3. DESIGN CONSIDERATIONS ON CON-AID TREATED ROAD

3.1 Introduction

CON-AID treatment is most suitable for poor quality soil consisting of some clayey material. With the ion exchange and water repellent properties, the treated soil has the tendency to improve its engineering properties, such as less swelling, higher density and higher strength. The section concentrates on the design issues related to CON-AID treated road, including some simple design consideration, the applicability of CON-AID and a guide to the application rate.

3.2 Information Required for Design a CON-AID Road

The following information should be collected for decision making process in the use of CON-AID.

a) *Traffic Volume Counts:* If the program involves upgrading of gravel roads, the traffic counts shall be provided at present National equivalent standard axle (esa) loads units per day, together with some estimates of expected growth rate and design life.

   Prioritization of Roads: Roads with less than 5,000 esa per day can be grouped and prioritized whilst the same can be done for roads with 5,000-7,000, 7,000-15,000 esa/day etc.

b) *Present Condition of Road and its soil properties:* Some in-situ tests, such as Dynamic Cone Penetrometer (DCP), can be performed in a staggered pattern across the length of proposed or existing road at a minimum rate of 5 tests per km or where significant changes in the pavement materials are noted. It is suggested that the existing roads be inspected and a 50 kg soil sample collected either from where variation in material type is identified or at least every 500m. Notes on road width, drainage as well as thickness of the remaining gravel should be made. The samples should be analyzed for Grading and Atterberg Limits (liquid and plastic limits and plastic index), maximum dry density and optimum moisture content and soaked CBR if required. For every road section, the soil encountered will be classified according to AASHTO or UCSC classification.

   The results of the investigation, including DCP tests and visual assessment, enable the length of road to be divided into relatively uniform sections for the purposes of rehabilitation.

c) *Locations of Borrow Pits*: Existing or possible gravel borrow pits should be identified. The position of such pits should be marked and noted, i.e., haul distance from borrow pit to road entrance and along centerline.

3.3 Applicability of CON-AID to Soil Encountered

The soil to be chemically stabilized with CON-AID shall be in-situ or borrowed material from borrow pits or commercial sources. It shall consist of a natural or artificial mixture of hard, durable soil (or gravel) or rock fragments and soils binder, free from organic material and shall conform to the following requirements:

a) The material shall fall into the AASHTO classification A-2, A-4, A-5, A-6 and A-7 with PI of 8 to 35% and percentage fine (passing the 0.075-mm sieve) between 15 and 55%:

- The material to be used should always be investigated by blending clay, sand, shingle, laterite or crushed / broken stone to the soil being stabilized.
- If % passing 0.075 mm or PI is too low, then add fines.
- If % passing 0.075 mm or PI is too high, then add stone, gravel or coarse sand.

b) The maximum dimension of course aggregate shall not exceed two-thirds of the thickness of the compacted layer.

c) Where heavier traffic encountered, consider having more than one layer of CON-AID stabilization.

d) When many stabilized layers are required, suggested CBR and compacted densities of the various layers are given below:

Table 3.1 Suggested CBR and Compacted Density Requirements for CON-AID Stabilized Layers

Soil Layer	CBR value	Compacted Density
Base	45-80	95% Mod AASHTO
Subbase	15-45	95% Mod AASHTO
Subgrade	7-15	90% Mod AASHTO

The CBR required for the project will depend upon the subgrade CBR and the traffic class. The suggested CBR can be used when there is no specification or drawing available, otherwise follow the project drawing or engineer's instruction.

e) Note that the groundwater or water used for mixing should have a pH value not exceeding 8, otherwise the reaction of CON-AID on the soils will not be fully effective.

3.4 A Guide of Application Rate

The application rate of CON-AID depends upon how reactive the clay mineral in the material is to CON-AID. Although clay minerals are relatively uniform in a specific geological region, the amount of clay present at a given place may vary depending upon the grading sizes of the material.

Taking the above into account, some additional information and material will be required by CON-AID Headquarter in Johannesburg. It is necessary to obtain representative samples along the road. The soil samples collected will be sieve to determine the grain size distribution (refer to the appendix for testing procedure). At least a 200 gram of the representative soil sample with grain size less than 0.425 mm will be sent to headquarter for Reactivity test together with the grain size results of the original soil.

