ANNEX II

BASIC GUIDELINES FOR ROAD CLASSIFICATION AND STANDARDS ON TRANS-AFRICAN HIGHWAYS

I. INTRODUCTION

This Annex provides minimum norms and standards for the TAH to improve the harmonization and compatibility of the TAH networks.

The TAH classification and design standards provide the minimum standards and guidelines for the construction, improvement and maintenance of the TAH routes. These take into consideration the general criteria of road safety, road user comfort, travel time, traffic flow and overall economic benefit.

All countries and stakeholders shall make every possible effort to conform to these provisions in construction of new routes and in the upgrade of existing ones. In the built up areas, efforts should be made to streamline the existing conditions, provide proper road signage and review the intersection designs to ensure road safety is addressed. The option of providing bypass, where feasible, should also be considered.

II. BENEFITS OF HARMONIZED HIGHWAY CLASSIFICATION AND DESIGN STANDARDS

It provides technical standards for the road, route signage and the development of transport infrastructure in a coordinated manner. The benefits include:

i. A harmonized set of technical standards, road signage and improved road infrastructure that will lead to the enhancement of Africa’s economic growth;

ii. Assist countries in overcoming the current physical infrastructure impediments and in unlocking their potential to generate higher levels of social and economic development;

iii. Facilitate seamless border crossing.

III. CLASSIFICATION OF TRANS-AFRICAN HIGHWAYS

1. Definition

Trans-African Highways routes are classified as shown in Table All-1.
**Table All-1: Classification of Trans-African Highways**

<table>
<thead>
<tr>
<th>Classification</th>
<th>Description</th>
<th>Pavement Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary</td>
<td>Controlled access highways/motorways</td>
<td>Asphalt or cement concrete</td>
</tr>
<tr>
<td>Class I</td>
<td>4 or more lanes</td>
<td>Asphalt or cement concrete</td>
</tr>
<tr>
<td>Class II</td>
<td>2 lanes</td>
<td>Asphalt or cement concrete</td>
</tr>
<tr>
<td>Class III</td>
<td>2 lanes (narrow)</td>
<td>Double bituminous treatment</td>
</tr>
</tbody>
</table>

i. **Primary class highways**

Primary class highway is generally a highway designed exclusively for high-speed vehicular traffic, with all traffic flow and ingress/egress regulated. They are also known as motorway or expressway. It provides an unhindered flow of traffic, with no traffic signals, intersections or property access. They are free of any at-grade crossings with other roads, railways, or pedestrian paths, which are carried by overpasses and underpasses across the highway. Entrance and exit to the highway are provided at interchanges by slip roads (ramps), which allow for speed changes between the highway and arterial thoroughfares and collector roads. Non-Motorized vehicles such as animal drawn carts, bicycles and pedestrians are not allowed to enter the controlled access highway (with certain exceptions under very special circumstances) in order to ensure traffic safety and minimisation of any hindrance to free flow of traffic.

ii. **Class I highways**

Class I highways are dual-carriageway highways and are divided by a median and access on them is partially controlled by means of high-efficiency at-grade intersections. Interchanges may be used at certain points, with due consideration given to safety and accident prevention. Access is to be confined to a limited number of exit and entry points, and special lanes are provided for changing speed and turning at intersections. On such roads, the direct entry and exit of vehicles to and from adjacent roads and establishments is prohibited.

iii. **Class II highways**

Class II highways are the roads designed to be of medium-size in accordance with the intended volume of traffic travelling at a moderate speed with due consideration to safety. They consist of two lanes, one in each direction. These are not separated by a median strip. Intersections on such roads are at-grade. Interchanges may be used when necessary. Roads of this type may be constructed only where there is land availability or financial constraints.
iv. **Class III highways**

Class III highways are of minimum desirable standards. It is similar to class II, but, with the exception of shoulder width and pavement type.

**A. GEOMETRIC DESIGN OF HIGHWAYS**

1. **Scope**

These guidelines are for the TAH networks primarily under rural conditions. It is expected that the individual network links are not likely to acquire urban characteristics during their design life.

i. **Traffic Volumes**

The design of new routes or the upgrade of existing routes is to be based on projected traffic volumes for the design life of the road, generally 15-20 years.

ii. **Average Daily Traffic (ADT)**

This is considered for design and is generally based on the data collected over one year period. The term Annual Average Daily Traffic (AADT) is used if the available data is for the one year period.

iii. **Design Approach**

In general, higher classification routes tend to have higher design speeds and serve greater volumes of traffic. Therefore they require cross-sections with greater lane and shoulder widths.

2. **Road Surface**

**The Road Surface**

The skid resistance of the road surface is a good indicator to ensure safety on roads and minimize the potential of accidents especially during wet weather conditions. Road surface texture affects the vehicle/tyre interaction. Pavement texture plays an important role in skid resistance. Pavement texture is of two types: micro-texture with wavelengths from 0 mm up to 0.5 mm, and; macro-texture with wavelengths from 0.5 mm up to 50 mm. Micro-texture provides dry friction and is a desired road surface property. Macro-texture provides wet road friction, especially at high speeds. For roads with speeds of around 75 km/h or more, good micro and macro texture are required. Excessive macro-texture increases rolling resistance and this, results in higher fuel consumption and greater CO₂ emission contributing to global warming. A macro-texture of about 1 mm mean profile depth is an acceptable number.
3. **Sight Distance**

   i. **Barrier Sight Distance**

   It is the distance limit below which overtaking is legally prohibited. The designers should give due consideration to minimize such situations and alert drivers via road signs as required. The recommended barrier sight distances for various design speeds are presented in Table All-2

   **Table All-2: Barrier Sight Distance**

<table>
<thead>
<tr>
<th>Design speed (km/h)</th>
<th>Barrier sight distance (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>110</td>
</tr>
<tr>
<td>60</td>
<td>170</td>
</tr>
<tr>
<td>80</td>
<td>240</td>
</tr>
<tr>
<td>100</td>
<td>320</td>
</tr>
<tr>
<td>120</td>
<td>430</td>
</tr>
</tbody>
</table>

   ii. **Decision Sight Distance (DSD):**

   It is the visibility distance of the road ahead to allow the driver to take action as required. Table All-3 provides the safe stopping distance where the vehicle can be brought to a halt.

