Bridge building and the restoration of roads in the rural areas of the Democratic Republic of Congo

A case study in the Mai Ndombe region, populated by the Basakata people

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TRITA-BKN. Master Thesis 241, Structural Design and bridges 2006-10-02
ISSN 1103-4297
ISRN KTH/BKN/EX--241--SE

A Minor Field Study
Bridge building and the restoration of roads in the rural areas of the Democratic Republic of Congo

A case study in the Mai Ndombe region, populated by the Basakata people.

Supervisors

Håkan Sundquist       Alexis Mafisango
Abstract

This purpose of this study was to give a general view on the state of the infrastructure in the rural areas of the DRC and how this affects the population. The survey was done in more detail in the Mai Ndombe region where the case study was preformed. The infrastructural and socio-economical situation in the rural areas are linked together since the bad state of the infrastructure is keeping the rural population isolated from the national, regional and international economy. The collapse of the road network in the DRC has lead to difficulties with transporting and selling crops, great difficulties with travelling to health care centres when needed and a wretched climate and conditions for companies that want to invest in the region covered by the case study. A proposal on a development project for improving the situation for the rural population is included in the report as well a technical part on how to rehabilitate the roads and bridges examined. My hope is that this study could contribute something to the process of improving the life quality for the population in the rural areas of the DRC, especially in the area covered by the case study, the Mai Ndombe region.

Keywords:

Infrastructure, rural areas, development project, socio-economical situation, isolated areas, roads, bridges, Mai Ndombe
Preface

This study has been carried out within the framework of the Minor Field Studies Scholarship Programme, MFS, which is funded by the Swedish International Development Cooperation Agency, Sida /Asdi.

The MFS Scholarship Programme offers Swedish university students an opportunity to carry out two months’ field work, usually the student's final degree project, in a Third World Country. The results of the work are presented in an MFS report which is also the student’s Master of Science Thesis. Minor Field Studies are primarily conducted within subject areas of importance from a development perspective and in a country where Swedish international cooperation is ongoing.

The main purpose of the MFS Programme is to enhance Swedish university students’ knowledge and understanding of these countries and their problems and opportunities. MFS should provide the student with initial experience of conditions in such a country. The overall goals are to widen the Swedish human resources cadre for engagement in international development cooperation and to promote scientific exchange between universities, research institutes and similar authorities in developing countries and in Sweden.

The International Office at the Royal Institute of Technology, KTH, Stockholm, administers the MFS Programme for the faculties of engineering and natural sciences in Sweden.

Sigrun Santesson
Programme Officer
MFS Programme
Summary

The lack of functioning infrastructure is one of the biggest obstacles for further development in third world countries. The big companies are unwilling to invest money because of the difficulties involved in running a company in countries that can not promise electricity, water and proper transport possibilities in the extent that they demand. It is not enough that the level of the salaries is very low which could give great earnings in the production of the big company’s services and products. Africa is especially affected by this and it is keeping companies from investing in their countries. The DRC is a very clear example of this. Decades of bad governance has lead to an infrastructural disaster where the roads throughout the country have deteriorated immensely. The lack of electricity, proper water and communications has held this huge country down for decades in spite of its tremendous opportunities. The DRC has also just come out of a big civil war that from 1998 until 2006 has cost around 4 million lives from war, hunger and diseases. This is accounted as the biggest disaster in human casualties since World War II.

The road network in many rural areas in the DRC has deteriorated immensely and large areas have become isolated from not only the international but also the national and regional economy. These collapsed roads hinder the farmers from transporting and selling their crops to the bigger cities. This leaves the farmers without a proper income and it keeps them trapped in poverty without an opportunity to improve their quality of life. The main objective in this thesis was to investigate a possible future project for opening up regions in the DRC that has been more or less isolated from the national economy for decades because of the collapsed infrastructure. This proposed project will include the restoration of the most important roads and bridges as well as the creating of an organization that will maintain the roads and also help the rural population to sell and transport their crops. The thesis includes a survey on three different levels. The first part treats the situation in the DRC concerning infrastructure, economy and social issues. This part also includes a summary on the DRC’s history that tells about the events that has lead up to the current situation. The summary also explains how social problems evolved and the Western countries involvement throughout the years, leading the DRC further and further down in despair.

The thesis continues after this to outline the rural areas in more detail seeking for suggestions how to improve the situation for the extremely poor people living in these areas. The case study treats the Basakata people living in the Mai Ndombe region. I am though quite sure that the study and its possible solutions could be applied for most rural areas in the DRC. The third and last part does in more detail conduct calculations for the roads in some extent but mostly for the bridges in performance as well as the estimated cost. Dimensions and the cost for the proposed bridges are given for bridges from three to twenty four meters, (often divided into smaller spans.)

Many problems involved in restoring infrastructure in this area are discussed and taken into account for all calculations. If a development project is to be launched in the area covered by the case study is a more detailed investigation required to further outline the region and create a more exact plan for how to implement the project. The thesis does though include a more general plan for a future project. I am though convinced that the ideas from the thesis as well as the calculations made on the bridges giving all dimensions needed for constructing could be used for possible future projects.
CONCLUSION (summary in French)

Le manque d'infrastructure est l'un des pires empêchements pour le développement des pays du tiers monde. Les grandes entreprises ne veulent pas y investir d'argent ou de capital à cause des difficultés qu'apporte ce manque. Il est évidemment difficile de faire avancer une entreprise dans un pays qui ne peut pas promettre le flux constant d'électricité, d'eau et de moyens de transport. Le niveau bas des salaires du tiers monde, qui peut donner de grands gain aux entreprises, n'est pas un argument suffisant pour y installer leur production, tant que l'infrastructure est si mauvaise. Surtout l'Afrique est touchée par ce manque d'entreprises et d'investisseurs. Un exemple très clair est celui de la République Démocrate du Congo. Pendant des dizaines d'années ce pays à souffert sous un mauvais gouvernement et la plupart des routes ont subit de grands dégâts. Ce manque d'électricité, d'eau potable, et de voies de transport à empêché le développement de ce pays, qui en lui-même a tant de possibilitées. RDC vient de sortir d'une guerre civile (1998-2006). Les batailles, la famine et les maladies ont couté la vie à environ quatre millions de personnes. C'est plus grande somme de morts depuis la seconde guerre mondiale.

Surtout dans les parties continentales du Congo, la structure des routes est une catastrophe et de nombreuses régions sont isolées du système économique international et même national. À cause des routes bloquées les paysants ne peuvent se rendre aux villes des allentours pour vendre leurs produits. Ceci empêche les paysants d'améliorer leur mode de vie et ils restent enfermés dans la pauvreté. Le but de cet écris est d'examiner le moyen de faire un projet futur qui puisse permettre d'ouvrir des régions de la RDC qui jusqu'à aujourd'hui, à cause du manque d'infrastructure, ont été isolées de l'économie nationale. Le projet décrit consisterais d'une réconstruction des routes principales, ponts inclus, et d'une organisation qui soit responsable de l'entretien des voies de transport et d'aider les paysants à vendre leurs produits. Cet écris est partagé en trois parties principales.

La première partie décrit la situation infrastructurelle et sociale actuelle dans la RDC. Cette partie contient un résumé de l'histoire du Congo qui explique comment on en est arrivé à cette situation. Il est aussi indiqué à quel point les pays européens qui se sont mêlé à la situation ont une grande partie de la faute. Deuxièmment c'est la situation rurale qui est décrite. L'étude Fall (sur place) est basée sur le peuple Basakata qui habite dans la province Mai Ndombe. Mais je suis certain que la situation et les besoins sont semblables dans la plupart des régions rurales du Congo. La troisième partie permet de voir plus en détail le travail de restauration nécessaire pour les routes et ponts en question et le coût approximatif. Ici nous trouvons un rapport sur le coût des ponts mesurant entre 3 et 24 mètres, à savoir que la plupart des ponts sont à construire en plusieurs parties.

Les difficultés majeures pour les restaurations d'infrastructure de cette région sont prises en compte, calculées et discutées dans le rapport. Mais si l'on souhaite réellement prendre en charge ce genre de projet de développement dans cette région il faudras d'abord faire un rapport plus détaillé. Cet écris est donc un plan général qui contient l'idée avec les rapports et les calculs de constructions de ponts qui seraient bien utiles dans un eventuel projet que j'espère aura lieu à l'avenir.
Sammanfattning (summary in Swedish)


De stora problem som finns med restaurerandet av infrastrukturen i detta område har här tagits i beaktande för alla uträknningar och eventuella lösningar diskuterade. Om ett utvecklingsprojekt i det här området skall bli verklighet i framtiden bör dock en mer detaljerad undersökning utföras för att ytterligare se över hur projektet skall se ut mer ingående Denna uppsats innehåller dock en generell plan för ett eventuellt framtida projekt och jag övertygat att denna idé och plan med inkluderande broberäkningar skall kunna användas i detta projekt som jag hoppas skall kunna bli en vecklighet i framtiden.
Acknowledgements

This Master of Science thesis is the final part of my degree in Civil Engineering at the Royal Institute of Technology, (KTH), Stockholm, Sweden. It was performed with cooperation with the department of Bridge Construction, CEBU in Semendua, DRC and the Swedish International Development Agency (SIDA) that has provided financial support. The study could never have been realized without the assistance and support from several key persons to whom I like to express my greatest gratitude.

My supervisor at KTH, Håkan Sundquist, special thanks for advice and guidance throughout the study.

My guide and friend Papy Lefeteka who helped and assisted me during my visit in the Inland of DRC.

My wife, Jesica Eriksson, who travelled with me on the journey and helped me and supported me as well as assisted me with the measurements during the entire trip.

Mister Oscar Masakale, working for UBS, who helped me a great deal before, after and during the journey.

Reverend Michel Inyenda Inabiota and his staff at CEBU in Semendua, who helped me and welcomed me during my visit in the Inland.

My supervisor in DRC, Engineer Alexis Mafisango who was available as a help with the examinations and calculations during my visit in the Mai Ndombe.

Mister Christer Daelander (working for UBS) who helped me a great deal throughout the study.

All the Engineers working for CEC in Bas-Congo, who gave me a very interesting tour and summary from their road project.

My sister Maria Eriksson-Baaz who took care of me in Kinshasa and helped me with all preparations for the trip to the Inland.

Mister Oumvane Ntangu Monshemvula who let me stay at his house in Kinshasa.

The Swedish missionary in Bas-Congo, who took care of me during the visit in Bas-Congo.

Läkarmission that contributed with necessary funds for my trip to the DRC.

SIDA and MFS coordinator Sigrun Santesson, for a lot of help with the MFS grant applications and some guidance before and after the trip.
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<td>Democratic Republic of Congo</td>
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<tr>
<td>AFDB</td>
<td>African Development Bank</td>
</tr>
<tr>
<td>UK DFID</td>
<td>The United Kingdom Department for International Development</td>
</tr>
<tr>
<td>KFW</td>
<td>German Government owned development bank</td>
</tr>
<tr>
<td>SMK</td>
<td>Svenska Missions Kyrkan</td>
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<tr>
<td>CEBU</td>
<td>Communaute Evangilique Baptiste Unité</td>
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<tr>
<td>CEBM</td>
<td>Communaute Evangilique Baptiste Mai Ndombe</td>
</tr>
<tr>
<td>SBU</td>
<td>Swedish Baptist Union</td>
</tr>
<tr>
<td>HIMO</td>
<td>Techniques en Haute Intensite de la Main d'Oeuvre</td>
</tr>
<tr>
<td>PMU</td>
<td>PingstMissionens Utvecklingssamarbete</td>
</tr>
<tr>
<td>CEC</td>
<td>Eglise du Christ au Congo, 23ème Communauté Evangilique du Congo</td>
</tr>
<tr>
<td>USDA</td>
<td>The United States Department of Agriculture</td>
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1 Introduction

1.1 The methodology used

I already had some sense about the state of the infrastructure in the DRC before my visit in 2006. I have spent several years there during my childhood and I had a recollection of roads and bridges that were in very poor condition. It was very interesting to return to the DRC and investigate this more closely and I have now learned much more about the country and its present situation. The main methodology that I used when performing the study was to travel around on a motorcycle on the important roads in the Mai Ndombe region and examine the state of the roads and bridges. I also made some interviews with the locals to see how they saw their situation and how the infrastructural collapse affects them. I did though not have the opportunity to make as many interviews as I wanted due to the language difficulties. The people in the Mai Ndombe region speak Lingala, French and other local languages and almost no one at all speak English, not even my guide. I therefore had to depend upon my French and Lingala, which are ok but not good and this made me a bit reluctant to perform interviews in the extent that I wanted.

I also made a trip to the Bas-Congo region to examine an old road project that was previously supported by SIDA among others. I was here given a tour and summary on their road project and this was very interesting and gave me some ideas for a possible road project in the Mai Ndombe region. The other data on the state of Congolese infrastructure and the situation in the country in general is mostly collected from reports from the World Bank, UN, AFDB and the European Union.

1.2 Problems

The by far most difficult problem faced in my study was the problem to communicate with the locals on a deeper level needed to make good interviews that could bring me valuable information to the report. I could easily communicate with most people on the trip on a more basic level, using the Lingala and French that I master but my vocabulary were not that big so I had to limit my question to much easier ones than I would have liked to. The possibility to use an interpreter in the inland was extremely limited since extremely few people spoke English at all and it was very hard to bring an interpreter everywhere due the very expensive costs for renting a motorcycle. My first intention was not though to use motorcycles but bicycles. The information I received before travelling to Mai Ndombe that it cost 0.5 dollar per day to rent a motorcycles made me desert my intention to use bicycles. This information did though appear to be false and the cost was instead 0.5 dollar/km and this made the trip in the inland a little bit shorter than expected but I am although quite satisfied with the study that I performed despite these difficulties. There were of course a lot more problems during my visit in the DRC that I to deal with but the problems with the language and high costs for travelling in the inland were the hardest one to face.
1.3 Extensions and limitations

I must be honest to confess that it was very hard to know were to limit the extent of my thesis since there are very much that could be included and it was indeed a bit difficult to see what to include in the theses and what I had to pass up. The most important objective for me for this thesis was to not only conduct a general survey on the state of the infrastructure and propose technical solutions on how to perform the bridges but also to include a proposal on how to improve the quality of life for the people of the Mai Ndombe. All this made the thesis a little bigger than intentioned but I am though satisfied with all that were included in this thesis and I hope it could bring something to reader and for the people in the Mai Ndombe in the long term.
2 The situation in the DRC

The Democratic republic of Congo has a very sad story. This huge country, so immensely rich of natural resources, but so poor in Infrastructure, financial resources and order has been ravaged by everything from crazy dictators, vicious colonists to greedy rebels for over 500 years ever since it was discovered by the Portuguese explorer Diogo Cao at the year 1482\(^1\).

It is sad to see this great country in this current difficult situation. One can imagine it in an analogy as a leopard caught in one trap after another, each one giving it more deep wounds and making it harder and harder to get up. If one would compare the natural resources with a rich country like Sweden would the DRC resemble a big leopard and Sweden would probably just match up to a little tame cat. There is though hope for this nation but there are a number of difficulties that has to be resolved to rise up this nation in it proper place in the world hierarchy.

One thing that has struck me during my short trip to the DRC is that one bad deed have give birth to more difficulties and this consequences to even more difficult problems and it has just become a bad chain of events making it more and more difficult to resolve this country’s difficulties. Much like following infections in a wound. It is essential to understand a country’s history to fully comprehend the different mechanisms behind the problems preventing it to develop. One of the main explanations for Congo is that the country has had a bad ruling, starting with King Leopold moving on to the Belgian colonists and finally the dictator Mobutu. This has had many bad consequences for the nation such as the deteriorated infrastructure and the wide spread corruption to name a few. I will now give a quick summary of the Congolese history that can explain how the country evolved to its present state and the actors that are responsible for driving the country further and further down in despair.

2.1 The history of DRC

2.2.1 Ancient history\(^2\)

Long before the Country were discovered by the European explorers it had an advanced culture and the variety of groups living in the Congo-delta had quite early learned important features such as intensive agriculture and metallurgy. From the 13\(^{th}\) century to the 16\(^{th}\) the land there were an advanced culture here with kingdoms such as Kongo, Luba and Lunda and the country had very early firm political structures which divided the country into villages, districts, provinces and kingdoms.

After the land had been discovered by Diogo Cao in the 15\(^{th}\) century the did European colonists start to exploit Congo from its natural resources and it also became the centre for the slave trade to the Middle East and America. During the late 17\(^{th}\) century was nearly 15,000 slaves a year taken from the settlements near the outer part of the Congo River. Three centuries followed with many civil wars and disturbances within the region and the Portuguese now accompanied by the French, Belgians and the Dutch gradually took a firmer grip of the region and many, many slaves were taken from the outer parts of Congo just until the 19\(^{th}\) century when slave trade began to be obsolete in Europe.

2.2.2 Further exploring of Congo

The inner parts of Congo were yet to be discovered and difficulties such as the dangerous streams of the Congo River, sicknesses and the tropical climate prevented the region to be further discovered.

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\(^1\) Utrikespolitiska institutet, facts on Kongo-Kinshasa at www.landguiden.se, chapter ancient history, page 1
\(^2\) Gondola, Didier Ch. The History of Cong, http://caxton.stockton.edu/hod/history
However in the mid 19th century were successful expeditions made by the British physician and missionary David Livingstone and the American Henry Morton Stanley. Stanley went away to find the doctor who had set off to find the source of the Nile River and he finally met up with the doctor in Ujiji in the inland of Congo. Stanley then returned to Europe but only to return later for more expeditions now followed by three hundred followers, mostly natives which of many did not survive the hazards of the terrible conditions and the ill-treatment of Stanley himself.

2.2.3 The Leopoldian Congo

After the European nations France, Belgium and Portugal had divided Congo amongst themselves it was finally given to the Belgian King Leopold. He announced his "Congo Free State" idea during the Conference in Berlin 1884-85 that treated the dividing of the colonies among the European Nations and the conference then decided to give Congo to him. The good image of Leopold as a humanitarian prince did though change when the atrocities against the Congolese people became known and it transformed his image into a colonial villain. The Congolese people were subjected to horrible atrocities during this time. Hands were cut off, people were whipped, and kidnapped, held hostage and many other cruelties were done in Leopold’s search for ivory and rubber. Leopold controlled Congo for twenty four years and during this time five to eight million people lost their lives in epidemic diseases, starvation or colonial violence in their service for Leopold. In the early 20th century reports started coming in from missionaries in Congo describing the horrors subjected to the native people by Leopold. This finally led up to a deal where the Belgian State bought Congo from Leopold for 155 millions Fr and another 50 millions as, “a mark of gratitude for his sacrifices made for the Congo”.

2.2.4 The Belgium Congo

In 1908 “the Congo Free state” now became “the Belgium Congo”. The Belgian decision to take over was not however motivated by moral and political obligation of ending the cruel treatment of the Congolese people. Instead it was the information received regarding the economic benefit their country could derive from dominion of this huge country, eighty times larger than its mother country, which persuaded Belgium to take on Congo. The Belgian Congo were though not so different from Leopold’s Congo and the Belgians continued to exploit the land from natural resources and human labour but were not as cruel as Leopold against the native people and one can say that Congo were as a profitable business providing the Belgian State with wealth.

Big companies signed treaties with the colonial government that granted the company a certain amount of land to extract resources from if they cooperated and followed through some requirements written in their deal. The people that had to make this happen was of course the Congolese that was impoverished by the companies that utilised a system of tight social control that deprived the people of their freedom. According to the anthropologist Jan Vansina the Congolese population were at least cut in half from 1880 to 1920 and this opinion is shared by many other witnesses to the cruelties implemented onto the Congolese people by Leopold, the Belgian government and many other organisations that worked in Congo during these years.

2.2.5 The economy of the Belgian Congo

The Belgian government with help from European companies did its best to exploit Congo from their natural resources and they were forced to build many miles of paved roads and railways to enhance their level of extraction of copper, diamonds, and other resources. By the 1930s over 4000 km of roads and railroads had been built, thereby boosting the level of extracting, that doubled the
production of copper and the production of diamonds by a factor of almost eight from 1920 to 1930 (Gondola 85). A similar boost for the production for other products such as cotton, palm oil, coffee, etc was also implemented.

The World War II created a greater demand of products from the Belgian Colony and this resulted in a substantial upswing for the Congolese mining business. This continued also after the war and in the year of 1959 Congo answered for 9% of the copper production, 49% of the cobalt production and 69% of the production of industrial diamantes in the world. For ensure the availability of enough low-wage labour required by the state-owned and private companies to keep up the high level of production did the state enact compulsory recruitment, which was reminiscent of the brutal forced labour of the Leopoldian Congo. Congo helped the allies’ forces providing it with many resources such as rubber, cotton and also some troops with Congolese soldiers that fought for the allied forces in several important battles in Northern Africa. The American Atomic bombs dropped over Hiroshima and Nagasaki were also built with Uranium taken from Congolese mines (Gondola 87).

### 2.2.6 Education

The Colony had a quite developed schooling system, and in 1955 10% of the population went to public school, comparing with India’s 6% the same year. The opportunities for education above comprehensive school were though extremely limited and in 1959 only 136 pupils completed upper secondary school in the whole country. Very few Congolese people had any important posts in the Belgian administrate system that ruled the country in the year of the liberation, which clearly shows in the table below.

<table>
<thead>
<tr>
<th>Ranks</th>
<th>Europeans</th>
<th>Africans</th>
</tr>
</thead>
<tbody>
<tr>
<td>High ranking functionaries</td>
<td>5 900</td>
<td>0</td>
</tr>
<tr>
<td>Mid-level functionaries</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Office managers</td>
<td>1 690</td>
<td>9</td>
</tr>
<tr>
<td>Assistant managers</td>
<td>1 976</td>
<td>24</td>
</tr>
<tr>
<td>Clerks</td>
<td>774</td>
<td>726</td>
</tr>
<tr>
<td>Low-level functionaries</td>
<td>0</td>
<td>10 791</td>
</tr>
<tr>
<td>Total</td>
<td>10 340</td>
<td>11 550</td>
</tr>
</tbody>
</table>

*Table 2.1: A table showing the dividing of the administrative posts for Europeans and Congolese people.*

The first Congolese student to register in a university left Congo to attend the University of Louvain in Belgium and it was not until 1954 that the Congolese were allowed to attend a University in Congo with the condition that philosophy, law and letters would be stricken from the curriculum to avoid the Congolese to stray from the Belgian path. In June 1960 only thirty Congolese held university degrees, earned at home or abroad. The unwillingness from the Belgian government to give important posts to the Congolese in the administration and keeping the Congolese from receiving a higher education became a key factor for Congo’s shaky start.

### 2.2.7 The Liberation

Belgium was very reluctant to deal with the timely issue of emancipation of the colonies and they did not do much to prepare for the emancipation of Congo compared to many other countries. Nationalism, reforms and emancipation of the colonies grew stronger in the colonies after World War II but in Belgian Congo did this mindset remain in place for another decade after the war. The absence of political parties and movements also slowed things down a bit. Other religious, ethnic, cultural and social organizations did though evolve before the real political organizations emerged in the mid 50s. Several ethnical associations emerged that spread ideas in favour of their particular group
such as preservation and strengthening of their language. ABAKO for example fought for their language Kikongo and the region of Bas-Kongo and many other associations had similar programs but with different ideas in favour of different groups and languages.

The protests started rising in the end of 1958 and riots broke out in January 59 during a meeting of ABAKO with the result of almost 50 dead and over 300 injured. A new more nationalistic party evolved in October 1958 called MNC and this party together with ABAKO played a big role in the final independence of Congo. In January 1960 forty four Congolese met with members of the Belgian parliament in Brussels to discuss the transfer of power in Congo. The strong, charismatic leader of MNC, Patrice Lumumba now released from the prison were he was put after the riots, steered the discussion toward setting a date for independence. This led to an agreement that independence would be granted on June 30, 1960, one month after the general election. The election lead to a win for the MNC though without winning a majority and Lumumba became prime minister and ABAKO’s leader Joseph Kasavubu the head of state, (Gondola 113).

Figure 2.3: One of the big leaders in Congolese history and a key figure in the liberation, Patrice Lumumba.

2.2.8 The first republic

There were several factors working at turning Congo from a prosperous colony into a chaotic state after the independence. The professor Van Bilsen, much active in the debate of Congo named the following three. A lack of elites, a lack of political experience and adverse economic conditions. Another significant factor was the Western state’s growing fear of that Congo’s woes would compel them to turn to the Soviet Union for help and they tried to keep this from happening by intervening in Congolese politics. The western states also feared that the new adverse political development in Congo would jeopardize their huge economic interest in Congo and that the extraction of mineral resources that they depended on would diminish. This lead to that Belgium, the U.S. and France got involved in the conflict and tried to steer the conflict in the way they wanted.

Reluctance by some Belgian officers to accept the new changes of the independence lit the flames of a conflict between Congolese soldiers and European officers and civilians, causing disturbances all over the country. Belgian answered with sending in 2 500 soldiers but this only lit the flames of violence even more. Together with this were several attempts for succedion made by the regions Katanga, Kasai, Kivu and Equateur and. Belgian soldiers also decided to go in to defend and help the region of Katanga in their succedion, mostly because the region has huge resources of miner.
The sucession of Katanga was by far the most dangerous conflict much because its natural resources. The western countries were now worried that the new republic would fail to ensure their need of the extracted minerals found in Katanga and this lead to that several countries got in some extent involved in the conflict. Belgium still wanted to dominate Congo, now in neo-colonial way and did provide the Katanga movement with hundreds of thousands tons of arms to protect their region. Lumumba and Kasavubu urged UN to help them drive the Belgian troops from Congo and break down the Katanga resistance but UN only wanted to keep the great power nations out of the conflict. UNs unwillingness to help Congo with this made Lumumba to turn to the Soviet Union for help and Katanga finally had to give in.

Lumumba’s urge to the Soviet Union together with his rancour against the atrocities made by the colonists to the Congolese people made him fall out of favour in the eyes of the American government. Eisenhower ordered the assassination of Lumumba but although CIA failed to this task he was finally murdered in 1961, in an assassination endorsed by the Belgian government and orchestrated by the Belgian Secret Service. The Western countries then saw a new candidate for Congo’s ruler that they easily could manipulate and bribe, a young lieutenant known for his ruthlessness and a man lacking any political agenda, a certain Joseph – Désiré Mobutu. Four years followed with civil war and in November 1965 did Mobutu, the leader of the rebel group ANC seize power with much help from Belgium and the U.S. He assumed the presidency for what he initially claimed would be a five-year period until new elections could be held, but Mobutu’s dictatorship did instead last for over thirty years.