The reactivity test performed will determine the effective of CON-AID on the soil as well as providing the laboratory application rate in litre per m^2. This laboratory application rate (LR) should be multiplied by % Passing 0.425 mm Sieve to give the Field Layer application rate. It should be noted that the thickness of soil layer used is 15 cm.

A guideline of application rates using CON-AID with reference to AASHTO soil classification is provided herewith, the suggested rates shall be used when there is no reactivity test performed on the material:

Table 3.2 Suggested Application Rate on Different Soil Types

Group	Subgroup	% Passing 0.075 mm Sieve	Plasticity Index	CON-AID Application Rate (liter/m^2)	Purpose of CON-AID Products
A-1	A-1-a	15 max	6 max	0.01	Facilitate compaction
	A-1-b	25 max	6 max	0.01	Stabilize fines
	A-2-4	35 max	10 max	0.01	Facilitate compaction
	A-2-5	35 max	10 max	0.015	Stabilize silt fines
A-2					
	A-2-6	35 max	11 min	0.015	Stabilize clay fines
	A-2-7	35 max	11 min	0.020	Increase CBR
A-3		10 max	Non-Plastic	N/A	N/A
A-4		36 min	10 max	0.020	Facilitate compaction
					Stabilize silts
A-5		36 min	10 max	0.025	Stabilize clays
A-6		36 min	11 min	0.02 – 0.03	Stabilize silty clays
A-7	A-7-5	36 min	11 min	0.02 - 0.03	Increase CBR
	A-7-6	36 min	11 min	0.02 - 0.03	Improve Workability
A-8				N/A	N/A

Note :

- Excessive amount of CON-AID will increase slipperiness of the surface, hence do not over apply. If the problem of slipperiness is encountered, place a thin layer of clean sand or gravel over the treated material.

3.5 Notes on Compaction

When the compaction of any layer of soil or gravel is envisaged, it is an advantage if the achievable density can be anticipated. This compaction density of any layer during construction phase is dependent upon:

- The soil type
- The moisture content
- The strength and densification of the underlying layer(s).

Density versus Moisture Content:

The moisture content which a soil of given density can accommodate within the voids is given by:

Moisture Content, $w_c = S\left[\frac{\gamma_w}{\gamma_d} - \frac{1}{G_s}\right]$

Where:	S	=	degree of saturation
	γ_w	=	density of water = 1 ton/m^3
	γ_d	=	dry density of the compacted soil (ton/m^3)
	G_s	=	specific gravity of the particle (usually = 2.65-2.75)

Typical degree of saturation in a compacted soil during construction is between 80 and 90%. Since it is always encouraged to compact on the wet side of the optimum (moisture content) for CON-AID treated road (see Figure 9), hence the initial degree of saturation may be as high as 90%. Hence, for a given required dry density, it is possible to estimate the required field moisture content during construction by the above equation.

