NATIONAL PARKS
AND
WILDLIFE SERVICE

GUIDE TO SPECIFICATION FOR CONSTRUCTION AND/OR UPGRADING OF FIRE TRAILS TO STANDARD SUITABLE FOR CARRYING 2-WHEEL DRIVE VEHICLES.

This guide is aimed to be used for works handled by Field Staff and should adequately indicate points which the Officer in Charge wishes to include in the contract documents.

The guide is relevant also as instruction for work carried out by Park staff, casual day labour or Sub Contractors.

The complete documents for a minor contract shall include:-

(a) General conditions which may consist of National Parks and Wildlife Service "Minor Contract Tender Form."

(b) Specification and Special Conditions.

(c) A simple form of Agreement which shall include a short description of the work such as starting and finishing points of the road etc. (Tender attached) Form

It shall be noted that for road works of moderate and larger size it will be necessary to produce drawings indicating horizontal and vertical alignment, curve radius, earth work quantities etc including information relevant to culverts, causeways or other structures as well as a detailed specification for the job.

The general condition and agreement applicable to moderate or larger size jobs will be "Australian Standard CA 24" of 1974.

The Guide is prepared in three parts as follows :-

1. Design Standards
2. Special Conditions.
3. Technical Specification
4. General Conditions and Form for Agreement

To facilitate selection of best alternative, explanation to a number of activities has been included in the Technical Specification.

1. DESIGN STANDARDS:

1.1. General aim of design is to produce a guide for upgrading a 4 wheel drive "trail"to a 2-wheel drive "Track" bearing in mind that a "track" is the lowest classification applicable to designation of a road.

1.2. The width of the track may vary with type of vehicles intended to be used in the area. A total road width of 4.0 metres (carriage way and shoulders) with a width of carriage way of 3.0 metres seems to meet normal requirements for this type of road. Curves may require wider carriage way depending on length of design vehicle. The design shall also include small widened areas arranged for passing of vehicles.

1.3 Curve radius are depending on design speed which in the case of tracks of type to be used in Parks may not exceed 25 km/h An acceptable minimum curve radius would be 10 metres. Bends where a vehicle can not get through in one sweep should not be allowed on a two wheel drive track.

1.4. Steepest grade to be allowed in design of tracks will be governed by type and normal surface condition as well as type of vehicle to be allowed on the track. It is recommended that steepest grade on firm surface generally shall not exceed 15%. In cases where a straight approach will allow a high entrance speed at bottom of a hill and when the uphill run is relatively short a grade of 20-25% may be allowed.

1.5 When it is anticipated that in the future a track may be upgraded to condition equal to accepted road standards the design of curves and grades should be carried out to fit as closely as possible to 50 km/h . A standard future upgrading would then involve road widening and possible surface improvement only.

2. SPECIAL CONDITIONS:

2.1. Landscape preservation.

The Contractor shall exercise care to preserve the natural landscape and shall conduct his construction operations so as to prevent any unnecessary destruction, or defacing of the natural surroundings in the vicinity of the work.

Except where clearing is required for the trail all trees, native shrubbery and vegetation shall be preserved and shall be protected from damage which may be caused by the Contractors construction equipment and operations.

Where unnecessary destruction, or defacing has occurred as a result of Contractors operation the same shall be repaired by replanting, reseeding or otherwise corrected at the Contractors expense.

2.2. Contractors Camp Sites.

Camps storage areas etc., used by the Contractor for the construction works shall be arranged in a manner to preserve the natural vegetation. The sites shall be kept tidy during the construction. After completion of work all areas used by the Contractor have to be cleared from debris and be left in a neat and natural appearing condition.

2.3. Blasting Precautions.

In addition to relevant safety regulations the Contractor shall adopt methods when using explosives which will prevent scattering of rocks, stumps or other debris outside the defined track or road areas. Ho! Ho!

2.4. Prevention of Water Pollution.

The Contractor shall comply with current regulations concerning the control of water pollution. Mechanized equipment shall not be operated in flowing water except as necessary to move equipment over river or water course.