   **Table All-3: Decision Sight Distance**

<table>
<thead>
<tr>
<th>Design speed (km/h)</th>
<th>Decision sight distance (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>130</td>
</tr>
<tr>
<td>60</td>
<td>190</td>
</tr>
<tr>
<td>80</td>
<td>240</td>
</tr>
<tr>
<td>100</td>
<td>300</td>
</tr>
<tr>
<td>120</td>
<td>350</td>
</tr>
</tbody>
</table>

   iii. **Passing Sight Distance (PSD)**

   It is the distance related to the overtaking maneuver by the driver. There can be a successful overtaking maneuver or an aborted maneuver. The recommended distances are presented in Table All-4.
Table AII-4: Passing Sight Distance on Level Roads

<table>
<thead>
<tr>
<th>Design speed (km/h)</th>
<th>Passing sight distance (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Successful maneuver</td>
</tr>
<tr>
<td>40</td>
<td>290</td>
</tr>
<tr>
<td>60</td>
<td>410</td>
</tr>
<tr>
<td>80</td>
<td>540</td>
</tr>
<tr>
<td>100</td>
<td>670</td>
</tr>
<tr>
<td>120</td>
<td>800</td>
</tr>
</tbody>
</table>

4. Terrain Classification

Terrain is the vertical and horizontal dimension of land surface. This is usually expressed in terms of the elevation, slope, and orientation of terrain features. Terrain affects surface water flow and distribution. Terrain classification is shown in Table AII-5.

Table AII-5: Terrain Classification

<table>
<thead>
<tr>
<th>Terrain classification</th>
<th>Cross slope</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level (L)</td>
<td>0 to 10 per cent</td>
</tr>
<tr>
<td>Rolling (R)</td>
<td>More than 10 to 25 per cent</td>
</tr>
<tr>
<td>Mountainous (M)</td>
<td>More than 25 to 60 per cent</td>
</tr>
<tr>
<td>Steep (S)</td>
<td>More than 60 per cent</td>
</tr>
</tbody>
</table>

5. Design Speed

The design speed is that speed which is used to determine geometric features of a new road or a road for improvement/upgrade for the purpose of road design. Design speeds are based on the terrain and road classification. Speeds of 120, 100, 80, 60, 50, 40 and 30 kilometers per hour are to be used for road geometry characteristics. Design speed for various highway classification and terrain classification is presented in Table AII-6.

Table AII-6: Design Speed, Highway Classification and Terrain Classification (km/h)

<table>
<thead>
<tr>
<th>Terrain</th>
<th>Primary</th>
<th>Class I</th>
<th>Class II</th>
<th>Class III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level (L)</td>
<td>120</td>
<td>100</td>
<td>80</td>
<td>60</td>
</tr>
<tr>
<td>Rolling (R)</td>
<td>100</td>
<td>80</td>
<td>60</td>
<td>50</td>
</tr>
<tr>
<td>Mountainous (M)</td>
<td>80</td>
<td>50</td>
<td>50</td>
<td>40</td>
</tr>
<tr>
<td>Steep (S)</td>
<td>60</td>
<td>50</td>
<td>40</td>
<td>30</td>
</tr>
</tbody>
</table>
6. **Cross-section**

*Right of way* is considered as a single unit including all the below cross sectional elements. It is generally the government owned land.

The cross section of a road includes some or all of the following elements:

i. *Carriage way* (the portion of the roadway provided for the movement of vehicles, excluding shoulders);

ii. *Roadway* (the portion of a highway, including shoulders, provided for vehicular use);

iii. *Median area* (the physical or painted separation provided on divided highways between two adjacent roadways);

iv. *Shoulders*: shoulder is the part of the road reserved for pedestrians or for parking in case of emergency.

v. *Animal drawn carts, bicycle and pedestrian facilities*;

vi. *Utility and landscape areas*;

vii. *Drainage channels and side slopes*;

viii. *Clear zone width* (i.e., the distance from the edge of the carriage way to either a fixed obstacle or non-traversable slope);

Some decisions about cross section are made during project development, such as the capacity and number of lanes for the facility. Other decisions, such as functional classification, are made earlier in the process. Within these parameters, the guidelines in Table AII-7 recommend a range of values for the dimensions to use for cross sectional elements. These include right-of-way width, lane width, shoulder width, median strip width, pavement slope, and shoulder slope. Animal-drawn carts, bicycles and pedestrians should be separated from through traffic by providing roads and/or sidewalks for the sections where smooth flow of traffic and safety is affected.