2.2.9 Mobutu’s Congo

Most Congolese welcomed the new regime, hoping that it would bring an end to the first chaotic years of the republic and take Congo into a new era of political stability and economic recovery. Mobutu managed to get support from the western countries, especially the U.S., that had helped him to get the power and also most of the neighbouring African countries. He also succeeded in striping the parliament from all the power and influence and giving all the power to him. Mobutu’s tactic to ensure his continuous power and reign were mostly to co-opt or repress his political opposition and he was very good at this. In 1967 he created his own political party, MPR (Popular Movement of the Revolution) and banned all other parties. The new regime acted harshly against all opponents, such as the students, rebels and other political movements. By 1970 had Mobutu total power over the population and the party, the army and the administration. The state companies were under strict control and he had led the people to believe that he was responsible for ending the disturbances and was in the process of restoring the economy.

2.2.10 Zaire

In October 1971 he renamed the DRC to Zaire and also changed the names of the big cities in an attempt to launch new ideas of obliterating all the vestiges of colonialism and instead seeking a new Nationalism in the pre-colonial heritage. He then conjured up mythical images of the pre-colonial
villages, presenting them as an idyllic community blissfully living under the authority of patriarchal, yet strong-willed chief, Mobutu himself. It is easy to here see the noticeable similarities between Mobutuism and Maoism.

2.2.11 Economical decay

Mobutu continued the Zaireanization on many areas, including the economy were he seized control of many foreign companies working in Zaire and gave over the control to local politicians or himself and this gave him many supporters among those who benefited of these measures. Economically for the country these measures though a disaster, depriving the country of its most skilled operators that just left the country after being deprived from their company leaving the companies into the care of politicians who lacked much business and managerial experience. Mobutu himself took a hold on a large proportion of the companies giving him tremendous wealth. These measures taken by Mobutu had many bad consequences leading to layoffs in Zaireanized enterprises, inflation, tax evasion, and a general decay of economical structures. Other bad consequences of the Zaireanization are the failing of reinforcing a work ethic and the adapting of several poor behaviours hindering the economical development even now. The most dangerous one of these is corruption, which has encouraged unscrupulous foreign entrepreneurs to set up ventures in the country and warred off more serious investors. The corruption spread widely, leading to that any sort of economic or legally service such as obtaining driver’s licence, passports and money other similar things required a bribe. Daily bribes rather than the small, sporadic wages provided for the income of many workers.

Another behaviour damaging the economy was the nepotism in the Zaireanized companies that led to that the new owners of the companies laid off many workers in their companies and instead hired workers from their own kinships and ethnic groups. This led to much embezzlement and pilfering because workers no longer had to abide to the work ethic that prevailed in the traditional setting. Even though Mobutu tried to reverse or soften some of his measures were the damage already done and it dragged down the country in economical decay. In 1986 did the inflation reach 100% and the debt $10 billion although some small, doubtful efforts were made by the IMF to improve the situation. Mobutu’s personal fortune was estimated to $5 billion in private bank assets, company shares and investments all over the world. The ruling of Mobutu could best be described with the words of (Clark 1998:9); “the state has never served any socially meaningful purpose that could promote the interests, however defined, of the Zairian people. Rather it exists, to the extent to which it exists at all, to enrich and empower the small group that controls it”.

2.2.12 The fall of Mobutu and civil war

The discontent of Mobutu’s regime grew stronger and stronger over the years and in April 1990 Mobutu was finally forced to give into the international and domestic pressure and declare an end to the single-party rule and call for the creation of a conference that would create a new constitution. Mobutu did though not give in without a fight but tried to stall the transformation process by a number of actions as murdering students and assassinating political opponents. Finally in August did the conference start but it was disturbed by big riots started by the Congolese army (FAZ) who were demanding to receive their salaries. Systematic looting and rioting for three nights of stores, public homes as well as public properties in Kinshasa as well as a few other cities destroyed property for a value of between $700 million and $1 billion. Several conflicts blazed up all over the country, especially in the east, much affected by the conflict in Rwanda and all finally evolved into a full-scale civil war in Zaire. Different rebel groups emerged and one important alliance of these different groups were called “The Alliance of Democratic Forces for the Liberation of Congo-Zaire”, AFDL, lead by Laurent Désiré Kabila.
The happenings in eastern Zaire did not give much response from Kinshasa and was seemed as remote and isolated. The lack of response was also reflected by the fact that Mobutu was forced to go to Europe for medical treatment. The AFDL received help from many countries that wanted to see Mobutu's regime come to an end. Angola, Uganda, Rwanda and also the U.S. government backed up Kabila's rebels in their quest to free Zaire from their dictator. The Congolese military, FAZ was in this time much disintegrated and this also facilitated the rapid progression of the Alliance troops.

When Mobutu returned from Europe in December 1996 he was now very determined in holding on to his presidency and he was forced to enlist mercenaries due to the collapse of FAZ. He tried to fight Kabila with Serbs, Hutus, Angolan, South-Africans among others but he had no chance against the rebels and they just came closer and closer. On May 17 – 97 did Kabila's forces march into Kinshasa and Mobutu and his followers were forced to flee. Mobutu fled to his presidential palace in northern Zaire and after that finally to Morocco where he received a political asylum from his long-time friend King Hassan II where he passed away on September 7 the same year. Finally had thirty years of dictatorship come to an end for the people of Congo.

2.2.13 Kabila’s Congo

When Kabila seized power he re-adopted the country’s old name, (The Democratic Republic of Congo), along with its old flag and national anthem. Voices were though heard that were concerned that Kabila did not have the ability to transform the country into a democracy. Kabila were chosen as a spokesman for the rebels not for his ability as a leader but most because he spoke English, French, Kiswahili and Kiluba fluently. He had tightened his grip of AFDL and repressed those who opposed his methods. Kabila were very reluctant in starting some kind of democratization process but instead used the same methods as Mobutu, excluding political opponents and banned all political parties but his own AFDL. He also formed a government with mainly Tutsi exiles, Katangan allies and other people from the AFDL. This did not go well with the people and especially not with the people in Kinshasa. Many casualties had come from the war and both the FAZ and the AFDL were responsible for many atrocities done to their own people with endless rapes, murders and driving several hundred thousands from their home. Kabila himself was very reluctant to share power and repressed, killed or imprisoned anyone that questioned his deeds or his power.

2.2.14 Mismanagement of Congo

Just as Mobutu has been was Kabila just a soldier that just happened to be in the right place in the right time and he was not at all prepared to what awaited him. He therefore started straying the same path as Mobutu. He took Mobutu’s old nepotism to new heights, giving key positions to the people in his clan. Kabila did not only apply nepotism to ridiculous levels, his management of the country was filled with corruption and huge mistakes. In April 1997 he signed a $1 billion agreement with the American Mining Fields giving them unrestricted access to Congolese copper, cobalt and zinc. This was done just a week after Mobutu was ousted. The Canadian Tenke Mining Corporation had then shifted from a previous contract with Mobutu to a new one with Kabila. Kabila also signed other treaties with groups and leaders in the nearby countries in Uganda and Rwanda giving them also
access to drain the DRC out of its resources. Burundian, Rwandan, Ugandan and/or Congolese soldiers moved around in eastern Congo visiting farms, storage facilities, factories and banks ordering them to open up the doors and give them the products they needed. During the most part of the time under Kabila’s ruling did the neighbouring countries just use eastern Congo as it were an extension of their own.

2.2.15 Civil war

In June 1998 there was a falling out between Kabila and the governments in the neighbouring countries and in August started the second Congolese civil war. This civil war was triggered by his decision to expel the Rwandan military officers who had helped him topple Mobutu. A new group supported by Rwanda and Uganda was formed that had an objective to overthrow the Kabila government while Kabila received help from Angola and Zimbabwe. Neither of these countries did involve in this war for any selfless reason or by an urge to help the Congolese people but mostly for economic or other political reasons. The Ugandan and Rwandan forces did though finally pull out of Congo in June 2000, leaving chaos behind. The atrocities made by the Rwandan and Ugandan soldiers to the Congolese people were similar to the atrocities made by Leopold soldiers one hundred years ago. Mass murders, rape and extrajudicial executions are some of the examples of the many atrocities preformed by these troops.

2.2.16 The way to peace

In July 1999 was a peace treaty signed in Lusaka between all the involved parties that among others included representatives from seven neighbouring countries that were involved but this treaty were not held, much because the countries could earn more of war than of peace. The country was now divided into four different fractions with its own resources as well as foreign troops at disposal. On January 2001 did Kabila however suddenly get assassinated by one of his bodyguards. There are still some question marks concerning this assassination and who that was behind it. After much stonewalling was Kabila’s son Joseph Kabila appointed as President. He swiftly initiated peace negotiations with all involved parties and several treaties were signed and broken while many battles were fought all over Congo, especially in the east. Finally in July 2003 did the different rebel groups agree on a treaty that gave each group a vice-president post in the government resulting in one president, (Kabila), and four other vice-presidents from the different groups. According to the UN had the civil war lead to the death of 3.3 million people from 1998 – 2003 due to famine, deceases and battles. This conflict is now accounted as the worst conflict in casualties since World War II.

2.2.17 DRC today

Some new conflicts did though evolve during the following years for various reasons but in smaller scale this time. In 2005 could an election for the new constitution be made with a result that approved the new constitution the DRC. A primary election has now been carried out in July 2006 which led to a second election between the sitting president Laurent Kabila and a former rebel leader named Bemba and one can only hope that this could become a new beginning for Congo. The second election is going to be carried out in October 2006 and one of these two candidates is going to rule Congo into an extremely important phase of the Congolese history. The people that I spoke to were though a bit doubtful concerning the different candidates and this concern could be enhanced by the fact that a fee of $50 000 must be paid to become a candidate for the presidency. Most of the people that have this amount of money in the DRC have often gotten hold of the money in ways that are more than doubtful. There are though forces working for a new prosperous DRC and one can
only hope and pray that these forces finally could get the upper hand without involvement from the greedy Western countries or a candidate that only is looking for power.

2.2.18 The search for coltan

A new mineral found in Congo is coltan which is a metal used in almost all modern electronic devices. Big findings of this mineral have been found in Congo and this has drawn even more vultures to Congo in the search for riches. As an example of this did the Rwandans stole coltan for several billions SEK during the civil war and sold them onwards to businesses in Europe and North America. If this money could be used for the restoration of the country instead of stolen by greedy nations that only wants a piece of Congo could Congo really start to rise up as a nation.

2.3 The restoration of the country in progress

Many key donors that were active in Congo before the 1990s but then interrupted their activities in Congo for over a decade resumed their activities and many emergency intervention programmes became implemented in the beginning of 2002, financed by the World bank. Many other recovery projects to help the country has been implemented since then financed by the World Bank, the African Development Fund (ADF), the European Union and other organizations. In December 2003 did the advisory group for the DRC meet in Paris with the Congolese Government to discuss how to solve the issue concerning ensuring the consistency of these interventions and they encouraged and helped the government to create a global, strategic framework of all interventions outside the country. This lead to the creation of the Minimum Partnership Programme for Transition and Revival (PMPTR) in 2003. This programme describes the Government-Donors partnership that is intended to back-up the transition and economic revival. It contains four major strategic axes and these are the following. To ensure the political stability and security; accelerate economic growth in a fair manner throughout the whole country, to improve the governance and the strength of the institutions and finally mitigate the social crisis and find a solution to it. The total cost for the PMPTR is estimated at 7.13 billion US $ of which 17.67 % are earmarked for the Transport sector.

![Figure 2.4: The rehabilitating of the railroads in progress.](http://www.afdb.org/pls/portal/docs/PAGE/ADB_ADMIN_PG/Dокументs/Operation)
3 Infrastructure in the DRC

The communications within the country has gradually gotten worse and worse since its liberation 1960 and the government has declared that one of its most important tasks now is to repair the existing roads and to build new ones. Congo has around 170 000 km of roads of which almost all are non-asphalted to be compared with Sweden which is a country five times smaller then Congo but has 425 000 km roads with a large proportion of asphalted roads.

This 170 000 km are in very bad shape and one can really question if all this really are roads worthy of the name. I can take one road as an example of the so called roads which is situated between the village of Bosobe and the city of Oshwe. On the best map over Bandundu that I could get a hold of , (which is from 1971), is this road drawn up as a big, important regional road with the importance to be compared with maybe road 40 in Sweden. When I asked the rural population living near this road of the road’s history they explained that this was a big road in the early 70s, passable during the 80s and impassable the last 15-20 years. Many bridges had collapsed on this road and the traffic had stopped coming and the road now looked more like a jungle trail then anything else when I tried to pass it.

![Figure 3.1: One collapsed bridge on the obsolete, important regional road Bosobe – Oshwe.](image)

3.1 The waterways

The Congo River and its tributaries still serves as the country’s most important conveyance and about 16 000 km are sailable but many distances are in big need of dredging. Most of the boats and barges travelling these distances are also in very bad shape since they are very old, sometimes even from the colonial time. A lack of fuel and spare parts are also additional problems for the bargemen travelling these enormous rivers.

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5 Information under headline “the waterways” is taken from the appraisal report ”Nsele-Lufimi and Kwango-Kenge roads rehabilitation project from the African development fund September 2005 page 3 (http://www.afdb.org/pls/portal/docs/PAGE/ADB_ADMIN_PG/DOCUMENTS/OPERATION)
3.2 The Maritime transport

There are three major ports linking to the Ocean and these are Matadi, Banana and Boma. The port in Matadi is by far the biggest among these three and it stands for 95% of the maritime transports and is therefore very important for the country’s trading activities by sea with a global traffic level of 1.65 million tons in 2004. The infrastructure on these ports is though obsolete and the facilities, transmission equipment and safety equipment are in big need of restoration and there also plans on doing this in the near future.

3.3 The Railways

The DRC has only four passages with railroad and these main lines are the passage connecting the city of Lumumbashi in the Katanga region situated in the south – east with Ilebo in the centre of Congo, Kinshasa – Matadi and also the distance in the east connecting Kamina with Kalemie and Kindu. The passages Lumumbashi – Ilebo and Kinshasa – Matadi is sometimes used to transport miner from the area very rich of natural resources situated in the south – east. The goods is then transported by railway up to Ilebo and with big barges from Ilebo to Kinshasa but this transport conveyance is often so unstable that the miner producers use the conveyance through Zambia down to South Africa instead. The railway network is 5033 km long of which 858 km are electrified and in 2004 was the railway accounted for the transportation of about 800 000 tons of products, (mostly mining), and close to 1.7 million passengers but the transport are though thwarted by the obsolete infrastructure and insufficient equipment limiting the speed from 50 km/h to 12 km/h during 2004. Restoration work on the 50 year old railway is though planned and in progress as we speak.

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6 Information under headline “the waterways” is taken from the appraisal report ”Nsele-Lufimi and Kwango-Kenge roads rehabilitation project from the African development fund September 2005 page 3 (http://www.afdb.org/pls/portal/docs/PAGE/ADB_ADMIN_PG/DOCUMENTS/OPERATION)

7 Utrikespolitiska institutet, facts on Kongo-Kinshasa, www.landguiden.se, chapter kommunikationer

3.3 Air transport

The fastest way to travel around in Congo, (although a bit dangerous due to several doubtful airlines working within the country), is by airplane and the airlines working in Congo are very important making it possible to travel around the country in spite of the collapsed roads. This is however not possible for the normal Congolese because the tickets usually cost much more than a year’s salary. So the average Congolese has to rely on the boats travelling the rivers or go by foot or bicycle. The DRC has about 232 airports and only 25 of these have paved runways. There are though surely much more airstrips in the inland that are not so frequently used by the local airlines. It is hard to estimate the total amount of people and cargo flown by the airlines in Congo every year but over 670 000 passengers and 120 000 tons of cargo flew through the five international airports (Kinshasa, Lumumbashi, Kisangani, Goma and Gbadolité) in Congo in 2004. The airport infrastructure are though as all infrastructure in Congo in bad shape and the obsolescence of airport facilities, air navigation and aircraft often cause accidents on the domestic level. The government has now plans for improving the infrastructure for the air transport to take away the constraints of this important transport sector.

3.4 Other important infrastructure

3.4.1 Public transportation and the economic situation

There are almost no public transportation driven by the state, not even in Kinshasa where one always can see lots of people standing beside the road waiting to get a ride with one of the many minibuses which are driven by local businessmen that has been able to get a hold of a vehicle and thereby an income. This scenario describes in some extent the situation in Kinshasa which is very chaotic. There is a huge lack of normal jobs and the average Congolese are forced to create an income by this simple idea. Try to get a hold of something that you could sell with a little profit. These items can be almost anything from a leash to cold bags of water, napkins, bathing balls or old maps over Congo. And since almost none of them have a shop they are forced to just stand in the street and sell the product that they want to sell. This is of course all non-taxed incomes and there are in fact very few normal, taxed businesses. The tax rules in Congo are though really complex and indeed very high so if a company would apply all this rules it would never survive for long. This leads to an extremely high rate of tax evasion among the few businesses working in Congo and a renewed tax - system is extremely important to try to change this situation. I talked to several entrepreneurs in Congo that had a good idea for a profitable business but were unable to do anything of it. Two explanations for this is that it is very hard to get a loan for starting a business and the tax system is very complex and non- favourable for business.

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Figure 3.3: A normal sight in Kinshasa due to the undeveloped public transport system.

3.4.2 Energy and electricity

The enormous Congo River is the second largest river in the world with an average flow rate of 42 000 cubic meters per second and among the big rivers is this the only one that has a significant slope. One passage has a difference of height of 102 meters on a distance of 15 km. All this facts makes this river the largest hydro power source in the world but the capacity has not been built out yet. For the present has only three percent been built out. Two dams were constructed in 1972 and 82, Inga I and Inga II, but they are currently not running properly11.

It is estimated that this river represents 13 % of the world's total hydro electrical potential and it could if fully built out satisfy the energy requirements of the whole African continent just by itself12. In spite these tremendous opportunities has the state huge difficulties with providing electricity to the people. The electric supply network is not properly built out and usual local solutions are electric generators and sometimes solar energy and the regularly households relays on coal and wood13. For now has only 6 % access to electricity and there is a huge lack of electricity in the rural areas and you can not even rely on electricity in the capital Kinshasa where the electricity comes and goes depending on the area you live in. Kinshasa has the same difficulties with the distribution of water where it just comes and goes depending on the area. It is not only the people of Congo that would benefit from the build out of Congo’s hydropower. South Africa is very interested in investing in the restoration of Congo’s hydropower to get access to the surplus of Congo’s hydropower12.

The world Bank, among other groups are now contemplating on investing 550 million dollars to rehabilitate the existing dams and investing another 5 billion dollars to construct another dam, Inga III that would generate approximately 3 500 mega watts. There are also plans on constructing the dam “Grand Inga”, a huge dam that would generate 39 000 mega watts at a cost of 50 billion dollars. The last project lays though in the far future due to its tremendous cost14.

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11 Facts taken from article on businessinafrica.net Power Pools, Published: 18-MAY-04 http://www.businessinafrica.net/energy_in_africa/523662.htm


13 Utrikespolitiska institutet, facts on Kongo-Kinshasa, www.landguiden.se, chapter energi

Figure 3.4: Some of the waterfalls of the Congo River that could be used for a new hydro electric plant.

3.5 Roads

The road network is divided into four official categories; national roads, priority regional roads, secondary regional roads and local roads. This is however only a theoretical classification of the importance of the roads and not at all a measure of the state of the roads. Some of the big roads are so bad that they are no even detectable by remote sensing methods, like National road 9 for example. Road transport in Congo is though among the key modes on transporting goods and persons. Road transport stands for about 50 % of the agricultural products transported for marketing purposes. The road network is travelled by 212 500 vehicles of which many are in bad shape and it is very hard to get a hold on spare parts for the vehicles outside of Kinshasa. The distances travelled by the big vehicles that can manage to travel the deteriorated roads are up to 1000 km and this can take 14 days or more depending on the condition of the roads.15

The main reason for the road network in Congo’s bad shape is decades of almost no maintenance at all and this is an affect of years and years of bad governance of the country. There is though a National and Regional Road Administration, “office du route”, but they have not done much during the years due to a lack of resources and the absence of salaries from the state. The situation has gotten even worse the last fifteen years since there have been no maintenance at all in many areas of Congo degrading National roads to small jungle trails. The total road network (in theory) consists of 20 000 km National roads, 20 000 km priority regional roads, 16 500 km secondary regional roads and 114 000 km of local roads. Of these total network is 2 250 to some extent paved, 15 000 km unpaved, 43 000 km of tracks, 21 000 km of country roads and 90 000 km of footpaths.16 So it is safe to say that are quite much work that needs to be done for the road network in the DRC.


16 http://www.unjlc.org/DRC/maps/
3.5.1 The rehabilitating of roads in progress

The government has though begun to restore the infrastructure with the funds and help from several big organisations and NGOs. The key actors are the World Bank and the European Union, but also the African development bank (AFDB), The United Kingdom Department for International development (UK DFID) and the German Government owned development bank (KFW) are much involved in restoring the major roads. The first task is to rehabilitate the three main corridors of the DRC, West to North – East, North to South and West to South-East. There are several major roads that need to be restored to fulfil this task. The first road to be restored were the important 350 km long road between Kinshasa and Matadi linking the Capital to the port situated near the Atlantic Ocean. This old, deteriorated road that was paved some centuries ago and it has now transformed into a nice-looking one-lane paved road but there are though small parts of the road still in need of further restoration17. The rehabilitating of the main road network in progress is for now mostly divided between the five key operators mentioned above. The World Bank is rehabilitating 3500 km, the European Union is funding 2 000 km, DFID is giving funds to 1 300 km, KFW to 280 km and finally AFDB is involved in restoring 150 km.

17 The implementation completion report on the emergency early recovery project from the World Bank November 2005
Several other smaller road rehabilitating projects are also in progress throughout the country by other NGOs but these are mostly projects intended to open up the access to critical areas in the short term and are not meant to create a sustainable road network in the DRC. The Congolese Government now intends to restore the practicability of a minimum road network required to back-up economic growth comprising the 10 200 km of national roads. Its improvements was based on the resources that could be generated to finance its maintenance which is essential if restoration is to be made on the road network in Congo. An ensured maintenance should be a demand made by the donors giving funds to road projects, otherwise will the restored road just deteriorate in just two or three years.

The Congolese government is also aiming at in the long term reopening the main road system through the assistance of the community of partners to achieve the priority network comprising 15 781 km\(^\text{18}\). This will though take many years since the priority lies on the National roads network to begin with and only this will take many years to complete, giving a political stability in the country of course.

### 3.5.2 The reopening of National Highway one, the gateway to Kinshasa and the sea\(^\text{19}\)

In February 2006 a project with funds given by the African Development Bank which included the restoration of the roads Kenge – Kwango and Nsele – Lufimi was launched that was supposed to begin to link the regions East and West Kasai and Bandundu which are the big breadbaskets of Congo with Kinshasa. This is although just a beginning of an effort of linking Kinshasa with these regions giving Kinshasa access to more agricultural products. These roads will also give the other regions access to other simple articles that are very hard to find nowadays in the Inland of Congo such as medicine, batteries, clothes, gasoline, etc. This is a very important road for the region in my case study because it will link the region with Kinshasa and make it possible to go from the Kassai River to Kinshasa in only one or two days.


\(^{19}\) The appraisal report ”Nsele-Lufimi and Kwango-Kenge roads rehabilitation project from the African development fund September 2005 page Viii (http://www.afdb.org/pls/portal/docs/PAGE/ADB_ADMIN_PG/DOCUMENTS/OPERATION)
3.5.3 Bridges\textsuperscript{20}

There are almost 20 000 bridges in the DRC and many of these are in extremely bad shape if even passable at all, especially in the rural areas. Most of the bridges in the rural areas are made of wood. It is common to just lay down a couple of wood logs over the river to make it passable. The bridges in and near the big cities are sometimes made of concrete or steel, but many of these bridges are also in quite bad shape and in need of maintenance. There are also over 325 obsolete ferries and floating support units and these are also in great need of maintenance.

\textsuperscript{20}http://www.unjlc.org/DRC/land/roads/snapshot_roads/2006-07-25.0204384674/view
3.6 Infrastructure in the rural areas of DRC

The absence of adequate, serviceable infrastructure is a big obstacle for development in Congo. This especially applies for the rural areas where maintenance of the roads has been disregarded and overlooked much more than the areas near the big cities. This subject will be treated more thoroughly in the following chapters.

3.6.1 The health situation and infrastructure

The collapsed road network affects the rural population (which mostly are farmers) in a very bad manner, preventing them from selling their agricultural products since the communications with the bigger cities in need of their products have collapsed. It also makes it very hard to attain medical care in time due the difficulties involved in travelling to a hospital. The health care with proper medicine, personnel and other things needed is not the only thing that has to be done for obtaining an ok health care situation in the rural areas of the DRC. The roads also have to be restored to make it possible for the rural population to reach the health stations in time. I talked with several locals that explained that they have been forced to travel over forty kilometres by foot on small jungle trails to get to a hospital. It would also be a good idea to purchase some kind of vehicle that can work as an ambulance for each health zone to get the patients to the hospitals in time.
4 The agricultural sector\textsuperscript{21}

The agriculture plays a prominent role in the economy of the DRC, accounting for 60\% of the GDP, 17\% of the export earnings and employing 70\% of the people. The country itself is also very suited for agriculture but very little land is being used compared to its potential. The export earnings from agricultural products has plummeted immensely over the past years, 334 million \$ in 1995 became 6.5 million \$ in 2000, due to a general decrease in the production of all export products.

4.1 Constraints to the development of the agricultural sector

The long civil war has entailed additional constrains to the development of the agricultural sector to add to the other constrains before the civil war that is caused by 30 years of bad governance. The situation has now gotten much worse than in the 60, 70 and 80's. The instability of the social-political situation has let to many destroyed crops and abandonment of many farms this leading to a drastic decrease in areas under cultivation. The farmers that has been able to pursue their activities have turned to traditional subsistence agriculture which is carried out with minimum agricultural inputs and hence unproductive. Subsistence agriculture is being carried out even in areas not so affected by the civil war, (such as the Mai Ndombe region). This is an affect of the deterioration of basic socioeconomic infrastructure, the very bad state of the feeder roads from the rural areas and the absence of organized marketing channels. These difficult constrains leads to a lack of supply of agricultural inputs and marketing of products and this resulting in a distortion of trade and a huge drop of the farmers income. Even the feeder roads to the rivers often used to transport agricultural products from the rural areas to the big cities are in really bad shape. This forces the farmers to go over 30 and often 40 km by foot to sell the amount of agricultural products that they can carry to the skippers travelling the big rivers.

There are also other constraints such as the disorganization of the sector's support services, like for example, research, technical supervision and financing of the farmer community and these constraints have become great obstacles for modernization of the country’s agriculture.

4.2 The potential of the agricultural sector

Despite these constraints, does the DRC’s agricultural sector have a great potential. The DRC has a very favourable climate and ecological conditions together with an immense hydrographical network. The tremendous potential of DRC’s agricultural sector can be described with some simple facts; 10\% of 80 million ha of possible agricultural land is being cultivated, the grazing land and savannah can bear 40 million animals while 7 million is currently being used, the fishery production can give 700 million tons per annum but is does now give less than 200 million tons and finally forests covers more than 125 million ha, most of which is poorly exploited.