Sanitary wastes from camp sites shall be disposed of by burial at approved sites.

2.5. Fire Hazard and Air Pollution

Burning of materials resulting from clearing of trees and brush or from combustible construction material or rubbish will only be permitted when atmospheric conditions for burning are considered favourable by relevant fire protection authority.

Storage and handling of inflammable liquid shall be carried out in strict accordance with current regulations and safety standards.

3. TECHNICAL SPECIFICATION

3.1. Setting Out.

The setting out of horizontal and vertical alignment including required profiles is the responsibility of the contractor. In the case of upgrading an existing trail a design may not be available. The Contractor may in such case set out his proposal to centreline and grades for discussion and approval by National Parks and Wildlife Service representative prior to commencement of work.

3.2. Clearing and Grubbing.

Clearing of trees and bushes including grubbing out of all stumps , roots and logs is to be carried out over the full width of the trail (track, road) including areas of cut or fill batters, approaches and areas near in and outlet of culverts or cross drains.

The Contractor has to satisfy himself prior to tendering if cleared material may be disposed of by burning or if removal from site will be required.

3.3. Cut and Fill

Those embankments less than 2.5 metres are to be constructed in horizontal layers not greater than 0.3 metres in thickness loose measurement with each layer well compacted by suitably compacting and diverting all trucks, tractors, and other equipment over it. Where embankments are over 2.5 metres the bottom portion to within 2.5 metres of the formation level may be constructed without compaction in layers, but allowance is then to be made for subsidences by increasing the heights of the embankment by 25 mm for each 0.3 metres of vertical heights of the noncompacted portion. Fillings against bridges and culverts are, in general, to be carried up simultaneously at each abutment or side and thoroughly compacted. Where embankments are formed of stone the material is to be carefully placed so that all large stones are well distributed and empty spaces completely filled with smaller stone, earth, sand or gravel to form a solid bank.

3.3. Cut and Fill (Cont'd)

Where the natural cross slope of the ground is steeper than three (3) horizontal to one (1) vertical, the base for the bank on the lower side is to be stepped and roughened to prevent slipping, and benched to hold the toe of the embankment. Before an existing embankment is widened, the slopes are to be cleared of long grass, leaves and debris and ploughed thoroughly, to give a bond with the new material.

Road construction carried out by grading only should be avoided as such construction (NEARLY) always causes the road surface to be located below surrounding ground resulting in the road sooner or later becoming a drainage channel.

In designing the road it is advisable that road levels in excavations be selected so as to give adequate fill quantities for construction of low embankments for roads over flat country.

See also item 3.4 below.

3.4. Borrowed Material

As far as possible the construction of new roadside borrow pits is to be avoided, and no new pits are therefore to be opened up without prior approval. Exceptions are borrow pits as wide shallow depressions (BESIDE A ROAD) to lift a road surface above natural ground level. The depressions with slopes 1:4 to be revegetated where practicable. However, (WHEN POSSIBLE) cuttings are to be widened or batters flattened or rounded to provide the necessary material (FOR ANY REQUIRED FILL). Widened cuttings are to be finished with suitable batters and shoulder cross-fall. Catch drains are not to be closer than 1.5 metres to the boundary of the road reserve or 2.5 metres to the top of the batter. Generally, those cuttings where the sight distance can be improved by widening or benching are to be selected to supply borrow material.

Where borrow pits are approved, the edges are to be not less than 3.0 metres from any fence, boundary, line of earthworks or traffic route. Borrow pits are to have batters not

Borrowed Material (cont'd)

steeper than two (2) horizontal to one (1) vertical and are to be left in a neat and tidy condition, with suitable drainage. On sloping ground, in order to prevent future erosion, the borrow pits are to be terraced or constructed as a series of steps sloped back against the natural slope of the ground.

3.5. Batters.

The sides of new fills and embankments on improvement works are to be trimmed to neat batters, normally 1½ horizontal to one vertical for earth, slightly steeper for rock, and flatter for sandy material.

