Guidelines on Use of CON-AID Liquid Soil Stabilizer

4.1 Introduction

This section describes the types of roads that can be treated with CON-AID, the construction techniques and sequences for CON-AID roads as well as post construction maintenance are also provided in this chapter.

4.2 Types of Roads

CON-AID stabilization can be applied to various types of roads, including:

a. Virgin Soil Roads

- These are new roads to be constructed over virgin territory.
- Attention should be paid to the expected traffic condition as well as to the nature of the material.
- After setting out the road, all vegetation should be removed and disposed of.
- Depending on the topography, vertical alignment involving earthworks may be required. Remember that fill materials need to be compacted and possibly treated with CON-AID. Layered work is therefore necessary.
- As for the wearing course, it may be necessary to import additional material for this layer before treatment.
- Follow the normal procedures.

b. Existing Soil Roads

- These are usually tracks over virgin soils.
- There is little difference between these and virgin soil roads. However, here there may have been some consolidation that could be incorporated as part of the pavement structure.
- Should the new gridline be more that 15 cm above or below the original road surface, special consideration must be given to in-situ material as the beneficial traffic compaction may now be lost.
- Once the above has been sorted out the normal; construction may be followed.

c. Existing Multi-layered Roads

- A multi-layered gravel road is normally a road that carries heavy traffic. Careful consideration must therefore be given to traffic requirements.

- In addition, the road may be crossing over very poor material (e.g., swampy area).
- In this case, the design engineer must investigate each layer as to its use and treatment possibility.
- Some ripping and stockpiling of existing layers may be necessary if work has to be done to some of the lower layers.

d. New Multi-layer Roads

- The multi-layer design is built for a specific reason: Generally to accommodate heavy traffic.
- Each imported layer must be treated as a separate material. The compaction and proof rolling for each material must be carried out. Each layer material may require improvement by treatment with CON-AID.

4.3 Mixing and Compaction Technique

The procedure described hereafter will generally focus on roadway construction only, though CON-AID may also be applied to other forms of construction such as parking areas, virgin soils, fills, etc.

4.3.1 Machinery Required

For this method of construction, the machinery equipment required are listed as follows:

Table 4.1 List of Machinery needed for Construction

Machinery	Minimum Size	Average Production	*1.1. Remarks on Average Production*
1. **Grader** with scarifying teeth	CAT 14 G	6-8 hrs per day	Hard / heavy ripping by grader scarifier may reduce production. Spreading from dumped stockpiles will improve production
2. **Water Tanker** with pressure pump to provide even spraying	6,000 to 8,000 liters	1/2 day	Must have pump to fill / discharge water quickly from the tanker. If water source is far from site, water supply to layer will be slow. If material is very dry or clay much water loads will be required. Moisture content of layer or dumped material will affect number of tanker loads required.
3. **Pneumatic tyred roller**	10 - 12 T	1/2 day	This is a good roller to compact around stone particles and so give even compaction of layer. Use immediately shaping starts compacting from the bottom of layer to top.
4. **Vibratory / flat 3 wheel roller**	10 - 12 T	1/2 day	Rollers required to get required specified density compaction to start early from bottom to top of layer
5. **Tamping / sheepfoot roller**	10 - 12 T	1/2 day, if required	If clay material is being used for lower layer this roller should be used compacting from bottom to top of layer
6. **Rotovator or Tractor with disc harrow**		1/2 day, if required	This plant can be used to break up clods of soil and to provide good mixing

Assumed that the specified layer (15 cm) material is either in place on the road (therefore requiring ripping or scarifying for mixing to take place) or sufficient material brought from borrow pits and dumped alongside road edge for 15 cm layer to be cut in from dumped piles by grader when mixing.

Average daily production is about 300 m length x 7-9 m width x 15 cm thickness or about 1.2 km - 1.5 km / week. (i.e., 2,000 m^2 / day or 9,000 – 10,000 m^2/week)

Note:

i) If smaller grader or badly conditioned / old grader is used, the daily production rate will be slower.

ii) If a smaller water tanker with small pump is used, more water loads taking up more time will reduce production rate.

iii) Using lighter roller will result in lower densities achieved. A simple solution will be to make use of heavily loaded dump trucks (15 - 20 T) as compactor.

iv) If the plants from i) through iii) are used, the production can reduce to only 100 m per day, particularly if material is dry under very hot windy weather conditions.

v) If material is too wet to begin with, then drying to OMC + 2% may be required.

vi) With appropriate experience, the production rate can increase to approx. 1.5 - 2.0 km per week.

vii) A minimum of four (4) labours will be required to remove debris and large stones during mixing.

