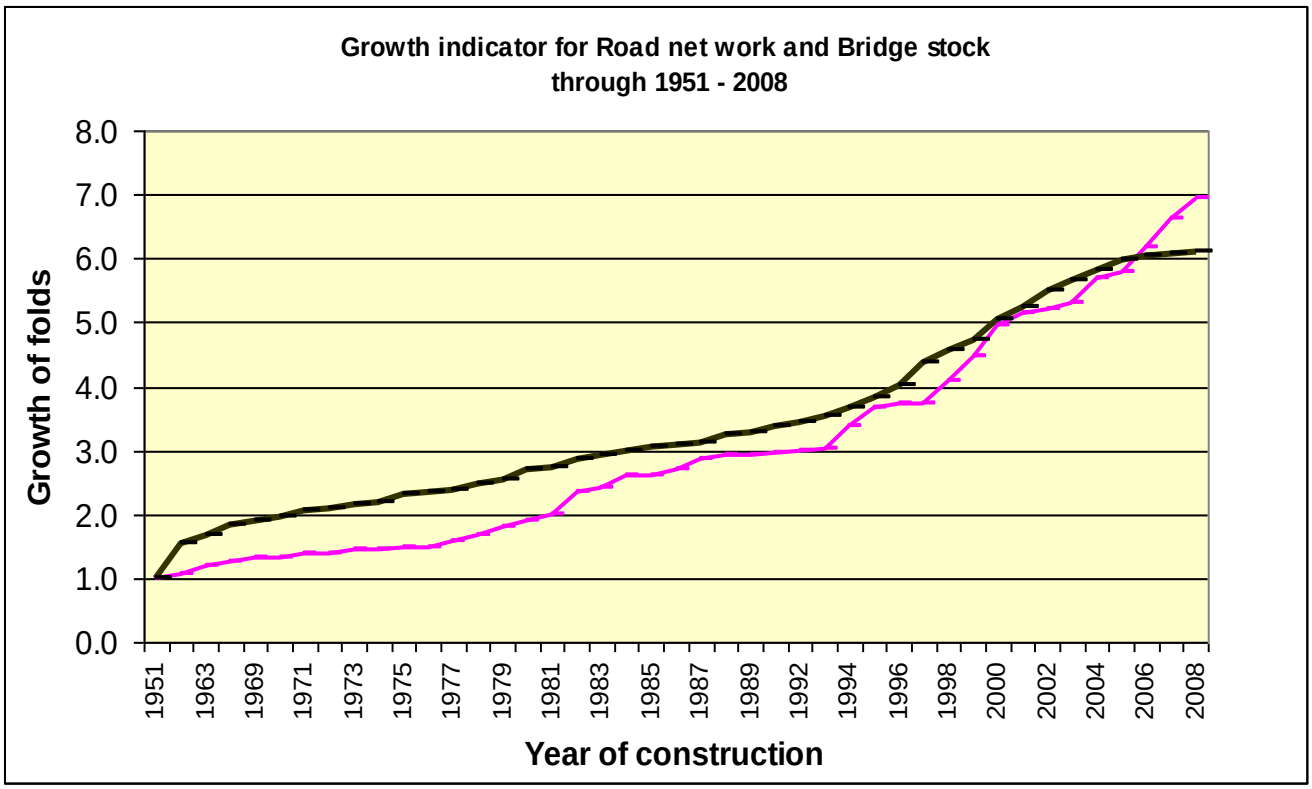
2002
2004
2006
2008


Growth indicator for Road net work and Bridge stock
through 1951 - 2008
Growth of folds
Year of construction
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
1951
1963
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1992
1994
1996
1998
2000
2002
2004
2006
2008

6.5 Development of Computer-aided Bridge Management System (BMS)

Many Road agencies considering bridge structures as vital part of the road only when a serious bridge failure happens which causes causality and notable accident. Otherwise, they give very less attention for regular inspection and timely maintenance actions. This is true in many countries in the world including Ethiopia.

Since the establishment of ERA, in 1951, despite the road network expansion and preservation work is the area high attention is given to, bridge structures have been most of the time neglected in terms of inspection and maintenance.

It was unthinkable to find well organized document that can tell condition of bridges in the road network. Even there had no way to know how many bridges and what kind of bridges is existing in the country.

Despite that, there was no standard and regular working methods, ERA bridge engineers were conducting bridge inspection when the need arose. But, until 1999, ERA had no official manual for bridge inspection and no standard bridge data collection forms in which physical, geographical, structural and condition data can be recorded. Therefore, no one could have told about quantity, type and physical condition of Ethiopian bridges in general.

In line with an intention to rehabilitate and expand Ethiopian Road Network, the Road Sector Development Program (RSDP) was launched in 1997. While formulating rehabilitation projects, one of the prevailed problems was absence of readymade information about service condition of Ethiopian bridges.

This problem, then, highly concerned and inspired the Head of the Bridge and Structures office of ERA. Consequently, in order to fill the long stayed vacuum in absence of bridge data, establishment of database for all bridge assets and necessity of developing computer aided bridge asset management system idea was born.

A self initiated Engineer took professional responsibility and started designing of prototype and modules for the intended Bridge Management system i.e. deciding Type of bridge data to be collected and the data entering way in to the system; Setting up of data analysis module and parameters which is mind of the program; and define type of Reports to be produced for any level information seeker.

As mentioned above, absence of vital bridge information precluded ERA to have a short and long term bridge improvement plan. Therefore, all the above mentioned prevailing conditions forced to work enthusiastically on design of BMS fitting and friendly to use in Ethiopian condition.

However there was a keen interest to take lesson from other country's experience in this matter, no chance was appeared to visit any other BMS software due to lack of

communication. Lately, it became known that use of BMS is not widely introduced in many countries even though some European countries, USA, and world famous big bridge construction firms are utilizing their own bridge management system.

Having the elaborated idea on how the BMS should look like and getting self enthusiastically, possibility of development the BMS software for our condition use believed to be achievable with own capacity. JICA as a partner in implementation of the development programs, technically and financially supported the BMS development proposal. In fact, JICA has also prepared a bridge inspection manual in 2001 that helped to imagine how the system should look like and also primarily used for designing of a BMS prototype.

Development of the desired ERA –BMS has taken long time since it was the first experience in the country. From year to year the system program came to be better and better in terms of accommodation as much as all the necessary bridge data with easy arrangements and fast access to the required type of information. Prioritization of bridges for immediate intervention based on different criteria's is one of the special features of this BMS.

This software is designed so that it can provide any kind bridge related information to any level of information seeker. In addition to the ERA-BMS, similar software for Culvert Management has been also developed and currently more than 40,000 culverts are registered with full data. The regular inspection and database updating work includes these culverts also.

As a matter of fact, Ethiopia is one of a few countries in Africa pioneer to establish its own BMS and implementing successfully.

Thanks to this the in house developed ERA- BMS software; we have now at hand physical, geographical, structural, picture and condition data of about 4300 bridges. A number of bridges are identified and prioritized for different type of improvement intervention. Significant number of bridges replaced as an output of this prioritization and others are waiting improvement actions scheduled ahead.

Today, designer of the in-house developed ERA-BMS and assistants of this task who worked hardly for the past many years to realize it, have a great pleasure to see how ERA currently owns such a huge bridge and culvert database by using modern computerized asset management system. As well as it can be deemed as a result of hard works achieved through tackling challenges faced in the process of introducing new concept of Bridge Asset Management and plantation of the regular bridge inspection system.

Moreover, it gives invaluable happiness to see as many as Engineers from Government and private firms involving in bridge inspection and repair works which was not common practice in the past years.

6.6 The 1st Round Nationwide Bridge and Culvert Inventory and Inspection

Following the In-house developed BMS software, that targets enabling the concerned Authorities to be systematically informed on the condition of bridges and their maintenance needs in the short and long run, besides producing all other bridge relevant information, a nationwide bridge Inventory and Inspection took place, which is the first in ERA history in its kind. The project covered collection of bridge and culvert data along the whole nearly 19000 km of Federal rood network.

After official instigation of the software's operation in 2005, the Nationwide Bridge Inventory and Inspection project was launched and it took place in 18 months of duration to cover all roads under Federal and Regional Road Authorities in two phases.

The first phase was from June 2005-April 2006 for Federal roads and the second phase was from April 2008-August 2008 for regional roads. This project was undertaken by 5 different local private firms and the project cost, 1.41 Mil USD, was financed by the Ethiopian Road Fund Office.

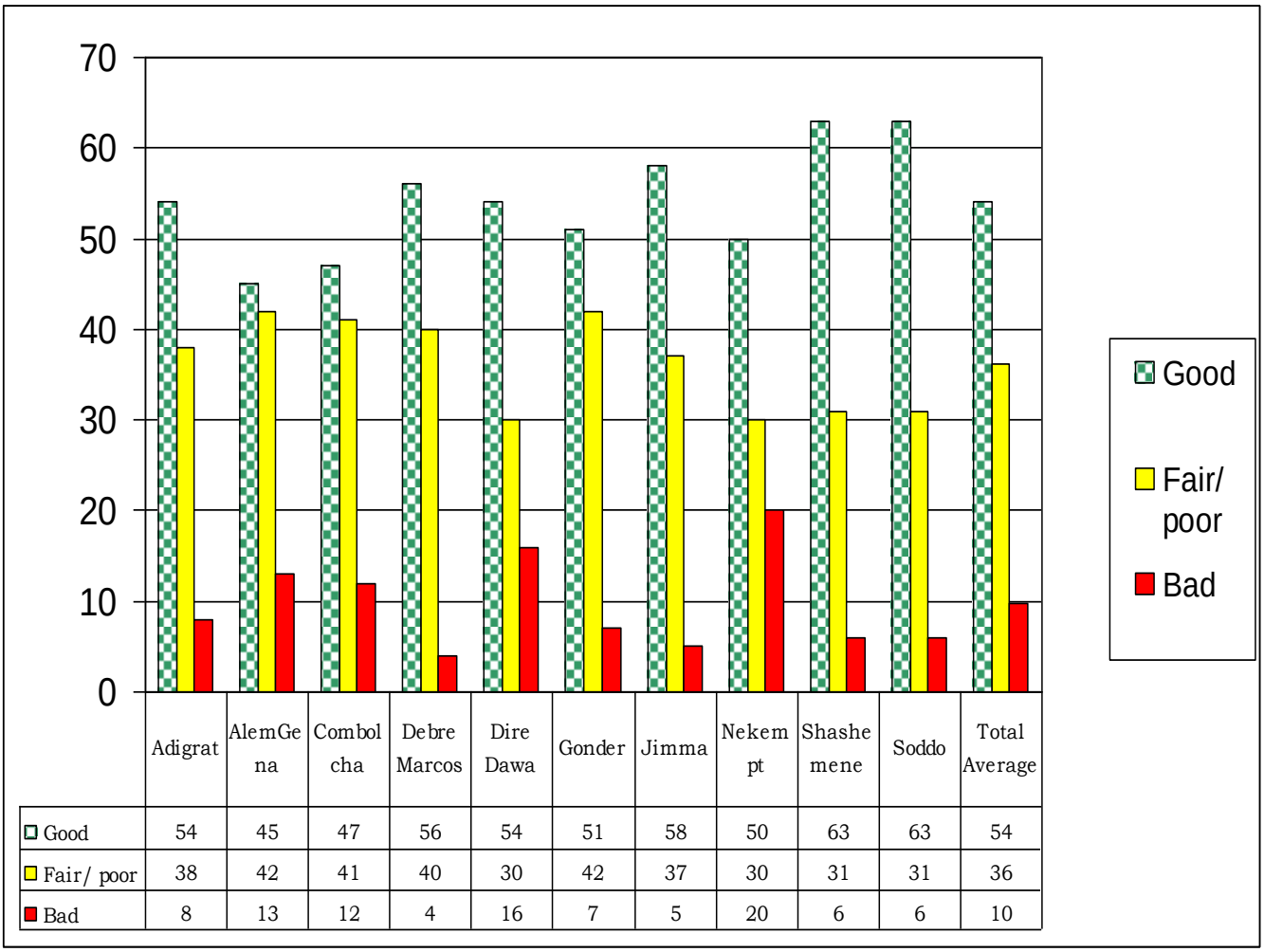
After collection of different bridge data such as the service condition, geographical, physical and historical data of each and every bridge and culvert, entering the data to the system program was achieved. As a result ERA could have known how many bridge assets existing in the Federal road network.