Batters of new cuttings are to be cut neatly and carried around curves in an even and regular manner. The batter is to be the same as that for similar types of material in the vicinity, otherwise no steeper than the following:-

Ordinary earth	1 horizontal to 1 vertical
Ordinary rock	½ horizontal to 1 vertical
Sandy material	2 horizontal to 1 vertical

3.6. Subgrade

All new embankments are to be finished with an upper layer, in general not less than 0.3 metres thick, of the best available approved sound earth, preferably gritty loam, free from clay and rock larger than 75 mm. Embankments less than 0.5 metres in depth are in general to be composed entirely of similar material. Where pavement and shoulders are not constructed as one, material for shoulders is to be specially selected. Where an old metal or gravel pavement is excavated, recovered material not required elsewhere on the work is to be used for surfacing the shoulders, and any excess after surfacing of shoulders to be used for subgrade.

Where the surface of the subgrade in cutting consists of clay or other unsound material of low-bearing value, or where unstable or soft patches develop during compaction,

Subgrade. (cont'd)

such areas are to be excavated to a minimum depth of 0.3.m and replaced with gritty loam, gravel or other approved material, well compacted by rolling. Low spots are to be built up with similar materials.

Where a roller weighting not less than 6 tons, or a sheepsfoot roller is available, compaction of subgrade is to be secured by this means in addition to traffic and grading. Where a suitable roller is not available the sub-grade is to be kept trimmed with a grader and thoroughly compacted by the passage of traffic or by loaded motor lorries.

In order to ensure adequate subsurface drainage in rock cuttings, the floor of the excavation is to be as free as possible from local depressions or pockets, and to sufficient depth to permit backfilling with suitable material to form the sub-grade, and boxed shoulders if required.

3.7. Shoulders.

Shoulders may be left slightly higher than necessary until compaction is completed providing the pavement is not likely to be damaged through drainage. When compacted, shoulders are to be graded off to the same cross fall as the pavement, the surplus material being used for widening.

3.8 Drainage.

The following means are adopted to protect the road from damage or deterioration by surface drainage :-

(a) By providing the pavement and shoulders with sufficient crown so that water is quickly shed to the sides. As far as practicable water is not to be allowed to flow longitudinally along the pavement or shoulders, particularly at the junction between the two. It is essential that the surface of the road be maintained free of depressions and to the correct cross fall. Except during construction and at super-elevated curves, shoulders are not to be higher than, or extend over, the edge of

Drainage (cont'd)

pavement, as otherwise impounded water may soak down and soften the shoulder material. Shoulders should generally have a slightly greater cross fall than the adjoining pavement.

(b) By providing properly graded table drains to collect water falling on pavement shoulders and batters, and to drain it to the nearest diversion drain, natural drainage depression, watercourse or culvert. Attention to table drains is important, as water lying therein may weaken the foundation of the road and cause failure, particularly on bitumen-surfaced roads. Table drains are therefore to be maintained true to cross section and longitudinal grading, and kept free from debris, silt and heavy growth of vegetation. On roads constructed in friable soils it is, however, often advantageous to encourage the growth of grass in the table drains and on the shoulders to protect the surface from erosion, but in such cases the grass should be kept cut reasonably short or burnt off to ensure that drainage will be unobstructed. Grassed drains and shoulders may collect silt, dust, sand and other material washed off the pavement, batters, etc., and the levels are thus often gradually raised in relation to the pavement, in which case it may be necessary to reshape the table drain and shoulder.

Table drains are to be of adequate depth, aligned parallel to the road shoulders, and suitably graded into side or diversion drains, watercourses, culverts, etc. Where steep grades cannot be avoided it may be necessary to line a drain with stone or concrete to prevent scour. Soil or debris from table drains is generally to be discarded, except where experience has shown that it is suitable for pavement or shoulder repairs. Particular attention is to be given to table drains along the higher side of super-elevated curves to prevent water

Drainage (cont'd)

spilling over the pavement and also in locations where the grade is only slight, such as on level sections of road, or in cuttings at crests, or sags in the longitudinal grade. In such places it is often necessary to deepen the drain or make it of varying depth in order to secure satisfactory drainage conditions.