**Table AII-7: Trans-African Highways Design Standards**

<table>
<thead>
<tr>
<th>Highway Classification</th>
<th>Primary</th>
<th>Class I</th>
<th>Class II</th>
<th>Class III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terrain Classification</td>
<td>L</td>
<td>R</td>
<td>M</td>
<td>S</td>
</tr>
<tr>
<td>Max Design Speed (km/h)</td>
<td>120</td>
<td>100</td>
<td>80</td>
<td>60</td>
</tr>
<tr>
<td>Width (m)</td>
<td>50</td>
<td>40</td>
<td>40</td>
<td>30</td>
</tr>
<tr>
<td>Min. Right of Way</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Min. Lane</td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
<td>3.25</td>
</tr>
<tr>
<td>Min. Shoulder</td>
<td>3.0</td>
<td>2.5</td>
<td>3.0</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>2.5</td>
<td>2.0</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>1.5 (2.0)</td>
<td>0.75 (1.5)</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Highway Classification</td>
<td>Primary</td>
<td>Class I</td>
<td>Class II</td>
<td>Class III</td>
</tr>
<tr>
<td>------------------------</td>
<td>---------</td>
<td>---------</td>
<td>----------</td>
<td>-----------</td>
</tr>
<tr>
<td>Min. Radii of Horizontal Curve (m)</td>
<td>520</td>
<td>350</td>
<td>210</td>
<td>115</td>
</tr>
<tr>
<td>Pavement Slope (%)</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2-5</td>
</tr>
<tr>
<td>Shoulder Slope (%)</td>
<td>3-6</td>
<td>3-6</td>
<td>3-6</td>
<td>3-6</td>
</tr>
<tr>
<td>Type of Pavement</td>
<td>Asphalt/cement concrete</td>
<td>Asphalt/cement concrete</td>
<td>Asphalt/cement concrete</td>
<td>Double Bitumen Surface Treatment</td>
</tr>
<tr>
<td>Max. Super-elevation (%)</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Max. Vertical Grade (%)</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>Structure Loading (Minimum)</td>
<td>HS20-44</td>
<td>HS20-44</td>
<td>HS20-44</td>
<td>HS20-44</td>
</tr>
</tbody>
</table>

**Note:** Figures in parentheses are desirable values.

For horizontal curve design, minimum curve radii should be determined in conjunction with super-elevation. The recommended width of the median can be reduced with the proper type of guard fence.

7. **Horizontal Alignment**

i. **Introduction**

Consistency of design is essential for the ease, comfort and safety of operation of the vehicle on the road. This is partly achieved by relating speed with the magnitude of successive elements of horizontal and vertical alignment. The topography of the terrain through which the road passes, determines its horizontal alignment.

ii. **Tangent**

Tangent also referred to as “straight” has two important dimensions its length and its bearing.

iii. **Length of Tangents**

The length of the tangent should neither too long or too short, but appropriate to the situation. For example if it is too long, it will make the drive monotonous risking safety and if too short, it will not allow sufficient distance in which to introduce the super elevation required to for the next curve risking safety. A minimum (desirable) tangent length of 12 km is recommended where vehicles tend to ravel at unaltered speed along tangents and round curves (a design speed of 120Km/h). For lower design speeds say 80 Km/h, a basic formula of maximum tangent length (measured in metres) could be 20
times the speed which equates to 1.6km. If the night time traffic is expected to be high, tangent length less that 12 km may be considered. Because of the head light glare, a median in the cross-section may be considered and shrubs planted. The minimum length of tangent must allow runoff of super elevation of the proceeding curve followed by development of that of the following curve. Generally a tangent length of less than 200 m is likely to be inadequate.

iv. Bearing of Tangents

Bearing of tangent is important as for example an east-west bearing will provide glare to the driver at sunrise and at sunset. A bearing due north could minimize this impact. A six percent gradient and a bearing of 5 degrees north of west will have the sun more or less resting on the centerline of the road at about 4 o’clock in the afternoon. It is recommended that the design should be evaluated; potential trouble spots identified and impact minimized by varying bearing or gradient of the road.

v. Curves

It is a recommended practice that in the process of route location, the location of a series of tangents is done first followed by the selection of curves.

a. Minimum Radii of Horizontal Curve

Minimum curve radii should be applied only when necessary and should be used in conjunction with transition curves. Compound curves should be avoided whenever possible. The minimum radii of horizontal curves are shown in Table All-8 for each highway classification.

<table>
<thead>
<tr>
<th>Terrain</th>
<th>Primary</th>
<th>Class I</th>
<th>Class II</th>
<th>Class III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level (L)</td>
<td>520 (1000)</td>
<td>350 (600)</td>
<td>210</td>
<td>115</td>
</tr>
<tr>
<td>Rolling (R)</td>
<td>350 (600)</td>
<td>210 (350)</td>
<td>115</td>
<td>80</td>
</tr>
<tr>
<td>Mountainous (M)</td>
<td>210 (350)</td>
<td>80 (110)</td>
<td>80</td>
<td>50</td>
</tr>
<tr>
<td>Steep (S)</td>
<td>115 (160)</td>
<td>80 (110)</td>
<td>50</td>
<td>30</td>
</tr>
</tbody>
</table>

Table All-8: Minimum Radii of Horizontal Curve (Unit: meter)

*Note: Figures in parentheses are desirable values.*

It is recommended that:

i. Application of the minimum curve radii be limited to unavoidable cases and values larger by 50 to 100 per cent should be applied;

ii. Combination of distance, radius and gradient of hairpin bends in the mountainous and steep terrain should be considered.

b. Transition curves
Transition curves should be applied to connect curves with radii smaller than the values shown in Table AII-9. It is also recommended that transition curves be applied even in cases where the radii are as large as twice the values in Table AII-9.