\textsuperscript{21} The appraisal report” Agricultural and rural sector rehabilitation support project in Bas-Congo and Bandundu provinces” from the African development fund March 2004 pages 1, 2 and 7. http://www.afdb.org/pls/portal/docs/PAGE/ADB_ADMIN_PG/DOCUMENTS/OPERATIONSINFORMATION /ADF_BD_WP_2004_35_E.PDF

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5 The Case study in the region of Mai Ndombe

5.1 The Mai Ndombe Province.

My case study was preformed in an area that until 2005 was called the Bandundu region. The old region of Bandundu was 295 268 km² which is about two thirds of the area of Sweden and it has a population of 5.2 million inhabitants (1998)\textsuperscript{22}. The Province capital Bandundu has about 120 000 inhabitants. The country has now according to the new constitution in 2005 been divided into twenty five provinces instead of just ten before, (both not including Kinshasa). This change has not yet been implemented but this will surely be done after the election is over which will be in October 2006. The affect this will have on my thesis is that the region that is included in my case study, although not fully performed, will be the Mai Ndombie province and not the northern part of the Bandundu province. The name Mai Ndombie comes from the big lake in the northern part of the region that is called Mai Ndombie, which means “the black water” in Lingala. The new province is 127.465 km² big and has over 1 million inhabitants. To give an idea of the size of the region can it be said that the district is 28% of the size of Sweden and the lake itself is 41 % the size of Sweden’s biggest Lake Vänern. The vegetation is mostly savannah in the south-west and rain forest in the north and east of the region. The region above the Lukenie River is covered by a large rainforest. In the north - eastern parts of the region can you also find the big National Parc of Salongo that holds many endangered species. Oil has been found near the big lake some twenty years ago but no one has though bothered to pursue this for many years, much because of the collapsed infrastructure and problems involved in operating a company here.

\textsuperscript{22} http://www.answers.com/topic/bandundu-province
5.1.1 The bigger communities in Mai Ndombe

The new region capital is going to be the city of Inongo, situated in the north, near the Mai-Ndombe Lake. It is very hard to get a hold of data concerning how many inhabitants that live in each town and village in this region but the biggest and most important cities/villages in the region are the following:

Inongo, Semendua, Bokoro, Bosobe, Tolo, Nioki, Kuto, Oshwe, Kiri, Lokolama, Isaka, Seko, Bendela, Konkeia and Mbien Kassai. There are surely a couple of more important villages/cities in the area not included here, but these are the towns/villages that I have more knowledge about and the cities that my contact in Kinshasa pointed out as the most important ones.

I chose this area because it is covered by the local NGO, (CEBU), that I have contact with. It is essential to have a tight contact with local NGOs if a possible Development project is to be implemented in the future. Unfortunately I lacked resources and the time required to perform a complete study on the proposed region but I have though made a general survey on the situation regarding infrastructure and development. (A complete study of the region could though not have been totally included within the frame of my theses because the region is too big).

Figure 5.2: A map over a part the Mai Ndombe region, taken from UNJLC, (a part of the UN that is responsible for the logistic part.)

The map covers almost the entire working field of CEBU and it was updated 2005, using satellites for detecting all figures as roads and rivers. The names of the villages are however not updates at all since Semendua for example is not pointed out and Bosobe is called by its old name, Boshwe. This is though the best map I could get a hold of and probably the most updated.
5.2 The local NGOs working in the region

The region outlined in this thesis is an area that used to be and still is although in smaller scale a working field of the Swedish Baptist Union. The first missionaries arrived here at the beginning of the 20th century and established a mission with several mission stations all around the region and missionaries continued to come here in a large scale until 1991. The missionaries were then forced to flee Congo due to the riots and disturbances mainly affecting the big cities. Some of the missionaries returned for small periods after it had calmed down and the activities continued, but in smaller scale until 1995 when all missionaries went home. There has been very few missionaries working in this area and always for small periods of time since then and after 2000 there has been no presence of Swedish missionaries at all in the rural areas of Mai Ndombe expect for some visits made by the leaders working with the international mission of the SBU.

I had the opportunity to visit two of the ten larger stations used by the SBU, Semendua and Bosobe. It is very easy to see here that many things, especially buildings, have started to deteriorate immensely due to the lack of resources of SBUs local sister communion CEBU. I only met one European (not counting the MAF pilots) in these rural areas so the presence of missionaries and western people in the Mai Ndombe has really dropped significantly since the 90s. The only European that I encountered was a Belgian women living with her Congolese husband in the only house besides the old Swedish boarding school that is in relatively good shape of the 20 houses before used by the missionaries in Semendua. The other houses are now used by the locals, many working for CEBU. They do though not receive any significant salaries for their job involving the administration of the CEBU so they lack resources for maintenance of their houses. Most of them also have large families to be added to the other relatives living with them and this leads to an even greater deterioration of the buildings. The most part of the houses are made of concrete with tin roofs and window frames and roof joists all made of wood. The roofs have though started to deteriorate, soon leading to holes in the tin roof. The roof joists and the window frames are many under heavy attack by termites and big cracks are beginning to appear in the concrete walls.

![Figure 5.3: Window frame attacked by termites in a house in Bosobe.](image)
5.2.1 The conflict CEBU - CEBM

There is another matter complicating cooperation in this area. There was a conflict within the CEBU about 12 years ago. A power struggle evolved between the CEBU leaders on Bosobe and Semendua and several events lead to a breaking out of the village/city Bosobe from CEBU creating their own communion named CEBM. Years have past since then and the tension between the two communions has decreased. Some people on the two sides have though still grudges towards another and they have not come together yet as one communion but there is though some collaboration between the two communions. CEBU is lead by the administration staff at Semendua and they represent all the other congregations in this region, (for example Oshwe, Duma, Mimia, Bendela, Konkeia, Camp Mpoko and many more). Most of the staff members including the president Inabiota are though going to be replaced in September/October 2006 due to embezzlement and a lack of confidence among the congregations. CEBM is lead by the administration at Bosobe with Isaolo as president, and they represent only Bosobe.

5.2.2 Swedish organisations working in DRC

The presence of Swedish organisations in Congo is for now quite diminished compared with 20 years ago. Diakonia, SMK and SBU shares an office in Kinshasa where a very nice and capable Congolese man, Oscar Masakale works for SBU together with Dr. Makuma who is responsible for the health projects that SBU is involved in. They share the office with Åsa Konde who takes care of Diakona’s affairs and Kimy Konde who works for SMK.

The presence of Swedish missionaries in the rural areas is extremely limited for now; both of the two SMK missionaries left in the rural areas, living in Bas-Congo went home in may -2006 leaving no Swedish missionaries working in the rural areas of Congo for either SBU or SMK at all, (one of them will though return after the summer). PMU has people working in the east of Congo, but I am not sure on how many, probably less than a dozen since this is a very dangerous area to work in.

It is really quite fascinating and elevating to see all the efforts that the SBU missionaries have made for the Congolese people in the area of my case study and perceive all the fruits that have become of it such as hospitals, schools and for me personally as a Christian, the great number of congregations
started here. It makes me proud to see I might say. Especially since my mother and father served here for nearly fifteen years, working as a doctor and a nurse. The church in Congo has made great efforts during the years trying to help its population to improve their difficult situation and has sometimes been almost the only organisation or institution that has been working properly both in the rural areas and in the big cities.

I am sure that it was not the intention of the churches to diminish their working staff in DRC in such a fast pace. It is also by a large part explained by the conflict and civil war that made it much harder to work within the region. I do though believe that there are several bad consequences of the benefit organisations non actual presence of their own working staff in the rural areas. The reduction of their contact with the rural areas to mostly e-mail and occasional visits as well the visits by the staff of CEBU in Kinshasa can lead to a lack of proper insight into the actual situation and an inadequate communication between the two organizations. One be-affect of this is a reduction of the amount of help given to the rural areas.

![Image of child welfare clinic in Bosobe](image)

**Figure 5.5:** The child welfare clinic in Bosobe constructed by Swedish missionaries and the Congolese state, (where I was born).

### 5.2.3 The church in Congo

The Catholic Church has been the biggest church in Congo ever since the beginning of the 20th century and the Belgian ruling gave it a special position during its ruling, providing it with special benefits and help. The protestant churches were though big critics of Leopold and the Belgian ruling over Congo and the atrocities done by them. After Mobutu became president did the Catholic Church though diverge from its path and became the government’s biggest critic. Mobutu then tried to crush the church but failed.

For the present does the Catholic Church still has the biggest part of followers, (almost 50 %), but many new churches and cults has emerged out of nowhere during the last ten years. Many people have gone to the church in search for help in their difficult situation leading into some kind of revival. It is though quite difficult to discern the righteous, honest preachers from the ones looking for money and power in this chaos of new emerged churches and movements. A large part of the population is though Christian, practising or none practising. A very small part is also Muslims. The old indigenous beliefs are also quite strong in the rural areas of DRC, sometimes mixed with Christian beliefs.
5.2.4 The socio-economical climate in the Mai Ndombe region

One thing that I find regrettable is the fact that many aid organisations in third world countries generally has failed to ensure a development in the long term in their working field. It is much easier to start up organisations and activities than to keep them alive after you have left. Especially when the state in the development country can not ensure a favourable socio-economical climate for the organisations and companies implemented. Maintenance and the creating of long service structures that can keep going although the region has a non-favourable socio-economical climate is vital for projects in third world countries according to me. The lack of resources among the population and its NGOs in the Mai Ndombe region has in some extent developed this sickness with deteriorating structures and economy as a result. Buildings, roads and mainly all things vital for enhancing the socio-economical situation for the people has deteriorated immensely. There are extremely few businesses and most people are just cultivating enough crops to survive and not for selling and both these situations originated in the complete collapse of the infrastructure. The infrastructure has though been in bad shape almost the whole time when SBU had working staff placed here, but the infrastructure has reached a new low the last decade.

One do not has to be an economist to comprehend that this is making the rural population extremely poor and preventing the development in the rural areas. Without any possibility to earn money do the people stay poor and stays in constant need of help and assistance. When the helping people then leave with there money and projects the people gets hopelessly trapped.
To enhance the development and the living standard in a country is naturally a job for the government and the local state institutions, but what happens when they fail to help their people? And continues failing this task for over fifty years. The responsibility then lays on the local NGOs, and there are very few local organisations that have the organization to do anything and no one has the resources required. It takes a very simple mathematical equation to explain this:

The state does nothing , the local population has almost no income and the only functioning, organized actor (the church) relies on the people’s gifts and since the people has almost nothing to give it adds up to almost nothing again. All this equals the society’s resources to almost nothing and it will stay that way until someone starts generating capital. An extremely bad status quo. The rural areas are in great need of jobs and capital to enhance their situation. They need to have some kind of substitute for the state that can help them to stimulate their economy when the state now is not doing its job.
5.2.5 The existing opportunities for the region

What the rural population needs are new opportunities to earn their own money and some kind of system to uphold their new found opportunities despite of bad governance. The state will hopefully create this opportunities and a system to uphold it some time in the future. But shall we wait for this? It is extremely hard to foresee when this will happen, especially since this region has not been given so much priority during the years from the Congolese state, much because their lack of miner.

The region has though very big opportunities to make money for themselves with agriculture and farming and could provide the major cities with agricultural products and other commodities needed. The rainforest starting from Bosobe (see map) also has a lot of forest with wood in form of wenge tree, a very strong and popular type of wood. There are at least one logging company working with this that takes trees from the area near Oshwe. They have been forced to construct some bridges themselves and enhance the road in this area to facilitate the transport of the trees from the forest to the river that they use as a conveyance to Kinshasa. This has lead to an enhancement of the old big regional road between Oshwe and Bosobe at the sections closer to Oshwe.

When the state fails, the church do not has the resources and the missionaries has left along with their money and investments it is the companies working within the region that is forced to enhance the infrastructure enabling them to carry on with their business. Unfortunately have most of the companies active within the region some ten, twenty and thirty years ago left when they got tired of all the difficulties involved in running a company here. It is very important to draw back the investors and companies to Mai Ndombe to create more jobs for the people and thereby boosting the economy for the whole region.
6 Infrastructure in the Mai Ndombe region

The infrastructure in the Mai Ndombe province is as in all of Congo in a really bad shape. In the area that is CEBUs and SBU's old working field there is only a very small part which is asphalted. This is 30 km of the 50 km road connecting the region capital Bandundu with Camp Mpoko. These 30 km has quite recently been restored and is still in quite good shape according to what I heard from the chauffeurs travelling this road. My study only covers a part of the working field of CEBU, CEBM and SBU since I lacked resources to study all the roads and bridges in the area. My proposal for a development project does though involve an area bigger than the area I got to visit myself. An additional survey is though required to get a hold of more information how to implement the project in detail and what areas that could be included in it. The whole region has an extremely bad access to energy and electricity. The electricity network is not at all built out and there are very few people that have access to electricity at all. The energy sources that are used by the extremely few that have the resources for it are mostly solar cells and diesel generators.

Figure 6.1: The one-lane roads in the rural areas, this is a very nice road one compared to most of the roads in this area.

6.1 Communications

The different areas and villages communicate only with radio since there is no telecommunication network yet. There are although plans on placing a mobile phone mast providing telecommunication opportunities to the area around Semendua including Bokoro and other nearby villages. Promises has been made for a couple of years now by a company working within Congo but nothing has happened yet but maybe it will be a reality in a couple of years. Infrastructure for internet does not exist either and I guess this will not change for many years to come. SBU has though helped CEBU with establishing technology making it possible to send e-mail via the radio communication which is a huge help with the communication between these communities.
6.2 The road network in the Mai Ndombe Province

The road network is not that built out and all of the existing roads are in need of immediate attention. The most important roads for the region are situated in the south part connecting to the old regional capital Bandundu that connects further to Kinshasa. There are also some old roads in the north part that could serve as a gateway to Kinshasa from the old Equateur region in the north. These roads are though not at all passable for the moment. The road network in the northern part of Mai Ndombe, almost totally covered by rainforest, is not built out at all and the roads that exist are very bad. One should though start to restore the roads in the southern part to connect the whole region with the road leading to Kinshasa. After this has been done should the road leading up from Oshwe up to the rainforest in the north, east of the big lake be rehabilitated. The area west of the Mai Ndombe Lake is also very important but it is not covered by the local NGO (CEBU) that I have contact with. It is essential to have good contact with local NGOs to implement development project. I also do not have that much knowledge about the region not covered by CEBU.

The road network included in the area covered by CEBU exists of several obsolete important regional roads connected with a number of feeder roads. It is though very hard to distinguish the feeder roads from the big regional roads since all of them have deteriorated immensely. The old major roads are road numbers 251, 262, 264, 267, 268 and 269. The most important of these roads is the road number 251 which connects Semendua with Camp Mpoko and this village is connected to the big city Bandundu which further leads to Kinshasa. Another important road is 264 which connect Semendua with Bosobe and further to Oshwe. The other roads mentioned above are also very important and should be restored when funds will be available for them. Road 251 and 264 should though be prioritized. Another essential road is the road from Oshwe up to the big rainforest in the north with communities as Lokolama, Ipope and Mimia.

Some old roads has deteriorated so badly that the population has stopped using it for decades, (often because of collapsed bridges), and this has lead to the creating of new roads now being used as new vehicle roads or just roads for motorcycles and pedestrians. A bigger study should be done to better outline the entire road network in this area but I have studied at least the two of the most important roads for the region.
6.3 The problems affecting the building process of infrastructure

There are many problems that have to be dealt with in the process of rehabilitating roads and bridges in the rural areas of the DRC. Some examples of these are a non-favourable climate, bad access and shortage of building material, lack of skilled personnel, impassable roads, and a bad socio-economical climate cluttered with corruption. I will here present some of the problems and explain their affect on the building process.

6.3.1 The climate

The DRC has a climate really working against the upholding of good infrastructure with immense, powerful rains during the rain period deteriorating the roads quickly, especially if vehicles utilize the roads just after big rains. Many deteriorated roads turn into totally impassable roads during the rain period and the level of the rivers differs much from rain period and dry period making it very hard to design bridges accurately. I made it a habit to always ask the rural population living near the bridges concerning the level of the rivers during the rain period to avoid making calculations with foundations that would just be washed away during big rains. I then made calculations based on the levels of the streams to make the bridges safe and serviceable. I have to add that almost all the distances that I studied were in very bad shape in spite of that the roads for now are very seldom used by vehicles and they are quite spared from the extra damage made by trucks using the roads after big rains. The roads are also spared from the stresses applied to the roads from normal vehicles using the roads in normal conditions since the traffic level is very limited for now. The extra stresses that will come with the vehicles using the roads after restoration must be taken in to consideration when designing the roads. To ensure a longer service-life on the roads are trenches also required to drain the water of the roads that otherwise would make big damage.

Erosion is a big problem making big holes in or beside the roads. The erosion has on some distances made such big damage to the road making them totally impassable and other detours has been created by the drivers to avoid these distances. During my journey from Semendua to Bosobe did the driver make at least five detours because the road had collapsed ahead due to erosion. I might say that the Congolese are often very inventive when it comes to solving problems because they are forced to solve big difficulties with very small resources and then has to improvise to solve problems. When our strap for the fan cut off on my trip to Bosobe did they made a new one made of rope and another one of the only seat belt left in the jeep. It can be added that the Congolese mechanics and drivers are often very skilled and it is also very cheap to repair your vehicle in Kinshasa. Spare parts are also very hard to get a hold of in the rural areas of the DRC.

Figure 6.3: Semendua after a heavy rain, the small village roads are as one can see totally flooded.
6.3.2 Consequences of the wretched socio-economical situation in DRC

The extremely low cash flow within the rural areas of Congo has many bad consequences on the Congolese society. One of the worst is that it keeps the people poor and creates a huge lack of basic articles such as clothes, hygiene articles, medicine, fuel and much more. Another big consequence on the society is a problem widely spread throughout the country. The people employed by the state such as hospital staff, police, white-collar workers, teachers etc are getting none or very small salaries. This adds even more to the corruption which is a major problem here. The DRC was listed as one of the fifteen most corrupted countries in the world\(^2\)\(^3\) by Transparency International in 2005. This also creates an enormous obstacle to launch projects for enhancing the situation.

It is easy to be judgemental towards the people standing for this corruption and one shall of course condemn their actions of corruption. It is though also important to understand that the people are very poor and has tremendous needs and when they see an opportunity to get some money it is hard to resist. If you and your children are hungry or sick is it very hard to say no. When you have money and food like in Western Europe is it quite easy to resist the temptation. I might say it is much worse when rich people in the West takes money then poor, sick people in a third world country. The pressure from your relatives is also very hard in Congo and it takes a really strong character to say no when your relatives comes asking for money or medicine that is not yours. This is anyhow according to me the biggest obstacle for development in the DRC since the money intended for different projects has a way of just disappearing.

6.3.3 How to run projects in an area cluttered with corruption

To avoid widespread corruption in proposed projects one has to devote time searching hard for people with really good character, divide the responsibility between them and create some kind of control system. I think it is also important to have people from the responsible organization from Europe come and visit at least a couple of times a year to inspect that everything is working as scheduled. I also believe that the church can play a role here preaching more about the virtue of honesty and the importance of having a good character. It is really sad to see that this behaviour of corruption and stealing is not even spared from the churches or preachers. It could be devastating to pour money for development projects directly into the church communities because this could lead to corrupting the church even more. I think one has to create some kind of new organisation or cooperative tightly linked to the local church communities, the rural population in all the villages, cities and the responsible organisation in Europe. For this particular case could the local communities be the CEBU and CEBM and the European organisation SBU. A new organisation must though be created that can operate the projects and keep the money from possibly corrupting the church but this organisation should though be linked to the local NGOs without poring money into them directly.

There are also other problems linked with the bad socio-economical situation in the country; theft. This can also have devastating affects for the companies in the region and a possible development project. One example of this is the story I heard about a coffee company that worked in Semendua during the 80s and a part of the 90s. They gave people jobs and money during this time but they got tired of people stealing from their store house and just finished up and left, leaving many people without jobs. The company also made some efforts with improving the roads when they were active which of course stopped when they left.

\(^2\)\(^3\) http://www.transparency.org/policy_research/surveys_indices/cpi/2005
I also talked with a Congolese man working with stock farming in this area concerning this. He also made some efforts with improving the roads but stopped fixing the bridges when some people stole the wood boards he used to build a bridge. He then just made temporary bridges that he brought with him on every trip to get over the streams on the way.

One good measure to prevent corruption is to give good salaries to the employees to make it easier to resist taking money. The missionaries also used night watches and iron bars in the windows to avoid thefts. This should be implemented for a possible future projects as well. It is essential to think through the problems of corruption and theft very thoroughly to keep it from affecting any possible future project in a devastating way. Safe, functioning structures must be created in the handling of money for any possible future project and although it requires a lot of thinking and effort I am sure it could be done.

6.3.4 The deteriorated roads and socio-economical situation

The collapsed roads and bridges complicate the building process a great deal making it much harder to transport material, equipment and workers to the working site. One shall avoid transporting things as much as possible to avoid time consuming and costly transportation. It would be best to try to use material found near the building site and personnel in the nearby villages as much as possible without endangering the quality of the roads and bridges. Using local material and local workers also inspires the economy of the local communities and teaches the people how to restore roads so they can be employed as working staff with the maintenance of the roads after the roads have been restored. The only functioning way to transport items such as material and equipment are the barges and boats travelling the Kasai and Lukenie rivers and this would be the way to transport the items needed for the projects that can not be found in the rural areas. One ought to first restore the road Semendua – Kassai River to ensure a clear transport way to the Kasai River and open up the connections with Kinshasa and Bandundu. When this is done will it be much easier to transport items either using Kasai as a conveyance or the roads after passing the Kassai on the way against Bandundu and Kinshasa. The ferry over Kasai is though in quite bad shape and must be rehabilitated.

6.3.5 Big trucks deteriorating the roads

The existing roads are all one-lined; one lane for the vehicles travelling the road to share so when vehicles meet does one of them have to move out of the way to keep them from colliding. This is though not that dangerous for now since there are extremely few vehicles travelling the roads because most of them are impassable. The vehicles that still try to travel these deteriorated roads are often big trucks and they make the roads even worse and impassable for small jeeps. It is especially bad for the roads when the big trucks try to pass while it is raining or just after rains because the roads are very vulnerable just after rains. In the road project in Bas-Congo that I visited they had solved this problem by laying out road blocks just until 4 hours after a rain. A similar action could be implemented for a possible future project in Mai Ndombe to protect the roads.
6.4 Traffic safety

If one is to improve the state of the roads it is extremely important to broaden the roads and make measurements to enhance the traffic security. The drivers usually increase their speed much faster than its safe when the roads gets enhanced and restored. This is clearly seen on the road from Kinshasa – Matadi where people drives much faster than their supposed to just because the road now has been improved and this leads to many accidents. If the DRC is behind other countries when it comes to roads are they way behind when it comes to traffic safety. I myself was just two seconds from a sure death while travelling the road between Kinshasa – Kimpese when our chauffeur made a foolish overtaking. This issue must be considered when designing roads because it can save many lives if the roads are preformed with a good traffic safety.

I saw maybe one or two traffic lights in Congo during my visit, (both in Kinshasa) and there are very few traffic lights the whole Congo. They often use traffic polices to guide the traffic instead when this is needed. The laws and regulations concerning how to load and drive trucks and cars in the DRC are not at followed properly and the police usually just stop drivers when they can get money from them. I am not that familiar with the exact regulations that exist but if you look at the picture below are these regulations either not followed or allow you to load your vehicles pretty much as you like. These further complicate the process of designing bridges because it is very hard to know the magnitude of the stresses that can be applied unto the bridge.
6.5 Maintenance and transporting companies

The so-called “office du route” has the responsibility to maintain the roads but they have totally failed to do their job because they have not received salaries and therefore have been reluctant to work for the last three decades. I do not know exactly how much they have done for the roads over the years but the former missionaries that were active in the Mai Ndombe I have spoken to claims that all of the roads has been in more or less bad shape but usually passable with strong jeeps during the 70s, 80s and the early 90s. They have though deteriorated even more during the late 90s and 00s making many roads totally impassable, much because of the collapsed bridges.

Some kind of system existed before making the different villages responsible for the maintenance of small distances close to their village. This was though not that successful since many villages failed to fulfill their responsibilities much because they received none or very little salaries for the job. I have been thinking about this idea myself but I believe one have to give real salaries to the people that are supposed to maintain the roads otherwise they will not fulfill their responsibilities. They rather work in the fields getting food to themselves, which I totally understand. If they would fix up their roads working for free they could though improve their situation themselves enabling transports to reach their villages and then sell their crops. I do though believe that they would get tired of always maintaining the roads which deteriorate very fast for no salaries. It is also not sure that the transports will reach their villages even if they would fix up and maintain the roads.

6.5.1 Transporting companies

The transport companies that for now can reach the villages to buy their crops always pay the farmers very little money for their crops, giving a very small profit for the rural population. It would be best if the transports could be secured by an organization not working only for getting a good profit. This organisation could visit the villages, buy the crops for an okay price and then transport it to Kinshasa and sell it there. It is also extremely hard for the villagers themselves to transport the crops to the river or another place where they could sell it themselves because almost none of them have access to vehicles or money for gasoline for the vehicles.

6.5.2 Long term thinking

Continuous maintenance must also be ensured to secure a sustainable development process in the region. To restore infrastructure without having any clear plan on ensuring maintenance of the roads afterwards is just futile and not at all thought through according to me. These are classic mistakes made by many benefit organisations on many different areas. They have implemented grand projects and have then lacked proper plans on have to ensure funding in the future for things as spare parts, maintenance and also personnel that has the knowledge to perform the maintenance when needed. The fruits of the projects are then just left rotting and big projects are just done in vain only creating fear in the benefit organization of making the same mistake twice. Instead of trying again they just stop giving benefit to similar projects and claim that this is a project for the state. To rely on the dysfunctional state to fix the situation is very naive. To only give funding for other short-term projects and not to projects that if implemented could boost the development in a region in long-term is not the way to go if the organizations are looking for sustainable development in the long term.
7 A project proposal

7.1 A Proposal for improving the situation for the rural population in the Mai Ndombe region

It is unfortunate that I lacked the resources to perform a more complete study of the area covered by the CEBU administration. I had though the opportunity to overlook the situation and this got me some ideas of the incitements required to improve the quality of life for the population in the rural areas of the DRC. The collapsed infrastructure is according to me and the people I met in the inland the major constraint for improving the quality of life and enhancing the low level of income for the average Congolese in this area. There are also no functioning structures enabling the rural population to transport and sell their products and they often receive bad payment for their crops. I have here two essential proposals that could be implemented for enhancing the situation for the rural population in Mai Ndombe.

1. Serviceable roads that would at least make it possible to ensure transport from the villages out to the big rivers Kassai or Lukenie. These roads must be maintained on a regular basis to keep them from deteriorating. Some kind of system or organization must be created that can generate enough money required to maintain the roads and bridges in the long term.

2. A serviceable transport system that makes it possible for the rural population to sell their products in their own villages to the potential buyers. Jeeps or trucks that come to their villages and buys their products for fair, good prizes on a regular basis and thereby.