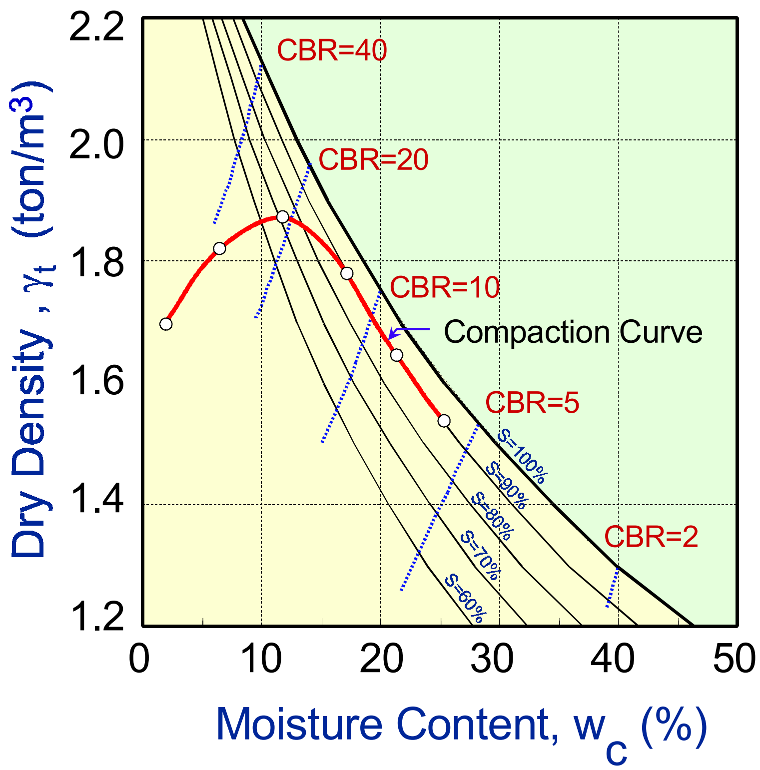

Figure 9 Typical Compaction Curve of Soil

<u>Density versus CBR value:</u>

The empirical relationship between density and soil CBR is given by:

$$\text{CBR} = \left(\frac{\gamma_d (ton / m^3)}{1.4} \right)^{10}$$

For a given soil, the CBR can be estimated based on this simple relationship. It should be emphasized that this should only be used as an initial estimate.

3.6 Other Design Issues

3.6.1 Drainage Type

Drainage is vital in roadway design. Poor drainage will lead to rapid deterioration of road when water is encountered close to the surface of the road. It is, therefore, important to provide proper drainage so that the soil beneath the road can be in a dryer state with higher strength or bearing capacity.

Water in a roadway comes from two possible sources:

- Surface water from precipitation such as run-off and flooding.
- Subsurface from seepage, high water table and capillary rise.

Surface water:

An important consideration in road construction should be to prevent water from collecting on the surface and then penetrating the base or wearing course. The road should therefore be shaped with a crown; cross-fall or super-elevation on curves with a fall of 3 – 5%. On unsurfaced roads, a slope of more than 5% often leads to erosion.

Along flat areas, it may be necessary to lift the road to facilitate run-off.

a. *Side drains:*

Water having run off the road, should not be allowed to collect on the roadside as it would penetrate into the road's foundation.

It is therefore necessary to drain off this water and any other surface water from areas alongside the road in side drains.

These side drains should be wide enough to take the expected flow of water without scouring and erosion. Flat bottomed drains are less prone to erosion than V-bottomed drains. On steeper grades some form of erosion protection is necessary.

b. *Mitre drains:*

In order to relieve the volume and velocity of flow in the side drains it is advisable to provide mitre drains depending upon the grade. Generally closer spacing on flat grades and greater spacing on steeper grades, but not so far as to cause excessive flow velocities.

c. *Cut-off or catch-water drains:*

When a road runs in a cut along the side of a hill water flowing down the hill can overtax the side drain. To prevent this from happening it is advisable to construct a cut-off drain at the top of the cut. The soil from the drain is placed on the downhill side to form a berm (raised / elevated mound).

d. *Culverts:*

The road structure should not interfere with cross drainage of the area. To facilitate cross drainage culverts are necessary. Attention should be given to their size and inlet and outlet control.

Subsurface water:

Common causes of road failure would be a high groundwater level, seepage and even springs beneath the road especially in cuttings. Experience has shown that the majority of subsurface water failures occur in cuttings. Filtered subsurface drains are often the only remedy.

Subsurface drainage can be costly and it is advisable to consult specialised expertise. The cost however, of subsurface drainage, properly placed, is always justified.

Drains with a too low flow velocity will silt up, whereas too high velocities will lead to scouring. In such cases where the natural topography is such that water will disperse naturally, drains can be avoided with considerable cost savings and problems avoided.

When dealing with low cost, high density township roads some special attention should be given to drainage. Consideration should be given to the following facts:

- Covered areas are proportionally large, resulting in increased run-off.
- The common custom is to have swept un-vegetated areas surrounding buildings. Again run-off is increased together with transportation of silt.
- Littering is high and refuse removal inadequate.
- Drains must be of a `larger capacity than normally provided for in townships.
- Wherever possible grade velocities must be such to permit the transport of silts.
- Since the amount of silt and debris is high, pipes tend to block very readily. To overcome this problem (and save costs) a shallow stone pitched gully may be a better alternative.
- Obviously a further consideration when considering the size of drains) is the rainfall pattern. The summer rainfall area, with its heavy thunderstorms, would require larger capacity drains than areas with more gentle precipitation.
- As already indicated the availability of maintenance in a particular area should be born in mind when designing drains.