Currently almost all technical and administrative data of all bridges in Ethiopia including photographs entered in to the BMS software.

Anyone who is interested to know any kind of information about Ethiopian bridges can easily get information by extracting from the software based on the specific type of report that can be produced from the REPORT menu.

Since we achieved to come from non existing bridge data in the country to the reliable detail data managements system for each bridge, we believed that it is mandatory to disseminate ERA-BMS from HQ to the District office level and even to Regional Rural Roods Authority so that ultimately we could have data of all bridges in Ethiopia and establish asset management units that can take responsibility in making regular bridge inspection and manage data at the respective jurisdiction once the main database established.

Since then bridge stock information could be classified by different enquiries as needed.



	Adigrat	AlemGena	Combolcha	Debre Marcos	Dire Dawa	Gonder	Jimma	Nekempt	Shashemene	Soddo	Total Average
Good	54	45	47	56	54	51	58	50	63	63	54
Fair/ poor	38	42	41	40	30	42	37	30	31	31	36
Bad	8	13	12	4	16	7	5	20	6	6	10

Description of bridge condition as per the 1st round nationwide bridge inspection(2006).

6.7 The 2nd Round Nationwide Bridge and Culvert Inventory and Inspection

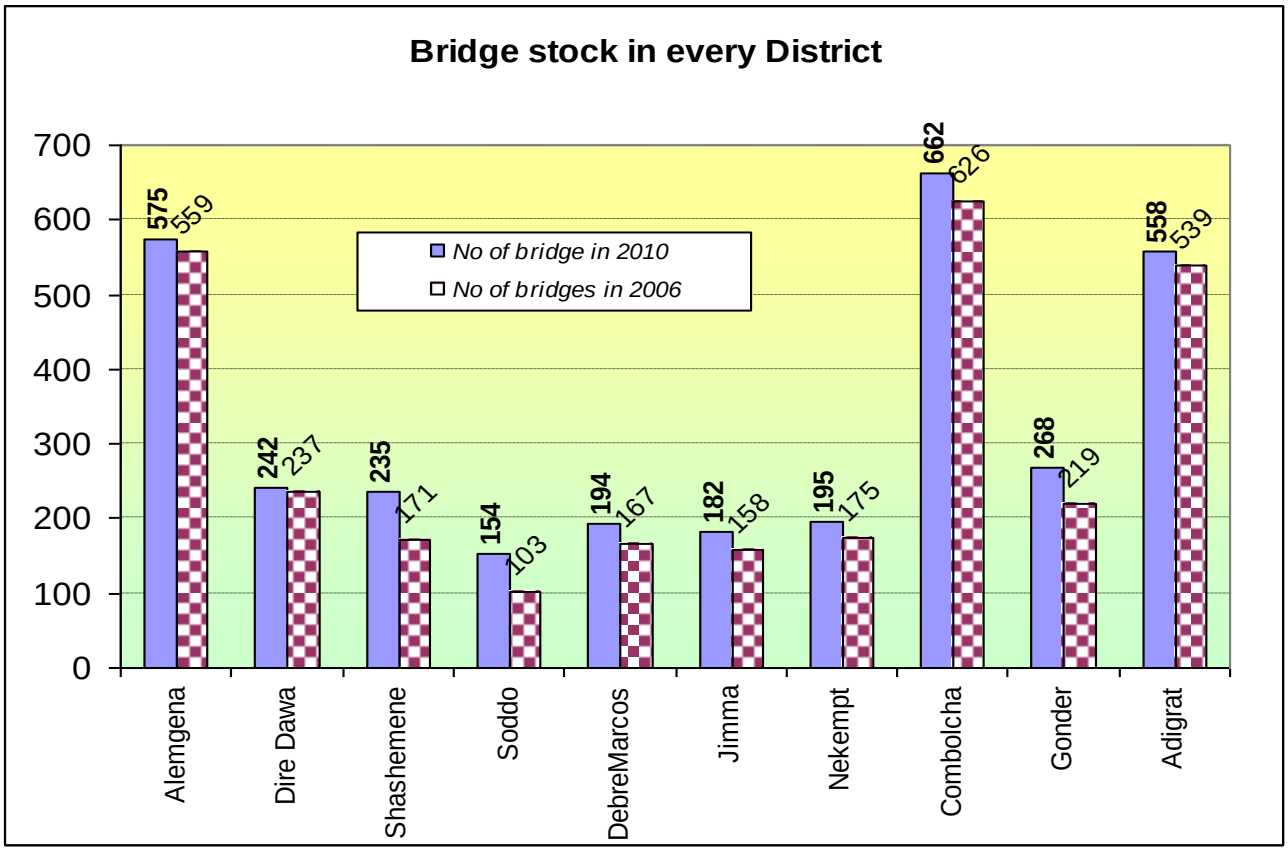
As per the ERA standard bridge Inventory and Inspection manual every bridge & culvert should be inspected in detail at 3 years interval. In this regard, the 2nd round nation wide inspection has been conducted in 2010.

In this round, not only merely inspection was conducted but also refining of the existing 2006 year database was made. As the first inventory was suspected to have some errors, in the 2nd round activity it was planed to take time for checking and correcting the previous database and update the general database to the current existing condition.

As for the 1st round for the 2nd round nationwide work also private consulting firms were employed to conduct the task.

As a result, a total bridge stock was increased by 310. This number includes all newly constructed and a few previously missed bridges. In the 2nd round more number of engineers were involved in the task comparing to the 1st round. Hence, updating of the database was mainly conducted by trained engineers.

In this round, engineers have made available drawings and plan for every bridge and the AutoCad drawings are entered in to the ERA-BMS software.



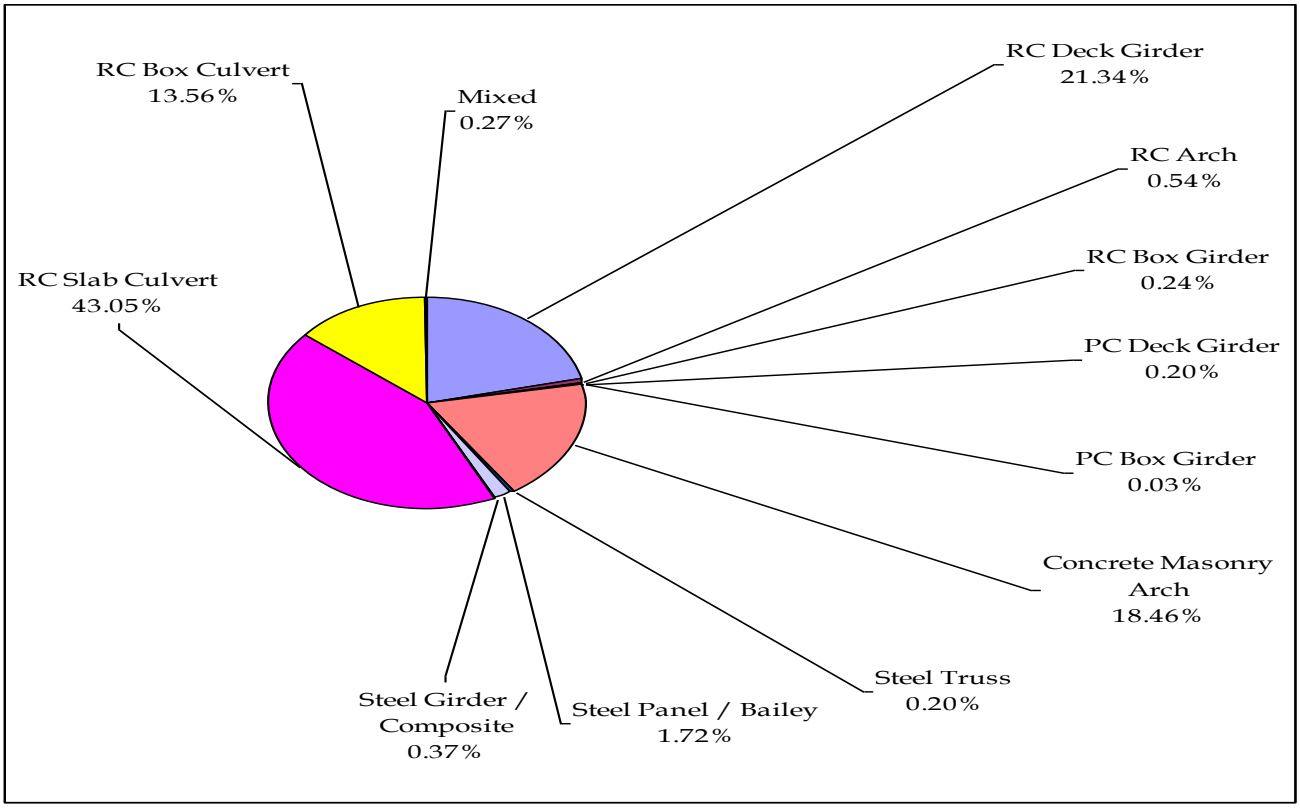
7 INFORMATION ON ETHIOPIAN BRIDGES

7.1 Ethiopian Bridges by Type

There are different types of bridge exist in Ethiopia. Historically, however there have been constructed significant number of bridges made of wood since early time, bridges made of masonry stone are common type as of today. Along with development of concept on concrete bridge design, many concrete bridges are constructed by using reinforcement steel.

