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The Use of Garbage in Road Construction and Maintenance

A Literature Review
Prepared for Development Workshop

By Jeff MacDonald
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Literature Review on the Use of Garbage in Road Construction/Maintenance

1.0 Introduction

This literature review was commissioned by Development Workshop during the spring of 1995. The objective of the study was:

To conduct a documentation and resource review of literature regarding the use of garbage in road construction/maintenance with the aim of extracting experience and lessons which may be appropriate to the peri-urban situation in Luanda.

The review will consist of several parts. First, there will be a brief summary of the findings in the literature on the cases found where garbage was used as a road repair material. Limitations relating to the types of materials available, pollution, moisture levels and compaction techniques will then be outlined and **referred to the civil engineering documents attached with the study**. There then follows an annotated bibliography of the most relevant literature concerning the use of waste as a road repair material as well as works dealing with labour-intensive roads project issues of planning and management. A full bibliography of all documents reviewed will then follow.

1.1 Research Activities and Contextual Factors Considered

The information examined for this study came from several sources. First, a general search for information on the Internet was performed. Based on the responses from experts in the field of civil engineering, a search for relevant documents was conducted first at the University of Guelph Library and then at the University of Toronto Engineering Library.

The selection of information was based on knowledge of the peri-urban situation in

Luanda and on the make-up of the solid waste in the area to be used in road repair projects. The information received on the content of the solid waste in the area was as follows:

- Fines < 20 mm	43 %
- organic material	5
- paper	6
- plastics	10
- glass	4
- metals	13
- textiles	9
- other materials	11
Average density = 218 kg/m ³	

The garbage in the *musseques* was cited as being half as dense as that in the central parts of the city.

The current resources for road repair which were mentioned include a group of 70 refugees using picks and shovels, supported by a tractor and two trailers. The purchase of a small compactor in the future was also stated as a possibility.

Keeping in mind as much as possible the contextual factors of the project, several sources of literature were found on the subject which prove useful for such an endeavour.

2.0 Solid Waste and Road Construction/Repair

Much of the information on solid waste as a road repair material comes from studies done in Europe and North America. Transportation departments in the Netherlands, Germany, Britain, the United States and other OECD countries were all involved in research and testing of waste materials in highway construction and road repair. As well, some research testing was performed in parts of Africa, namely Kenya and Malawi. These studies not only examined different types of industrial and residential waste but also the potential problems with moisture, compaction and pollution which may occur.

2.1 Annotated Bibliography of Relevant Sources

Jones, R.H. and A.R. Dawson, eds. 1989. Unbound Aggregates in Roads. Butterworths. London, UK.

A good introduction into the issues surrounding the use of waste materials is an article by R.A. Macarthy printed as part of the proceedings and papers from the Unbound Aggregates in Roads conference held at the University of Nottingham in 1989. The article, General Report: Waste Alternative Materials is enclosed with this review. The important issues addressed in the paper which are relevant to the peri-urban situation of Luanda are: examination of the materials at the source for potential decomposition, particle size, particle strength, compactability and potential chemical reactions. These issues are referenced in the article to three other papers in the book namely, Penning, A., Specifications For Materials Used as an Unbound Aggregate, Suss, G.H., Natural and Waste Material - a Chance For Competition? and de Jong, E.J., Technical Note. Alternative Materials in Road Construction - an Approach For Research Implementation. These three articles are also included with the package and the main highlights of them are covered in the conclusion section of this paper.

Also included among the articles from this book is a paper by Grace, H. and D.G. Toll, entitled The Improvement of Roads in Developing Countries to Bituminous Standards Using Naturally Occurring Laterites. While material on the upgrading of gravel or dirt roads to paved ones may be outside the scope of short or medium-term project planning for Project Sambizanga, it may prove useful as a reference for long-term roads project planning.

Organization of Economic Co-operation and Development. 1977. Use of Waste Materials and By-Products in Road Construction. OECD. Paris.

The report represents the most comprehensive review of the use of waste materials in road repair and construction. It examines all types of solid waste material and their potential use in road construction and repair. Chapters one and two outline the structure of the report, provide a review of the terms used and a summary of the types of waste materials available and currently used among OECD countries. Based on the data of waste materials available in the peri-urban regions of Luanda, chapters 16-19 were selected as the most relevant material for the purposes of the roads project. These chapters include information on demolition waste, waste rubber, plastics, glass, battery cases, wood and wood by-products and food waste. Chapters 20 and 21 outline economic, environmental and energy considerations involved in using the materials and also provide general conclusions and recommendations.