7.1.1 An organization working as a substitute for the state

The biggest reason for this difficult situation in these rural areas of DRC is in fact the absence of a functioning state. The solution must then according to me be to implement an organisation working as a substitute for the state, performing at least one of the essential tasks of the state: Ensuring the development of a good economy for its inhabitants by upholding a functioning infrastructure that can inspire the economy. The proposed organization should of course not be responsible to fulfil all the responsibilities of the state. It would only be responsible for restoring and maintaining the essential roads and bridges. To believe that one can help people from poverty in an area that lacks passable roads is very naïve according to me.

One big problem is that the proposed substitute for the state lacks the income that the state receives which is required for ensuring a continuous maintenance and ongoing work for the region. Another problem is to solve the logistic difficulties involved in ensuring places where the farmers can interact with the potential buyer of their products. Both these problems could be solved in the implementation of one idea. The proposed organization could resolve the logistic problems mentioned with acting as both buyer and transporters of products from Mai Ndombe to Kinshasa. The organization would be responsible for sending jeeps or trucks to each village on a regular basis and buying the products themselves for reasonable prizes, relieving the rural population of the burden of transporting the products to the potential buyers and also generating resources for the organization. All the profit from these businesses could be invested into maintaining the restored roads and opening up more closed areas with rehabilitating more roads in the Mai Ndombe. The organization could also transport and sell other items from Kinshasa that the farmers needs but is hard to find in the rural areas. The maintaining of the roads would employ the population in the villages giving them jobs and money and thereby stimulating the economy even more.
It is also needed to improve the quality of the old cultivation in these areas since this often is quite obsolete and this would further enhance the earnings of cultivation. It would be preferably to also include this in a possible development project in the region. Another thing that is important is to try to draw new companies and investors to the region that can give jobs to the people not working with agriculture. New farms and plantations could be started by the organization working as a substitute to the state to bring more earnings to the work of maintain the restored roads and rehabilitating new roads. An investigation should be implemented to examine what crops that could be cultivated in the region that could be soled to Kinshasa or abroad. The opportunities exist in the region for companies, (given that at least some of the infrastructure would be restored), the thing that is needed is the funds required to start new plantations and big farming companies.

7.2 Present connections between Mai Ndombe and Kinshasa

Almost all the transports to Kinshasa are now going on the big rivers. There are also aeroplanes that travel to Mai Ndombe but very few locals can afford to go by aeroplane so they are forced to go by the rivers. Very many people can not even afford to go with the big barges and have to stay in the inland. The fast ferry, used by the people that have a little more money, takes about three days from Kinshasa to the Mai Ndombe. There are no places for sleeping on these barges so you have to sit and sleep or not sleep at all for three days. There is also the choice on travelling with the slower barges if you do not have a lot of money. The slower barges takes from ten days to two weeks, and the people are just forced to sit, stand up or lie down along with a hundred more passengers on the huge heap of manioc sacs and share the two toilets with the other hundred or sometimes two hundred passengers. There is no roof over them so they have to have some kind of protection from the rains or just let the rains fall over them.

The conditions for “public transport” from this area to Kinshasa are really awful and it is essential to ensure the possibility of going by cars or trucks to Kinshasa all the way to improve the quality of the public transports. It is only around 530 km to Kinshasa from Semendua using the roads and this trip could be made in two days if they could travel with a speed of 25 km/h but the roads are for now in such a bad condition that unusually takes more than three days. A trip from Kasai to Kinshasa would surely take from three days to a week depending on the season and vehicle. My recommendation is that the ferry over Kassai would be replaced with a another, bigger ferry allowing big trucks to cross Kassai and also the implementation of a public transport line going from a couple of the bigger villages via Semendua to Kinshasa each week.

7.3 The transports from Mai Ndombe to Kinshasa using the big rivers

In order to meet the needs from the rural population for transporting their agricultural products to Kinshasa should the river transports be used as a primary transport route. The agricultural products will be bought at each village and then transported to the big rivers Kassai and Lukenie for further transports. One big barge would take most of the agricultural products from the area closer to the Kassai and then travel to Kinshasa once a month. This trip will take a maximum of ten days. It then stays some days in Kinshasa collecting the goods needed in the rural areas and then goes back to Mai Ndombe. One similar barge is needed on the Lukenie River as well transporting goods from the area closer to the Lukenie River. The schedule would be the same for both barges going to Kinshasa and back to the Mai Ndombe once a month.
7.3.1 An additional transport route using trucks to link Mai Ndombe with Kinshasa

It is really extraordinary that a country can lack proper road infrastructure in the extent that Congo does today. The country depends extremely much on the big rivers for transports. I do though believe that one should try aiming at connecting Mai Ndombe with Kinshasa not only with the river transport but also with trucks going from the Mai Ndombe to Kinshasa and back. The distance between Bandundu and Kinshasa is passable according to what I heard from the chauffeurs I talked to, although it is in very bad shape. If the road would get restored all the way to Bandundu and the rehabilitating in progress of the National roads are continued as planned could it take less than two days to travel from Semendua to Kinshasa (540 km). It now often takes more than the double to perform this trip, if it is possible at all. One truck would, according to my plan travel from the Mai Ndombe-region to Kinshasa every other Monday, reaching Kinshasa at latest Tuesday evening and staying one day in Kinshasa for collecting goods. The truck then returns back for Mai Ndombe on Thursday. The truck is then maintained and maybe used for other purposes until it returns for Kinshasa one week after its return. It could then at least travel to Kinshasa every other week if the roads between Bandundu and Kinshasa are properly restored. This would be very good for the Mai Ndombe area and would create even better and stronger connections with the big cities in the DRC.

7.3.2 Issues and problems affecting the transports

It is though probably a bit more expensive to travel the roads than the rivers because the big barges can carry a very heavy load compared to the trucks. One thing that complicates things even more in foreseeing the profit that could be made for the organizations for both using trucks and big barges is that there are many places along the way both on the roads as well as the rivers that demand money for letting the travellers pass. Like some kind of road fee. This money does though probably just goes into the hand of some doubtful persons and not at all to the people fixing the roads or clearing the river. There are also other additional problems to using the river as a transport route. The level of the river is at some spots during the dry period so low that the big barges can get stuck. It is because of this also very important to find experienced people that can manage and steer the ships to keep this from happening.

7.4 A summary of the content for the proposed project

A possible, future project will not be an immense infrastructure project but a smaller development project costing around one million dollars that will have an object of creating the following features:

- The restoration of around 400 km of roads with included bridges
- The creation of an organization, working together with the rural population and the local communities CEBU and CEBM, maintaining the roads and helping the people to sell and transport their crops to Kinshasa.
- A modernization of the cultivation in the region and thereby enhancing the production level for the rural population.
- The creation of plantations and farms that can give people jobs and bring more money for maintaining the infrastructure and opening up new areas.
8 The restoration of the roads and bridges

The proposed development project includes 40% part of an actual restoration of essential infrastructure. Restoration of infrastructure is though normally very expensive so it is very important to keep the expenditures low. It is also important to remember the objective of the restoration, which is to open up rural areas to the economy. To construct big, beautiful roads is and must be a task for the state. If an organization responsible for the maintenance could be created will they restore the roads a couple of times a year which leads to that some expensive measures for long serviceability could be ignored. The money that the organization earns from the transporting part and the plantations will then be invested in restoring more roads and bridges and thereby opening up more isolated areas.

8.1 Funding and the big needs for the construction of new bridges

One thing that complicates the project a great deal is that there are so many roads and bridges that need to be rehabilitated and restored in the Mai Ndombe. I had the opportunity to examine almost 30 bridges and 350 km of roads that were in extremely bad shape. I also paid a chauffeur to measure and examine an additional 190 km that includes one major bridge. There are also surely over 2 000 km more of roads and over 100 more bridges in need of restoration just in the part of the Mai Ndombe region covered by the CEBU. To only choose to project a couple of the bridges and roads out of this broad selection is very hard. The most important aspect to be considered when choosing a certain bridge or road is of course the affect it would have on the socio-economical climate if this particular road or bridge were restored. The bridges or roads giving the largest socio-economical affect on the region if constructed should of course be the ones to be designed and constructed.

There are also the dilemma of using the quality of enhancements to be done on the bridges and roads in need of rehabilitation. Big funding is required to restore all the roads and bridges that are in need of restoration. But the object is though not of course to restore all the roads and bridges in the region but to improve the quality of life for the rural population, but this includes improving some collapsed infrastructure. Of course it would be best if funding could be given to restore all the roads in the region into big, nice looking roads but this would cost to much, surely over 100 million dollars, but I think it would be very hard to receive this amount of money. To launch grand, expensive road project for over 5 million dollar is though according to me a job for the state with help from big organizations like the World Bank and the European Union.

Smaller, development projects for less than 5 million dollars are though projects that could be implemented by smaller benefit organizations together with local NGOs. The rural areas of Congo will also not be prioritised by the Congolese state until they had restored the bigger important roads connecting to the bigger cities and especially those linking to areas with many natural resources. The Mai Ndombe region does sadly fit in to this description of un-prioritized areas. I am convinced, and many other authorities that have knowledge of the situation in the DRC and Mai Ndombe, that it will take many years, maybe over a decade or more, until the state will restore the infrastructure in this region. One big decision has though to be made concerning the quality of the restored infrastructure for the proposed development project of one million dollars that easily can be explained like this:

1. 200 kilometres of road restored with excellent quality
2. 400 kilometres restored with good quality
3. 600 kilometres restored with ok quality
8.1.1 The costs for the restoration of infrastructure

It is really hard to estimate the cost of restoring roads in the DRC and also to choose the quality of the roads. I do though have access to figures from a preformed project estimating the prize per kilometres taken from a project proposal made by CEC for the proroutes projects in Bas-Congo, sponsored by SIDA, among others. They performed excellent roads with trenches, a particular rake for the road, drainage stations almost every kilometre and bridges made of concrete. This rehabilitation did though cost around 17 500 dollars/ km. If 40 % of the 1 million dollars for a possible development project would go to the rehabilitation of the infrastructure would it only be enough for the road Semendua – Kassai. To construct a road with this quality is not the way to go for this possible project since it is not only an infrastructure project but a project which object is to open up isolated regions that for now are excluded from the economy. I believe that either number 2 or possibly number 3 is the option to choose for the proposed project.

8.2 The method of HIMO

When implementing projects in areas with a collapsed economic system one has to take this in consideration and try to use the project itself to improve the economical situation by using the population and local material as much as possible. One method that takes this is consideration is the method called HIMO used on the Proroutes project launched by the CEC in the Bas-Congo region. This method uses much working staff instead of big machines and thereby giving jobs and money to the local rural population. I consulted the engineers that had worked according to this method and they gave me advice and also some documents explaining how to implement projects using this method. These documents included a complete guide how to implement road projects in the DRC using this method, explaining how to administrate the project, technical annexes explaining how to perform the roads, how many people that are to be used and much, much more. The method HIMO would be perfect for a road projects in the Mai Ndombe region providing an economical boost to the population and improving the infrastructure that will enable the rural population to transport and sell their agricultural products. The outcome of using HIMO is a 4 m broad road with trenches on both sides with a proper stable soil as material for the road.

Figure 8.1: The working method HIMO in action
8.3 The roads examined

The roads that I had the chance of examining are the following:

- Semendua – the river Kasai (32 km), road 251
- The river Kasai – Camp Mpoko (25 km), road 251
- Semendua - Bosobe, (the long way, 120 km), road 264
- 18 km on the road Bosobe – Oshwe, road 264
- 45 km on the road Bosobe – Bokoro, (just until the village Semobili), feeder roads
- 60 km of the shorter road Bosobe – Semendua, feeder roads
- Semendua – Seko – Camp Mpoko (50 km)

Figure 8.2: Another map drawn up by me, using an old map from 1971 and a map that I had a local draw up for me in Bosobe. The green line shows the roads I examined during my visit in the region.
8.3.1 Additional roads

The last 65 km of the way from Bosobe to Oshwe road was impassable and I could not carry on because there were a couple of bridges that had totally collapsed (they were non-existing one might say). The additional 65 km on the road to Oshwe were though in better shape because a company working with Lumber (Wenge) had fixed the road that were essential to them for transporting their lumber. I had also planned on going to Mimia and Ipope to examine some bridges and roads there but I lacked resources to continue the 250 km by motorcycle or going the distance with aeroplane. The aeroplanes just go to this area a couple of times a month and it is not even sure there are available seats on the planes. I did though pay a chauffeur that was going this way to examine and take pictures of the bridges.

8.3.2 Important unexamined roads

The important roads that I lacked resources to examine are the following:

Semendua – Bokoro (64 km)
Semendua – Tolo (70 km)
Semendua – Konkeia – Isaka – Nioki (110 km)
Semendua – Bendela (100 km)
The last 65 km on the road Bosobe – Oshwe
Oshwe – Lokolama – Mimia (190 km)
Mimia – Ipope (50 km)
Semendua – Inongo (this road is not even drawn up but it would be very good for the region if implemented. It stretches around 300 km.)

These roads are all basically in the same shape as the roads I examined, all according to the people I have talked to concerning the state of the road network in this region.

8.4 The bridges in the Mai Ndombe region

Most of the bridges in the Mai Ndombe region are made of wood and they often just consists of some wood logs laid over the stream to make it passable for pedestrians, bicycles and motorcycles. I have also seen some bridges made of steel parts taken from old trucks. Most bridges lack proper foundations and the logs are just lain over some gathered stones. I did though see some good-looking foundations made of concrete but the concrete are though often not as strong as it should be because it is common to use less cement in the concrete mixes than usual. This is because cement is much more expensive than the other material used for concrete and the builders often want to save money by using less cement in the concrete. I also found old deteriorated concrete foundations constructed by the Belgians over 50 years ago on the road between Bosobe and Oshwe and it is really hard to know the condition of these obsolete foundations. The bridges are big keys in the improvement of the infrastructure in this area and they are a huge constraint to the utilization of the deteriorated roads making many roads totally impassable, even for big trucks.
8.4.1 The planning of bridges and roads in the Mai Ndombe region

One thing that had a great impact on the planning of the bridges for me was the fact that I lacked resources to conduct a more thorough survey on the road network and the bridges in particular. The quality as well as the magnitude of the whole survey was constrained by the lack of resources as well as the fact that the infrastructure had collapsed itself. The collapsed roads and bridges that I examined became a hinder themselves because it limited the way of transport to using mostly motorcycles, bicycles or to go by foot. I used a jeep for one of my journeys but it took even more time than it would have taken with motorcycles. All the travels to the Mai Ndombe and in Mai Ndombe did cost around 1 000 dollars just for transports so the resources I had diminished very fast.

A project containing several hundred of kilometres of roads as well as around thirty bridges could of course not be planned in detail within the frames of my theses. A possible future infrastructure/development project will of course cover an area bigger than the area I had the chance to examine but I did though have the chance of examining some of the most important roads and bridges in the area. The following chapter includes calculated dimensions for 15 spans between 3 and 6.5 meters for a certain vehicle loads, several proposals on how to perform all bridges examined and finally a calculated cost for the performance of each road and bridge examined.
9 The planning of the bridges

It is really quite complex and difficult to design bridges in areas with a collapsed infrastructure and wretched socio–economical climate. To perform a study with only equipment at hand for the examinations that can be fit on a motorcycle and can cost a maximum of 5 000 SEK to purchase was indeed a real challenge for me. Since the communications in the inland of the DRC are almost non-existent with no internet or phones was it very hard to contact my supervisor in Sweden for guidance. The help that I could receive from my supervisor in the DRC was also very limited and he could not give me any significant help on the way. I have though succeeded to plan all bridges that I examined with a quite good accuracy and I have tried after best ability to take all important factors in consideration. All important factors are given and explained in this chapter as well as the actual calculations giving the dimensions of the bridges.

9.1 Standardizations

The state institutions in the DRC are at the moment not functioning properly and it often takes a lot of work and surely some bribes to receive the information that one require. The documents that I needed for my calculations were the Congolese standard for bridges, roads and building materials. These documents are though no doubt available only in French and my French vocabulary in technical French terms is unfortunately very limited. These together with that the Congolese standards are obsolete and not totally accurate or updated lead me to choose not to work so much with these standards and procedures.

The literature on tree bridges is not substantial since wood is not so frequently used as material for bridges nowadays. I did though find a reference to a couple of books on timber bridges written by Michael A. Ritter for the USDA Forest Service in a report on some tree bridges made by the Swedish company “Svenska Träbroar AB”. These books helped me a bit with some elements in the planning of the bridges. The books did though apply American standards for the calculations on wood as well as for the bridges and this made it a bit harder. The reports from STAB did instead use Swedish standards in their calculations. To add even more complexity to the problem did the course on non-heavy building materials (Light-weight structures) such as wood apply Eurocode 5 as standards while the courses on bridges I have taken adopted the Swedish standards. All these different procedures made it quite hard decide on how to perform my calculations, especially since all the procedures differs from the DRC when it comes to Climate and standard loads. It was also quite difficult to find the mechanical properties for the material and how to adopt these in my calculations. The building mechanics are though of course the same for all standards and models so the difference is not that big.

9.1.1 Choosing design models

I now had to adopt a model that could be applied for calculating simple, serviceable bridges in the rural areas of the DRC. I also had to gather information on the proposed material and the maximum load that could be applied to the structure as well as considering all other important factors that are important for the performance of the bridges. The first thing that had to be made clear was the main objectives of the performance of the bridges. As discussed before is it important to keep the expenditures low to make it possible to rehabilitate as much roads as possible and to thereby open up more areas to the regional and national economy.

The main objective is to perform cheap, serviceable bridges that are easy to repair without complex spare parts that are hard to get a hold of. The maintenance should be so easy to perform that it could be done by the rural population without an extensive guidance from engineers. The structure should
also be performed with a minimum of sawing because there are very few sawmills in the region that are functioning. The transport to the potential sawmills are also expensive and are very troublesome due to the state of the road network in the region. All this conditions points at performing the bridges with the objectives below:

- Simplicity.
- Avoiding excessive working with the material (a minimum of sawing).
- Functionality.
- A low cost.
- Generating the largest proportion as possible of the cost for the construction of the bridges to the rural population in the nearby villages. (In other terms, use people instead of machines and local material instead of material that has to be taken from Kinshasa or other regions.)
- Long and secure serviceability for the bridges, at least fifteen years for the bridges itself and more than thirty years for the foundations.

**9.2 Bridge structure chosen**

All main objectives for the bridges mentioned above made me choose a very simple bridge structure that will match up to the requirements set for the bridges. The structure chosen is a simple structure consisting of a series of longitudinal timber beams supporting a transverse timber deck of plank.

*Figure 9.1: A section of the Bridge structure*
9.3 Model for loads

At first I started to calculate the loads applied to the structure according to the Congolese standards that I got from an old bridge calculation for a bridge constructed in the DRC in 2001. These were calculations made by engineers from CEC for a four meter concrete bridge written in technical French. The calculations could though not give me adequate information on the loads applied according to Congolese standards. The methods they used were from standardizations preformed in 1966 and I could not relay fully on these obsolete methods. I then decided to apply two calculation methods to be sure on my calculations. One method using simple building mechanics and one using table that gave me the deflection, maximum bending moment and reaction force for a certain load applied on different spans from 3 m to the maximum span chosen, 6.5 m. (See chapter on the calculations.)

9.3.1 Overloads

One important factor that had to be considered when choosing a model for the loads was to implement some kind of security factor that will take the possible overloads into account. The chauffeurs travelling the roads in Congo does not respect the boundaries set by the bridge constructer and the Congolese state and this has to be taken into consideration. The chauffeurs usually does not have knowledge of the loads they are carrying and normally just drive and hope for the best if the bridge seems stabile. Another thing that further adds to the danger of overloads in this area is that there is a company working in the here around Oshwe that works with wenge tree that maybe will try to choose the roads for transports if they will be restored and the roads must then be dimensioned for the possible overloads caused by these large trucks carrying wenge tree.

The Congolese standards do permit a maximum vehicle load of 32 tons total for a big truck divided into three axels and the chosen load model must at least match up to these standards. I checked how the safety factors for Eurocode 5 and BRK are implemented in the calculations as well the size of the factors used and also how big the possible overloads for the worst scenario will be to have something to compare with. I then calculated three different scenarios to see how big the vehicle loads would be for each one.

1. A big jeep loaded with fifteen men weighing 80 kg each, carrying 40 kg baggage each along with other goods weighing 2000 kg.

   This calculated total vehicle load is calculated to be around 6 000 kg, divided unto two axle loads.

2. A big truck loaded with manioc sacks and 15 men weighing 80 kg sitting on top of the sacs with 30 kg baggage each plus the driver with 2 companions weighing 80 kg each together with 30 kg baggage.

   This calculated total vehicle load is calculated to be around 25 000 kg. A load standard of at least 25 tons should be applied here. This is divided into three axles, 10 % on the front axel, 45 % on the middle axel and 45 % on the last axel.

3. Another big truck loaded with heavy wenge timber taking on the same amount of men as the truck above.

   This calculated total vehicle load is calculated to be around 36 000 kg. A load standard of at least 36 tons should be applied here. This is divided into three axles, 10 % on the front axel, 45 % on the middle axel and 45 % on the last axel.
9.3.2 Vehicle loads according to American standards

The table giving the bending moment, reaction force and data needed for the deflection calculations found in Ritter 2 were a big asset for me and I used these as a model for the load applied to the bridge. I also found a very good vehicle load according to American standards that were quite similar to the Congolese standards that I decided to choose as the vehicle load for the proposed bridges. This load is given as below:

Vehicle load HS 20 – 44 according to American standards.

8 000 pounds (3.6 tons) – 4.3 m – 32 000 pounds (14.5 tons) – 4.3 m – 32 000 pounds (14.5 tons)
A total of 32.6 tons.

9.3.3 The chosen safety factor for the overloads

The safety factor I have chosen for the loads will match up to the highest overload possible according to my rough estimations for a possible worst case scenario, the 36 ton load total. This factor will be implemented for all mechanical properties to ensure the safety of the bridge for the worst case scenario. The security factor for the overloads is chosen to be 0.9 which is enough to cover the overload.

9.3.4 Safety factor for the consequences of a collapse of the structure

The consequences of a possible collapse of the structure are for these bridges very serious, much because the trucks always are heavily loaded with goods as well as people. I have heard of several accidents that have taken place in the DRC caused by bridges that had collapsed and all resulted in many casualties. The bridges that I have chosen to design are although not that big and the streams are also quite small but the traffic safety for the passengers sitting on top of the big trucks is non-existent and they could get crushed under the big truck if it would overturn in case of a collapse of the bridge. The safety factor for the consequences of a possible collapse of the structure is chosen to be 0.85 that is just a little over the security factor 0.83 according to the Swedish standard given for very serious consequences of a possible collapse of a structure.
9.3.5 How the load is divided unto the beams

The total load of a truck is of course divided unto the beams in a certain manner. Each axle load is first divided into two wheel loads and the wheel load is then divided unto the beams. The wheel loads can not just be computed to be divided unto half of the number of beams used for the structure because it depends very much on several factors. The size of the truck, where the truck is situated on the bridge, how wide the bridge is and how the deck distributes the loads unto the beams. The loads are not equally distributed to each beam and some kind of estimation has to be made. I made a first estimation by looking at an estimation method from Ritter 1 7-8. I used this method to get a good estimation and then raised the value gotten from Ritter a bit to be on the safe side. The load from the bridge itself is though equally distributed on each beam.

9.4 Material chosen

Several factors were considered when I chose the material for the bridges. Two of the most important factors that affected this choice was to keep the expenditures low and aim at generating as much of the cost for the bridge construction as possible to the rural population. The best choice according to these factors was to use a local, cheap material. Another factor that also convinced me in my choice of material was to avoid problems with transports. The material I chose for the bridge construction was wood, preferably the strong wenge tree that grows near the proposed bridges.

The life expectancy of wood bridges differs very much depending on the surrounding environment and the protection of the trees against insects, water, and so on. I have though aimed at calculating bridges that can have a life expectancy of at least fifteen years. After this could some of the wood be replaced with new beams and some new planks for the deck. It is though extremely hard to foresee the service life for the bridges but I believe that the bridges can manage at least fifteen years without having to replace the major parts of the construction. It is though not difficult neither expensive to maintain the bridges or to build a new wood bridge just using the drawings of the old bridge. I have done some calculations comparing the total cost of building a bridge of wenge tree with a bridge made of concrete. According to my rough estimations would it cost around 2 500 dollars to make a ten meter long bridge made of wenge tree and at least 80 % of the costs would be generated to local communities. According to the calculations made by CEC on their concrete bridges constructed in Bas-Congo it would cost 35 000 dollars to make this ten meter long bridge and possibly 40 % of these costs would return to the rural population.

The life expectancy of the concrete bridges in this area is though surely much longer, maybe 20 to 60 years compared to 15 to 40 years for wood bridges. The object of the project is though to ensure sustainable development in the region using the benefit given to open up as many isolated rural areas as possible to the national and regional economy and not to create big, nice-looking, expensive roads and bridges.

The structure that I have chosen for the structure is quite simple but it will be easy to construct and it will have a quite long service life. Simple, serviceable and cheap constructions should be used for the bridges here. Nails, mountings, screws, etc with good quality are also hard to get a hold of so this is also a reason for keeping the structures simple. It must also be added that wenge tree is quite hard to work with and sawing, nailing and screwing is somewhat difficult which further explains my decision to keep the structures simple.
9.4.1 Material model chosen

It was indeed quite hard to get a hold of material on wenge. I tried to search for literature on wenge in the libraries but I was unable to find proper material and was then forced to search the internet for answers. I found several websites giving the material properties of wenge from actors that seemed professional and reliable and chose these as the sources of the facts used in my calculations. The mechanical properties found on wenge did though differ a bit from each other and I had to investigate the reliability of each source as well as which quality of the wood the mechanical properties were given for. I have here introduced a couple of safety factors for the mechanical properties to weigh up for abnormal wood, knots, and other variations in the wood that affects the mechanical properties.