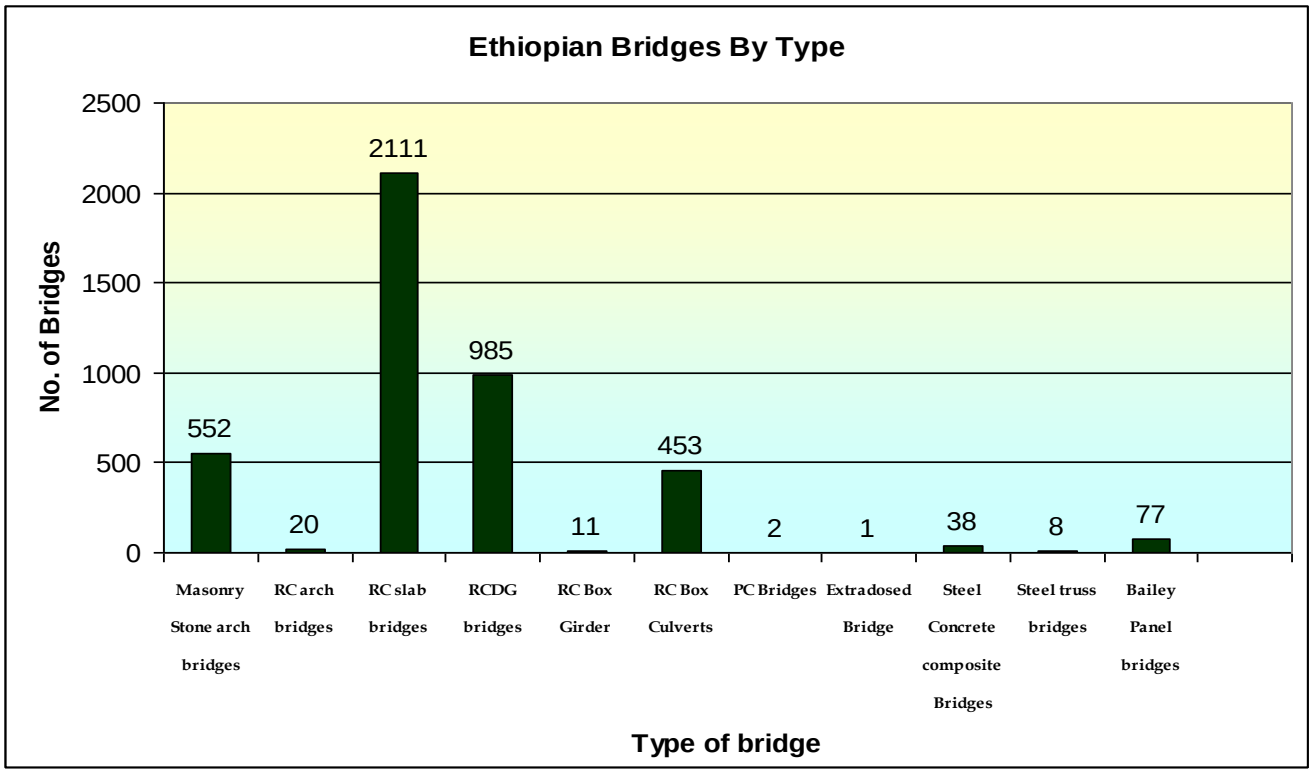
Due to cheap labor cost and availability of natural masonry stone, many Ethiopian bridge designers prefer masonry type piers and abutments. Construction of masonry and concrete arch bridges, which was fashion in 1930-40s and 1980 years, phase out and replaced by Concrete Girder bridges.

Construction of Steel Truss bridges, however a few in number, was widely introduced in 1930s. Bridges over Tekeze, Gibe, Mereb rivers and others can be mentioned as an example. Construction of Steel Girder and Concrete Deck composite bridges was introduced during Emperor Menilik. The attempt to construct it over Abay bridge is historical evidence.



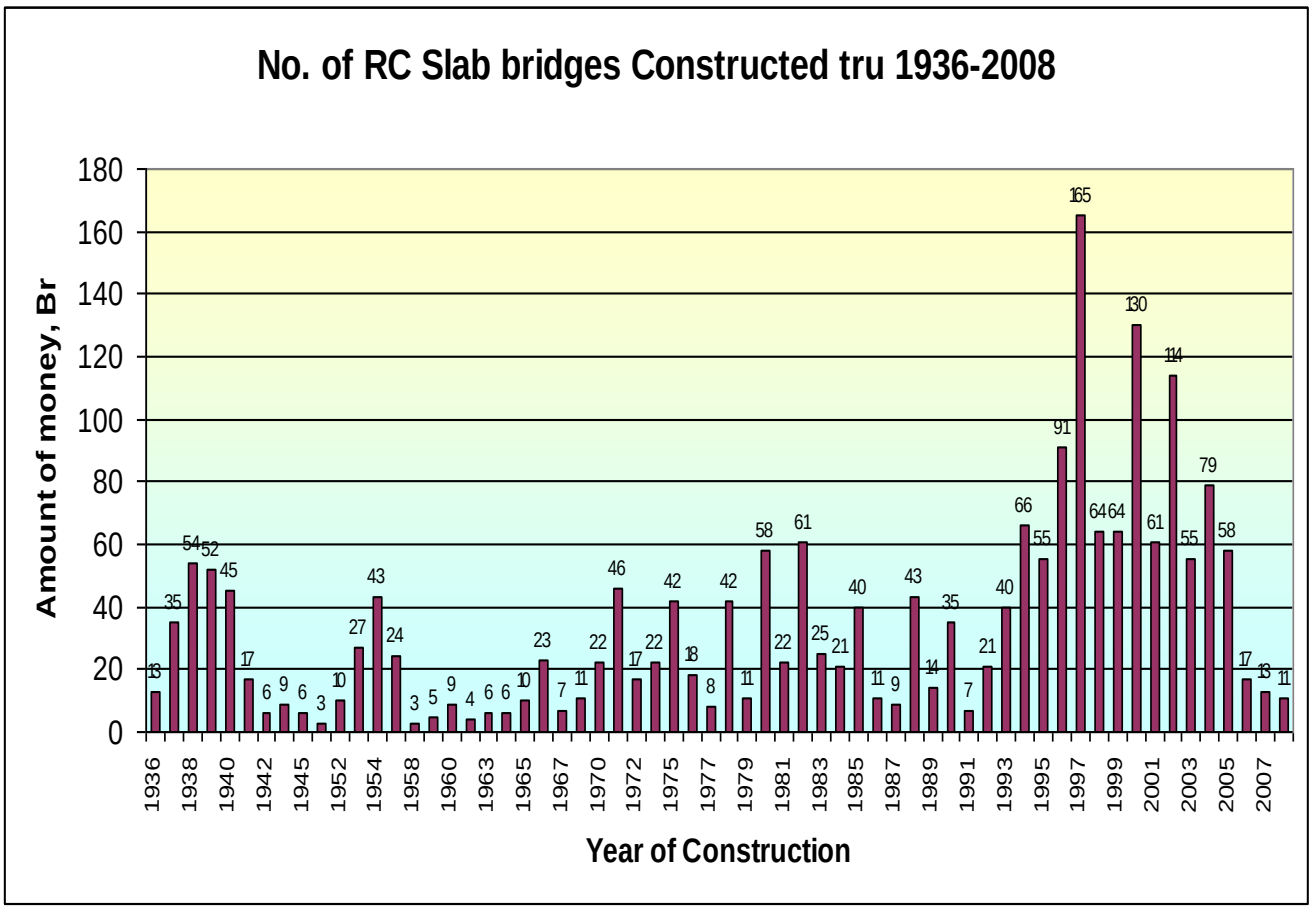
In order to provide access to many of remote areas in the country placing of temporary Bailey panel bridges over different small and medium size rivers began in 1950s. A huge amount of budget was allocated and imported Bailey panel bridges in 1960s and 2001.

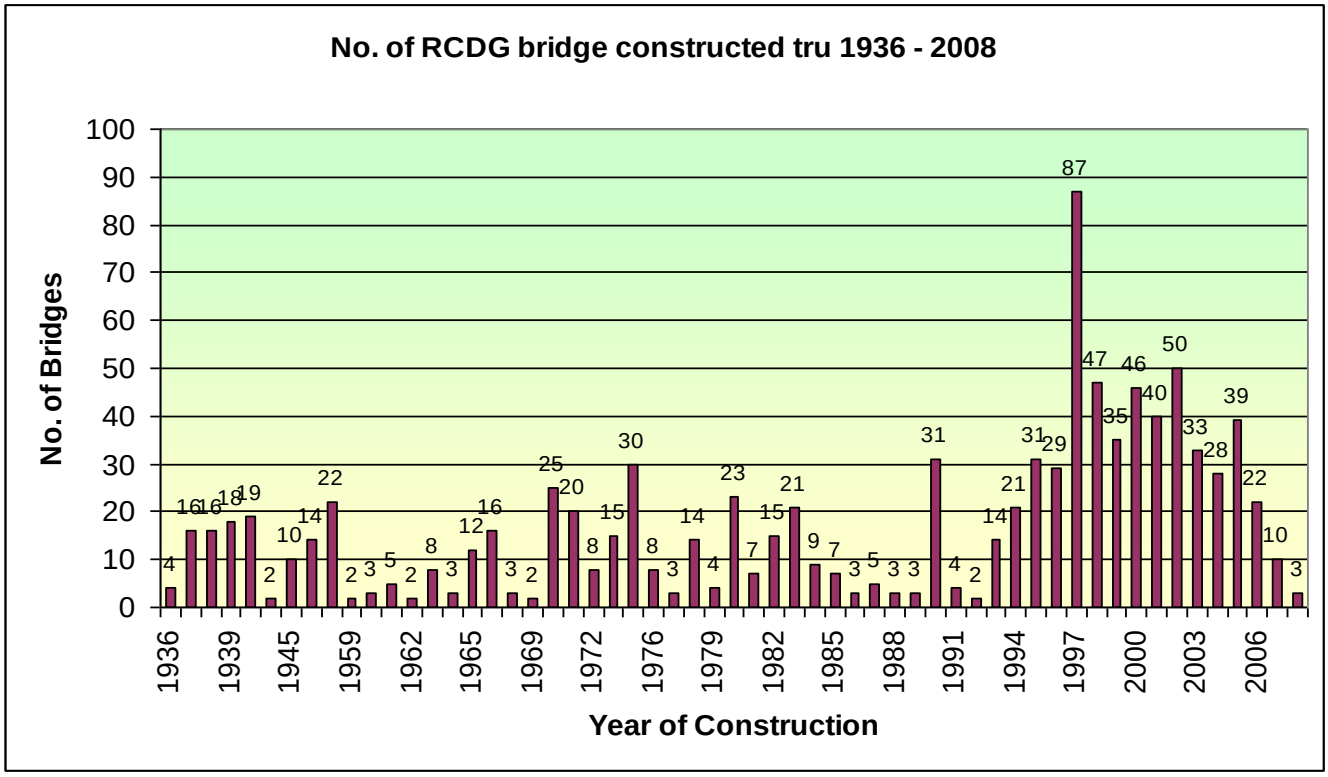
In 21st century, thanks to Japanese Government, Ethiopia has got a modern bridge called **Extra dosed** type bridge which is a combination of Cable stayed and Box Girder Bridge. The bridge is constructed by Japanese Engineers in 2008 over Abay (Blue Nile) River under grant aid scheme to replace the service of the existing old RC Arch bridge.