It is important to note that much of the materials examined in this report were to be used in asphalt or concrete construction rather than as a base filler for roads such as those in peri-urban Luanda. The information selected was based on the availability of certain materials in the context of the project and the understanding of the uses to which they are to be put.

Ahmed, Imtiaz. 1993. Use of Waste Materials in Highway Construction. Noyes Data Corporation. Park Ridge, NJ.

Most of the content of this work is concerned with the use of industrial waste or by-products in the development of pavement technologies. However, there is a section of relevance for Project Sambizanga on the use of waste glass (pp. 45-55), which makes up approximately 4%

of the garbage in the barrios. The chemical make-up of glass and the size of the particles to be used in filling are mentioned as important factors.

Inyang, Hilary I. and Kenneth L. Bergson, eds. 1992. Utilization of Waste Materials in Civil Engineering Construction. ASCE. New York.

This book deals more generally with the issue of the uses of waste materials in all types of civil engineering projects. As with the book by Ahmed, which is cited as a reference in this work, most of the writings related to waste materials and roads are concerned with highway and pavement-related uses. Nevertheless, there are two articles which examine a variety of different waste materials and their potential use. Although most of the material within the articles is also concerned with industrial waste, they are included because they give further evidence of the types of factors one must consider when decided to use a specific waste material or not. They are also included as possible future reference for the project should different types of waste materials become available.

National Research Centre: Highway Research Board. 1973. Utilization of Waste Materials and Upgrading of Low-Quality Aggregates. Washington, DC.

The enclosed paper from this report, Recycled Concrete (pp. 1-8), has been included with this review for the same reasons. Concrete smashed to a specific size serves as a good filler for road-bases and can also be used as an aggregate in surface paving, should this become part of the project's parameters.

Millard, R.S. Road Building in the Tropics. 1993. Department of Transport. London.

The use of waste materials for the purposes of road repair projects raises the important matter of compaction. Dr. Millard's book, while focusing mainly on the development of paved highways, contains a good review (pp. 257-269) of the matters relating to the compaction of earthworks and road-beds, once the materials have been selected. While data on the types of soils available in the project site is absent, this section outlines the moisture content and compaction techniques required to secure a solid base and cover for the repaired road.

2.2 Labour-Intensive Road Construction Cases

While some of the sources in the bibliography contained no material on the use of solid waste as a road repair material, there are a few which were examined for cases where such a practise may have already been attempted. While there were none for roads in a peri-urban context, some of them outline the planning and implementation of labour-based roads projects in several developing countries.

Barwell, I.J., et al. 1985. Rural Transport in Developing Countries. Intermediate Technology Publications Ltd. London.

This book's purpose is two-fold:

- to improve understanding of the nature of the transport needs of rural people in developing countries and of the extent, and means whereby, they are currently met
- to contribute to the development of practical policies to provide transport facilities which will better meet the needs of rural communities

This book provides case studies on nine different countries namely, Malaysia, India, Nigeria, Kenya, Western Samoa, Korea, the Philippines, Tanzania and Bangladesh. They cover a variety social and geographical conditions as well as a wide variety of different means of transport. The book focuses specifically on rural transport networks and consequently pays attention to the role of simple, low-cost forms of transport and transportation activities far from the major road networks.

deVeen, J.J. 1980. The Rural Access Roads Programme: Appropriate Technology in Kenya. International Labour Organisation. Geneva.

This book is a description and analysis of the government of Kenya's Rural Access Roads Programme (RARP), started in 1974. It describes the systems and procedures developed for the programme and how problems were overcome.

The major conclusion of the book is that this particular case study demonstrated how labour-intensive construction methods can be economically and technically viable, provided that organisation and management techniques are adapted to their use. While this is much the same argument as the one put forth in the book edited by Edmonds and Howe, this book is a more detailed description of the procedures and logistics involved in project implementation than the case studies examined in the other book.

Specifically, the issues dealt with in the RARP include:

- Organisational structure
- Appropriate technology
- Design standards
- Planning at headquarters and at the survey level
- Recruitment, motivation and training of personnel

- Road maintenance

While the content is very project-specific and the project itself somewhat dated, certain management techniques or lessons, especially concerning personnel recruitment and training, may prove useful for Project Sambizanga.

Edmonds, G.A. and J.D.F.G. Howe, eds. 1980. Roads and Resources: Appropriate Technology in Road Construction in Developing Countries. International Labour Organisation. London.