4.3.2 Construction Procedure

The sequence of construction illustrated in Figure 10, can be described as follows:

a) Clearing:
Remove vegetation, root systems and excessive organic topsoil material where encountered by means of a grader blade. The width, line and curves should be set out in such a manner that it can be maintained so as to ensure that construction will be possible within these boundaries.

b) Excavate side drains:
Excavate side drains adjacent to the proposed shoulder on either side of the formation using a grader, back-actor or bulldozer, placing this material to make up the required layer thickness (if the material is suitable for the layer construction) or to produce a formation fill that is at least 0.5 m above the high water flood level, and shaped at 3-5% camber or crossfall for surface drainage.

c) Layer thickness:
When the total specified thickness of the stabilized layer is between 15 and 30 cm, the stabilized layer should be constructed in 2 layers of equal thickness; when greater than 30 cm, it shall be constructed in 3 layers of equal thickness.

d) Imported material:
Imported material may be required to provide a loose (bulked) thickness of at least 200 mm if there is insufficient suitable material in position for the layer construction. Furthermore, the material control will be strength (CBR), PI (8-35%), and percentage passing 0.075 mm (15-55%). If these requirements are not met, the imported material should provide the required blending.

e) Loose layer material:
The layer material to be stabilized must be loose (to a depth of at least 200-mm) and may have to be scarified by grader to produce this condition. The bulking factor is usually between 25% and 35%.

f) Quantity of CON-AID:

The quantity of CON-AID to be applied to the stabilized section is obtained by multiplying the given field application rate (laboratory application rate (LR) supplied by headquarter multiplied by % passing the 0.425 mm sieve) by the stabilized area (length x width) for 15 cm layer thickness.

Required liters of CON-AID, R = Lx W x Application rate in liter/m^2

where: W = Width of road in meters

L = Length of construction section in meters.

R = Application rate of CON-AID in litre / m^2.

g) Quantity of water:

The percentage water required will be the difference between the optimum moisture content (OMC) and the in-situ moisture content on site. The quantity of water will thus be:

L x W x T (thickness - 15 cm) x D (required density of 2 ton/m^3, say) x MC (Difference between OMC and in situ MC) = Quantity (liters). Divide this quantity by tanker load capacity to establish the number of water tanker loads required.

h) Quantity of CON-AID per tanker:

Divide the total quantity of CON-AID required by the number of tanker loads required to yield quantity of CON-AID to be added to each tanker load. Although this is the preferred method (to use as many tanker loads as possible for more even CON-AID application), it may arise that high in-situ moisture content or short production lengths exist that may dictate that the CON-AID be added to fewer tanker loads (even only 1) with the resultant increase in the possibility of poor or uneven distribution.

i) Mixing CON-AID into water:

The mixing of CON-AID in the tanker is done by adding the required amount of CON-AID per tanker to the water and then alternatively driving the water tanker backwards and forwards over a short distance ($\pm$10 m), by circulation with water pump fitted to the tanker or the tanker traveling to site (over a long distance).

j) Mixing of materials:

The diluted solution is sprayed onto the layer while being processed by grader, Rotovator or disc harrow to break down material while removing solid large material ($\pm$ 100 mm) by hand until all the required water and CON-AID have been applied and the soil mixture is homogeneous and above OMC (1-2%). Should the material be below OMC additional water without CON-AID should be applied. If during construction, a rainstorm is about to fall the layer should be shaped into a pronounced camber and lightly compacted to prevent additional water getting into the layer being processed. If during construction, a rainstorm falls onto open work then work should be halted until the weather is sunny and/or windy when the material should be opened out to dry back to OMC + 1-2% before completing the mixing. Occasional grader cutting to open the material will help in the drying process.

k) Compaction:

The layer material should be spread by grader to provide thin uniform layer (± 5 cm) so that compaction can begin by using conventional equipment of at least 10 tons mass compacting from the lower layers to the top final layer at the correct shape and to the required specified density. When mixing clay, a tamping or sheep-foot roller is most effective. A rubber tyred roller must be used on the surface for final compaction together with other flat wheel compactors. During the compaction process, a grader should lightly skin the surface to provide the final shape. It should be noted that large stones might be dragged causing depressions or furrows. These should be filled by hand with CON-AID treated material from the roadside and compacted. If areas of course segregated material occurred on the surface, then these should be sprayed with a heavy application of water and rolled with a rubber tyred roller to produce a bound surface with fines brought up from below the surface.

Additional Notes:

Fills:

- Fills must be brought up in layered construction. Should a roller be available capable of compacting thick lifts, then the 15-cm layer thickness may be increased.
- Side slopes must be maintained at the proper safe angle. Too steep a slope can cause slips with disastrous effects.

Saturation Conditions:

- No road can float on water and special precautions must be taken in such conditions.
- Proper drainage is vital in road construction and it should be given serious prior attention.
- The road should be lifted to a height of approximately 1 meter above general ground level in low-lying areas.
- CON-AID is very useful in preventing water absorption by such fill materials.

4.3.3 Other Considerations

Opening to Traffic:

During construction and immediately after final compaction, the roadway may be opened to traffic. Any deformation should be corrected by grading and compaction before the material dries out fully.

Curing:

After the stabilized layer has been compacted to the required density and brought to the required lines and grades in accordance with the typical cross section, the completed section must be moist cured. If the layer is the uppermost layer to be stabilized, this moist-curing shall be for a minimum period of 10 days by watering 2-3 times each day with a water tanker, unless otherwise directed by the engineer. If further courses are to be added, the stabilized layer may be covered immediately after acceptance of the layer by the engineer. If this layer is not covered immediately, then moist-curing must proceed for 10 days. It should be noted that small amounts of CON-AID would remain on the road surface that may create slippery surface. However, after continual watering (curing) or a number of rainstorms, the CON-AID on the surface will be absorbed by the soil or washed off, then the surface will no longer be slippery. *It is suggested that traffic sign to be erected for this short period to notify the public of the possible slipperiness.*

Maintenance:

It must be realized that CON-AID is not a ***cementitious*** soil stabilizer. Normal wear of the gravel road surface, i.e., gravel loss, rutting and dust can be expected. To improve the surface to its original state, normal grader blade maintenance procedures must be followed. The best time to proceed with this operation is just after some rain. Treated material that has collected on the edge of the road surface as gravel loss, must be used to even out the surface irregularities. The existing surface must not be broken. If untreated material is collected from the side of the road to complete this operation the surface must be treated with very diluted application of CON-AID at a rate of ± 0.005 liter/m^2. The surface of the road can now be left for further compaction by traffic.

Reworking stabilized layer:

If at a much later date the road surface (whether surfaced or unsurfaced) has deteriorated into a bad condition (potholes, corrugations, etc.), the shape and surface can be restored by ripping or scarifying the layer, applying water (no extra CON-AID), mixing in all the material including broken down surfacing material, shaping and compaction.

Surfacing:

If surfacing is to take place, the layer moisture content must be lowered to at least *65%* of the OMC before bitumen application.

4.4 Spraying On Technique

This procedure can be considered as an acceptable alternative to the mixing method where the traffic cannot be readily diverted off an existing road, which may not give satisfactory service during rains.

In this case, consideration may be given to the application of CON-AID by spraying the diluted CON-AID water directly onto the road surface without scarifying but after light reshaping where necessary.

a. Plant required:

- Water bowser of known volume and uniform spray facility
- Motor grader.

b. Preparation of diluted CON-AID water:

- Estimate the volume of CON-AID to be applied on the assumption that the sprayed on layer is 15 cm in thickness as for the Mixing and compaction Method.
- The total quantity of CON-AID needed must now be divided into reasonable quantities to allow only small applications at any onetime. This will depend upon the amount of CON-AID: water soaking into the surface and the rate of drying so that the traffic can negotiate the road with little, if any, slipperiness.
- The whole process may require 5 to 10 applications of small amounts until the full quantity of CON-AID for the section has been applied without any runoff.
- Calculate the volume of CON-AID used.
- The ratio of CON-AID to water must be at 1: 500.