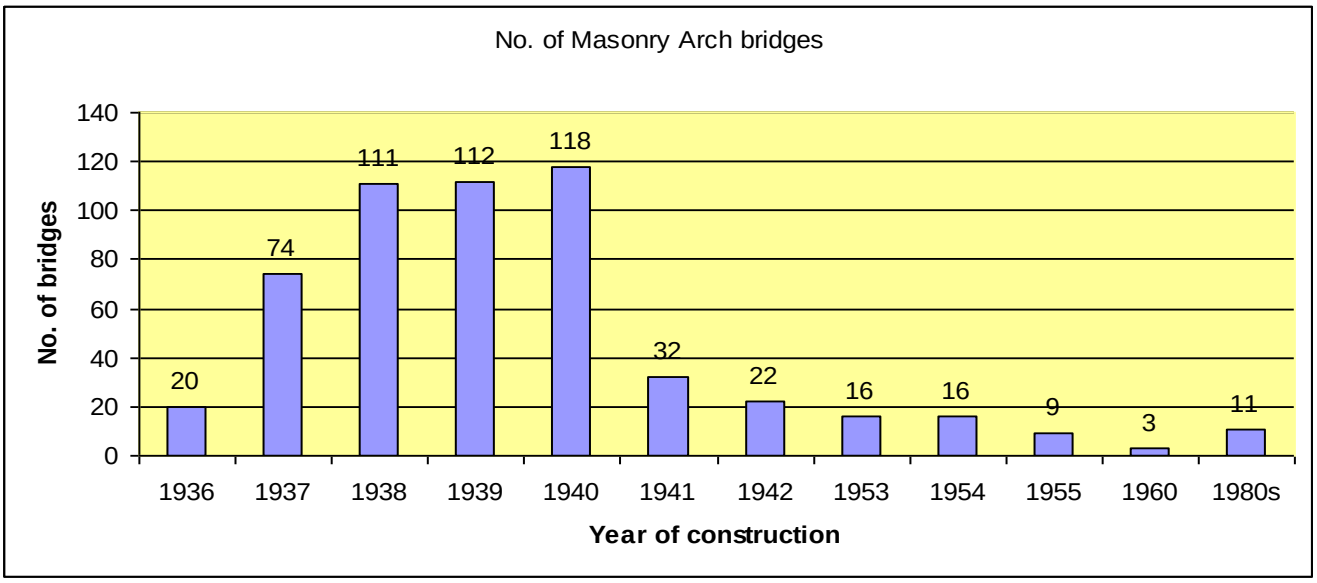


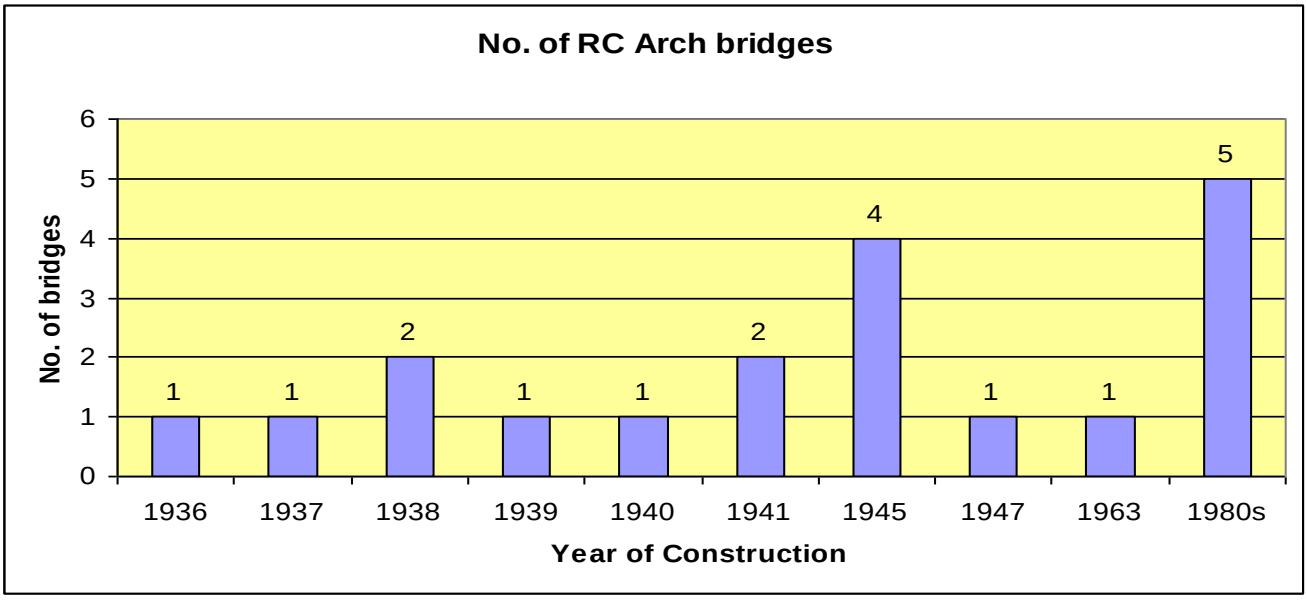
Type Of Bridges	Qtty	Percentage
Masonry Stone arch bridges	552	12.96
RC arch bridges	20	0.47
RC slab bridges	2111	49.58
RCDG bridges	985	23.13
RC Box Girder	11	0.26
RC Box Culverts	453	10.64
PC Bridges	2	0.05
Extradosed Bridge	1	0.02
Steel Concrete composite Bridges	38	0.89
Steel truss bridges	8	0.19
Bailey Panel bridges	77	1.81
	4258	**100**

Registered in ERA- BMS database -Type of bridges as of September 2008


No. of RC Slab bridges Constructed tru 1936-2008
Amount of money, Br
Year of Construction


No. of RCDG bridge constructed tru 1936 - 2008
No. of Bridges
Year of Construction





As we can see from the above graphs, most of Arch bridges in Ethiopia are constructed in 1930s and 1940s. And gradually dropped until 1980s after which no construction of Arch Bridge is done. Rather a number of arch bridges are replaced by different type after collision due to age and overloading.

The first RC Box Girder bridge is Abay No4 along Bure-Nekempt which was constructed in 1989. Then after, in 2000s a Box Girder bridge became popular for single span up to 40 mt long.

7.2 Ethiopian Bridges by Length

Comparing to the total amount of bridges in the country, most of Ethiopian bridges are medium or short size bridges. As per the ERA bridge inspection manual , 4.0 mt length is the minimum requirement to be named a `bridge structure`. Drainage structure length of less than 4mt is classified as Culvert.

Out of 4258 bridges in the country only 23 bridges extend 100mt long.

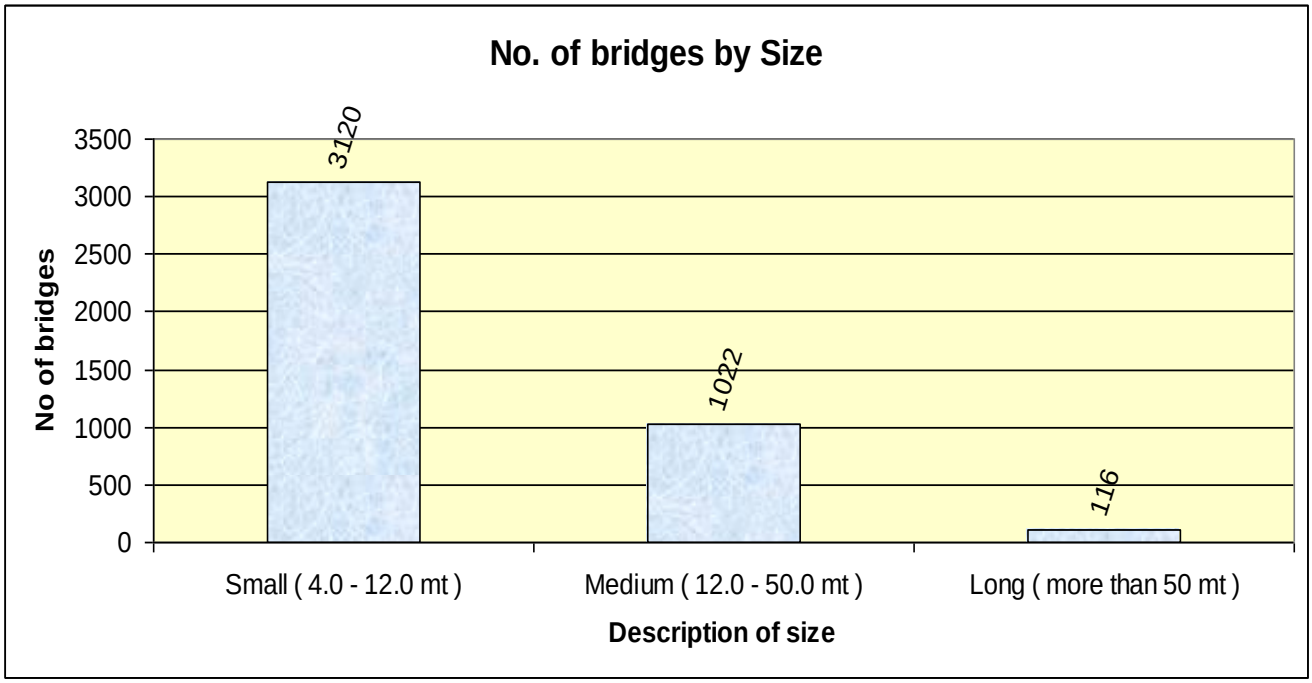
The ERA bridge Inspection manual classifies bridges as Short, Medium and Long in terms of bridge opening length, which is the distance from center of one end bearing to center of the other end bearing.

In this regard we have;-

3120 Small bridges length of 4.0 -12.0 mt

1022 Medium bridge length of 12.0 – 50.0 mt

116 Long bridges length of more than 50.0 mt



The total length of all bridges is more than 53 km whereas the total bridge length including wing wall of abutment for bridge embankment extends 79 km. This means there is one Bridge at every 560 mt distance in average.

If we look length of single spans, the longest central span is 145 mt which is for Abay No.6 (Blue Nile) Extradosed type bridge constructed by Japanese Kajima in 2008.

A 128 mt single span Steel bridge is also under construction over the Omo river at Southern part of the country.

As the majority bridges are short with single span, there are also some bridges with multiple spans. Abay No 3 at Bahirdar town has 13 spans of each 14.4 mt. Harmukale bridge along Diredawa – Dewele, Ferfer bridge along Mustahil – Ferfer, and Awash bridge along Alemgena – Lemen each have 11 spans.

