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Consultancy Report

(Road Costs-Value Engineering)

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for:

Chemonics Int'l

RECAP Project

USAID-Madagascar

March 17-April 02, 2001

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(In coordination with Mr. Tony Carvalho, Design Engineer)
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Summary: This consultancy consisted, for the most part, of three (3) definitive activities:

1) Researching and compiling a Handbook containing more than 20 technical reports focused specifically on proven, low-cost road design and construction activities, similar to those planned for the RE-CAP project.
2) Developing a Madagascar Value Engineering (VE) Handbook and conducting a VE Seminar for more than 20 Malagasy engineers and technical personnel.
3) Reviewing, "on- the- ground", a number of road reconstruction activities, railroad activities, and port renovations proposed in the RE-CAP project.

The more significant findings, results, and/or concerns resulting from these activities are as follows:

- A finding that two of the four major bridge structures on Route RIP-4 are dangerously close to collapse. In addition, a third bridge structure should be examined to determine the extent and effectiveness of recent (past 3 to 4 years) repairs. (Note: A fourth bridge on this route collapsed in November 2000). **Should collapse of the existing bridges occur (highly probable)** while vehicles or people are traversing these structures **the loss of life is probable. A certified bridge engineer should inspect these structures immediately and consider immediate closure of the facility or facilities.**
- The conclusion that the three most significant engineering concerns on the rural roads are drainage, drainage, drainage.
- The most significant engineering concerns related to the railway are concern for the compaction of embankments, and the sizing of drainage outlets.
- The finding that Value Engineering is new to Malagasy engineers but a subject of high interest.
- Cost control is of interest but needs a more pro-active approach.
- Construction management/engineering experience of local engineers is limited and may require reinforcing.
- The focus on vertiver, while a highly important and proven method for controlling erosion, may be so great, that other important methods and approaches are possibly being overlooked, e.g. soil nailing, devegetating or un-weighting of slopes, etc.

- The finding that routine maintenance on each of the roads reviewed was exceptionally poor - drains were plugged and often undersized, surface deformations were seldom, if ever repaired, and heavy vegetation has often over weighted back slopes, increasing landslides and plugging drains.
- Only minimal cost review was possible due to the early stages of design.

Recommendations: In response to the above findings the consultant's recommendations are as follows:

Recommendation #1. Roads. Priority #1 must be the replacing/repairing of the bridges on the first 50 Km of RIP-4. Prior to initiating the reconstruction of any RIP 4 roadway, assurance must be given by the Malagasy Government that: a) Bridge #1 will be immediately inspected and strengthened (more likely replace the sub structure and running surface; b) Bridge's #2 and #3 will have their substructures and running surfaces replaced; and c) that Bridge #4 will be replaced with a new structure, preferably a submersible bridge type structure. The Value Engineering process should be used to determine which alternative is the best value.

Recommendation #2. Roads. If there is insufficient donor/government funding to repair/replace the RIP-4 bridges and also improve the entire roadway, consideration should be given to performing only spot maintenance on the second 45 Km of RIP -4 and spend the money on the bridges. First priority for roadway improvements should be to repair/improve drainage.