Another factor that affects the strength of the wood is the moisture content and this factor also has to be considered with introducing a safety factor for this. Wenge is though very resistant to moisture and this does not affect the wood that much so the moisture content safety factor is not that big. I have according to all conditions affecting the wood as well as the moisture resistance of wenge chosen the moisture content factor to be 0.85 for the bending moment, compression and shear properties and 0.90 for the E-modulus used for the deflection criteria. The other safety factor taking into account the abnormalities of the wood that decreases its strength against fracture is chosen to be 0.8. The key properties of the wood are given below with all essential safety factors:

9.4.2 Material model with safety factors

\[ E_d = E_h \cdot k_{load} \cdot k_{moisture} \]

\[ (k_{load} = 0.9, k_{moisture} = 0.9) \]

\[ f_{m\_d} = f_{m\_k} \cdot k_{load} \cdot k_{risk} \cdot k_{moisture} \cdot k_{mat} \]

\[ (k_{load} = 0.9, k_{moisture} = 0.85, k_{risk} = 0.85, k_{mat} = 0.8) \]

\[ f_{c90\_d} = f_{c90\_k} \cdot k_{load} \cdot k_{risk} \cdot k_{moisture} \cdot k_{mat} \]

\[ (k_{load} = 0.9, k_{moisture} = 0.85, k_{risk} = 0.85, k_{mat} = 0.8) \]

\[ f_{v\_d} = f_{v\_k} \cdot k_{load} \cdot k_{risk} \cdot k_{moisture} \cdot k_{mat} \]

\[ (k_{load} = 0.9, k_{moisture} = 0.85, k_{risk} = 0.85, k_{mat} = 0.8) \]

![Figure 9.3: A plank of Wenge tree](image)
9.5 Wenge tree

I did find several different sources for the mechanical properties that I used in my calculations. The sources for Wenge tree is though very limited and I doubt that much work has been done for establishing exact values for the mechanical properties for this African, exotic hardwood. The botanical name for Wenge is Millettia Laurenti and it is very similar to the similar wood named Panga Panga (Millettia Stuhlmanni). The wenge tree can be found in parts of the rain forests in Cameroon, Gabon, Tanzania, Mozambique, The republic of Congo and the DRC. Timber from Wenge is produced regularly in small scale in the countries that has the resources and the possibility to produce it and it is exported only in very low volumes. The supply of Wenge tree on the global market is very limited, much because the problems with transports, its high price and lack of incites required for ensuring a proper production of timber. The sapwood is pale yellow or whitish in colour and the heart wood is dark brown, mostly black, with fine closely spaced dark veins and white lines. It is primarily used for architectural purposes and furniture pieces but also for parquet and strip flooring, joinery and general construction.

9.5.1 Durability, preservation and workability

Wenge dries quite slowly but without much distortion. The heartwood is extremely resistant to impregnation and also generally very durable and resistant to termite attack. The fact that it is highly resistant to the harmful effects of the weather makes it suitable for exterior applications, (such as bridges). The wood is very hard so sawing and machining is somewhat difficult and a quite rapid blunting of cutting edges occurs. It is also quite hard to nail and screw and some pre-boring can be required in some cases. (I do though have knowledge of that big nails smeared with oil has previously been used for a bridge some twenty years ago. This method can surely be used for these bridges as well.) The material does though respond quite well to hand tools. The material is also very difficult to glue and the varnishing properties are quite poor. The trees have a trunk diameter of 0.6 m to 1.2 m and attain a height of normally 15 to 25 meters.

9.5.2 The mechanical the properties for wenge tree

It was somewhat difficult to get a hold of reliable values for the mechanical properties since the material is not that widely used. I did though find several facts on wenge on the internet and I used these data for the calculations. I will present the data below and explain where I got it from and the general opinion found on the specific property. The most important property for the calculations was the E-modulus because the criterion that gave me the dimensions for the beams were the deflection, which depend highly on the E-modulus. For the deck was the leading criterion the shear strength. These two values, especially the E-modulus must be chosen very carefully and the value has to be reliable. I have though a quite margin for almost all criteria investigated.

9.5.3 The Bending strength

Wenge has a very high bending strength that varies with density but it is generally considered to be very high. I have taken this value from the research unit of Cirad, forestry department, situated in France. They gave the value of 144 MPa with a standard deviation of 43 MPa for wood with 12 % moisture content. The values I will adapt in my calculations will be values for wood with 12 % moisture content. This made me assume the bending strength capacity to 100 MPa. This value is surely on the safe side since I found other values much higher than this at other organizations such as 87 to 136 MPa depending on the moisture content that was found on the website for woodworkers’ source, a company that works together with the National Hardwood Lumber Association in the U.S.
9.5.4 The compression perpendicular to the grain

The strength qualities in compression perpendicular to grain are very high and the compression parallel to the grain is exceptional. I could unfortunately not find any exact value for the compression perpendicular to the grain anywhere, only compression parallel to the grain. I was then forced to adopt the value for the compression parallel to the grain and transform this into the compression perpendicular to the grain with a chosen factor. This factor describes the relationship between the perpendicular compression and the parallel compression for normal hardwoods.

I have chosen this by taken the highest value for this relationship for all hardwoods according to Eurocode 5. This factor was between 2.85 and 3.05 for hardwood D30, D35, D40, D50 and D60, and 2.5 for the sort that is the strongest hardwood (D70) and also the most similar wood compared to wenge. Since I am on a little unsafe ground here when assuming a property that is not affirmed by an organization or company did I choose a factor of 3.5 to be on the safe side.

The value found for parallel compression is 44 - 72 MPa depending on the quality of the wood for woodworker’s source, 71 MPa for wood with 12 % moisture content according to USDA and finally, 85 MPa with a standard deviation of 15 MPa for a wood with 12 % moisture content according to Cirad. A value of 70 MPa were chosen for the parallel compression and the perpendicular compression capacity is computed to be 20 MPa using the 3.5 factor.

9.5.5 The density

Wenge is a very heavy material and the density varies very much from the moisture content. The density for wood with a moisture content of 12% is reported to be around 870 kg/m³ with a standard deviation of 8 kg/m³ according to Cirad. The woodworkers’ source gave me maximum values of a little over 1000 kg/m³ while the USDA forest service claimed that the maximum density is 1000 kg/m³. Other sources gave maximum values slightly under 1000 kg/m³ for normal wet wood. All these data made me choose 950 kg/m³ as density for wenge and this value is given surely on the safe side and is also a value given for wood with a very high moisture level.

9.5.6 Shear strength

The shear strength was also hard to find and only I got this mechanical property from two sources. The woodworkers’ source gave it a shear stress capacity for 16.7 MPa for dry wood. The other source is from a supplier of wenge called the Simba wood flooring that sells flooring from exotic African hardwood. This company gave a value for the shear strength of 14.5 MPa. This made me choose a value of 14.5 MPa for the shear strength to be on the safe side. There are though no big risk for shear strength failure for the beams what so ever and the only risk is for the deck but it is safe even for a value of less than 7 MPa.

9.5.7 The E-modulus

This value was really quite hard to find and choose since the value varied very much depending on the source. It is also the by far most important value for the calculations so I had to choose a reliable value. Cirad claimed that the E-modulus was quite high compared to other sources, 21050 MPa with a standard deviation of 695 MPa, (12% moisture content). The woodworker’s source gave a value for 16.5 MPa for dry sample and 14.4 MPa for a green one. The USDA forest service value was 17.6 MPa and another source found on the website produced by the big lumber company Bamako that sells wenge gave a value for calculation of 17 MPa. All this sources made me choose a value of 17 MPa for
the E-modulus because this was a value used for actual calculation on Wenge tree by a supplier of Wenge. See analyze of the sources below.

**9.5.8 The sources reliability**

Since I did not have knowledge of some well known, acknowledged organization that is totally reliable as a source for the mechanical properties for exotic African hardwood was I forced to search extensively for reliable sources among books and the internet. It was very hard to find appropriate books for this information but I managed to find several quite reliable sources such as the research unit of Cirad that is the forestry department situated in France, the USDA forest service and the woodworker’s source. I also find several companies dealing with wenge tree that could give me reliable values such as Bamako and Simba flooring.

It is hard to foresee which value that is the one to use with all these different sources. The values also differed quite a bit with the moisture content and this also further added to the complexity of the issue. The value that is going to be used with the modification factor is though the value for wood with 12% moisture content so I have used these values as much as possible if they do not differ too much with the other sources that gave values for dry wood and green wood. At last must it be added that all criteria except the deflection for the beams were met on the safe side with the chosen properties and would also have been met with values at least 60% under the chosen properties.

**9.6 The dimensions available for the beams and the planks**

It is essential to create boundaries on how big dimensions for the beams and planks that are available for the superstructure since the dimensions for the wood is limited by the size of the trees. If the trees are big and high can the beams be made longer and higher. Wenge is a very big tree in size that can have a diameter of 0.6 to 1.2 m and attain a height from 15 to 25 m according to the sources that I found. I have according to the size of the tree chosen a dimension for the beams that is on the safe side according to me and the facts I have found from all sources. The beams can be constructed with a maximum dimension of 200*450 mm and a length of 7.5 m, (0.2*0.45*7.5 m). Big beams can though surely be made longer and higher than this but I have chosen this value to be on the safe side and to avoid searching hard for proper trees for the beams. If a tree with a maximum diameter of 0.8 m is found and the diameter decreases with two centimetres per meter will the trunk diameter be 0.65 m after 7.5 m. This is surely on the safe side for a beam with a dimension of 200*450 mm.

The tree planks only need to have a length of 3250 mm for the deck and the minimum dimension is chosen to be 70*150 mm and the maximum width for the 70 mm thick deck does not really have any boundaries but can vary from 150 mm up to what ever width that can be found. It is though easier with wide planks since the needed amount planks are reduced if the planks are wide. They do though have to be 3250 mm long.
10 How to construct the bridges

The material, bridge structure and dimensioned load are now chosen. Now comes the part of in more detail plan the bridges and finally perform them in reality. The process of constructing the bridges has to cope with several troublesome conditions and problems that have to be discussed and solved. Some choices also has to be made on which fastenings that are to be used and how big spans that can be used. I will though however first discuss how the foundations should be performed and then move on to the superstructure.

10.1 The foundation for the bridges

Thirty – five different soil samples were collected from twenty-five of the examined bridges. All samples were though shaken during my journey on the motorcycle and could not be examined properly because they have been steered and it was very difficult to get a good idea of how the soil will react with water using the steered samples. I did though examine all collected samples on site to get an approximate opinion of the state of the soil. If the soil seemed unsteady and weak did I move the proposed start of the bridge a meter from the place of the examined soil and preformed a new test. All tests were taken one meter down into the soil because the equipment that I have taken with me that could be used to take samples five meter down were heavily attacked by rust and could not be used for investigating the soil further down than one meter. I did instead of performing extensive tests on the soil use another method that I though am aware does not give exact answers. I do though believe that the method can be applied in reality if proper equipment are unavailable and still give the answers needed for the planning of the bridges. I was also forced to choose between spending surely a week or so in the lab examining the samples or spend these days writing on my report. I found it more important to work on the report to further outline the situation in the Mai Ndombe region than to perform these extensive tests and I believe this choice was surely the right one to make.

10.1.1 Method used for examining the soil

The method that I chose besides examining the soil on the spot was to ask the rural population on how much the streams and rivers floods during the rain period to get an opinion on were to put the abutments and pillars to get a bridge that covers the whole area affected and reached by the rivers. I have here chose to start the bridges and first abutments at the spots not affected and reached by the floods. To perform bridges in areas affected by such heavy rains and floods like Congo is in fact very difficult because the state of the soil varies very much during the year depending on rain and dry period. The big stresses subjected to the foundations made my chose to perform the bridges with big, steady foundations that will insure a long serviceability. It would be best to perform the abutments in concrete to ensure a long service life for the foundation and keep them from being washed away during the floods in the rain season. The abutments are much stronger and heavier than my other option to use abutments out of wood, and they will surely last for decades to come if performed properly.

10.1.2 Material availability for the abutments

The exact dimensions and design of the foundations does though highly depend on the availability of proper material as rocks and grovel needed for the concrete foundation as well as the different conditions for each bridge. I can not dimension all the abutments in detail in advance because I do not have all knowledge needed concerning material availability and the exact conditions for every bridge. I will though give proposals on how to perform the abutments generally for all bridges and
proposals in more detail for some of the most important bridges. The availability of material does highly depend on the vegetation and area. It is much easier to find material for the abutments and pillars for the bridges near the savannah but it is surely harder to get a hold of proper rocks and grovel for the bridges in the rainforests. The cement will have to be bought from Kinshasa and transported on the river as long as possible and then let the available vehicles transport it to the bridge. It will though surely be a hard work finding all the material needed for the foundations and one should avoid making abutments bigger than needed.

10.1.3 The settings of the abutments

Another thing that is hard to predict is the settings for the foundations. It is important to make big, strong foundations to keep this from happening. Another measure is to elevate the bridge at least 20 cm from the level of the water to keep the bridge from sinking into the water if the abutments would start to sink down. Some settings are though to be expected for the bridges to a small extend in the beginning and more after some years. I will though try to make the foundations big and strong to prevent from big settings as much as possible. Big pillars out of heavy wenge wood could also be implemented for areas were it is hard to find proper material for the foundations. This is though an option I object to since it will not be that stable in the future but it is a possible makeshift solution.

10.1.4 The placing of the bridge and foundations

One of the most important issues that have to be considered is to ensure good foundations for the bridges since these often are heavily attacked by rains and floods and are most likely to be washed away if they are not strong and steady. It was very hard to now where to start the bridges because the rivers and streams vary immensely and sometimes floods over ten meters on the side of the rivers during rain season. It is essential to avoid to build a small bridge that during the dry period covers the stream but during the rain period just becomes a dry section in the middle of the river. I tried to prevent this from happening by asking the rural population at every bridge how high the water level can raise during the rain period. I have here used two methods to keep this from happening. For bridges where the streams just floods calmly with just elevating the level of the stream without swiftly-flowing water attacking the road have I just decided to elevate the road before the bridge and start the bridge where the stream is stronger. (See the drawing for the Ngove stream.) For the streams that have swiftly – flowing water attacking the roads during the floods have I chosen to start the bridge from the place reached by the floods.

10.1.5 The area before and besides the bridge

It is of course best to construct the abutments high over ground level but there is much work involved in elevating the ground before the bridge to the level of the bridge and one should avoid to make the bridges very high. As an example is an elevation of the road before the bridge of seventy centimetres needed if the abutment is twenty centimetres over the ground level and the bridge itself is forty centimetres high counting both beams and deck. One shall though of course not risk that the abutments could be washed away or the water from reaching the beams and decreasing the strength of the beams with an abnormal moisture content level. The road before and after the bridge could be elevated with rocks on the bottom to ensure stability, strong bricks or concrete on top of that and tree planks at the top to get a smooth, good surface for the road. The tree planks do not have to have a good quality and is just needed to get stability and a good surface for the road before the bridge. The leftovers from the bridges could be used here. Another important measure is to make trenches on the sides of the foundations one or two meters from the abutments and pillars to receive a proper drainage and keep the erosion from damaging the foundation.
10.1.6 How to get a hold of the material for the abutments

Several actions could be performed before starting to construct the actual bridge to limit the time needed for the project because one day extra of building increases the cost of the bridge with at least 75 dollars. One problem is to get a hold of material for the abutments and to keep all the workers from being stuck at searching for proper material. To keep this from happening could it be announced in the nearby villages that proper rocks, grovel and sand is needed for the bridges and can be bought for maybe 50 Congolese francs (around one SEK) per filled wheelbarrow. If 100 wheelbarrows are needed for one abutment could the cost for the material for two abutments for a possible bridge stop at 25 dollars which is more than ok. There are not many suppliers of rocks, grovel and sand in this area and this could be the way to go to get a hold of material for the abutments in a fast manner and also generating money to the population. I am also quite sure that people would cooperate and work, although the salary is not that substantial because most of them lack day jobs other than working in the field. The unemployment rate is extremely high in this region and most jobs do in fact give less money than this job would. The material could be collected in the villages and then transported out to the job site when the foundations will be casted.

10.1.7 The casting of the foundation

One hard part of constructing the bridges is to cast and perform the foundations. Big, secure forms have to be constructed for the casting of the concrete abutments. These abutments could be constructed in advance out of wood planks. At least two forms have to be created, one for the bottom plate and one for the actual abutments. It is though best if four forms could be constructed, two for each abutment so that they could be casted on the same day and thereby limiting the labour cost. An additional protection from the stream is also probably needed to keep the water from damaging the foundation during the casting of the foundation. This could be done with either leading the stream from the foundation or building some fence that could be set to protect the foundation. All this measures does highly depend of the size of the stream and cannot be foreseen for every bridge examined. A device for sucking out any water that could poor into the forms should also be bought and used if needed.

The concrete should be prepared on the work site with all material that has been transported there such as rocks, grovel, sand, cement and water. One or several big tubs has to be either constructed out of tree planks, old steel parts from an old truck or bought if big tubs can be found and bought in this region which I really doubt. It is though probably cheapest to construct big tubs out of tree planks so I recommend using this option. The concrete should be prepared using shovels or other proper equipment.

10.1.8 The size of the foundations

The foundations should be performed at least one and a half meters down into the ground and preferably reach under the deepest level of the stream if possible and preferably one meter further down under the deepest level of the stream if performed in the middle of the river. A device for sucking water is required here to help to remove the water if it penetrates under the form or in possible cracks in the actual form. The soils samples I collected did though not contain that much water but was indeed stable and string, although taken just one meter under ground level. I recommend to first taking an additional test for checking the soil one or two meters down into the ground level on the spot that is chosen to be the place to start the bridge. If the soil seems steady without any water that can be seen from the bear eye could the bridge be started with digging for the first abutment. The form for the abutment should be sent down further down into the soil along with level of the digging to keep water from entering the form. For abutments in the water should the
forms be put down into stream and the water sucked out and the digging could be started when the water needed to be removed to make it possible to dig has been sucked out. The digging will then continue down until the earth seems stabile. When the earth seems stabile and the water has stopped to come in from the soil underneath can the foundation start. The level 40 cm close to the bottom should be made 20 cm wider on all four sides to make place for the bottom plate chosen to make the structure bigger to spread out the stresses on the soil caused by the heavy foundation and to thereby avoid settings. First should big rocks be laid down with a layer of around 20 cm and after that should a 20 cm plate of concrete be casted unto the layer of the rocks. After that can the whole abutment be casted unto the plate. The abutments should be performed to be between 10 and 40 cm above ground level depending on the level of the stream during rain period. It is not that good to let parts of bridge be under water during a couple of months every year although that Wenge is very persistent to water and moisture. Wenge dries out really slow and should not be subjected to water under long periods of time because it can be hard to get rid of the moisture that has been taken in while it was attacked by water and moisture. See example for the abutments below:

\[ \text{Figure 10.1: The dimensions for the abutments} \]

\[ \text{Figure 10.2: The dimensions for the abutments} \]

**10.2 The superstructure**
The superstructure is going to be as discussed before performed with plank deck supported by a six beams. The structure also has a simple rail fence on the sides to keep the bridge safer for pedestrians. The wenge tree needed for the superstructure is collected from the rainforest in the nearby area.

**10.2.1 Transporting and cutting the trees**

All streams examined are situated in smaller or bigger parts of the rainforests and the material availability of wenge tree varies very much from bridge to bridge. A direct examination of the nearby forest is required to get an exact view on the material availability for each bridge and since this has not been conducted in detail can the material availability not be exactly foreseen. It will surely be harder to find the trees needed for the bridges that are to be preformed for the streams situated in a small section of the rainforest and it is possibly required to search in the bigger section of the rainforests closer to Bosobe for proper wood for the beams. Even if the big trees could be found in a nearby villages is it very hard to transport them to site of the proposed bridge and a truck is surely needed for transporting the big, heavy wenge trees longer than 500 m.

It is also important to search for the trees close to some kind of road that can be used by the truck for transporting the logs. To move these big trees big by hand is extremely heavy work and it is thereby essential to limit the stretches that have to be made by foot due to the bad terrain in the heavy rain forest. The procedure for handling the trees should be according to below:

- Search for the big trees that are can produce the beams required for the bridge spans but also trees that can be used for the deck. (The leftover for the trees used to produce the beams should of course be used for the deck as well).

- When all trees required for producing the superstructure has been found are they sawn down with a big, strong motor saw. They are then sawn into the lengths needed for the beams as well as the deck while lying on the ground or possibly rolled to a place that makes is easier to saw up the trees.

- After this must the logs bee moved unto the truck where they are laid on the back of the truck with the help of a simple pulley, crane or something similar. The logs are although very heavy, weighing up to 4.5 tons for a 6 m long log with 1 m diameter. Big logs with a diameter over 5 dm that are to be used for the beams does surely needs to be sawn into a piece that is as small as possible to produce the beams using a motor saw in the forest.

- The big logs and sawn into pieces that can be transported to the truck by foot using two ropes for each man that are rapped under the logs and tied to a handle that can be used for carrying the logs to the truck using the whole group of twenty men to carry each log. This is a hard task to solve due to the immense weight of the logs but I am sure it can be solved. It is also possible to perform all the sawing with the portable saw mill in the actual forest and then move all planks and beams from this site to the site of the bridge. This is probably the way to go if the distance between the truck and the trees that is to be used for the superstructure is to long.

- All logs are to be pre-sawn by motor saws and then sawn more thoroughly and exactly by a portable saw mill to the planks and beams for the superstructure.
10.2.2 Putting the superstructure on place

When the trees have been sawn up to the beams required are they put in place on the abutments one at a time and screwed onto the bearing shoe. The deck is then nailed to the beams and finally are the planks protecting the superstructure from unwanted material from the abutment nailed unto the ends of the beams. The nails have to put on diagonally for this protection since there is a lack space needed for nailing on the sides of the beams.

10.3 The fastenings

The selection of fastenings to choose among is this area is very limited and this must be either bought in Kinshasa, some other place that sells this or manufactured by the craftsmen in the work shop in Semendua. This can of course not be done with the nails for the deck put possibly for the fastenings for the beams.

10.3.1 The fastenings for the beams

The fastenings for the beams should be made strong to resist the applied to the structure and also to protect from thieves that could steal the beams. The bearing shoe is a good proposal to ensure the serviceability of the structure. These fastenings are surely expensive and hard to get a hold of in this region and they can possible be produced in the work shop in Semendua using pieces of old trucks. If the required pieces could be found some where else for cheap price is that of course the best option. The thing required for this is two big bearing shoes and big attachment bolt. The bearing shoes should be casted on to the foundations when the foundations itself are casted if this is possible. The bearing shoes and bolts can possibly also be welded when they are screwed on place to keep the beams to be stolen by thieves.
10.3.2 The fastenings for the deck

The best, cheapest and easiest fastenings that could be used for the deck is big nails that are between 10 and 20 mm long. The wenge tree is quite hard to work with so it is essential to choose some kind of oil to put on the nails to lower the friction and make it possible to get the nails into the tree. This has been done very successfully with another bridge made of wenge some twenty years ago so I am very sure that it will work now as well. Four or six nails per plank of 20 cm and beam should be used to make the structure secure. This will add up to $6 \times 6 \times 5 = 180$ nails per meter Bridge. This turns into a significant cost for the bridge so it is important to try to find big, cheap, serviceable nails.

10.4 Lateral supports for the beams

Lateral supports are required for the high beams to keep them stable and not reduce the bending moment capacity. I have examined the bridges concerning lateral instability for all spans and added lateral supports if needed. I here applied a calculation method described in Ritter 1. There where though not that big risk for lateral instability for most beams, only the beams over 5.5 m long had to have one lateral support. The lateral supports will be cross frames that are put between the beams with a certain distance decided by the calculation. See figure below.
• **C<sub>l</sub>**  The lateral stability of beams factor

The lateral stability is checked by the factor Cs that is calculated according to below:

The slenderness factor Cs is given by

\[ C_s = \sqrt{\frac{l_e \cdot H_{\text{beam}}}{B_{\text{beam}}^2}} \]

The beams are divided into three different variants; small, intermediate and long beams.

They are divided according to this equation:

\[ 0 \leq C_s \leq 10 \text{ Short beams, } 10 \leq C_s \leq C_k \text{ Intermediate beams and, } C_k \leq C_s \leq 50 \text{ Long beams} \]

If Cs is under 10 is there no risk for lateral instability. The lateral supports for the bridges are the planks on each side of the beams that are also used as protection for the beams from material that can affect the superstructure in a bad manner. An additional lateral support is also needed for all bridges with a span over 5.5 m according to my calculations using the method from Ritter.

H<sub>beam</sub> is the height of the beam and B<sub>beam</sub> is the width of the beam.

\[ l_e = 1.84 \cdot l_u \text{ when } \frac{l_u}{H_{\text{beam}}} \geq 14.3 \text{ and } l_e = 1.63 \cdot l_u + 3 \cdot H_{\text{beam}} \text{ when } \frac{l_u}{H_{\text{beam}}} \leq 14.3 \]

l<sub>u</sub> is the distance between the lateral supports.
11 Calculations for the superstructure

The calculations for the superstructure are divided into two parts. One that treats all bridges examined in general, giving a proposal for each bridge with dimensions for the span, the entire superstructure and the foundation. Two bridges are treated more thoroughly with measures for the superstructure as well as the foundation. These two bridges are the bridges over the Ngove and Ywyna stream which are on the way to the River Kassai and are surely the most important bridges that I examined. I have also made some calculations for the beam deck according to a calculation model taken from Ritter 1.

11.1 Calculations for the beams

I started off by giving the initial dimensions for the beams and the deck and then calculated the height of the beam needed for the different spans according to all essential criteria. Only the equations and the results are presented in the actual rapport. The calculations for all bridges from 3 to 6.5 meters are also available if anyone would like to see these.

11.1.1 Criteria to be fulfilled by the beams

The bridge structures were dimensioned according to four different criteria for the beams and three criteria for the deck. The structure itself is very simple and consists of a series of longitudinal timber beams supporting a transverse timber deck of plank. The criteria that must be fulfilled are these four below.

- Bending moment (including lateral stability).
- Deflection.
- Horizontal Shear
- Bearing length and strength

When investigating the different criteria for the bridge did I soon came to the conclusion that the criterion that it is by far the most dangerous for the structure is the deflection criterion. This forced me into choosing much bigger beams than required for the bending moment. If one could ignore the deflection criteria could the beams had been made surely more then 5 cm lower than for the bending moment criteria. For the deck was the most dangerous criterion the shear capacity.

11.1.2 Bending moment

The bending moment stress is checked with this equation: \( f_{b,d} \geq S_b \)

The bending moment resistance stress is given by;

\[
f_{b,d} = f_{b,k} \cdot k_{load} \cdot k_{moisture} \cdot k_{risk} \cdot k_{mat}
\]
The applied bending moment stress is given by:

$$S_b = \frac{M_{\text{max, tot}}}{W_{\text{beam}}}$$

$M_{\text{max, tot}}$ is the total bending moment applied to each beam and it is calculated according to this equation;

$$M_{\text{max, tot}} = M_{\text{veh, max, DF}} + M_{\text{bridge, DF}}$$

$M_{\text{veh, max, DF}}$ is the maximum vehicle load distributed to each beam and is given by the formula below;

$$M_{\text{veh, max, DF}} = M_{\text{veh, max}} * DF_{\text{LL}}$$

$M_{\text{bridge, DF}}$ is the dead load from the structure that is divided to each beam and is given by this formula;

$$M_{\text{bridge, DF}} = M_{\text{bridge}} * DF_{\text{DL}}$$

### 11.1.3 Distribution factor

The vehicle load is distributed according to a distribution factor $DF$ that describes the part of the wheel load taken by one beam. The total axle load is first divided into a wheel load and the deck then distributes the load down to each beam. For my proposed superstructure that has six beams can tree beams maximum share the load of one wheel load. All three beams do not however work together in an optimal manner and the wheel load can not just be divided into three equal parts. I did found some information on this in Ritter 1 which I used as a control for my own calculations.