c. Application:

- Apply one full bowser load over the section evenly and at such a rate of travel that no runoff occurs.
- Allow the applied CON-AID water to penetrate into the road surface. The road may remain open to traffic.
- When dry, the next day or sooner, if required, apply, neat water to help the CON-AID to penetrate into the treated layer.
- Repeat this operation until the full quantity of CON-AID needed for the layer has been applied.

d. Maintenance:

- Reshape and smooth the treated surface as and when necessary after rains until a permanent non-rutting surface has been achieved.

5. FIELD SURVEY, QUALITY ASSURANCE AND TESTING OF CON-AID TREATED SOIL

5.1 Introduction

Field exploration and site investigation play an important role in roadway design and construction. Field and laboratory tests are performed to identify the problem areas, so that proper design and precautions can be made. During construction, testing is performed to sure that the quality of work is met with the design specifications. Post construction testing is especially important for CON-AID treated road since the behavior of CON-AID road differs from the conventional road. As explained in earlier section that CON-AID treated road has the tendency to self-adjust its properties to suit the traffic condition, and the strength of the treated soil will improve with time, hence extending the life span of the road. Whereas for conventional road, the properties of the material beneath deteriorate with time and traffic load as illustrated in Figure 11. It is, therefore, important to conduct field testing during the service of the road so that better records can be established for future design. Testing procedures for each type of field and laboratory are given in the appendix.

5.2 Pre-Construction

As mentioned in Section 4, any roadway construction will require some field exploration and laboratory testing to identify the topographic of the route and the soil type along the study area. The information collected will be used for the design of the new road or rehabilitated road. Geological and topographical maps should be obtained (if any) from government agencies for planning and design.

5.2.1 Field Survey

Field survey is essential in designing a road. The information, such as terrain and drainage conditions, soil types, possible borrow areas, should be collected during the survey. It is also advisable to interview with local people related to the local climate, weather, traffic and the sources of construction materials; this data can be very useful in design and construction.

5.2.2 Laboratory and Field Testing

As discussed in Section 3, visual soil classification should be made for soil type along the studied route should be determined. Representative in-situ or borrow pit soil samples should also be collected, say, at every km, unless there is a significant change in the topography or soil condition. Ensure that samples of different materials should be collected.

Laboratory testing, such as, Moisture content determination, Atterberg limits, grain size distribution (by sieving and hydrometer), Proctor compaction and CBR tests should be conducted to classify the soil type along the route.

DCP testing should be carried out in a staggered pattern across the length of road at a minimum rate of 5 tests per km or where significant changes in the pavement materials are noted. Attention should also be paid the existing subsoil condition as well as the drainage condition.

Since all soils containing some fines react differently with CON-AID depending on the clay mineralogy and fines content, at least 200-gram soil sample of the fines passing through the 0.425-mm sieve of the different in-situ or borrow pit soils should be sent to headquarter for *Reactivity tests*. These samples should be handed to the local CON-AID representative. CON-AID will supply the required spray rate in liter/m^2 (per 15-cm layer) after analyzing the laboratory test results.

5.3 During Construction

5.3.1 Construction Record

To ensure that acceptable quality standards are maintained during construction, the following checking / testing should be conducted during the construction period.

- material quality
- width of the layer
- layer thickness
- quantity of CON-AID added
- thorough mixing
- adequate surface camber / slope for drainage
- visual appearance

A sufficient random selection of sampling sites should be selected to ensure an unbiased decision is obtained for the test results.

5.3.2 Field and Laboratory Testing

Field testing, including moisture content determination and sand cone field density tests should be carried out to ensure that the compacted soil has satisfied the design compaction requirements. In addition, DCP tests should be also conducted to yield the equivalent CBR during construction. This information will be used to evaluate the performance of CON-AID roads at a later stage.

5.4 Post Construction

5.4.1 Site Inspection

It is extremely important to monitor both untreated and treated CON-AID sections. At the end of a year, the extent to which CON-AID has improved the wearing course performance will enable predictions to be made with fair degree of accuracy.