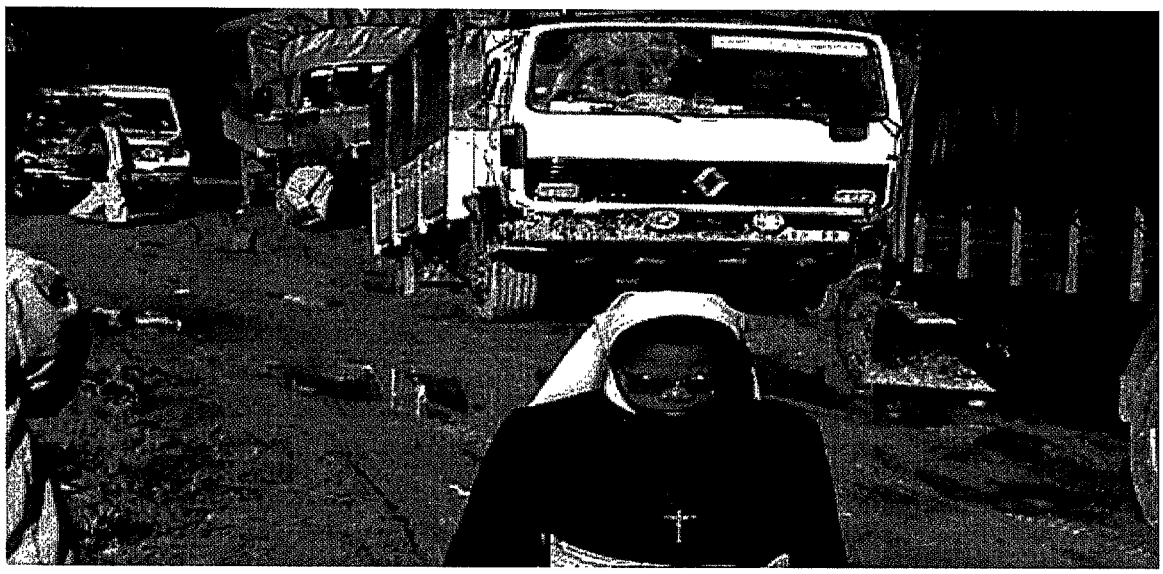

Figure 1 - A typical poorly drained roadway in need of repair.

Recommendation #3. Railway. There is clear evidence that the railway work has been well managed and a lot of work has been done for the level of funding. However, concern must be given to providing some form of mechanical compaction for the larger fills (embankments). Hand tamping alone typically leads to later failure, or as a minimum, considerable future maintenance. Funds should be made available for some form of air tampers, single-cycle diesel tampers (often called "Bongos"), or preferably vibratory plate compactors and sheepsfoot rollers. It is likely that an old "sheepsfoot" roller is lying around nearby at an old construction site that could be borrowed and used.

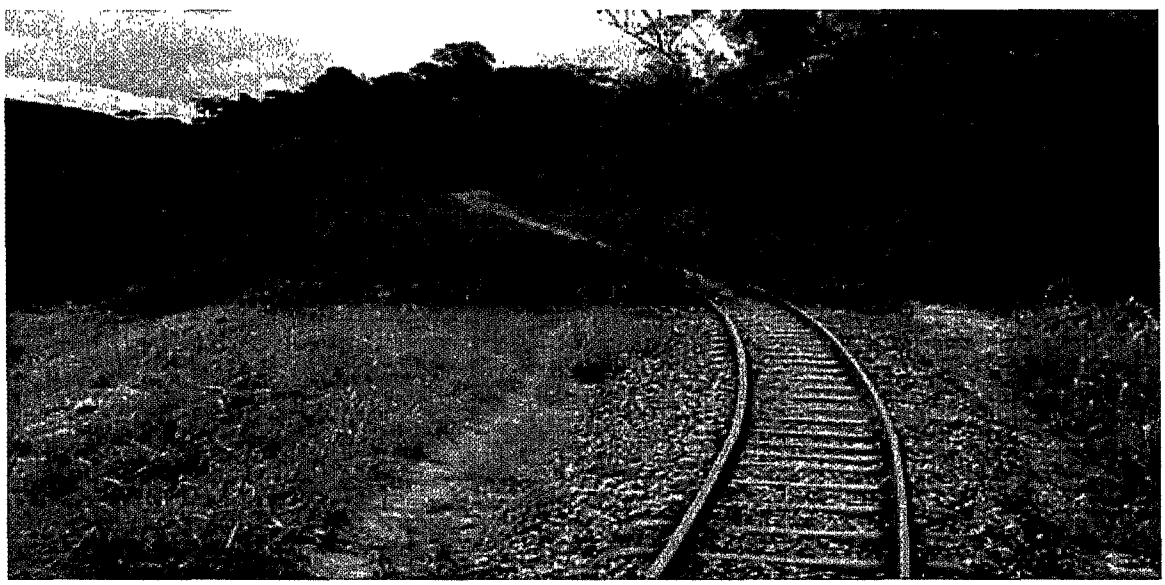

Figure 2 - Slope repaired but further work required.