**Table AII-9: Minimum Radii for Application of Transition Curves** (Unit: meter)

<table>
<thead>
<tr>
<th>Terrain</th>
<th>Primary</th>
<th>Class I</th>
<th>Class II</th>
<th>Class III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level (L)</td>
<td>2100</td>
<td>1500</td>
<td>900</td>
<td>500</td>
</tr>
<tr>
<td>Rolling (R)</td>
<td>1500</td>
<td>900</td>
<td>500</td>
<td>350</td>
</tr>
<tr>
<td>Mountainous (M)</td>
<td>900</td>
<td>500</td>
<td>350</td>
<td>250</td>
</tr>
<tr>
<td>Steep (S)</td>
<td>500</td>
<td>500</td>
<td>250</td>
<td>130</td>
</tr>
</tbody>
</table>

The minimum transition curve length is presented in Table AII-10.

**Table AII-10: Minimum Transition Curve Length** (Unit: meter)

<table>
<thead>
<tr>
<th>Terrain</th>
<th>Primary</th>
<th>Class I</th>
<th>Class II</th>
<th>Class III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level (L)</td>
<td>100</td>
<td>85</td>
<td>70</td>
<td>50</td>
</tr>
<tr>
<td>Rolling (R)</td>
<td>85</td>
<td>70</td>
<td>50</td>
<td>40</td>
</tr>
<tr>
<td>Mountainous (M)</td>
<td>70</td>
<td>50</td>
<td>40</td>
<td>35</td>
</tr>
<tr>
<td>Steep (S)</td>
<td>50</td>
<td>50</td>
<td>35</td>
<td>25</td>
</tr>
</tbody>
</table>

c. **Successive curves**

As the topography becomes more rugged, the intervals between the curves shorten, until a stage is reached when successive curves can no longer be dealt with in isolation. This leads to reverse curve; broken-back or flat back curve; or a compound curve.

i. **A reverse curve** is a curve followed by a curve in the opposite direction. Any abrupt reversal in the alignment is to be avoided. Any reversal of alignment should include a length of connecting tangent.

ii. **A broken-back curve** is a curve followed by a curve in the same direction. These are not desirable since drivers do not accept successive curves in the same direction. In case these cannot be avoided, it is suggested that the connecting tangent should be at least 150m long with a single cross fall rather than reverting to a normal camber for short distances.

iii. **A compound curve** is a set of successive curves in the same direction but does not have an intervening tangent. It provides the flexibility in fitting the road to the terrain.

d. **Super-elevation**

As the vehicle turns when moving on a circular path, it forces itself outwards due to centrifugal force and is counterbalanced by its own weight and the road-tyre friction.
The minimum radius of curvature relevant to speed is determined based on the maximum rate of elevation and the side friction.

i. **Maximum rates of super-elevation and side friction factors**: The maximum recommended rate for the design of rural roads is 10 percent. For gravel surfaces lower rates should be applied as the vehicle will slip.

ii. **Design super-elevation rates**: The method recommended is to use super-elevation to balance all the centrifugal force generated at the average running speed, with side friction balancing additional centrifugal forces generated at high speeds.

iii. **Run-off**: It is the term used to denote the length of road needed to accomplish the change in cross-slope from a fully super elevated section to a section with the adverse camber removed. The appearance of the super-elevation runoff largely governs its length.

8. **Vertical Alignment**

i. **Introduction**

The topography of the land traversed has an influence on the alignment of roads. Topography affects horizontal alignment and vertical alignment. The vertical alignment is the combination of parabolic vertical curves and tangent sections of a particular shape. It should be as smooth as practical and economically feasible. This means that there should be a balance of cutting and filling to eliminate the rolling nature of land. As a guide, a vertical curve that coincided with a horizontal curve should as far as practical should be contained within the horizontal curve and be of same length. It is recommended that a ‘roller coaster’ or ‘hidden dip’ type of profile should be avoided as it misleads the driver in terms of availability of sight distance.

ii. **Curvature**

A vertical alignment provides a constant rate of change of gradient and a horizontal curve provides a constant rate of change of bearing.

a. **Minimum rates of curvature**

It should be determined by the sight distance as well as by comfort of operation and aesthetics.

b. **Minimum Length of Vertical Curves**

When the algebraic difference between the successive curves is less than 5%, the vertical curve is generally omitted. If it is greater than 0.5%, a minimum length of 240m is suggested for primary highways. A recommended minimum length of vertical curves for all road types other than primary highways is presented in Table All-12.
Table All-12: Minimum Lengths of Vertical Curves

<table>
<thead>
<tr>
<th>Design Speed (km/h)</th>
<th>Length of Curve (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>80</td>
</tr>
<tr>
<td>60</td>
<td>100</td>
</tr>
<tr>
<td>80</td>
<td>140</td>
</tr>
<tr>
<td>100</td>
<td>180</td>
</tr>
<tr>
<td>120</td>
<td>220</td>
</tr>
</tbody>
</table>

c. Maximum Vertical Gradient

If maximum vertical gradient is used in the design, once constructed to a given vertical grade, the highway cannot be upgraded to a lesser gradient without the loss of the entire initial investment. The maximum vertical grade for all highway classes is shown in Table All-13.

Table All-13: Maximum Vertical Grade

<table>
<thead>
<tr>
<th>Terrain Classification</th>
<th>Maximum Vertical Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level (L)</td>
<td>4 per cent</td>
</tr>
<tr>
<td>Rolling (R)</td>
<td>5 per cent</td>
</tr>
<tr>
<td>Mountainous (M)</td>
<td>6 per cent</td>
</tr>
<tr>
<td>Steep (S)</td>
<td>7 per cent</td>
</tr>
</tbody>
</table>

d. Climbing lane:

A climbing lane is an auxiliary lane added outside the continuous lanes and has the effect of reducing congestion in the through lanes by removing slower moving vehicles from the main traffic stream. In class 2 and 3, climbing lanes should be provided in upward gradient in terrains in mountainous and steep terrains. It is desirable to provide a climbing lane to up-gradient highways with heavy truck traffic where the length of the gradient exceeds the values in Table All-14. The critical length of gradient section for the provision of a climbing lane is recommended for highway classifications: Primary and Class I, as shown in Table All-14.