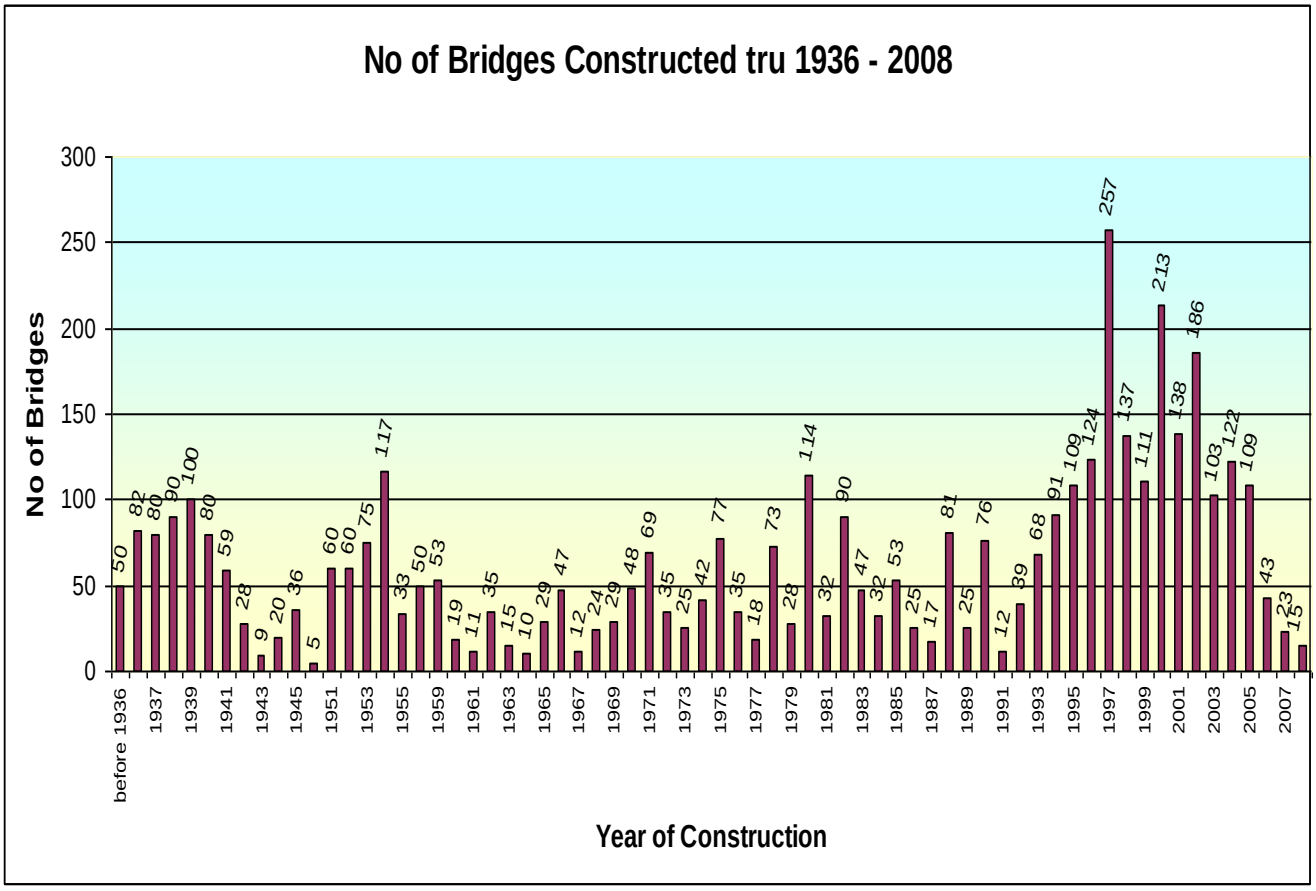
Abay No.3 bridge, which has 207 mt long and constructed by Italians, is the first long bridge in its time, in 1947.

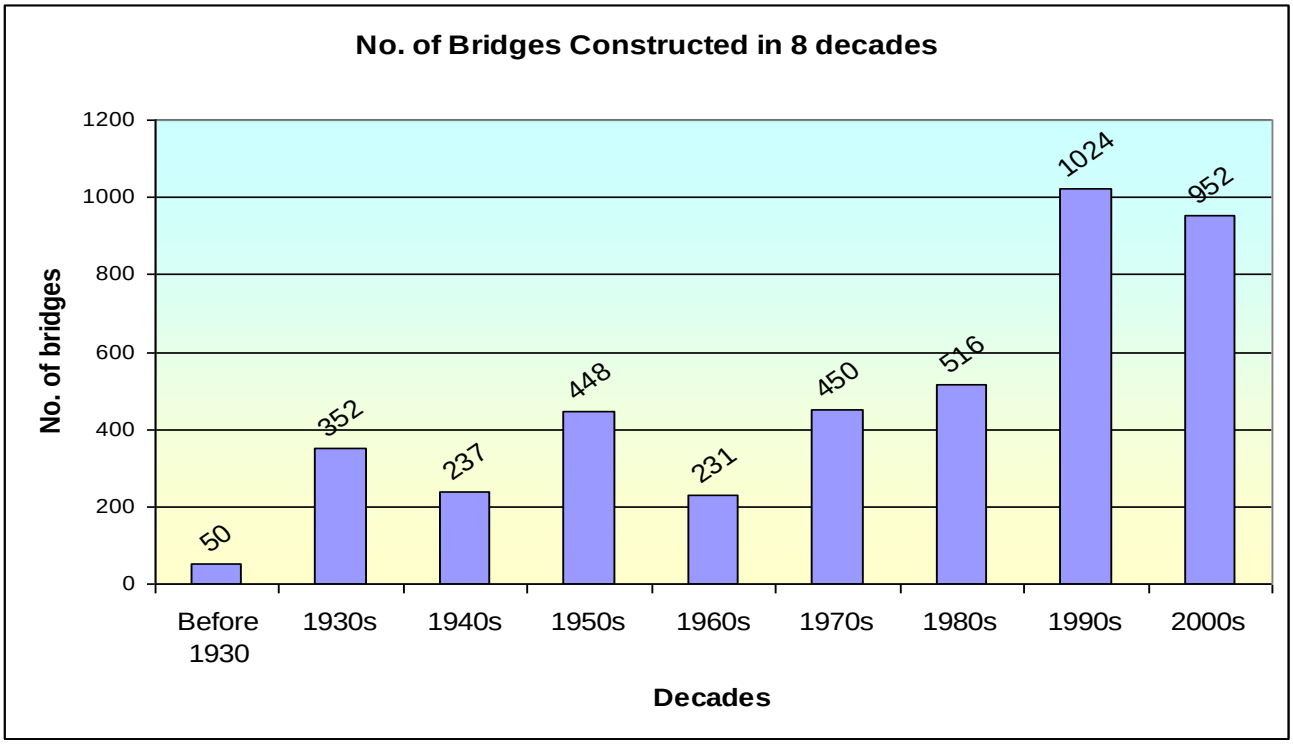
Baro bridge at Gambella town is also one of the longest bridges in Ethiopia (Total length 305 mt) that proudly designed and constructed by Ethiopian Engineers, with in less than 1 year period, in 1980.

7.3 Ethiopian bridges by year of construction.

As discussed before, history of bridge construction in Ethiopia points at 17th century when construction of stone bridges was introduced. In addition to different type and size of bridges made of logs and timbers, more than 50 bridges are estimated as constructed before 1930s.

High picks for bridge construction is shown in 1954, 1980, and years 1995-2005 when more than 100 bridges per year are constructed. Following decentralization of Rural roads to Regional Governments, many small size bridges like Slab Culverts are constructed.





7.4 Total asset value of Ethiopian bridges

Today, most if not all transportation and road agencies are moving towards implementing asset management systems or components of asset management systems. Asset management systems for bridges generally answer fundamental questions about ownership, location, and condition, and most also address the cost of preservation and improvement needs, as well as the forecasting of future performance.

But so far there are few tools to estimate the economic value of bridge assets and the effect of agency policy on this valuation. This question has become especially important to many agencies and it is also a useful performance measure for management decision support.

Most modern BMS have all the necessary data and models to perform the asset valuation calculations for individual bridges, subsets of bridges, or for the entire network. However, not every bridge management system can answer the additional questions: How many Birr do we need to maintain or improve the current condition? and what will the condition be as a result of a given level of funding? This requires sophisticated set of cost, deterioration, treatment performance, and financial models specifically developed for the bridges in the particular inventory.

In order to provide the information that asset value report requires, bridge agencies have other fundamental questions to answer – what is the value of our bridge assets?, what is the depreciated value of these assets? Although it would seem natural that BMS should be able to provide this information, BMS today typically fall short of the mark in the area

of asset valuation of bridges. Agencies therefore have to prepare bridge asset valuations manually. This problem is compounded by the fact that traditionally, clear direction has not been given in the use of valuation methods for civil engineering infrastructure as a whole, and especially for bridges.

Usually two general approaches are under use to the asset valuation of transportation assets. These are the 'Traditional Approach (Depreciation)' and the 'Modified Approach (Preservation)'.

Ideally, to report the value of an agency's bridge assets all historical costs should be known and recorded in the books over the life of the asset. But, usually these costs are not generally available retroactively and 'Estimated Historical Costs' are allowed for infrastructure assets instead of actual historical costs. The Estimated Historical Cost of an asset can be determined by calculating the current replacement cost and deflating that cost to the year of acquisition of the asset.

In case of Ethiopian bridges, only the original construction cost is collected so far and the total acquisition cost is here reflected. The original construction cost of Ethiopian bridges mainly collected in the 1st nationwide bridge inventory and inspection project implementation.

In the 1st round Inspection 4258 bridges are counted and original construction cost of these bridges amounted nearly 2.0 Bil EtBr. These bridges are constructed since 1936 when modern stone and concrete bridges had started being widely constructed.

District	Original Cost, Mil Br
Alemgena	121
Adigrat	161
Combolcha	156
DebreMarcos	232
Dire Dawa	110
Gonder	46
Jimma	50
Nekempt	26
Shashemene	47
Sodo	40
Total	**989**

The total cost considers all bridges administered by ERA and constructed before 2009 ie before 2nd round nationwide inventory. Currently the Total cost would be estimated to be **1.4 Bil Br**

7.5 Bridge Improvement works in recent years

As discussed in section 5.4.3, bridge rehabilitation works are taking place under RSDP since 1997. Since then especially while development of BMS software was undergoing and the capacity building activities were intensively conducted by ERA-JICA technical support scheme, a number of bridges were selected for improvement and replacement. Some bridges were chosen for replacement even before collapse due to the fact that they were found in critical condition.

Bridge improvement works mainly conducted by ERA own force, different contractors employed by ERA for road construction projects, as well as by individual bridge projects. In parallel to the improvement activities handled by the mentioned ongoing projects, prioritization of bridges for improvement was conducted based on the ERA BMS software analysis and recommendations.

In this regard significant numbers of bridges are selected for detail investigation and replacement works. Procurement of consulting firms for the task is undergoing for different packages of bridge structures.

According to the 2005 nationwide bridge inspection database, more than 10% of bridges under ERA have found in very critical condition that needs urgent action. Only 50% bridges from the total stock found in GOOD condition.

Thanks to the ongoing road rehabilitation projects under the RSDP, a number of bridges added to the same projects which were not initially included due to lack of condition survey data at the project formulation period.

Other bridges, which are along the roads not under rehabilitation program decided to be improved by own force. Currently more and more bridges are packaged and contracted out for detail design, construction and supervision projects.

Currently about 35 bridges are under construction by different international contractors. Some of them are replacement of the old existing and some are new bridges along new alignment.

One of these bridges is The Omo River steel bridge project cost of 120 Mil Br. This bridge will be the longest central span of steel bridge in the country.

The East Awash River Bridge is one of the long bridges expected to be constructed in the coming recent years. This bridge project is financed by Japan Government.