The aspects to monitor must include the following:

- Traffic volume - esa / ADT
- Gravel loss - by actual measurement
- Ridability - using measuring apparatus
- Dust - using measuring apparatus
- Intervals between grader blade pass required keeping road surface within acceptable limits.

Monitoring should be done at 3 month or 6 month intervals. It is suggested that for the first year, monitoring at 3 month intervals be instituted. It will be well advised that the same staff collect the information so that variations due to personal interpretations are eliminated.

5.4.2 Field and Laboratory Testing

In order to make an assessment of the rate of strength development; field testing should be carried out periodically after construction. Similarly to earlier stages, DCP tests, moisture content determination and sand cone field density tests should be conducted at prescribed chainage the CON-AID road. Tests shall be conducted whenever possible (say, monthly at beginning stage and quarterly after a year). The information will be collected to form database and to evaluate the performance of CON-AID roads, so that future CON-AID road design can be more cost effective as well as of higher quality.

6. OTHER RELATED ISSUES

6.1 Investigation into Strength Development of CON-AID Treated Materials

It has been known for sometime that CON-AID treatment, like other stabilisers, appears to develop strength over a period of time. Furthermore, the question may be asked: What is the life expectancy of a CON-AID road? This led to the investigation of some CON-AID roads that have been monitored over the years. Some case studies are presented in the section.

It should be noted that the desired tests were not always carried out during those early days. Nevertheless, interesting data came to light, and some of these are discussed herein.

6.2 Case Studies

The first investigation was done on township roads in the Free State town of Ladybrand (since these are the oldest roads known to have been treated with CON-AID).

Ladybrand is situated at the foot of an escarpment. The water table is, therefore, high and in some places, it rises to the surface in the form of springs. The materials are generally soft mudstones and decomposed dolerite. Both these materials broke down to active clays. Laboratory tests showed a CBR in the vicinity of 10 percent with a plasticity index of 12 to 15 percent. The presence of water aggravated the poor quality of the material. Dynamic cone penetrometer tests were carried out from time to time by engineers. Two roads were looked at namely Voortrekker Road and Botha Street.

6.2.1 Voortrekker Road

This road was of interest in that it was originally constructed as an ordinary township road with light traffic. Five years later, a quarry was opened at the other side of the town, and 35-ton trucks used the road as a haul road. Unfortunately, no testing was done at this time and assumptions had

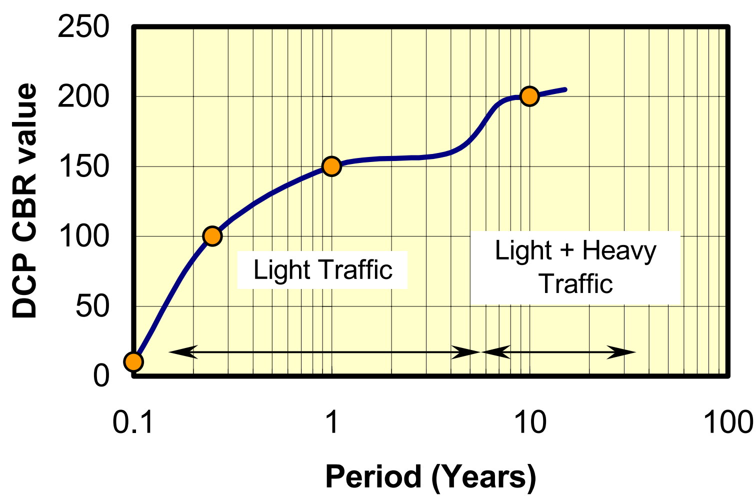

Figure 12 CBR versus Time for Voortrekker Road

to be made for this period.

The DCP-CBR plot against time illustrates the change of values of the foundation as seen in Figure 12. From the graph, it only took 3 months to raise the CBR from 10 to 100. After one year, the tendency was to level off with the existing traffic. After the quarry advent and truck traffic began to use this road, the CBR value increased once again.

6.2.2 Botha Street

This street was in a new township development that was slow in being built up, and has carried very little traffic.