Recommendation #4 - Port. This was my second visit to the port. More experienced people than I have reviewed, and will continue to review, this facility. My concern would be with doing "too much" at this site until significant import/export activity is assured. By this I mean, "repair two or three structures well - not do a little work on all 8 or 10 structures". Also there are aluminum "lighters" (barges) being used in other parts of the world that have a much shallower "draft". This type of equipment should be considered before much thought is given to breaking into the reef or doing considerable dredging in the port. The existing record of imports/exports indicates that demand may be decreasing rather than increasing.

Recommendation #5 - General. The lack of maintenance is evident everywhere (as it often is in most developing, and even developed countries). Any major investment in construction/reconstruction must be accompanied with funding for maintenance training of local personnel. Experienced personnel must lead this training.

Recommendation #6 -Value Engineering. There was insufficient design at this time to perform any detailed VE. There is a real need however to follow through with at least a minimum VE of the bridge designs. Tony and the Lalana personnel should be able to make at least an initial VE study.

Recommendation # 7 - Construction Engineering. The level of road design (straight line surveying) engineering being conducted by Lalana is appropriate for this type work. There is considerable evidence that the Malagasy engineers have a good feel for the technical aspects of rural road construction. What is less evident is if they have sufficient "pro-active" desire to "hold contractors feet to the fire". An oversight visit by an experienced rural road construction manager some two or three months after construction has started, should be given strong consideration. This would be to assure contract compliance and reinforce the Malagasy engineers they are on the right track.

Discussion:

Technical Notebook: This consultancy began with the research and compilation of a "Low-Cost Handbook" that was left with the RE-CAP office. This handbook contains more than 20, low-volume, rural road technical reports, focused on minimizing cost, maximizing value, and improving low volume rural roads. The reports all contain proven methods for improving low volume roads with minimal funds. Report titles include:

- Toward a Low-cost Structures Design Manual for Rural Roads in Developing Countries.
- Reinforced Soil for Bridge Support Applications on Low-Volume Roads.
- Prioritization Procedures for Improvement of Very Low-Volume Roads.
- Low-Level Stream Crossings in Developing Areas-South Africa.
- Management of Tertiary Road Networks in Rural Areas of South Africa.
- Determining Maintenance and Rehabilitation Programs for Low-Volume Roads Using HDM-III: Case Study from Nepal (Note: HDM-IV is now available).
- Approach Toward Provision of Low-Volume Rural Roads in Emerging Countries - South African Experience.
- Impacts of High-Intensity Rainstorms on Low-Volume Roads and Adjacent Land.
- A New Approach to Highway Drainage Design.
- Economical Structures for Low-Volume Roads.
- Launched Soil Nails: New Method for Rapid Low-Impact Slope Repairs.

These reports are taken from actual projects and/or management activities that have been accomplished by highly experienced, internationally recognized engineers and technicians. There is more than enough material here for a graduate level course in low volume road construction and management. The RE-CAP project is encouraged to translate excerpts from these reports into French for our Malagasy colleagues. While the study and understanding of this

material is important, it should be noted that, "Quality in low-volume road construction is often more dependent on timely action by experienced personnel than on technical analysis or engineering design."