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Water from table drains is to be diverted at intervals of about 100 m into outlets from catch drains, culverts or diversion drains. Where practicable, water from table drains is to be diverted at any appreciable reduction in the down grade in order to avoid deposition of silt on the flatter sections.

(c) By providing catch drains on the high side of the road to intercept surface water from catchments beyond the road limits. Catch drains are to have a cross sectional area of not less than 0.2m^2 and an effective depth of not less than 0.3 m. Catch drains are to be not less than 2.5m. from the edge of the cutting and are to be so graded (usually not flatter than 1 in 100) as to ensure free flow of water to culverts, watercourses, etc., without scouring. Experience will determine the maximum grade which will be safe against scour for each type of soil. Catch drains are to be cut in regular lines, neatly diverted around trees, as may be necessary.

It is often undesirable to interfere with natural grasses in country subject to scour, or where the entry of water into the subsoil by the cutting of the drain may affect the stability of the ground, above or below the road. In such cases level banks 0.5 m, 0.3 m wide at the top and with 1½ to 1 batters are to be constructed in lieu of catch drains. Material for such banks can often be obtained by neatly rounding the top edge of

Drainage (cont'd)

the adjoining cutting, or by borrowing from some location not subject to scour. In suitable locations where sufficient space is available within the road reserve the bank can be formed by pushing up with a grader from the lower side. Grass is to be encouraged to grow on these banks.

In country where land slides are likely to occur it may be desirable to construct additional catch drains or levee banks well away fromroad cuttings for the purpose of reducing the soakage of water into material likely to slip when saturated.

(d) By providing diversion drains or check banks wherever necessary to direct water from table and catch drains into natural drainage depressions, culverts, etc., or otherwise dispose of it without damage to road, PARK LAND, or private property. Diversion drains or check banks are to be constructed with very flat batters so as not to form an obstruction to traffic, travelling stock, etc.

(e) By cross drainage at culverts, bridges, open stormwater crossings, etc., which are to be kept free from debris, silt, stones, etc., and care taken to see that all table, catch and diversion drains are connected thereto in a satisfactory manner. The culvert or crossing should receive all the drainage from the catchment for which it was designed, as otherwise structures further along the road may be seriously overtaxed, resulting in flooding and damage to road or private property. When necessary the channel within the road reserve is to be clared to permit of the proper flow of stormwater. Where drainage easements have been obtained, or the road passes through PARK LAND, it may be necessary to CONSTRUCT channels outside the road reservation. Surface cross drains over roads shall be constructed from material of sufficient stability to take traffic without being subject to excessive erosion

3.9. Subsoil Drainage

This is required to prevent or remedy softening of the subgrade soil by water to such an extent that it becomes unstable and cannot carry loads transmitted to it, resulting in failure or distortion of the pavement. Water in the soil may be due to the following :-

(1) Water directly percolating through the road surface from above, or through the shoulders;

(2) seepage from higher ground or natural springs, particularly in cuttings in rolling or hilly country;

(3) water rising from below by capillary action, in flat country, swamps, or country affected by the rise and fall of tides.

Improvement in the first case can be effected by making the pavement more impervious and proper maintenance of shoulders. In the second and third it is necessary to lower the level of the ground water by subsoil drains or deep side ditches, or, alternatively, raising the level of the road.

In undulating or reasonably flat country, it will usually be cheaper to construct and maintain deep side drains than to install subsoil drains as in paragraph (b) below.

The usual methods of dealing with subsoil water are:-

(a) DEEP SIDE DRAINS

While often effective, these can generally be constructed only in locations which do not endanger traffic or travelling stock, generally at the edge of a widened shoulder. Drains will vary in shape depending upon whether they are constructed by grader, ditcher, elevating grader or by hand and the depth with depend on the conditions and fall to obtain a free outlet.