The DCP test results for this road are seen in Figure 13. Due to slow development this street has had hardly any traffic. In addition, it was one of the streets from which water was seeping. Consequently, due to the absence of traffic, a high strength was not achieved at an early stage, but after eight years, the same strength as Voortrekker Road was reported.

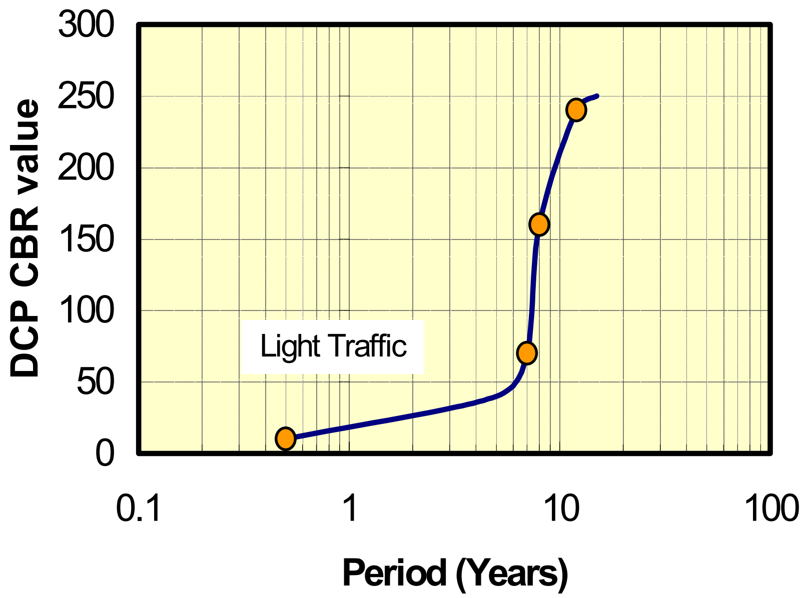

Figure 13 CBR versus Time for Botha Road

Nevertheless, both these roads never exhibited any sign of failure at any time.

6.2.3 Tzaneen SPCA Road

Tzaneen is in the tropical low areas on the eastern side of South Africa. The materials consist of highly decomposed granites due to the high rainfall. This gravel road leads to the SPCA office outside the town. The road is also used at times by heavy trucks hauling timber. Some DCP tests were carried out before construction commenced, and a CBR of 90 percent was registered as shown in Figure 14. The construction was carried out at a rather low moisture content resulting in many air voids.

Subsequent to cons-truction some heavy rains fell and the road, within 30 days, was reported be in a poor shape due to traffic destruction. The road began to recover, and at 60 days, it had the original CBR of 90%. After 120 days, the CBR was above 150.

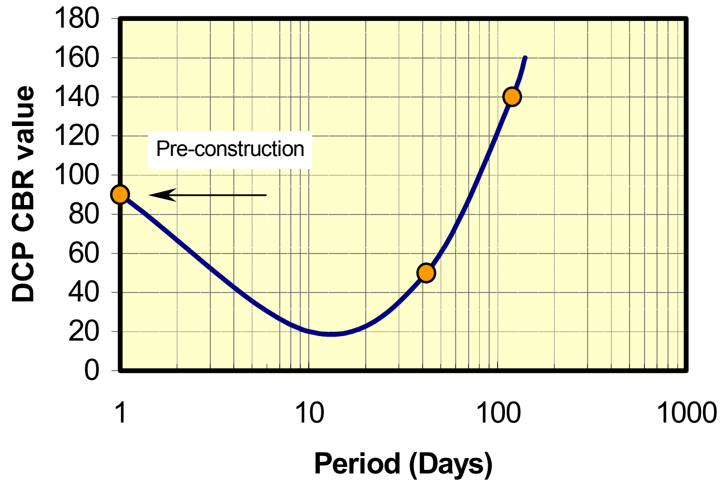

Figure 14 CBR versus Time for Tzaneen SPCA Road

In spite of having lost considerable strength due to poor construction and rain, the road recovered very well. It was reported that the road remained passable at all times although it is suspected that some rutting took place around ten days after construction.