8 PRIORITIZATION OF BRIDGES FOR IMPROVEMENT

8.1 Condition Assessment

Bridge rehabilitation/replacement works have been carried at several locations on the road work ever since ERA established as a responsible body for roads and bridges. Most of such actions were materialized after the damage on the bridges reached to critical level and become life threatening and requiring more cost than the cost required for earlier interventions.

After the implementation of BMS and a responsible body for monitoring and evaluation of the bridge stock in the country, the number of such drastic measures is expected to drop rapidly and give away to more comprehensive risk analysis approach to determine the type of intervention, cost and timing in order to minimize cost and ensure public safety.

It is common practice that most of the bridges are designed for a life of hundred years. As long there is no change in the design parameters, most bridges serve more than the design life. However due some changes in the loading or the environment and errors introduced in the design or construction stage, an earlier premature structural/functional failure could happen. Such premature failures are usually aggravated by lack of frequent routine/periodic maintenance.

Most of the failures of the bridges inspected have failed due to the following reasons

I. Design problems

1. ***Missing of bearing shelves*-**on masonry abutment, this is the main source of non uniform load distribution on the abutment and causes cracks, peel of stone, displacement and eventually collapse of the Bridge.
2. ***Missing of approach slab***-which results in excessive settlement of the approach backfill which in turn will expose the structure for traffic induced impact load. This causes cracks and other distresses on the substructure which will extend to the foundation.
3. ***Inadequacy of bridge opening*-**inadequacy of opening for the prevailing flood from the catchment area could induce quite excessive force mainly on the substructure; this is mainly due to lack proper assessment based on hydrologic data.
4. ***Scour on foundation*-**in most cases bridge designers gives little consideration for scour protection structures. But scour on foundation of abutment is one of the major causes of Bridge distress.

II. Construction problems

1. ***Quality of concrete***- Unless there is s good supervision work is conducted on site; the concrete quality may not meet the specification for the desired effect. This is may happen due to material quality like silt content of fine aggregate; water cement ratio is not well controlled due to application of backward technology of concrete mixing and luck of awareness of site workers.
2. ***Missing of deck drain protrusion-*** the deck drains luck extruded portion and this causes splash of water on the soffit of the deck slab and faces of girders, this results in prolonged damping of the concrete cover and water will find way to the rebar and rebar corrosion induced volume increment will occurs and consequently concrete cover peel off
3. ***Concrete cover provision***- the reinforcement does not attain sufficient concrete cover; this could cause rebar corrosion and concrete peel off.
4. ***Curing-***due to lack of proper curing, the structure could be exposed to shrinkage crack and eventually water will seep through these cracks and causes further deterioration of concrete.

8.2 Approach to Assessment of Condition & Intervention Decision

Bridge inspections are conducted to initiate maintenance action, to provide a continuous record of bridge condition and rate deterioration, and to establish priorities for repair and rehabilitation programs. It is necessary to have a complete, accurate and current record of each bridge under the respective jurisdiction. Complete information is vital to the effective management of bridges. Furthermore, such information provides a record which may be important in legal action.

Bridge management involves a number of activities. Such as the collection of inventory data, inspections, assessment of damaged structures, administration of heavy transport, quantifying and allocation of funds for repair and maintenance, etc. all with the purpose of ensuring traffic safety and maintaining the Drainage structures in the desired condition at the lowest possible cost. Therefore, the present description concentrates on the activities leading to the priority ranking of rehabilitation works or Culvert and Bridge improvement master plan these activities are dealt with separately below.

In Bridge Management System accumulated data related to design construction and field inspection are the backbone of the system. Strong database that contains such information helps to make detailed analysis on the condition of bridges and helps to reach an optimum economical solution.

Automated systems for maintenance management of bridges require information on current and future needs for maintenance and repair actions. Often, this information is provided by condition survey of the crossing structures elements. Condition survey, performed during routine bridge inspections, indicates the relative health of elements, but usually do not identify particular types of deterioration nor specific actions that

are needed. Instead, the scale of actions, from minor maintenance, to repair and rehabilitation, to replacement, is incidental from such surveying.

Therefore, the extent of deterioration must be known, together with its type. The extent of deterioration determines the quantity of maintenance actions to be applied. The action and its quantity are combined to produce an estimate of maintenance costs. This was achieved only by detail evaluation of the crossing structures conditions.

- Determine the type of inspection required,
- Determine the type of equipment and tools necessary to perform the inspection,
- Determine which members or locations are noted in previous inspections or maintenance records to have existing defects or areas of concerns.
- Estimate the duration of the inspection and the scheduled work hours.
- Establish coordination with or notification of other agencies or the public, as needed.

During field inspections, condition rating is assigned to each segment. The inspection is based on schematic plans of the bridges showing the locations and boundaries of all segments. Condition states for segments are processed later to generate the report of conditions and quantities needed.

The most time consuming and costly task probably was setting up data collection systems to support BMS and to facilitate action to be taken, even though all districts currently have established data base and ongoing bridge inspection program. Although most of the data collected is useful for BMS, districts in most cases require more detailed information on the condition of bridge elements.

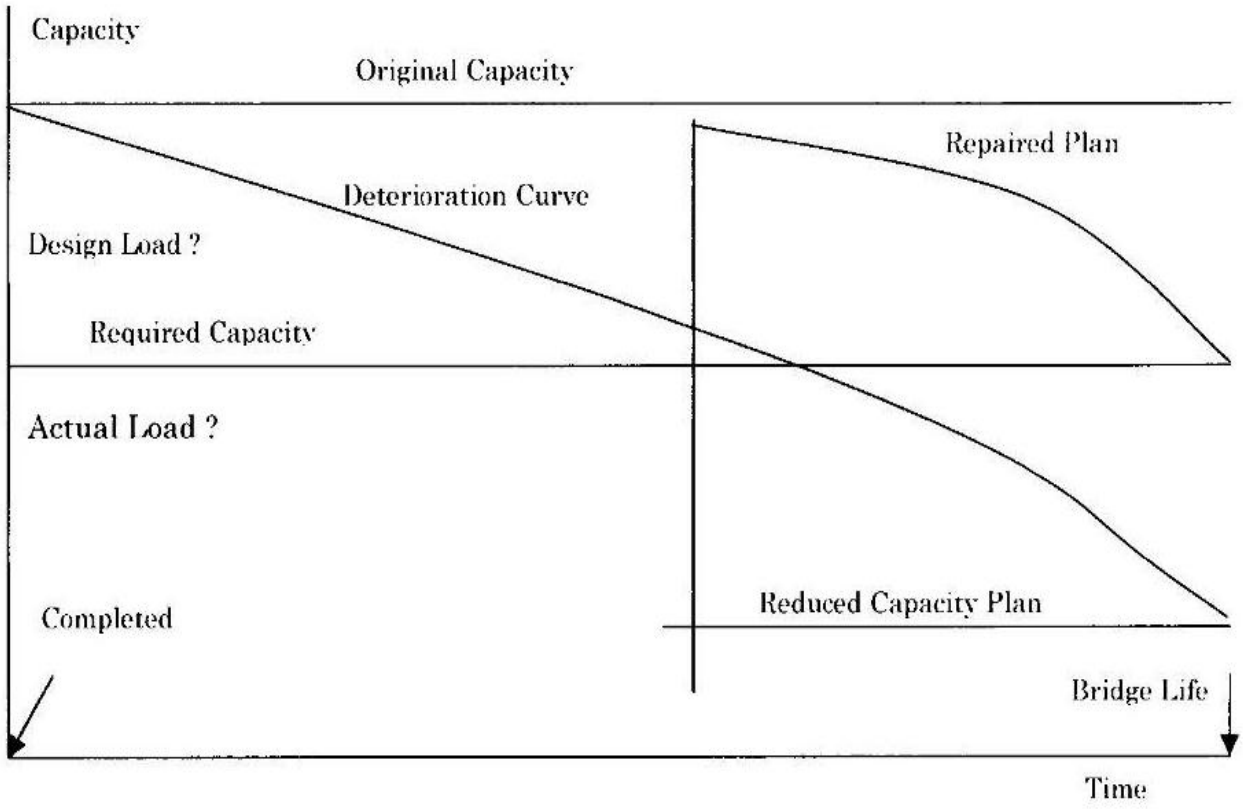
Unlike roads where roughness of the pavement surface is a governing factor for smooth operation of the road transport system, safety is the predominant factor related to bridges and other drainage structures. Ensuring the existence of functionally and structurally sound bridges on the road network have great importance where the traffic volumes and axle load (excess beyond the legal limit) have been observed to increase with regard to public safety.

Apart from the technical evaluation based on the condition of bridges, other consideration should be part of the decision making process. These include

- The type of bridge element considered for major intervention
- Either the bridge is major or ordinary type
- Traffic consideration with respect the functional classification of road where the bridge is located.
- Strategic importance
- Future increase in functional demands
- Environmental factors

8.3 Methodology for selecting maintenance action

Basis of maintenance of concrete structure is that the structure is adequately maintained such that its performance is always above the required level during its service life. However, since concrete is used in different structures such as buildings, dams, bridges, etc., which perform under different environmental conditions, it is not possible to lay down identical performance criterion for all structures.



8.3.1 Maintenance Category

Due to the fact that there must be different actions for different situation, the maintenance action can be classified into four different categories specified as follows;

A: **Preventive maintenance** -- the maintenance to prevent the appearance of visible deterioration on the structure during the service life.

B: **Corrective maintenance** -- the maintenance in which, appropriate counter measures should be taken after degradation appearance of the structures has appeared.

C: **Observational maintenance** -- the maintenance carried out primarily on the basis of visual inspection without any direct measure and permits certain deterioration of the structure.

D: **Non-inspection maintenance** -- the maintenance applied to the structure in which the direct inspection is difficult or practically impossible to be carried out, such as underground structures.

As time goes, deterioration of concrete structure is expected to grow as well. The concrete deterioration curve shows how the bridge capacity reduces through time where maintenance intervention is absent. Timely intervention extends the bridge service life and saves money that could be spent for repair of major defects or total replacement.

Timely intervention helps to maintain good service of the bridge for additional years by binging it to the required capacity. Before go for any kind of maintenance action, determination of the residual bearing capacity of the bridge is recommended. Then engineers can design the required type and level of maintenance to acquire the required capacity.

In such kind of work, movement of traffic must be considered possibly not to interrupt. Maintenance intervention can be done repeatedly as the residual bearing capacity guides. The maintenance design is expected to preset to which level is intended to bring the load bearing capacity.

8.3.2 Maintenance Strategy

To fulfill the rational and reliable maintenance activities that will help keeping the service of the structure always at the required level, it is necessary to evaluate the time-dependent degradation process of the performance of structure during the life, with adequate reliability.