Table All-14: Critical Length of Gradient Section for the Provision of a Climbing Lane

<table>
<thead>
<tr>
<th>Terrain classification</th>
<th>Primary</th>
<th>Class I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level (L)</td>
<td>3% - 800m</td>
<td>3% - 900m</td>
</tr>
<tr>
<td></td>
<td>4% - 500m</td>
<td>4% - 700m</td>
</tr>
<tr>
<td>--------------------</td>
<td>-----------</td>
<td>-----------</td>
</tr>
<tr>
<td>Rolling (R)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mountainous (M)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steep (S)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

9. **Drainage**

The designer must ensure that the construction materials, particularly in the design layers, will maintain their designed bearing capacity even when saturated. It is also to be ensured that the water from the road surface drains quickly so as to minimize hydroplaning resulting in skidding. Road is not intended serve as a drain for other areas.

10. **Safety Barriers**

i. **Guardrails**

Careful consideration should be given to the installation of guardrails to enhance safety. Guard rails are traffic barriers installed on the outside of the carriageway. It should be ensured that the guard rails in themselves do not become a traffic hazard. On existing roads, an important consideration for guardrail installation is a history of accidents. In the case of new roads, it is necessary to consider whether the outcome of an accident is likely to be more serious without guardrails than with them. The installation of the guardrails should be at the edge of the outer shoulder.

ii. **Median Barriers**

These are installed on medians to reduce the likelihood of cross-median accidents or to offer protection against obstacles in the median. These are not normally used on roads with speed limits of less than 80 km/hr.

11. **Intersections:**

An *intersection* is a road junction where two or more roads either meet or cross at grade (they are at the same level). The primary objective of intersection is to ensure effective utilization of the road network and to reduce the severity of potential conflicts between vehicles or between vehicles and pedestrians/bicycles, while facilitating the necessary maneuvers. As safety, speed and cost of operation of vehicles on the network are greatly influenced by the effectiveness of its intersections; consideration should be given to its location and effective design, to optimize traffic flow with full consideration to safety.

12. **Interchanges**
An **interchange** is an intersection at which conflicts between different traffic movements are resolved by introducing a vertical separation between them. The decision to limit the access to a given road is dependent upon the desired speed and ease of flow of traffic. An interchange provides a rigid control to access. When two primary class highways intersect, the traffic volume is generally too high to provide “at grade” intersection. Under such situations an interchange is required. Interchanges also assist in enhancing road safety. There are two types of interchanges based on their function. The “access interchanges” (minor) are between expressways and roads and serve the local areas by providing access to the primary class highways. The “system interchanges” are the nodes of the primary class highway network linking the individual primary class (expressway) into a cohesive unit. This has ramps with free flowing terminals at both ends. As the volume of turning movement is high, there is a need to ensure that the ramps are designed to cater for high speeds.

13. **Pedestrians and Pedal Cyclists**

Pedestrian and pedal cyclist accidents generally occur in the proximity of towns, in densely populated rural areas such as schools, bus stops, shops and housing next to the road way. Provisions are to be made for facilities such as footways, bridges, bus stops, refuge islands, footbridges and subways; and cycle lanes depending on the volume of pedestrians, pedal cyclists and the vehicular traffic. The design decision should also take into consideration the conflict zones and accident prone areas.

i. **Footways:**

Provision of paved footways is dependent on the vehicle –pedestrian hazard. This is based on the volume of the pedestrian and vehicular traffic, and the design speed. Higher is the design speed greater is the need for footways.

ii. **Bridges**

On routes where footways are provided and there is a bridge, footways are to be continued across the bridge. The minimum footway width on the bridge structures is recommended to be 1.2 m.

iii. **Bus Stops:**

Bus stops can be a potential safety hazard and require proper designing. The elements that require consideration include: a deceleration lane for buses to provide easy entry into bus stops; a bus bay with holding area far enough from the roadway edge to eliminate sight distance issues; and a merging lane to provide re-entry of buses to the road/highway.

iv. **Refuge Islands**

Refuge islands are provided in the middle of the road to assist pedestrians cross wide or busy roads. These allow pedestrians to cross traffic flow in one direction at a time.
v. Footbridges and Subways:

These are to be provided where: there is a persistent tendency by the pedestrians to cross the highway, at grade, at specific points; there is considerable distance from other highway crossing facilities; there is track record of pedestrian/vehicle related accidents at specific locations; and there is a requirement due to topography of the location. The recommended width of foot bridges and subways should be in the range of 2.1 to 3.0 m depending upon the length of the footbridge and the subway (greater the length, greater the width).

vi. Cycle Lanes:

It is recommended that cycle lane should be provided where the number of cyclists on the road is in the order of 20-70 in an hour of the day. These lanes are to be provided on the paved shoulder and should be appropriately marked so that the vehicular traffic using the road is aware of the cyclists using the shoulder.

14. Deceleration and Acceleration Lanes

Deceleration and acceleration lanes should be provided for access to or exit from the main carriageway at interchanges or related areas. These lanes shall be of constant width and either followed or preceded by a taper.

15. Railway Intersections

It is desirable for the railway intersections with the TAH routes for the primary and Class I classification to be grade separated.