(b) SUBSOIL DRAINS (PIPED OR OTHERWISE)

This type of drain will usually be constructed in the shoulder area parallel with the pavement, and will extend from the source of the underground water to a point where a free outlet is obtainable, e.g., at culverts, watercourses or start of embankment. In many cases mitre drains will be needed to

Subsoil Drainage. (cont'd)

take water from under the pavement to the longitudinal subsoil drain. In cases where it is deemed desirable to place the longitudinal drain at the edge of the pavement, precautions should be taken to avoid breaking and partial collapse of the pavement edge. Subsoil drains directly beneath the table drain are undesirable because of the risk of scouring and entry of excessive quantities of silt into the drain, which in time will cause complete blockage.

Subsoil drains will normally consist of agricultural pipes, either 100 or 150mm diameter, laid open jointed in the bottom of trenches at least 0.25 m wide and to a depth not less than 0.4 m. below the level of the table drain.

Plastic (PVC) perforated subsoil chain pipes are less expensive to lay and are therefore coming into general use as a substitute for the EW - pipes.

After laying the pipes, the trenches are to be filled to within 150 mm of the surface with clean rounded gravel or crushed rock, which should pass a $\frac{3}{4}$ in. sieve and be mainly retained on a No. 52 sieve. Coarse sand, graded from $\frac{1}{8}$ in. down, is often a satisfactory alternative filling, especially in heavy clay soils. The top 150mm of the trench should be filled with impervious material well compacted. Where subsoil drains are laid under the pavement the full depth of the trench should be filled with gravel, crushed rock or coarse sand as above.

Where small quantities of water are involved and agricultural (OR OTHER SUITABLE) pipes are not readily available, it will be permissible to construct subsoil drains generally as described above but omitting the pipes. In some cases it has been the practice to backfill drains with large size broken stone, but this is to be avoided because of the tendency of the adjoining soil to fill the voids and render the drain ineffective.

All drains are to be constructed on grades of not less than 1 in 100 to proper and effective outlets and both ends are to be marked with indicator pegs clear of the roadway. Outlets are to be regularly inspected, particularly during wet weather to ensure that they are capable of discharging freely.

(c) SHOULDER DRAINS

On sections of road where the subgrade is of an impervious material, such as clay or rock, water percolating down through the pavement or shoulder is likely to collect on the subgrade or in the base course, and may eventually cause damage to the pavement. Interception of such water is therefore an important matter, particularly under bitumen pavements. This is usually done by forming shoulder drains at sags, on long grades, low points on super-elevated curves or other suitable points. Shoulder drains are usually cut at an angle of about 60 degrees to the road centre line on grades steeper than, say, 3 per cent., and at right angles on flatter grades. These drains are to be not less than 200mm wide, with inlets lower than and extending into the subgrade and should be graded through the full width of the shoulder to a free outfall. The drain should be packed with clean, tough, durable broken stone or gravel of small size. It is often desirable to add coarse sand or small screenings to the coarser material to reduce the tendency for the drain to become blocked by silt filling the voids.

(d) DRAINAGE IN ROCK CUTTINGS

The present practice when constructing box cuttings in rock is to provide, as far as possible, an even subgrade after excavation, and install longitudinal subsoil drains on each side of the pavement under the edge of the boxing. Where depressions result unavoidably from blasting operations, they are to be connected by drains cut in the rock to the main drains. These subgrade drains are at least 150mm wide and on a grade of at least 2 per cent.

Subsoil Drainage (cont'd)

In existing rock cuttings it is often necessary to install the abovementioned drainage as a maintenance matter. The need for such drainage will become apparent by the pavement showing persistent local weakness and the evidence of water pockets when repairs are undertaken.

Where no suitable outlet is available for the drainage of a small, isolated depression in a rock cutting, it is to be filled entirely to subgrade level with weak concrete (amount 1:3:6 mix) or cement stabilized gravel and the pavement then replaced in the usual manner.

(e) DRAINAGE ON LONG GRADES.

On long grades where the subgrade is of an impervious material such as clay or rock, and where the base course is of more porous material such as waterbound macadam, or free gravel, there is sometimes a tendency for water to flow longitudinally along the road through the pavement, causing failure at points lower down the grade due to an accumulation of water. Shoulder drains are not always sufficient in such cases and it may be necessary to construct transverse subsoil drains to suitable outlets in accordance with (b) above.