This book argues for giving strong consideration to labour-intensive methods when planning and implementing road construction projects. It maintains that delays in road construction projects are not so much due to low labour productivity as to a lack of adequate project planning, proper scheduling and poor design. It supports the point that with a larger work-force that can be easily mobilized, labour-intensive roads projects can have the same gestation lag as high-technology ones.

Part I of the book addresses institutions and issues of implementation including resource use, planning and administration, equipment and appropriate technology. Part II then explores four case studies of labour-intensive roads projects in Mexico, Afghanistan, India and Iran in light of these issues.

Among the general conclusions drawn from the case studies is the need for commitment to a labour-based approach to road building. This commitment must exist at both the grassroots level, where the recipients of an improved transportation network see its direct benefits, and at

the institutional level, whether government, NGO or private sector, where the capacity to deal with inevitable problems is employed to solve them rather than adopt a more high-technology strategy.

The move from equipment-intensive to labour-based methods therefore has ramifications outside the merely technical. Popular participation and commitment become important even in the decision-making process. (p. 194)

The other major conclusion from this book is the need to integrate roads projects with other local development projects, through the complementary activities of extension, social and welfare services, if the purpose of improving infrastructure is to serve as a catalyst for community development. This conclusion seems to be very compatible with the aims of Project Sambizanga.

Howe, John and Peter Richards, eds. 1984. Rural Roads and Poverty Alleviation. Intermediate Technology Publications Ltd. London.

This work has a broader scope of coverage in terms of road planning design than the other three in this section. The first two chapters are concerned with the economic context of rural roads and criteria for their planning. They offer models for analysis of roads programmes in terms of access to markets and increased personal mobility as well as some quantitative models for cost-benefit analysis in developing country contexts.

The bulk of the book, though, consists of impact studies of rural roads projects in several developing countries, namely: Egypt, India, Botswana and Thailand. The impact studies are more concerned with the effects of road development on poverty alleviation in the countries studied rather than on issues of project development, design and planning. A substantial review

of the literature on the impact of rural roads on poverty alleviation is contained in chapter three. As this may pertain to the goals or objectives of Project Sambizanga's road maintenance initiatives, this book could prove useful as a possible resource for future project evaluation. However, the rural emphasis of the book may give it only limited application to the context of Project Sambizanga.

3.0 Conclusions and Recommendations

While the literature on the use of waste materials in road repair is substantial, given the resources and scale of the project site, the available information sources become more limited. Nonetheless, the books, papers and articles cited do all suggest that the use of waste material in road repair is not only feasible, but also desirable. As well, the use of labour-intensive techniques has been strongly argued to be an effective approach to road construction/repair, if the issues of planning and management are addressed.

However, the literature also suggests that certain key considerations be taken into account when using waste as a road repair material. These are outlined below:

1) Types of materials selected

It is important to make sure that the materials selected will provide a strong and lasting roadbase. Millard (257) mentions that weight restrictions on vehicle loads in many developing countries often exceed those in Europe or North America. It is assumed that this is the case in Angola. Thus, the need for strength in the roadbed is accentuated. Materials chosen should also be low in contaminants, especially if there is potential for their seepage into groundwater supplies.

2) Mixture and Moisture

While the strength of the large waste materials used in filling road depressions is important, so too are the materials used for filling up the holes. The large amount of fines in the garbage, especially more dense ones, would be ideal for this activity, since they are of significant quantity, readily available and will reduce the amount of waste substantially. However, it is key that moisture levels among the fines be as low as possible when used, since the drying effect combined with the daily compaction of traffic may cause further depressions to occur in the same spot.

3) Compaction

The process of compaction is just as important as the selection of the waste materials to be used. If done thoroughly, the further compaction of materials by vehicles will not result in recurring depressions on the same spots.

Recommendations based on the relevant material from the sources examined and on the data supplied from the project site are as follows:

- material which decomposes quickly such as organic waste and paper should be sorted out from the rest of the available waste.
- large materials such as metals can be useful as a re-enforcing agent in larger depressions. Waste materials such as concrete and glass should be broken down to small sizes so that compaction can be as thorough as possible.
- the materials chosen as unbound filling aggregates, such as fines or gravel should have as low a moisture content as possible, whether compaction is done by hand or machine

since the natural drying effects of the fill, once it is in place, will cause settlement of the repaired area.

- the purchase of a small compactor, which was mentioned as a possibility, would prove useful for consistent quality of road-bed hardness as well as increasing labour productivity, if related issues such as energy availability and cost are manageable.

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