6.2.4 Mondi Forest - Sabie

Like Tzaneen, Sabie is also on the eastern side of South Africa with a high rainfall. Sabie is extensively forested of which Mondi is one of the larger companies.

Materials are mudstones and where this road is situated, old granitic gneiss is found. Active clays are also encountered. The road is an access road to one of Mondi's sawmills. The CON-AID section was part of an investigation by CSIR to evaluate different stabilising agents. The CON-AID section did very well and a report is produced.

The DCP tests were carried out as shown in Fig. 15. The original plan was to conduct the monitoring for a number of years, but Mondi stopped it as they were satisfied that CON-AID was the product to use. An untreated control section was also done and it was monitored as well. As the road serves a sawmill, it carries high volume of heavy lumber trucks.

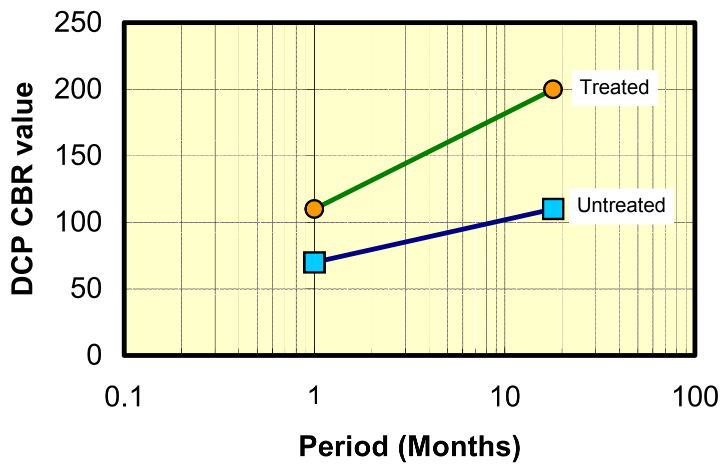

Figure 15 CBR versus Time for Mondi Forest Sabie

To make matters worse, the mill is situated in a valley so fairly steep grades exist.

Of special interest, is the fact that the control was also monitored. A comparison was therefore made of the treated against the untreated. It should be noted that after one month, the CBR of the treated section was higher than the untreated section. Although the untreated increased in strength, the difference at the 18-month period had considerably increased.

It is unfortunate that the monitoring did not continue that one might expect that the untreated material had probably reached its traffic compaction peak and the commencement of failure is expected in the untreated section. In the treated section, the strength is most likely to be still on the increase.

6.2.5 Conclusions

From the cases presented, it is evident that the CON-AID treatment goes through an initial *green* period during which the early strength is low. With the passage of time an *aged* situation is reached when the conventional strength is achieved (or exceeded). It is, therefore, necessary to take care not to overload the structure at this early stage.

It would appear that *aging* and strength development are due to:

1. The drying –out effect of the CON-AID.
2. The natural agglomeration of the clay particles due to drying out.
3. Continued traffic compaction.

Slowing down of the process on the other hand is probably caused by:

1. Continued wet conditions, or extended dry conditions.
2. Slow traffic compaction.
3. Heavy loads displacing material.

It is not possible at this point in time to give any specific time for the green period, but should sufficient data become available it might be possible. The three major factors that influences, the *green* period is:

1. Nature of material.
2. Climatic conditions.
3. Traffic conditions.

6.3 Life Span of CON-AID Stabilized Layer

In theory, CON-AID treated road will last forever if the construction procedure and instructions are followed properly, but spatial variability of subsoil and drainage is expected. An optimum design of earth road, in terms of cost and benefit, should consist of some expected failures, and 100% success is usually considered to be over-conservative. Therefore, one should expect some failures on CON-AID roads, but the rate of failure would be less than untreated road at the same construction cost.