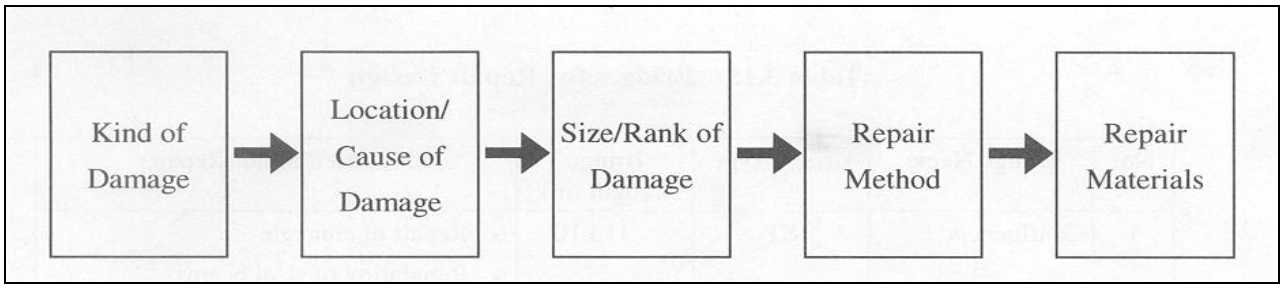
However, since the performance degradation cannot be always strictly analyzed based on the current engineering level. It should be verified indirectly considering a future deterioration condition expected by using the deterioration evaluate model.

Here, it is needless to say that the periodic inspection results are indispensable for evaluating the performance of structure. The overall processes mentioned above are surely carried out on the basis of the "maintenance strategy". Namely, the maintenance strategy comprehensively encompasses "inspections", "estimation of deterioration levels and rates", "evaluation of performance of structure", "remedial actions", and "recording". Off course, the combination of these steps differs to the different maintenance category, considering the importance of the structure, hazards to the third parties, and environmental conditions.

The complexity and magnitude of the repair procedure will depend on whether: Only the cause of the defect has to be removed; The structure must be restored to original condition; The structure needs to be upgraded for its load carrying capacity and / or for its geometry.

There are several options in the evaluation of restoration of the true function of a defected structure and these could be: Total replacement of the structure; a combination of partial replacement and repair; based on the severity of defect in localized areas of the structure; Undertaking extensive rehabilitation/ strengthening measures.

There are several repair methods applicable to defect and the most suitable method can be selected by comparing alternative methods from technical and economical points of views. However, this approach is complex and difficult unless by experienced engineers. For the convenience to select repair methods, relation charts of defect types and repair methods are recommended for major defects.



If an inspection indicates that remedial measures need to be taken, there are several basic steps bridge owners can take to rehabilitate a bridge structure. The causes and mechanism of defect in a particular case must be identified, then the optimal strategy devised as follows:

1 Assess the bridge condition, detailed investigation, diagnosis, special tests and re- calculations for appropriate selection of rehabilitation strategy;
2 Determine the type, rate and extent of defect and cause, and assess the structural performance due to deterioration and defects;
3 Identify all relevant rehabilitation strategies for future management of the structure;
4 Predict the development of defect for each strategy in order to estimate future cost;
5 Calculate the cost and benefit for each strategy;
6 Determine the strategy or set of strategies that requires the minimum investment for the expected life of the structure (an appropriate life-cycle cost analysis). Upgrading or downgrading of the structure may also be considered;
7 Define future inspection and maintenance requirements;
8 The inspection team should produce a report showing findings, suggestions and recommendation based on the above mentioned. The report is paramount important for any proceedings and decisions to be done by budget allocating body.

Maintenance of today's bridge infrastructure presents many challenges. Transportation engineering and maintenance personnel must maintain around the clock service to millions of people each year while maintaining millions of cubic meters of concrete distributed throughout their facilities. This infrastructure includes

bridges. Presently only a limited number of accurate and economical techniques exist to test these structures for integrity and safety as well as insure that they meet original design specifications.

No single technology can locate all physical anomalies or irregularity in and below the concrete, these techniques along with data fusion can assist in the following investigations, to name a few:

1 Locating voids and delaminating in bridge pavements and scour around bridge support columns,
2 Determining location and types of reinforcing steel in concrete,
3 Ensuring quality control on new concrete installation.

8.4 Possible Decisions on Bridge Improvement

The results of inspections are used to plan and coordinate preventative maintenance operations on the drainage structures that is, the conditions of the structures were evaluated and proper Action was taken. Therefore the documentation includes detail condition and recommendation action but not limited to these, it also includes photographs and sketches that describe damages requiring remedial action.

The definition of interventions in the case of bridges should be established very clearly in order to avoid any ambiguity regarding the decision made based on the condition assessment and further analysis.

With the context of this report three type maintenance interventions should be defined. These are rehabilitation, improvement and replacement/ reconstruction.

I. **Rehabilitation:** Any maintenance activity that aims at to restore the bridge to the service level once it had but lost due to various defects/failures. This type of intervention becomes necessary when the bridge is ageing, change in hydraulic and live load parameters, foundation settlement or damage due to external causes.
II. **Improvement:** Improvement of bridges consists strengthening, widening raising of existing structures etc. to upgrade the level of service such as load carrying capacity, width of carriageway etc
III. **Replacement/Reconstruction:** This type of intervention is required when the whole or major component of the bridge need replacement which are beyond rehabilitation due to safety and economic reasons.

Generally up to date condition ratings are useful for Bridge Management System and for preparation of Bridge and Culvert improvement Master Plan as these are the largest, and often only, source of information on Bridge conditions. Therefore site inspection and deterioration models have specific meanings.

Maintenance actions are selected in response to distinct changes in the condition of bridge elements that denote stages of service life. Condition states are defied in terms of extent of damage. This allows a simple identification of needed maintenance actions.

When identifying and evaluating relevant rehabilitation strategies it is necessary to have an open mind and not focus only on the condition of the bridge itself. It is necessary recalling that a rehabilitation strategy is a series of actions carried out in order to make sure that the bridge fulfils its purpose. The relevant action may normally be categorized into three types.

- Make a through repair to bringing the bridge back to good or new condition or provide immediate minor rehabilitation in order to postpone major repair.
- Replace the crossing structures as they are no longer safe, and
- Perform Regular inspection and follow up for the safe performance of all the crossing structure.

9 THE REQUIRED IMPROVEMENT COST and IMPLEMENTATION PLAN

Most of Rivers crossing structures are single purpose structures that provide an essential function in society today. It is imperative that they are maintained and managed such that they continue to provide the necessary links within local and national road networks.

The ultimate goal of bridge maintenance planning is to find the best strategies and operational plan that are not only technically feasible but also are considered optimal by decision makers. This can be achieved by identifying all possible objective and conflicts, evaluating as many alternatives as possible and finally reaching rational plans.

The fundamental importance of any management system is the determination of priorities for potential repair options, from which budgets may be formulated and work schedules planned. These may be assigned during the assessment stage, perhaps by reference to the maintenance specification, but must then be translated to a form appropriate to computer manipulation such as drawings, reports and any other form, following Detail inspection of Crossing structures, and assessment of potential work required. The bridge and culvert improvement master plan should then contain outline work programs for the next five years in advance.

Criteria which are regarded as relevant in deciding priorities for each category of work were also noted. This gave a large number of factors or attributes which would influence the ranking of work types and of different bridges.

In addition to the specific cost created by the principal inspection module, there is a need for long term estimates for rehabilitation of crossing structure. The long term Budgeting Module is intended for this purpose.

The general idea is that average repair intervals and corresponding average repair costs as well as average service lives and replacement costs are estimated for those crossing structures type and principal dimension of all standard components and conditions are registered in the BMS. Based on this data, the future budgets requirement is calculated. Although there might be some uncertainties the consultant had tried its best to estimate sufficient budget for all the expected intervention activities in improving the condition and performance level of the drainage structures.

The bridge management system or the culvert and bridge improvement master plan need to comprise a module for managing the flow of money used for bridge maintenance. This element controls the development of budgets for the individual rehabilitation works, As well as the total for all works, thus keeping track of the budgets throughout the fiscal year.

It is an important procedure that conveniently combines costs and benefits is the calculation of the whole life cost for a bridge for some specified required life span. The benefits of remedial treatments that produce an improvement in condition and subsequent low

deterioration rates are reflected in a reduced requirement for future maintenance work and disruption to traffic. In practice the costs of future maintenance work, needed to maintain the bridge to a set condition for the remainder of its design life, can be estimated for each maintenance procedure.

The extent of deterioration must be known, together with its type. The extent of deterioration determines the quantity of maintenance actions to be applied. The action and its quantity combine to produce an estimate of maintenance costs.

Measurement of quantities and dimensions of elements during field inspections can be a source of cost estimation. Each defect in a particular crossing structure element has a known quantity and Known location. And the benefit of maintenance is to improve the condition of the Crossing structure so that it maintains its condition target. Thus the benefit can be quantified in terms of the immediate improvement in condition state following remedial treatment and the subsequent change in the rate of deterioration. Accordingly as per the detail site visit and measurement and the subsequent immediate improvement or recommendation, the quantity of each selected and reported crossing structure is calculated and presented in the following tables.

In addition to the previously described, some of the crossing structures may not developed any sever signs of distress at the time of inspection. However some common defects may exists and if the condition of the crossing structures left with out intervention, further deterioration may develop. Hence, future maintenance cost as well as the workload will increase due to restricting the bridge to traffic flow, load restriction for long time.

The total budget required to implement the recommended remedial intervention methods as per the detail drawings annexed in this report is summarized for the required action of the client. The required total budget is also divided for each physical year of the coming five years so that the client might use it for budget controlling purposes.

In 2003 EFY (2010- 2011), for the first time ERA has allocated 10 Mil Br dedicated for bridge rehabilitation works alone. In previous time bridge rehabilitation works incorporated either in emergency works or in road improvement projects.

Since concept of the need for preserving bridge asset gradually grown up and became acceptable by top managers of ERA, dedicated budget is allocated thanks to the output of the BMS.

For the first time, in 2003 EFY, 10 Ml Br was dedicated for bridge maintenance. This was allocated by Ministry of Finance as new object code. In EFY 2004, only 16 Mil Br was distributed for the same work due to constraint of the National budget funded by the Road Fund Office however greater amount was proposed.

When we come to the Master Plan implementation, a total of **394,870,084 Br** is estimated to be allocated for the next 5 years. Budget allocation alone can not grant the desired service of bridge structures, But, District capacity building works should also be implemented in parallel. This includes retaining of skilled engineers, provision of the required equipment

and tools necessary for bridge inspection and maintenance works, strict plan and follow up of bridge improvement works by District managers, timely response for assistance from districts and bridge crew,...

District	Distribution of estimated budget for bridges improvement, Br					
	1st year	2nd year	3rd year	4th year	5th year	Total required Budget estimate, Br
Alemgena	8,738,052	18,468,613	10,051,814	23,174,412	10,649,880	71,082,771
Dire Dawa	9,425,757	11,834,240	1,129,549	500000	700000	23,589,546
Shashemene	9,472,156	21,799,091	16,803,576	2,123,519	3,750,324	53,948,666
Soddo	8,105,456	16,614,163	3,641,163	4,100,468	1,927,333	34,388,584
DebreMarcos	8,662,750	18,137,500	7,794,500	8,791,000	11,297,750	44683500
Jimma	4,049,750	15,255,750	4,472,000	4,009,250	2,884,125	20,754,875
Nekempt	4,817,250	13,000,000	3,580,500	3,270,750	4,318,000	18,986,500
Combolcha	51,787,857	14,629,311	2,267,181	3,140,000	3,800,000	75,624,349
Gonder	7,988,779	11,561,755	1,440,000	1,420,000	1,420,000	23,858,590
Adigrat	8,114,543	14,302,183	6,013,454	3,622,524	2,900,000	27,952,704
Total	**121,162,350**	**155,602,607**	**57,193,737**	**54,151,923**	**43,647,412**	**394,870,084**

10 STRATEGY FOR IMPLEMENTATION OF THE MASTER PLAN

10.1 General

Rehabilitation and strengthening of the existing bridge is unaccustomed practice in our country. If we mention, rehabilitation of the Abay No 3 bridge and strengthening of the Gibe River bridge these are the recent practices achieved successfully. However such types of repair works were limited to certain specific bridges and hence do not insure avoidance of problems associated with failure of bridges and closure of roads in all the network of the federal roads of the country. This is one of the main reasons which necessitate launching of the Bridge Management Support Services.