On long steep grades in cuttings in mountainous country it is often difficult to control the flow of stormwater in table drains. Special arrangements will often be made to construct concrete mountain-type kerb and gutter. This will permit bitumen surfacing of the shoulder, which prevents shoulder erosion and the entry of surface water.

3.10 Slope Erosion Protection

Where high embankments (cut or fill) are unavoidable slope erosion protection may be required. As the methods for construction varies within the State and depends on material available it is recommended that the District Soil Conservation Officer be consulted, for advice as to suitable method.

3.11 Pavement

Some of several available alternatives for pavement of fire trails (tracks) is enumerated below.

(a) Natural grassed surface is the ideal "pavement" when only occasional traffic is anticipated. For roads on flat rock ridges or stabilised sand and gravel ridges where no DRAINAGE is required road construction may consist of clearing and grubbing only.

(b) Various gravel type Pavements.

(a) Gravel. This is usually a naturally occurring material of graded stone, sand, silt and clay particules, which is taken from the nearest suitable deposit and spread on the formation to form a pavement of suitable depth, usually 100-200 mm (AFTER) compaction, depending on the quality and strength of the subgrade material. Gravels deficient in certain particle sizes may often be improved by introducing the missing particules from another deposit, e.g., stabilizing with sand or loam. The majority of pavements in New South Wales are of natural gravel and routine grading is the principle method of maintenance.

While it is usually desirable to have a thin, even "floating" layer of gritty material to protect the compacted gravel surface, care is to be taken that the quantity does not become excessive and thus constitute a hazard to traffic.

Harshly graded or loose surfaces may require tyning to bring up "fines" from the lower layers or, alternatively, the loose or harsh surface may be blinded with limited quantities of clayey loam. Loose gravel which cannot be stabilized immediately should be temporarily bladed to the sides .

Gravel pavements which become slippery when wet should be stabilized by blending sand or grit with the surface layer and reshaping or resheeting may at times be necessary.

(b) Shale - In areas where suitable natural gravels are not available for road pavements, it is often possible to obtain hard shales, which require quarrying and, as a result, comprise mainly large pieces. These need breaking down on the road by intensive rolling (steel tyred, cleated or sheepsfoot rollers), grading and watering until a smooth surface is obtained, containing sufficient fine material to permit maintenance by routine grading. Where rapid breaking down of shales cannot be achieved by these means, pre-crushing may be needed to minimise inconvenience to traffic. Shales should preferably be spread over the full formation width in order to facilitate breaking down, and to avoid the introduction of inferior boxing material, which would create pockets of weakness and risk of potholes in the shale.

(c) Sand-clay or loam - Maintenance of these fine-grained pavements is mainly concerned with the elimination of scours and wheel tracks, and the prevention of slippery or loose conditions. Corrugations are not normally a serious problem with sand clay pavements, unless excess sand accumulates on the surface. Sand-clay pavements do not usually attain their best condition for a considerable period after construction due to unavoidable variations in the mixture. The pavement must therefore be carefully watched and any deficiencies in the proportions of sand and clay corrected by stabilizing.

Sand-clay pavements generally require more frequent reshaping than other unsurfaced types, because of the more rapid loss of fine particules under traffic and erosion by wind and water.

(d) Fine Crushed Rock - This type of pavement is used as an alternative to gravel when the latter is not available, and is constructed from crushed aggregates carefully graded below 25 mm size, with quarry grit or other fine granular material as a filler and binder. It is costly and used only where suitable natural pavement materials are unavailable. Because of its high initial cost and tendency to unravel under traffic, it is usual to apply a bitumen seal soon after construction. If fine crushed rock is to be bitumen surfaced immediately after construction, very limited amounts of loam will be used and binding will be accomplished by controlled moisture content. Drying out will permit easy unravelling and corrugation under traffic. It is therefore necessary to continue watering, grading and rolling up to the stage of bitumen surfacing.

If bitumen surfacing is to be deferred, it is necessary to include in the pavement mixture additional controlled quantities of loamy binding material. In the latter case, maintenance will be as for gravel pavements, except that patching should be carried out using the same materials as in the pavement, carefully premixed and moistened.