6.3.1 Unpaved Roads

a) Gravel Loss:

Gravel loss of unpaved stabilized layers will depend on traffic volume, speed of vehicles, maintenance of the surface, type of material and climatic conditions. Generally the gravel loss of the treated wearing courses is 25% of that of the untreated wearing course. Usually, as the layer has hydrophobic properties, the moisture content stabilizes at a moisture content lower than optimum moisture content (50-60%). Drier climates and lower PI will result in increase particle loss. In dry climates, high PI materials can be used successfully as these materials, when treated will remain stable during wet spells and not deform, thus increasing the life span of the road. In wet climates, deformation and rutting will be reduced dramatically. The particles are arranged closer to each other as the adsorbed water moves from the layer. From the above, unpaved treated gravel roads will clearly not be totally dust free. Development of dust will depend on the material type and climatic condition, but will, overall, be much reduced when compared with untreated roads.

b) Maintenance:

All roads must be maintained at regular intervals. For traffic volumes of less than 300 ADT per day grading twice a year, i.e., at the beginning after the first rain and end of the rainy season will most probably sufficient. For higher ADT the grading operation will be more frequent. It is not advisable to grade a dry road surface. The best time to grade the road is just after rain. The maintenance period of untreated material for comparable traffic and material is roughly six times that of CON-AID treated materials.

6.3.2 Sealed Roads

Treating materials containing clays will result in pavement layers in which water will move more freely. If these layers are well drained materials with higher than normal specified PI levels can be used as base courses. Seals, depending on traffic volume, can then be applied on the treated materials, if a dust free road surface is a requirement.

Sealing of roads must only commence after the moisture content in the layer has been reduced to 50-60% of OMC and the typical hairline cracks in the surface have appeared (between two to four weeks depending on the traffic compaction.)

a) Pavement thickness: A further advantage is that excess CON-AID will penetrate in the presence of moisture to lower layers and will over a period of 18 months increase the effective treated pavement thickness from 15 cm to ± 30 cm. As CON-AID is adsorbed by the free cations in the clay mineral system, the reaction is permanent. DCP probes can therefore be compared between untreated and treated section

b) Layer Moisture:
The introduction of CON-AID to the soil matrix will permanently change the hydrophilic nature of the clay minerals to **hydrophobic**. Due to this process, experience has shown that the layer will have a moisture content lying around 50-60 % of OMC of the soil in question.

6.4 Do's and Don't

(b) When preparing and mixing, ensure that the operation stays within the set width of the road construction.

(c) Should the material be lumpy, ensure that the lumps are broken up sufficiently to effect an intimate mix of the soil and CON-AID water.

(d) Remove all oversized stones during the operation. If not, some *growing stones* will be experienced later on. This can cause serious tyre damage in an unsealed road. The maximum size is 50 mm but 37,5 mm is preferred.

(e) For measuring out CON-AID, ensure that containers with marked volumes or better still, graduated volumes are available. A plug with a tap fitted would ease decanting and prevent spilling.

(f) When CBR PLUS or CON-AID SUPER are used, it is advisable to pre-dilute before placing in the bowser containing water.

(g) Ensure that proper dilution takes place by driving the truck for some distance, or backward and forward.

(h) Mixing must be uniform and homogenous. Take care at the beginning and end of the section for proper valve control to ensure that the flow of CON-AID commences and ceases at the correct place.

(i) Ensure that the correct roller is used. A static flat drum roller is not effective on clay.

(j) Do not break up the surface too deep for a construction layer. If the loose material is a greater depth than the compaction ability of the roller you end up with a loose compacted layer which is bound to fail under traffic loading. The bulking factor is usually between 25% and 35%.

(k) Ensure that the shape is maintained during construction. If the road has to have a camber guard against the so-called flat crown i.e., sloping sides and flat at the centre.

(l) Remember that proper drainage is always of the utmost importance.

(m) Remember that in the early *green* stage heavy traffic could be damaging, particularly after rain.

(n) Too little CON-AID is better than over applying CON-AID. We can always add more CON-AID by spray applying. Surplus CON-AID is not easy to reduce.

(o) When mixing (particularly with a grader) ensure that the operation does not become progressively deeper and deeper. The consequences will then be the same as 1 above.

(p) Do not place the CON-AID in the bowser first. The CON-AID will settle in the lower part and be lost when the valve is opened. Furthermore, frothing will take place when the water is added afterwards.

(q) Do not confuse **dilution rate** with **application rate**. Guard against too strong a concentration in the bowser. Do not go below 1: 100 CON-AID: water, preferably. Remember: the higher the concentration, the more critical the spraying becomes to ensure an accurate uniform application of CON-AID.