16. Vertical Clearance

Minimum vertical clearance should be 4.6 meters, which is the recommendation for safe passage of standard ISO containers.

17. Border Crossing Points

Trans-African highways cross national boundaries at many points and it is recommended that Joint Border Posts should be constructed.

B. ROAD PAVEMENT AND STRUCTURAL DESIGN CONSIDERATIONS

1. General

For a pavement to function effectively it should have: an impervious (dense) surface to minimize ingress of water; shoulders at least 1 m wide; and a minimum road camber or cross fall of 2 percent.
2. Road Pavement Design

The design process primarily has the following steps:

i. Estimation of cumulative traffic loading expected during the design life;
ii. Defining the strength of the sub-grade (soil) over which the road will be built;
iii. Defining the nominal operating climate (wet or dry);
iv. Determining any practical aspects which will influence the design selection; and
v. Selecting possible pavement structure.

3. Estimating Design Traffic Loading

i. Design Life

It is the period during which the road is expected to carry traffic at a satisfactory level of service, without requiring major rehabilitation or repair work. A design life of 15-20 years or more is recommended.

ii. Design Traffic Loading

For the design of pavements, estimation is made for Equivalent Single Axles (ESAs) in the design lane in the year of opening of the new road to traffic. This is then projected and cumulated over the design period to give the design traffic loading.

iii. Traffic Growth Rate

The selection of growth rate should be based on all available indicators including historical data, and socio economic trends.

4. Determining Sub-grade Strength

The sub-grade strength of the soil is determined in order to calculate the pavement structure including different layer thicknesses based on the designed traffic loading. The sub-grade can comprise alternatives including one or combinations of the following:

i. Sub-grade
ii. Capping layer
iii. Drainage layer
iv. Select fill
v. General fill
vi. Treated in-situ material
vii. Natural unprocessed in situ material, other than that moved from other location and/or compacted.
The strength is determined based on the geological and soil property assessment along with strength tests such as the California Bearing Ratio (CBR), Dynamic Cone Penetrometer (DCP). For the design using CBR value, the CBR strength is determined for the wettest moisture condition likely to occur during the design life, at the density expected to be achieved in the field.

5. Defining Wet or Dry conditions

It is difficult to completely prevent the influence of water on pavements and sub-grade. The reasons that can increase the ingress of water include:

i. Rain, particularly on unprotected and/or poorly maintained pavements
ii. Inundation
iii. Positive water head
iv. Ponded water
v. Construction water
vi. Inadequate surface drainage
vii. Soil suction from areas such as adjacent ponded water and/or water tables.

Other factors that influence, apart from the broad climatic considerations, include drainage and maintenance regimes that are anticipated for the road. If there is frequent ingress of water to the pavement layers, it will result in rapid pavement deterioration under traffic.

For the purposes of design, “predominantly dry regions” are considered to be those where the annual rainfall is less than 250 mm and there is no likelihood of moisture ingress due to factors such as significant flooding. The regions where the rainfall is more than 250 mm are generally classified as “predominantly wet regions”.

6. Practical Considerations

Other factors that influence the design of pavements include: availability of the quality and quantity of materials for road construction; general topography; and use of local established methods of construction. In addition, consideration is to be given to vehicle overloading, sub-grade CBR values less that 2% and design traffic greater that 30 million ESAs.

7. Selection of Pavement Structure

The pavement design engineer makes the decision of using a combination of: granular/cement sub-bases, granular/cement/bituminous bases, and asphaltic concrete or cement concrete depending upon the dry and wet conditions; traffic loading; and materials availability.

“Primary” and “Class I” highways should have a cement concrete or asphaltic concrete surfacing as a minimum. Class III may be paved with double bituminous treatment.
8. Structure Loading

The TAH Network should have a high design load capacity. The minimum design loading of HS 20-44, the international standard corresponding to full-size trailer loading, should therefore be used for the design of structures.


Harmonization and enforcement of axle load, gross vehicle mass and vehicle dimension limits across the TAH network is required to control vehicle overloading and damage to the roads and improve safety. The recommended limits are presented in Table All-15.

![Table All-15 Vehicle Specifications](image)

<table>
<thead>
<tr>
<th>Specification</th>
<th>Maximum Allowable</th>
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</thead>
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<td>Single Front Axle - Steering (tons)</td>
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</tr>
<tr>
<td>Single Front Axle – Non-Steering (tons)</td>
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</tr>
<tr>
<td>Gross Vehicle Mass (tons)</td>
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<td>Vehicle Dimensions (m)</td>
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<td>Width</td>
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<td>Height</td>
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<tr>
<td>Length</td>
<td>24.0</td>
</tr>
</tbody>
</table>

C. C: ROAD BRIDGES AND CULVERTS

The concrete highway bridges and culverts are designed to achieve acceptable levels that include: safety, serviceability and durability. They must be designed to carry the traffic loading intended for that segment of the TAH.

The guidelines presented are of general nature and are primarily applicable to the reinforced and/or pre-stressed concrete structures where ordinary aggregates are used. Special consideration should be given and specific codes referred to where: concrete is made with high-alumina cement; steel bridges; composite bridges; consideration of fatigue; bridge bearings; and design of foundations.