According to Ritter I, page 7-8 is the distribution factor defined with this formula;

$$DF = \frac{\text{Beam}\_\text{spacing}}{\alpha_{DF}}$$

$\alpha_{DF}$ is a coefficient taken from Ritter 1, table 7.2 and is for my calculations defined for a bridge designed for one traffic lane and a nominal deck thickness of 4 inches. It is in my case defined as 4.5 feet, which is 1.22 meters. Beam_spacing is the distance between the centres of the beams. For my superstructure did I receive a distribution factor of 0.40. I did though choose 0.45 as a distribution factor for my superstructure to be on the safe side.

The distribution factor for the dead load is 1/6 because it is divided equally to each beam.

The bending moment applied from the dead load is computed according to the formula below;

$$M_{\text{bridge, DL}} = \frac{((B_{\text{beam}} * H_{\text{beam}} * \gamma_{\text{ex, load}} + B * H_{\text{deck}}) * g * \rho_{\text{wenge}} * L_{\text{beam}}^2)}{8}$$

$\gamma_{\text{ex, load}}$ (1.25) is a factor that considers the extra dead load applied to the structure besides the deck and the beams.

$L_{\text{beam}}$ is the length of the beams.
I have decided to compute the maximum load from the vehicle load in two ways. Either by using

\[
M_{\text{veh, max}} = \frac{P_2 \cdot L_{\text{beam}}}{4}
\]


The bending resistance (\(W_{\text{beam}}\)) is calculated with this formula;

\[
W_{\text{beam}} = \frac{B_{\text{beam}} \cdot H_{\text{beam}}^2}{6}
\]


\subsection*{11.1.4 Deflection}

This must be fulfilled to avoid a deflection that is damageable for the beams;

\[
deflection \leq \frac{L_{\text{beam}}}{300},
\]

(This most common deflection criterion used for timber bridges is though L/360 but I have chosen

that L/300 is enough for these bridges since they are very seldom used by the big trucks they have

been dimensioned to handle. I have also implemented two security factors for the E-modulus so the
criterion is surely on the safe side.)

I have calculated the deflection according to two different methods. The first method is by using the
table from Ritter 2 and computing the deflection with the formula below.

\[
deflection = \frac{\text{def}_{\text{koeff, table}}}{E_d \cdot I_x}
\]

\(I_x\) is the moment of inertia for the beams and \(E_d\) is the E-modulus revised with all safety factors.

For the other method did I use the normal formula for maximum deflection that is given by the

following formula for at least spans up to 7 meters.

\[
deflection = \frac{P_2 \cdot L_{\text{beam}}^3}{48 \cdot E_d \cdot I_x}
\]

\subsection*{11.1.5 Horizontal shear}

The horizontal shear criterion is fulfilled according to this equation;

\[
S_v \leq f_{v, d}
\]

The shear stress capacity is given by;
$f_{v, d} = f_{v, k} * k_{load} * k_{moisture} * k_{risk} * k_{mat}$

The horizontal shear stress caused by the applied load is calculated with this formula;

$$S_v = \frac{1.5 * V_{shear, tot}}{A_{beam}}$$

The total shear force is given by;

$$V_{shear, tot} = V_{LL} + V_{DL}$$

The vertical shear force caused by the dead load is calculated as below;

$$V_{DL} = ((B_{beam} * H_{beam} * 6) + B * H_{deck}) * g * \rho_{wenge} * \gamma_{ex, load} * \left(\frac{L_{beam}}{2} - H_{beam}\right) * DF_{DL}$$

The vertical shear caused by the live load is calculated a bit different depending on the length of span. The equation for the distributed live-load vertical shear used to compute horizontal shear below is though the same for all spans.

$$V_{LL} = 0.5 * \left[\left(0.6 * V_{LU}\right) + V_{LD}\right]$$

The maximum vertical shear from the vehicle lines distributed laterally as specified for the bending moment is given by;

$$V_{LD} = V_{LU} * DF_{LL}$$

The maximal vertical shear from an undistributed wheel line is defined as below;

For a bridge span from 3 to (4.3 + Lmax_shear) meters:

$$V_{LU} = \frac{P_2 *(L_{beam} - L_{max, shear})}{L_{beam}}$$

For a bridge span from (4.3 + Lmax_shear) to 6.5 meters:

$$V_{LU} = \frac{P_2 *(L_{beam} - L_{max, shear}) + P_3 *(L_{beam} - L_{max, shear} - L_{p2, p3})}{L_{beam}}$$
11.1.6 Bearing length

The minimum bearing is calculated as below;

\[ L_{bearing} = \frac{R_{tot}}{B_{beam} \cdot f_{c90_d}} \]

The maximum total reaction force at the supports is given by;

\[ R_{tot} = R_{DL\_DF} + R_{LL\_DF}, \text{ where } R_{LL\_DF} = R_{LL} \cdot DF_{LL} \text{ and } R_{DL\_DF} = R_{DL} \cdot DF_{DL} \]

The reaction force caused by the dead load is either given by the load table as below or calculated by the formula for the maximum reaction force;

\[ R_{LL} = R_{a\_table}, \text{ the maximum reaction force is computed according to these two formulas below;} \]

For spans between 3 and 4.3 m:

\[ R_{LL} = \frac{P_2}{2} \]

For spans between 4.3 and 6.5 m:

\[ R_{LL} = \frac{P_2 \cdot (L_{\text{beam}} - x) + P_3 \cdot (L_{\text{beam}} - L_{P2\_P3} - x)}{L_{\text{beam}}} \]

(Where \( x \) is the placing of the vehicle load \( P2 \) and is given for the value that gives the highest reaction force.)

The maximum reaction force at the supports from the dead is calculated as below;

\[ R_{DL} = \frac{(B_{\text{beam}} \cdot H_{\text{beam}} \cdot 6 + B \cdot H_{\text{Deck}}) \cdot g \cdot \rho_{wenge} \cdot \gamma_{ex\_load} \cdot L_{\text{beam}}}{2} \]

The compression stress capacity is given as;

\[ f_{c90_d} = f_{c90_d} \cdot k_{load} \cdot k_{moisture} \cdot k_{risk} \cdot k_{mat} \]

11.2 Results from the calculations for the beams

All possible dangerous criteria for the beams has now been checked and the deflection criterion where the one that gave the dimensions for the beams since all other criteria were met with a good margin. I have for the bending moment, deflection as well as for the bearing length used two different methods. One using the available table in Ritter 2 that gave the maximum reaction force, bending moment and deflection caused by the 32.6 ton truck and the other one using simple calculations for building mechanics. Both of them where not that difficult and they showed very similar answers.
All calculations are not presented here but only the results giving the height of the beam that was the dimension for the beams that were searched in the calculations. I have calculated the height of the beams for all spans used for the examined bridges as well as several additional spans. All dimensions given can be used for bridges with spans between 3.0 and 6.5 m.

<table>
<thead>
<tr>
<th>Span length (m)</th>
<th>3.00</th>
<th>3.25</th>
<th>3.50</th>
<th>3.75</th>
<th>3.95</th>
<th>4.00</th>
<th>4.25</th>
<th>4.50</th>
<th>4.60</th>
<th>4.75</th>
<th>4.90</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beam height (mm)</td>
<td>260</td>
<td>270</td>
<td>290</td>
<td>300</td>
<td>310</td>
<td>320</td>
<td>330</td>
<td>340</td>
<td>350</td>
<td>350</td>
<td>360</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Span length (m)</th>
<th>5.00</th>
<th>5.10</th>
<th>5.25</th>
<th>5.50</th>
<th>5.70</th>
<th>5.75</th>
<th>5.80</th>
<th>6.00</th>
<th>6.10</th>
<th>6.20</th>
<th>6.30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beam height (mm)</td>
<td>360</td>
<td>370</td>
<td>370</td>
<td>390</td>
<td>400</td>
<td>400</td>
<td>410</td>
<td>410</td>
<td>420</td>
<td>420</td>
<td>420</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Span length (m)</th>
<th>6.30</th>
<th>6.50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beam height (mm)</td>
<td>430</td>
<td>430</td>
</tr>
</tbody>
</table>

Table 11.1: A table given the dimensioned heights for the beams for different spans.

11.2.1 The bearing length calculated

The calculations for the bearing length showed that a bearing length of around 5 cm for the 6.50 span was more than enough. My chosen bearing length of 370 mm for the beams are therefore surely enough for all bridges.

11.2.2 All criteria met

The beams have been checked for deflection, bending strength and horizontal shear and all criteria were met and the most dangerous criterion that gave the dimensions for the beams were the deflection.

11.3 Calculations for the deck

I have for all calculations used a deck thickness of 70 mm. This must be checked for several criteria according to a method presented in Ritter 2. (Since this is a method applied for lengths and forces given in American standards must the formulas sometimes be modified a bit.) The deck has to be checked for three different criteria. The bearing length is not required because there is now there is enough bearing length on the beams for the deck. The deck has to be controlled for bending moment, horizontal shear and deflection and it is done according to the formulas presented below.

11.3.1 The bending moment

This criterion has to be fulfilled for bending moment;

\[ S_{b_{\text{deck}}} \leq f_{b_{\text{d}_{\text{deck}}}} \]
The bending moment stress capacity is previously given.

The total bending moment stress caused by the applied load is computed as below;

\[ S_b = \frac{M_{b\_tot\_deck} \times 0.80}{S_{deck}} \]

The total maximum moment over the deck is defined as below;

\[ M_{d\_tot\_deck} = M_{d\_deck\_DL} + M_{d\_deck\_LL} \]

The maximum bending moment from the dead load is;

\[ M_{d\_deck\_DL} = \frac{A_{deck} \times \rho_{wenge} \times g \times L_{deck\_eff}^2}{8} \]

The area of the deck is computed with the following formula;

\[ A_{deck} = b_{deck} \times H_{deck} \]

The so called effective deck span is defined as the distance between two beams plus one half of the width of one beam and it is computed as below;

\[ L_{deck\_eff} = L_{beam\_spacing} + \frac{B_{beam}}{2} \]

The distance between two beams is defined as \( L_{beam\_spacing} \).

For vehicle loads HS 15-44 and HS 20-44 is the vehicle loads defined according to the equation below taken from Ritter 1;

Bending moment for the deck for vehicle loads HS 15-44 and HS 20 -44;

\[ M_{b\_deck\_LL} = (3000 \times \frac{L_{deck\_eff}}{\text{inch}} - 25893) \times \text{Pin\_Nm} \]

Inch is a coefficient used to transform \( L_{deck\_eff} \) from meters to inches to make the formula that is defined by pounds*inch applicable.

Pin\_Nm is a coefficient that transforms the results given in pounds*inches into Newton*meters.

**11.3.2 Horizontal shear**

The criterion that has to be fulfilled for horizontal shear:

\[ S_{v\_deck} \leq f_{v\_deck\_d} \]
The shear stress capacity is given by:

\[ f_{v\_deck\_d} = f_{v\_deck\_k} \times k_{load} \times k_{moisture} \times k_{risk} \times k_{mat} \]

The total shear stress on the deck caused by the applied forces is defined as:

\[ S_{v\_deck} = \frac{1.5 \times V_{\text{shear\_deck\_tot}}}{A_{\text{deck}}} \]

The total shear force is given by:

\[ V_{\text{shear\_deck\_tot}} = V_{\text{deck\_LL}} + V_{\text{deck\_DL}} \]

Dead load vertical shear is computed at a distance \( H_{\text{deck}} \) from the support according to equation 7-49 on page 7-124 in Ritter I and is defined by the equation below:

\[ V_{\text{deck\_DL}} = A_{\text{deck}} \times \rho_{\text{wenge}} \times g \times \left( \frac{L_{\text{deck\_eff}}}{2} - H_{\text{deck}} \right) \]

The shear force caused by the vehicle load is computed by placing the edge of the wheel load distribution width a distance \( H_{\text{deck}} \) from the support. The wheel load is converted to a uniform load and computed as below;

\[ q_{\text{LL\_deck}} = \frac{P}{b_t} \]

\( P \) is the wheel load and \( b_t \) is the wheel distribution width computed as below according to equation 7-42 on page 7-139 in Ritter I;

\[ b_t = \sqrt{0.025 \times P \times \text{inch}} \]

Since the equation is given in inches is it essential to convert it into meters

When all these given can the shear force on the deck caused by the vehicle load by calculated according to the formula below taken from page 7-141 in Ritter I;

\[ V_{\text{LL\_deck}} = \frac{q_{\text{LL\_deck}} \times (L_{\text{deck\_eff}} - H_{\text{deck}}) \times (L_{\text{deck\_eff}} - H_{\text{deck}})}{L_{\text{deck\_eff}}} \]
11.3.3 Deflection

The criterion for the deflection that has to be fulfilled is the following;

\[
\text{Deflection}_{\text{deck LL}} \leq \frac{L_{\text{deck eff}}}{500}
\]

The maximum deflection for a standard 12 000 pound wheel load on deck spans greater than 0.45 meters and less than 2.70 meters is computed by the equation below;

(Equation 7-48, page 7.122 in Ritter I.)

\[
\text{Deflection}_{\text{deck LL}} = \frac{1.80}{E_{d \text{ eq}} * I_{x \text{ eq}}} * \left[138.8 * L_{\text{deck eff eq}}^3 - 20780 * L_{\text{deck eff eq}} + 90000\right] \text{inch}
\]

Since the equation is given in inches and pounds must the variables be converted according to these equations;

\[
E_{d \text{ eq}} = E_d * \frac{\text{inch}^2}{9.82 \text{pound}}, \quad I_{x \text{ eq}} = I_x * \frac{1}{\text{inch}^4}, \quad L_{\text{deck eff eq}} = L_{\text{deck eff}} * \frac{1}{\text{inch}}
\]

11.4 The results from the calculations for the deck

All criteria for the deck were calculated and met with planks that have a minimum dimension of 70*150 mm. The most dangerous criterion was the horizontal shear but this criterion was enough met on the safe side. A value for the shear capacity of 50 % less than the value that I used would also have met the criterion.
12 The roads and bridges in detail

All examined bridges and roads are presented here giving the state of the road/bridge and a given proposal for the superstructure for all bridges. A more exact plan of the substructure for all bridges can not be fitted within the frames of this thesis so I have chosen to plan the bridges on the important road Semendua – Camp Mpoko more thoroughly. The basic dimensions for the substructure are though given for all bridges but not the exact height of the abutments and where to put them in detail on the spot for the proposed bridge.

12.1 The road Semendua – the Kassai River (251)

This road is in quite bad shape and I doubt that it would be passable with jeeps or trucks, much because the collapsed bridges of the Ngove and Ywna River. This road is much damaged by erosion that has created big holes in the road making it very hard even for jeeps to pass. This road is very important for the region since it connects to Kassai, which is an important waterway connecting the region with Kinshasa.

12.1.1 The Ngove stream

Eleven kilometres from the mission station in Semendua is there a bridge consisting of four deteriorated logs. Jeeps cannot pass over this poor bridge and a new bridge has to be constructed to make it passable for cars. There is no solid ground that could serve as a bridge abutment so one needs to build new abutments, preferably in concrete. When consulting the rural population concerning this bridge did they explain that the stream floods heavily during the rain period up to 12 meters on the side closer to Semendua.

Figure 12.1: A segment of the road Semendua – Camp Mpoko, heavily damaged by erosion.
Essential data collected for the bridges:
Distance from a secure, dry spot to the river = 12 meters
Distance over the river = 9.0 meters
The river is about 4.0 meters wide and 0.7 meter deep this day, (the end of the rain period.)
It can though transform into a much wider river during the rain period and the water can flood up to
12 meters more on the side closer to Semendua.
The stream had a flow of approximately 0.8 m/s at the day of examination.

Proposed measures for the bridge

The bridge should not be constructed to cover the whole stream when flooded because the level of
the stream is not that high on the areas over 5 m from the actual stream. It becomes only a couple of
centimetres deep on the road 6 – 12 m from the stream. It would be very expensive to make a bridge
covering over 20 m so the best idea would be to elevate the road affected by the floods until the
bridge start instead of making the bridge 20 m long. This bridge is however very important for the
region and must be made with two spans to ensure it sustainability during rain season. My proposal is
to perform this bridge with two spans of 5.5 m each. All abutments should be 0.8 m long and reach
down around 2.0 into the ground. It is also required to elevate the road before the bridge to protect
the road from the floods and make the road to reach to the high bridge. The first beam should start
0.4 m from the ledge of the first abutment to the middle of the second abutment. The last beam
reaches from the centre of the middle pillar to 0.4 into the last abutment.

Figure 12.3: The Ngove stream as it is now with water levels during the dry period and when it is
flooded during the rain period.
The area connecting to the bridge is going to be elevated according to the picture above. The soil under the abutments are for this bridge as well as all others secured by laying several big rocks to keep the foundation strong and avoid big settings.

The proposed dimensions for this bridge are as below:
The Semendua side, abutment 1 (0.8 m) – 5.5 m – abutment 2 (0.8 m) – 5.5 m – abutment 3 (0.8 m)
A total 12.6 m counting the beams and 13.4 including the outer abutments

The beam dimension required for the first span:
The Semendua side, abutment 1 (0.37 m) – 5.5 m – abutment 2 (0.4 m)
A total length of 6.27 m. The 5.5 m span requires a beam dimension of 200*390 mm

The beam dimension required for the second span:
The Semendua side, abutment 2 (0.4 m) – 5.5 m – abutment 3 (0.37 m)
A total length of 6.27 m. The 5.5 m span requires a beam dimension of 200*390 mm

The dimensions for the abutments and superstructure:

![Figure 12.5: The dimensions for the proposed Ngove Bridge.](image)

### 12.1.2 The Lebe River

This bridge is very nice compared with other bridges in this area. It consists of steel collected from an old, broken truck. Jeeps can pass this bridge easily and even bigger trucks have been taken this road before and passed without problem. It is though now under heavy attack by rust and it is falling apart at one part of the bridge as you can see on the pictures. This bridge can maybe hold one or two years more but it would be best to replace this bridge with a more stable bridge of concrete or wenge tree. The bridge is 10.5 meters wide counting from the solid ground and 6.5 meters counting from concrete foundations. The abutments are about 2 meters long. No soil samples were collected from this bridge since it already had proper abutments.
Figure 12.6: The steel bridge over the Lebe stream.

Figure 12.7: A part of the bridge that is starting to collapse because the steel is under heavy attack by rust.

**Proposed measures for the bridge**

This old bridge is deteriorating fast and although it is passable for now is it a security risk for big trucks. It can manage jeeps but overloaded trucks weighing around 30 tons can probably not pass the bridge and a new bridge is required here to make it sure for bigger trucks to pass. Additional tests should be done for the bridge but I recommend that it would be replaced at the same time as the other bridges between Semendua and Kassai. The new bridge is to be constructed with one span of 6.5 meters. It will not be that expensive since there already are proper abutments that could be used.
The proposed dimensions for this bridge are as below:
*The Semendua side, abutment 1 (2.0 m) – 6.5 m – abutment 2 (2.0 m)*

The beam dimension required for the bridge:
*The Semendua side, abutment 1 (0.3 m) – 6.5 m – abutment 2 (0.3 m)*
*A total length of 7.1 m. The 6.5 m span requires a beam dimension of 200*430 mm*

### 12.1.3 The river of Ywna

This so called bridge is very hard to examine at all since it consists of many different kinds of material all but together in a total mess under the bridge. It bearing structure consists of old steel pieces of a truck, now heavily attacked by rust. It is hard to make out anything in this mess of tree, steel, leaves and soil but one can see that the builder has laid 4 steel profiles on some rocks. The soil was filled
with many small stones and it was very hard to take a soil sample. To try to pass this bridge with a car would be very dangerous and I strongly advice to make a new bridge of wenge tree to make this bridge suitable for cars. Another aspect that makes this bridge even more complex is that the water passes in some kind of waterfall under the bridge and the water falls up to 4 meters while passing under the bridge. To see this in detail is very difficult due to the mess under the bridge with a chaos of branches and timber. The bridge span is 4.5 meters long and 2.5 meters wide and the river itself is 3 meters wide and one meter deep this day, but it varies in both wideness and deepness depending on the amount of rains. The river flowed with a speed of 1 m/s the day of inspection, but this also varies a lot.

![Figure 12.10: The Bridge over the Ywyna stream.](image)

![Figure 12.11: The total mess under the Ywyna Bridge with old steel, rocks, grass and branches.](image)

**Proposed measures for the bridge**

This bridge has to be made wider because it is for now only 2.5 m wide and it has to cleared from all branches and rusted steel beams. New abutments must be constructed but the ground is though quite solid so the abutment does not have to be that big. The bridge itself is going to have only one span that needs to be five meters long. The abutments should be made 0.8 m long.
Figure 12.12: The Ywyna Bridge as it looks now.

Figure 12.13: The Ywyna Bridge with the proposed bridge.

The proposed dimensions for this bridge are as below:
The Semendua side, abutment 1 (0.8 m) – 5.0 m – abutment 2 (0.8 m)

The beam dimension required for the bridge:
The Semendua side, abutment 1 (0.37 m) – 5.0 m – abutment 2 (0.37 m)
A total length of 5.74 m. The 5.0 m span requires a beam dimension of 200*360 mm
12.1.4 The river of Kasai

This huge river is really a big blessing for the region, much because it is a very important waterway, making it possible to transport articles to and from Kinshasa. It also provides with a lot of sustenance in from of all the fish that is taken from the river. This big tributary from the enormous Congo-river differs a bit in size from around 400 meters at its slimmest passage (in the area covered by the administration of CEBU) that is situated near Bendela, to up to 700 m at its widest passage. The passage between Semendua and Camp Mpoko is though very broad, around 600 meters. This river is not only a blessing for the region but also a big obstacle for connecting the region with Bandundu and Kinshasa since there is no bridge over Kasai anywhere along its long extent due to its enormous size. I am sure that it will take many decades until a bridge will be constructed over this river and one have to depend upon the obsolete ferries to pass the river. There is a ferry over Kasai on the road from Semendua but it is in really bad shape and I really doubt that it could take on more than possibly a small jeep. A new, bigger ferry is needed here to enable trucks loaded with agricultural products to travel from the Mai Ndombe to Kinshasa. There are extremely few jeeps and trucks going from this area all the way to Kinshasa, much because the collapsed roads and bridges but also the bad condition of the ferries over Kasai. There existed a ferry over Kassai near Bendela some years ago and I am not sure if this ferry is functioning anymore. It is at least in very bad shape according to what I have heard from the chauffeurs travelling the region.

12.1.5 The ferry over Kassai

The obsolete ferries over the big rivers in Congo is isolating communities and regions from the national and regional economy and they must be restored or replaced in order to make it possible for vehicles to reach the villages. It must be made possible in the future to travel from the Mai Ndombe region to Kinshasa with trucks and just not always depend on the river transports. It could also become a profitable business for transport companies to transport goods from the Mai Ndombe region to Kinshasa and back if the ferry could get restored. It must also be added that it will not help the region that much if only jeeps could use the ferries since it is probably more expensive to take a jeep to Kinshasa then to travel the river so the traffic would not increase that much if only restored for smaller vehicles. Cheap and fast transport communications must be made possible besides the
river transports. A preparation and restoration of the road just before and after the place of the ferry also has to be performed to make it possible to pass onto and from the ferry for the vehicles.

Figure 12.15: The huge river of Kassai.

12.1.6 An area often attacked by floods 2 kilometres after Camp Mpoko

This area is under the rain period often flooded and it becomes very hard to pass during this time and some kind of measures has to be taken. The road is not that frequently used but it would deteriorate quickly into an impassable part of the road when it will become more utilized by big trucks if no measures are implemented. The rural population showed where the water floods during the rain period and it seems like a distance of 30 meters is affecting the road. It is not justifiable to perform a bridge covering this whole area due to the immense cost of constructing a 30 m long bridge so one has to choose another option. The floods do also just reach a level of one or two decimetres over the road at twenty meters of the 30 meter long area affected by the floods and this area could be protected by elevating the road 20 centimetres and protecting the road with rocks or concrete at the sides as well creating big strong ditches.

Figure 12.16: An area attacked by floods after Camp Mpoko.

Proposed measures for the bridge

This is as I said before an important road for the region and it is essential to restore the road and construct the bridges needed. It would be a good idea to consult the rural population before starting
to construct the bridges concerning the more exact magnitude and placing of the floods. One problem is that this bridge is found in the savannah, unlike the other bridges so it could be hard to find big trees required for the big beams. This road is not for now frequently used by vehicles due to its the bad condition so it has been spared from big stresses caused by big trucks so it looks quite ok here but it would deteriorate fast if frequently used by big trucks. The road as well as the bridges must be designed to resist the stresses caused by the new vehicles that would use the road when rehabilitated. One bridge with two spans of 4.5 m each as well as an elevation of the road 10 m before the bridge and 10 m after bridge should be preformed to ensure a serviceable part of the road.

The proposed dimensions for this bridge are as below:
The Semendua side, abutment 1 (0.8 m) – 4.5 m – abutment 2 (0.8 m) – 4.5 m – abutment 3 (0.8 m)

The beam dimension required for the first span:
The Semendua side, abutment 1 (0.37 m) – 4.5 m – abutment 2 (0.4 m)
A total length of 5.27 m. The 4.5 m span requires a beam dimension of 200*340 mm

The beam dimension required for the second span:
The Semendua side, abutment 2 (0.4 m) – 4.5 m – abutment 3 (0.37 m)
A total length of 5.27 m. The 4.5 m span requires a beam dimension of 200*340 mm

12.2 The road Semendua – Seko (– Camp Mpoko)

This is the other road that links Semendua with Camp Mpoko and it is actually bigger than the previously discussed road. The road has a couple of smaller parts that is attacked by floods and also two very small streams. It has though many distances that has huge holes made by the big trucks that sometimes travel this road. It does not however have a ferry that can take jeeps and trucks over Kassai so it is just a road that can take products to Kassai and not onwards to Bandundu and Kinshasa. This road has a big need of rehabilitating as well because of the huge holes in the road but the streams are although very small and this is why this road is used more frequently than the other Semendua – Kassai road. It should be discussed more thoroughly which road that are to be rehabilitated because I do not though believe that it should be prioritized to restore both because the need of restoration is very big on other roads as well. The road that is to be chosen for restoration of these two should though be a road that have opportunities for a restoring a ferry route over Kassai.

Figure 12.17: The huge holes in the Semendua – Seko road.
12.3 The longer road Semendua – Bosobe (264)

This 120 km long distance had not been used for several months when I tried to travel from Semendua to Bosobe to examine the bridges. It took me two days to reach Bosobe, much because the very old jeep broke down and the extremely bad condition of the road. Over twenty big trees had fallen over the road and that had to be removed with help from the axes we had with us. The road just seemed to disappear for the most part of the trip. This road does not deserve the name road but instead possibly a small path. Much work remains to make this road worthy of its name. It took though only ten hours for the jeep to return to Semendua the same way, much because we had cleared the road from its obstacles the day before.