Value Engineering Handbook and Seminar

Value Engineering (VE) analysis is required by law for all U.S. Federal Agencies (see FAR 48), numerous State Governments, as well as many European and Australian Agencies. The U.S. Federal Highway Administration (FHWA) regulations require that a VE study be conducted on any highway/roadway project exceeding $25.0 million. The State of Virginia requires such an effort on all projects exceeding $5.0 million. More importantly, however is the fact that a VE analysis consistently identifies more than 20% of unnecessary costs in virtually any project, process or activity. VE is a simple, straightforward process that focuses on finding different, lower cost methods, for providing the required functions at an equal or higher quality. In the case of low volume roads the opportunities for improvements are most often found in the following specific areas:

- Drainage - Use the most appropriate drainage structures, e.g. whenever possible use dips and radiers instead of culverts; use submersible bridges in lieu of elevated structures, enhance lead off ditches below the roadway and consider out sloping of roadway instead of in-sloping in certain difficult to drain areas, etc.

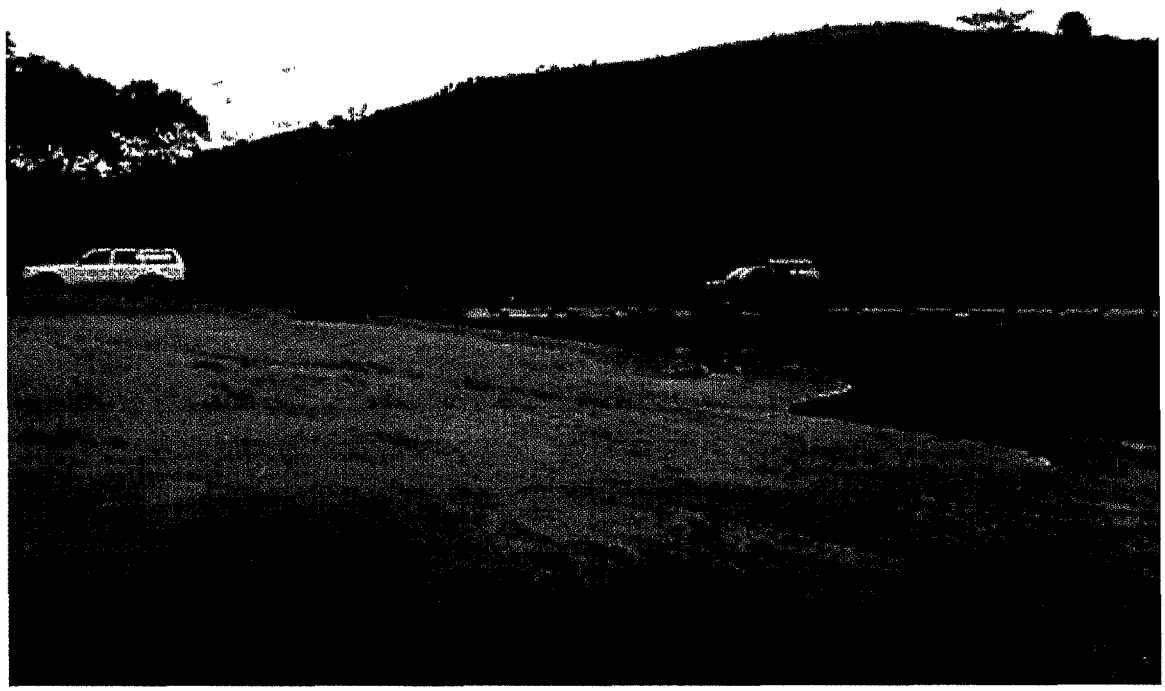

Figure 3 - Submersible Bridge - Appropriate but Expensive.