(e) Broken Stone - Waterbound macadam pavements, comprising crushed rock particles of approximately 50-75 mm with voids filled with finer material were constructed extensively prior to the growth of motor traffic. Because of the rapid attrition of the finer material by motor tyres, and the difficulty in adequately maintaining the coarse surface thus exposed, the majority of such pavements are now

covered either by a bitumen surface or a running course of natural gravel.

The method could be successful for steep grades on fire trails where speed is not important.

Construction comprises spreading of the large size rock in a layer approximately 100 mm, rolling to interlock the particules, filling with about 20mm ~~wide~~ aggregate followed by crusher dust, further rolling and finally watering and continued rolling until compaction is complete. If additional pavement depth is required further layers are constructed in the same manner.

If a surface course is to be applied soon after construction is complete, maintenance is limited to rolling, watering and possible addition of crusher dust.

(c) Wheel track Strengthening.

For certain areas it may be possible to obtain a satisfactory (INEXPENSIVE) carriage way strength by gradually filling the wheel tracks with stone or gravel material.

(d) Bitumen Pavement.

Steep grades on the road (track) will require excessive maintenance of the carriageway unless the surface receives bitumen treatment.

There are several types of bitumen surface to choose from. For fire ~~t~~rails or tracks in steep country a "spray coat" seal or "penetration mecadam" may be the most likely choice. Apart from giving a rough surface and a good grip for rubber tyres the above methods only cost approximately 30 - 50% of premixed mecadam (Hot mix).

In considering the suitability or otherwise of bitumen pavement for a particular road a couple of conditions have to be taken into account. The first is the habit of bitumen pavement to "age" and deteriorate if left long times without traffic loading. Very low traffic intensity may (therefore) result in heavy maintenance.

The second condition is the danger of the bitumen pavement on the very steep hills to slide particularly during hot summer days.

If risk for any of these conditions is apparent bitumen should not be selected as paving material.

(e) Concrete Wheel Track Strips.

Concrete strips are expensive to construct but more durable than any other alternative.

The distance between strips and width of strips to be decided for each road. Strips may have to be widendd in curves. On sharp bends the space between strips may have to be constructed as a concrete slab.

Average minimum thickness of strips to be 150mm. (MAXIMAL) length of strip to be 10.0 metres. Joints between strips to be filled with bitumen impregnated (CANITE) canite. Each strip on rock to be fixed (to the rock) with 20mm rock bolts and reinforced with one centre layer A.S. 307 trench mesh.

Transverse groves 25*12 mm (approx) @ 75mm c/c on top surface to facilitate (FRICTION).

Space between strips to be filled with broken stone and arrangement to be made for (DRAINAGE) at intervals.

3.12 Finishing work

The entire road way to be surface finished after completion of earth works. The finishing will include trimming of shoulders, slopes of embankments, access areas etc., as well as a general clearing up of the area with regard to rock and soil materials.

3.13. SAFETY Railing

Considering that the trail or track type of road is fairly narrow GUARD RAIL protection may be required on certain parts of road. The Armco type GUARD RAIL is to prefer but if funds are not available for this fairly expensive (TYPE OF GUARD RAIL) timber posts and old lift wires may be used.

3.14 Structures.

Pipe drains should preferably be constructed with CULVERT 0.4 m below road surface. This will call for either properly constructed HEAD walls or gully pits.

In high country on rocky plains pipe drains are uneconomical and shall as a rule be substituted with concrete causeways.

For crossing rivers and creeks concrete causeways are most suitable at wide sites. For deep narrow creek beds the pipe culvert may be preferred but before deciding on a culvert it is necessary to consider if the restricted water way will cause a flood to rise above the road surface (TO EXTEND TO) and cause damage to the structure.

Concrete pipe culverts always require firm foundation. In swampy or soft creek beds it will be necessary to construct a raft or to construct a pile FOUNDATION to carry the concrete culvert.

Structures usually need some type of design and it is strongly recommended that in cases where the Contructor can not carry out the design as part of contract request be made to Head Office for design and specification.