12.3.1 The river near the village of Seduri

An Engineer named Ntwa constructed a nice temporary bridge made of wood for us to use just a couple of days before so there was no trouble to pass here. This bridge will though probably only hold until the next rain period. It was very hard to examine this bridge because we arrived here after dark and this made it difficult to make a good examination. I did though take some measures of the bridge, collected a couple of soils samples and tried to take some pictures. The bridge is 10 meters long including one and half meters on each side that is used for the temporary abutments. The river itself from shore to shore is 6.0 m but the ledges close to the bridge are weak and it is essential to reinforce the ledges with concrete to make it stronger.
Proposed measures for the bridge

This temporary bridge has to be replaced with a new bridge since it will not hold for more than probably 5 tons. A new bridge with new strong abutments out of concrete has to be constructed here. The level of the bridge and the bottom of the river is here very big so it would be best to avoid making an extra abutment in the middle of the river because it would surely have a total height of 4 m. It is better to look hard for big trees that could be used for making the big beams needed for a bridge span of 6 meters since it is hard to make a bridge pillar in the middle of the stream. The abutments should be made 0.8 meter long and reach down 2 m into the ground. The level of the river can rise up to one meter over the level during my examination but there is no risk for the water to reach up to the proposed bridge.

The proposed dimensions for this bridge are as below:
*The Semendua side, abutment 1 (0.8 m) – 6.0 m – abutment 2 (0.8 m)*

The beam dimension required for the bridge:
*The Semendua side, abutment 1 (0.37 m) – 6.0 m – abutment 2 (0.37 m)*
*A total length of 6.74 m. The 6.0 m span requires a beam dimension of 200*410 mm*

12.4 The road between Bosobe and Oshwe

This road was a big, nice looking road 25 years ago and it was still passable for vehicles around 20 years ago. Much have happened since then. The road has deteriorated totally on the last 15 - 20 years and it nowadays looks more like a small jungle path just passable by foot with a machete as your help. The deep jungle starts after Bosobe and 12 km after Bosobe does this jungle road turn into an overgrown path. One can only see remains from the old bridges built by the Belgian Engineers long ago. According to my guide it has been impossible to travel the distance Bosobe – Oshwe by car using this particular road for at least 10, possibly 15 years due to the collapsed bridges. There is also another road/path used by the rural population to travel this distance by foot, bicycle or motorcycle. It is though not possible to travel this road by car since it crosses the big river of Lukenie that is a couple of hundred meters wide and there are no ferries going over but only small canoes, that are unable to take on any cars. An additional road has also been created from Semendua to Oshwe but I do not have so many facts about it besides that it exists. I found several huge trees on the way to these bridges with a trunk diameter of over 1 m so the beams for these bridges could surely be made with the maximum length of 7.5 m and a beam height of 0.5 m if needed.
12.4.1 The river of Lukelela I

Three logs lay over this stream and the only way to pass it was to walk down on the log going down into the water and then leap over to the other log coming out of the water, a bit dangerous one might say. To examine the bridges on this road was by far the hardest task so far since the road was totally overgrown. I found some remains from the foundations made by the Belgians but these have deteriorated immensely and I doubt that they could be used as proper abutments for the bridge. New abutments should be made for all the bridges over Lukelela. The stream itself was only 4.5 m wide and 1 m deep at the day of examination but it floods a couple of meters on each side during the rain period.

![Figure 12.21: The river of Lukelela I.](image)

Proposed measures for the bridge

The river this day was not that big because it was at the end of the rain period but it can flood up to 4.5 meters on each side and the soil is quite weak on the shore so it is required to construct big strong abutments on the shore. One bridge span of 6.3 m is required here to make the bridge safe from the floods. A thirty cm elevation of 2 m of the road connecting to the bridge on each side is also needed here to protect against the floods.

The proposed dimensions for this bridge are as below:
Bosobe side, abutment 1 (0.8 m) – 6.3 m – abutment 2 (0.8 m)

The beam dimension required for the bridge:
Bosobe side, abutment 1 (0.37 m) – 6.3 m – abutment 2 (0.37 m)
A total length of 7.04 m. The 6.3 m span requires a beam dimension of 200*430 mm

12.4.2 The river of Lukelela II

This stream only has some remains from Belgian engineers from long ago in form of a large bridge pillar in the middle of the stream. It also has some remains of concrete abutments on each side which are hardly detectable due to all vegetation. These two abutments on the sides are though too old and cannot be used. A couple of logs are just laid over the stream and it is very dangerous to pass, even by foot.
Proposed measures for the bridge

This bridge should be preformed with two spans and new abutments on the sides. The river seldom floods on the sides during the rain period so it is not necessary to make the bridge longer on the sides than necessary. The soil is though no that solid near the ledges so they have to be reinforced with concrete if the abutments are to be preformed here. The river itself was only 3 m wide on the Bosobe side and 3.5 m on the Oshwe side. Two spans with 4.5 and 5.0 m is enough for this bridge. It can be dangerous to perform the abutments to close to the ledge because of the danger of erosion so it is best to start the abutments one or two meters from the ledges. The old abutment in the middle also has to be reinforced with concrete to ensure long serviceability.

The proposed dimensions for this bridge are as below:
Bosobe side, abutment 1 (0.8 m) – 4.5 m – abutment 2 (1.0 m) – 5.0 m – abutment 3 (0.8 m)

The beam dimension required for the first span:
Bosobe side, abutment 1 (0.37 m) – 4.5 m – abutment 2 (0.5 m)
A total length of 5.37 m. The 4.5 m span requires a beam dimension of 200*340 mm
(The first beam will though be 200*360 mm because the two beams have to be on the same level.)

The beam dimension required for the second span:
Bosobe side, abutment 2 (0.5 m) – 5.0 m – abutment 3 (0.37 m)
A total length of 5.87 m. The 5.0 m span requires a beam dimension of 200*360 mm

12.4.3 The river of Lukelela III

This bridge has deteriorated abutments as all the other Lukelela bridges so new abutment are needed here as well. The river is app. 4.5 m long and 1.5 meters deep and the river can flood up to 1.5 meters on each side during the rain period. It must be added that a lot of work needs to be done to make room for all the Lukelela bridges and broaden the road because they are currently totally overgrown.
**Proposed measures for the bridge**

A bridge span of 6.5 m with two concrete abutments is required here to make a serviceable construction. The new abutments should be placed one meter from the ledges due to the danger of erosion damaging the soil that could finally make the abutments to fall into the river. The stream can flood a couple of meters on each side at a level of about 1 dm over the ground level so it would be best to elevate the bridge 20 cm over the ground level to keep the water from reaching and thereby damaging the bridge.

The proposed dimensions for this bridge are as below:
*Bosobe side, abutment 1 (0.8 m) – 6.5 m – abutment 2 (0.8 m)*

The beam dimension required for the bridge:
*Bosobe side, abutment 1 (0.37 m) – 6.5 m – abutment 2 (0.37 m)*
*A total length of 7.24 m. The 6.5 m span requires a beam dimension of 200*430 mm*

**12.4.4 The river of Lukelela IV**

This river does not even have a temporary bridge and it is not possible to pass if you do not have a canoe or feel like a swim. My local guide did though offer to swim over so I at least could measure this bridge. There is a big pillar in the middle of the stream constructed by the Belgians some 60 years ago. The river was approximately 16 meters wide and 2.5 m deep at the deepest when I examined it and it had a steady stream of 1.0 m/s.
Proposed measures for the bridge

The bridge is very long and I believe that two additional abutments are required here due to the length of the spans. It is 7.5 from the ledge of the river to the ledge of the abutments in the middle of the stream and it has the same dimensions on the other side of the river. The new abutments are going to be up to around 5 meters high with at least 1 m under the bottom of the river, up to 2.5 m in the actual river and 1.5 m under the bottom of the river. Even the forms needed for the casting of the abutments are going to be hard to make and this bridge does indeed involve a lot of work and will surely cost more than the other smaller bridges designed so far. The middle abutment does need to be overseen more thoroughly but does surely need to be reinforced with some more concrete. The “road” connecting to the river is not that affected by floods but the abutments should though start at least 1 m from the ledge due to the risk of erosion. All four bridge spans should be made 4.5 long and the abutments 0.8 m long as usual. The abutment in the middle of the stream is though 1.0 m long.

The proposed dimensions for this bridge are as below:
Bosobe side, abutment 1 (0.8 m) – 4.5 m – abutment 2 (0.8 m) – 4.5 m – abutment 3 (1.0 m) – 4.5 m – abutment 4 (0.8 m) – 4.5 m – abutment 5 (0.8 m)

The beam dimension required for the first span:
The Bosobe side, abutment 1 (0.37 m) – 4.5 m – abutment 2 (0.4 m)
A total length of 5.27 m. The 4.5 m span requires a needed beam dimension of 200*340 mm.

The beam dimension required for the second span:
The Bosobe side, abutment 2 (0.4 m) – 4.5 m – abutment 3 (0.5 m)
A total length of 5.4 m. The 4.5 m span requires a beam dimension of 200*340 mm.

The beam dimension required for the third span:
The Bosobe side, abutment 3 (0.5 m) – 4.5 m – abutment 4 (0.4 m)
A total length of 5.4 m. The 4.5 m span requires a beam dimension of 200*340 mm.

The beam dimension required for the forth span:
The Bosobe side, abutment 3 (0.4 m) – 4.5 m – abutment 4 (0.37 m)
A total length of 5.37 m. The 4.5 m span requires a beam dimension of 200*340 mm.
12.4.4 The rivers of Lukelela V, VI, VII and VIII

I could not examine these streams due to the difficulties of passing Lukelela IV but the local guide explained that these bridges are very similar to Lukelela III and the streams are between 3 m and 5 m long and requires spans between 4.5 and 6.5 m. I have therefore calculated the spans of 4.5, 5, 5.5, 6.0 and 6.5 m and will give proposals for these bridges that are presented below.

**Proposed measure for the bridges**

All the bridges should be made in one span if big trees could be found near the stream that could produce the beams needed for the construction. If this is not possible must an additional abutment be created in the middle of the stream but that option is not presented here, only the option with one span. It is very hard to exactly predict the dimensions and conditions since I have not seen the actual stream so I will just present the beam dimensions below. The abutments are all 0.8 long.

**The beam dimensions required for a bridge span of 4.5 m.**

Bosobe side, abutment 1 (0.37 m) – 4.5 m – abutment 2 (0.37 m)  
A total length of 5.24 m. The 4.5 m span requires a beam dimension of 200*340 mm

**The beam dimensions required for a bridge span of 5.0 m.**

Bosobe side, abutment 1 (0.37 m) – 5.0 m – abutment 2 (0.37 m)  
A total length of 5.74 m. The 5.0 m span requires a beam dimension of 200*360 mm

**The beam dimensions required for a bridge span of 5.5 m.**

Bosobe side, abutment 1 (0.37 m) – 5.5 m – abutment 2 (0.37 m)  
A total length of 6.3 m. The 4.44 m span requires a beam dimension of 200*390 mm

**The beam dimensions required for a bridge span of 6.0 m.**

Bosobe side, abutment 1 (0.37 m) – 6.0 m – abutment 2 (0.37 m)  
A total length of 6.8 m. The 6.0 m span requires a beam dimension of 200*410 mm

**The beam dimensions required for a bridge span of 6.0 m.**

Bosobe side, abutment 1 (0.37 m) – 6.5 m – abutment 2 (0.37 m)  
A total length of 7.24 m. The 6.0 m span requires a beam dimension of 200*430 mm

12.5 The shorter road connecting Bosobe with Semendua and Bokoro.

This road is not even fully mapped out on my old map from 1971 but it is although in quite good shape. Some parts of the road can be travelled in the tremendous speed of 50 km/h or more and this was the best looking road that I travelled on in this region. It is though not that wide and two cars can not meet here without having to stop and move away into the grass to make room for the other vehicle. The road must be broadened if it is going to be used by regular traffic. The big obstacles on this road are the many collapsed bridges which makes it totally impassable for jeeps. Motorcycles can travel this way if they receive help from some canoes on the streams that are impassable even for motorcycles. If these bridges would get constructed will it be possible to reach Semendua in surely less than five hours with a jeep. The problems start when you reach the village Seduri (Bosobe – Semendua) since this distance is extremely bad. When I went this distance by car it took us more than 3 hours to travel around 30 km. The distance between Bosobe and Seduri (55 km) could though be travelled in about one and a half hours if the possible bridges would be constructed. Without the bridges is it impossible to go this way with bigger vehicles. There are quite many villages on the
distance Bosobe – Seduri and it would be very good for the population if these bridges would be constructed and the road enhanced.

\[\text{Figure 12.25: A map over the area between Semendua and Bosobe.}\]

\[\text{Figure 12.26: A nice looking part of the road between Bosobe and Seduri.}\]

**12.5.1 The river of Ngoli**

A couple of kilometres from Bosobe do you find the small river of Ngoli. The river often floods during the rain period and sometimes reaches an area of 8 m on the side closer to Semendua. A big area around this stream is affected by the floods during the rain period so it would be good to prolong the bridge at least 4 m after the actual stream. The area 4 m after the stream has floods that sometimes reach over 20 cm over the ground level.
Facts collected from the stream:
Position: 3.30429 S, 18.81843 E.
The stream was approximately 3.5 meters wide and one meter deep at the day of examination.

Proposed measures for the bridge

The bridge should be performed with two spans and elevate the distance covered by the floods that is not included in the proposed bridge. An elevation of 20 cm is probably enough for this distance. The soil closer to Semendua is also not that strong and is attacked by erosion on the side of the road. It would be a good idea to reinforce the sides damaged by erosion with some big rocks or concrete to keep the road from deteriorating even more.

The dimensions for the proposed bridge and elevated section:
Bosobe side, abutment 1 (0.8 m) – 5.0 m – abutment 2 (0.8 m) – 5.0 m – abutment (0.8 m) – elevated area (2.0 m)

The beam dimensions for the first span:
Bosobe side, abutment 1 (0.37 m) – 5.0 m – abutment 2 (0.4 m)
A total length of 5.77 m. The 5.0 m span requires a beam dimension of 200*360 mm

The beam dimensions for the second span:
Bosobe side, abutment 2 (0.4 m) – 5.0 m – abutment 3 (0.37 m)
A total length of 5.77 m. The 5.0 m span requires a beam dimension of 200*360 mm
12.5.2 The river of Mabiki I

This bridge consists of three wood boards and they lay upon some rocks reinforced with cement on both sides. If big vehicles would use this road more frequently would it deteriorate fast so it is essential to reinforce all the sides affected by the water. Erosion is a big problem on these roads and big trucks would soon destroy the weak roads damaged by erosion if they are not reinforced. An additional protection against erosion other than to reinforce with rocks and concrete is to plant bamboo trees that are very good as a protection from erosion since they hold the soil together with its strong roots.

![Figure 12.29: The river of Mabiki I.](image)

Facts collected from the stream:
Position; 3.30443 S, 18.81603 E
The stream was approximately 4 m wide and 1 m deep at the day of examination.

Proposed measures for the bridge

The soil on both sides is not that strong and it would be best to construct the abutments one meter from the stream to keep the structure stable and prevent the abutments from being washed away when affected by floods. The ledges have to be reinforced with rocks and concrete to protect the abutments to be attacked by erosion. Otherwise could the abutments collapse into the stream in a couple of years or so. The bridge should be preformed with one span that is 6.0 m long.

The dimensions for the proposed bridge an elevated section:
Bosobe side, abutment 1 (0.8 m) – 6 m – abutment 2 (0.8 m)

The beam dimensions required for the bridge:
Bosobe side, abutment 1 (0.37 m) – 6 m – abutment 2 (0.37 m)
A total length of 6.74 m. The 6.0 m span requires a beam dimension of 200*410 mm

12.5.3 The river of Mabiki II

This bridge consists of two wood boards that lay directly on the road. The roads connecting to the river are weak and damaged by erosion so the shores have to reinforced and the bridge prolonged at least 0.5 m. The shore on the side closer to Semendua has a weak soil and the road on that side should be elevated a 20 cm to protect the road from the floods.
Facts collected from the stream:
Position: 3.30446 S, 18.81321 E
The stream was approximately 5.0 m wide and 1.2 m deep at the day of examination.

Proposed measures for the bridge

This bridge is to be preformed with one span that is 6 m long. The elevated section should be made two meters long to ensure a long serviceability of the road section. New abutments of concrete are required here as well. The shores must be reinforces with stones and concrete and the roads connecting to the roads elevated one meter at the side closer to Bosobe and two meters on the side closer to Semendua. An elevation of 20 cm is enough for both shores.

The proposed dimensions for this bridge are as below:
Bosobe side, abutment 1 (0.8 m) – 6.2 m – abutment 2 (0.8 m) – elevated area (2.0 m)

The beam dimension required for the bridge:
Bosobe side, abutment 1 (0.37 m) – 6.2 m – abutment 2 (0.37 m)
A total length of 6.94 m. The 6.2 m span requires a beam dimension of 200*420 mm

12.5.4 The river of Nzo

This river has only one little wood board that serves as a bridge and it is even dangerous trying to pass it with a motorcycle. The road next to the stream is attacked by erosion on the sides and this has weakened the soil and the road is reduced to a two meter wide road on the ledge of both shores. The bridge can not start close to the ledges because of the erosion and has to be extended at least one meter on each side. It is not reinforced anywhere and new bridge abutments are required to make a stable construction. Reinforcement along the sides of the road is also required to ensure the stability of the road when it will be fit to take on big trucks.
Facts collected from the stream:
Position; 3.30446 S, 18.81321 E.
The stream was approximately 4.5 m wide and 1 m deep at the day of the examination.

Proposed measures for the bridge

The bridge should be preformed with a 6m long span and new strong concrete abutments. The shores are to be reinforced at both sides to protect from erosion. The road must also be made wider to make room for the bridge that requires a wideness of the road of at least 3.15 m. If big trees are hard to find for the beams can a pillar be constructed in the middle of the stream and the bridge preformed with two spans instead. That option is though however not presented here.

The proposed dimensions for this bridge are as below:
Bosobe side, abutment 1 (0.8 m) – 6.5 m – abutment 2 (0.8 m)

The beam dimension required for the bridge:
Bosobe side, abutment 1 (0.37 m) – 6.5 m – abutment 2 (0.37 m)
A total length of 7.3 m. The 6.5 m span requires a beam dimension of 200*430 mm

12.5.5 The river of Leka I

This bridge consists of four deteriorated wood logs lying on the ground. The road next to the stream consists of deteriorated wood logs mixed with bad soil and the abutments should not be place here on this weak ground. The bridge has to be extended a couple of meters on each side to ensure a solid foundation. The soil has to be more carefully checked when the logs have been removed and the soil under the logs properly examined before the dimensions of the structure are chosen exactly. The river itself is more like a swamp on one side and a stream at the other side but this stream does though transform into a bigger stream during rain season.
Facts collected from the stream:
Position; 3.31414 S, 18.75125 E.
The stream was approximately 5.1 m wide and 0.6 m deep at the day of examination.

Proposed measure for the bridge

It is very hard to know exactly where to start the bridge before a more careful investigation of the soil under the logs has been conducted. The soil in the actual stream does though look like clay and the river seem more like a swamp than a stream. It would involve a lot of work to construct an abutment in this swamp/stream so I recommend making a bridge with one span and constructing big, strong abutments and reinforcing the ledges of the stream. A span of 6.1 is probably enough for this bridge. One should also broaden the road to get room for the bridge.

The proposed dimensions for this bridge are as below:
Bosobe side, abutment 1 (0.8 m) – 6.1 m – abutment 2 (0.8 m)

The beam dimension required for the bridge:
Bosobe side, abutment 1 (0.37 m) – 6.1 m – abutment 2 (0.37 m)
A total length of 6.84 m. The 6.1 m span requires a beam dimension of 200*420 mm

12.5.6 The river of Leka II

Two old wood logs serve as a bridge here. This road is also damaged by erosion next to the bridge and the stream always floods during the rain period. These floods reach over the logs and can go up to three meters on each shore. The road connecting to the stream has also been attacked by erosion which has made the soil quite weak on the shores connecting to the stream. The new bridge construction should be elevated at least twenty centimetres over the ground level to keep the water from reaching the level of the bridge. There is no foundation for the bridge that can be used as abutments so new abutments out of concrete has to be constructed.
Facts collected from the stream:

Position: 3.31393 S, 18.75068 E

The stream was approximately 5.3 m wide and 1.5 m deep at the day of examination.

It also had a steady stream of 0.7 m/s.

**Proposed measure for the bridge**

The bridge has to be prolonged at least 0.5 m on each side due to the floods and erosion for ensuring a long serviceability. One bridge span with 6.3 m is probably enough for this stream. An elevation of the bridge span of 20 cm is also needed to keep the water from damaging the beam during the rain period. The service life for the structure will surely be prolonged with several years if the bridge is elevated so that the water not reaches the beams for some weeks during the rain period. It is not that dangerous if the beams would lie partly under water for a week or so but it can reduce the strength of the beam if it is in contact with water for several weeks. Wenge tree is though persistent to moisture and water but it can not resist when being in contact with water several months every year. This would hurt the structure and reduce the service life of the structure. I have therefore decided to start the beams 30 cm over ground although that the road has to be elevated to get up in the same level as the bridge. One should also reinforce the shores as much as possible to protect from erosion and floods.

The proposed dimensions for this bridge are as below:

Bosobe side, abutment 1 (0.8 m) – 6.3 m – abutment 2 (0.8 m)

The beam dimension required for the bridge:

Bosobe side, abutment 1 (0.37 m) – 6.3 m – abutment 2 (0.37 m)

A total length of 7.04 m. The 6.1 m span requires a beam dimension of 200*420 mm

**12.5.7 The river of Mukaw I**

Three wood logs are just laid over this little river to take make it possible to cross by foot. To cross the stream with a motorcycle or even bicycle is quite troublesome, (I carried on my investigation trip by foot from here). The yearly floods that reach up to three meters on each side of the stream during the rain period motivate to prolong the bridge at least one meter on each side.
Facts collected from the stream:
Position; 3.19965 S, 18.63317 E
The stream was approximately 3.8 m wide and 1 m deep at the day of examination.

Proposed measures for the bridge

This bridge should be preformed with one span that is 5.8 m. It is also required to protect the shore from floods and erosion using big rocks or concrete blocks. The bridge also needs to be elevated at least 20 cm over the ground to protect the bridge from the flooded water.

The proposed dimensions for this bridge are as below:
Bosobe side, abutment 1 (0.8 m) – 5.8 m – abutment 2 (0.8 m)

The beam dimension required for the bridge:
Bosobe side, abutment 1 (0.37 m) – 5.8 m – abutment 2 (0.37 m)
A total length of 6.54 m. The 5.8 m span requires a beam dimension of 200*410 mm

12.5.8 The river of Mukaw II

This bridge is made by different pieces of wood put together to a quite odd looking tree bridge and the “constructers” have used whatever piece of wood they could spare. It is though passable by foot and with bicycle. The road is attacked by erosion as always, which motivates to prolong the bridge one meter from the ledges of the stream. The floods do not usually reach the level of the road but the erosion has though weakened the soil on the ledges. New abutments are needed here as well.
Facts collected from the stream:

Position; 3.19910 S, 18.63291 E,
The stream is app. 3.7 m wide and 1 m deep this day.
It was 4.5 m from the two ledges of the road.

Proposed measures for the bridge

The best suggestion is according to me to perform the bridge with a span of 5.7 m. Protection against erosion on the sides as well as new abutments out of concrete is needed here also. The bridge does not have to be elevated to protect from the floods so the bridge can be preformed at the same level as the ground.

The proposed dimensions for this bridge are as below:
Bosobe side, abutment 1 (0.8 m) – 5.7 m – abutment 2 (0.8 m)

The beam dimension required for the bridge:
Bosobe side, abutment 1 (0.37 m) – 5.7 m – abutment 2 (0.37 m)
A total length of 6.44 m. The 5.7 m span requires a beam dimension of 200x400 mm.

12.5.9 The river Mukaw III

This is a quite big river in comparison to the other small streams I had seen so far. It has two abutments on the shores and one in the middle of the river, all three constructed by the Catholics working in this area some years ago. This bridge can serve as a good example for describing the magnitude of the differences of the water levels in the rivers between the rain period and the dry period. The middle bridge pillar that was over a half meter over the water level when examined can become ten centimetres under the water level during the rain period. The abutments must because of this be elevated twenty centimetres over the level of the middle abutment. It is also important to prolong the bridge at least 4 meters on each shore to protect it from the immense floods.
Figure 12.36: The river of Mukaw III.

Facts collected from the river:
Position; 3.19856 S, 18.63252 E
Bridge; the river itself was 19.8 m wide and 2 m deep at the day of examination.
It also had a steady stream of 1.0 m/s.

Proposed measures for the bridge

Two new abutments need to be created between the shores and the big abutment in the middle. The 9.3 m spans are too long so they have to be divided in two. The bridge abutment in the middle needs to be elevated 20 cm and the small abutments on the shores has to be elevated at the same level as the middle abutment. Two additional abutments has to be constructed 4.0 meters from the existing abutments on the shores to make the road passable when the river floods during the rain period. All abutments need to be made wider to make it suitable for the broad bridge. The shores can become 30 cm under water when flooded so protection of the shores with concrete blocks or big rocks is also needed.

The proposed dimensions for this bridge are as below:
Bosobe side, abutment 1 (0.8 m) – 4.0 m – abutment 2 (0.8 m) – 4.25 m – abutment 3 (0.8 m) – 4.25 m – abutment 4 (1.2 m) – 4.25 m – abutment 5 (0.8 m) – 4.25 m – abutment 6 (0.8 m) – 4.0 m – abutment 7 (0.8 m)

(All beams have to be constructed with the highest beam dimension in the span because all beams has to have the same height.)

The beam dimension required for the first span:
Bosobe side, abutment 1 (0.37 m) – 4.0 m – abutment 2 (0.4 m)
A total length of 4.77 m. The 4.0 m span requires a beam dimension of 200*320 mm

The beam dimension required for the second span:
Bosobe side, abutment 2 (0.4 m) – 4.25 m – abutment 3 (0.4 m)
A total length of 5.05 m. The 4.25 m span requires a beam dimension of 200*330 mm

The beam dimension required for the third span:
Bosobe side, abutment 3 (0.4 m) – 4.25 m – abutment 4 (0.6 m)
A total length of 5.25 m. The 4.25 m span requires a beam dimension of 200*330 mm

The beam dimension required for the forth abutment:
Bosobe side, abutment 4 (0.6 m) – 4.25 m – abutment 5 (0.4 m)
A total length of 5.25 m. The 4.25 m span requires a beam dimension of 200*330 mm

The beam dimension required for the fifth span:
Bosobe side, abutment 5 (0.4 m) – 4.25 m – abutment 6 (0.4 m)
A total length of 5.05 m. The 4.25 m span requires a beam dimension of 200*330 mm

The beam dimension required for the sixth span:
Bosobe side, abutment 6 (0.4 m) – 4.0 m – abutment 7 (0.37 m)
A total length of 4.77 m. The 4.0 m span requires a beam dimension of 200*320 mm

12.5.10 The Mukaw IV stream

This bridge consists of two wood logs laid over the little river and this temporary bridge is not even suitable to pass with a bicycle. An old man tried to pass this bridge with is bicycle loaded with some material he had collected but he slipped and felled into the stream with his bike and had to receive help from some helpful persons to get up, (see picture). The road is under heavy attack from erosion which has weakened the soil near the stream significantly. The shores near the bridge have been reduced by erosion so the first abutments should not be constructed very near the stream but instead at least one meter from the actual stream. The floods during the rain period reaches at least three meters on each side so the bridge has to stretch several meters on each shore.