- Alignment - Consider improved, but appropriate realignment, to reduce excavation. (Note: Not a high opportunity target for the RIP-4 project.)
- Contract Preparation and Bidding - Increase marketing efforts in contract actions to increase competition. (Note: A High Opportunity Target in the RIP - 4 project due to too few contractors chasing too many jobs in Madagascar.)
- Surfacing materials - Review material specifications and material sources (use multiple borrow areas or roadside borrow to reduce haul; use larger aggregate to reduce maintenance, use alternative materials to construct bridges and radiers)
- Construction management - Review construction management procedures (focus on field design using experienced low-volume road technicians) and strengthen "pro-active" construction inspection - especially along rice paddies.
- Erosion Control - Increase slope management to prevent erosion before it starts by "ün-weighting" back slopes; and,
- Life-Cycle Costing - Focus on life cycle costs recognizing that low volume roads are more often over engineered to improve rideability, which increases speed that destroys road structure, than designed to control speed, which reduces maintenance.

The VE process and handbook were presented to an audience of Malagasy Engineers and technicians at a three-hour seminar on Friday March 23, 2001 at the American Center in Antananarivo. While few questions were raised during the seminar, numerous attendees had detailed questions immediately following the session. An additional four hours was spent during the afternoon with the Lalana staff covering how best to implement VE in the project.

Field Review (Note: Throughout the field review Mr. Carvalho (Tony) and I, along with our Malagasy counterparts, discussed the best engineering approach to use at each site. The detailed engineering will be in Tony's report. This report highlight's those design-engineering items that I feel strongly about.

Roads: Drainage, Drainage, Drainage. By far the most important design feature on low-volume roads is drainage. Drainage design is more critical on low-volume roads because the engineer cannot afford (nor can he/she economically justify) high cost structures. However, without appropriately constructed, and well-maintained drainage, failure is usually imminent and conclusive. Nowhere is this more evident than on the Madagascar roads reviewed during this consultancy. Indeed most every road traveled had above average alignment (e.g., the R-4 road alignment is outstanding) and appropriate surfacing, but failure of drainage structures (often caused by poor or non-existent maintenance) has led to failure of the roadway. For discussion purposes we will categorize drainage into three types: a) major structures, i.e. bridges - primarily the four on RIP-4, b) medium structures, i.e. box culverts, radiers, etc; and c) minor structures such as culvert pipes, rolling dips and lead off ditches.

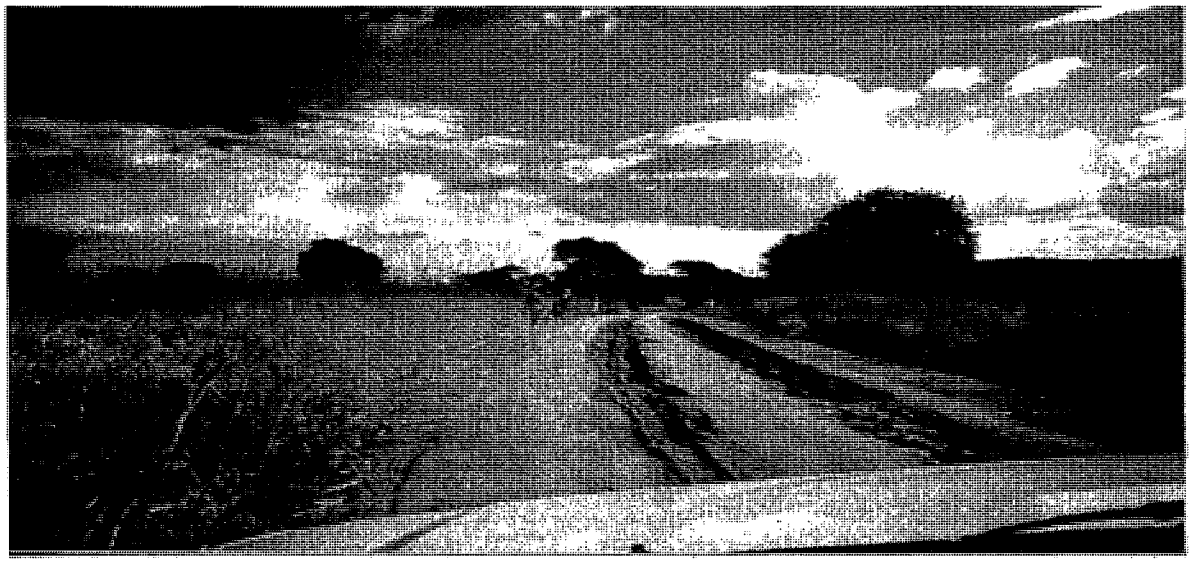

Figure 4 - Poorly drained roadways lead to saturated surfaces that lead to roadway failure.