1. Design Philosophy

i. General:
In the design of structures, basic considerations should include: the safety of structures; risk and methods of analysis; and optimization procedures. A practical approach to design known as “Limit State Design Method” is presented. It uses practical safety factors. It is seen to be an improvement over the Factor of safety of Working Stress Methods.

ii. The Limit Design Method:

It is a practical procedure that achieves acceptable probabilities and ensures that the structure will remain fit for the required purpose with intended life. In considering safety margins, the impact of the consequences of failure should include: risk of life or public reaction due to possible failure; and economic consequences due to inability of the use of lost structure and cost of repair. The consequences of failure can be classified as:

- Not serious – negligible risk to life and small economic consequence
- Serious - risk to life exists and considerable economic consequences
- Very serious-high risk to life and/or high economic consequences

Therefore when developing the calculation model for the design process, relevant factors such as: uncertainties with respect to action, overall structure response, response of individual elements, workmanship and quality control should be considered. The models should lead to designs for different limit states and to acceptable degrees of safety and structural reliability.

The structural design is undertaken in two stages: one, dealing with the analysis of the structure as a whole, and the other dealing with the individual sections of the structural elements. A “limit state design” process is recommended. It is a decision making process in which various uncertainties are taken into consideration in assessing the design variables with a view to obtain an acceptable variable probability.

iii. Levels of Limit State Design

There are three levels at which structural safety can be applied in the design process:

a. Level 1: It is a semi-probabilistic process, specifically defining the characteristic values of loads or actions and the strength of materials.

b. Level 2: A design process in which the loads or actions and the strengths of materials and sections are represented by their known or expected distributions and some reliability level is expected.

c. Level 3: It is a design process based on exact probabilistic analysis for the entire structural system with safety based on some interpreted failure probability.

iv. The serviceability limits for design include:
a. Deformation

The deformation of the structure, or any part of the structure should not adversely affect the appearance or efficiency of the structure, violate minimum specified clearances, cause drainage difficulties, or give cause for public concern.

b. Local Damage or Cracking

Damage occurring in specific parts of the structure e.g. caused by localized overstressing, which might entail excessive maintenance, or lead to corrosion, and hence adversely affect the appearance or efficiency of the structure, should be limited.

c. Vibration

Where there is a likelihood of the structure being subjected to excessive vibration from causes such as wind forces or moving traffic resulting in resonance, appropriate analyses should be carried out to ensure design adequacy.

v. General considerations:

a. Overall stability and robustness

It should be ensured that the structure configuration and interaction between the structural members lead to a robust and stable design. The structure should have adequate resistance to lateral actions.

b. Durability

It refers to the detailed aspects of design, specifications and control of materials and work quality and impact of environment. These aspects should be covered for the design life of the structure.

c. Utility and aesthetic quality

Overall cost benefit to society and aesthetics should be ensured.

2. Actions

i. An “Action” is an assembly of: concentrated or distributed forces (direct actions); or imposed or constrained deformations (indirect actions). Due consideration should be given to this factor during the design phase.

ii. Actions according to their variation in time are: permanent actions (self-weight of structures, weight of any controlled superstructure, forces applied by earth pressure, pre-stress, deformations due to mode of construction, shrinkage of welds and concrete, water pressures); variable actions (working loads, self-weight of structures during
construction, erection loads, moving loads, forces from wind, earthquakes, water and temperature); and accidental actions (impact due to vehicular collision, explosions, unpredictable subsidence of soil, rock avalanches, unexpected storms and earthquakes).

iii. **Actions according to their variation in space** are: fixed actions (distribution over the structure is unambiguously defined primarily by deterministic parameters); and free actions (that cannot be defined by a unique variable without some idealization).

iv. **Actions according to their nature** are: static actions (which do not cause significant acceleration of the structure); and dynamic actions (cause significant acceleration to the structures).

v. **Actions and situations**: In covering the life of the structure that includes construction phase and use both permanent situation (duration same as the life of the structure) and temporary situation (transit and accidental) should be considered.

3. **Properties of Materials**

   The material properties and their statistical variations are to be determined from tests on appropriate standard test specimens. These properties are then to be converted to the relevant properties of the actual material in the structure by using the conversion factors or functions. If the material is to be produced on site, it should be ensured that the material meets the specified characteristic strength.

4. **Geometric Data**

   In the design, possible variation in the geometric data should be considered. In most cases this variability is small or negligible compared with the variability associated with the” Actions” (Para 34) and “Material Properties” (Para 35).

5. **Definition of Design Values**

   For a structure, the variability of actions is defined in terms of characteristics values. If the data is available, these are based on the statistical interpretation otherwise it is based on experience, and includes implications of any future developments. The nominal values to be adopted should reflect local conditions and are for a return period of 100 years. For construction materials where the statistical data on the strength of materials are available, they are used in the code. If they are not available, nominal values are used as characteristics values in all computations.

6. **Analysis**

   The methods of analysis used to assess compliance with the requirements of the various limit states should be based on the behavior of the structure. The methods used and the degree of sophistication or refinement thereof will depend on the nature,
purpose and configuration of the structure and the nature of the actions to which it is subjected.

7. Soil-structure Interaction

The soil or the rock on which the structure is to be constructed should be considered as an integral part of that structure. It is essential that the properties of the soil should be determined that are sufficient in terms of the design assumptions to ensure reliability. The upper and lower limits of estimated settlement, swelling or heaving should be used to establish extreme effects on the structure.

8. Erection, Control and Acceptance

The assessment of the loads and location of erection plant should be made accurately. The amount of partial factor applied to these loads should be appraised for each case on its merits, making due allowance for the accuracy of the evaluation of temporary loads. Where temporary flexible supports or suspension cables are used to suspend parts of the permanent structure during erection or construction, any interaction with the permanent structure or part thereof, including temperature effects should be accurately assessed, as should the effects on the permanent structure of removing such supports.