The implementation strategy involves, identification of critical bridges designing of maintenance methods, provision of effective training to the district engineers and personals, continuous assessment of capacity of districts, inviting the private contractors for major repair or reconstruction works and asking them how much interested they will be to conduct routine maintenance works, and the like.

The master plan will be implemented based on the following general strategy.

- **Identification of critical bridges** – ERA has identified some of the critical bridges as top prioritized bridges based on the inspection works (FBII).
- **Provision of maintenance design** – Consultants have prepared detail design drawings, bill of quantities and all required documents for the implementation of the rehabilitation and repair works of the critically selected bridges.
- **Estimation of budget** – Estimation of the total cost and cost required in every fiscal year so as to implement the repair works of the bridges and culverts. The cost is estimated based on unit rates of damage repair which are revised and submitted with the revised bridge repair specification.
- **Capacity building works.** Provision of continuous training on bridge inspection and repair works.
- **Preparation of tender documents** for major rehabilitation of reconstruction works specification and working drawings should be prepared.
- **Construction supervision** of the rehabilitation works is also required by the consultant whenever the implementation commences.
- **Evaluation and reporting** The magnitude of improvement works performed should be measured to check against the BoQ. It is important to make the necessary adjustments to insure maximum utilization budget and effectiveness of the master plan.

10.2 Prioritization of Bridge structures for improvement

Bridge Authorities are faced with the difficult task of allocating scarce resources to various bridge works. Therefore Bridge management system should have the way to prioritize concentration of Bridges of varying age, size, material of construction and strategic importance. So as to make the action that will be taken more easy and speedy.

The objectives of the prioritization system are:

- To provide a consistent comparison of different bridges
- To provide a consistent basis for comparing strengthening , maintenance, improvement and upgrade works
- To provide a fair basis for the allocation of funding
- To maximize the benefits from the available resources

In order to be practicable, the prioritization system should be simple and robust, and should account the differences in commercial, social and traffic characteristics in each of the road segments. At the same time it has to cater to a wide range of structural maintenance and upgrade works. Priorities Bridge works with a view to maximize the benefits from the money spent.

Different, factors were carefully analyzed which expresses bridge priority score; such as Risk of failure or extent of distress, the class of the road, roads under upgrading project, span length, Alternative route or detour and social impact of structures is used as a main criteria in prioritizing the structures.

10.3 Stakeholders and Division of Works

In order to perform the maintenance activities in a controlled and rapid manner the project should be managed in a proper way this includes the application of Knowledge, skills, tools, and techniques to project activities and there proper allocation with respect to time and work load. These leads to the development of divisions of works that shall be implemented By DRMC and that shall be implemented or outsource to other contractors.

The necessity for classification of the work is, to categories the workmanship and skill, hence to allow the workman a better knowledge of his business, to save time in progressing from one type of work to another, and to facilitates the invention of tools and machines.

Therefore as per the above understanding the consultant tried to evaluate the DRMC capacity based on its past projects experience and comes to a decision that all the maintenance activities shall be handed by District Road Maintenance Contractor and those structures which needs further study like hydrology and hydraulics or design of structures or recommended to be replaced shall be controlled by private contractors, and this recommendation is presented.

Involvement of Private Contractors

As per the discussions and minutes of meeting held with the stake holders which include district engineers of the client and the consultant it can be agreed that the private contractors shall involve in handling the major rehabilitation works like bridges that require demolishing and reconstruction of full or parts of bridges. In such cases where capacity of the DRMC can handle the major rehabilitation works the work can be given to the same. However if the construction pace of DRMC is found to hamper the objectives of the master plan then the private contractors will be invited to involve.

Capacity building of DRMC and DED Professionals

One of the objectives of any infrastructure development is related with capacity building of certain target groups of people. It is believed that this is the only insurance to keep the development in a sustainable manner. Likewise bridge management support services are being provided keeping in mind this objective and involving the district engineers in the process and in decision making so that they become capable of handling the task after the consultant finalizes the contract. The other method of capacity development that the consultant uses is provision of intensive trainings to district engineers and other professionals who involve in maintenance activities of bridges and culverts.

11 CAPACITY BUILDING AND SUSTAINABILITY

11.1 Capacity building activities

Bridges, However constitute the most vulnerable elements of the road network, they are neglected for long time in-terms of Inspection and Maintenance. It is mainly due to shortage of skilled manpower and absence of any kind of readymade bridge information in the country.

As discussed in previous pages, development of BMS and owning of the bridge/Culvert stock database has brought radical change in organized decision to improve these structures by allocating budget dedicated to this specific works.

When the capacity building issue in bridge works raised, it is not possible to bypass without mentioning JICA`s name and its contribution provided to ERA for the last 10 years. Without JICA`s Technical Assistance, the achieved performance may not be unthinkable.

The JICA experts in cooperation with ERA Engineers have prepared a bridge inspection manual in 2001 that highly inspired ERA engineers to take responsibility for development of BMS software. The developed software was introduced to all concerned engineers in ERA and outside of ERA with assistance of JICA training schedules.

As to our best knowledge, computerized and systematic management of bridge asset is not well introduced in Africa. Some countries like South Africa and a few neighboring countries like Botswana and Zambia are using such system. Otherwise so far we could not reach to any country's information in this regard. Therefore, Ethiopia can be deemed as one of pioneer countries in Africa in utilization of in-house developed modern bridge asset management system.

Once the bridge asset management need is introduced in Ethiopia, further introduction of all bridge management cycle related knowledge believed to be disseminated to ERA districts, RRAs and private sector. In this regard consecutive trainings are designed and intensively conducted by ERA and JICA bridge engineers at the selected bridge sites and at class room.

As a result, by now, as many as 500 participants mainly Civil Engineers are passed through trainings in bridge inventory, inspection, maintenance and database management. Many of trained engineers are involving in same activities being employed in ERA and in private sector.

11.2 ERA-JICA cooperation activities

Bridge related activities are being undertaken by both parties since 1999 in order to enhance the bridge skill and performance in bridge construction and maintenance.

- Preparation of draft bridge inspection manual, by JICA Bridge Expert, (1999-2000)
- Revision of bridge inspection manual /2000/
- Development of computerized bridge management system./2000-2002/ and Developing ERA-culvert management system (ERA-CMS)
- Revised versions of ERA-BMS software (ERA-Bridge Management System)
    - 1st version of ERA-BMS Software /in March 2002/
    - 2nd version of ERA-BMS Software /March 2005/
    - 3rd version of ERA-BMS Software / March 2007/
- Bridge Inspection manual had been prepared and ERA- BMS was ready, due to shortage of skilled manpower and other resources, ERA planned to handover the inspection work to the private firms. But, ERA must give training on general concept of the work requirement and use of Manuals.
- To overcome inability of collecting bridge data, Federal bridge inventory & Inspection (FBII) project was launched in June 2005 and contracted out to local private firms.
- After Completion of FBII project, on mid 2006, ERA could have database of more than 3000 bridges (total opening of $\leq$ 4mt) and 28,000 culverts data base which are found on nearly 20,000 km federal road net work .
- After 6 years of hard work & effort, ERA could own its bridge management system with full data base that can show the current condition of each bridge.

11.3 CDBM Project

In addition to the above mentioned activities, a special program on capacity building was launched in January 2007. Brief data of the project is as follow

- Project :- Capacity development on Bridge Management (CDBM) project
- Organized by :- Japan International cooperation Agency (JICA)

- Preliminary study of the project :- Studied by Japanese study team on January 2007
- Agreement :- After the study team had a series of discussions with the representative of Ethiopian road authority and other concerned organization on the implementation of the project, it was made on January 2007 between Ethiopian roads Authority (ERA and Japan International Cooperation Agency (JICA).
- Overall goal and purpose of of the project :-

    Goal :- Appropriate maintenance and rehabilitation of bridges are implemented, which contributes to the improvement and service level of Ethiopian Road Network

    Purpose:- Capacity development of bridge management in Ethiopia.

    1 Introduce Concept of bridge management cycle.

2 Assist ERA in effective implementation of the in-house developed software for bridge asset management system,
3 Develop capacity in bridge rehabilitation activities.

- Counter Part training :- C/p training in Japan for Eight engineers including project manager & project coordinator.
- Workshop & training on introduction of bridge management system, "Concept of Bridge Management Cycle ", and practical bridge repair on site trainings in different districts was given for about 310 participants (Engineers drawn from ERA, RRA , and private sectors) with in the past 5 years.
- Donation: - Different office and field equipments including Vehicles as seen in the donation letters.
- Revision of Bridge repair specification,
- Revision of ERA standard Bridge Design Manual – 2002,
- Revision of Version 5 BMS Software and, , Check prioritized bridges for improvement by paying Visit Districts and RRAs.

11.4 Sustainability Plan

Bridge management systems may be used as a tool in allocating limited resources to the inspection, maintenance, rehabilitation and replacement of bridges. The integrity of BMS is directly related to the quality and accuracy of the bridge inventory and physical condition data obtained through field inspections. A good data base is the foundation of an effective BMS. Such system should be both effective and responsive so that the unique characteristics and special problems of individual bridges are considered in developing an appropriate inspection plan and maintenance mechanism.

Bridge management requires a practical, objective, and systematic consideration of the problem with a set of economic and technical tools. Specifically, Bridge management system is rational approach to planning, designing, constructing, maintaining, rehabilitating, and replacing bridges. As a result the consulting service has been developed to assist bridge owners by establishing inspection procedures and maintenance action that meet the bridge safety and performance standards.

As the bridge asset management activity has a continuation nature, in order to sustain use of BMS in all concerned offices, a capacity building works are taking place by involving as many as possible Engineers. The trainings are focusing on Bridge asset preservation and management; Inspection and *Inventory*; as well as repair works.

Currently our policy and practice lies on to give chance to all bridges to be visually inspected at least once per year and the detail condition survey at every three years. All the obtained data shall be recorded on ERA standard formats and uploaded to the software. As a result, all bridges shall be prioritized by intervention requirement and timely improvement actions shall be proposed to the decision makers.

In order to assure sustainability of the system in working condition, utilization of it disseminated to all ERA District and Regional Offices with provision of the Software and bridge inspection tools. Continues Technical Assistance is also being provided.

In order to tackle shortage of skilled manpower at these offices, trained and experienced private firms are employed to assist district offices for 3 years period.