Major Drainage Structures: Note: As stated in the summary, two of the three remaining large bridges on RIP 4 appear dangerously close to collapse. Any work or further analysis on these structures should be under the direct supervision of a specialized, certified bridge engineer (preferably from, or by, the Malagasy Authority)--- not a general, civil engineer. Public Life Safety is involved. It is the opinion of this engineer that USAID and Chemonics should consider strongly the implications of improving the roadway without certified assurance from the Malagasy government, or other donors, that funding for the replacement/repair of the bridge structures has been contractually committed. The risk of inviting the public to use a facility with hazardous features carries with it abnormally high financial and moral responsibility. Having said this, the following discussion will focus primarily on improving the four large river crossings on the RIP 4 route.

Although a detailed structural analysis was not conducted at any of the sites, this engineer has inspected enough bridges to conclude that the RIP-4 Bridge #1 structure (Km 10.2), which has been recently strengthened still appears deficient and dangerous for even 10 ton loading. What is not known is to what load level Bridge #1 has been strengthened, and/or for what estimated life. This type information is vital if sound planning is to occur. The bridge sub-structures for Bridges #2 and #3 (at Km 40.2, and approximately Km 46) appear to already have structurally failed, and appear beyond repair. A cursory review indicates that collapse is imminent (corrosion has eaten through 60 to 70% of the load carrying structural members--some members are totally gone). Bridge #4 at approximately Km 48 has collapsed. Note: The abutments at each of the sites appear useable but should be closely inspected prior to any new construction.

Figure 5 - Rusted and failing structural members

One cannot overlook the fact that Bridge #4 (the collapsed structure) is of the same type and age as Bridge #'s 1,2, and 3. In fact, a cursory visual inspection indicates that the structural materials in #4 may have even been less corroded than those on the standing structures.

When designing the bridges, consideration should be given to replacing Bridge #4 with a submersible concrete structure.

From a Value Engineering perspective, different designs and materials should be considered at each site with the focus on life cycle costing. It is possible that materials from a Bailey type structure further up the road, which has washed out and was replaced with a new submersible bridge built by the CAP project, could be salvaged for use in reconstruction efforts at Sites 1-4. It is worth a short professional analysis!

Medium Size Drainage Structures. There are a multitude of washouts on virtually every road we reviewed. In many (most?) cases these were caused by a lack of maintenance of existing structures rather than poor engineering or construction. In some locations there is need for a "low-cost" box culvert, radier, or short bridge to handle the run-off. The low-cost technical handbook referred to earlier in this report and which was left with the RE-CAP office provides 4 or 5 alternative designs that can be used in different situations and with different materials (wood, steel, concrete, plastic). Local engineers should be able to

modify several of these designs for local use. I encourage also that the Lelana engineers consider use of some of the excess rail and/or steel found along the railway for developing a "Malagasy Local Bridge/Stream Crossing Standard Design" which can be used on the medium size (4 to 6 meters in length) drainage crossings.

Small Drainage Structures. These include small culverts, cross drains and side drains. Here again there are numerous examples of failed maintenance. What should be considered is increasing the size, primarily the width, within reason, and with a concern for not increasing erosion. In a majority of the failed sites, failure occurred due to blockages by vegetation and/or too short and narrow a run-off on the down stream side of the drainage. Increasing the width - not the depth, or slope - will most likely increase the roadway's life even with poor maintenance. The same is true for drainage structures on the rail line.

End Report