9. Highway Carriageway and Lanes

Carriageway is defined as part of the running surface which includes all traffic lanes, hard shoulders, hard strips and marker strips. The carriageway width is the width between raised kerbs. If there are no raised kerbs, it is the width between guard rails or safety fences, less the amount of setback required for these fences, being not less than 0.6 m or more than 1.0 m from the traffic face of each fence. The traffic lanes are the lanes that are marked on the running surface of the bridge and are normally used by traffic.

10. Bridge Components

i. Superstructure

It is that part of the structure which is supported by piers, towers or abutments. Arches and spandrel columns are considered to be a part of the superstructure

ii. Substructure

It is the piers, towers, abutments and wing walls that support the superstructure

iii. Foundation

It is that part of the substructure which is in direct contact with, and transmits action to the ground.
11. Culverts

A culvert is a drain or pipe that allows water to flow under a road. Culverts differ from bridges mainly in size and construction. Culverts are generally smaller than bridges, ranging from 0.3 m pipes to larger reinforced concrete structures. Culverts are typically surrounded by soil.

In the design culverts under roadways the quantities of concrete, reinforcing steel and backfill information is required. Hydraulic calculations for roadway cross drainage are done based on flow value and a tail-water depth. This is used to calculate the controlling Headwater (inlet or outlet control) and outlet velocity for culverts. Various types of culvert such as standard concrete pipes, box culverts and corrugated steel pipes can be used depending on the requirement.

D. ROAD MAINTENANCE AND REHABILITATION

1. General

Effective road maintenance of all TAH routes contribute to reliable transport at reduced cost, as there is a direct link between road condition and vehicle operating costs (VOC). An improperly maintained road can also represent an increased safety hazard to the user, leading to more accidents, with associated human trauma and property costs. In general, road maintenance activities can be divided into four categories:

i. Routine Works

These are undertaken each year. Examples include verge cutting and culvert cleaning, both of which are dependent on environmental effects rather than on traffic levels. Reactive works are those where intervention levels, defined in the maintenance standard, are used to determine when maintenance is needed. An example is patching, which is carried out in response to the appearance of cracks or pot-holes

ii. Periodic Works

These are the activities undertaken at intervals of several years to preserve the structural integrity of the road, or to enable the road to carry increased axle loads. It normally excludes those works that change the geometry of a road by widening or realignment. Works can be grouped into the works types of preventive, resurfacing, overlay and pavement reconstruction

iii. Special Works.

The activities include emergency works to repair landslides and washouts that result in the road being cut or made impassable; and

These are construction works that are identified as part of the national development planning activity. As such, they are funded from the capital budget. Examples are the construction of by-passes, or the paving of unpaved roads in villages. The TAH routes and all related facilities are to be maintained to ensure the safety and comfort of highway users. Clearly defined programs are to be set up for the maintenance of roads in the network so as to avoid traffic delays. The maintenance programs for both routine and periodic works are to be set up to cover all aspects of the road, including asphalt surfaces, concrete and steel structures, bridges, cut and fill areas, water drainage areas, traffic signals and signs of all types, as well as tree growth, and road side vegetation.

It is requested that non-classified TAH routes should be upgraded to any of the TAH Classes during rehabilitation.

2. Road Maintenance/Pavement Management Systems

For the maintenance framework of the TAH network, it is essential to implement specialized Road Maintenance/Pavement Management System. Such maintenance programs should be managed by special groups who will be responsible for road condition data collection. The data should be analyzed, maintenance options developed and recommendations made to the management in the form of a report for the most effective road improvement treatment regime. Budget allocations should be made for maintenance/rehabilitation operations. The authorities concerned with the implementation of planning policies and maintenance/rehabilitation should take into account all the related aspects, such as installing traffic signals, defining vehicle speeds and ensuring the proper performance of maintenance works in accordance with the programs established for that purpose.

3. Other Considerations

In carrying out maintenance works, special care should be taken to ensure safety of workers, proper signage to warn traffic of road works and mitigation of any environmental impact. This should be undertaken as part of the planning of the maintenance works which include road work signage and adequate safety gear for workers. Effective maintenance policy should be implemented that ensures continuity of service during maintenance works. Preferably such works should be performed at off peak times to minimize traffic delays.

Highway safety devices, such as portable traffic signs and signals, should be in place at the work sites to improve workplace safety and flow of vehicle traffic. Such devices should be clearly visible both in the day and at night. Periodic inspections should be conducted to make sure that they are clear and are providing their intended messages and that they are in accordance with the international practices.
The continuity of the flow of traffic under adverse weather conditions over the entire TAH road network should be ensured. Care must be taken to remove any soil or sand from the roadway and all traffic signs and signals be cleaned periodically.

E. ROAD SAFETY, SOCIAL AND ENVIRONMENT

1. Road Safety

All countries should consider and address road safety as an integral component for new construction, upgrades, and review of existing roads (by way of road safety audits) of Trans-African Highways network. Details are presented in Annex III.

i. TAH Guidelines for signs, signals, markings, equipment, facilities, tunnels and installations are presented in Annex III A

ii. TAH Guidelines for road infrastructure safety management are presented in Annex III B

2. Social and Environment

All countries should ensure that there is minimal impact on society and environment as a result of construction, maintenance and operation of new Trans-African Highways and upgrade of existing highways. As a minimum, environmental impact assessment, following the national standards should be undertaken and mitigation measures implemented for all upgrades and new construction of highways. Details are presented in Annex IV and Annex V.
<table>
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<th>Specification</th>
<th>COMESA</th>
<th>SADC</th>
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AC: Asphaltic Concrete; CC: Cement Concrete