![Figure 12.37: The Mukaw stream IV.](image)

Facts collected from the stream:
Position; 3.19825 S, 18.63233 E
The stream was approximately 3.5 m wide and 0.7 m deep at the day of examination

Proposed measures for the bridge

One bridge span of 5.5 m is enough for this bridge. It is important to protect almost all bridges from erosion and floods on the shores with big rocks or concrete blocks and this is needed here as well. If these actions were ignored will the erosion continue to damage the road connecting to the streams and will finally start to damage the abutments and the floods would reach probably one or two meters longer up on the road than covered by the bridge. New abutments are needed here on both sides and an elevation of the bridge of at least 20 cm over the ground level is also needed to improve the sustainability in the long term.
The proposed dimensions for this bridge are as below:
Bosobe side, abutment 1 (0.8 m) – 5.5 m – abutment 2 (0.8 m)

The beam dimension required for the bridge:
Bosobe side, abutment 1 (0.37 m) – 5.5 m – abutment 2 (0.37 m)
A total length of 5.44 m. The 6.3 m span requires a beam dimension of 200*390 mm

12.5.11 The Mukaw V stream

This bridge is just three wood logs laid over the stream leaning on some branches put together as a support for the bridge. The road before and after the stream connects with flooded water from the stream on both sides of the road and erosion has deteriorated the road into a road that at some passages is only 2 meters wide. The heavy rains cause big floods on the road connected to the stream during the rain period. Due to the bad condition of the road affected by the stream is it important to both elevate the bridge 30 centimetres over ground level and to start the bridge at least 2 meters before and after the stream to ensure the condition of the road in the long run. The roads connecting to the bridge has to be elevated as well to protect the flooded water from damaging the road. Two meters on each side that is twenty cm over the ground level is surely enough. The road also has to be made wider on the part of the road that has been reduced to an only 2 meter wide road.

![Image of the Mukaw stream V.](image.png)

**Figure 12.38:** The Mukaw stream V.

Facts collected from the stream:
The exact position was not taken here; the stream is though situated 200 meters from Mukaw IV. The stream was approximately 6.4 m wide and 0.8 m deep at the day of examination.

Proposed measures for the bridge

The bridge should be preformed with two spans due to the size of the stream and the floods that attacks the road during the rain period. A new concrete abutment has to be constructed in the middle of the stream as well as one on each shore. The two spans should be made 4.5 m each and start around two meters from each shore. A protection against the floods is required here as well because the floods will otherwise reach up to 4 meter on each side.
The proposed dimensions for this bridge are as below:
Bosobe side, abutment 1 (0.8 m) – 4.6 m – abutment 2 (0.8 m) – 4.6 m – abutment 3 (0.8 m)

The beam dimension required for the first span:
Bosobe side, abutment 1 (0.37 m) – 4.6 m – abutment 2 (0.4 m)
A total length of 5.37 m. The 4.6 m span requires a beam dimension of 200*350 mm

The beam dimension required for the second span:
Bosobe side, abutment 2 (0.4 m) – 4.6 m – abutment 3 (0.37 m)
A total length of 5.37 m. The 4.6 m span requires a beam dimension of 200*350 mm

12.5.12 The Mukaw stream VI

This bridge has some kind of abutments made of bad quality concrete. The foundations made by the rural population should by accounted as the lowest quality of concrete according to Swedish standards and should be reinforced with new concrete. These foundations are 75cm*200cm on each side so they have to be made 575 cm wider on each side of the foundations.

Figure 12.39: The Mukaw stream VI.

Facts collected from the stream:
Position; 3.19708 S, 18.63179 E
The stream was approximately 5.0 m wide and 1 m deep at the day of examination.

The proposed dimensions for the bridge

The connecting roads look quite ok and the connecting roads are not that affected by floods so the bridge does not have to be made so much longer than the bridge itself. The bridge span between the abutments is though to long and one additional abutment has to be created in the middle of the stream and the bridge preformed with 2 spans. The bridge spans will then be 3.95 m long each.

The proposed dimensions for this bridge are as below:
Bosobe side, abutment 1 (0.75 m) – 3.95 m – abutment 2 (0.8 m) – 3.95 m – abutment 3 (0.75 m)

The beam dimension required for the first span:
Bosobe side, abutment 1 (0.37 m) – 3.95 m – abutment 2 (0.4 m)
A total length of 3.92 m. The 4.75 m span requires a beam dimension of 200*350 mm
The beam dimension required for the second span:
Bosobe side, abutment 2 (0.4 m) – 3.95 m – abutment 3 (0.37 m)
A total length of 3.92 m. The 4.75 m span requires a beam dimension of 200*350 mm

12.6 The road connecting Semendua and Bosobe with Bokoro

Parts of this road are not even drawn up on the old map. It connects further with the village Bamaba situated by the Lukenie River and further on to the bigger village Bokoro. The road from Semaza to the bridges is also in quite bad shape, especially closer to the bridges and much work is required to restore this road. There are though several small villages along this road that depend on the road for transporting goods but I do not believe that it would get prioritised before the other examined roads.

12.6.1 The river Mukaw VII

This bridge consists of several pieces of wood laid over some bridge supports made of wood logs. It is passable with both bicycle and motorcycle but not with jeeps. The Mukaw River has many little streams that cross the roads in this area and this is the seventh Mukaw stream I examined and the first on the road against Bokoro. It has no existing abutments and new concrete abutments must be constructed on both sides and reinforcements should be made on the sides of the road connecting to the stream to protect against erosion. The bridge should stretch at least two meters on each side of the river to ensure the stability of the foundation, prevent it from being damaged by erosion and to find room for the 3.15 m wide abutment. The road connecting to the river is quite small due to the erosion.

Facts collected from the stream:
Position; 3.27720 S, 18.63344 E
The stream was approximately 5.7 m wide and 1.3 m deep at the day of examination

Proposed measure for the bridge:
The bridge construction should be made with two spans with an additional abutment in the middle to ensure a long service life. It is very important to ensure some kind of protection against erosion for
the sides connecting to the stream, otherwise will the small road deteriorate to an even smaller road in a couple of years. The floods does not usually reach over the existing bridge so the bridge does not have to elevated that much over ground level, 10 cm is enough.

The proposed dimensions for this bridge are as below:
Bosobe side, abutment 1 (0.8 m) – 4.9 m – abutment 2 (0.8 m) – 4.9 m – abutment 3 (0.8 m)

The beam dimension required for the first span:
Bosobe side, abutment 1 (0.37 m) – 4.9 m – abutment 2 (0.4 m)
A total length of 5.67 m. The 4.9 m span requires a beam dimension of 200*360 mm

The beam dimension required for the second span:
Bosobe side, abutment 2 (0.4 m) – 4.9 m – abutment 3 (0.37 m)
A total length of 5.67 m. The 4.9 m span requires a beam dimension of 200*360 mm

12.6.2 The river Mukaw VIII

A handful of wood logs lies over the stream and makes it passable by foot and perhaps with a bicycle. The soil on both shores are weak and the river is often subjected to floods so the abutments must be elevated 20 cm over ground level and constructed at least two meters from the weak soil on the shore. The floods can reach up to three meter on each side during rain period.

Facts collected from the stream:
Position: 3.27774 S, 18.63298 E
The stream was approximately 6.6 m wide, 1 m deep and had a steady stream of 0.5 m/s at the day of examination.

Proposed measures for the bridge

The stream is a little too wide to let the bridge be performed with only one span, especially since the shores has weak soil and the area connecting to the bridge often is subjected to floods. An additional abutment has to be constructed in the middle of the stream along with one abutment on each shore. The bridge should be elevated 30 cm from ground level to keep the water from reaching the bridge.
during rain period. The shore should also be protected from erosion with placing rocks or concrete on the ledges of the river.

The proposed dimensions for this bridge are as below: 
*Bosobe side, abutment 1 (0.8 m) – 5.1 m – abutment 2 (0.8 m) – 5.1 m – abutment 3 (0.8 m)*

The beam dimension required for the first span: 
*Bosobe side, abutment 1 (0.37) – 5.1 m – abutment 2 (0.4 m)*
*A total length of 5.87. The 5.1 m span requires a beam dimension of 200*370 mm*

The beam dimension required for the second span:
*Bosobe side, abutment 2 (0.4 m) – 5.1 m – abutment 3 (0.37)*
*A total length of 5.87. The 5.1 m span requires a beam dimension of 200*370 mm*

12.7 The road Oshwe – Mimia

I did unfortunately not have the opportunity to examine these roads myself but I heard that they are passable with motorcycles but not with big vehicles. It is an important road that connects the north eastern part of the Mai Ndombe region with the area between Lukenie and Kassai, which further connects down to Bandundu and Kinshasa. This area is even more isolated than the area between Kassai and Lukenie. It must though first be prioritised to restore at least a couple of feeder roads to Kassai and Lukenie before this road could be restored because the first objective is to connect the whole region of Mai Ndombe with the bigger cities and therefore must at least the major roads closer to Kinshasa and Bandundu be restored first. The road Oshwe - Mimia is though in bad shape since it has not been rehabilitated for decades and there is much to do for enhancing this 190 km long road. The vegetation is deep jungle all the way so it will take a lot of effort for clearing the way from trees and grass. The road is not as bad as the road Bosobe – Oshwe since it is nowadays used by motorcycles and bicycles. There are though not many rivers on the way at all according to the chauffeurs that I talked to. The only big river that has to be crossed is the Lokoro river that is around 21 m wide.

12.7.1 The Lokoro River

The river bridge over Lokoro has three spans that consist of some old wood logs laid over the deteriorated abutments. It is quite hard to dimension this bridge exactly since I have not seen the bridges myself and can only depend on the information I got from the chauffeur from Mimia in form of the pictures taken by the chauffeur and the facts I got concerning the size of the river and the existing bridge spans. The bridge has 4 spans with two big and one small abutment in the river and two abutments on the sides. All abutments are made of old concrete. One of the abutments is 1.2 m long and 3.5 m wide and the other two bigger are quite big, 2.0 m long and 4 m wide. The river is 21 m wide and 3.5 deep at its deepest.
Proposed measures for the bridge

The abutments are elevated and are in quite good shape although their significant age. A Swedish missionary that I talked claimed that these abutments are from the age of the Belgian colonization, over 60 years ago. Some work to reinforce them is therefore surely needed but I can not know to what extent since I have not seen them on site. The proposal given for the Lokoro Bridge has the following dimensions:

Abutment – 3.5 m – pillar (1.2 m) – 3.5 m – pillar (2.0 m) – 4.5 m – pillar (2.0 m) – 4.5 m – abutment.  
A total 21.2 m not counting the outer abutments.
12.8 The road Mimia – Ipope

I have not received that much information on this road more than that it has 11 bridges with bridge spans between 4 and 7 meters and that it is very bad shape and not at all suitable for cars for now. The vegetation is deep jungle all the way and it is quite similar to the road Oshwe – Mimia. It is though important for the native population and could be become very important for a possible, future tourism attraction in the national park of Salongo that begins near Ipope. If this road could be restored along with a road connecting with the Mai Ndombe Lake with its marvellous white beaches could the first incentives be prepared for a tourism activity in the north region of the Mai Ndombe. Plans for tourism in this area lays of course in the far future but it is important to consider all aspects when planning for restoring roads that could bring new opportunities to the region.

12.8.1 The Lokeli River

This river is a bit smaller than the Lokoro River and requires 3 or 4 spans.

12.8.2 Other rivers

There are 11 small bridges that need to be restored on this way to make it passable for cars. These are all one span bridges with spans between 3 and 7 meters.
13 The projecting of the roads

An extensive plan of the roads can not be included in this report because it can not be fitted within the frames of this thesis. I will though give a summary of the proposed road project that explains the basic frames of the plans on how to implement the project and what it consists of.

13.1 The output of the road project

It is important to choose a quality of the planned roads in a very exact manner. Details that are essential to determine are for example; the exact dimensions for the road, the chosen material, ditches and maybe other erosion protection for the roads. The main objective for the development project has to be considered here to choose an appropriate level of quality for the projected roads. The main objective for the project is as previously discussed to open closed areas to the regional and national economy and not to perform new big roads, so the quality of the roads are not be of highest quality. It is a job for the state to perform big, high quality roads. The quality can not though be too low since this is a long-term project with an annual maintenance. If the quality of the road is too low will the road deteriorate quickly and the maintenance will cost too much for the proposed organization to handle and the road will go back to its originate state in some years. A protection against erosion is necessary to ensure the long term serviceability. The main deteriorating mechanisms that damages the road is the erosion, rains, vegetation and big trucks travelling the roads after big rains so it is essential to protect the roads from these mechanisms with as small means as possible. (See chapter 8 for more information concerning this.)

13.1.1 The road

When considering all important factors affecting the road and the main objectives of the project have I chosen a road according to below:

- A one lane road in each direction with a width of approximately 2 meter for each lane.
- A slope for each lane that leads the water to the ditches.
- Ditches at both sides to lead the water away from the road.
- A protection in the ditches to keep the flow rate of the rain water in the ditches low to prevent erosion from damaging the sides of the roads.

![Figure 13.1: The dimensions for the proposed road.](image)
13.2 How to perform the roads

The roads should be preformed according to the HIMO method which is done mostly by hand and not that much with machines. This will generate more money to the rural population and this is an essential factor in the restoration of the infrastructure. All road projects will be done according to the organization used in the HIMO method. The top organ in charge of the project consists of two engineers, one treasurer and one person in charge of the purchasing. It is hard to exactly point out the tasks for this organ but some of these are to steer the projects, calculating the bridges and other difficult structures. They will also administrate the work, keeping contact with the leaders of the villages as well as the teams that are out working. Below this organ are the Construction leaders that are in charge of monitoring and supporting four construction teams each. Each team consists of 20 construction workers, one foreman and one man in charge of making food and bringing water to the working group. For a more thorough summary of the road project will I have to recommend contacting me in person because a more extensive summary can not fit within the frames of this thesis.
14 Cost calculations for the roads and bridges

14.1 Cost calculations for the bridges

The material cost, (dollars):
(The cost is computed for a ten meter long bridge.)

<table>
<thead>
<tr>
<th>Material</th>
<th>Material per m</th>
<th>Total Amount needed</th>
<th>Cost per amount material</th>
<th>Total</th>
</tr>
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<td>1.5 trees/m</td>
<td>15</td>
<td>30</td>
<td>450</td>
</tr>
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<td>Cement sacks</td>
<td>4 sacks/abutment</td>
<td>12</td>
<td>20</td>
<td>240</td>
</tr>
<tr>
<td>Stone/grovel for abutments</td>
<td>5 m³/abutment</td>
<td>15</td>
<td>10</td>
<td>150</td>
</tr>
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<td>Extra foundation with stones</td>
<td>2.5 m³/abutment</td>
<td>7.5</td>
<td>10</td>
<td>75</td>
</tr>
<tr>
<td>Nails</td>
<td>3 boxes of nails/m</td>
<td>10</td>
<td>20</td>
<td>200</td>
</tr>
<tr>
<td>Steel bearing shoes</td>
<td>2/abutment,beam</td>
<td>36</td>
<td>5</td>
<td>180</td>
</tr>
<tr>
<td>Bolts for the shoes</td>
<td>2/shoes</td>
<td>72</td>
<td>1</td>
<td>72</td>
</tr>
<tr>
<td><strong>Total cost for material</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>1337</strong></td>
</tr>
</tbody>
</table>

*Table 14.1: A table giving the cost for the material needed for a 10 m long bridge.*

The work cost for the bridges, (dollars):
(One team with one boss and twenty workers is assumed to perform the bridge in ten working days.)

<table>
<thead>
<tr>
<th>Workers</th>
<th>Cost/day (or liter)</th>
<th>Amount needed</th>
<th>Total cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreman</td>
<td>4/day</td>
<td>10 days *1 worker</td>
<td>40</td>
</tr>
<tr>
<td>Construction workers</td>
<td>2/day</td>
<td>10 days * 20 workers</td>
<td>400</td>
</tr>
<tr>
<td>Water/food provider</td>
<td>2/day</td>
<td>10 days *1 worker</td>
<td>20</td>
</tr>
<tr>
<td>Night watch</td>
<td>2/day</td>
<td>10 days *1 worker</td>
<td>20</td>
</tr>
<tr>
<td>Food and water</td>
<td>0.2/day</td>
<td>10 days * 22 workers</td>
<td>44</td>
</tr>
<tr>
<td>Sawmill</td>
<td>1.5/liter</td>
<td>15 liters *10</td>
<td>225</td>
</tr>
<tr>
<td>Motor saws</td>
<td>1.5/liter</td>
<td>10 liter *10</td>
<td>150</td>
</tr>
<tr>
<td>Pickup/truck</td>
<td>1.5/liter</td>
<td>7 liter *10</td>
<td>105</td>
</tr>
<tr>
<td><strong>Total cost for work</strong></td>
<td></td>
<td></td>
<td><strong>1004</strong></td>
</tr>
</tbody>
</table>

*Table 14.2: A table giving the cost for the labour and fuel needed for a 10 m long bridge.*

Total cost for material and work = 2341 dollars for a ten meter bridge.

14.2 Cost calculations for the roads

Vehicles needed for road project (dollars):

<table>
<thead>
<tr>
<th>Vehicle/machine</th>
<th>Cost/vehicle</th>
<th>Amount needed</th>
<th>Total cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pickup</td>
<td>30 000</td>
<td>1</td>
<td>30 000</td>
</tr>
<tr>
<td>Motorcycle</td>
<td>2 000</td>
<td>4 (2 supervisors + 2 engineers)</td>
<td>8 000</td>
</tr>
<tr>
<td>Bicycle</td>
<td>100</td>
<td>10 (8 foremen + 2 extra)</td>
<td>1 000</td>
</tr>
<tr>
<td>Mobile sawmill</td>
<td>8 000</td>
<td>1</td>
<td>8 000</td>
</tr>
<tr>
<td>Diesel generator</td>
<td>2 000</td>
<td>2</td>
<td>4 000</td>
</tr>
<tr>
<td><strong>Total cost</strong></td>
<td></td>
<td></td>
<td><strong>51 000</strong></td>
</tr>
</tbody>
</table>

*Table 14.3: A table giving the cost for the vehicles and machines needed for the road project.*
Tools and equipment needed for road project (dollars):

<table>
<thead>
<tr>
<th>Tool/equipment</th>
<th>Cost/tool</th>
<th>Amount needed</th>
<th>Total cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheel barrows</td>
<td>80</td>
<td>32</td>
<td>2 560</td>
</tr>
<tr>
<td>Shovels</td>
<td>15</td>
<td>80</td>
<td>1 200</td>
</tr>
<tr>
<td>Hoes</td>
<td>20</td>
<td>80</td>
<td>1 600</td>
</tr>
<tr>
<td>Rakes</td>
<td>20</td>
<td>40</td>
<td>800</td>
</tr>
<tr>
<td>Pinch bars</td>
<td>25</td>
<td>40</td>
<td>1 000</td>
</tr>
<tr>
<td>Machetes</td>
<td>20</td>
<td>80</td>
<td>1 600</td>
</tr>
<tr>
<td>Hammers</td>
<td>10</td>
<td>40</td>
<td>400</td>
</tr>
<tr>
<td>Saws</td>
<td>25</td>
<td>40</td>
<td>1 000</td>
</tr>
<tr>
<td>Axes</td>
<td>20</td>
<td>16</td>
<td>320</td>
</tr>
<tr>
<td>Chisels</td>
<td>15</td>
<td>24</td>
<td>360</td>
</tr>
<tr>
<td>Masonry tool</td>
<td>15</td>
<td>16</td>
<td>240</td>
</tr>
<tr>
<td>Ropes for measuring the roads</td>
<td>10 (500 m)</td>
<td>8</td>
<td>80</td>
</tr>
<tr>
<td>Buckets</td>
<td>10</td>
<td>32</td>
<td>320</td>
</tr>
<tr>
<td>Pots for cocking</td>
<td>15</td>
<td>24</td>
<td>360</td>
</tr>
<tr>
<td>Cans for water</td>
<td>10</td>
<td>24</td>
<td>240</td>
</tr>
<tr>
<td>Mobile steam roller</td>
<td>100</td>
<td>8</td>
<td>800</td>
</tr>
<tr>
<td>Motor saws</td>
<td>300</td>
<td>8</td>
<td>2400</td>
</tr>
<tr>
<td>Total cost for tools and equipment</td>
<td></td>
<td></td>
<td>15280</td>
</tr>
</tbody>
</table>

*Table 14.4:* A table giving the cost for all tools and equipment needed for the road project.

Working cost per day for eight teams with the included cost for gasoline/diesel (dollars):

<table>
<thead>
<tr>
<th>Worker/vehicle/other</th>
<th>Cost per day or per L diesel</th>
<th>Amount each day</th>
<th>Total cost/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineers</td>
<td>8</td>
<td>2</td>
<td>16</td>
</tr>
<tr>
<td>Supervisor</td>
<td>6</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>Foremen</td>
<td>4</td>
<td>8</td>
<td>32</td>
</tr>
<tr>
<td>Road workers</td>
<td>2</td>
<td>160</td>
<td>320</td>
</tr>
<tr>
<td>Food/water providers</td>
<td>2</td>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td>Food and water</td>
<td>0.2</td>
<td>180</td>
<td>36</td>
</tr>
<tr>
<td>Pickup</td>
<td>1.5</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>Motorcycles</td>
<td>1.5</td>
<td>12</td>
<td>18</td>
</tr>
<tr>
<td>Total cost work cost/day</td>
<td></td>
<td></td>
<td>480</td>
</tr>
</tbody>
</table>

*Table 14.5:* A table giving the cost for all labour and fuel needed for the road project.

The labour cost is calculated according to below:

The eight teams are assumed to restore 100 m per team and day. This adds up to 100*8 meters per day which equals 800/m day. (A work of 5 m road/worker is estimated to be fulfilled every day.)

It can also be a good idea to implement some kind pay system that has a piecework rate that can reward more according to the effort they are putting into the job. 0.5 dollars/meter rehabilitated road or some thing similar. The piecework rate must though of course be changed depending on the state of the road that is to be restored if this system is going to be used.
14.3 Total cost for the road project

Total cost for Vehicles, machines, tools and all necessary equipment is as below:

\[ 51\,000 + 15\,280 = 66\,280 \text{ dollars, (20\% transport cost + loss).} \]
\[ 63\,560 \times 1.2 = 79\,536 \text{ dollars} \]

A budget of 1 million dollars for a development project will give 40\% of this amount to infrastructure, which is 400\,000 dollars.

\[ 400\,000 - 80\,000 = 250\,000 \text{ dollars (vehicles, machines and additional equipment needed)} - 2500 \times 10 \text{ (ten bridges of ten meters each included)} = 295\,000 \text{ dollars} \]

295\,000 dollars is then left for paying the workers each day restoring 800 m of roads.

\[ 295\,000 / 500 = 590 \text{ days, giving } 590 \times 800 \text{ m} = 472 \text{ km of restored including 10 bridges.} \]

Proposed roads that can be restored with this budget:

- Semendua – Camp Mpoko: 55 km
- Semendua – Bosobe: 120 km
- Bosobe – Oshwe: 80 km + 100\% extra cost* = 160 km
- Semendua – Konkeia – Isaka – Nioki: 110 km

**Total:** 445 km

* This road is in really bad shape and it will surely cost twice as much than the other roads included in this budget.

Another study and consultation with people that has more knowledge of the region is required to determine the most important roads that are to be prioritised. It must also be added that this is only a primary cost calculation and it is founded on the literature on the HIMO method, a demand for benefit made by the CEC in 2003 and information that I have received from my friend and contact in Kinshasa, Mister Papy Lefeteka, concerning prizes for the material and equipment needed.
15 Conclusions

My stay in the rural areas the DRC made a big impression on me. It was hard to see the rural population in this country with such huge opportunities be stuck in this difficult situation with extremely few possibilities to improve their quality of life by themselves. The state has let them down for decades and most incitements needed to boost the economy and ensure an acceptable level of development and fight poverty are non-existing. The most fundamental incitements needed for a society such as roads and a proper transport system are not functioning properly.

There are now two choices for benefit organizations that have a heart for the DRC. The first choice is to let it be and claim that is a job for the state, and that they can not support such projects. It is essential to understand that this state that is supposed to do its job is a state that has not been functioning properly since its start and that it already has a huge challenge of restoring over 15 000 km of roads to begin with and surely several 100 000 km more after this has been done. There are also an immense work load on improving all other important social issues such as health and education among others. This is a challenge that will cost surely over 10 billion dollars the following decade to begin with and much more in the decades to come. (All scenarios are given for a political stability in the country.) I can understand that it is very important to put the money on Health projects which I totally agree on but it is also vital to fight poverty and help Congo with its enormous challenges that lay ahead with improving the country’s economy. The project and the implementation of the proposed organization that I have presented here will also be functioning by itself in a couple of years and can continue to ensure development in a large part of one of the DRC’s 26 regions.

The area covered in my case study has also not been prioritized by the Congolese state over the years and will surely not be the most prioritized region in the restoration of the country so it will surely take many years until something overwhelming happens that can start turning things around for the people in the Mai Ndombe. The region is though very important for Kinshasa as one of the major breadbaskets for the big capital and should be given some priority but the state will probably prioritize the regions with more miners before it takes on the Mai Ndombe region.

I recommend not deserting the Congolese state with its immense job ahead and instead help were long term help can be given and implement a development project in the Mai Ndombe region. This is not a short term help but the creation of an own organization that can work independently to try to develop and help its own people to break free from its difficult situation. The proposed development project will include several important parts that will help the people in the Mai Ndombe on different areas: The rehabilitation of the minimum infrastructure required for economic growth and the creation of an independent organization, though well grounded in the eyes of the rural population as an organization working for them. This organization will support farmers with the cultivation and create many job opportunity in the region with the road rehabilitation and the implemented plantations. All this could be done for funds between one and two million dollars. A pilot study should be preformed here to further investigate the possibility of implementing a development project with the basic frames that I have given in my thesis. A discussion should at least be awakened within SIDA and the Swedish organizations that are working in the DRC if this proposed project is something that could be implemented in the future.

I am though well aware that my project proposal is not perfect but I strongly believe that the ideas can be used for improving the quality of life for the people living in the Mai Ndombe region ans possibly also other rural areas of the DRC. I do also believe that the planning on the bridges can be used for rehabilitating the bridges if something will be done in the future for restoring the infrastructure in this region.
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